



SEATTLE CITY COUNCIL

Legislative Summary

CB 118378

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124766

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Final Action: 05/08/2015

Title: AN ORDINANCE relating to Seattle Public Utilities; authorizing the Director of Seattle Public Utilities to submit the "Plan to Protect Seattle's Waterways" and to fulfill the obligations set forth therein, to fulfill obligations under a Consent Decree required by the United States Environmental Protection Agency and the State of Washington Department of Ecology.

Date

Notes:

Filed with City Clerk:

Mayor's Signature:

Sponsors: Bagshaw

Vetoed by Mayor:

Veto Overridden:

Veto Sustained:

Attachments:

Drafter: Ed Mirabella

Filing Requirements/Dept Action:

History of Legislative File

Legal Notice Published:

☐ Yes

☐ No

Ver- sion:	Acting Body:	Date:	Action:	Sent To:	Due Date:	Return Date:	Result:
1	Mayor	03/31/2015	Mayor's leg transmitted to Council	City Clerk			
	Action Text: The Council Bill (CB) was Mayor's leg transmitted to Council. to the City Clerk Notes:						
1	City Clerk	03/31/2015	sent for review	Council President's Office			
	Action Text: The Council Bill (CB) was sent for review. to the Council President's Office Notes:						
1	Council President's Office	04/02/2015	sent for review	Seattle Public Utilities and Neighborhoods Committee			
	Action Text: The Council Bill (CB) was sent for review. to the Seattle Public Utilities and Neighborhoods Committee Notes:						

- 1 Full Council 04/20/2015 referred Seattle Public Utilities and Neighborhoods Committee
- Action Text: The Council Bill (CB) was referred to the Seattle Public Utilities and Neighborhoods Committee
- Notes:
- 1 Seattle Public Utilities and Neighborhoods Committee 04/28/2015 pass Pass
- Action Text: The Committee recommends that Full Council pass the Council Bill (CB).
- Notes:
- In Favor: 3 Chair Bagshaw, Vice Chair Sawant, Member Harrell
- Opposed: 0
- 1 Full Council 05/04/2015 passed Pass
- Action Text: The Council Bill (CB) was passed by the following vote and the President signed the Bill:
- Notes:
- In Favor: 9 Councilmember Bagshaw, Council President Burgess, Councilmember Godden, Councilmember Harrell, Councilmember Licata, Councilmember O'Brien, Councilmember Okamoto, Councilmember Rasmussen, Councilmember Sawant
- Opposed: 0
- 1 City Clerk 05/06/2015 submitted for Mayor's signature Mayor
- Action Text: The Council Bill (CB) was submitted for Mayor's signature to the Mayor
- Notes:
- 1 Mayor 05/08/2015 Signed
- Action Text: The Council Bill (CB) was Signed
- Notes:
- 1 Mayor 05/08/2015 returned City Clerk
- Action Text: The Council Bill (CB) was returned to the City Clerk
- Notes:
- 1 City Clerk 05/08/2015 attested by City Clerk
- Action Text: The Ordinance (Ord) was attested by City Clerk
- Notes:
-

CITY OF SEATTLE
ORDINANCE 124766
COUNCIL BILL 118378

AN ORDINANCE relating to Seattle Public Utilities; authorizing the Director of Seattle Public Utilities to submit the "Plan to Protect Seattle's Waterways" and to fulfill the obligations set forth therein, to fulfill obligations under a Consent Decree required by the United States Environmental Protection Agency and the State of Washington Department of Ecology.

WHEREAS, the City of Seattle (City) owns, maintains and operates a system of sanitary sewerage and storm and surface water drainage as part of Seattle Public Utilities' drainage and wastewater system; and

WHEREAS, the combined sewer system overflows (CSOs) from the City of Seattle's system are regulated by the State of Washington under the terms of a National Pollutant Discharge Elimination System (NPDES) permit; and

WHEREAS, the United States Environmental Protection Agency (EPA) has made Findings and Conclusions and issued a Consent Decree pursuant to Section 402 of the Clean Water Act, 33 U.S.C. section 1342(b); and

WHEREAS, the City in 2012 approved Ordinance 123908 authorizing the Director of Seattle Public Utilities to submit for court approval the Consent Decree and to fulfill the City's obligations contained therein; and

WHEREAS, City in 2013 approved ordinance 124129 authorizing the Director of Seattle Public Utilities to submit for court approval an amended Consent Decree and to fulfill the City's obligations contained therein; and

1 WHEREAS, the Consent Decree requires the City to implement its CSO reduction program by
2 2025 but also includes provisions allowing the City to defer certain CSO investments if
3 alternative projects that yield greater benefit to the receiving waters can be identified by
4 2018; and

5 WHEREAS, Seattle Public Utilities has developed: a Long Term Control Plan to implement its
6 CSO reduction program by 2025; an Integrated Plan to defer certain CSO investments in
7 favor of using alternative projects that yield greater benefit to the receiving waters; and
8 an Integrated Plan Alternative, known as the "Plan to Protect Seattle's Waterways," to
9 both implement the City's long term CSO reduction program and reduce stormwater
10 pollution using the Integrated Plan; and

11 WHEREAS, the Director of Seattle Public Utilities recommends that the "Plan to Protect
12 Seattle's Waterways" be submitted to the United States Environmental Protection
13 Agency and the State of Washington Department of Ecology in partial fulfillment of the
14 City's obligations to implement its CSO reduction program; NOW, THEREFORE,

15 **BE IT ORDAINED BY THE CITY OF SEATTLE AS FOLLOWS:**

16 Section 1. The Director of Seattle Public Utilities is authorized to submit to the United
17 States Environmental Protection Agency (EPA) and the State of Washington Department of
18 Ecology (Ecology) the "Plan to Protect Seattle's Waterways" (Plan), attached hereto as
19 Attachment 1, and to fulfill the City's obligations contained therein.

20 Section 2. The Director is further authorized to submit to EPA and Ecology any Plan
21 amendment that is required by EPA or Ecology and that does not increase the cost of or
22 significantly alter the City's compliance obligations, and to fulfill the City's obligations
23 contained therein.

Section 3. The provisions of this ordinance are declared to be separate and severable.
The invalidity of any portion of this ordinance, or the invalidity of its application to any person
or circumstance, does not affect the validity of the remainder of this ordinance or the validity of
its application to other persons or circumstances.

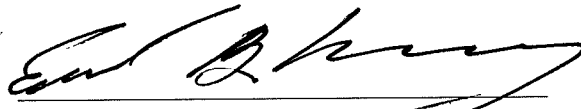
Section 4. This ordinance shall take effect and be in force 30 days after its approval by the Mayor, but if not approved and returned by the Mayor within ten days after presentation, it shall take effect as provided by Seattle Municipal Code Section 1.04.020.

Passed by the City Council the 4th day of MAY, 2015, and signed by me in open session in authentication of its passage this 4th day of MAY, 2015.



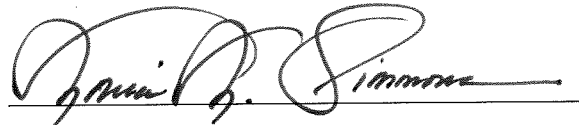
President _____ of the City Council

Approved by me this 8th day of May, 2015.



Edward B. Murray, Mayor

Filed by me this 8th day of MAY, 2015.



Monica Martinez Simmons, City Clerk

(Seal)

Attachment 1 – Plan to Protect Seattle’s Waterways
Volume 1: Executive Summary
Volume 2: Long-Term Control Plan
Volume 3: Integrated Plan
Volume 4: Environmental Impact Statement



Protecting Seattle's Waterways

Volume 1

The Plan to Protect Seattle's Waterways Executive Summary

Final | **May 29, 2015**



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Executive Summary

The City of Seattle has prepared a comprehensive strategy, called The Plan to Protect Seattle's Waterways, to reduce overflows and discharge of pollutants from combined sewers and the storm drain system. The City must control sewer discharges to protect public health and the environment, and to comply with the Clean Water Act, the United States District Court Consent Decree, and state regulations. The Plan proposes two alternatives to reach compliance. One alternative, the Long Term Control Plan, will control all combined sewer overflows by 2025. The second alternative, the Integrated Plan, will integrate the control of combined sewer overflows with the reduction of pollutants from stormwater discharges and defer some low priority combined sewer overflow control projects beyond 2025.

What is the Plan to Protect Seattle's Waterways?

Seattle is served by a combined sewer system that handles both stormwater runoff and wastewater generated by businesses and residents. Heavy rains can overwhelm the sewers and cause Combined Sewer Overflows, or CSOs. These sewage discharge events can contribute pollutants to surrounding water bodies and impact their quality and uses. In addition, stormwater runoff collected in separate pipes from streets, parking lots, and buildings contributes a wide range of pollutants to the city's waters.

What is stormwater runoff?

Stormwater is rain and melting snow that runs off surfaces that cannot readily absorb water, such as streets, rooftops, and parking lots. As stormwater flows across these hard surfaces, it picks up pollutants such as oil, grease, and metals, carrying them through the City's storm drain system to lakes, streams, rivers, and Puget Sound. It also flows into the combined sewer system and causes overflows of raw sewage and polluted stormwater into Seattle waterways. Recent scientific studies have determined that polluted stormwater runoff poses a significant impact to local water quality.

The City of Seattle (the City) has prepared a comprehensive strategy, called The Plan to Protect Seattle's Waterways (the Plan), to reduce overflows and the discharge of pollutants from combined sewers and the storm drain system. Specifically, the Plan achieves the following objectives:

- Identifies areas of Seattle where projects are needed to reduce CSOs.
- Evaluates alternatives for reducing CSOs in these areas.
- Identifies additional areas where projects to control and reduce polluted stormwater runoff will improve water quality.
- Recommends a schedule for designing and constructing projects.
- Estimates program costs and rate impacts on City customer bills.
- Considers public and stakeholder input.

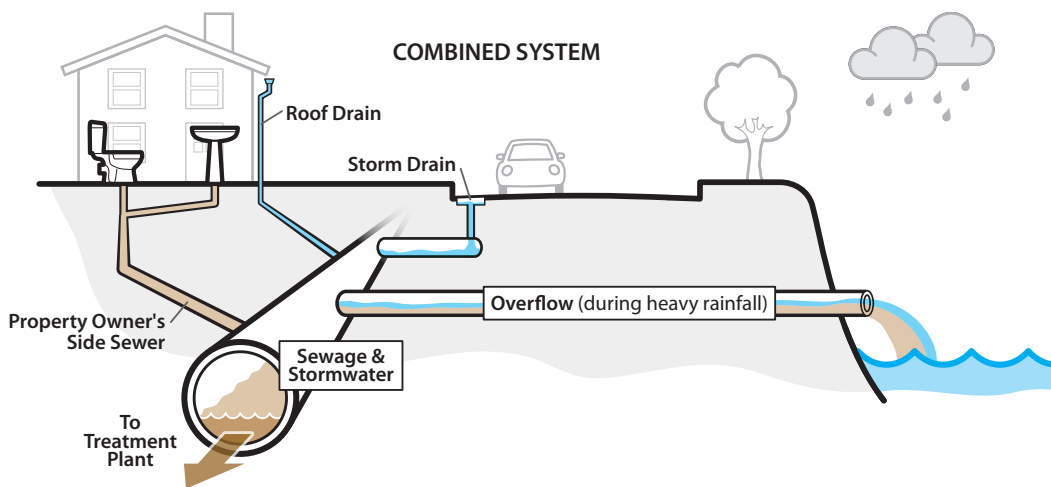
There are four Volumes included in the Plan. This Executive Summary is Volume 1, followed by Volume 2 Long Term Control Plan (LTCP), Volume 3 Integrated Plan, and Volume 4 Environmental Impact Statement (EIS).

Why are CSOs a problem?

About two-thirds of Seattle is served by a combined sewer system, which was designed to carry sewage and stormwater runoff from streets, rooftops, and parking lots in a single pipe—a “combined sewer”. Under dry weather conditions in Seattle, all sewage flows to the treatment plant. During wet weather conditions however, stormwater runoff is considerable and can cause the capacity of the combined sewer system to be exceeded. When this mixture of stormwater (about 90%) and raw sewage exceeds the pipe’s capacity, it results in a CSO.

CSOs present a range of public health and environmental concerns. Pollutants conveyed in CSOs can create human health risks from contact with water or consumption of fish/shellfish from areas of recent CSO discharge and can also cause impacts to aquatic life. The high variability in flow rates within the sewer system associated with heavy storms can also cause operational problems at the wastewater treatment plant.

The image in Figure ES-1 depicts how overflows can occur under heavy rain conditions in combined sewer systems.



Combined Sewer Overflow Quick Facts

The City of Seattle and King County both manage CSO outfalls in the Seattle area: the City manages 86 outfalls; King County manages 38.

In 2014 a total of 406 CSO events from City-managed outfalls resulted in 116 million gallons of overflow.

Figure ES-1. Schematic of a CSO

How is stormwater involved?

In some neighborhoods in Seattle, stormwater is not combined with sewage, but instead drains into a separate pipe (“separated system” as shown on figure ES-2) and is discharged into nearby water bodies. While CSOs happen

occasionally when it rains, stormwater discharges occur every time it rains and have the potential to contribute pollutants such as metals, pesticides and pathogens that can be harmful to people and aquatic life.

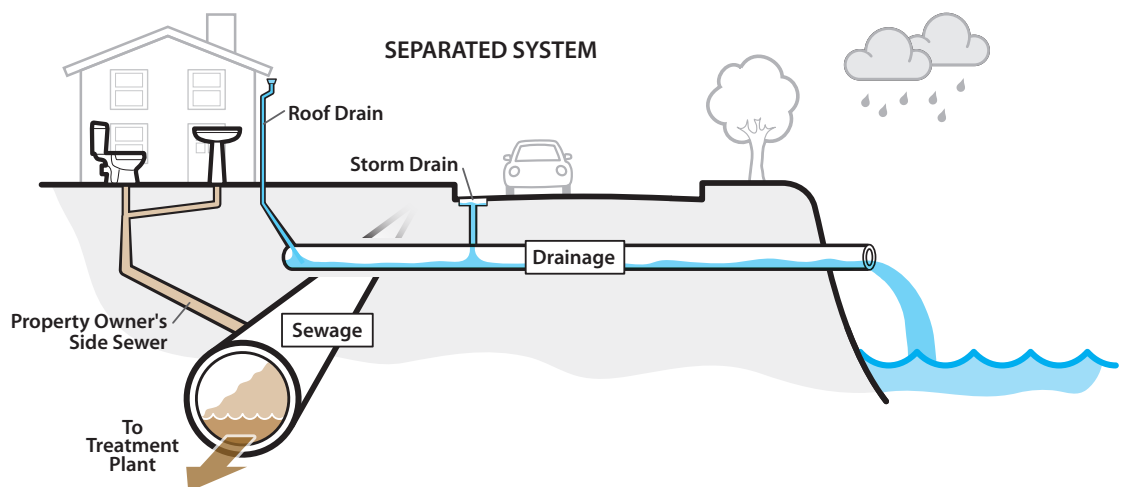


Figure ES-2. Schematic of a Separated System

What Federal and State Regulations pertain to CSOs?

The federal Clean Water Act (33 United States Code 1251) requires water quality sufficient to allow people to swim, boat, fish, and enjoy our waterways. The law's requirements are intended to protect the environment, human health, and quality of life. Municipalities must obtain authorization to discharge wastewater, CSOs, and stormwater into surface water bodies.

The Clean Water Act established the National Pollutant Discharge Elimination System (NPDES) program. The program limits the discharge of pollutants in order to meet water quality criteria. In Washington, the NPDES program is administered by the Washington State Department of Ecology (Ecology). Ecology's regulations in the Washington Administrative Code (Chapter 173-220) govern the City's and King County's NPDES permits.

The City manages sewage and stormwater throughout Seattle. Stormwater is managed in accordance with

Ecology's NPDES municipal stormwater permit requirements. The City reports progress on its compliance activities annually to Ecology. The stormwater permit applies to the municipal separate storm sewers operated by the City within the geographic boundaries established by the permit.

The City's most recent wastewater NPDES permit (WA0031682) was modified on September 13, 2012; it allows wet weather discharges from permitted CSO outfalls. The permit also requires implementation of the "Nine Minimum Controls" to ensure adequate capacity and maintenance of the sewer system, defines monitoring requirements, establishes requirements for detailed reporting to Ecology, and allows discharges only as a result of precipitation events. The City's NPDES permit must be renewed by November 2015.

What is the U.S. Environmental Protection Agency CSO Control Policy?

The Environmental Protection Agency, or EPA, has a CSO control policy that provides the national framework for control of CSOs. Published on April 19, 1994, the policy provides guidance on how communities with combined sewer systems can meet Clean Water Act goals in as flexible and cost-effective a manner as possible. The policy has three

main elements: Nine Minimum Controls, Long Term Control Plans, and Requirement to Meet Water Quality Standards. The LTCP specifically addresses all three policy elements.

What are the State Requirements?

Washington state law (Revised Code of Washington 90.48.480) requires local governments to achieve the greatest reasonable reduction in CSOs at the earliest possible date. The Washington Administrative Code (173-245-020(22)) defines the "greatest reasonable reduction" as an average of no more than one untreated discharge per year per outfall. The City's NPDES permit and Consent Decree direct that a moving 20 year period be used for long-term averaging. Outfalls meeting this standard are considered controlled while outfalls that experience an average of more than one CSO occurrence per year are considered uncontrolled and require City action.

On an annual basis, the City is required to report the duration and volume of each CSO discharge during the most recent year, steps taken during the most recent year to

reduce CSOs, the CSO outfalls now meeting the definition of greatest reasonable reduction, and work planned for the next year to reduce CSOs.

What are the presumption and demonstration approaches?

The presumption approach presumes that water quality goals will be achieved through performance standards, such as the no more than once per year untreated discharge standard. The demonstration approach relies on monitoring to determine the effectiveness of CSO control measures. The State accepts the City and King County strategy of using the Presumption Approach followed by effectiveness monitoring.

What is the Consent Decree?

Until recently, EPA and Ecology have focused primarily on CSO control when administering NPDES CSO discharge requirements. Seattle and other cities across the country have asked EPA for greater flexibility to make smart investments, using a range of tools to achieve federal and state water quality requirements, allowing jurisdictions to customize approaches to their specific situations. Recognizing the contribution of stormwater to water quality issues in local water bodies, and recognizing the overall benefits that can be achieved from a blend of stormwater and CSO reduction projects, the City negotiated a Consent Decree with EPA and the U.S. Department of Justice, that allows a more flexible and integrated approach for Seattle's compliance with the Clean Water Act and State regulations.

The Consent Decree, entered in United States District Court for the Western District of Washington on July 3, 2013, required the City to submit a draft LTCP for regulatory and public review by May 30, 2014 and submit a final LTCP for regulatory approval by May 30, 2015, with the City's recommended solution. The Consent Decree also allowed the City to develop, as an alternative, an "Integrated Plan" that proposes stormwater control projects to be implemented by the City and defers completion of some CSO facilities. The Integrated Plan must demonstrate that the proposed stormwater control projects will result in significant benefits to water quality beyond those that would be achieved by implementation of the CSO control projects alone.

The Consent Decree encourages the use of green infrastructure, also called natural drainage systems, together with traditional engineered measures, as long as the City demonstrates its effectiveness and the combined measures provide substantially the same or greater levels of control than traditional engineered measures alone.

The Consent Decree includes a number of requirements for the Integrated Plan, including a pollutant load reduction analysis and an evaluation of projected benefits to water quality, ecology, and human health that would result from implementing the identified stormwater projects. The Integrated Plan must demonstrate that the proposed stormwater projects will provide greater water quality benefits compared to those CSO control projects that would be deferred, and that they must meet the requirements of the Clean Water Act, Ecology's NPDES and municipal separate storm sewer system (MS4) permits, and EPA's CSO Control Policy.

What is the Consent Decree?

The Consent Decree is a written agreement between the City of Seattle, Washington State Department of Ecology, the Environmental Protection Agency, and the U.S. Department of Justice that describes the actions that the City of Seattle must take to address violations of the Clean Water Act.

What has the City already done about CSOs?

To date, the City has completed five CSO control plans beginning in 1980, as listed below.

- 1980 Facility Plan (201 Facilities Planning)
- 1988 CSO Reduction Plan
- 2001 CSO Reduction Plan Amendment
- CSO Reduction Plan Amendment 2005 Update
- 2010 CSO Reduction Plan Amendment

These CSO control plans have resulted in the construction of various CSO control projects throughout the City, which have substantially reduced CSO discharges. Some

of the projects involved maintenance or modification of existing sewer facilities, while others involved construction of diversion structures to direct flows away from CSO outfalls, or construction of storage facilities to store excess wastewater until flows decrease enough for the stored wastewater to be returned to the conveyance system. The CSO control projects that have been completed since 2008 are shown on Figure ES-3.

What is the City currently doing about CSOs?

Overall, the City's strategy to reduce CSOs has consisted of a three-pronged approach:

- **Fix it First - Sewer System Improvements:** Sewer system improvements are relatively simple improvements to the existing system that provide more capacity for storage or make the system operate more effectively. These solutions can be much more cost-effective than building new facilities. Some examples include raising overflow weirs and replacing mechanical parts that regulate gates.
- **Keep Stormwater Out – Natural Drainage Systems:** Natural drainage, also called green infrastructure, consists of a variety of practices that keep stormwater out of the sewer system by using natural processes to slow, filter, and absorb stormwater.
- **Store What's Left – Underground Storage:** If the first two types of solutions don't solve the problem, then additional underground storage facilities would need to be built. Underground storage can include tanks, pipes, or tunnels.

Currently, the City is implementing a series of underground storage, sewer system improvement, and green infrastructure projects aimed at reducing CSO discharges. These current CSO control projects are grouped into two categories, as shown on page 15: the 2010 Plan Projects, and the Early Action Projects. The underground storage projects were identified in the City's 2010 CSO Reduction Plan Amendment as high-priority projects intended to reduce CSO discharges into Lake Washington. The sewer system improvement and green infrastructure projects

are being implemented because they set the stage for future underground storage projects, which are identified in the LTCP. The sewer system improvement and green infrastructure projects are expected to reduce CSO discharges and will likely eliminate the need for or reduce the size of future underground storage facilities. The current CSO reduction projects are shown on Figure ES-3.

Although the current CSO reduction projects are expected to significantly reduce CSO discharges, in order to comply with the State and Federal regulations described above, the City must achieve additional CSO reductions. The City has developed two alternatives to achieve these additional reductions – the LTCP Alternative and the Integrated Plan Alternative. The following sections describe these alternatives in greater detail, discuss their impacts, and present the City's Recommended Alternative.

Addressing the Remaining CSOs

Over the last 25 years, the City of Seattle has successfully reduced CSO discharge volumes into surrounding receiving waters by nearly 70 percent. However, there is still work to be done to control the remaining CSOs, and the final reduction in CSO volume is the most challenging.



Figure ES-3.
Completed and ongoing CSO
reduction projects for the 2010
Plan and Early Action projects

What is the Long Term Control Plan?

As part of its regulatory compliance efforts, the City must prepare a CSO Reduction Plan, with amendments every five years. The LTCP is the City's 2015 CSO Reduction Plan Amendment, and defines a comprehensive program and schedule for implementing projects and measures to control overflows at all of the City's 86 CSO outfalls.

The LTCP builds upon the alternative analysis work that was performed as part of the development of the City's 2010 CSO Reduction Plan Amendment.

The final LTCP was submitted to EPA and Ecology on May 29, 2015. The solutions identified in the LTCP must be approved by Ecology and EPA, and will be constructed in the years following 2015.

What does the LTCP do?

The LTCP builds upon the 2010 CSO Reduction Plan Amendment. The LTCP defines a comprehensive program and schedule for implementing projects and measures to control the remaining CSO outfalls.

What is the LTCP Alternative?

As a planning-level document, the LTCP presents a comprehensive strategy to reduce the remaining uncontrolled CSO discharges in the city. The City must address these CSOs to protect public health and the environment, and comply with the Clean Water Act and state regulations. The LTCP includes CSO control measures and an implementation schedule to meet the Consent Decree Construction Completion milestone date of December 31, 2025 and the "controlled" status for each outfall as defined in the Consent Decree. The LTCP Alternative includes CSO reduction projects in the Leschi, Montlake, Portage Bay, Duwamish, East Waterway, Magnolia, Central Waterfront, Ballard, Fremont/Wallingford, Delridge, and North Union Bay neighborhoods, each of which contain uncontrolled outfalls.

The LTCP Alternative consists of the Recommended LTCP Option, which was selected from among the various options to control CSOs as presented in the LTCP.

The City published a draft LTCP and accompanying draft EIS in May 2014 inviting public and regulatory agency comment on four options for meeting CSO control requirements. The draft LTCP presented a detailed evaluation of the monetary and non-monetary factors for each of the options. Within the four options, two general strategies were considered: the first was a strategy under which the City would complete all of the necessary actions independently of any other agency, while the second would seek opportunities to partner with

King County to achieve economies of scale or reductions in community and environmental impacts for each agency's parallel CSO control issues.

Following receipt of public and agency comments, additional refinements were made to the four options. The City received updated storage release rates from King County that were used to analyze and adjust the sizing of the proposed control measures. Cost estimates were updated based on the new sizing, then community and environmental impacts were re-assessed. The four options were compared and two of the options (Neighborhood Storage Option and Shared West Ship Canal Tunnel Option) were selected for final analysis. Since the costs of the two options were determined to be similar, the final analysis focused more on environmental and community impacts and the ability of the City and King County to collaborate on a shared project.

The City and King County have been working to coordinate and implement their respective CSO projects and LTCP and in 2014 agreed on a coordination strategy including factors that are to be considered in any ongoing agreement to enter into a shared project. These factors are compared for both the Shared West Ship Canal Tunnel and the Neighborhood Storage Options in Table ES-1.

Table ES-1. Comparison of Final LTCP Options

Determinant Factor	Shared City/King County Objectives	Neighborhood Storage	Shared West Ship Canal Tunnel
Financing	Comparative cost effectiveness; equitable sharing of financial risks and rewards	Cost difference is not a determining factor in the recommendation because the options considered are within the same cost range	
Scheduling	Maintain ability of each agency to meet legally imposed mandates	Complicated permitting due to multiple dispersed locations for tanks, pump stations, and conveyance facilities	A minor schedule milestone modification to the King County Consent Decree may be required for 3rd Ave W; however, compliance will be achieved for 11th Ave NW five years ahead of schedule
Community Impacts	Minimize overall construction and operating impacts on affected communities	Community disruption affects a greater number of neighborhoods; property removed from other uses, additional truck trips and traffic disruption from greater length of conveyance required	Community disruption more concentrated (reduced number of affected neighborhoods); portion of property returned to inventory for other uses, less truck traffic and less traffic impact from conveyance construction
Regulatory Considerations	Maximize likelihood of meeting compliance standards and flexibility to meet future changed conditions	Meets compliance standards based on current climatic conditions; limited flexibility	Serves regulatory request for enhanced coordination between agencies; provides increased flexibility to operate CSO control as a regional system and meet changing climatic conditions
Lead Agency Designation and Responsibilities	Optimize project delivery based on project characteristics	Both agencies have specialized experience in storage facility construction	Shared project agreements are being negotiated; SPU will be the lead agency; a joint oversight committee will be formed to manage the project

Based on the evaluation of the agreed-upon key factors for selection of a shared project, the City has identified the Shared West Ship Canal Tunnel Option as the recommended LTCP Option, as shown in Figure ES-4. This option was selected because it has fewer impacts to the community and the environment, and because it provides the City and King County with greater regulatory and operational flexibility to meet future changed conditions.

The LTCP Alternative consists of the Recommended LTCP Option, which is the Shared West Ship Canal Tunnel Option. This option controls four of the largest combined sewer areas with a single underground storage and conveyance facility. The West Ship Canal Tunnel is proposed as a shared option because the four combined sewer areas (two from the City and two from King County) with the largest control volumes are relatively close to one another. The facility would extend from Fremont/Wallingford to Ballard and would provide the storage needed to address sewage overflows in the City's Ballard and Fremont/Wallingford areas and from King County's 3rd Avenue West and 11th Avenue NW CSO areas. The facility would eliminate the need

for a separate King County CSO control project at an outfall near 3rd Avenue West and a large-diameter King County pipeline from 11th Ave NW to the Ballard Regulator.

Within this option, and therefore, within the Recommended LTCP Alternative, the remaining CSO areas would be controlled by their respective neighborhood control measures.

Prior to implementing any shared City and King County projects, the agencies will enter into an inter-local agreement.

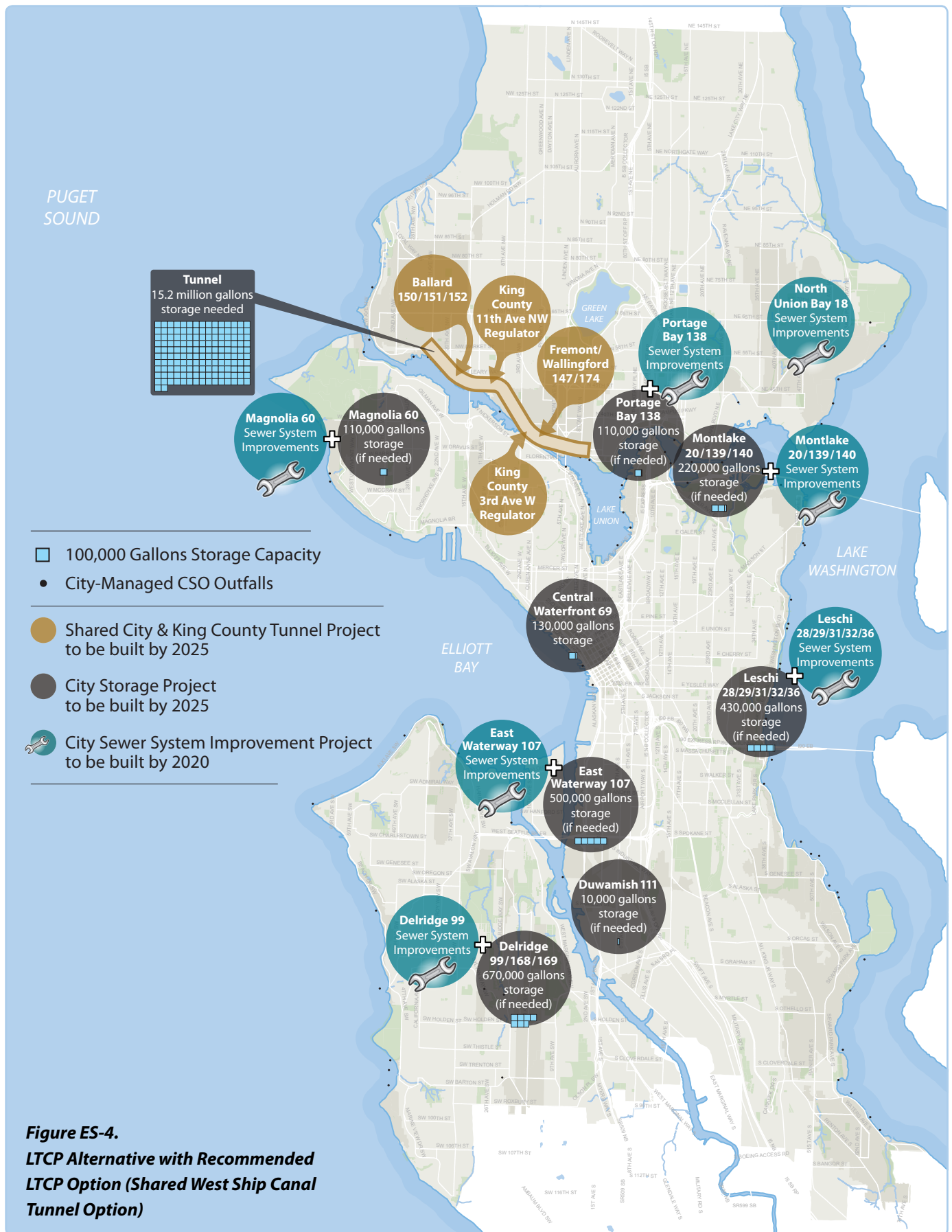


Figure ES-4.
LTCP Alternative with Recommended
LTCP Option (Shared West Ship Canal
Tunnel Option)

What is the Integrated Plan?

The Consent Decree allows the City to submit an Integrated Plan that proposes stormwater projects in addition to the CSO control measures included in the approved LTCP. Some of the CSO control projects can be deferred in order to enable earlier implementation of the stormwater projects, as long as the stormwater projects will result in significant benefits to water quality beyond those that would be achieved by implementation of the CSO controls alone.

The Integrated Plan is an alternative to the LTCP. Whereas the LTCP focuses solely on reducing CSOs, the Integrated Plan meets EPA guidelines for addressing stormwater and CSO control in one plan.

The Integrated Plan identifies stormwater projects that will be completed by 2025, in addition to the CSO reduction projects that will be completed by 2025 and those CSO reduction projects to be deferred until after 2025. By prioritizing and sequencing projects in this way, greater water quality benefits may be achieved, and achieved sooner, than by CSO reduction projects alone.

What does an Integrated Plan do?

Under the Integrated Plan, the City proposes construction of stormwater and the largest CSO control projects by 2025, while deferring some CSO projects until 2030. The Integrated Planning process identified stormwater projects that provide significant benefits over some low frequency/low volume CSO projects. These low frequency/low volume CSO projects will have their planned construction deferred until after 2025.

What is the Integrated Plan Alternative?

The Integrated Plan Alternative aims to reduce CSOs and stormwater pollution. This alternative would implement stormwater projects along with the recommended LTCP Option (Shared West Ship Canal Tunnel Option). Six relatively small CSO control projects would be deferred up to five years while the stormwater projects are implemented. This alternative integrates stormwater pollution management with CSO reduction strategies to lead to a greater improvement in water quality, and represents a more comprehensive approach to water quality management in Seattle's waters. The proposed stormwater projects would result in significant benefits to water quality beyond those that would be achieved by implementation of lower benefit CSO controls alone.

Whereas the LTCP Alternative focuses solely on reducing CSOs, the Integrated Plan Alternative meets EPA guidelines for integrating stormwater and CSO controls in one plan. Under the Consent Decree, the City may submit an Integrated Plan, provided that the stormwater projects will result in significant benefits to water quality beyond those that would be achieved by implementation of CSO controls alone, and the CSO control projects deferred may

be completed by a specific date after 2025. The proposed stormwater control projects would be in addition to the CSO control measures included in the LTCP, and they would not replace any LTCP CSO control projects but would allow some to be deferred. The proposed Integrated Plan projects are shown on Figure ES-5 and are listed in Table ES-2 on page 14 and 15.

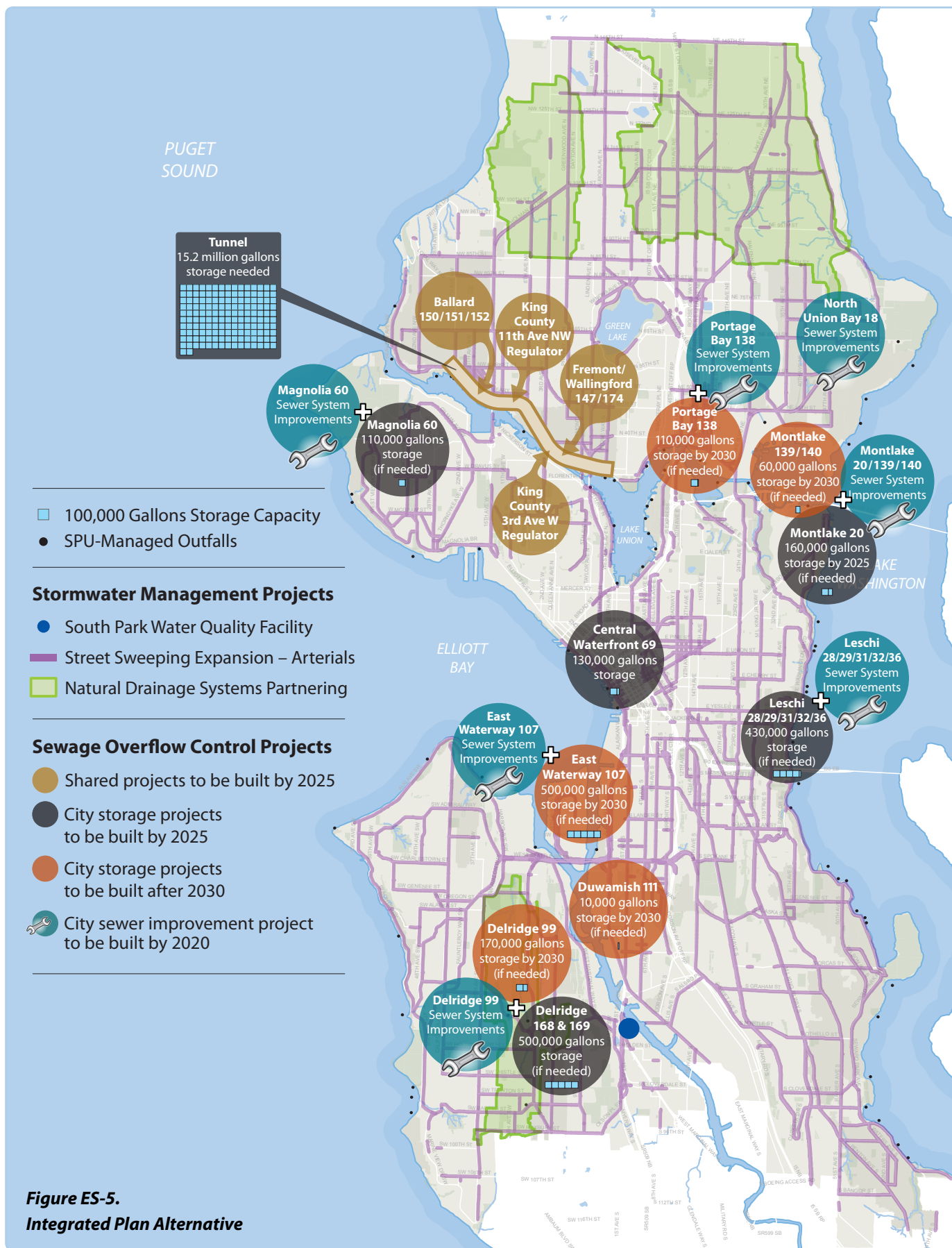


Figure ES-5.
Integrated Plan Alternative

What is the EIS?

The programmatic Plan EIS evaluated the impacts associated with adopting and implementing either of the two Plan alternatives: (1) the LTCP Alternative, and (2) the Integrated Plan Alternative. The EIS also included an evaluation of a No Action Alternative, as required by SEPA. The programmatic EIS was used to assist decision makers in assessing the environmental impacts associated with implementation of the Alternatives developed for the Plan.

What is an EIS?

An Environmental Impact Statement is a document that discloses the probable significant adverse environmental impacts of a proposed project or plan, evaluates reasonable alternatives, discusses ways to avoid or minimize impacts, and identifies any proposed mitigation measures.

Are there significant impacts that can't be mitigated?

Implementation of the Plan will involve a wide range of short term impacts associated with the construction of large infrastructure projects, including large tanks, tunnels, pump stations, and associated pipes and appurtenances. Depending upon the size, location, and type of project, these impacts would include potentially significant traffic impacts, including temporary road closures and traffic detours. Other construction-related impacts of potential significance include short term increases in noise and dust, and potential disruptions of access to business, residential, or recreational facilities. These impacts, however, are expected to be reduced by compliance with all applicable regulations and permit requirements, and as such would not be considered significant under SEPA.

Operational impacts include the potential for odor and noise generation, land use and recreational impacts and potential operational implications to King County's regional wastewater system. Given appropriate design and coordination with affected parties, there are no significant long term or operational impacts associated with implementation of the Plan Alternatives that cannot be mitigated.

How do cumulative impacts compare among the Alternatives?

Cumulative impacts are those that could result from the combination of individual effects of multiple actions (projects) over time. The Plan would be implemented in an urbanized area, and projects identified in the Plan could be constructed in areas that may have recently been subject to large-scale construction projects, or will be subject to construction of future planned projects. In addition, there is a potential for construction under the Plan implementation to coincide with the construction of other projects. For instance, King County's 2012 CSO Control Plan identifies several CSO reduction projects that would be located in the same general areas where projects under the City's LTCP Alternative would be constructed.

What are the LTCP Alternative cumulative impacts?

The LTCP Alternative would have a potential for cumulative impacts affecting a broad area because it involves construction of a number of storage tanks and pipes in neighborhoods throughout the City, including the Ship Canal, Lake Washington, Longfellow Creek/Duwamish, Magnolia and Elliott Bay/Lake Union neighborhoods.

While many of these projects would be constructed within public rights of way, there would be construction-related traffic, road closures and/or traffic constraints, dust, odor, and other short term impacts that would last between one and five years. In addition to the projects constructed by the City, King County would construct additional storage tanks and storage pipes in the Montlake and North Union Bay neighborhoods, adding to the impacts in those neighborhoods. The prolonged periods of construction effects could constitute a cumulative impact.

Compared to construction impacts associated with separate control measures such as storage tanks, the single, large tunnel may result in fewer overall impacts in terms of the number of neighborhoods affected. However, the tunnel would create longer duration (up to 3.5 years or more) impacts at the tunnel entrance portal, which would likely be located along the Lake Washington Ship Canal in Ballard, and the exit portal, which would likely be located in the Fremont/Wallingford neighborhood.

What is Included in the LTCP Alternative?

- Shared West Ship Canal Tunnel to control the Ballard and Fremont/Wallingford CSO areas for the City, and the 3rd Ave. W and 11th Ave. NW CSO areas for King County
- Independent storage facilities for remaining uncontrolled CSO areas in the City

What are the Integrated Plan Alternative cumulative impacts?

The cumulative impacts associated with the Integrated Plan relate largely to construction of the LTCP storage facilities, as described for the LTCP Alternative. Implementing the Integrated Plan Alternative would not represent a substantial increase in cumulative impacts over the LTCP Alternative. The expansion of street sweeping on City arterials would not affect overnight parking and NDS Partnering would have minimal short-term (construction-related) and long-term impacts. Construction of the South Park Water Quality Facility would not result in extensive construction-related impacts. The facility is expected to be sited in an area with compatible land use, with a low potential to cause long term changes in use. Under the Integrated Plan Alternative, construction of LTCP projects would be delayed in some neighborhoods, potentially resulting in reduced or increased cumulative impacts depending on the neighborhood and project schedules.

What does the Integrated Plan Alternative consist of?

- Natural Drainage System (NDS) Partnering
- Street Sweeping Expansion
- South Park Water Quality Facility
- Projects comprising the recommended LTCP Option

What is the City's Recommended Alternative?

The City is recommending that the Integrated Plan Alternative be implemented for compliance with the Consent Decree. The Integrated Plan Alternative integrates stormwater pollution management with CSO reduction strategies in order to provide a comprehensive approach to water quality management. The Recommended Alternative consists of the Integrated Plan stormwater projects combined with the Shared West Ship Canal Tunnel Option from the Long Term Control Plan. Table ES-2 lists the CSO control projects and stormwater measures that comprise the Recommended Alternative.

The CSO control projects will reduce overflow frequencies to meet Consent Decree and NPDES permit requirements. The stormwater projects will reduce pollutant loads from portions of the City served by separate storm sewer systems that drain to sensitive water bodies. As a result, the Recommended Alternative will provide greater benefits to surface water quality than those provided by the CSO control projects alone.

Table ES-2. Recommended Alternative

Project	CSO Outfalls Impacted	Project Description	Construction Completion
Neighborhood CSO Projects			
Leschi Sewer System Improvements (+ Storage, if needed)	28, 29, 31, 32, 36	Sewer system improvements	2017
		3 off-line storage pipes plus 1 off-line storage tank, if needed	2025
Montlake Sewer System Improvements (+ Storage, if needed)	20	Sewer system improvements	2020
		Off-line storage pipe, if needed	2025
	139, 140	Sewer system improvements	2020
		2 off-line storage pipes, if needed	2030
Portage Bay/Lake Union Sewer System Improvements (+ Storage, if needed)	138	Sewer system improvements	2020
		Off-line storage pipe, if needed	2030
Duwamish Storage (if needed)	111	2 off-line storage pipes, if needed	2030
East Waterway Sewer System Improvements (+ Storage, if needed)	107	Sewer system improvements	2020
		Off-line storage tank, if needed	2030
Magnolia Sewer System Improvements (+ Storage, if needed)	60	Sewer system improvements	2020
		Off-line storage pipes, if needed	2025
Central Waterfront Storage	69	Off-line storage pipe	2025
North Union Bay Sewer System Improvements	18	Sewer system improvement	2017
Delridge Sewer System Improvements (+ Storage, if needed)	99	Sewer system improvements	2019
		Off-line storage pipe, if needed	2030
	168, 169	Off-line storage pipes, if needed	2025

Table ES-2 continued. Recommended Alternative

Project	CSO Outfalls Impacted	Project Description	Construction Completion
Shared CSO Projects			
Shared West Ship Canal Tunnel Option	150/151, 152	Shared deep tunnel with Ballard/Fremont/Wallingford and King County 3rd Avenue W and 11th Avenue NW	2025
	King County 3rd Avenue West		
	147, 174		
	King County 11th Avenue Northwest		
Stormwater Projects			
NDS Partnering	N/A ^a	Roadside Bioretention	2025
South Park Water Quality Facility		Basic-Active Stormwater Treatment Facility	2025
Street Sweeping Expansion Arterials		Street Sweeping using vacuum assist sweepers	2016 ^b
2010 Plan Projects			
Genesee	40, 41	Off-line storage tank	2015
	43	Off-line storage tank	2015
Henderson South	49	Off-line storage tank	2025
Windermere	13	Off-line storage tank	2015
Central Waterfront	71	Inline pipe storage	2020
Ballard Green Infrastructure Solutions	150/151, 152	Roadside raingardens	2017
Delridge Green Infrastructure Solutions	168, 169	Roadside raingardens	2019
Sewer System Improvements	see Figure ES-3	Sewer system improvements in various CSO areas	by 2015
Early Action Projects			
Henderson North	44, 45	Off-line storage tank	2018
Henderson South	46	Sewer system improvement	2015
	47 and 171	Conveyance/flow transfer	2015

a. Not applicable; measure would be implemented in separate storm sewer areas.

b. No construction required. Expanded program in place by end of 2016.

Under the Recommended Alternative, the City would implement and assess sewer system improvements in most CSO areas prior to the construction of the more expensive and disruptive storage projects. If the sewer system improvements work as expected, the storage projects will either not be needed or will be smaller than currently sized. The tunnel would provide the storage needed to address overflows from four of the largest CSO areas, two from the City and two from King County. It would eliminate the need for separate King County CSO projects near 3rd Avenue West and 11th Avenue Northwest.

The three stormwater control projects in the Recommended Alternative would use a combination of gray, green, and programmatic measures to reduce pollutant loads from areas that do not drain to the combined sewer system. The proposed stormwater projects would benefit receiving water bodies that the City has deemed high priority based on the criteria in the Consent Decree. Figure ES-6 presents the projects under the Integrated Plan Alternative.

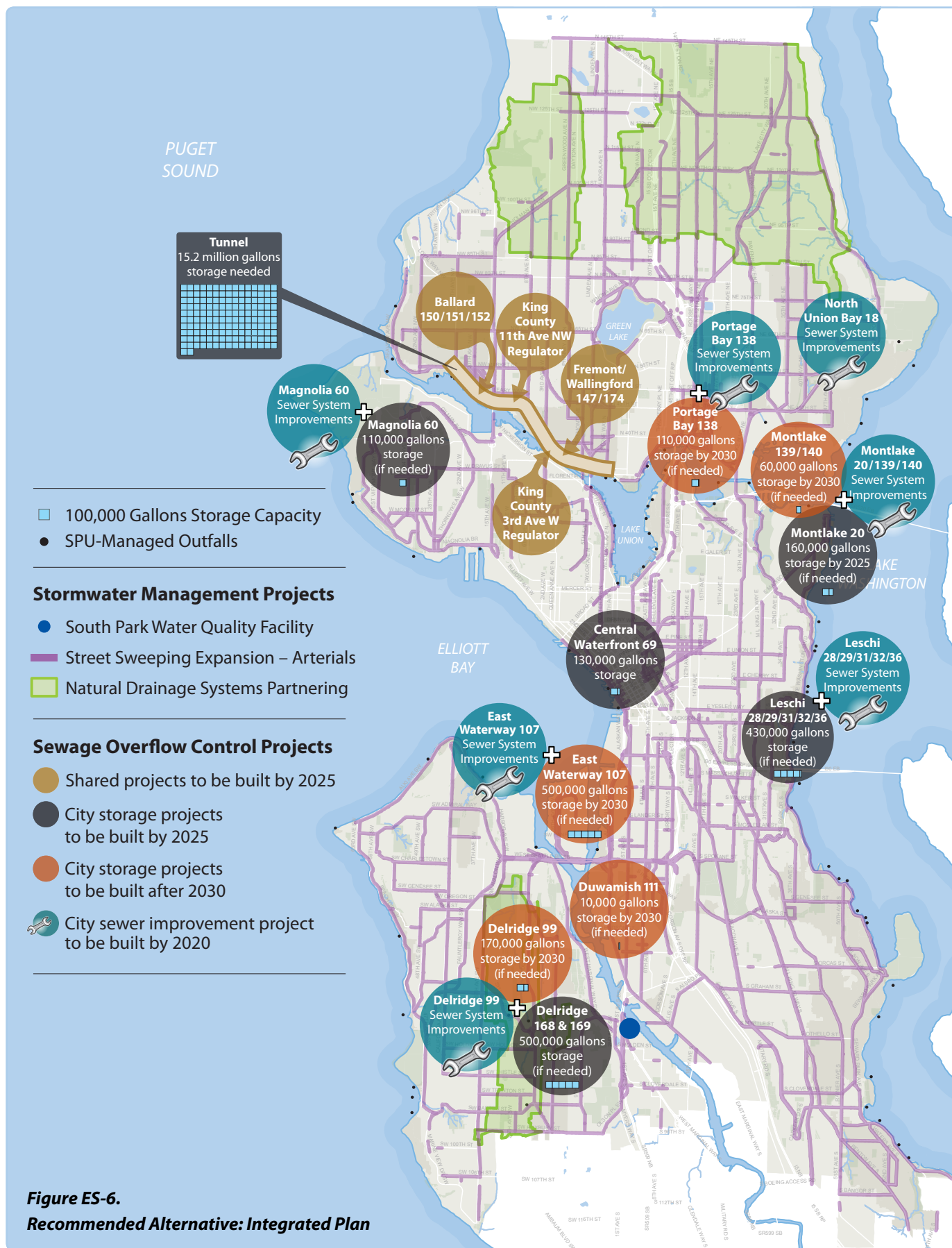


Figure ES-6.
Recommended Alternative: Integrated Plan

How will the City and King County coordinate on CSO projects?

The City recognizes the importance of strong coordination with King County in controlling CSOs in Seattle. The LTCP Alternative has elements that may have an impact on King County's downstream wastewater system. The LTCP Alternative includes sewer system improvements that will convey additional wastewater volume to the downstream King County system. As a result, coordination between the City and King County is critical to successfully designing, constructing, and operating the City's proposed CSO control projects .

The City and King County are continuing to work together to closely analyze and refine the preferred LTCP Alternative to enhance cost-effectiveness, produce better environmental outcomes, and minimize disruption to communities. King County has also determined the benefits of a shared project to the regional system, and the implications of such a project to its own LTCP and Consent Decree. Development of a shared project will be dependent on the City's and King County's analytical results as well as a number of joint factors mutually agreed upon in the City and King County coordination strategy. A term sheet detailing the coordination strategy was signed by the City and King County. These factors include such things as which agency will be responsible for the design, construction, and operation of the shared facility, each agency's project cost-share, operational and implementation roles and responsibilities, the process for dispute resolution, and the ability to fulfill regulatory and contractual obligations. A shared project agreement between the two agencies will be necessary prior to designing and constructing the project. In addition, the City and King County will analyze the impacts of any recommended project on the downstream King County system and agree on an approach to addressing those impacts prior to constructing the project.

What is the implementation schedule for the Recommended Alternative?

Figure ES-7 presents the overall schedule for the Recommended Alternative. All of the stormwater and CSO control measures would be constructed by 2025, except

for six CSO control measures that would be constructed by 2030.

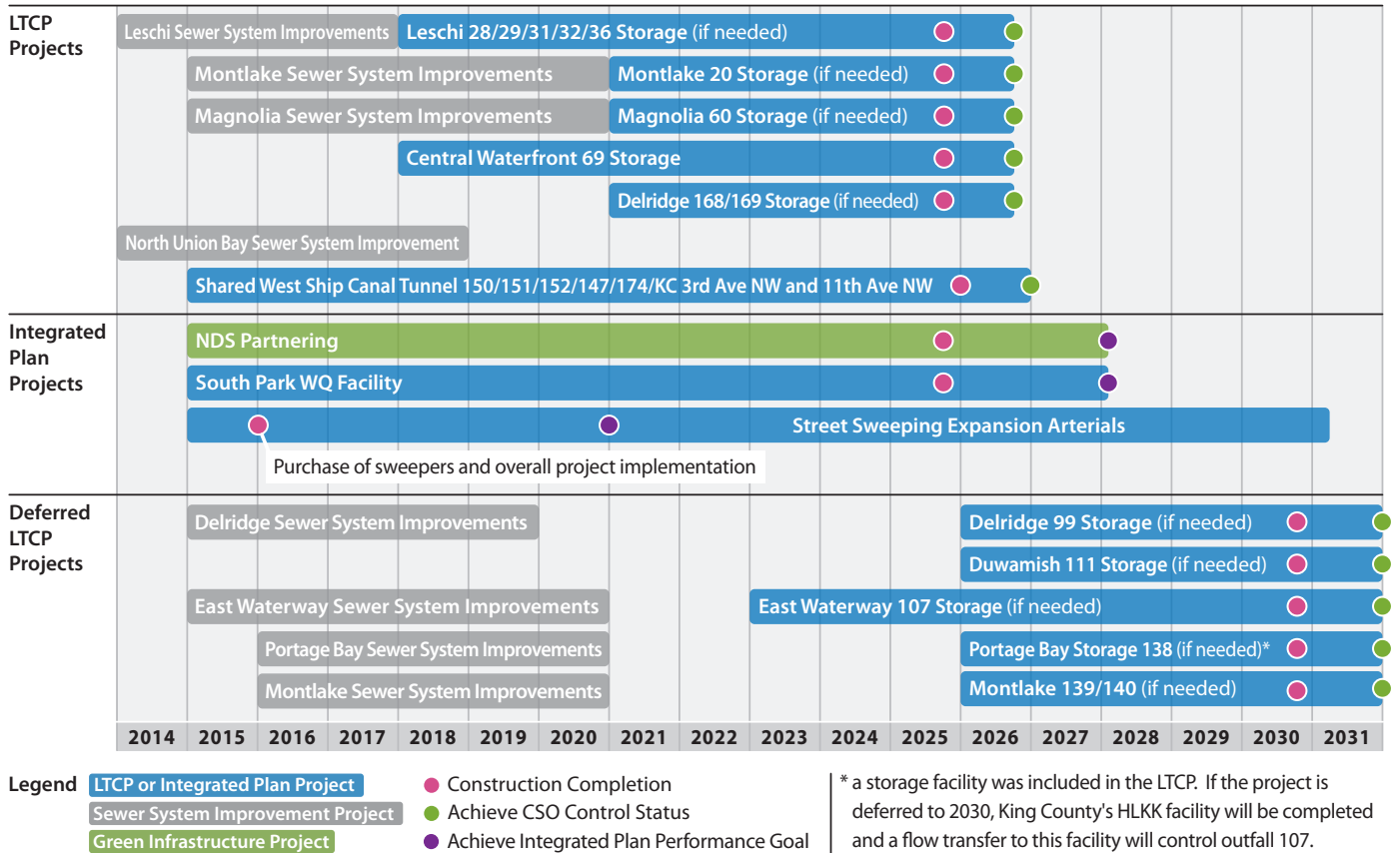


Figure ES-7. Recommended Alternative Schedule

Does not include all of the currently ongoing projects. See Table ES-2 for complete list of projects.

What are the rate impacts?

Using planning-level cost estimates, the City evaluated the overall impact to the monthly wastewater and drainage rates to implement the Integrated Plan alternative.

What are the baseline rates?

The first step is to estimate the monthly baseline rates that do not include the Recommended Alternative. The monthly wastewater and drainage rates for the current Strategic Business Plan (SBP) were used to estimate the baseline rates from 2015 through 2030. The King County treatment baseline rates also include the King County treatment increases provided by King County in June 2013

and the rate impact estimates provided in the King County Executive's 'Recommended Combined Sewer Overflow Control Plan', June 2012. The baseline monthly rates are listed in Table ES-3.

Table ES-3. Baseline Monthly Wastewater and Drainage Rate Estimate (with Inflation)

Baseline Rates	2015	2020	2025	2030
Wastewater ^a	\$17.85	\$26.84	\$35.89	\$42.51
Drainage ^b	\$29.15	\$42.38	\$52.65	\$58.12
King County Treatment Wholesale Rate ^c	\$33.31	\$41.42	\$39.26	\$39.82
Total Baseline Rate	\$80.31	\$110.64	\$127.80	\$140.46

a The wastewater baseline rate represents the typical residential monthly system rate based on 4.3 ccf (100 cubic feet) drinking water consumption per month. All LTCP-related capital costs have been removed.

b The drainage baseline rate represents the typical residential monthly rate for the average parcel, which is a small residential lot between 5,000-6,999 square feet. All LTCP-related capital costs have been removed.

c King County charges a wholesale treatment rate to cities and local wastewater districts who send flows to the regional system. The City of Seattle passes through this rate to customers via the treatment component of the sewer rate. This analysis assumes the typical residential monthly bill with drinking water consumption of 4.3 ccf.

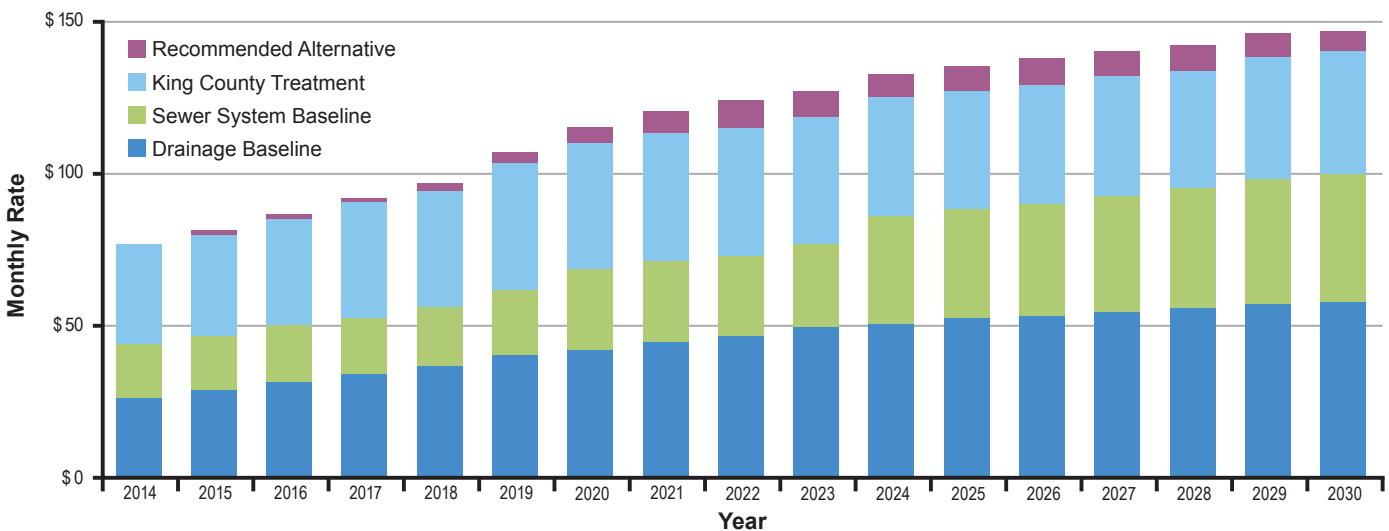
What are the rate impacts for the Recommended Alternative?

The City analyzed how the Recommended Alternative may affect monthly wastewater and drainage rates between 2015 and 2030. Table ES-4 shows the total monthly estimated rates between 2015 and 2030 if the Recommended Alternative is implemented, the stormwater

projects are implemented by 2025, and a portion of the LTCP projects is deferred to 2030. Figure ES-8 presents the total monthly Wastewater and Drainage Rates for City of Seattle ratepayers following implementation of the Recommended Alternative.

Table ES-4. Monthly Wastewater and Drainage Rate Estimate for the Recommended Alternative (with Inflation)

Recommended Alternative	2015	2020	2025	2030
Total Baseline Rate	\$80.31	\$110.64	\$127.80	\$140.46
Recommended Alternative Projects	\$1.18	\$4.84	\$7.63	\$6.58
Base Rate + Recommended Alternative Projects	\$81.49	\$115.48	\$135.43	\$147.04

**Figure ES-8. Monthly Wastewater and Drainage Rate Increase Estimates for Recommended Alternative**

What is the schedule for completing the Plan to Protect Seattle's Waterways?

Figure ES-9 summarizes the schedule for completing the Plan to Protect Seattle's Waterways. On May 29, 2015, the Final Plan for Protecting Seattle's Waterways was submitted to EPA and Ecology for approval. An updated Post Construction Monitoring Plan was also submitted for

approval. It is anticipated that the Plan will be approved by late summer 2015 and implementation will commence immediately, in accordance with the approved milestone implementation schedule provided in the Plan.

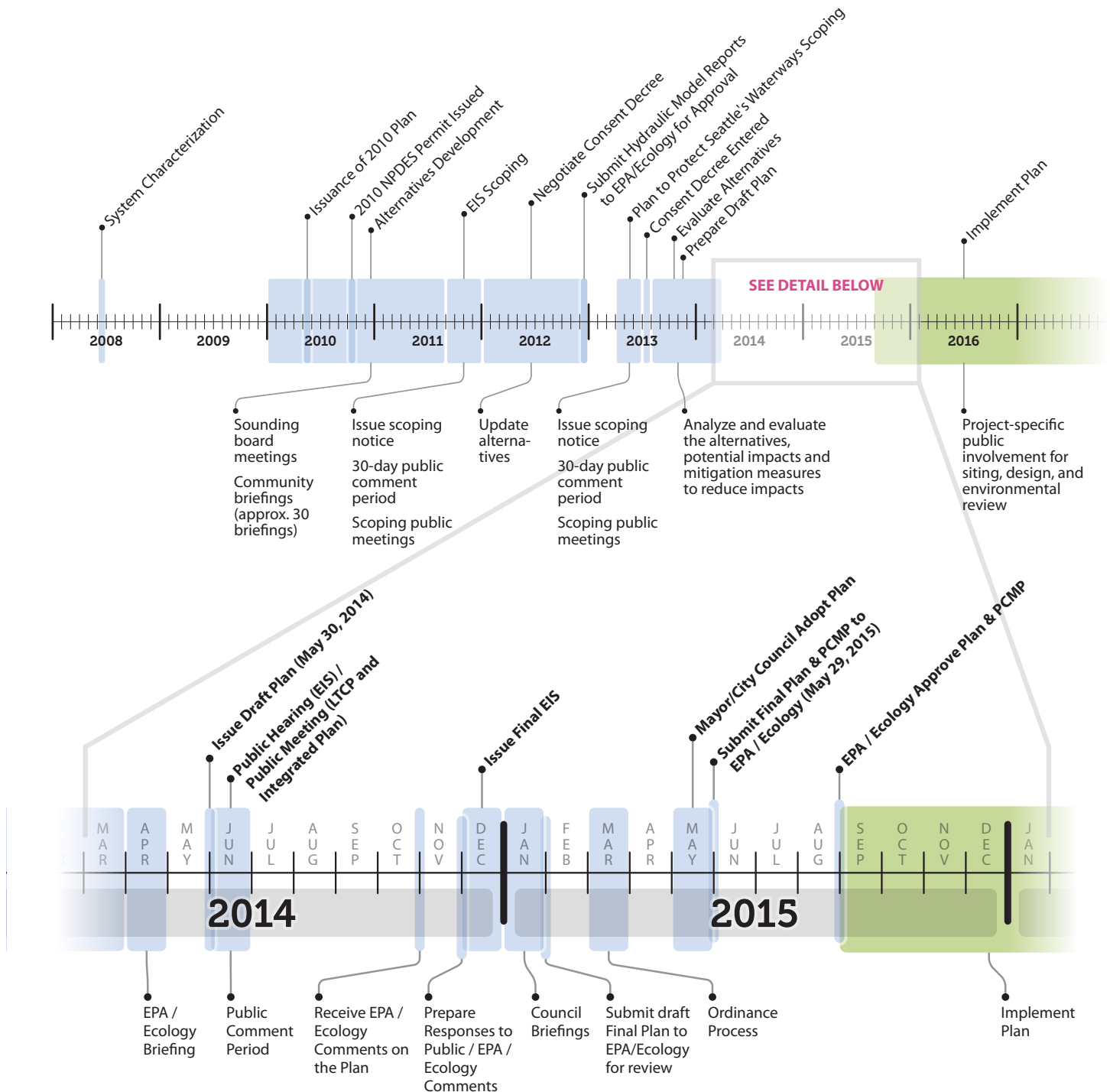


Figure ES-9. Current and Overall Protecting Seattle's Waterways Schedule



Protecting Seattle's Waterways

Learn more about
the Plan to Protect
Seattle's Waterways
online at

www.seattle.gov/CSO

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Protecting Seattle's Waterways

Volume 2

Long Term Control Plan

Final | May 29, 2015



**Volume 2
Long Term Control Plan**

Final
May 29, 2015

Prepared for:
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3/12/2015



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SPU Project No. C-308039
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Appendix B	East Waterway NDPES107 Hydraulic Model Report SPU/KC Interceptor Model Calibration Report
Appendix C	SPU Financial Capability Assessment
Appendix D	LTCP Option Rating and Ranking Report (MODA)
Appendix E	Phase 4 Flow Monitoring Report
Appendix F	Sensitive Area Study
Appendix G	Long-term Model Simulation Results
Appendix H	Inflow and Infiltration Analysis Report
Appendix I	GSI Feasibility Analysis Report
Appendix J	Conceptual Cost Calculator (3C) Model and User Guide
Appendix K	Operating Cost Model
Appendix L	Final LTCP CSO Control Measures Performance Modeling Report
Appendix M	Updated LTCP Options Decision Support Material

Appendix content submitted electronically under separate cover

List of Abbreviations and Glossary

Term	Definition	Term	Definition
2010 Plan	2010 CSO Reduction Plan Amendment	DNRP	King County Department of Natural Resources and Parks—Wastewater Treatment Division
3C	LTCP Conceptual Cost Calculator	DWF	dry-weather flows
3R	Repair, Rehabilitation and Replacement	DWO	dry weather overflow
AACE	Association for the Advancement of Cost Engineering	Ecology	Washington State Department of Ecology
ACU-SWM	Automated Calibration and Uncertainty Analysis for Storm Water Management Model	EIS	Environmental Impact Statement
CCTV	closed-circuit television	EPA	U.S. Environmental Protection Agency
CDPD	cellular digital packet data	FOG	fats, oils, and grease
CFR	Code of Federal Regulations	FSE	food service establishment
cfs	cubic foot/feet per second	FTE	full-time equivalent employee
CIP	capital improvement program	GHG	greenhouse gas
City	City of Seattle	GI	green infrastructure
CMMS	Maximo 7 Computerized Maintenance Management System	GIS	geographic information system
CMOM	Capacity, Management, Operations, and Maintenance	GOF	goodness-of-fit
Consent Decree	Final and Fully Executed Consent Decree	HCC	hydraulic control chamber
COTool	cleaning optimization tool	HLKK	Hanford, Lander, Kingdome, King Street
CSO	combined sewer overflow	I/I	infiltration and inflow
CSS	combined sewer system	Joint Plan	Joint Operations and System Optimization Plan
CV	control volumes	JOIST	Joint Operations Information Sharing Team
CWA	Clean Water Act	LTCP	Long Term Control Plan
CY	cubic yards	LTS	long-term simulations
		MAUT	multi-attribute utility theory

MG	million gallons	SOP	standard operating procedures
MGD	million gallons per day	SPU	Seattle Public Utilities
MMSD	Milwaukee Metropolitan Sewerage District	SSO	sanitary sewer overflow
MODA	multiple objective decision analysis	State	State of Washington
NASSCO	National Association of Sewer Service Companies	SWMM5	EPA Storm Water Management Model, Version 5
NDS	natural drainage systems	TBD	to be determined
NIRR	no impact release rate	TBM	tunnel boring machine
NMC	Nine Minimum Controls	The Plan	The Plan to Protect Seattle's Waterways
NPDES	National Pollutant Discharge Elimination System	WAC	Washington Administrative Code
NPV	net present value	WQS	water quality standards
O&M	operations and maintenance	WRIA	Watershed Resource Inventory Area
PACP	pipeline assessment and certification program	WSDOT	Washington State Department of Transportation
PCMP	post-construction monitoring plan	WTD	King County Wastewater Treatment Division's
POTW	publicly owned treatment works	WWTP	wastewater treatment plant
QA/QC	quality assurance/quality control		
RCM	reliability centered maintenance		
RCW	Revised Code of Washington		
ROW	right-of-way		
SCADA	Supervisory Control and Data Acquisition		
SDOT	Seattle Department of Transportation		
SEPA	State Environmental Policy Act		
SF	square feet		
SMC	Seattle Municipal Code		
Soft Costs	all non-construction costs		

Term	Definition
20-year moving average	The average number of untreated discharge events per CSO outfall over a 20-year period for purposes of compliance with Washington Administrative Code (WAC) 173-245-020(22)
Alternative	There are 3 alternatives for the Plan to Protect Seattle's Waterways. • The LTCP Alternative is focused solely on reducing CSOs under an approved Long-term Control Plan (LTCP). • The Integrated Plan (IP) Alternative includes reduction of both CSOs and stormwater pollution • The EIS will also evaluate a No Action Alternative to provide a baseline for comparison of potential effects of the Plan alternatives, as required by the State Environmental Policy Act (SEPA)
Average annual volume	An annual CSO overflow volume based on a twenty year moving average
Code of Federal Regulations (CFR)	A compilation of federal laws
Combined sewer overflow (CSO)	During rainfall events, the volume of the stormwater entering a combined sewer system often is greater than the capacity of the collector pipes and sewage treatment plant and, as a result, the untreated sewage and stormwater mixture flows directly into receiving waters through designated overflow points
Combined sewer system (CSS)	The wastewater collection and conveyance system owned or operated by the City, including all pipes, force mains, gravity sewer segments, pump stations, lift stations, interceptors, diversion structures, manholes, and appurtenances thereto, designated to collect and convey municipal sewage, including residential, commercial, and industrial wastewaters, and stormwater, through a single-pipe system to King County's wastewater treatment plants, King County's CSO treatment plants, or to permitted CSO outfalls
Consent Decree	A written agreement entered in <u>United States District Court for Western District of Washington</u> on July 3, 2013, between the City of Seattle, Washington State Department of Ecology, the EPA, and the United States Department of Justice that describes the actions that The City must take to address violations of the Clean Water Act caused by Combined Sewer Overflows.
Controlled	The control of a CSO outfall in accordance with WAC 173-245-020(22)
Control Measure	Construction, control measures, actions, and other activities set forth in the City's Long Term Control Plan or any supplemental Compliance Plan.
Control Status	The Consent Decree's definition of "greatest reasonable reduction" of CSOs; an average of no more than one overflow occurrence per outfall per year determined on a 20 year moving average
Control Volume	The amount of combined sewage that would need to be stored in order for a basin to achieve control status
Controlled Basin	A basin that experiences an average of one or fewer CSO occurrences annually on a 20 year moving average

Term	Definition
Cost-benefit analysis	Systematic process for calculating and comparing benefits and costs of a project, decision, or government policy
Combined Sewer System	An infrastructure strategy that builds a single pipe to carry both stormwater and sewage in lieu of two separate pipes.
Combined Sewer Overflow	Discharge of a combination of sewage and stormwater at designated and permitted overflow points from a combined sewer system when the local system's hydraulic capacity is reached to prevent sewage backup into homes and onto surface streets or private property.
CSO Area	A logical grouping of one or more outfalls based on hydraulic relationships, receiving waters, neighborhoods, or other readily recognizable features
CSO control measure	The construction, control measures, actions, and other activities set forth in the City's Long-Term Control Plan or any Supplemental Compliance Plan provided for in Section V.B. of the Consent Decree
CSO outfall	The outfall structure from which a CSO is discharged
CWA	Clean Water Act; passed by congress in 1972, meant to restore and maintain the integrity of the nation's waters
Design criteria	The minimum attributes of a given CSO control measure, such as storage volumes, treatment capacities, or pumping and/or conveyance capacities as specified in the Long-Term Control Plan or any Supplemental Compliance Plan provided for under Section V.B. of the Consent Decree
Designated receiving water	Waters determined by SPU as having sufficient capacity to receive discharges of drainage water such that a site discharging to the designated receiving water is not required to implement flow control. Includes the Duwamish River, Puget Sound, Lake Washington, Lake Union, Elliott Bay, Portage Bay, Union Bay, and the Lake Washington Ship Canal
Dewatering	The pumping of groundwater from an excavated area to facilitate construction
Early Action Projects	A series of projects mandated by Section V.A. of the City's Consent Decree that requires the City to implement all CSO control measures necessary to reduce discharges from CSO outfalls in North and South Henderson CSO areas.
Ecology	The State of Washington Department of Ecology
Environmental Impact Statement (EIS)	A document that discloses the probable significant adverse environmental impacts of a development project or a planning proposal, discusses reasonable mitigation of identified impacts, and evaluates alternatives to the project and/or proposal. EISs are required under certain circumstances by the Washington State Environmental Policy Act (SEPA)
Environmental justice	The fair treatment of people of all races and incomes with respect to actions affecting the environment. Fair treatment implies that there is equity of the distribution of benefits and risks associated with a proposed project and that one group does not suffer disproportionate adverse effects

Term	Definition
EPA	The U.S. Environmental Protection Agency and any of its successor departments or agencies
EPA CSO Control Policy	Explains how to control CSOs while meeting CWA requirements; includes implementation of the Nine Minimum Controls and the development of a Long-Term Control Plan including the following elements: 1. Characterization, Monitoring, and Modeling of the CSS 2. Public Participation 3. Consideration of Sensitive Areas 4. Evaluation of Alternatives 5. Cost/Performance Considerations 6. Operational Plan 7. Maximizing flow to the existing Publically Owned Treatment Works (POTW) 8. Implementation Schedules 9. Post-Construction Monitoring Plan
EPA LTCP Guidance Document	<i>Combined Sewer Overflows Guidance for Long-Term Control Plan</i>
Green infrastructure (GI)	Systems and practices that use or mimic natural processes to infiltrate, evapotranspire, and/or harvest stormwater on or near the site where it is generated. Green infrastructure may include, but is not limited to, green roofs, downspout disconnection, trees and tree boxes, rain gardens, vegetated swales, pocket wetlands, infiltration planters, vegetated median strips, permeable pavements, reforestation, and protection and enhancement of riparian buffers and floodplains.
Groundwater	Water that infiltrates into earth and is stored in the soil and rock within the zone of saturation below the earth's surface. Groundwater is created by rain, which soaks into the ground and flows down until it is collected at a point where the ground is not permeable. Groundwater then usually flows laterally toward a river, lake, or ocean. It is often used for supplying wells and springs.
Hard cost	The actual cost of constructing a project (i.e., paid to the contractor) plus sales tax
HLKK	An acronym for a proposed stormwater treatment plant to be built in the vicinity of King County's Hanford, Lander, Kingdome, and King Street Regulators.
Hydrobrake	A static stormwater treatment device that can be installed in a pipe network to control release of excess flows at a measured rate.
Impaired waters	Waters whose beneficial uses are impaired by pollutants
Infiltration and	A general category of extraneous water that enters a sewer system and uses its sewage-carrying hydraulic capacity, thereby contributing to overflows. Sources are either from the

Term	Definition
inflow (I/I)	groundwater leaking through deteriorated joints and cracks (infiltration) or openings/illicit connections at manholes (inflow).
Launching portal	A primary portal used to insert a tunnel boring machine for excavation of tunnels. Liner section installation and ventilation operations would also occur at these portals.
Long Term Control Plan (LTCP)	The Long Term Control Plan under development by the City in accordance with Section V.B. of the Consent Decree, as well as any additional remedial measures for eliminating or reducing the City's CSOs included in any Supplemental Compliance Plan developed and implemented in accordance with Section V.B. of the Consent Decree.
LTCP Option	An overall system approach that will ultimately resolve all SPU uncontrolled outfalls; the four LTCP Options are: Neighborhood Storage, Shared Storage, Shared West Ship Canal Tunnel, Shared Ship Canal Tunnel
MODA	Multiple Objective Decision Analysis; an evaluation tool that incorporates consideration of non-monetary (social and environmental) factors as well as cost to compare competing solutions in a comprehensive manner
Monte Carlo simulation	A computational algorithm that uses repeated random sampling to obtain numerical results; e.g., by running simulations many times to calculate probabilities of outcomes.
Neighborhood Solution	A CSO control measure that is implemented by Seattle Public Utilities independent from other agencies or jurisdictions.
NPDES Permit	The City's National Pollutant Discharge Elimination System permit, No. WA-003168-2, issued by the State of Washington Department of Ecology on October 27, 2010 and modified on September 13, 2012.
Open cut	See "trenching"
Partially separated stormwater system	Street drainage system that routes stormwater runoff from paved areas to separate storm sewers and conveys the remaining drainage, generally all flows from private properties, in a combined sewer.
Performance criteria	The Performance Criteria specified in the Long-Term Control Plan or any Supplemental Compliance Plan provided for under Section V.B. of the CD.
Pile	A large pole driven into the earth to support a building or other superstructure
The Plan	The Plan to Protect Seattle's Waterways, includes four Volumes: Executive Summary, Long Term Control Plan, Integrated Plan, and Environmental Impact Statement
Post-Construction Monitoring Plan (PCMP)	The plan that the City developed in accordance with Section V.B. of the Consent Decree, as well as any additional post-construction monitoring or modeling activities included in any Supplemental Compliance Plan developed and implemented in accordance with Section V.B. of the Consent Decree. The PCMP has two parts: Post-Construction Performance Monitoring (overflow frequency), and Sediment Sampling (water quality).
Post-Construction Performance	Satisfies requirements set in Consent Decree Appendix C: LTCP Requirements, Section D, Post-Construction Monitoring Program.

Term	Definition
Monitoring	
Pump station	A structure that houses pumps and other equipment for lifting stormwater or wastewater in pipes to higher elevations so that it can continue to flow by gravity
Rain garden	Small, vegetated depressions with designed soil mixes that retain runoff for subsequent infiltration or delayed release to the combined sewer system
RainWise	A voluntary program sponsored and partially funded by the City to encourage homeowners to construct private stormwater retention facilities on their property to reduce flows and pollutant loads to the combined sewer system
Receiving water	Any body of water that receives CSO and stormwater discharges
Recovery or retrieval portal	A primary portal used to remove a tunnel boring machine following construction of a tunnel.
Retrofit program	A program designed to reduce CSOs by optimizing the use of existing systems through advanced technologies such as real-time controls, as well as minor structural modifications such as weir height adjustments.
Sanitary sewer system	The portion of the wastewater collection system designed to convey only sewage, and not stormwater, from residences, commercial buildings, industrial plants, and institutions for treatment at a wastewater treatment plant.
Sensitive Area Study	A study that uses a 7 point criteria scale to score basins and determine which basins have the largest negative impact on receiving water bodies and human health.
Sewer overflow	Any overflow, spill, diversion, or release of wastewater from or caused by the sanitary sewer system or the combined sewer system upstream of a City's CSO outfall. This term shall include: (i) discharges to surface waters of the State or United States from the sanitary sewer system and (ii) any release of wastewater from the sanitary sewer system to public or private property that does not reach waters of the United States or the State.
Shared	A reduction strategy that is implemented jointly by the City of Seattle and King County.
soft cost	The costs of engineering design, contract administration, legal services, and other non-hard costs associated with a project.
State Environmental Policy Act (SEPA)	A Washington State law (Chapter 43.21C RCW) that requires state agencies and local governments to consider environmental impacts when making decisions regarding certain activities, such as development proposals over a certain size, and comprehensive plans. As part of this process, environmental impacts are documented and opportunities for public comment are provided
Storm drain	A system of gutters, pipes, or ditches used to carry stormwater from surrounding lands to streams, lakes, or other receiving water. Also refers to the end of the pipe from which the stormwater is discharged
Storm sewer	A pipe (separate from sanitary sewers) that carries only stormwater runoff from buildings and land surfaces
Stormwater	Stormwater is rain and melting snow that runs off surfaces that cannot readily absorb water, including streets, rooftops, and parking lots. As stormwater runs across these hard

Term	Definition
Runoff	surfaces, it picks up pollutants such as oil, grease, and metals, carrying them through the City's storm drain system to our lakes, streams, rivers, and Puget Sound. It also flows into the combined sewer system and causes overflows of raw sewage and polluted stormwater into Seattle waterways
Surface water	Any water, including fresh water and salt water, on the surface of the earth
System characterization	Uses flow monitoring, hydraulic modeling, and existing data on the Combined Sewer System to develop a detailed understanding of conditions
SWMM	EPA's Storm Water Management Model (SWMM) is a rainfall-runoff simulation model used to simulate runoff quantity and quality from urban areas. SWMM tracks the quantity and quality of runoff, and the flow rate, flow depth, and quality of water in each pipe and channel.
Total project cost	The sum of all costs for a project including hard costs, soft costs, property costs, contingencies and management reserves.
Trenching	A method for installing pipe near surface, also called "open cut". The trenching method consists of three stages: digging a trench and stockpiling excavated materials; installing pipe in the trench; and backfilling the trench and restoring the surface
Truck trip	A trip made by a truck hauling materials to or from a construction project
Tunnelling	Method used for excavating a tunnel within the earth. A tunnel boring machine (TBM) is inserted through a launching portal and retrieved from a recovery portal.
Uncontrolled outfall	A CSO outfall that experiences an average of more than one untreated CSO discharge event annually on a twenty year moving average
Wastewater collection system	The collection and conveyance system owned or operated by the City, including all pipes, force mains, gravity sewer segments, pump stations, lift stations, interceptors, diversion structures, manholes, and appurtenances thereto, designed to collect and convey municipal sewage, including residential, commercial, and industrial wastewaters, and stormwater, to King County's wastewater treatment plants or to a permitted CSO outfall. The wastewater collection system includes the combined sewer system, sanitary sewer system, and the partially separated system.

Summary

The Plan to Protect Seattle's Waterways

The City of Seattle (City) owns and operates a Wastewater Collection System that collects residential and industrial wastewaters, and conveys the collected wastewater to regional conveyance systems and wastewater treatment plants owned and operated by King County. About two-thirds of the City is served by a combined sewer system (CSS) that carries a combination of untreated sewage and stormwater. During heavy rains, the CSS can be overwhelmed and overflows at designed relief points in order to avoid sewage flooding in streets and backups into homes and businesses. These overflows are called "Combined Sewer Overflows" or CSOs, and they contribute pollutants to surrounding water bodies and impact their quality and uses. Untreated stormwater runoff from streets, parking lots, and buildings also contributes a wide range of pollutants to receiving waters in Seattle.

The City is preparing a comprehensive strategy, The Plan to Protect Seattle's Waterways (the Plan), to reduce CSOs and stormwater pollutants in order to protect public health, the environment, and to comply with federal and state regulations. The Plan is being developed under a Consent Decree agreement with the U.S. Environmental Protection Agency (EPA), the Washington State Department of Ecology (Ecology), and the U.S. Department of Justice. The Consent Decree was entered in United States District Court for Western District of Washington on July 3, 2013. The Plan will define projects to control a significant source of contamination and when implemented, the Plan will bring the City into compliance with the State and Federal requirements for CSO discharges.

Specifically, the Plan will:

- Identify areas of Seattle where projects are needed to reduce combined sewer overflows.
- Evaluate alternatives for reducing combined sewer overflows in these areas.
- Identify additional areas where projects to control and treat polluted stormwater runoff will improve water quality.
- Recommend a schedule for designing and constructing projects.
- Estimate program costs and associated impacts on Seattle Public Utilities customer bills.
- Consider public and stakeholder input.

The Plan includes an Executive Summary (Volume 1), the Long Term Control Plan (Volume 2), the Integrated Plan (Volume 3), and the Environmental Impact Statement (Volume 4).

This volume, the LTCP, includes the following chapters:

1. Introduction and Background
2. System Characterization
3. Development and Evaluation of Alternatives for CSO Control
4. Selection and Implementation of CSO Control Measures
5. Selection and Implementation of Recommended LTCP CSO Control Option

Chapter 1 Introduction and Background

Previous CSO Planning

Seattle has completed five major CSO planning efforts since the 1980's to identify CSO reduction projects. Some projects associated with these plans involved maintenance or modification of existing sewer facilities while others

involved construction of diversion structures to direct flows away from CSO outfalls or storage facilities to store excess wastewater until flows decrease enough for the stored wastewater to be returned to the conveyance system. The major CSO reduction planning efforts were as follows:

- 1980 Facility Plan (201 Facilities Planning)
- 1988 CSO Reduction Plan
- 2001 CSO Reduction Plan Amendment
- CSO Reduction Plan Amendment 2005 Update
- 2010 CSO Reduction Plan Amendment

Over the last 25 years, the City of Seattle has successfully reduced CSO discharge volumes into surrounding receiving waters by nearly 70 percent. However, there is still work to be done to control the remaining CSOs and the final reduction in CSO volume is the most challenging.

Regulatory Requirements

The City's CSO Control Program is subject to a number of federal and state regulatory requirements that must be considered in the development of the LTCP, including the following:

- Clean Water Act
- CSO Control Policy and Guidance Documents
- Consent Decree, United States of America and the State of Washington vs. City of Seattle, WA.,
- Washington Administrative Code
- National Pollutant Discharge Elimination System Waste Discharge Permit, No. WA0031682 as modified

In addition, the City must also meet the requirements of two enforcement orders:

- Modified Request for Information and Compliance Order by Consent
- Agreed Order No. 8040 between City of Seattle and Ecology

The Consent Decree has established a schedule for LTCP implementation that includes the following major milestone dates as shown in Table S-1.

Table S-1. LTCP Implementation Milestone Dates	
Submit Draft LTCP	May 30, 2014
Submit Final LTCP and PCMP for approval	May 30, 2015
Construction Completion of all CSO control measures in the approved LTCP	December 31, 2025

The City has utilized published EPA guidance documents for the development of its LTCP. The Final LTCP recommends cost-effective CSO controls that will attain water quality standards using the presumption approach in accordance with state, federal, and the City's Consent Decree requirements. One year following construction completion of each CSO control measure, the City will document that the associated CSO outfall has been "controlled" to no more than one untreated discharge (overflow) per year based on a 20-year moving average."

This date may be extended if there is insufficient precipitation during the year following construction completion to demonstrate that a CSO Outfall has been controlled.

The City of Seattle and King County both manage CSO outfalls in the Seattle area: The City currently manages 86 outfalls; King County manages 38. In 2014, a total of 406 CSO events from City-managed outfalls resulted in 116 million gallons of overflow.

CSO Control Status

CSO control is being provided in three phases as summarized below:

- 2010 Plan Projects: Eight outfalls will be controlled through capital projects completed during the years 2010-2020, including CSO reduction projects for Windermere, Genesee, West Seattle, Henderson and the Central Waterfront CSO areas. South Henderson CSO outfall 049 is uncontrolled based on the 2013 Annual CSO Report and the City will complete construction by December 31, 2025, and achieve controlled status by December 31, 2026. The City is also implementing system improvement projects (retrofits) through a parallel program to reduce CSOs. Additional CSO reduction efforts were initiated through the Green Infrastructure program in Ballard, Magnolia, Montlake, North Union Bay, Fremont/Wallingford, and Delridge CSO areas.
- Early Action CSO Programs and Measures: The Consent Decree requires early action for the two North Henderson (044 and 045) and three South Henderson (046, 047 and 171) uncontrolled CSO outfalls. Construction will be completed for the new facilities for basins 044/045 by 2018 and for basins 046/047 and 171 by 2015. Construction of CSO facilities for outfalls in Genesee (044 and 045) will be completed in 2015. Controlled status will be achieved for each of these outfalls one year after completion of construction.
- LTCP: The remaining 22 uncontrolled CSO outfalls will be controlled through the implementation of the approved LTCP which recommends CSO control measures and an implementation schedule to meet the Consent Decree Construction Completion milestone date of December 31, 2025, and the achievement of control status for each outfall as defined in the Consent Decree.

Chapter 2 System Characterization

Nine Minimum Controls

On April 11, 1994, EPA issued a CSO Control Policy. Included in the policy were nine minimum technology-based controls (Nine Minimum Controls or NMC) for addressing CSOs that did not require extensive engineering studies or construction and could be instituted prior to implementation of long term measures. The control policy states that CSO control options should include implementation of the NMC and development of an LTCP in order to meet CWA regulations. Accordingly, the City has commenced a detailed NMC implementation plan.

The CSO outfalls addressed in the LTCP are those outfalls that remain uncontrolled after implementation of the NMC strategies, Early Action projects, and the 2010 Plan projects. Individual CSO locations display characteristics that can vary greatly. Existing data from the 2010 Plan was evaluated as a starting point of the LTCP, but further research was necessary to determine current baselines and control volumes. Therefore, the City conducted extensive system characterization.

CSO Flow Monitoring Program

Flow monitoring was conducted to characterize flows and operational conditions, and identify overflow frequencies and volumes in order to calibrate system modelling of the CSS. The City installed flow meters at 264 sites and collected 3 years of data in 12 CSO areas for uncontrolled CSO outfalls associated with the LTCP. The

data provided a solid foundation for hydrologic and hydraulic model calibration and supported the City's efforts to continuously reduce CSOs in compliance with its NPDES permit and the Consent Decree in the most cost-effective manner.

The flow monitoring data was included in the December 2010 LTCP Flow Monitoring Report.

Sensitive Areas

EPA guidelines for Sensitive Areas assist in determining which CSOs have the largest negative impact on receiving water bodies and human health. The LTCP will give the highest priority to controlling overflows in sensitive areas. The SPU's Sensitive Area Study was completed in accordance with the EPA CSO control policy that states:

EPA expects a permittee's long-term CSO control plan to give the highest priority to controlling overflows to sensitive areas. Sensitive areas, as determined by the NPDES authority in coordination with State and Federal agencies, as appropriate, include designating Outstanding National Resource Water, National Marine Sanctuaries, waters with threatened and endangered species and their habitat, waters with primary contact recreation, public drinking water intakes or their designated protection areas, and shellfish beds.

Uncontrolled CSO Basins were ranked using methods defined in published EPA Combined Sewer Overflows Guidance for Screening and Ranking. All uncontrolled CSO outfalls were evaluated and scored using the seven criteria outlined in the guidance document. The seventh criterion (reserved for site-specific concerns not addressed through the other criteria) was defined as annual average CSO frequency and overflow volume based on 20-year long-term simulations using the approved LTCP Hydraulic Model. Priority ranking was then determined by deriving final scores for each outfall's combined total.

The initial (draft LTCP) Sensitive Areas analysis was revised based on CSO control performance reported in the 2013 Annual Report and updated hydraulic model results using a 20 year moving average. The results of this analysis are shown in Figure S-1 and are reported in Section 5.3.6. The updated report replaced the earlier version as Appendix F.

Hydraulic Modeling

Hydraulic models were developed for the uncontrolled CSO basins and outfalls using Build 5.0.022 of EPA SWMM5. SWMM is a dynamic rainfall-runoff simulation model used for single-event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of sub-catchment areas that receive precipitation and generate runoff. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage, pumps, and regulators. SWMM tracks the quantity of runoff generated within each sub-catchment, and the flow rate and flow depth in each pipe and channel during a simulation period comprising multiple time steps.

Figure S-2 shows the LTCP basin boundaries included in the hydraulic modeling process.

The LTCP Hydraulic Model Report was prepared in accordance with Consent Decree Appendix C, Item B.2, which established requirements for the development and documentation of hydraulic models. The report summarizes the project background, development, and calibration of computer models of the CSS in the 12 uncontrolled CSO areas. These hydraulic models were developed to assess the performance of the existing system, predict wet weather flows, estimate the frequency and volume of CSO events, and support the analysis of

system modifications and new CSO control facilities. The reports were submitted to EPA and Ecology for approval in December 2012 and were approved in April 2013.

The EPA's CSO Guidance for Long-Term Control Plan (EPA 832-B-95-002) document indicates that the primary objective of CSS modeling is "to understand the hydraulic response of the CSS to a variety of precipitation and drainage area inputs". Using the flow monitoring statistics, hydraulic models were calibrated so that the City could calculate control volumes for each uncontrolled outfall. A control volume is the amount of combined sewage that would need to be stored in order to meet the overflow performance standard of not more than one discharge event per outfall per year based on a 20-year moving average. The City has determined the uncontrolled CSO outfall annual overflow frequencies, annual overflow volumes and the control volumes required to meet the performance standard. Table S-2 presents the LTCP hydraulic model simulation results based on the 20-year moving average.

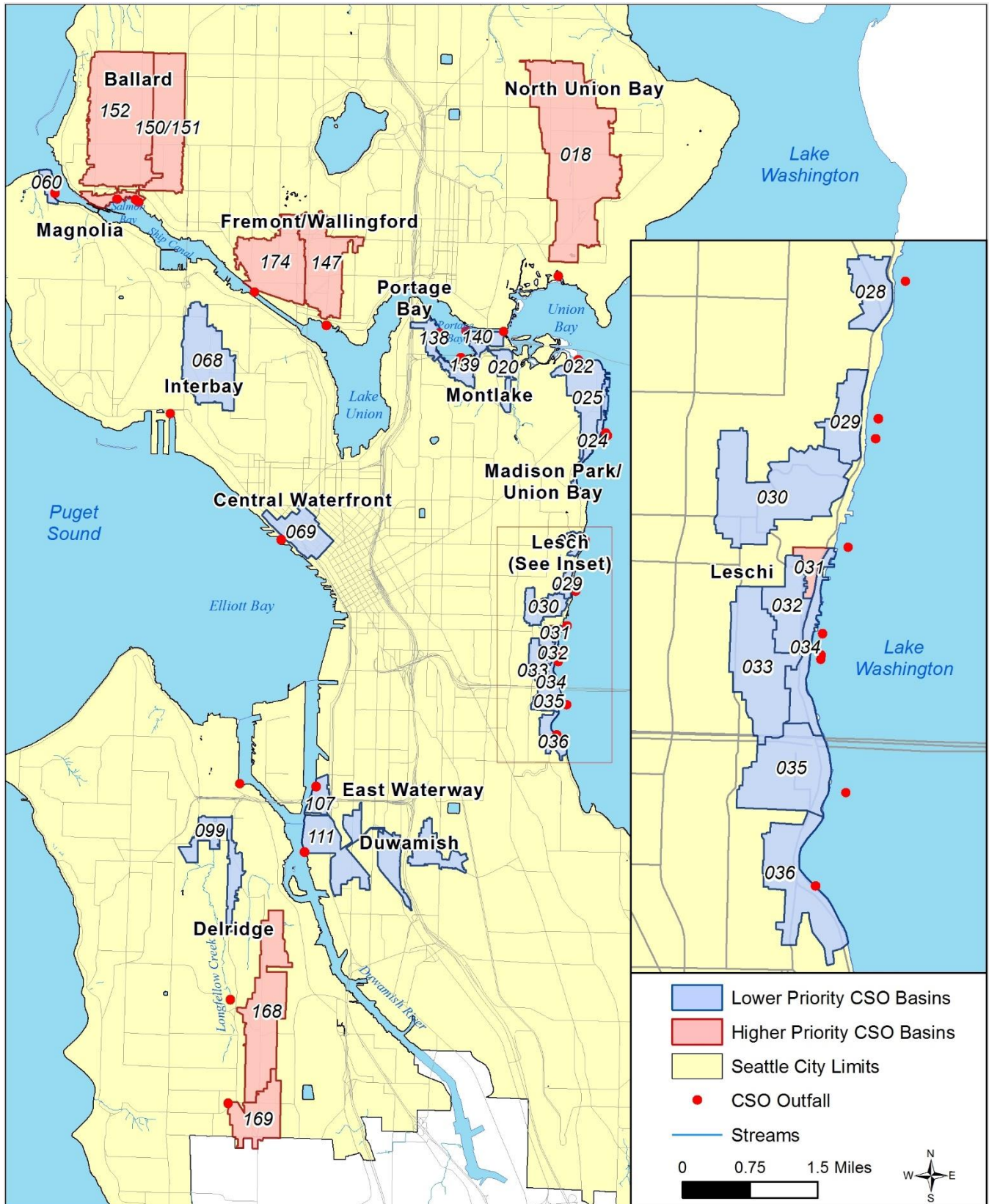


Figure S-1. LTCP Basins Ranked by Highest Priority by Sensitive Area Study

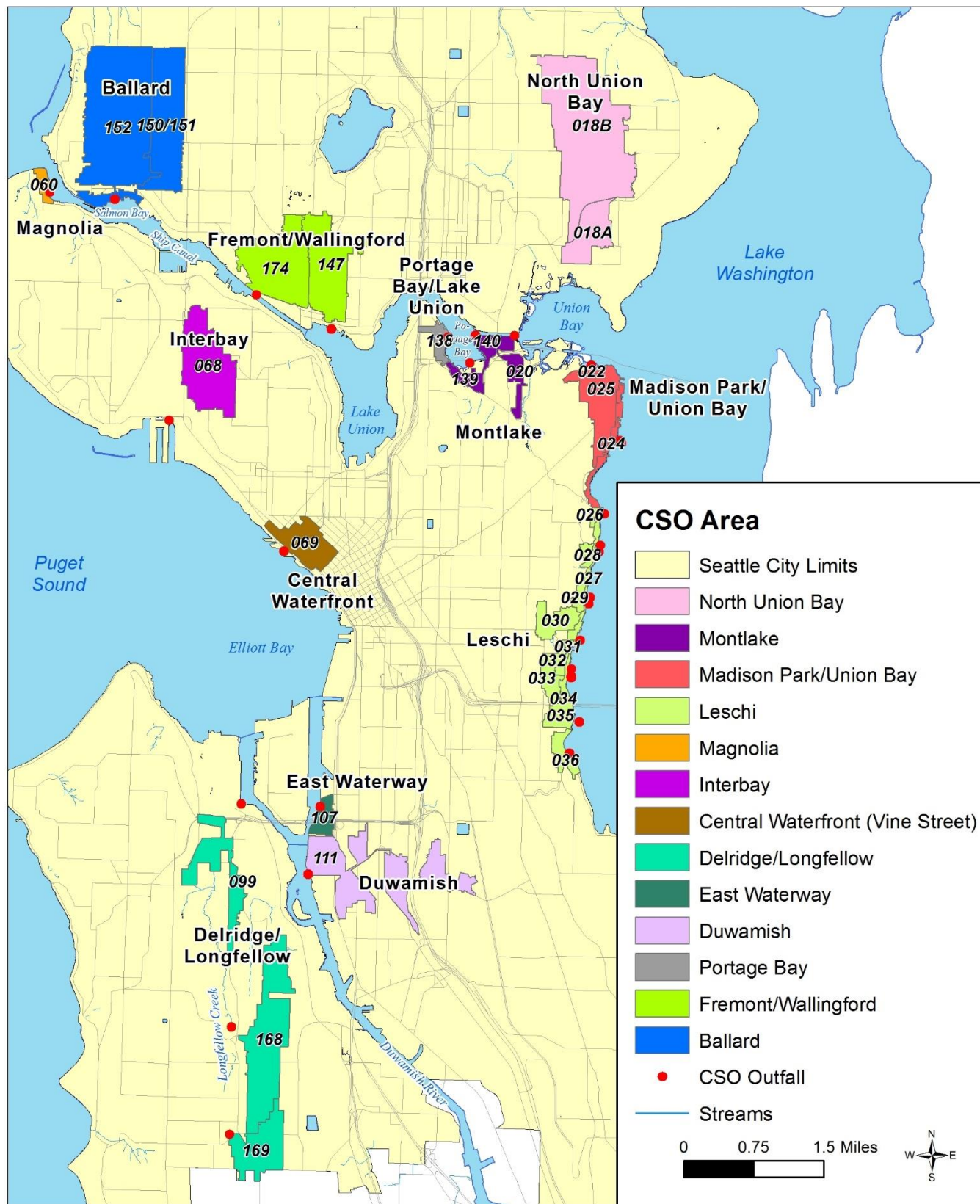


Figure S-2. LTCP Model Basin Boundaries

Table S-2. LTCP Hydraulic Results

CSO area	CSO overflow structure number	Average annual overflow frequency ^a	Average annual overflow volume (MG) ^{a,c}	Control volume with climate change (MG) ^c	Control volume without climate change (MG) ^{b,c}
North Union Bay	018A	4.1	0.7	0.26	0.19
North Union Bay	018B	2.4	4.3	1.37	0.98
Montlake	020	1.1	0.64	0.16	0.12
Leschi	026	0.1	<0.01	0	0
Leschi	027	0	0	0	0
Leschi	028	1.2	0.03	< 0.01	< 0.01
Leschi	029	1.6	0.01	0.02	0.01
Leschi	030	0.6	0.06	< 0.01	< 0.01
Leschi	031	16	0.93	0.31	0.25
Leschi	032A	1.7	0.05	0.01	< 0.01
Leschi	032B	6.6	0.22	0.07	0.05
Leschi	033	0.1	<0.01	0	0
Leschi	034	0.9	0.3	0.03	< 0.01
Leschi	035	1.1	0.01	< 0.01	< 0.01
Leschi	036	2.1	0.12	0.03	0.017
Magnolia	060	3.1	0.26	0.11	0.09
Interbay	068A	0.5	0.18	0.02	< 0.01
Interbay	068B	0.6	0.09	0.01	< 0.01
CWF Vine St.	069	1.4	0.54	0.13	0.05
Delridge	099	1.5	0.81	0.17	0.11
East Waterway	107	4.6	0.9	0.5	0.45
Duwamish	111B	1.1	0.2	< 0.01	< 0.01
Duwamish	111C	1.1	0.2	< 0.01	< 0.01
Duwamish	111H	0.7	0.21	0.01	< 0.01
Portage Bay	138	1.7	0.31	0.11	0.07
Montlake	139	1.2	0.04	0.01	< 0.01
Montlake	140	4.4	0.28	0.05	0.02
Fremont	147A	37.5	8.6	2.08	1.90
Fremont	147B	4.4	0.3	0.07	0.06
Ballard	150/151	16	2.9	0.62	0.45
Ballard	152	47.8	23.5	5.38	4.38

Table S-2. LTCP Hydraulic Results

CSO area	CSO overflow structure number	Average annual overflow frequency ^a	Average annual overflow volume (MG) ^{a,c}	Control volume with climate change (MG) ^c	Control volume without climate change (MG) ^{b,c}
Delridge/Longfellow	168	2.3	4.42	2.00	1.45
Delridge/Longfellow	169	1.8	2.81	1.19	0.74
Fremont-Wallingford	174	8.6	3.8	1.06	0.99

^a From 32 or 34 yr simulation with Rainfall scaling =1.0

^b Estimated control volume after removal of climate change uncertainty but keeping other uncertainties

^c Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

During 2014, outfall 026 was formally abandoned. Figure S-3 displays 87 CSO outfalls (including the abandoned outfall 026) and specifies their control status based on the 2013 Annual CSO Report.

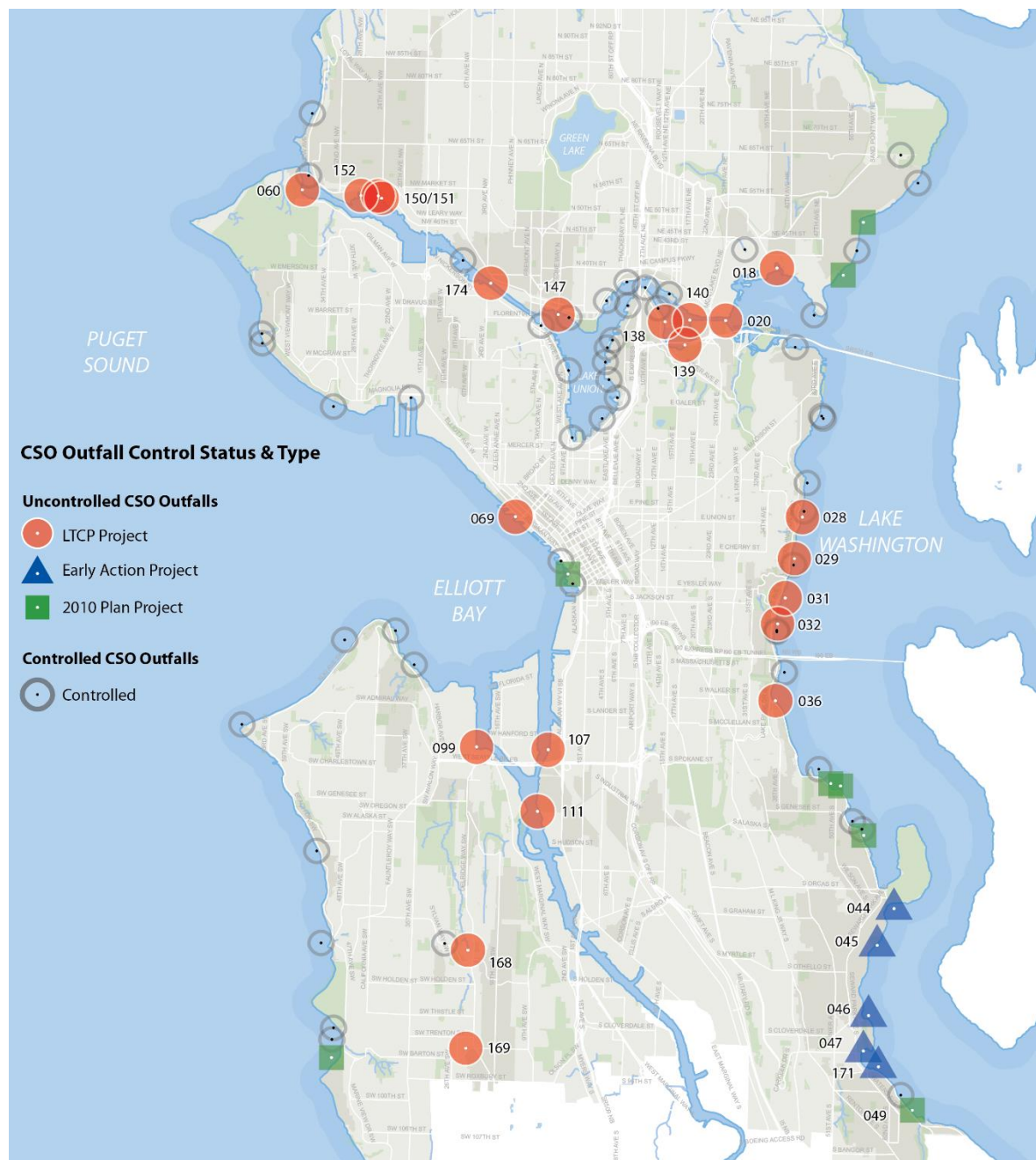


Figure S-3. Seattle's CSO Outfall Locations, Control Status and Project Implementation Phases

Chapter 3 Development and Evaluation of Alternatives for CSO Control

Approach

The Consent Decree (Appendix C, Section C, Paragraph 2) states, "The LTCP shall build upon the alternative analysis work that was performed as part of the development of the City's 2010 CSO Reduction Plan Amendment". The 2010 Plan specified a series of CSO reduction projects for the most critical overflow areas and included projects that will be designed and constructed in accordance with a schedule included in the City's NPDES Permit as well as projects that will be completed in accordance with the Consent Decree Early Action

projects. Projects were included for the Windermere, Genesee, Henderson, Ballard, North Union Bay, Interbay, Montlake, Fremont-Wallingford, Central Waterfront, West Seattle and Delridge CSO areas. The 2010 CSO Plan also included preliminary recommendations for CSO Control measures for the remaining uncontrolled CSO basins.

City and King County CSO Project Coordination

The City recognizes the importance of strong coordination with King County in controlling CSOs in the City. All of the proposed LTCP options have elements that may have an impact on King County's downstream wastewater system. Three of the proposed LTCP options include shared City/King County projects along the Ship Canal. Several of the proposed LTCP options include sewer system improvements that will convey additional wastewater volume to the downstream King County system. Regardless of which LTCP option is selected, coordination between the City and King County is critical to successfully designing, constructing, and operating the proposed CSO control projects in the City.

The City and King County are continuing to work together closely to analyze and refine a recommended LTCP option to enhance cost-effectiveness, produce better environmental outcomes, and minimize disruptions to communities. King County has determined the benefits of a shared project to the regional system and the implications of such a project to its own Long Term Control Plan and Consent Decree. Development of a shared City/King County project will be dependent on the City's and King County's analytical results as well as a number of joint factors that will be mutually agreed to in the City/King County coordination strategy. These factors include such things as which agency will be responsible for the design/construction/operations of the shared facility, each agency's project cost-share, operational and implementation roles and responsibilities, the process for dispute resolution, and the ability to fulfil regulatory and contractual obligations. A shared project agreement between the two agencies will be necessary prior to designing and constructing the project. In addition, the City and King County will analyze the impacts of any recommended project on the downstream King County system and agree on an approach to addressing those impacts prior to constructing the project.

LTCP CSO Control Measures

Since the 2010 CSO Reduction Plan was prepared, the control status of some uncontrolled CSO outfalls has changed, as documented in the 2013 Annual CSO Report. In addition, more accurate control volumes have been determined for numerous CSO outfalls as the result of the extensive system characterization effort that was conducted. Because of these changes, some CSO control measures that were eliminated in the 2010 Plan are now being reconsidered, and some recommendations from the 2010 Plan are no longer under consideration.

Sewer system improvements (or retrofits) were proposed as a recommended control measure in the 2010 CSO Plan only for the Delridge CSO area. However, by using the calibrated hydraulic models and supporting flow monitoring data to both test and confirm potential solutions for the City's CSO areas, additional low-cost sewer system improvements have been identified that significantly reduced or eliminated the need for competing storage measures. It is anticipated that as retrofit opportunities are identified and successfully implemented in succeeding program years, they will be incorporated into the detailed planning and design of storage facilities to reduce the size and scope of those facilities.

From this starting point, ongoing alternative evaluation relied on refinements in system characterization, additional demonstration projects under the Green Infrastructure program, retrofit analysis and feasibility, regulatory input, public comment, and other factors to screen for and focus on in the LTCP list of control measures. Table S-3 lists LTCP CSO control measures that have been evaluated in the LTCP.

Table S-3. CSO Control Measures Evaluated in the LTCP

2010 CSO Reduction Plan		LTCP	
2010 recommended control measures	CSO outfall	Feasibility for LTCP after evaluation	CSO outfalls
Roadside rain gardens	150/151, 152, 060, 020, 140, 030	The Consent Decree requires that the City identify measures to control all uncontrolled outfalls. The City must document the performance of Green Infrastructure in targeted CSO basins before EPA and Ecology will allow the City to reduce the size of any “grey” control measures. If the effectiveness is proven and approved, the City may implement smaller “grey” control measures and take credit for flow reductions associated with Green Infrastructure.	150/151, 152, 099, 168, 169, 018, 020, 139, 140, 147, 138
(RainWise) residential rain gardens	152, 060, 018, 068, 020, 040, 147, 174		099, 168, 169, 111, 028, 029, 031, 032, 036, 018, 020, 139, 140, 147, 174, 138
Cisterns	152, 140, 030		(see RainWise)
Permeable pavements	152, 140		Future re-evaluation
I/I control	152, 020, 34	Due to a lack of cost-effectiveness, will not be considered for CSO Outfalls 152, 020, and 034	N/A
Regulating devices and backwater gates or hydraulically operated sluice gates	169 & 169	CSO retrofit control measures will provide partial control of CSO Outfalls 168 and 169	018, 111, 168, 169
Flow diversion	None	Although not considered in 2010 Plan, may be feasible for CSO Outfall 107 because of close proximity to King County treatment plant	060, 018, 028, 029, 031, 032, 036, 020, 139, 140, 107, 111, 099
In-line storage	150/151, 060	Not technically applicable	N/A
Off-line storage	152, 069, 147, 174, 111, 107, 031, 030, 032, 034, 035, 036, 025, 024, 138, 168, 169,	Will continue to be considered because of cost-effectiveness	060, 150/151, 152, 147, 174, 020, 139, 140, 138, 028, 029, 031, 032, 036, 069, 107, 111, 099, 168, 169
Deep tunnel storage	None	Because of potential shared King County/City project opportunities, the LTCP will evaluate the cost-effectiveness of deep tunnel storage	150/151. 152, 147, 174, 018, 020, 139, 140, 138, 028, 029, 031, 032, 036,
Treatment	None	The 2012 King County CSO Plan evaluated CSO treatment opportunities and determined that the King County Hanford-Lander-King St-Kingdome CSO plant is the most cost effective shared treatment opportunity.	107

The City and King County started to identify potential collaborative CSO control measures in 2009. The two agencies evaluated 40 potential shared projects and identified four feasible shared projects to evaluate in each agency's respective CSO plan: shared Fremont/Wallingford/3rd Ave. W Regulator storage, shared North Union Bay/University Regulator storage, shared Montlake/Montlake Regulator storage, and a tunnel along the Ship Canal. Following the submittal and approval of King County's recommended CSO Control Plan, a second shared tunnel alternatives was developed (Shared West Ship Canal Tunnel) to control Ballard/Fremont/Wallingford/3rd Ave. W.

LTCP Options

The final City-only (independent) and shared alternatives were combined into four system-wide options including:

- Neighborhood Storage Option: Includes independent City storage facilities (storage tanks or CSO storage tunnel)
- Shared Storage Option: Includes 3 shared storage facilities with King County plus independent City storage facilities and flow diversions.
- Shared West Ship Canal Tunnel Option: Includes a shared West Ship Canal Tunnel with King County plus independent City storage facilities and City flow diversions
- Shared Ship Canal Tunnel Option: Includes a shared Ship Canal Tunnel with King County plus independent City storage and City flow diversions.

Table S-4 provides a basin by basin description of the four LTCP CSO control options.

Table S-4. LTCP CSO Control Options				
NPDES basins	LTCP Options			
	Neighborhood Storage	Shared Storage	Shared West Ship Canal Tunnel	Shared Ship Canal Tunnel
Ballard	Off-line storage tank or deep tunnel with Fremont/Wallingford Basin	Off-line storage tank	Shared deep tunnel with Fremont/Wallingford and King County 3rd Ave West Regulator	See Table note
Magnolia	Off-line storage pipe	Off-line storage pipe	Flow diversion to North Interceptor	Flow diversion to North Interceptor
North Union Bay	Collection system improvement	Shared off-line storage tank	Collection system improvement	See Table note
Central Waterfront	Off-line storage pipe	Off-line storage pipe	Off-line storage pipe	Off-line storage pipe
Fremont/Wallingford	Off-line storage tank or deep tunnel with Ballard Basin	Shared off-line storage tank	Shared deep tunnel with Ballard and King County 3rd Ave West Regulator	See Table note

Table S-4. LTCP CSO Control Options				
NPDES basins	LTCP Options			
	Neighborhood Storage	Shared Storage	Shared West Ship Canal Tunnel	Shared Ship Canal Tunnel
Duwamish	2 off-line storage pipes	2 off-line storage pipes	2 off-line storage pipes	Flow diversion to Duwamish Interceptor
Delridge	3 off-line storage pipes	3 off-line storage pipes	3 off-line storage pipes	Flow diversion to Harbor trunk plus 2 off-line storage pipes
Montlake	3 off-line storage pipes	Shared off-line storage tank	3 off-line storage pipes	See Table note
Leschi	3 off-line storage pipes plus 1 off-line storage tank	Shared off-line storage tank	3 off-line storage pipes plus 1 off-line storage tank	See Table note
East Waterway	Off-line storage tank	Flow diversion to King County Hanford-Lander-Kingdom-King Street treatment plant	Flow diversion to HLKK treatment plant	Flow diversion to King County Hanford-Lander-Kingdom-King Street treatment plant
Portage Bay	Off-line storage pipe	Off-line storage pipe	Off-line storage pipe	See Table note

Shared deep tunnel with Ballard, Fremont/Wallingford, North Union Bay, Montlake, Portage Bay, Madison Park, Leschi, and King County University, Montlake and 3rd Ave West Regulators

Chapter 3 provides additional detail on the four final LTCP options as presented in the draft LTCP in May 2014. These options were the basis for public participation, other agency reviews and additional refinement as discussed in Chapter 5 of this Final LTCP.

Project Costs

The City developed cost models for planning-level construction costs, allied soft costs, annual operation and maintenance cost, total project costs and net present value (NPV). The cost models were validated through a comparison with the actual construction bid prices for the Windermere and Genesee CSO projects. Tunnel costs and schedules were validated by third party expert consultant and contractor.

Facilities constructed under the LTCP will include real-time controls and will require extensive commissioning. These commissioning costs have been capitalized along with engineering and construction costs. Non-capital costs include recurring annual operation and maintenance expenses, fees paid to King County for treatment of additional flows, ongoing flow monitoring for system control, and post-construction monitoring to demonstrate Consent Decree compliance.

Total project costs based on 2013 construction costs were developed and presented in the Draft LTCP in May 2013 and are further described in Chapter 3. Additional detail is also provided for operational and maintenance costs.

The project costs were modified during the refinement process and are described in Chapter 5.

Chapter 4 Selection and Implementation of CSO Control Measures

Rating and Ranking

The Draft LTCP performed a "rating and ranking" of the LTCP options in accordance with the EPA's "Combined Sewer Overflows Guidance for Long-Term Control Plan, 1995". Non-monetary factors were evaluated based on the conceptual development work on the LTCP options. This technique is called Multiple Objective Decision Analysis (MODA) and incorporates a mechanism for consideration of non-monetary, social, and environmental factors as well as cost to create a structured comparison of competing solutions in support of a decision.

Environmental Impacts

There are two tables in Chapter 4 (4-10, Summary of Construction Impacts and 4-11, Summary of Operational Impacts) that list each LTCP Option and their impacts based on 13 different resources. These resources are:

1. Earth
2. Air Quality
3. Surface Water
4. Biological Resources
5. Energy and Climate Change
6. Environmental Health and Public Safety
7. Noise and Vibration
8. Land Use and Visual Quality
9. Recreation
10. Historic, Cultural, and Archaeological Resources
11. Transportation
12. Utilities
13. Socioeconomics and Environmental Justice

Construction and operational impacts for each option are primarily related to Noise and Vibration, Land Use and Visual Quality, Recreation, and Transportation, which are summarized below in Table S-5. Because this is a plan-level evaluation, project details and construction methods have not yet been defined. Actual construction activities would vary and would be determined during subsequent, project-specific review. Please refer to Chapter 4 for full versions of Environmental Impacts tables.

Table S-5. Summary of Major Impacts Considered in the EIS

Construction impacts	Operational impacts
Neighborhood Storage Option	
The Neighborhood Storage Option would likely result in the most geographically dispersed impacts throughout the Plan area. Construction impacts would last from between 1.5 years for a storage pipe to as long as 5 years for a large storage tank. Noise and Vibration: Construction of projects would result in short-term, moderate to substantial, increases in noise. The longest duration impacts would occur in Ballard and Fremont/Wallingford associated with storage tank construction. Land Use and Visual Quality: Temporary easements would be needed from some private landowners, depending on the project. Property acquisition could be required for storage tanks and tunnel portals. Impacts would potentially be greatest under this option. Recreation: Impacts could occur if tanks or tunnels are located in or adjacent to parks. SPU would attempt to avoid siting tanks or tunnels in park locations. Transportation: Potential construction-related transportation impacts would be highly visible and are of concern to local residents, business owners, and commuters. Transportation impacts would include increases in traffic volumes due to construction-generated truck trips and commute trips of construction workers, and roadway lane and sidewalk closures where construction activities take place. More dispersed impacts would occur under this option. Under this option, localized impacts would occur in certain areas (e.g. Leschi) where the ability to accommodate lane closures for storage pipe construction is highly constrained due to limited arterials.	Operational impacts are not expected to be significant. Noise and Vibration: The net operational effects would be minor in the Plan area. Noise would be generated by pump stations and odor control facilities. All facilities would be designed and maintained to reduce noise to permissible levels. Because this option would likely have the most project sites needing pump stations and other facilities, potential noise impacts are greatest for this option. Land Use and Visual Quality: Private property or permanent easements could be acquired. Visual impacts would be minimal. Recreation: This option has the highest potential to cause park and recreation impacts because it would likely include the most tank facilities. If located in a park, it could constrain certain future uses of that area for park purposes. However, there is a potential to provide recreational facilities on top of storage tanks following construction. Transportation: Overall, the operational effects from vehicle trips generated by facility maintenance are expected to be minor Utilities: There is a potential for downstream impacts to King County's wastewater facilities. The City will work closely with King County to avoid potential impacts, but if downstream impacts cannot be avoided, the City will work with the County to develop appropriate and adequate mitigation.
Shared Storage Option	
The Shared Storage Option reduces the total number of tanks constructed, but concentrates impacts at shared tank locations in the Ship Canal and Lake Washington neighborhoods. Construction duration ranges from 1 year for sewer system improvements to 4.5 years for a large shared storage tank. Noise and Vibration: Impacts would be similar to the Neighborhood Storage Option but would be of potentially higher intensity and concentrated at fewer locations. Land Use and Visual Quality: Impacts would be similar to the Neighborhood Storage Option, but fewer project sites would be required. However, the larger, shared tanks would require a larger construction footprint. Recreation: Impacts would be similar to the Neighborhood Storage Option but concentrated at	The Shared Storage Option concentrates impacts at shared tank locations in the Ship Canal and Lake Washington neighborhoods; however, operational impacts of the shared tanks are expected to be minor for most resources. Noise and Vibration: Impacts would be similar to the Neighborhood Storage Option but there would be less noise-generating pump stations and mechanical facilities. Land Use and Visual Quality: Impacts would be similar to the Neighborhood Storage Option. Recreation: Impacts would be similar to the Neighborhood Storage Option, but fewer project sites would be required. If located in a park, the larger, shared tanks could have a larger impact. Transportation: Impacts would be the same as under the Neighborhood Storage Option.

Table S-5. Summary of Major Impacts Considered in the EIS

Construction impacts	Operational impacts
fewer locations. Transportation: Impacts would be similar to the Neighborhood Storage Option but concentrated at fewer locations.	Utilities: There is a potential for downstream impacts to King County's wastewater facilities. The City will work closely with King County to avoid potential impacts, but if downstream impacts cannot be avoided, the City will work with the County to develop appropriate and adequate mitigation.
Shared West Ship Canal Tunnel Option	
The Shared West Ship Canal Tunnel Option reduces the total number of tanks constructed, but concentrates impacts at tunnel construction locations in the Ship Canal neighborhoods. Construction duration would range from 1 year for some flow diversion projects to as long as 6 years for the shared tunnel. Noise and Vibration: Impacts would be similar to the Neighborhood Storage Option but would be of potentially higher intensity and concentrated at fewer locations. Vibration impacts along the tunnel routes are likely to be a concern to property owners. Land Use and Visual Quality: Land use impacts would potentially be the least under the tunnel options, though impacts would be concentrated at fewer locations (tunnel construction locations). Recreation: Impacts would be similar to the Neighborhood Storage Option but concentrated at fewer locations. Transportation: Impacts would be similar to the Neighborhood Storage Option but concentrated at fewer locations. This option would result in substantially more truck trips over a multi-year period in Ballard compared to the Neighborhood Storage and Shared Storage Options. There is a potential to remove tunnel materials by barge, with the potential to eliminate over 16,000 potential truck round trips	Operational impacts of the tunnel are generally expected to be minor, but will require agreements with King County to ensure that operational impacts to their facilities do not occur, or appropriate mitigation if impacts are unavoidable. Noise and Vibration: Impacts would be similar to the Neighborhood Storage Option but there would be less noise-generating pump stations and mechanical facilities. Recreation: This option would have less potential for long-term impacts than both the Neighborhood Storage and Shared Storage Options since the tunnel would replace the need to site several storage tanks in the Ship Canal Neighborhoods, with less potential for recreation impacts. Land Use and Visual Quality: Impacts would be similar to the Neighborhood Storage Option, though less property or easements would need to be retained following construction. Area needed for construction staging could be sold following tunnel construction. Transportation: Impacts would be the same as under the Neighborhood Storage Option.
Shared Ship Canal Tunnel Option	
The Shared Ship Canal Tunnel Option reduces the total number of tanks constructed, but concentrates impacts at tunnel construction locations in the Ship Canal and Lake Washington neighborhoods. Noise and Vibration: Impacts would be similar to the Neighborhood Storage Option but would be of potentially higher intensity and concentrated at fewer locations. Vibration impacts along the tunnel routes are likely to be a concern to property owners. Land Use and Visual Quality: Land use impacts would potentially be the least under the tunnel options, though impacts would be concentrated at fewer locations. Recreation: Impacts would be similar to the Neighborhood Storage Option but concentrated at	Impacts would generally be minor for most resources. Operation of the tunnel would be conducted in accordance with agreements with King County, to avoid operational impacts to King County facilities. If impacts to downstream facilities cannot be avoided, the City will work with the County to develop appropriate mitigation. Noise and Vibration: Impacts would be similar to the Neighborhood Storage Option but there would be fewer noise-generating pump stations and mechanical facilities. Land Use and Visual Quality: Impacts would be similar to the Neighborhood Storage Option, though less property or easements would need to be retained following construction. Roughly one-half acre of land would be permanently required for the tunnel, and the land acquired for

Table S-5. Summary of Major Impacts Considered in the EIS

Construction impacts	Operational impacts
fewer locations. Transportation: Impacts would be similar to the Neighborhood Storage Option but concentrated at fewer locations. This option would result in substantially more truck trips over a longer period on the south side of the Ship Canal at the potential tunnel launch location. The potential to excavate materials by barge would be similar to the Shared West Ship Canal Tunnel Option, with the potential to eliminate over 32,000 potential truck round trips.	construction could be sold. Recreation: This option would have less potential for long-term impacts than all options since the tunnel would replace the need to site several storage tanks, with reduced potential for recreation impacts. There would be a potential for impacts on the south side of the Ship Canal and in North Union Bay if the tunnel portals are sited in a park or recreation area. Transportation: Impacts would be the same as under the Neighborhood Storage Option.

Implementation of LTCP Options

The implementation schedules include the sequence and duration of steps to complete for each LTCP CSO Control Measure including design, construction, commissioning and demonstration of control. The implementation schedules will affect rates, employment, public and local businesses, agency resource allocation, and other agencies projects.

If it is not possible for the City to design and construct all measures simultaneously, the LTCP includes a phased schedule based on the relative importance of each measure, with the highest priority given to those projects which have the highest pollutant reduction.

The LTCP used two methods to determine the priority of projects. The first method followed the EPA guidelines for Sensitive Areas, which gives the highest priority to the highest ranked sensitive areas. The second method compares the relative cost-effectiveness of each CSO project on a total project cost per gallon of CSO discharge volume reduced. The highest priority is given to the CSO projects with the lowest cost per CSO discharge gallon reduced.

For each CSO Control Measure, the Consent Decree requires the implementation schedule to specify the critical milestone dates for the following project activities: Engineering Report, Plans and Specifications, Construction Start, Construction Completion and Achievement of Controlled Status. Because the CSO projects range in construction complexity and project costs, the CSO projects have project durations ranging from 3 years to 14 years based on SPU project implementation experience. The project durations assumptions are listed in Table S-6.

Table S-6. Option Development (Months)						
CSO control measure	Overall project duration	Engineering report	Plans and specifications	Construction start	Construction completion	Achievement of control status
Large CSO tanks (1 MG or larger)	148	36	36	6	54	16
CSO tanks	109	24	24	6	39	16
Pipe storage	73	12	12	6	27	16
Flow diversion	109	24	24	6	39	16
Collection system improvements (retrofits)	73	12	12	6	27	16
West Ship Canal Tunnel	148	36	36	6	54	16
Ship Canal Tunnel	184	36	36	6	90	16

Detailed schedules for each of the four options are presented in Chapter 4. These schedules were established in support of balanced City resource allocation and to level rate impacts.

The implementation schedules were re-analyzed for the preferred option and are presented in Chapter 5. The schedules meet the Consent Decree construction completion milestone dates for the City (2025); however, the Shared West Ship Canal Tunnel schedule does not meet King County's Consent Decree milestone construction completion date for 3rd Ave W (2023). A minor schedule milestone modification to the King County Consent Decree will be required.

Projected Rates

Using planning-level cost estimates, the City evaluated the overall impact to the monthly wastewater and drainage rates to implement the LTCP and the Integrated Plan alternatives. A preliminary rate schedule was developed in the Draft LTCP published in May 2014 and is presented in Chapter 4.

Subsequent to publication of the Draft LTCP, the refinements discussed in Chapter 5 were incorporated into a revised rate analysis and are shown in Chapter 5.

Operational Planning

While the City and King County own and operate discrete wastewater collection and conveyance systems, parts of King County's system are interconnected with the City's where the operation of one impacts the operation of the other. All of the wastewater collected in the City's Wastewater Collection System is discharged to a King County owned interceptor for transport to one of King County's wastewater treatment plants. In addition, the City owns CSO outfalls which are located upstream and in close proximity to King County owned CSO outfalls. The City is currently working with King County to prepare a Joint Operations and System Optimization Plan ("Joint Plan") for the City's Wastewater Collection System and those interdependent portions of King County's regional wastewater conveyance and treatment system that are hydraulically connected to the City's system. The result of this effort is the development of a Joint Plan that is consistent with both entities' operational objectives, ensuring the optimal level of coordination and information sharing is maintained, and optimizing system and shared operations between both entities. The Joint Plan will describe a procedure for operating their existing systems, include a process for incorporating the Joint Plan into the design of new capital projects for the combined systems, ensure the optimal level of coordination and information sharing is maintained, and optimize system and shared operations. The Final Joint Operations and System Optimization Plan ("Joint Plan") will be submitted for approval to EPA and Ecology in March 2016. The operations plan presented in the Draft LTCP will include preliminary results from the Joint Plan and will be subject to revisions based on the approved Joint Plan. Based on the recommended LTCP option, SPU will prepare a final operation plan incorporating the final implementation schedule and updated Joint Operations and System Optimization Plan information.

Operations and maintenance staffing requirements have been prepared for specific positions, number of FTEs, and staff responsibilities for each LTCP option. Table S-7 summarizes the additional operations and maintenance LTCP staffing requirements for current (2015), near term (2020), Construction Completion (2025) and Achievement of Controlled Status (2030).

Table S-7. Operations and Maintenance Staffing Needs for Proposed LTCP Options				
LTCP option	LTCP staffing requirements (FTEs)			
	2015 (current)	2020 (near term)	2025 (construction completion)	2030 (controlled status)
Neighborhood Storage				
Operations	0.0	0.5	4.2	4.2
Maintenance	0.0	0.7	7.4	7.4
Total O&M staff	0.0	1.2	11.6	11.6
Neighborhood West Ship Canal Tunnel				
Operations	0.0	0.5	4.1	4.2
Maintenance	0.0	0.7	7.1	7.1
Total O&M staff	0.0	1.2	11.2	11.2
Shared Storage				
Operations	0.0	0.4	2.9	2.9
Maintenance	0.0	0.4	6.1	6.1
Total O&M staff	0.5	0.8	9.0	9.0

Table S-7. Operations and Maintenance Staffing Needs for Proposed LTCP Options				
LTCP option	LTCP staffing requirements (FTEs)			
	2015 (current)	2020 (near term)	2025 (construction completion)	2030 (controlled status)
Shared West Ship Canal Tunnel				
Operations	0.0	0.5	4.1	4.1
Maintenance	0.0	0.7	6.9	6.9
Total O&M staff	0.0	1.2	11.0	11.0
Shared Ship Canal Tunnel				
Operations	0.0	0.2	2.0	2.0
Maintenance	0.0	0.2	4.5	4.5
Total O&M staff	0.0	0.4	6.5	6.5

The general overall operating strategy is to provide sufficient real time flow monitoring for each CSO facility to determine the influent flows, CSO facility performance, CSO overflow and CSO storage release flows back into the City or King County interceptor system. Figure S-4 illustrates how the typical LTCP CSO facility will need to operate using the proposed Fremont-Wallingford Neighborhood Storage Tank as an example.

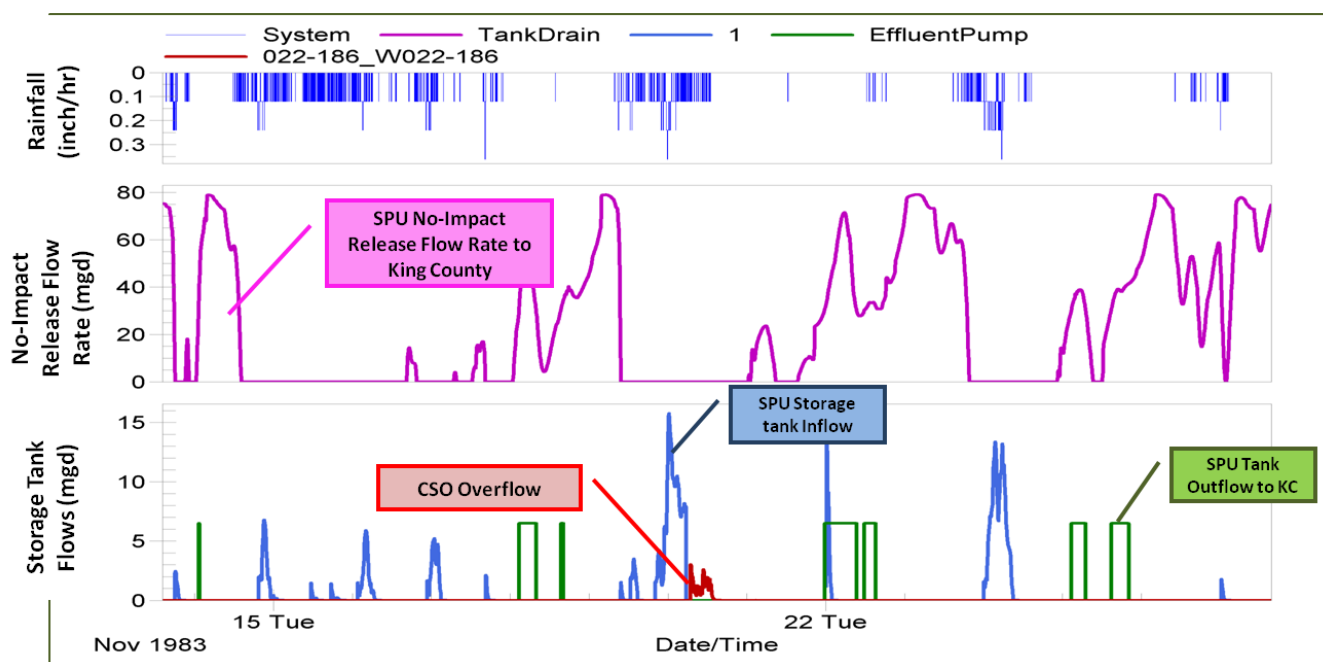


Figure S-4. Example of Fremont/Wallingford Storage Operating Strategy

As the rainfall increases (top row in Figure S-4), CSO flows will increase in both the King County and City sewer systems. To prevent CSOs, rain-induced combined sewer flows (bottom row) will be diverted into the proposed LTCP storage projects to prevent overflows. As rainfall subsides and interceptor capacity is available, stored flows can be released back into the sewer system.

However, since all City flows go into the King County interceptor system, the King County interceptor and treatment plant capacity is a major factor in determining how the City CSO facilities operate and when the City CSO facilities can release City stored flows into the King County system. Available King County interceptor capacity is shown over time as “no impact release rates” (middle row). LTCP facilities will need to release stored flows multiple times during prolonged CSO event such as the example storm event shown.

Sufficient flow monitoring and real-time control systems must be provided to determine when and how much flow needs to be diverted into storage and when the stored flows can be released to the King County interceptor system.

Chapter 5 Selection and Implementation of Recommended LTCP CSO Control Option

Overview

Subsequent to issuance of the draft LTCP publication in May 2014, and receipt of comments, additional refinements were made to the four final LTCP options. The City received updated storage release rates from King County that were used to analyze and adjust the sizing of the proposed control measures. Cost estimates were updated based on the new sizing, then community and environmental impacts were re-assessed. The four options were compared and two of the options (Neighborhood Storage and Shared West Ship Canal Tunnel options) were selected for final analysis. Since costs of the options were similar, the final analysis focused more on environmental and community impacts and the ability of the City and County to collaborate on a shared project.

Public and Regulatory Agency Participation Program

SPU has included a comprehensive public and regulatory agency participation program in preparing the draft and final LTCP. A summary of the overall participation program is presented in Table S-8.

Table S-8. Public Participation Plan	
Consent Decree requirements (Appendix C, Section A.1-A.5)	Proposed public participation
How the City will make LTCP information available for public review.	Community Guide update briefings Video for website Briefings offered Spring/Fall (Spring 2013 - Spring 2015) or if specifically requested by a stakeholder group. Website updates to be completed spring/fall (Spring 2013 – Spring 2015)
How the City will solicit public comments on the development of the LTCP	Briefings given to stakeholder group (Sounding Board) in 2010-2011 Scoping meetings Scoping Summary Reports Online Questionnaires in Spring 2013, Fall 2013, and Spring 2014 Public meeting on the Draft LTCP/Integrated Plan and Public Hearing on Draft EIS June 2014 Public Ordinance Process to adopt the preferred alternative (Spring 2015)

Table S-8. Public Participation Plan	
Consent Decree requirements (Appendix C, Section A.1-A.5)	Proposed public participation
Summary of public hearings during LTCP development to provide public with information and to solicit public comments.	Draft EIS public hearing summary report LTCP/Integrated Plan Public and Regulatory Agency Participation Summary Report
Program for consideration of comments provided by the public as the City develops the LTCP.	Public Meeting
How the City will ensure that Plaintiffs are kept informed of the LTCP development. Regular report submittal to Plaintiffs summarizing public comments.	Quarterly meetings with EPA/Ecology (addresses both LTCP and Integrated Plan) Status updates in annual CSO Reports. Submission of Draft Final Plan for review and comment (February 2015)

Public and Regulatory Comments

Following publication of the Draft LTCP in May 2014, the City received comments from the public, agencies and EPA/Ecology, which have been incorporated into the Final LTCP. Comments were also received on the draft EIS and were incorporated into the Final EIS which was published in December 2014.

Evaluation of King County Boundary Conditions or “No Impact Release Rates”

All of the City’s CSO basins discharge into the King County system through various facilities. In order to analyze potential impacts to their system, King County provided time series of flow rates at key locations in their interceptor system. These time series of flow rates, called no-impact release rates (NIRR), provide times and maximum flow rates for release of stored flow from the City CSO control facilities that would result in minimal or no impact on the operation of King County’s facilities. Please refer to Figure S-4.

The City analyzed the CSO Control Measure using the approved Version 5 (SWMM) v22 models using the King County NIRRs to confirm that the CSO control measures would comply with regulatory performance requirements and minimize impacts to the King County system. Where necessary, minor modifications were made to the City’s LTCP CSO control measures to account for the NIRR restrictions.

Joint Evaluation of King County and City Shared Options

The City recognizes the importance of coordination with King County in controlling CSOs in Seattle. All City LTCP options have elements that may impact King County’s downstream wastewater system. Three of the evaluated LTCP options include shared City/King County projects along the Ship Canal. Several of the evaluated LTCP options include sewer system improvements that would convey additional wastewater volume to the downstream King County system. All interagency coordination will be conducted in accordance with commitments included in the SPU and King County coordination strategy, developed by both agencies. The coordination strategy considers specific factors that will be considered in evaluating and making a recommendation on which CSO projects will be undertaken jointly or independently by either the City or King County. Section 5.4.2 discusses the evaluation factors and the process.

Assessment of Control Benefits from System Improvement Program

The City has been conducting an ongoing program to identify, design, and construct system improvement projects in CSS areas. These projects are typically smaller in scope and consist of minor, low-cost modifications to existing infrastructure.

The implementation of these improvement projects will likely result in a reduction in the control volume required to bring the LTCP basins into control. The impact of these improvements on the control volumes of CSO control measures recommended in this LTCP will be analyzed after the construction of the improvement projects. If the sewer system improvement is successful and controlled status is attained, it will be documented in the annual CSO Report and no future storage facility will be needed. If the sewer system improvement reduces the control volume but does not achieve controlled status, reductions in the size of the future storage facility will be address in the engineering report that is submitted for approval for the individual LTCP project.

As improved system characterization and hydraulic model application has occurred during the LTCP planning process following issuance of the Draft LTCP in May 2014, the potential for significant CSO control resulting from system improvements has become apparent. For this reason, the LTCP refinement activity has made substantial changes in the prioritization and scheduling of the individual CSO control measures to allow time for construction and evaluation of system improvements proposed under the Retrofit Program.

Final LTCP Options for Evaluation

Two LTCP options were retained for final evaluation: Neighborhood Storage and Shared West Ship Canal Tunnel. Table S-9 summarizes the LTCP CSO areas and the specific CSO control measures for each option.

Table S-9. Final LTCP Option Descriptions and CSO Control Measures

CSO area	LTCP options	
	Neighborhood Storage	Shared West Ship Canal Tunnel
Ballard	Off-line storage tank	Shared deep tunnel with Fremont/ Wallingford and WTD 3 rd Ave. W and 11 th Ave. NW
Magnolia	Off-line storage pipe	Off-line storage pipe
North Union Bay	Collection system improvement	Collection system improvement
Central Waterfront	Off-line storage pipe	Off-line storage pipe
Fremont/ Wallingford	Off-line storage tank	Shared deep tunnel with Ballard and WTD 3 rd Ave. W and 11 th Ave. NW
Duwamish	2 off-line storage pipes	2 off-line storage pipes
Delridge	3 off-line storage pipes	3 off-line storage pipes

Table S-9. Final LTCP Option Descriptions and CSO Control Measures

CSO area	LTCP options	
	Neighborhood Storage	Shared West Ship Canal Tunnel
Montlake	3 off-line storage pipes	3 off-line storage pipes
Leschi	3 off-line storage pipes plus 1 off-line storage tank	3 off-line storage pipes plus 1 off-line storage tank
East Waterway	Off-line storage tank	Off-line storage tank
Portage Bay	Off-line storage pipe	Off-line storage pipe

Identification of Recommended LTCP Option

Based on the evaluations of the two final options, results of the EIS prepared for the LTCP, and cooperative agreements with King County, the City selected the Shared West Ship Canal Tunnel Option as the recommended LTCP option. The City would be the lead agency for construction and operation of the facility under the terms of a joint project agreement to be executed with King County.

The Shared West Ship Canal Tunnel option is recommended because it is a more flexible means of controlling CSOs in the area of the West Ship Canal that also should result in the least long-term impacts to the neighborhoods where the tunnel would be located. Cost difference is not a determining factor in the recommendation because the options considered are within the same cost range. The determining factors in support of the recommendation are as follows:

- The Shared West Ship Canal Tunnel option allows the City and King County to work together to build a single facility to serve multiple common needs. Opportunities to achieve economies of scale and operational flexibility are greater with the Shared Tunnel than with separate neighborhood storage tanks.
- The Shared West Ship Canal Tunnel option is consistent with terms contained in each jurisdiction's Consent Decrees requiring coordination of the planning, implementation, and operation of CSO control within the combined system serving the Seattle area.
- The Shared West Ship Canal Tunnel option will likely have greater impacts to neighborhoods during construction than the Neighborhood Storage option. However, once constructed, the Shared West Ship Canal Tunnel will largely be underground. The impact to neighborhoods resulting from hosting permanent facilities is less than the Neighborhood Storage option.

Flow diversion for the East Waterway CSO control measure under the recommended LTCP option was revised to a neighborhood storage CSO control measure because the King County Hanford/Lander/King Street/Kingdom (HLKK) CSO plant will not be completed until December 31, 2030 and without an operating HLKK CSO Plant, the City will not meet its Consent Decree construction completion date of December 31, 2025. Constructing a neighborhood storage CSO control measure will allow the City to meet its Consent Decree construction completion date of December 31, 2025.

Flow diversion for the Magnolia CSO control measure was revised to a neighborhood storage pipe because of hydraulic capacity limitations of the existing King County North Interceptor at the Magnolia CSO discharge location. Constructing a neighborhood storage CSO control measure will allow the City to discharge its CSO flows to the WTD interceptor without impacting the WTD interceptor hydraulic capacity.

There were no other changes to the option descriptions provided in Section 3.6.2

A summary of the comparison between the two final options is presented in Table S-10.

Table S-10. Comparison of Final LTCP Options			
Evaluation factors		LTCP option	
Factor	Items to be considered	Neighborhood Storage Option	Shared West Ship Canal Tunnel Option
Financing	Financial benefits are to be realized and shared by both agencies through economies of scale and other efficiencies from replacing a larger number of independently designed and constructed storage projects with a smaller number of jointly developed storage projects.	The construction and long-term operating costs of the two alternatives for the City ratepayers are very similar. The total project cost and NPV of the two alternatives, given the accuracy of project development phase cost estimates, does not indicate a significant cost difference between the two options.	
Scheduling	The effect of implementing joint projects on either the City's or King County's ability to meet their respective Consent Decree milestone dates and King County's approved LTCP project implementation sequence will be considered. Both utilities must agree that a shared project can be managed within their respective schedules before recommending shared project implementation.	More complicated permitting/regulatory compliance requirements from dispersed large tank construction and operation.	The City's and King County's Consent Decrees contain identical language requesting the agencies to work together for a regional solution. The tunnel option requires a partnership for a joint project with WTD that independent tanks do not require. Completion of Construction for King County's 3rd Ave W facility will require an amendment in the milestone for construction completion from December 31, 2023 to December 31, 2025. The agencies are working together to confirm the schedule for construction completion.

Table S-10. Comparison of Final LTCP Options

Evaluation factors		LTCP option	
Factor	Items to be considered	Neighborhood Storage Option	Shared West Ship Canal Tunnel Option
Community impacts	The evaluation of whether to develop shared CSO control projects in lieu of independent City and King County projects needs to consider the number of affected communities and the scale of larger joint CSO control facilities on host communities. Shared CSO control projects present the opportunity for the City and King County to reduce the total number of CSO control facilities to be constructed, which can reduce the number of communities impacted by their construction, operation, and maintenance. Conversely, larger joint CSO control facilities could result in larger-scale impacts to host communities.	There are significantly more short-term construction impacts from major tank construction and more long-term community impacts from land use restrictions and loss of property for dedicated major tank sites.	Community impacts from construction noise, traffic disruption, property consumed and removed from potential other uses and street disruptions are lower with this option. A large portion of the tunnel construction sites could be sold for private use following the completion of construction.
Regulatory considerations	All CSO control projects must meet the control standard of no more than one CSO event per year. The evaluation of shared or independent CSO control projects should consider which type(s) of project are most likely to meet compliance standards.	Both agencies have evaluated CSO control options of storage or treatment. The King County LTCP approved plan contains both treatment and storage projects based on cost effectiveness (cost and regulatory compliance). These projects are required to meet a phased implementation schedule included in King County's consent decree.	The Shared West Ship Canal Tunnel provides greater flexibility to adequate control for all seven outfalls due to the ability to optimize storage for each basin depending on the variability of rainfall and flows in each basin. The Shared West Ship Canal Tunnel CSO control measure is estimated to have a 20-year moving average CSO overflow frequency of 0.5 events per year and an annual CSO volume reduction of 80%.
Local agency designation and responsibilities	Efficient implementation of a joint CSO control project may require the designation of a lead agency or the creation of a joint project management structure will be considered. Key evaluation decisions include which agency will act as lead, and what responsibilities are inherent in a lead agency, or whether a joint project management structure is appropriate and what responsibilities are inherent in a joint project management structure. The final recommendation on a joint project will be documented in a joint project agreement.	Both agencies have recent experience in the construction of large storage tanks. King County has extensive experience in the operation of facilities off-site from their treatment works and has dedicated operators and maintenance staff. The City has constructed and operated numerous pipe storage facilities and two large cylindrical storage tanks. The City is currently constructing new state of the art rectangular tank storage facilities. The Windermere and Genesee CSO storage	The City will be the lead agency for a Shared West Ship Canal Tunnel. King County and the City will enter a project-specific agreement to construct and operate the Shared West Ship Canal Tunnel.

Table S-10. Comparison of Final LTCP Options

Evaluation factors		LTCP option	
Factor	Items to be considered	Neighborhood Storage Option	Shared West Ship Canal Tunnel Option
		facilities will be complete in 2015. The City is also performing final design of the Henderson CSO storage facilities which will be completed by 2018.	

Overview of Project Costs

The project costs and net present values of the various components of the LTCP options were presented in Chapters 3 and 4. Following the short-listing of the two final options, the costs of each were updated to reflect the results of ongoing refinement and evaluation. Major areas of cost revision were:

- Previous estimates (expressed in 2013 dollars) were escalated to August 2014 dollars.
- Final control measure modeling resulted in minor changes to control measure sizes and volumes.
- Project schedules were adjusted as appropriate to allow retrofit projects to be completed prior to final design of the LTCP control measures. This will allow SPU to optimize the size of final control measures, and it resulted in changes to NPVs.
- More detailed analysis of pre and post-construction monitoring affected that portion of the cost.
- Substitution of storage projects for the proposed flow diversions in the Magnolia and East Waterway neighborhoods affected the overall option NPVs.

Because Ballard and Fremont/Wallingford are the largest basins and are included in a shared project with King County, further refinement of the costs was deemed to be appropriate. The City and King County engaged an independent cost estimator to prepare an independent project cost estimate for the major elements of each of the options. This was done for two primary purposes: one was to update King County project costs that were dated and prepared under different methods and the other was to assure that the estimates used to compare the agencies' projects were done on an equivalent basis.

Detailed costs are presented in section 5.7. Overall costs comparisons for the two final options are shown in table S-11.

Table S-11 Final Option Total Project Cost and Net Present Values

Option	Total project cost, \$M	City total project cost share, \$M	Total project NPV, \$M	City NPV cost share, \$M
Neighborhood storage tanks	\$394	\$394	\$401	\$401
Shared West Ship Canal Tunnel	\$503	\$387	\$491	\$386 ^a

Notes:

NPV = Net Present Value

^a As a shared project, King County would also contribute funding for the Shared West Ship Canal Tunnel. The cost shown in this table is limited to the City's share of the NPV. See Section 5.7.4 for details on the cost share methodology.

Performance Evaluation of Recommended LTCP Option

Based on the CSO Control Measures and No Impact Release Rates previously described, the 20-year moving average annual overflow frequency and volume were estimated for each CSO outfall using the LTCP hydraulic models incorporating the recommended CSO Control Measures. The results are shown in Table S-12. All recommended LTCP CSO Control Measures will reduce the annual CSO overflow frequencies to less than one event per outfall per year based on a 20-year moving average.

Table S-12. Projected Annual Performance After Implementation of CSO Control Measures

CSO area	CSO outfall number	Recommended CSO control measure	20-year moving average annual overflow frequency ^a	Average annual overflow volume (MG) ^b	Peak no-impact release rate (MGD) ^c	Comments
Shared West Ship Canal (Joint City and King County)						
Fremont /Wallingford	147	15.24 MG deep tunnel storage located north of the Ship Canal	0.5	1.5	n/a	Overflows diverted to tunnel until tunnel is full
Fremont/ Wallingford	174		0.5	1.0	n/a	Overflows diverted to tunnel until tunnel is full
Ballard	150/ 151		0.5	1.0	n/a	Overflows diverted to tunnel until tunnel is full
Ballard	152		0.5	3.6	n/a	Overflows diverted to tunnel until tunnel is full
WTD 3 rd Ave West	008		0.5	3.1	n/a	Overflows diverted to tunnel until tunnel is full
WTD 11 th Ave NW	004		0.4	3.9	n/a	Overflows diverted to tunnel until tunnel is full
Tunnel Performance and Effluent Pump Station Flow Rate			Not Applicable	Not Applicable	32	Tunnel Effluent PS discharge rate based on Ballard Wet Weather Siphon NIRR
Off-line storage						
Montlake	020	0.16 MG off-line storage pipe	0.6	0.40	0.32	Flows released from storage are passed through existing City Pump Station13 so that peak outflow from the basin is not increased
Leschi	028	0.01 MG off-line storage pipe	0.5	0.02	0.02	
Leschi	029	0.02 MG off-line storage pipe	0.5	0.03	0.04	
Leschi	031	0.33 MG off-line storage tank/pipe	0.5	0.17	0.66	Outflow from common storage tank
Leschi	032		0.4	0.01		

Table S-12. Projected Annual Performance After Implementation of CSO Control Measures

CSO area	CSO outfall number	Recommended CSO control measure	20-year moving average annual overflow frequency ^a	Average annual overflow volume (MG) ^b	Peak no-impact release rate (MGD) ^c	Comments
Leschi	036	0.03 MG off-line storage pipe	0.5	0.06	0.06	
Magnolia	060	0.11 MG off-line storage pipe	0.5	0.15	0.22	
Central Waterfront	069	0.13 MG off-line storage pipe	0.7	0.50	0.26	
Delridge/ Longfellow	099	0.17 MG off-line storage pipe	0.8	0.55	0.34	
East Waterway	107	0.5 MG off-line storage tank	0.7	0.01	1.0	
Duwamish	111	0.01 MG off-line storage pipe	0.7	0.09	0.02	
Portage Bay/Lake Union	138	0.11 MG off-line storage pipe	0.6	0.15	n/a	Flows released from storage are passed through the existing City PS #20 so that please outflow from the basin is not increased
Montlake	139	0.01 MG off-line storage pipe	0.5	0.02	n/a	Flows released from storage are passed through the existing City PS #25 so that please outflow from the basin is not increased
Montlake	140	0.05 MG off-line storage pipe	0.4	0.08	n/a	Flows released from storage are passed through the existing City PS #25 so that please outflow from the basin is not increased
Delridge/ Longfellow	168	0.25 MG off-line storage pipe	1.0	2.50	n/a	Peak outflow rate not increased
Delridge/ Longfellow	169	0.25 MG off-line storage pipe	0.5	0.80	n/a	Peak outflow rate not increased
Flow Diversion						
North Union Bay	018	Modifications to CSO control structure 018B	0.8	1.8	n/a	Increase peak flow from 5.5 MGD to 9 MGD to WTD

Notes:

^a 20-year moving average overflow frequency with Rainfall scaling factor of 1.0

^b Estimated volumes less than 5,000 gallons are shown as < 0.01 MG. Volumes of 5,000 to 10,000 gallons are rounded up to 0.01 MG

^c Maximum discharge rates from storage facilities based on WTD provided "no-impact release rates"

LTCP Option Implementation Schedules

Figure S-5 presents the overall schedule for the recommended CSO control measure projects. The schedules show the project duration and the Consent Decree milestone dates for construction completion and the achievement of controlled status.

The implementation of CSO projects has been prioritized based on the results of the sensitive area study. The high priority CSO basins from the City sensitive area study include the following CSO basins:

- Ballard 150, 151, and 152
- Fremont/Wallingford 147 and 174
- Delridge 168 and 169
- North Union Bay 018

The uncontrolled CSO basins in the Ballard and Fremont/Wallingford CSO areas will be controlled with the completion of the Shared West Ship Canal Tunnel. This CSO control measure is one of the first projects to begin, due to the long duration of the project.

A sewer system improvement project is currently being implemented in Basins 168 and 169 in Delridge, with an NPDES permit milestone deadline to complete construction by November 1, 2015. If post-project performance monitoring indicates that these retrofit projects do not bring the basins into control, an additional CSO control measure would be implemented beginning in 2021. The CSO control measure for Basin 018 in North Union Bay is currently being implemented, with a scheduled construction completion date of September 30, 2017.

The implementation schedule for the lower priority CSO basins was determined based on budget availability and coordination with the retrofit program. See figure S-5.

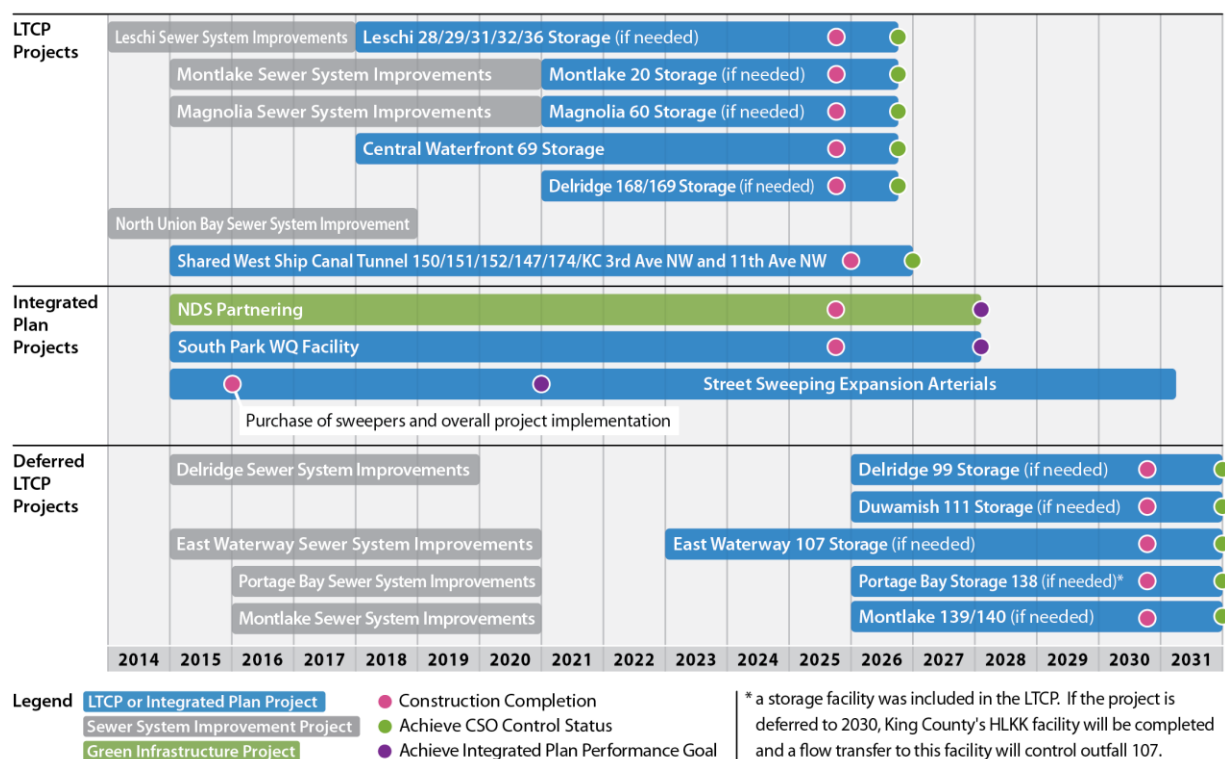


Figure S-5. Overall Schedule for the Recommended CSO Control Measure Projects

Factors Potentially Affecting Schedule

The LTCP Implementation schedule reflects the project order and sequence that the LTCP CSO control measures will be implemented between 2015 and the achievement of control status. The implementation schedule will affect sewer rates, City resource workload, City resources, and local and regional projects. There are major internal and external factors that impact the timing and implementation decisions of the LTCP options and/or individual LTCP projects were identified for the LTCP.

City drainage and wastewater rates will need to be increased to implement the LTCP options. In addition, the City rate payers will also be paying for the implementation of the 2010 Plan CSO projects and the Consent Decree Early Action Projects during the same time period (2015-2025). The implementation schedule for the LTCP projects have considered rate impacts in order to reduce or “flatten” the rate increases.

The City and King County both have CSO Consent Decrees and NPDES Permits with varying compliance dates and priorities that makes coordination of shared projects challenging. The City and King County will enter into an agreement for working together on plans, projects, and activities that have the potential to affect both agencies. The City and King County have developed a coordination strategy that addresses projects having the potential to impact both agencies, and it includes factors for determining joint or independent projects, project coordination levels, and tiered project management and oversight levels. It is expected that this strategy will be updated and modified periodically over time.

The City and King County are each implementing Capital Improvement Programs (CIPs) within the City of Seattle, including independent and joint combined sewer overflow (CSO) control, capacity improvements, sanitary sewer overflow (SSO) control, drainage improvement and asset management projects. King County has an approved Long Term Control Plan. The City has prepared a Final LTCP. King County and the City are developing and will implement a Joint System Optimization and Operations Plan. Both agencies will also implement post-construction monitoring plans in the same water bodies. Both agencies agree to assess the cost-efficient level of coordination on all of these projects, and where coordination seems useful, both agencies will work together to develop joint project agreements or detail sheets for each project with the appropriate coordination activities for each project phase.

CSO Basin 107 (East Waterway) will be impacted by the future King County Hanford-Lander-King St – Kingdome CSO Treatment Plant project (HLKK Project). The proposed HLKK Project includes an up to 151-MGD CSO treatment facility and modifications to the Elliott Bay Interceptor to divert wet weather flows to the CSO treatment facility. The flow diversion may result in decreased CSO control requirements for CSO Basins 107 depending on the final configuration. The City’s Consent Decree currently requires that CSO Basin 107 obtain construction completion by 2025. Close coordination of the CSO Basin 107 project with King County’s HLKK project will need to occur to identify the most cost-effective solution and implementation schedule.

The proposed CSO Basin 069 (Central Waterfront) control measure for the recommended LTCP option must be coordinated with the Elliott Bay Seawall (North) Project. The CSO Basin 069 project location will be significantly impacted by the Elliott Bay Seawall (North) project construction which is currently scheduled for 2018-2020. The specific construction schedule cannot be finalized until the City obtains funding for the Elliott Bay Seawall (North) project construction. Constructing the CSO Basin 069 project before the Elliott Bay Seawall (North) project would result in additional disruption to the community and significant additional construction costs for the Seawall project to protect the CSO Basin 069 project in place.

Financial Plan for Recommended LTCP Option

Based on the planning level cost estimates prepared and the implementation schedules for each LTCP option, the City analyzed how the recommended LTCP option may affect monthly City wastewater and drainage rates. Table S-13 shows the total monthly estimated rates (baseline and including the costs of the recommended LTCP option) between 2015 and 2030.

LTCP option	2015	2020	2025	2030
Total baseline rate only	\$80.31	\$110.64	\$127.80	\$140.46
Recommended Shared West Ship Canal Tunnel Option	\$81.36	\$115.44	\$133.15	\$145.57

Figure S-6 Monthly Wastewater and Drainage Rates for Baseline and LTCP Implementation, shows the total monthly rate (Total Baseline Rate and additional LTCP Rates).

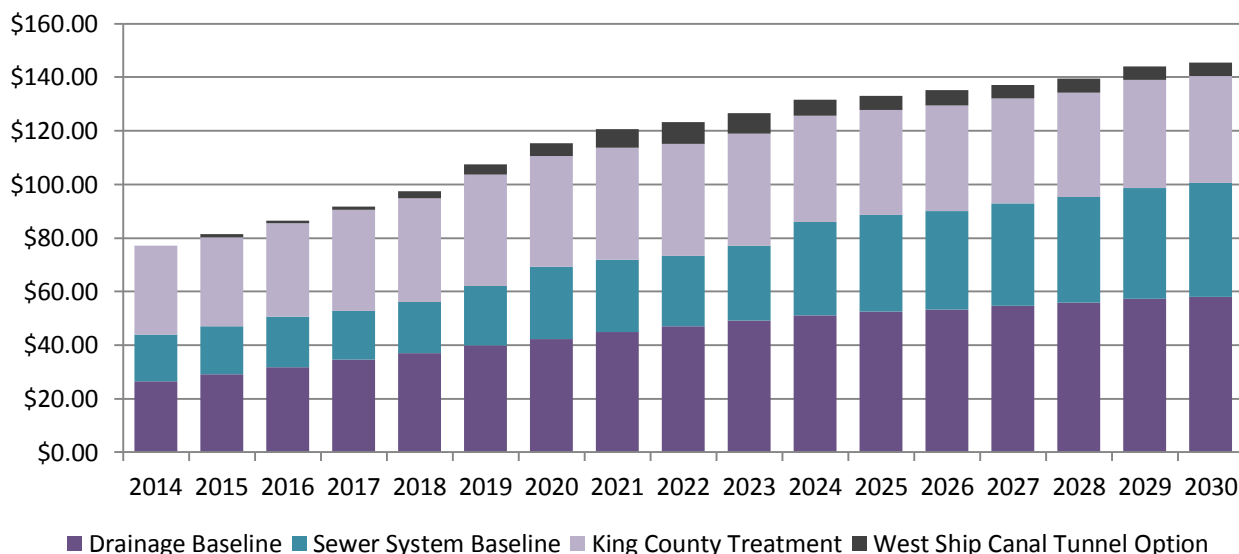


Figure S-6. Monthly Wastewater and Drainage Rates for Baseline and LTCP Implementation

City/King County Monitoring and Modeling Memorandum of Agreement

The City and King County have developed flow monitoring and modelling requirements for the purpose of quantifying whether and how large of an impact the completed CSO control measures have on downstream King County facilities. In general, these requirements include several years of pre-construction flow monitoring to establish baseline conditions, followed by a minimum of five years of post-construction flow monitoring. This data is then used to determine what payments the City will be required to make to King County for increased capital and/or operational expenses at downstream locations.

These requirements will be finalized with the approval by each agency of term and detail sheets for each shared project.

Measure of Success

The measure of success for the City's CSO program will be the successful construction and operation of the recommended LTCP projects by the required critical milestone dates and performing Post-Construction Monitoring to demonstrate achievement of CSO control status in accordance with the Consent Decree.

Achieving CSO control status has been defined in the Consent Decree and requires flow monitoring of the constructed CSO control measure to obtain actual operating information, revising the approved hydraulic model to incorporate the "as-constructed" CSO control measure project, calibrating the "as-constructed" model with actual performance and flow data, performing a moving 20-year average annual overflow frequency analysis using one year of actual performance data and 19-years of computer simulations (assuming the constructed CSO control measure was operating in those years), and submitting a Post-Construction Monitoring Plan Report to EPA/Ecology.

The Post-Construction Monitoring Plan will summarize the data collected and analyze whether the completed CSO control measures have met/continue to meet the design criteria and performance criteria specified in the LTCP, and whether the City's operation of its CSS complies with the CSO Control Policy and Clean Water Act implementing regulations, all applicable state law and regulations, and the City's NPDES Permit. EPA/Ecology approval of the Post-Construction Monitoring Plan Report will confirm that the City's CSO control measures satisfied the Consent Decree requirements for Post-Construction Monitoring.

LTCP Timeline

The Draft LTCP performed a "rating and ranking" of the LTCP options in accordance with the EPA requirements in the *"Combined Sewer Overflows Guidance for Long-Term Control Plan, 1995"*. On May 29, 2014, the Draft LTCP was submitted for EPA and Ecology review and comment. In addition, the City issued the Draft EIS. Following the appropriate public process, a Final EIS was issued in December 2014.

Additional evaluation of LTCP options was performed and a preferred LTCP option was recommended in early 2014. In early 2015, the City Council reviewed and adopted the Final LTCP through a City Ordinance process. By May 30, 2015, the Final LTCP will be submitted to EPA and Ecology for approval. By the end of 2015, the final plan is anticipated to be approved by EPA and Ecology and LTCP implementation will commence in late 2015 or early 2016. Construction completion of all approved LTCP projects shall be achieved by December 31, 2025.

The LTCP timeline showing major milestones and activities is shown on Figure S-7.

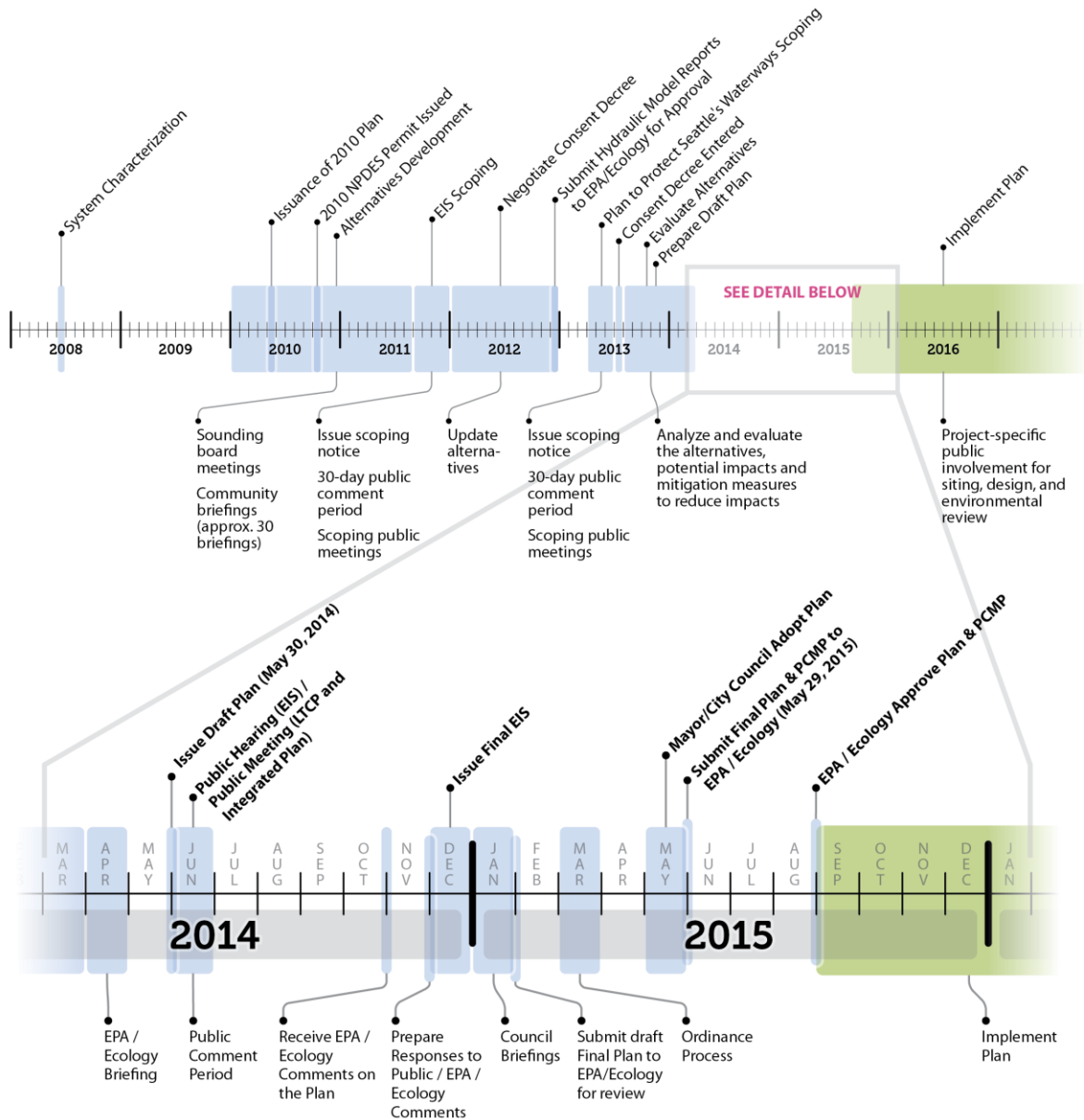


Figure S-7. Current LTCP Schedule

CHAPTER 1

Introduction and Background

1.1 Long Term Control Plan Document Organization

The following sections describe the organization of the Long Term Control Plan (LTCP) document and how it fits in with the overarching Plan to Protect Seattle's Waterways.

1.1.1 The Plan to Protect Seattle's Waterways Organization (4 Volumes)

The Plan to Protect Seattle's Waterways contains four volumes that describe the plan to protect and improve the water quality in and around the City of Seattle (City). The four volumes are summarized below:

- Volume 1: Executive Summary – The Executive Summary contains a summary of the LTCP, Integrated Plan, and the Programmatic EIS.
- Volume 2: LTCP – The LTCP contains a recommended plan to reduce combined sewer overflows (CSOs) in the City to meet state and federal requirements.
- Volume 3: Integrated Plan – The Integrated Plan proposes CSO as well as stormwater projects prioritized and sequenced to achieve water-quality benefits beyond what would be achieved with CSO investments alone. While all CSOs must still achieve the state standard, compliance may be achieved under a revised schedule that extends beyond 2025.
- Volume 4: Programmatic Environmental Impact Statement (EIS) – The Programmatic EIS covers environmental impacts from the projects recommended in the LTCP and the Integrated Plan.

1.1.2 LTCP (Volume 2) Document Organization

The organization of the LTCP is described below.

- Chapter 1 Introduction – This chapter includes a history of the City's control policy for CSOs and a summary of the policy's key elements. Also provided are general descriptions of the current CSO control efforts, regulatory requirements, and an overview of the long-term planning approach.
- Chapter 2 System Characterization – This chapter provides extensive analysis of CSO areas. The chapter includes descriptions of how the Nine Minimum Controls have been implemented by the City, descriptions of receiving water bodies, results of the sensitive area study, and summaries of the flow monitoring and modeling efforts by the City. The chapter also includes the baseline conditions for CSO basins in the City.
- Chapter 3 Development and Evaluation of Alternatives for CSO Control – This chapter discusses the approach and factors used to identify, develop, evaluate, and select CSO control measures that make up the recommendations in the LTCP. Four LTCP options are presented for final consideration and evaluation.
- Chapter 4 Evaluation of LTCP CSO Control Options – This chapter includes an explanation of the values-based risk management process used to rate and rank the LTCP options. Issues discussed include community values, benefit/cost analysis, environmental impact, technical concerns, and implementation schedules compatible with the Consent Decree requirements. Also discussed is the public participation process during the LTCP process.
- Chapter 5 Selection and Implementation of Recommended LTCP CSO Control Option – This chapter

summarizes the public and regulatory participation process and comments that were received on the draft LTCP. It also describes the process used to refine the options that were developed in Chapters 3 and 4 and the final evaluation and factors that were used to select the recommended option. Updated information is also presented on community and environmental impacts, operational impacts, design criteria for the recommended CSO control measures, capital and operational costs, control measure performance, implementation schedules and a financial analysis.

1.2 Introduction and Background

1.2.1 Introduction

The LTCP is an update to the City's plan for reducing overflows from its combined sewer system (CSS) into surrounding water bodies. Over the past 20 years, the City's CSO Program has significantly reduced the number of CSO events and overflow volumes. Many of these projects were identified in the City's 1988 CSO Reduction Plan (Reference 1) and its subsequent amendments in 2001 (Reference 2), 2005 (Reference 3), and 2010 (Reference 4). The LTCP addresses the remainder of the City's CSS and aims to limit untreated overflows at each CSO outfall to an average of no more than one per year on a 20-year rolling average, a performance standard established in the City's National Pollutant Discharge Elimination System (NPDES) CSO permit (Reference 5). The City of Seattle and King County both manage CSO outfalls in the Seattle area: The City currently manages 86 outfalls; King County manages 38. In 2014 a total of 406 CSO events from City-managed outfalls resulted in 116 million gallons of overflow.

1.2.2 Background

CSOs are untreated discharges of wastewater and stormwater into water bodies that occur during storm events when combined sewers are full. Combined sewers, which carry both wastewater and stormwater, exist in many parts of older cities across the nation, including the City of Seattle. Stormwater can cause extreme variations in wastewater flows, resulting in challenges to the treatment process and the need for large wastewater facilities. To protect treatment plants and avoid sewer backups into homes, businesses, and streets during heavy storm events, combined sewers in the City have been designed to overflow into the surrounding water bodies.

The City's combined sewer system dates from the 1890s. The City is responsible for the sewage collection system serving sewershed areas of up to 1000 acres in size. The King County Department of Natural Resources, Wastewater Treatment Division, is responsible for sewer trunks serving areas greater than 1000 acres and for wastewater and CSO treatment plants.

Beginning in the 1950s, additions to the sewer system were designed as separated systems, with separate networks of pipes for sewage and stormwater.

Since the 1960s, the City has undertaken a number of efforts to partially separate previously combined systems; in partially separated systems, stormwater from streets and parking lots runs into separate storm drains, but stormwater from other sources, mostly building roofs, still enters a combined system.

The earlier separation projects were supplemented with storage tanks where necessary to further reduce CSOs. During the 1980s, increasing the storage capacity became Seattle's preferred solution to controlling CSOs. Seattle has constructed 38 facilities for overflow control.

The City does not own a wastewater or CSO satellite treatment plant. All the sewage collected in the City's wastewater collection system is conveyed to King County for regional conveyance and treatment, or is discharged via one of the CSO outfalls. King County operates three secondary wastewater treatment plants (WWTP) (West Point WWTP, the South WWTP, and the Brightwater WWTP) and four CSO storage and treatment facilities (Alki, Carkeek, Mercer/Elliott West, and Henderson/Norfolk). Ultimately, the treated wastewater from all of these facilities discharges to Puget Sound, Elliott Bay, or the Duwamish River.

1.3 Regulatory Requirements

In 1972, the federal Clean Water Act (CWA) (Reference 6) was passed by Congress. The primary objective of the CWA is to restore and maintain the integrity of the nation's waters. This objective translates into two national goals: to eliminate the discharge of pollutants into the nation's waters and to achieve and maintain fishable and swimmable waters. One way that the first goal is being achieved is through the National Pollutant Discharge Elimination System (NPDES) permit program. The second goal is being addressed by developing pollution control programs to meet water quality standards for water bodies.

The CWA requires all wastewater treatment facilities and industries that discharge effluent into surface waters to have an NPDES permit. In Washington State, NPDES permits are issued by the Washington State Department of Ecology (Ecology) and define appropriate technology controls and limits on the quality and quantity of effluent discharged from point sources such as treatment plants, CSOs, and industrial facilities. The City holds an NPDES permit for its 86 CSO outfalls.

The City developed this LTCP in compliance with requirements of the EPA CSO Control Policy (Reference 7); the July 3, 2013, Consent Decree (Reference 8); and the City's NPDES permit for the combined sewer system, as discussed in the following paragraphs.

1.3.1 Consent Decree Requirements

On July 3, 2013, the Final and Fully Executed Consent Decree (the Consent Decree) with the City of Seattle was approved by the United States District Court for the Western District of Washington. The Consent Decree established an enforcement mechanism that will ensure that certain dates are met for implementation of the LTCP. The Consent Decree establishes the requirements paraphrased below:

1. Early action CSO control program and measures: The City shall implement all CSO control measures necessary to reduce discharges from CSO Outfalls 044 and 045 (North Henderson) and CSO Outfalls 046 and 047/171 (South Henderson) by the following dates:
 - a. Construction completion for CSO Outfalls 046 and 047/171 by December 31, 2015
 - b. Achievement of controlled status for CSO Outfalls 046 and 047/171 by December 31, 2016
 - c. Construction completion for CSO Outfalls 044 and 045 by December 31, 2018
 - d. Achievement of controlled status for CSO Outfalls 044 and 045 by December 31, 2019
2. Development and implementation of long-term control plan and post-construction monitoring plan:
 - a. The LTCP shall specify
 - i. all CSO control measures that the City must implement to ensure compliance with the provisions of the CWA and its implementing regulations that apply to CSOs, any applicable state law and regulations that apply to CSOs, those portions of the City's NPDES permit that apply to CSOs, and EPA's CSO Control Policy;
 - ii. all design criteria and performance criteria developed for each CSO control measure; and
 - iii. a schedule of critical milestones for each CSO control measure.

- b. The City shall develop and perform a post-construction monitoring program.
3. Capacity, Management, Operations, and Maintenance (CMOM) Performance Program Plan: On December 31, 2012, the City submitted to EPA and Ecology for their approval a comprehensive CMOM Performance Program Plan (Reference 9). The City shall annually review its CMOM Performance Program Plan and update the program as necessary to ensure the City is achieving the performance thresholds contained in the approved CMOM Performance Program Plan. The City shall report in its annual report the metrics regarding sanitary sewer overflow (SSO) performance.
4. Fats, Oils, and Grease (FOG) Control Plan: On December 31, 2012, the City submitted to EPA and Ecology for their approval a FOG Control Program Plan (Reference 10) designed to ensure that grease accumulations are not restricting the capacity of the wastewater collection system contributing to overflows. The City shall annually review its FOG Program Plan and update the program as necessary. The City shall submit as part of its annual report summaries of FOG inspections and enforcement actions taken by the City during the preceding year.
5. Revised Floatable Solids Observation Program Plan: On December 31, 2012, the City submitted to EPA and Ecology for their approval a revised Floatable Solids Observation Program Plan (Reference 11). The City shall annually review and update the plan as appropriate.
6. Joint Operations and System Optimization Plan (Joint Plan) between City and County: No later than March 1, 2016, the City shall submit to EPA and Ecology a Joint Plan that the City will develop with King County. This Joint Plan shall be applicable to the City's and the County's respective CSO systems, and that
 - a. is consistent with each entity's operational objectives
 - b. optimizes the capacity of both systems while balancing risk to both entities. The City and King County shall review the joint plan every three years and update the plan as necessary to ensure the operational level of coordination and information sharing is maintained between the two entities.

1.3.2 Ecology Agreed Order No. 8040

The Ecology Agreed Order Number 8040 (Reference 12), which was approved by the Seattle City Council in October 2010, is an agreement that commits the City to implementing the LTCP by December 31, 2025. According to the Agreed Order:

In order to meet the requirements of WAC 173-245-020(22), SPU shall complete construction of CSO reduction projects identified in the 2010 CSO Reduction Plan Amendment or future amendments submitted by the City and approved by Ecology to reduce CSOs from the remaining 37 uncontrolled CSO basins down to an average of one overflow per site per year by December 31, 2025. Future CSO Reduction Plan Amendments may not result in a compliance date later than December 31, 2025.

1.3.3 EPA LTCP Requirements

In April 1994, EPA published a CSO Control Policy to explain how communities and states could control CSOs while meeting CWA requirements and to provide a process to be followed in addressing CSOs. The first step in the process is the development and implementation of a Nine Minimum Controls (NMC) Plan (Reference 13) which includes controls or measures that can reduce CSOs without significant engineering studies or major construction. This step has been completed by the City, and the processes in the NMC Plan continue to be followed.

The next step is the development of an LTCP. The CSO Control Policy requires that cities such as Seattle that have CSOs take the needed action to bring the discharges into compliance with the CWA. The policy states:

Permittees with CSOs are responsible for developing and implementing long term CSO control plans that will ultimately result in compliance with the requirements of the CWA. The long-term plans should consider the site-specific nature of CSOs and evaluate the cost effectiveness of a range of control options/strategies.

The CSO Control Policy lists specific elements that must be evaluated and developed in LTCPs, as listed below:

1. Characterization, monitoring, and modeling of the combined sewer system
2. Public participation
3. Consideration of sensitive areas
4. Evaluation of alternatives
5. Cost/performance considerations
6. Operational plan
7. Maximizing flow to the existing Publicly Owned Treatment Works (POTW)
8. Implementation schedule
9. Post-construction compliance monitoring

The CSO Control Policy recommends that the development and implementation of the LTCP be covered under an enforceable mechanism such as a consent decree that provides for enforcement of the schedule.

1.3.4 Ecology Requirements

In 1984, Ecology introduced legislation requiring agencies with CSOs to develop plans for “the greatest reasonable reduction [of CSOs] at the earliest possible date.” In January 1987, Ecology published a new regulation (Chapter 173-245 WAC) (Reference 14) that defined the greatest reasonable reduction in CSOs as “control of each CSO such that an average of one untreated discharge may occur per year.” The City’s NPDES permit and consent decree establish a standard of no more than one untreated discharge per year based on a 20-year moving average. The number of untreated discharges that occurred over each of the previous 20 years (or that would have occurred had the CSO control measures been in place) is reported for each CSO site and then averaged. This moving average will be used each year to assess compliance with the performance standard for CSOs identified as controlled.

1.3.5 NPDES Permit (2010-2015)

The City’s wastewater collection system is regulated by Ecology via NPDES Waste Discharge Permit WA0031682. This permit was re-issued on October 27, 2010, went into effect on December 1, 2010, was modified on September 13, 2012, and will expire on November 30, 2015.

This permit contains a number of terms and conditions, as paraphrased below:

1. Monitoring requirements: The City must use automatic equipment at all permitted outfalls to monitor discharge location, discharge duration, discharge volume, and weather-related information (precipitation and storm duration).
2. Reporting and recording requirements: The City must submit a monthly CSO discharge monitoring report to summarize CSO monitoring results.
3. Operation and maintenance: The City must at all times properly operate and maintain all facilities and

- systems of conveyance and control (and related appurtenances) that are installed.
4. Nine minimum controls: The City must implement the Nine Minimum Controls for CSOs and document them in the annual CSO report.
 5. CSO reports and engineering documents:
 - a. The City must submit an annual report to Ecology for review and approval by March 30th of each year. The annual report must include a summary of the number and volume of CSOs from each outfall for the prior year, indicate which CSO outfalls are categorized as controlled, and include documentation of compliance with the Nine Minimum Controls.
 - b. The City must submit an amendment of its CSO Reduction Plan (Reference 4) to Ecology for review and approval with the application for permit renewal.
 - c. The City must submit to Ecology an engineering report, plans, and specifications for each CSO reduction construction project.
 6. Compliance schedule: In order to achieve the greatest reasonable reduction of combined sewer overflows at the earliest possible date, the City must complete the activities shown in Table 1-1, as described in the 2010 CSO Reduction Plan Amendment (2010 Plan).

Table 1-1. 2010-2015 NPDES Permit Compliance Schedule

Project or activity	Required completion date
Windermere CSO Basin	
Complete and submit draft plans and specifications	March 30, 2012
Complete and submit for review and approval final plans and specifications	August 31, 2012
Begin construction	December 31, 2012
Complete construction	August 30, 2015
Genesee CSO Basin 043 project	
Complete and submit a draft engineering report	December 31, 2010
Complete and submit for approval a final engineering report	May 31, 2011
Complete and submit draft plans and specifications	January 31, 2013
Complete and submit for review and approval final plans and specifications	June 30, 2013
Begin construction	August 31, 2013
Complete construction	October 31, 2015

Table 1-1. 2010-2015 NPDES Permit Compliance Schedule

Project or activity	Required completion date
Genesee CSO Basins 040 and 041 project	
Complete and submit a draft engineering report	December 31, 2010
Complete and submit for approval a final engineering report	May 31, 2012
Complete and submit draft plans and specifications	January 31, 2014
Complete and submit for review and approval final plans and specifications	June 30, 2014
Begin construction	August 31, 2014
Complete construction	October 31, 2015
South Henderson CSO Basin projects (046 and 047/171)	
Complete and submit a draft engineering report	August 30, 2011
Complete and submit for approval a final engineering report	March 31, 2012
Complete and submit draft plans and specifications	October 31, 2014
Complete and submit for review and approval final plans and specifications	March 30, 2015
Begin construction	May 31, 2015
North Henderson CSO Basin projects (044 and 045)	
Complete and submit a draft engineering report	August 30, 2012
Complete and submit for approval a final engineering report	January 31, 2013
Complete and submit draft plans and specifications	October 31, 2014
Complete and submit for review and approval final plans and specifications	March 30, 2015
Begin construction	May 31, 2015

Table 1-1. 2010-2015 NPDES Permit Compliance Schedule

Project or activity	Required completion date
CSO retrofit projects	
Complete construction of hydraulic improvements to overflow structures for CSO Basins 018, 095, 111, 147, and 152	December 31, 2011
Complete construction of Windermere retrofit for CSO 013	December 31, 2012
Complete construction of weir height adjustments for category 3 weirs ^a	November 30, 2011
Complete construction of weir height adjustments for category 4 weirs ^b	October 31, 2011
Complete construction of Longfellow/Delridge Basin (168 and 169) modifications	November 1, 2015
Complete construction of Henderson retrofits for CSO Basins 047 and 049	November 30, 2015
Green Infrastructure (GI) projects	
Start construction of GI roadside rain garden projects in Ballard Basins 150/151 and 152	October 31, 2015
Start construction of GI roadside rain garden projects in Delridge Basin 168 or 169	October 31, 2015
Pump station backup power capital improvement projects	
Complete installation of emergency generator plugs ^c	June 30, 2011
Complete installation of new permanent generators at pump stations 7, 25, 39, 43, 49, 59, 62, 63, and 77	June 30, 2012
Complete installation of new permanent generators at pump stations 39	December 31, 2013
CSO outfall repairs^d	
Complete repairs on CSO Outfall 085	December 31, 2011
Complete repairs on CSO Outfalls 064, 095, and 150	December 31, 2014

Table 1-1. 2010-2015 NPDES Permit Compliance Schedule

Project or activity	Required completion date
Complete repairs on CSO Outfalls 028, 031, 045, 129	November 1, 2015
Public notification of CSO events	
Have web-based public notification system of CSO events operational	March 31, 2011

Notes

- a Weirs are specified in Table 2-1 of SPU's NMC Compliance Report, May 2010.*
- b Weirs are specified in Table 2-1 of SPU's NMC Compliance Report, May 2010.*
- c As listed in Table 2, Page 5, NMC #5 of SPU's NMC Compliance Report, May 2010*
- d For each of the CSO outfall repairs listed in this table, SPU shall repair the deficiencies noted in the August 2006 Outfall Evaluation Report (Reference 15). If additional deficiencies are discovered during the repair of these outfalls, SPU shall submit a plan that describes the approach and schedule for these additional repairs.*

7. Requirements for controlled CSO outfalls:
 - a. Compliance with the performance standard will be determined annually and based on a 20-year moving averaging period, including past years and the current year, and will be based on historical discharge data, modeling, or other reasonable methods as approved by Ecology.
 - b. For controlled CSO Outfalls 062 and 013, the City must begin to implement a post-construction compliance monitoring program adequate to verify compliance with water quality standards and protection of designated uses as well as ascertain the effectiveness of CSO controls.
8. Outfall rehabilitation plan: The City must submit to Ecology for review and approval an outfall rehabilitation plan by October 31, 2015, that describes outfalls to be repaired or replaced during the next permit cycle.
9. Sediment monitoring: The City must submit to Ecology for review and approval a Sediment Sampling and Analysis Plan for sediment monitoring at controlled CSO Outfalls 062 and 013. The City must also submit a Sediment Sampling and Analysis Plan for uncontrolled CSO Outfalls 107, 147, and 152. Following Ecology approval of the plans, The City must collect sediment data and submit a Sediment Data Report containing the results of all sediment sampling and analysis.
10. Application for permit renewal: The City must apply for renewal of this permit prior to May 31, 2015.

Ecology modified the permit on September 13, 2012, to incorporate changes requested by the City on June 14, 2012, including:

- Elimination of three outfalls that were sealed and no longer in use
- Revision of the GI implementation requirements.
- Modification of the schedule for installation of an emergency generator at Pump Station 39
- Modification of the outfalls to be rehabilitated

1.3.6 EPA Modified Request for Information and Compliance Order By Consent

In March 2008, the EPA performed a compliance inspection of Seattle's wastewater collection system. EPA found that the City was not in total compliance with the Nine Minimum Controls. Subsequent to the inspection, the EPA and the City entered into a Request for Information and Compliance Order by Consent (Compliance Order) in August 2009 (Reference 16). This Compliance Order was subsequently amended to incorporate minor

modifications in December 2009. The amended Compliance Order requirements included the development and implementation of the following plans:

- CSO Weir Height Adjustments Project Plan
- Gravity Pipe Cleaning Preventative Maintenance Data Analysis Plan
- CSO Control Structure Inspection and Cleaning Plan
- Pipe Cleaning QA/QC Plan
- Observation of solids and floatables at CSO outfall locations
- Emergency generator plugs and backup generators

The City submitted these documents to EPA in a timely manner.

1.4 History of CSO Control

Planning for CSO control is a dynamic process that must respond to changing regulations and conditions. To date, the City has completed five CSO control plans, beginning in 1980. This section presents a history of CSO control planning by the City.

1.4.1 Previous CSO Reduction Planning Efforts

The City has completed several planning efforts since the 1980s to identify CSO reduction projects. Some of the projects involved maintenance or modification of existing sewer facilities. Others involved construction of diversion structures to direct flows away from CSO outfalls or storage facilities to store excess wastewater until flows decrease enough for the stored wastewater to be returned to the conveyance system. The major CSO reduction planning efforts are described in the following sections:

1.4.1.1 1980 Facility Plan (201 Facilities Planning)

The 1980 Facility Plan (201 Facilities Planning) addressed CSO reduction in high priority areas based on human contact potential and environmental protection: Longfellow Creek, Lake Washington, and Puget Sound beaches. Storage facilities were recommended for 50 outfalls, with an estimated cost of \$13.2 million (1978 dollars).

1.4.1.2 1988 CSO Reduction Plan

The 1988 CSO Reduction Plan addressed CSO reduction in Portage Bay, Lake Union, the Ship Canal, Elliott Bay, and the Duwamish River. The plan recommended storage facilities for 30 uncontrolled outfalls, with an estimated cost of \$60 million (1988 dollars).

1.4.1.3 2001 CSO Reduction Plan Amendment

The 2001 CSO Reduction Plan Amendment proposed the implementation of various best management practices as a way to reduce the volume of CSOs prior to the implementation of additional storage projects. This plan re-evaluated previously studied areas of Seattle and expanded the evaluation to include other areas. Estimated cost of the recommended improvements was \$58 million (2001 dollars).

1.4.1.4 CSO Reduction Plan Amendment 2005 Update

The 2005 update was prepared to evaluate the effectiveness of best management practice projects from the 2001 amendment that had been completed, and to revise cost estimates and schedules for remaining projects from the 2001 amendment.

1.4.1.5 2010 CSO Reduction Plan Amendment

The 2010 CSO Reduction Plan Amendment was a regulatory requirement by WAC 173-245-090(2). Per the regulation, the plan must include three elements:

1. an assessment of the effectiveness of the CSO Reduction Plan to date
2. a re-evaluation of the CSO sites' projects priority ranking
3. a listing of projects to be accomplished in the next five years

The 2010 CSO Reduction Plan Amendment is an update to Seattle's previous planning efforts for reducing overflows from the combined sewer system into surrounding surface waters. The 2010 CSO Reduction Plan Amendment identified CSO outfalls that currently meet the state regulatory requirement of WAC 173-245-020(22), as well as future projects that will limit untreated overflows at each CSO outfall to no more than one per year on average. The plan indicates that by 2015, the City will have accomplished the following projects:

- Construct CSO retrofits to optimize CSO control infrastructure in multiple uncontrolled CSO basins
- Complete the construction of the Windermere CSO reduction project
- Substantially complete the construction of the Genesee CSO reduction project
- Initiate construction on the Henderson CSO reduction project
- Construct Green Infrastructure projects in the Ballard CSO basin to measure the effectiveness of green solutions
- Complete installation of new permanent generators at certain pump stations
- Fully implement a web-based public notification system of CSOs
- Complete the 2015 CSO Reduction Plan Amendment (the LTCP)

The 2010 CSO Reduction Plan Amendment summarized compliance with EPA's Nine Minimum Controls for CSO systems, provided a revised CSO baseline frequency and volume estimates, and described CSO control alternatives.

1.4.2 Historical CSO Reduction Efforts

The City has been constructing CSO control facilities since 1968, first by re-routing roadway drainage to partially separate combined sewer areas. This was followed by construction in the 1980s of 35 storage facilities with over 8.1 million gallons (MG) of capacity to provide additional storage during storm events. More recently, emphasis has been placed on constructing retrofit projects to enhance system operating efficiency.

From 1968 through 1976, costs related to CSO reduction were incurred for partial separation projects that were completed under the Forward Thrust program. Both partial separation and storage facilities were constructed during the 1980s. From 1997 through 2005, CSO reduction costs were incurred for the Denny Way/Lake Union project (in conjunction with King County) and retrofits of existing facilities. In total, the City has expended over \$524 million (2009 dollars) on CSO control and reduction efforts, including about \$385 million (73 percent) for partial separation projects, \$134 million (26 percent) for storage projects, and \$5 million (1 percent) for retrofits.

1.4.2.1 History of CSO Discharges

Over the last 25 years, the City of Seattle has successfully reduced CSO discharge volumes by nearly 70 percent. The volume of CSO discharges by the City has declined from an estimated 400 MG per year in the 1980s to an average of approximately 155 MG per year from 2007 to 2012 (Reference 18). Similarly, overflow frequency has declined from an estimated 2,800 events per year in the 1980s to an average of approximately 287 events per

year from 2007 to 2012 (Reference 18). For 2013, a volume of 38 million gallons were discharged in 219 CSO events (SPU 2013).

The City has been collecting reliable flow monitoring data since 2008. The data includes overflow event time, frequency, duration, and volume. These data, along with rainfall information, are reported to Ecology both monthly and annually.

The CSO reduction will be implemented through three separate phases of the CSO implementation program. These phases are summarized below:

- 2010 Plan Projects: Seven outfalls will be controlled through capital projects completed during the years 2010-2018, including CSO reduction projects for Windermere, Genesee, Central Waterfront, and West Seattle CSO areas. Additional CSO reduction efforts were initiated through the Green Infrastructure program in Ballard, Magnolia, Montlake, North Union Bay, Fremont/Wallingford, and Delridge CSO areas.
- Early Action CSO Programs and Measures: The Consent Decree requires early action for the two North Henderson (045 and 046) and three South Henderson (046, 047 and 171) uncontrolled CSO outfalls. CSO Outfalls 044 and 045 will achieve controlled status by December 31, 2019, and CSO Outfalls 046, 047, and 171 will achieve controlled status by December 31, 2016. South Henderson CSO Outfall 049 is also uncontrolled based on the 2013 Annual CSO Report and the City will complete construction by December 31, 2018 and achieve controlled status by December 31, 2019.
- LTCP: The remaining 22 uncontrolled CSO outfalls will be controlled through the implementation of the approved LTCP, which recommends CSO control measures and an implementation schedule to meet the Consent Decree Construction Completion milestone date of December 31, 2025, and the achievement of control status for each outfall as defined in the Consent Decree.

1.4.2.2 Constructed CSO Reduction Facilities

The City's existing CSO storage facilities range from 16-inch diameter pipe to 100-foot-diameter, 35-foot-deep concrete storage tanks. Storage volumes range from a few hundred gallons to 1.6 MG. The CSO storage tanks and pipes were, for the most part, designed to store excess runoff from a 1-year, 24-hour design storm (i.e., a storm that statistically should be exceeded only once per year). The two largest tanks, located along Longfellow Creek in the Delridge neighborhood, were designed for a 10-year, 24-hour storm. Experience and extensive flow monitoring data have shown that most of the constructed facilities have substantially reduced the number and volume of overflows. However, in many cases additional system improvements are required to achieve the design objective (average of no more than one CSO event per year).

Table 1-2 lists the facilities constructed from 1985 through 2004 by basin and by construction contract (Reference 4).

Table 1-2. Constructed CSO Reduction Facilities		
CSO basin number	Major facility elements	Year
Windermere		
013	Flow control structure with weir; off-line storage Downstream flow control chamber with HydroBrake; in-line storage	1988

Table 1-2. Constructed CSO Reduction Facilities		
CSO basin number	Major facility elements	Year
014	Downstream manholes with two overflow weirs and HydroBrake; in-line storage	
015	Downstream manholes with overflow weir and HydroBrake; in-line storage Two control structures to divert flow into detention; off-line storage; downstream outflow-overflow chamber with HydroBrake and weir.	
North Union Bay		
018	Upstream flow control manhole with overflow weir, in-line storage, downstream manhole with HydroBrake Upstream inflow control chamber (with overflow weir to storm overflow control chamber), storm overflow control chamber (with overflow weir to pump station discharge), off-line storage, and downstream manhole with HydroBrake	1989
Montlake		
020	Two overflow weirs associated with lift station. The first weir diverts flow to off-line storage. Flows overflowing second weir directed to outfall	1988
140	HydroBrake with off-line storage. Stored flows are pumped back to gravity system.	1994
Union Bay		
023, 024, 025	Two separate outfalls. Flow control structure with overflow weir and in-line storage. Overflow weir at inlet to wet well.	1987
Leschi		
029	HydroBrake with in-line storage	1986
030	HydroBrake with in-line storage	
032	HydroBrake with in-line storage	
033, 034	Two HydroBrakes with off-line storage	1987
035	HydroBrake with off-line storage	
036	HydroBrake with in-line storage	
North Genesee		
038	HydroBrake with in-line and off-line storage	1987

Table 1-2. Constructed CSO Reduction Facilities		
CSO basin number	Major facility elements	Year
Genesee		
040	HydroBrake with in-line storage	1986
042	HydroBrake with off-line storage	
043	HydroBrake with in-line storage	
Henderson		
044	HydroBrake with off-line storage	1985
045	HydroBrake directs flow to Pump Station 10	
047, 171	Two orifice/weir manholes regulate flow to lift station. Excess flows diverted to in-line storage. HydroBrake regulates flow from storage. Control facility has two separate outfalls. HydroBrake with in-line storage Weir control structure with in-line storage Weir diverts excess flow to storm drain (both basins)	1985
049	HydroBrake with off-line storage	1985
Magnolia		
062, 063	HydroBrake with in-line storage	1987
	Two in-line flow control structures with downstream HydroBrake. Two overflow outfalls from this CSO control facility	
Interbay		
068	Flow control structure with HydroBrake and weir; off-line storage; overflow manhole with weir Flow control structure with HydroBrake and overflow weir; in-line storage	1990
Central Waterfront		
070	Diversion structure with orifice and flap valve. Overflow structure with flexible check valve	1993
West Waterway		
099	Flow control structure with HydroBrake; overflow structure with 2 weirs; off-line storage; low flow diversion from storm drain to lift station	1993

Table 1-2. Constructed CSO Reduction Facilities

CSO basin number	Major facility elements	Year
Duwamish		
111	Five overflow structures with weirs; low flow diversion from storm drain to County's Duwamish Pump Station HydroBrake with in-line storage	1994
Lake Union/Portage Bay		
130, 132, 135, 175	Five new connections to reroute flow to King County's Denny Way/ Lake Union CSO Control Facility and City's share of facility cost: • Roy Street and Eighth Avenue North • Republican Street and Eighth Avenue North • Roy Street and Dexter Avenue North • Valley Street and Westlake Avenue North • Valley Street, east of Fairview Avenue North	1997 - 2004
138	HydroBrake with off-line storage	1994
Delridge		
168	HydroBrake with off-line storage tank	1984
169	HydroBrake with off-line storage tank	1984
170	Overflow weir in manhole; HydroBrake; off-line storage	1983

1.4.2.3 Committed 2010 CSO Reduction Projects

The City's focus through 2015 is to reduce CSOs at the most critical and sensitive sites through a cost-effective blend of traditional and sustainable infrastructure. The path forward involves a four-pronged approach:

1. optimize existing CSO infrastructure through low-cost retrofits
2. construct large CSO infrastructure projects to reduce overflows to Lake Washington
3. construct natural "green" solutions to reduce CSOs throughout the City
4. develop and implement a Long Term Control Plan to control all remaining CSOs and achieve water quality goals.

Table 1-3 presents the projects scheduled to be completed.

Table 1-3. 2010 Plan CSO Reduction/Control Projects		
Applicable CSO basins	CSO control measures	Implementation status as of May 2014
Windermere		
013 015	Off-line storage retrofit	CSO Basin 013 construction began in October 2012 and is planned for November 2014 completion. CSO Basin 015 construction completion August 2012. Post-construction monitoring started Sept 2012 and will continue until 2014.
Genesee		
040 041 043 040, 041 and 043	Off-line storage Off-line storage Off-line storage Green infrastructure	CSO Basin 040 and 041 storage have been combined into a single off-line storage project. CSO Basin 043 has a separate off-line storage project. Both projects began construction in April 2013 and planned for October 2014 completion. Residential RainWise program is offered in these basins.
Ballard		
150/151 and 152	Green infrastructure	CSO Basin 152 pilot project constructed in 2011-12 and post-construction monitoring was performed in 2012-13. Additional GI right-of-way projects will start construction 2015. RainWise is offered in this basin.
Magnolia		
060	Green infrastructure	Residential RainWise program is offered in CSO Basin 060. No other green infrastructure projects are planned.
North Union Bay		
018	Green infrastructure	Residential RainWise program is offered in this basin. Additional GI projects in evaluation.
Interbay		
068	Green infrastructure	This basin is now controlled based on the 2012 Annual CSO Report.
Henderson		
049	Off-line storage	A storage project is in the preliminary engineering phase.
Montlake		
140	Green infrastructure	Residential RainWise program is offered in this basin.
Fremont/Wallingford		
147 & 174	Green infrastructure	Residential RainWise program is offered in this basin.

Table 1-3. 2010 Plan CSO Reduction/Control Projects

Applicable CSO basins	CSO control measures	Implementation status as of May 2014
Central Waterfront		
069 070 & 071	Off-line storage Off-line storage	Since the northern portion of the Elliott Bay Seawall project (which includes CSO Outfall 069) will not be constructed until after 2020, it was determined that the LTCP should include a CSO Outfall 069 project. During the SDOT's Elliott Bay Seawall and Central Waterfront Project design phases, it was determined that CSO Basins 070 and 071 should be coordinated and constructed with the first phase of the Elliott Bay Seawall project. The anticipated completion date is 2018-2020.
West Seattle		
095	Retrofit	CSO Basin 095 construction completed June 2013. Post-construction monitoring started July 2013 and will continue for 1 year.
Delridge		
168 169	Retrofit Retrofit	Bid in 2014. Construction completion December 2014. Post-construction monitoring will start January 2015 and continue for two years. RainWise program is offered in these basins. Green Infrastructure projects will start construction 2015.

1.4.2.4 Consent Decree Early Action CSO Control Programs and Measures

The Consent Decree requires the City to implement early action CSO control measures in the Henderson CSO area. Those requirements include:

- Construction completion for CSO Outfalls 046 and 047/171 by December 31, 2015
- Achievement of controlled status for CSO Outfalls 046 and 047/171 by December 31, 2016
- Construction completion for CSO Outfalls 044 and 045 by December 31, 2018
- Achievement of controlled status for CSO Outfalls 044 and 045 by December 31, 2019

Additionally, the Consent Decree requires that if a CSO outfall is not controlled within one year following construction completion of the CSO project, the City must submit to the EPA and Ecology a Supplemental Compliance Plan that outlines how the City will bring the outfall into compliance.

Their project status is shown on Table 1-4.

Table 1-4. Early Action Projects

CSO basins	CSO control measures	Implementation status as of May 2014
North Henderson		
044 045	Off-line storage	CSO Basin 044 and 045 storage will be a 2.65 MG off-line storage project. The project is in final design.

Table 1-4. Early Action Projects		
CSO basins	CSO control measures	Implementation status as of May 2014
South Henderson		
046	Off-line storage	This project involves an upgrade of Wastewater Pump Station 9 which is located at South Grattan Street. The upgrade consist of increasing the pumping capacity from 3.2 MGD to 3.9 MGD and replacing the force main.
047/171	Off-line storage	A storage project is being constructed to serve Basins 047 and 171.

1.4.3 City CSO Discharge Control Status

The following sections present the control status of the City's CSO outfalls and the methodology used to determine the control status. As prescribed by Ecology, a CSO outfall is considered controlled if it discharges no more than once per year on a 20-year moving average.

Several approaches of varying complexity were available for estimating CSO control status. The approach used for each basin was chosen based on the stage of completion and method of analysis being performed by the various consultants employed by the City to assess basins in various areas of the City. Some methods were based on direct use of overflow data reported to Ecology, and others were based on computer modeling. Table 1-5 describes the various estimating approaches.

Table 1-5. Summary of CSO Control Status Estimating Approaches	
Annual overflow data approach	
Underlying principle	Control status may be estimated from direct monitoring of overflows.
Description	Review the City's permanent CSO monitoring data to establish long-term range of overflow frequency.
Required information	Accurate, reliable flow monitoring data indicating frequency and volume of overflows for the subject basin
Use and accuracy	This approach is considered appropriate for planning purposes. In the 2010 CSO Reduction Plan Amendment, this approach was used to determine the control volume for the majority of the CSO basins. This approach was also used to determine which CSO areas should undergo detailed hydraulic and hydrologic modeling.

Table 1-5. Summary of CSO Control Status Estimating Approaches	
Annual overflow data approach	
Annual overflow data approach	Computer models can use detailed system information and historical flow records to estimate overflow frequency and volume over long periods and a wide range of conditions. Long-term simulation allows evaluation of overflow performance for a wider range of conditions than available from the permanent metering program. It therefore provides a higher level of confidence that the selected control volume is not a statistical anomaly.
Underlying principle	Develop a hydrologic/hydraulic model of one basin or several connected basins using available system information. Conduct flow monitoring to provide data for calibration of the model. Use the calibrated model to simulate a range of historical flow events for validation and further refinement based on comparison of model results to recorded data. Use the final refined model to simulate flows for approximately 30 years of rainfall data recorded by the City's rain gauge network. Identify the 31st largest overflow volume and use it as the basin's CSO control volume.
Description	City GIS records provide hydraulic loading data (census data, roof or pavement area, etc.) and sewer network physical characteristics. Sewer system as-built information enables error correction and confirmation of attributes at key hydraulic structures. Rainfall data have been recorded at 17 locations across the City with most gauges having a data record back to 1978. Models are calibrated using data from short-term flow metering and rainfall information from a suitable rain gauge. Further refinement is made by validation against historical overflow records. As part of the refinement process, a field survey program was performed to verify physical parameters at a number of key structures.
Required information	Long-term model simulations are considered the highest level of accuracy for determining control volumes for CSO basins. Long-term simulations were used to determine the control volumes for the uncontrolled CSO outfalls.

1.4.3.1 CSO Discharges Control Status

Table 1-6 presents the control status for all City of Seattle CSO basins as indicated in Appendix A of the Consent Decree.

Table 1-6. Consent Decree CSO Discharges Control Status		
CSO area	CSO outfall	Consent Decree control status
Ballard	057	Controlled
	059	Controlled
	150/151	Uncontrolled
	152	Uncontrolled
Central Waterfront	069	Uncontrolled
	070	Controlled

Table 1-6. Consent Decree CSO Discharges Control Status		
CSO area	CSO outfall	Consent Decree control status
	071	Uncontrolled
	072	Controlled
Delridge	099	Uncontrolled
	168	Uncontrolled
	169	Uncontrolled
	170	Controlled
Duwamish	107	Uncontrolled
	111	Uncontrolled
Fremont/Wallingford	147	Uncontrolled
	148	Controlled
	174	Uncontrolled
Genesee	038	Controlled
	040	Uncontrolled
	041	Uncontrolled
	042	Controlled
	043	Uncontrolled
	165	Controlled
Henderson	044	Uncontrolled
	045	Uncontrolled
	046	Uncontrolled
	047	Uncontrolled
	048	Controlled
	049	Uncontrolled
	171	Uncontrolled

Table 1-6. Consent Decree CSO Discharges Control Status		
CSO area	CSO outfall	Consent Decree control status
Interbay	068	Uncontrolled
Lake Union/North	141	Controlled
	144	Controlled
	145	Controlled
	146	Controlled
Lake Union/West	120	Controlled
	121	Controlled
	124	Controlled
	127	Controlled
Leschi	026	Controlled
	027	Controlled
	028	Uncontrolled
	029	Uncontrolled
	030	Controlled
	031	Uncontrolled
	032	Uncontrolled
	033	Controlled
	034	Uncontrolled
	035	Controlled
	036	Uncontrolled
Madison Park/Union Bay	022	Controlled
	024	Controlled
	025	Uncontrolled
Magnolia	060	Uncontrolled

Table 1-6. Consent Decree CSO Discharges Control Status		
CSO area	CSO outfall	Consent Decree control status
	061	Controlled
	062	Controlled
	064	Controlled
Montlake	020	Uncontrolled
	139	Uncontrolled
	140	Uncontrolled
North Union Bay	018	Uncontrolled
	019	Controlled
Portage Bay	129	Controlled
	130	Controlled
	131	Controlled
	132	Controlled
	134	Controlled
	135	Controlled
	136	Controlled
	138	Uncontrolled
	175	Controlled
West Seattle	078	Controlled
	080	Controlled
	083	Controlled
	085	Controlled
	088	Controlled
	090	Controlled
	091	Controlled

Table 1-6. Consent Decree CSO Discharges Control Status		
CSO area	CSO outfall	Consent Decree control status
	094	Controlled
	095	Uncontrolled
Windermere	012	Controlled
	013	Uncontrolled
	014	Controlled
	015	Uncontrolled
	016	Controlled
	161	Controlled

1.5 Long-Term Planning Approach Summary

The following sections summarize the planning approach used to develop the City's LTCP, including a description of relevant EPA LTCP requirements, control criteria, the relationship between the City's and King County's CSO programs, and the public participation process.

1.5.1 Compliance with EPA CSO Control Policy

The EPA CSO Control Policy lists nine elements that should be addressed in the overall planning approach. Table 1-7 presents the locations in this LTCP where the EPA CSO Control Policy elements are addressed.

Table 1-7. Comparison of EPA CSO Control Policy Elements and LTCP Chapters	
EPA CSO Control Policy element	LTCP section
Characterization, monitoring, and modeling activities as the basis for selection and design of effective CSO controls	Chapter 2, Section 2.3, 2.4, and 2.6
A public participation process that actively involves the affected public in the decision-making to select long-term CSO controls	Chapter 4, Section 4.2 Chapter 5, Section 5.2
Consideration of sensitive areas as the highest priority for controlling overflows	Chapter 2, Section 2.5
Evaluation of alternatives that will enable the permittee, in consultation with the NPDES permitting authority, water quality standards (WQS) authority, and the public, to select CSO controls that will meet CWA requirements	Chapter 3
Cost/performance considerations to demonstrate the relationships among a comprehensive set of reasonable control alternatives	Chapter 4, Section 4.1

Table 1-7. Comparison of EPA CSO Control Policy Elements and LTCP Chapters

EPA CSO Control Policy element	LTCP section
Operational plan revisions to include agreed-upon long-term CSO controls	Chapter 4, Section 4.5 Chapter 5, Section 5.11
Maximization of treatment at the existing POTW treatment plant for wet-weather flows	Chapter 2, Section 2.2.
An implementation schedule for CSO controls	Chapter 4, Section 4.4 Chapter 5, Section 5.9
A post-construction compliance monitoring program adequate to verify compliance with water-quality-based CWA requirements and ascertain the effectiveness of CSO controls	Chapter 5, Section 5.12
Selection of a recommended control option	Chapter 5

1.5.2 Conformance with Consent Decree Requirements and EPA Guidance for Long-Term Control Plan

1.5.2.1 Consent Decree Requirements

In addition to the EPA's CSO Control Policy, the Consent Decree stipulates specific criteria and requirements for the LTCP. Table 1-8 is a matrix that summarizes where the Consent Decree LTCP requirements are addressed in Volume 2 LTCP. Appendix A includes a detailed matrix of the Consent Decree requirements, and where the LTCP report addresses the requirements.

Table 1-8. Consent Decree Compliance Matrix

Consent Decree item	Consent Decree reference and description	LTCP section	Comments
Appendix C, LTCP Requirements			
A.1 through A.5	A. Public and Regulatory Agency Participation Program.	Chapter 4, Section 4.2 and Chapter 5 Section 5.2	Describes the public and regulatory agency participation program performed for the LTCP Refer to 2013 CSO Annual Report (Reference 18)
B.1 and B.2.	B. Hydraulic Model Development and Hydraulic Model Report	Chapter 2, section 2.6 Appendix B	Describes the hydraulic modeling for the LTCP. East Waterway CSO Basin 107 Hydraulic Model Report is included in Appendix B.
C.1. through C.14	C. Long Term Control Plan	Chapter 3	Chapter 3 describes how the LTCP used the 2010 CSO Reduction Plan as the basis for the CSO control measure alternative analysis, CSO control measure screening, project cost methodology, and the development of the LTCP options.

Table 1-8. Consent Decree Compliance Matrix

Consent Decree item	Consent Decree reference and description	LTCP section	Comments
		Chapter 4	Chapter 4 describes the evaluation of project costs, implementation schedule, rate analysis, and the rating and ranking of the LTCP options. This chapter is based on financial direction provided in <i>Combined Sewer Overflows: Guidance for Financial Capability Assessment and Schedule Development</i> (Reference 19). The City has completed this assessment and it can be found in Appendix C. The chapter also describes the final decision-making process for the selection of the recommended LTCP CSO control measures for the LTCP. The <i>Option Rating and Ranking Report (MODA)</i> is included as Appendix D.
		<i>CSO Alternative Analysis Report</i> (December 31, 2014)	A draft Final LTCP was submitted for EPA review in February 2015 for preliminary approval. That submittal is documented (in Chapter 5, Section 5.4) the selection process for a recommended LTCP option. EPA/Ecology agreed that this would satisfy the requirement for the CSO Alternative Analysis Report submittal.
		<i>LTCP Implementation Schedule Report</i> (December 31, 2014)	An implementation schedule was included in the draft LTCP for the four options presented. A draft Final LTCP was submitted for EPA review in February 2015 for preliminary approval. That submittal documented (in Chapter 5, Section 5.9) the selection process for a recommended LTCP option. That draft also included a detailed implementation schedule for the recommended LTCP CSO control measures. EPA/Ecology agreed that this would satisfy the requirement for the Implementation Schedule Report submittal.
		<i>Financial Analysis Report</i>	A financial analysis was included in the draft LTCP for the four options that were presented. A draft Final LTCP was submitted for EPA review in February 2015 for preliminary approval. That submittal documented (in Chapter 5, Section 5.10) the selection process for a recommended LTCP option. That submittal included an evaluation of the City's financial capability to fund the selected alternative or combination. EPA and Ecology agreed that this would satisfy the requirement for the Financial Analysis Report submittal.

Table 1-8. Consent Decree Compliance Matrix

Consent Decree item	Consent Decree reference and description	LTCP section	Comments
D.1 through D.3	D. Post-Construction Monitoring Program	Chapter 5, Section 5.12 Final PCMP (May 31, 2015)	Describes the post-construction monitoring program for the CSO control measures. Detailed <i>Post-Construction Monitoring Plan</i> (PCMP) required under the Consent Decree will be submitted as a separate document by May 31, 2015.

1.5.2.2 EPA Guidance for Long-Term Control Plan

The EPA guidance document *Combined Sewer Overflows, Guidance for Long Term Control Plan* (1995) (Reference 20) provides guidance and recommendations on how to prepare a comprehensive long-term control plan for CSOs. Table 1-9 is a matrix that summarizes where the *EPA Guidance for Long Term Control Plan* requirements are addressed in Volume 2, the LTCP.

Table 1-9. EPA Guidance Document Compliance Matrix

Guidance Document item	Guidance document reference and description	LTCP section	Comments
Chapter 1 - Introduction			
1.1	Background	All LTCP Chapters	Background information only, no specific LTCP requirements
1.2	History of the CSO Control Policy	All LTCP Chapters	Background information only, no specific LTCP requirements
1.3	Key elements of the CSO Control Policy	All LTCP Chapters	CSO Control Policy principles used in the preparation of the LTCP
1.4	Guidance to support implementation of the CSO Control Policy	All LTCP Chapters	EPA reference documents used in the preparation of the LTCP
1.5	Goal of this guidance document	All LTCP Chapters	EPA guidance document goals used in the preparation of the LTCP
1.6	Long-term planning approach summary	All LTCP Chapters	Overall EPA planning approach incorporated in the preparation of the LTCP
Chapter 2 – System Characterization			
2.1	Public participation and agency interaction	Chapter 4, section 4.2; Chapter 5, Section 5.2	Describes the public and regulatory agency participation program performed for the LTCP

Table 1-9. EPA Guidance Document Compliance Matrix			
Guidance Document item	Guidance document reference and description	LTCP section	Comments
2.2	Objective of system characterization	Chapter 2, section 2.1	Describes the system characterization objectives
2.3	Implementation of the Nine Minimum Controls	Chapter 2, section 2.2	Describes the City's implementation program for the Nine Minimum Controls
2.4	Compilation and analysis of existing data	Chapter 2, sections 2.3, 2.4, and 2.7	Describes the existing CSO system information, flow monitoring data, sewer modeling and CSO control status evaluation work.
2.5	Combined sewer system and receiving water monitoring	Chapter 2, section 2.4	IV.9 (ee) of the Consent Decree defined a presumptive approach which was used for this LTCP No receiving water monitoring was performed under the presumptive approach.
2.6	Combined sewer system and receiving water modeling	Chapter 2, section 2.6	IV.9 (ee) of the Consent Decree defined a presumptive approach which was used for this LTCP. No receiving water monitoring was performed under the presumptive approach.
Chapter 3 – Development and Evaluation of Alternatives for CSO Control			
3.1	Public participation and agency interaction	Chapter 4, section 4.2 Chapter 5, Section 5.2	Describes the public and regulatory agency participation program performed for the LTCP
3.2	Long-term control plan approach	Chapter 3, section 3.1	Describes long-term control plan approach including compliance with performance criteria IV.9 (ee) of the Consent Decree defined a presumptive approach which was used for this LTCP.
3.3	Development of alternatives for CSO control	Chapter 3	Chapter 3 describes how the LTCP evaluated various CSO control measures, screened CSO control measures, and developed the LTCP system wide options including joint projects with King County.

Table 1-9. EPA Guidance Document Compliance Matrix			
Guidance Document item	Guidance document reference and description	LTCP section	Comments
3.4	Evaluation of alternatives for CSO control	Chapter 4, section 4.1 Chapter 5, Section 5.3 and 5.4	CSO alternative analysis and rating and ranking of LTCP options
3.5	Financial capability	Chapter 5, Section 5.10	Financial analysis performed for LTCP options.
Chapter 4 – Selection and Implementation of CSO Control Measures			
4.1	Public participation and agency interaction	Chapter 4, section 4.2 Chapter 5, Section 5.2	Describes the public and regulatory agency participation program performed for the LTCP
4.2	Final Selection and development of recommended plan	Chapter 4, section 4.1	CSO alternative analysis and rating and ranking of LTCP options
4.3	Financing plan	Chapter 5, Section 5.10	Financial analysis performed for Draft LTCP options.
4.4	Implementation schedule	Chapter 4, section 4.4 Chapter 5, Section 5.9	LTCP Implementation Schedules prepared for LTCP options.
4.5	Operational plan	Chapter 4, section 4.5 Chapter 5, Section 5.11	Operations and maintenance approach prepared for LTCP options
4.6	Post-construction compliance monitoring	Chapter 5, Section 5.12	PCMP overview described in LTCP. Final PCMP described in a separate report.
4.7	Re-evaluation and update	Chapter 5, Section 5.8	Data evaluation and CSO performance reporting requirements described

1.5.3 Demonstration versus Presumption Approach

The EPA CSO Control Policy identifies two general approaches to CSO control: the demonstration approach and the presumption approach. The demonstration and presumption approaches provide municipalities with targets for CSO controls that achieve compliance with the CWA, particularly protection of designated uses.

Under the demonstration approach, the municipality would be required to successfully demonstrate compliance with each of the following criteria:

1. The planned control program is adequate to meet WQS and protect designated uses, unless WQS or uses cannot be met as a result of natural background conditions or pollution sources other than CSOs.

2. The CSO discharges remaining after implementation of the planned control program will not preclude the attainment of WQS or the receiving waters' designated uses or contribute to their impairment. Where WQS and designated uses are not met in part because of natural background conditions or pollution sources other than CSOs, a total maximum daily load, including a waste load allocation, a load allocation, or other means should be used to apportion pollutant loads.
3. The planned control program will provide the maximum pollution reduction benefits reasonably attainable.
4. The planned control program is designed to allow cost-effective expansion or cost-effective retrofitting if additional controls are subsequently determined to be necessary to meet WQS or designated uses.

Under the presumption approach, controls adopted in the LTCP should be required to meet one of the following criteria:

1. No more than an average of four overflow events per year, provided that the permitting authority may allow up to two additional overflow events per year. For the purpose of this criterion, an overflow event is one or more overflows from a CSS as the result of a precipitation event that does not receive the minimum treatment specified.
2. The elimination or the capture for treatment of no less than 85 percent by volume of the combined sewage collected in the CSS during precipitation events on a system-wide annual average basis.
3. The elimination or removal of no less than the mass of the pollutants identified as causing water quality impairment through the sewer system characterization, monitoring, and modeling effort for the volumes that would be eliminated or captured for treatment under item 2 above.

Appendix C, C.1 of the Consent Decree indicates that "meeting the performance criteria [of one CSO per outfall per year on a 20-year rolling average] is equivalent to meeting the presumption approach in the LTCP guidance."

1.5.4 CSO Control Performance Criteria (Moving 20-year Average)

As indicated in the Consent Decree and Ecology regulations, the CSS will be considered controlled if there is no more than one overflow per year per outfall, on a 20-year moving average.

The Consent Decree further explains how to calculate the 20-year moving average:

For previously controlled CSO Outfalls and where monitoring records exist for the past 20 consecutive years, the twenty year moving average shall mean the average number of untreated discharges per CSO Outfall over the 20 year record. On an annual basis, the twenty year moving average will be calculated and includes the current monitored year and each of the previous 19 years of monitored CSO data. For CSO reduction projects and controlled CSO Outfalls where a complete twenty year record of monitored data does not exist, missing annual CSO frequency data will be generated based on the predicted CSO frequency for a given year as established in the approved engineering report or facility plan. For each CSO reduction project, the engineering report or facility plan shall predict the CSO frequency for each CSO Outfall based on long-term simulation modeling using a 20-year period of historical rainfall data, the hydraulic model, the CSO control project design and assuming the CSO control project existed throughout the 20-year period. For CSO reduction projects, the level of control is the number of discharge events per CSO outfall per year that are estimated to occur based on the designed CSO control project over a 20-year period. The level of control will be estimated for each year for a period of 20 years in the engineering report or facility plan. For

the time period between the approval of the engineering report and the CSO reduction project's Construction Completion date, the City shall use the same model for the approved design along with the corresponding measures for eliminating or reduction the City's CSOs included in any Supplemental Compliance Plan developed and implemented in accordance with Section V.B.

1.5.5 Relationship between City and King County CSO Control Efforts

Both King County and Seattle Public Utilities own CSO outfalls within the City of Seattle limits. Based on agreements made at the start of the regional system in 1958, both King County and the City are responsible for CSOs and are working to control them under long-term CSO control plans.

Because the City drainage basins are smaller, overflows from the city system are usually smaller in volume and shorter in duration but may occur more frequently than overflows from the county system. King County is also amending its long-term CSO control plan. The two agencies communicate frequently and participate in each other's CSO control planning efforts. The City will consider shared CSO control projects with King County if the projects are deemed to be cost-effective for ratepayers, provide a better environmental outcome, or have the potential to minimize construction disruption to nearby communities.

1.5.6 Public and Regulatory Agency Participation Program

The Consent Decree specifies that the LTCP shall include a public and regulatory agency participation program. The purpose of this program is to ensure that there is ample public participation throughout all stages of development of the City's LTCP. Table 1-10 describes how public and regulatory agency participation requirements of the Consent Decree have been implemented in the LTCP.

Table 1-10 Public and Regulatory Agency Participation Program

Consent Decree requirement	Public and regulatory agency participation approach
The means by which the City will make information pertaining to the development of the LTCP available for public review.	The City's Community Guide updates will provide updates on the LTCP/Integrated Plan and Programmatic EIS: • Animations • Visualizations • Video for website • Briefings • Website updates • Updates to the project listserv
The means by which the City will solicit comments from the public on the development of the LTCP.	• Scoping meetings (October 2011) • Online Questionnaires • Re-scoping meetings (May 2013) • Briefings • Public Meeting/Hearing on the Draft LTCP/Integrated Plan/EIS Spring 2014 • Comments and questions can be submitted anytime to the City via e-mail at CSO_LTCP@seattle.gov.

Table 1-10 Public and Regulatory Agency Participation Program

Consent Decree requirement	Public and regulatory agency participation approach
Summary of public hearings at meaningful times during the LTCP development process to provide the public with information and to solicit comments from the public regarding components of the LTCP.	• Draft EIS public hearing summary report • <i>LTCP/Integrated Plan Public and Regulatory Agency Participation Summary Report</i>
Program for consideration of comments provided by the public as the City develops the LTCP.	Summary reports to be prepared for all public meetings. The summary reports will include a comment response section: • Scoping summary report (2011) • Re-scoping summary report (spring 2013) • Final EIS comment response • <i>LTCP/Integrated Plan Public and Regulatory Agency Participation Final Summary Report</i>
Measures that the City will employ to ensure that Plaintiffs are kept informed of the City's progress in developing its LTCP development process and regular submittal of reports to Plaintiffs summarizing the public comments received throughout implementation of the Program.	• Quarterly meetings with EPA and Ecology (addresses both LTCP and Integrated Plan) • Webinars for plaintiffs at meaningful times – emphasis of webinar will be to report on public involvement activities and comments received at major milestones. • June/July 2013: Re-scoping recap • May 2014 Draft LTCP/Integrated Plan/DEIS rollout • Oct/Nov 2014: LTCP/Integrated Plan/DEIS public hearing recap

1.5.7 2010 CSO Reduction Plan Amendment as LTCP Starting Basis

This LTCP uses the 2010 CSO Reduction Plan Amendment as the starting point for developing CSO reduction projects. As indicated in the Consent Decree:

The LTCP shall build upon the alternative analysis work that was performed as part of the development of the City's 2010 CSO Reduction Plan Amendment (2010 Plan). Alternatives that were screened out as part of the 2010 Plan will not be evaluated further in the LTCP.

In Chapter 3, the LTCP will discuss the recommended projects in the 2010 CSO Reduction Plan Amendment and what changes have been made to the recommendations.

1.5.8 Controlling Uncontrolled CSO Basins

In 2013, there were 219 overflow events and 38 million gallons discharged from Seattle Public Utilities' permitted outfalls. Table 5-8 of the City's 2013 CSO Annual Report shows which CSO basins are controlled and which are uncontrolled based on up to 20 years of flow monitoring supplemented with hydraulic modeling as appropriate. The 35 uncontrolled CSO basins will be controlled through the City's CSO reduction program. Table 1-11 lists the uncontrolled CSO basins and where each basin's recommended control measure is identified.

Table 1-11. Controlling Uncontrolled Basins		
CSO area	CSO basin	CSO reduction project source
Ballard	150/151	LTCP project
	152	LTCP project
Central Waterfront	069	LTCP project
	071	2010 CSO Reduction Plan project
Delridge	099	LTCP project
	168	CSO Retrofit Program and LTCP project
	169	CSO Retrofit Program and LTCP project
Duwamish	107	LTCP project
	111	LTCP project
Fremont/Wallingford	147	LTCP project
	174	LTCP project
Genesee	040	2010 CSO Reduction Plan project
	041	2010 CSO Reduction Plan project
	043	2010 CSO Reduction Plan project
Henderson	044	Early Action
	045	Early Action
	046	Early Action
	047	Early Action
	049	2010 CSO Reduction Plan project
	171	Early Action
Leschi	028	LTCP project
	029	LTCP project
	031	LTCP project
	032	LTCP project
	036	LTCP project
Magnolia	060	LTCP project

Table 1-11. Controlling Uncontrolled Basins		
CSO area	CSO basin	CSO reduction project source
Montlake	020	LTCP project
	139	LTCP project
	140	LTCP project
North Union Bay	018	LTCP project
Portage Bay	138	LTCP project
West Seattle	095	2010 CSO Reduction Plan project
Windermere	013	2010 CSO Reduction Plan project
	015	2010 CSO Reduction Plan project

1.5.9 CSO Discharges Covered by LTCP

The CSO basins included in the LTCP are those that are uncontrolled and do not already have CSO reduction projects being implemented in them, or basins that are controlled but hydraulically linked to uncontrolled LTCP basins (which could cause them to become uncontrolled).

Table 1-12 presents the CSO basins that were evaluated in the LTCP.

Table 1-12. CSO Basins Included in the LTCP	
CSO area	CSO basin
Ballard	150/151, 152
Central Waterfront (Vine Street)	069
Delridge	099, 168, 169
Duwamish	111
East Waterway	107
Fremont/Wallingford	147, 174
Leschi	028, 029, 031, 032, 036
Magnolia	060
Montlake	020, 139, 140
North Union Bay	018
Portage Bay	138

1.5.10 Factors Considered in LTCP Approach

As described in the Consent Decree, the LTCP approach must consider several factors:

- Evaluation of the technical feasibility and applicability of each alternative or combination of alternatives at each CSO outfall or grouping of CSO outfalls
- A determination of the estimated project costs, including capital costs, annual operation and maintenance costs, and life cycle costs, for each separate component of each alternative or combination of alternatives
- An analysis of alternatives for reducing the City's CSOs, including:
 - An evaluation of the annual performance capabilities and effectiveness of various alternatives
 - An analysis of design and development capabilities for the alternatives, including basin-specific information on flow management, topographical or hydrological constraints, and construction capacities
 - An evaluation of project costs, including capital costs, annual operations and maintenance costs, and total present worth
- The screening of selected CSO control alternatives, involving additional evaluation of the geotechnical environment and property information, as well as the preparation of the appropriate environmental review, for the identified project area
- The basis for the City's selection of the preferred alternatives
- An evaluation of the City's financial capability to fund the selected alternative or combination of alternatives
- An expeditious schedule for the design, construction, and implementation of all CSO control measures
- An assessment of the costs, benefits, and effectiveness of the alternatives evaluated for reducing CSOs
- The basis for determining that the CSO control measures set forth in the LTCP will ensure that the City's CSOs comply with the CSO Control Policy
- The basis for determining that the schedule for implementing the LTCP attains construction completion of all CSO control measures no later than December 31, 2025

1.5.11 Measures of Success

The NMC and the LTCP requirements under the CSO Policy require that the effectiveness of the controls be measured to determine if the goals of the Policy and the requirement of the CWA have been met. The evaluation of the effectiveness of the LTCP against the NMC and CSO LTCP requirements will be measured based upon the EPA published guidelines. In addition to these required measures of success, the LTCP will also focus on five specific values:

- Identify areas of Seattle where projects are needed to reduce sewage overflows
- Evaluate alternatives for reducing sewage overflows in these areas
- Recommend a schedule for designing and constructing projects
- Estimate program costs and associated impacts on Seattle Public Utilities customer bills
- Consider public and stakeholder input

CHAPTER 2

System Characterization

2.1 Objective of System Characterization

The primary objective of system characterization is to develop a detailed understanding of the current conditions of the combined sewer system and receiving waters. System characterization consists of three activities:

- Compiling and analyzing existing data on the CSS
- Monitoring flow throughout the CSS
- Modeling the CSS

This assessment, a crucial component of the planning process, establishes existing baseline conditions and provides the basis for determining receiving water goals and priorities and identifying specific CSO controls in the LTCP.

2.1.1 Purpose

The purpose of combined sewer system characterization and evaluation, monitoring, and modeling is to better understand the response of the system to various wet-weather events, the characteristics of the overflows, and the baseline CSO conditions. The CSS characterization information is imperative for developing a CSO control plan adequate to meet the Clean Water Act and Consent Decree.

2.1.2 Characterization Elements

The major elements of a sewer system characterization are listed below with the description from the United States EPA guidance document *Combined Sewer Overflows Guidance for Long-Term Control Plan* (EPA LTCP Guidance Document). Subsequent sections describe major elements in more detail:

- Characterization and evaluation – “The permittee should evaluate the nature and extent of its sewer system through evaluation of available sewer system records, field inspections, and other activities.”
- Monitoring - “The permittee should develop a comprehensive, representative monitoring program that measures the frequency, duration, flow rate, volume, and pollutant concentration of CSO discharges and assesses the impact of the CSOs on the receiving waters.” This can include the following: number of CSOs, locations of CSOs, frequency of CSOs, and volume of CSOs.
- Modeling – “The primary objective of CSS modeling is to understand the hydraulic response of the CSS to a variety of precipitation and drainage area inputs.” Once the model is calibrated and verified, it can be used for numerous applications that support CSO planning efforts.

2.1.2.1 Characterization and Evaluation

One of the first technical activities within system characterization is the characterization and evaluation of existing data. The following subsections describe the four components of characterization and evaluation; watershed mapping, collection system understanding, CSO and non-CSO source characterization, and receiving water investigation.

See Section 2.3 for details on characterization and evaluation activities completed by the City.

2.1.2.1.1 Watershed Mapping

The EPA LTCP Guidance Document defines a watershed as “a water body and the entire land area that drains into that water body.” Watershed mapping consists of delineating watersheds and subwatersheds, and overlaying relevant data including topography, political boundaries, land use categories, soils, infrastructure, natural resources, recreational areas, special fish and habitat areas, and existing pollution control structures.

2.1.2.1.2 Collection System Understanding

The EPA LTCP Guidance Document indicates that a municipality should “evaluate the nature and extent of its combined sewer system through evaluation of available sewer system records, field inspections and other activities necessary to understand the number, location and frequency of overflows and their location relative to sensitive areas and to pollution sources in the collection system, such as indirect significant industrial users.”

See Sections 2.3.1, 2.3.3, and 2.3.4 for details on collection system understanding activities completed by the City.

2.1.2.1.3 CSO and Non-CSO Source Characterization

The EPA LTCP Guidance Document recommends that municipalities should “identify areas that contain probable sources of significant loadings, such as industrial areas with significant indirect industrial users.”

2.1.2.1.4 Receiving Water Investigation

The EPA LTCP Guidance Document recommends that municipalities should characterize the receptors of CSOs and watershed pollutant sources and their effects as completely as possible. See Section 2.3.7 for details on the results of the receiving water investigations.

2.1.2.2 Monitoring

The EPA LTCP Guidance Document indicates that in many cases, “existing data will not be sufficient to establish existing baseline dry-weather or wet weather conditions. Thus, the next step in the long-term planning process generally will be to develop and conduct a monitoring program to adequately characterize existing conditions, as well as provide the necessary calibration and verification data for system modeling.”

The City has conducted an extensive rainfall and flow monitoring program throughout the CSS. This program has consisted of flow monitoring at CSO locations since 2000, two seasons (2008-2009 and 2009-2010) of detailed flow monitoring in the LTCP CSS basins, additional flow monitoring at specific locations since 2010, and continuous rainfall monitoring at 17 rain gages across the CSS since 1978. See Section 2.4 for details on monitoring activities completed by the City’s CSO Program.

2.1.2.3 Combined Sewer System Modeling

The EPA LTCP Guidance Document indicates that the primary objective of CSS modeling is “to understand the hydraulic response of the CSS to a variety of precipitation and drainage area inputs.” The calibrated and verified model can be used for numerous applications that support CSO planning efforts, including predicting overflow occurrence and volume, predicting performance of portions of the CSS that have not been extensively monitored, developing CSO statistics, optimizing the CSS performance as part of the Nine Minimum Controls implementation, and evaluating and optimizing control alternatives. The City has calibrated and verified 13 hydrologic and hydraulic models of CSS basins in Seattle.

2.2 Implementation of Nine Minimum Controls

The EPA CSO Control Policy, published in 1994, provides guidance to stakeholders for coordinating the planning, selection, and implementation of CSO controls that meet the requirements of the CWA. Among other things, the policy establishes two main objectives for permittees: implementation of nine minimum controls (Reference 21) and development and implementation of an LTCP.

As the name implies, the LTCP is intended to be a far-reaching plan that presents a comprehensive approach to the identification, evaluation, and implementation of long-term, capital-intensive controls to reduce the impact of CSOs. The development and implementation of the LTCP can take several decades to complete.

Conversely, it was intended that the NMCs “reduce CSOs and their effects on receiving water quality, do not require significant engineering studies or major construction, and can be implemented in a relatively short period of time.” The EPA envisioned that “implementing the nine minimum controls is among the first steps a municipality should take to reduce combined sewer overflow impacts.” Similar to the intent of the LTCP, efforts undertaken for the NMCs are not considered as temporary measures. They should be integrated into a community’s long-term efforts to control CSOs.

The following subsections describe the City’s implementation of the NMC’s.

2.2.1 Nine Minimum Controls Performance

The controls ensure that maximum use is being made of existing infrastructure, management emphasis, and regulatory programs prior to major investment in new capital projects. They are intended to enhance combined sewer system performance through focused maintenance and relatively low-cost improvements. The nine minimum controls have been integrated into the City’s regular operation and maintenance procedures. They include enhanced or more frequent maintenance and retrofit of flow-control devices such as HydroBrakes and weirs. They are typically low-cost, easy to implement, and less disruptive than other CSO reduction approaches.

The following subsections describe the NMC work that was performed in 2013 on each of these nine control measures.

2.2.1.1 Control 1: Provide System Operations and Maintenance

Reduce the magnitude, frequency, and duration of CSOs through proper operation and maintenance (O&M) of the combined sewer system.

Each year the City performs extensive system O&M activities to reduce the frequency and volume of preventable overflows. Routine maintenance activities include sewer inspections, cleaning, and non-emergency point repairs; catch basin inspection, cleaning, and repairs; control structure and storage structure cleaning; valve and flap gate inspection, cleaning, lubricating, and servicing; and pump station electrical, mechanical, and facilities inspection and servicing. The City uses the National Association of Sewer Service Companies (NASSCO) pipeline assessment and certification program (PACP) defect coding system to identify and prioritize pipes to be scheduled for maintenance or rehabilitation.

Once a sewer has been identified as having a maintenance-related problem, the sewer is placed on a routine cleaning schedule to prevent future maintenance-related backups. The initial cleaning frequency is based on the cause of the initial backup, and the cleaning frequency is increased or decreased over time as appropriate. Corrective activities include:

- Jetting for light to medium debris
- Dragging for heavy debris in pipes greater than 18-inch diameter
- Hydrocutting for roots and grease
- Rodding for pipes with an active blockage
- Chemical root treatment, in sanitary and combined sewers only, when roots are present with no grease

The City's routine maintenance frequencies range from as short as once a month to as long as once every six years. The challenge for sewer utilities is to clean sewers as frequently as necessary to maintain system capacity but no more than necessary, as cleaning sewers shortens the sewer's functional life span. In 2011 the City launched the use of a cleaning optimization tool (COTools) (Reference 22) to analyze sewer pipe cleaning data and recommend appropriate cleaning frequencies. The City staff review these software-generated recommendations and implement those that provide the right balance between sewer capacity and sewer lifespan. In 2013, the City continued to use COTools to analyze and adjust pipe maintenance frequencies.

Pump station electrical and mechanical components are replaced as necessary during routine pump station maintenance. In 2008, the City began implementing Reliability Centered Maintenance (RCM) (Reference 23) at its wastewater pump stations. The objective of RCM is to ensure the right maintenance is performed at the right intervals, which optimizes life-cycle costs while increasing system reliability. In addition, RCM ensures the right data is collected and evaluated, adding discipline to the decision-making process around operations, spare parts inventory, maintenance strategies, and data collection.

Over a three-year period, maintenance strategies were developed for each of the 68 wastewater pump stations, taking into consideration site-specific conditions and the consequences of failure. The RCM strategies were used to create work order that contain maintenance tasks and intervals that were implemented in 2011. Data collected from these work orders are analyzed and used to adjust future maintenance tasks and intervals. In 2013, the City continued to use and adjust the RCM-based strategies.

The City's 2013 O&M accomplishments are summarized in Table 2-1. Compared to 2012 O&M accomplishments, productivity increased in most areas. Most significantly, the City cleaned over 25 percent of the collection system in 2013. In addition, the City cleaned approximately 63 percent more pipe and inspected approximately 10 percent more sewers in 2013 than in 2012. The O&M activities summarized in Table 2-1, and the capacity, management, operation, and maintenance (CMOM) program initiatives described in Section 2.2.2 helped the City limit the number and volume of overflows in the collection system.

Control 1 also requires that the City take affirmative steps to prevent tidal inflow into the combined sewer system. The City reviews flow monitoring results on a regular basis to determine whether there are any outfalls experiencing tidal inflow and, if so, to help determine solutions. In 2011, the City replaced leaking flap gates at Overflow Structures 111A and 111C to prevent inflow from the tidally influenced reach of the Duwamish River. In early 2012, the City sealed Overflow Structures 111E and 111F, further preventing tidal inflow from the Duwamish River. And in 2009, the City sealed the leaking flap gates at Outfalls 069, 070, 071, and 072 along the Central Waterfront, effectively changing the overflow elevation at these outfalls to the previously designated "emergency overflow weirs", which are higher than the high-water level of Elliott Bay.

Table 2-1. 2013 Operation and Maintenance Accomplishments

Activity	Quantity
Miles of mainline pipe cleaned	418
Miles of mainline pipe inspected via CCTV	124
Miles of mainline pipe rehabilitated	10.6
Number of pump station inspections	1,802
Number of maintenance holes inspected	518
Number of force mains inspected and repaired, replaced, or rehabilitated	2
Number of CSO structure inspections	304
Number of CSO structure cleanings	129
Number of CSO HydroBrake inspections	225
Number of CSO HydroBrake cleanings	51
Linear feet of pipe receiving chemical treatment to inhibit root growth	63,152
Number of catch basins inspected	905
Number of catch basins cleaned	2,025
Number of catch basins repaired	21
Number of catch basin traps replaced	136

2.2.1.2 Control 2: Maximize Storage of Flows

Maximize the use of the collection system for wastewater storage, in order to reduce the magnitude, frequency, and duration of CSOs.

The City maximizes storage in its collection system through a multi-faceted approach that includes:

- Regular collection-system maintenance so that existing capacity is available during storm events
- Retrofits to storage facilities whose existing capacity is not fully utilized
- Increasing the height of overflow weirs when doing so increases collection system storage capacity without creating backups
- Eliminating excessive inflow and infiltration

In 2013, the City continued to perform regular O&M activities as described in Control 1. Those activities helped to minimize sewer blockages and optimize system capacity.

In addition, the City continued to design and construct system retrofits to better utilize existing sewer system capacity. Work on system retrofits is described in the City's CSO Annual Report.

2.2.1.3 Control 3: Control Nondomestic Sources

Implement selected CSO controls to minimize CSO impacts resulting from nondomestic discharges.

Two important programs are implemented to help control nondomestic discharges into the Seattle sewer system: the Fats, Oils, and Grease Control Program and the Industrial Pretreatment Program.

The City administers the City's FOG Control Program, enforcing Seattle Municipal Code requirements to pretreat FOG-laden wastewater before it is discharged to the sewer system. FOG has a deleterious effect on the sewer system as it combines with calcium and grease in wastewater to form hard calcium deposits that adhere to the inside of sewers, decreasing their capacity. FOG Control Plan development activities are summarized in the City's CSO Annual Report.

FOG control inspection and enforcement activities conducted in 2013 are summarized in Section 3.3 of the City's 2013 CSO Annual Report.

The Industrial Pretreatment Program is administered by King County. King County issues industrial waste pretreatment permits that include appropriate discharge limits. King County also provides regular site inspections and periodic permit reviews. The City and King County work together if permittees are found to have a negative impact on the sewer system.

2.2.1.4 Control 4: Deliver Flows to the Treatment Plant

Operate the collection system to maximize flows to the treatment plant, within the treatment plant's capacity.

The City maximizes flow to the King County treatment plant by implementing the measures described in Controls 1 and 2 and also through a program of routine system performance monitoring and analysis.

In 2010, the City integrated its former water and wastewater control centers into a single Control Center (CC). The Control Center is staffed 24 hours a day and receives real-time Supervisory Control and Data Acquisition (SCADA) information.

Initially, the Control Center received SCADA information only from the City's 68 wastewater pump stations. The City continues to regularly analyze performance of the 68 pump stations to ensure that they are operating at their design capacity during storm events. Control Center staff respond to any alarms at the wastewater pump stations or the CSO facilities that would indicate a drop in performance or other problem. In addition, the City monitors pump station, overflow structure, and outfall flow data as it is collected and uses the data to detect maintenance issues that may be affecting system performance.

In 2011, monitoring and controls for the City's first sewer system facility with active controls and SCADA connectivity were also brought into the Control Center. In 2012, a second major control project was completed and brought into the Control Center for full operation. The project, located in the Windermere Area (Basin 13), includes two storage tanks and a motor-operated gate valve. The valve is programmed to fill or evacuate storage based on water levels in the downstream sewer (the Lake Line). Upon completion, the CSO storage projects in the Windermere, Genesee, and South Henderson CSO areas will be monitored from the Control Center.

In 2013, the City made continued progress constructing and implementing the infrastructure, hardware, and software that comprise the Drainage and Wastewater I-SCADA Program. This capital program will allow the City to transition from consultant-provided flow monitoring services to a City operated monitoring network. By the end of 2013, seven CSO sites and all 17 rain gauges had been transitioned. The goal is to have all monitoring locations transmit real-time data to the Control Center by the end of 2015.

The program also included the upgrade of SCADA equipment in all of the City's wastewater pump stations. This work was completed in early 2013. Implementation of a major upgrade of the Wonderware SCADA software and the hardware used in the Control Center was also completed in 2013.

2.2.1.5 Control 5: Prevent Dry-Weather Overflows

Prevent dry weather overflows; they are not authorized. Report any dry weather overflows within 24 hours and take prompt corrective action.

The City experienced three dry weather overflows (DWOs) from its permitted CSO outfalls in 2013, none of which were caused by the City or any other City entity:

- The first DWO occurred on February 1, 2013, at Outfall 071 on the Central Waterfront, and was caused by a subcontractor on the SR-99 bored tunnel construction contract. The subcontractor inadvertently removed a maintenance hole cover that allowed debris into a 21-inch diameter sewer, blocking flow and causing an estimated 58,760 gallon DWO. The City issued Notices of Violation to the lead agency (Washington State Department of Transportation) (WSDOT) and the prime contractor (Seattle Tunnel Partners).
- It should be noted that proactive efforts by the City helped avoid two additional DWOs on February 15 and July 2, 2013, when subcontractors drilled into two large diameter the City sewers. To reduce the risk of recurring construction-caused problems, the City issued Notices of Violation to WSDOT, Seattle Tunnel Partners, and Malcolm Drilling.
- The other two DWOs occurred at Outfall 129 on the east side of Lake Union. Both were caused by unusually high 45-60 mile per hour winds, which led to failure of private side sewers serving houseboats in Lake Union, which in turn caused high flows, debris, and upset conditions in the collection system. The first of these two DWOs occurred between November 2 and November 4, and the volume was approximately 53,670 gallons. The second DWO occurred on November 6, and the volume was approximately 11,240 gallons. Once the houseboat management association repaired the private side sewers, collection system flows returned to normal.

The details of these DWOs were provided in letters to Ecology and EPA.

The City also experienced five exacerbated CSOs in 2013 (wet-weather overflows at CSO outfalls that, while already discharging as a result of precipitation, were exacerbated by mechanical failures, blockages, equipment outages, or power outages):

- On January 9, 2013, a 590-gallon CSO at Outfall 012 was exacerbated by equipment and sensor malfunctions at City wastewater pump station 51. The equipment and sensors were subsequently repaired.
- On January 9, 2013, a 2,693-gallon CSO at Outfall 022 was exacerbated by an inflow of rocks and sediment from a broken side sewer lateral that restricted the pumping performance at City wastewater pump station 50. Emergency operation and maintenance procedures were put in place until the lateral could be repaired.
- On April 7 and 13, 2013, two CSOs at Outfall 022 (907 gallons and 7,802 gallons, respectively) were exacerbated by an inflow of rocks and sediment that restricted the pumping performance at City wastewater pump station 50, also causing SSO discharges from the overflow chamber into the street. The vault at this air-assisted lift station was cleaned to restore functionality and planning was initiated for a pump station rehabilitation project.

- On September 6, 2013, a 902-gallon CSO at Outfall 19 was exacerbated by a pump replacement project at Wastewater Pump Station 35. The pumps had reached the end of their life and were being replaced, starting in August and beginning with the largest pump (which provides storm event pumping capacity). Work to replace the largest pump had not been completed when early rains occurred on September 6. Replacement of the large pump was completed before the next storm event.

To help prevent DWOs and exacerbated CSOs, each combined sewer system overflow location has been configured with an alarm that is triggered if there are potential overflow conditions. The alarms alert analysts or field crews to assess the situation and take corrective action if possible.

In addition, whenever the City experiences a DWO or exacerbated CSO, the City investigates to identify the cause and takes action to address the overflow and reduce or eliminate the probability of recurrence. Investigation includes manual inspection of the site where the overflow occurred, CCTV inspection of adjacent pipe, and review of SCADA data. Whenever possible, the outfall structure and adjacent pipes are cleaned immediately following the event, and the City reviews and analyzes the cleaning results. The City holds monthly “after action” review meetings to learn from experience and apply any lessons learned toward preventing additional SSOs, DWOs, and exacerbated CSOs. The City also looks at the rolling history of DWOs and exacerbated CSOs to determine if there are any patterns and if a systematic solution is required. For example, in past years pump station electrical outages contributed to DWOs, so the City implemented projects to ensure that each pump station has either an on-site backup generator or an emergency plug that allows a portable generator to be easily placed in service.

A summary of the DWOs and exacerbated CSOs from 2007-2013 is included in Table 2-2.

Table 2-2. Dry Weather Overflows (DWOs) and Combined Sewer Overflows (CSOs) Exacerbated by System Maintenance Issues 2007 – 2013				
Year	Dry-weather overflows		CSOs exacerbated by system maintenance issues ^a	
	Number of overflows	Volume (gallons)	Number of overflows	Volume (gallons)
2007	7	499,264	--	--
2008	1	148,282	8	470,444
2009	1	3,509	3	156,153
2010	0	0	13	12,320,400
2011	0	0	10	2,317,068
2012	0	0	11	5,846,647
2013	3 ^b	123,670	5	12,894

Notes

- a CSOs exacerbated by system maintenance issues were not reported prior to 2008. The ‘exacerbated CSOs’ listed in this table are listed as CSO discharges in Table 5-4 of Reference 18 and are included in the discharges summarized in Tables 5-5, 5-6, 5-7, and 5-8 of Reference 18.
- b None of these DWOs were caused by the City.

2.2.1.6 Control 6: Control Solids and Floatable Materials

Implement measures to control solid and floatable materials in CSOs.

The City implements several measures to control floatables:

Catch basins are designed to prevent floatables from entering the system. Specifically, the City's catch basins are designed to overflow only when the water level in the catch basin is well above the overflow pipe opening. Because floatables remain on the water surface, they are trapped in the catch basins.

Catch basins are inspected and cleaned regularly to remove debris and potential floatables. In 2013, City crews:

- Inspected 905 combined sewer system catch basins
- Cleaned 2,025 combined sewer system catch basins
- Replaced 136 traps in combined sewer system catch basins
- Repaired 21 combined sewer system catch basins

In addition, the City of Seattle runs several solid waste and city clean-up programs to prevent and reduce the amount of street litter, including:

- Street sweeping, including increased efforts for Fall leaf pickup
- Spring cleaning
- Storm drain stencilling
- Recycling event
- Public litter and recycling cans
- Waste free holidays
- Product bans
- Illegal dumping investigation and response

2.2.1.7 Control 7: Prevent Pollution

Implement a pollution prevention program focused on reducing the impact of CSOs on receiving waters.

The City conducts multiple pollution prevention programs to keep contaminants from entering the sewer system and subsequently being discharged in sewage overflows. Pollution prevention programs performed by the City in 2013 include:

- Public education programs
- Solid waste collection and recycling
- Product ban or substitution
- Control of product use such as cleaning and yard care recommendations
- Illegal dumping prevention
- Bulk refuse disposal
- Hazardous waste collection
- Commercial and industrial pollution prevention
- Spill response
- Business inspections
- Water quality complaint response

The City of Seattle Department of Transportation (SDOT) performs street sweeping, including sweeping downtown streets every night and cleaning alleys three nights per week. In 2013, SDOT street sweeping crews swept 8,650 curb miles in the combined sewer system area.

The City also supports public education programs on pollution prevention, such as:

- Spring Clean
- Clean and Green
- Adopt-a-Street
- Adopt-a-Drain
- Storm drain stencilling
- Surface Water Pollution Report Line
- Pet waste disposal
- Natural yard care
- Car tips (to decrease automobile leaks)
- Reduce, reuse, and recycle tips

The City also has reduced the potential for pollution by reducing the volume of sewage entering the sewer system. For years, the City has been a leader in potable water conservation through the Saving Water Partnership, actually reducing the regional water system annual demand while the population has increased. As a result of these efforts, the total Seattle regional water system demand has dropped from a base (winter) flow of approximately 150 MGD in the late 1980s to a current base flow of 100 MGD, thus reducing the capacity demands on the regional sewer system by approximately 50 MGD.

The City and King County are both utilizing green infrastructure to reduce the volume of stormwater entering the combined sewer system. The City encourages installation of rain gardens and cisterns on private properties and is installing roadside rain gardens in street rights-of-way. Please see Section 4.2 of the City's 2013 CSO Annual Report for more information on these GI programs.

Finally, if sewage contamination of surface waters occurs due to side sewer breaks or illicit connections or discharges, the City uses regulatory tools such as notices of violation and associated penalties to help remedy the problem in a timely manner.

2.2.1.8 Control 8: Notify the Public

Implement a public notification process to inform the citizens of when and where CSOs occur.



The City, together with King County and Seattle King County Public Health, maintains a sewage overflow notification and posting program. Signs at each outfall identify the outfall and warn of possible sewage overflows. The signs include the phone number for the CSO Hotline, staffed and managed by Seattle King County Public Health. Seattle King County Public Health also provides a website with detailed information about CSOs, potential public health hazards, and precautions the public may take to protect themselves. If sewage overflows occur due to side sewer breaks or illicit connections or discharges, the City posts additional warning signs at impacted waterways until the problem is resolved.

In addition, King County has hosted an overflow website since December 2007, providing notification of recent and current King County CSO overflows. In

Figure 2-1. Example of Outfall Signage

2009, the City began working with King County to incorporate City of Seattle real-time overflow information on the King County site. This work was accomplished in 2011. Now the community is able to access consolidated information to assist in making choices about use of local waters. In 2013, the public notification web pages were viewed 11,736 times, with a peak one-day use of 2,167 views on September 30, 2013. An example of the real-time overflow notification website is shown on Figure 2-2.

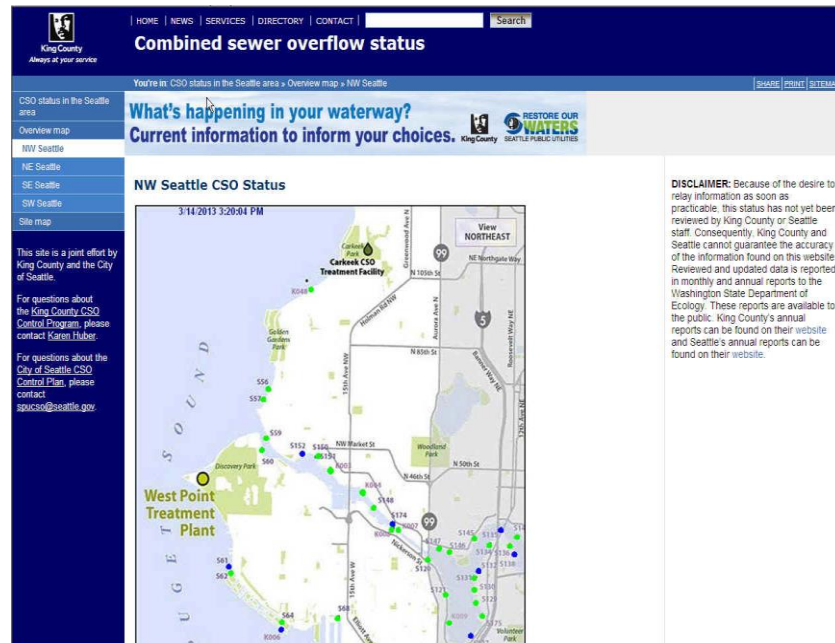


Figure 2-2. King County/SPU Real-Time Overflow Notification Website

2.2.1.9 Control 9: Monitor CSOs

Monitor CSO outfalls to characterize CSOs and the effectiveness of CSO controls.

The City monitors each of its CSO outfalls to detect sewage overflows. The City also tracks the performance of its flow monitors to ensure consistent, high-quality measurements. The flow, precipitation, and flow monitor performance monitoring programs and results are described and summarized in Section 2.4 of this report.

In addition, the City concluded its Seattle Combined Sewer Overflow Supplemental Characterization Study 2010 (Reference 24) that analyzed the constituents in combined sewer overflows.

2.2.2 CMOM Performance Program Plan

The CMOM Performance Program Plan committed the City to completing performance, productivity, and efficiency initiatives in each of the following program areas:

- Planning and scheduling
- Sewer cleaning
- FOG control program
- Repair, rehabilitation, and replacement
- Condition assessment
- SSO response

Work in each of these program areas is described in the City's CSO Annual Report.

2.2.3 Joint Operations and System Optimization Plan

The City's and King County's consent decrees each contain language directing both agencies to work together to develop a single Joint Operations and System Optimization Plan (Joint Plan). In 2013, the Joint Plan team began development of the plan by focusing on understanding the interconnectedness between each agency's systems, each agency's operable facilities, and the greatest areas for optimization opportunities. Highlights of the year include the following:

- Completed a memorandum of understanding committing both agencies to development of the Joint Plan by March 1, 2016
- More than 60 staff – management, technical staff (planners, engineers, modelers), and operators – from each agency participated in 10 educational activities over the course of the year. The educational activities involved facility tours and technical presentations of key operable facilities in each agency's system.
- Shared operational objectives were developed and jointly approved for use, which satisfies the Consent Decree requirement for shared operational objectives for King County Wastewater Treatment Division's (WTD) and Seattle Public Utilities' (SPU) combined systems.
- Divided the combined wastewater system managed by SPU and WTD into 13 planning basins for joint operations analysis. Basins were delineated based on hydrologic and hydraulic parameters, operational strategies, locations of significant operable facilities, and input from technical staff.
- Developed and approved two early actions for implementation – formation of a Joint System Event Debrief Committee and formation of a Joint Operations Information Sharing Team (JOIST)
- Submitted a 2013 Annual Progress Report for the Joint Plan on December 17, 2013, as required by both agencies' consent decrees (Reference 25)

In 2014, the Joint Plan team began development and evaluation of operational alternatives in planning basins where there is the greatest opportunity for operations and system optimization. In addition, more early actions, similar to the Joint System Event Debrief Committee and JOIST, will likely be developed and implemented.

2.3 Description of System

This following sections present a detailed description of the physical characteristics of the CSS and receiving water bodies.

2.3.1 Geographical Area and Climate

The City of Seattle is located in western Washington State between the saltwater Puget Sound (an arm of the Pacific Ocean), to the west, and the freshwater Lake Washington, to the east. To the west, beyond the Puget Sound, are the Kitsap Peninsula and Olympic Mountains on the Olympic Peninsula; to the east, beyond Lake Washington and the eastside suburbs, is the Cascade Range.

The City of Seattle is divided by the Lake Washington Ship Canal, which consists of two man-made canals, Lake Union, and the Hiram M. Chittenden Locks at Salmon Bay, as shown below in Figure 2-3. The population of the City is approximately 620,000, and the area is approximately 84 square miles. The topography of the City is primarily hilly. Land uses within the City are primarily urban (residential, commercial, and industrial).

Seattle typically has moderate, dry summers and mild, wet winters. Regional climate data are reported at Seattle-Tacoma International Airport. Average annual precipitation is 37.1 inches.

The Seattle area experiences three categories of storm types (MGS Engineering Consultants, Inc. (MGS), 2003), as described below:

- Short-duration storms are primarily warm-season events that produce high precipitation intensities over isolated areas; they are often the controlling storm types for sizing conveyance structures in urbanized areas.
- Intermediate-duration storms occur throughout the year but are most common in the fall and early winter. These storms often contain moderate to high precipitation intensities for a period of several hours and precipitation commonly occurs over 6 to 18 hours.
- Long-duration storms are associated with continental-scale weather systems originating over the Pacific Ocean and precipitation occurs over very large areas. Long-duration storms are primarily late fall and winter events, characterized by low to moderate precipitation intensities and durations of 24 hours or more. The long-duration storm is usually the controlling storm type for the design and analysis of stormwater detention facilities where both runoff volume and peak discharge are primary considerations (MGS, 2003).

2.3.2 Existing Wastewater Collection System

The City's wastewater collection system includes gravity sewage pipelines, pump stations, force mains, CSO outfalls, and CSO control facilities. Currently, the collection system includes:

- Approximately 448 miles of sanitary sewer pipes
- Approximately 968 miles of combined sewers
- 68 sewage pump stations
- 5.5 miles of force mains
- 87CSO outfalls
- 38 CSO control detention tanks and pipes
- 28 HydroBrakes
- 3 controlled sluice gates

The pipe diameters range from 4 to 144 inches, of which approximately 62 percent are 8-inch collector pipes. The average age of the City's collection system piping is 75 years. Approximately one-third of the system is combined, one-third partially separated, and one-third fully separated. Figure 2-4 presents the wastewater collection system in the City of Seattle.

The City does not own a wastewater or CSO satellite treatment plant. All the sewage collected in the City's wastewater collection system is conveyed to King County for regional conveyance and treatment or is discharged via one of the CSO outfalls. King County operates three secondary wastewater treatment plants (West Point WWTP, the South WWTP, and the Brightwater WWTP) and four CSO storage and treatment facilities (Alki, Carkeek, Elliott West and Henderson/MLK). Ultimately, the treated wastewater from all of these facilities discharges to either Puget Sound, Elliott Bay, or the Duwamish River.

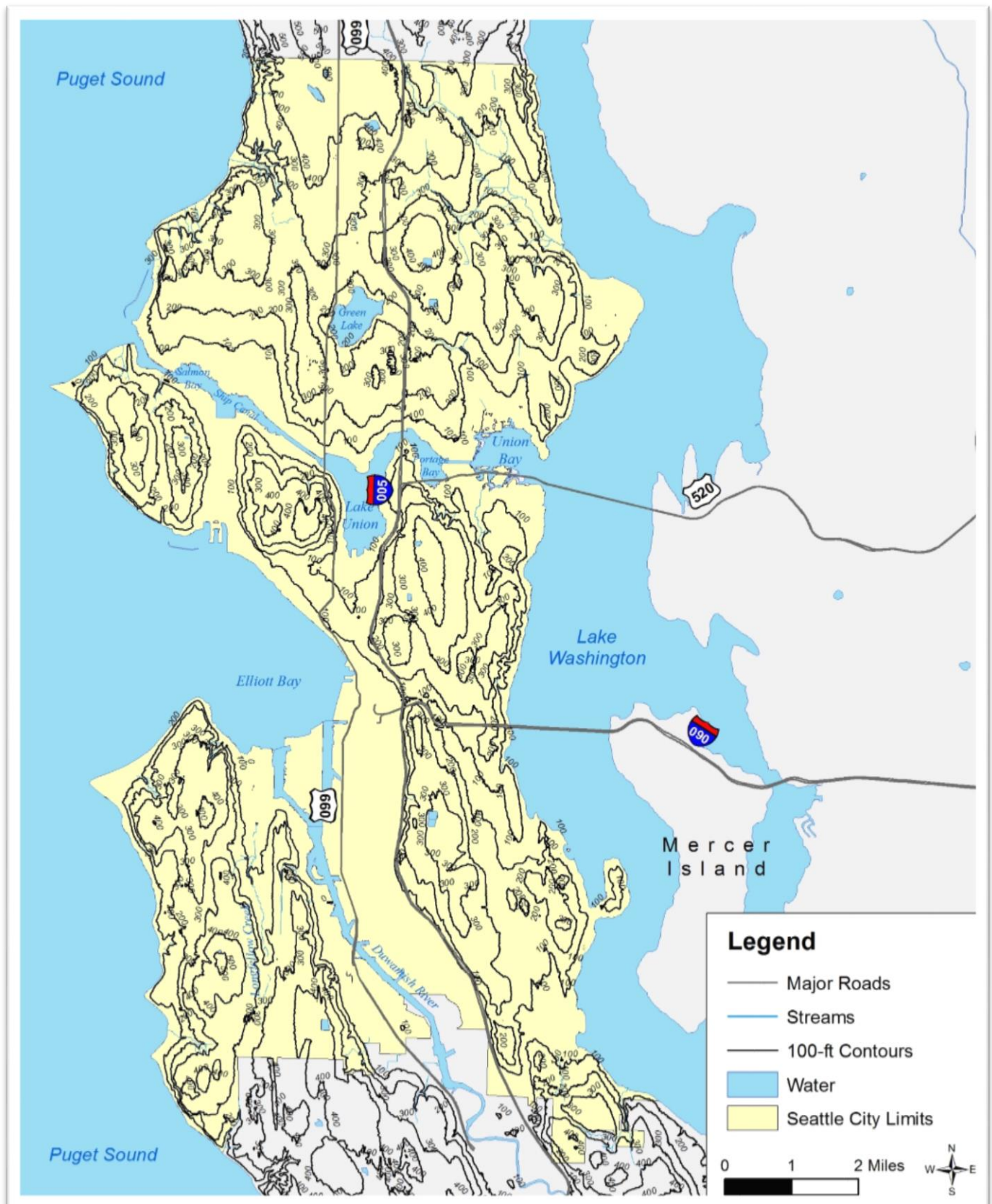


Figure 2-3. Geography and Topography of Seattle

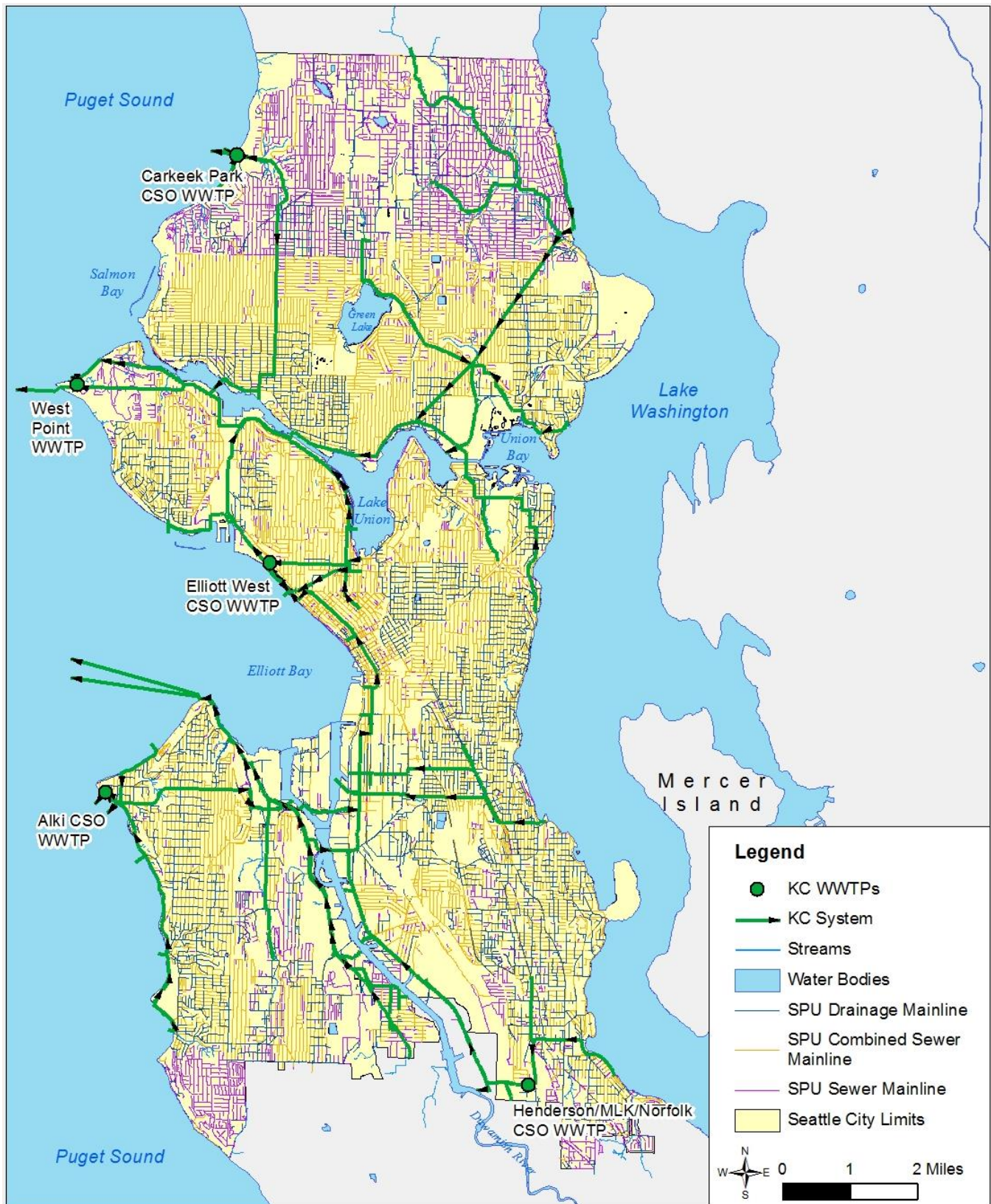


Figure 2-4. Wastewater Collection Systems in Seattle

2.3.3 CSO Outfalls

Table 2-3 presents a list of the City's CSO outfalls and their respective locations.

Table 2-3. CSO Basin Number and Location	
CSO outfall number	Location
012	NE 60th St. at NE Windermere Rd.
013	Windermere Park NE 50th St.
014	55th Ave. NE at NE 43rd St.
015	51st Ave. NE at NE Laurelhurst Ln.
016	Webster Pt NE at W Laurelhurst Dr.
018	38th Ave. NE at NE 41st St.
019	NE 45th St. at Montlake Blvd. NE
020	Shelby St. at E Park Dr.
022	39th Ave. E at E Lakeside Blvd.
024	43rd Ave. E at E Lee St.
025	43rd Ave. E at E Lee St.
026	Denny Blaine Pl. E ^a
027	Lake Washington Blvd.
028	Lake Washington Blvd. E at E Pike St.
029	Lake Washington Blvd. E at E James St.
030	Lake Washington Blvd. E at E Alder St.
031	Lake Washington Blvd. S at S Main St.
032	Lake Washington Blvd. S at S Dearborn St.
033	Lake Washington Blvd. S at S Charles St.
034	Lake Washington Blvd. S at S Charles St.
035	Lake Washington Blvd. S at S Massachusetts St.
036	Lake Washington Blvd. S at S College St.
038	Lake Washington Blvd. S at 45th Ave. S
040	Lake Washington Blvd. S at 49th Ave. S
041	Lake Washington Blvd. S at 50th Ave. S
042	Lake Washington Blvd. S. at S Snoqualmie St.

Table 2-3. CSO Basin Number and Location

CSO outfall number	Location
043	Lake Washington Blvd. S at S Alaska St.
044	Lake Washington Blvd. S south of Juneau St.
045	57th Ave. S at S Brighton St.
046	S Island Dr. at S Grattan St.
047	Seward Park Ave. S at S Henderson St.
048	Rainier Ave. S at S Perry St.
049	Rainier Ave. S at S Cooper St.
057	Seaview Ave. NW at NW 68th St.
059	Seaview Ave. NW at NW 57th St.
060	W Cramer St. at 39th Ave. NW
061	W Ray St. at Logan Ave. W
062	W Ray St. at Logan Ave. W
064	32nd Ave. W at Logan Ave. W
068	W Garfield St. at 17th Ave. W
069	Alaskan Way at Vine St.
070	Alaskan Way at University St.
071	Alaskan Way at Madison St.
072	Alaskan Way S at S Washington St.
078	Harbor Ave. SW at Fairmont Ave. SW
080	Harbor Ave. SW at SW Maryland Pl.
083	Alki Ave. SW at SW Arkansas St.
085	Alki Ave. SW at Point Pl. SW
088	SW Beach Dr. north of SW Bruce St.
090	SW Beach Dr. at Murray Ave. SW
091	Fauntleroy Way SW north of SW Trenton St. in Lincoln Park
094	Fauntleroy Ave. SW north of SW Director St.
095	Fauntleroy Ave. SW at SW Brace Pt Dr.
099	SW Hinds St. at Duwamish River West Waterway
107	SW Hinds St. at Alaskan Way S
111	S Oregon St. at East Duwamish

Table 2-3. CSO Basin Number and Location

CSO outfall number	Location
120	Westlake Ave. N at Aurora Ave. N
121	Westlake Ave. N at Crockett St.
124	Westlake Ave. N south of Aloha St.
127	Fairview Ave. E at Yale Ave. E
129	Fairview Ave. E at E Newton St.
130	Fairview Ave. E. at E. Lynn St.
131	Fairview Ave. E at Louisa St.
132	Fairview Ave. E at E Roanoke St.
134	Fairview Ave. E at E Allison St.
135	Eastlake Ave. E at Portage Bay Pl. E
136	Portage Bay Pl. E at E Allison St.
138	E. Shelby St., Portage Bay
139	16th Ave. E at Louisa St.
140	E Shelby St. at W Park Dr.
141	Brooklyn Ave. NE at Boat St.
144	Latona Ave. NE at NE Northlake Way
145	N 36th St. at NE Northlake Way
146	Carr Pl. N at N Northlake Way
147	Stone Way at Northlake Way
148	8th Ave. NW at NW 41st St.
150/151	24th Ave. NW and NW Market St.
152	28th Ave. NW and NW Market St.
161	NE 65th St. and 65th Ave. NE
165	Lake Washington Blvd. at S Alaska St.
168	Delridge Ave. SW at SW Myrtle St.
169	Between 24th and 25th Ave. SW north of SW Thistle St.
170	27th Ave. SW at SW Webster St.
171	Rainier Ave. S at Ithaca Pl. S
174	NW 36th St. at 2nd Ave. NW
175	E Garfield St. at Fairview Ave. E

a Outfall was abandoned I on 9/9/14.

Figure 2-5 is a map of the basins listed in the previous table.

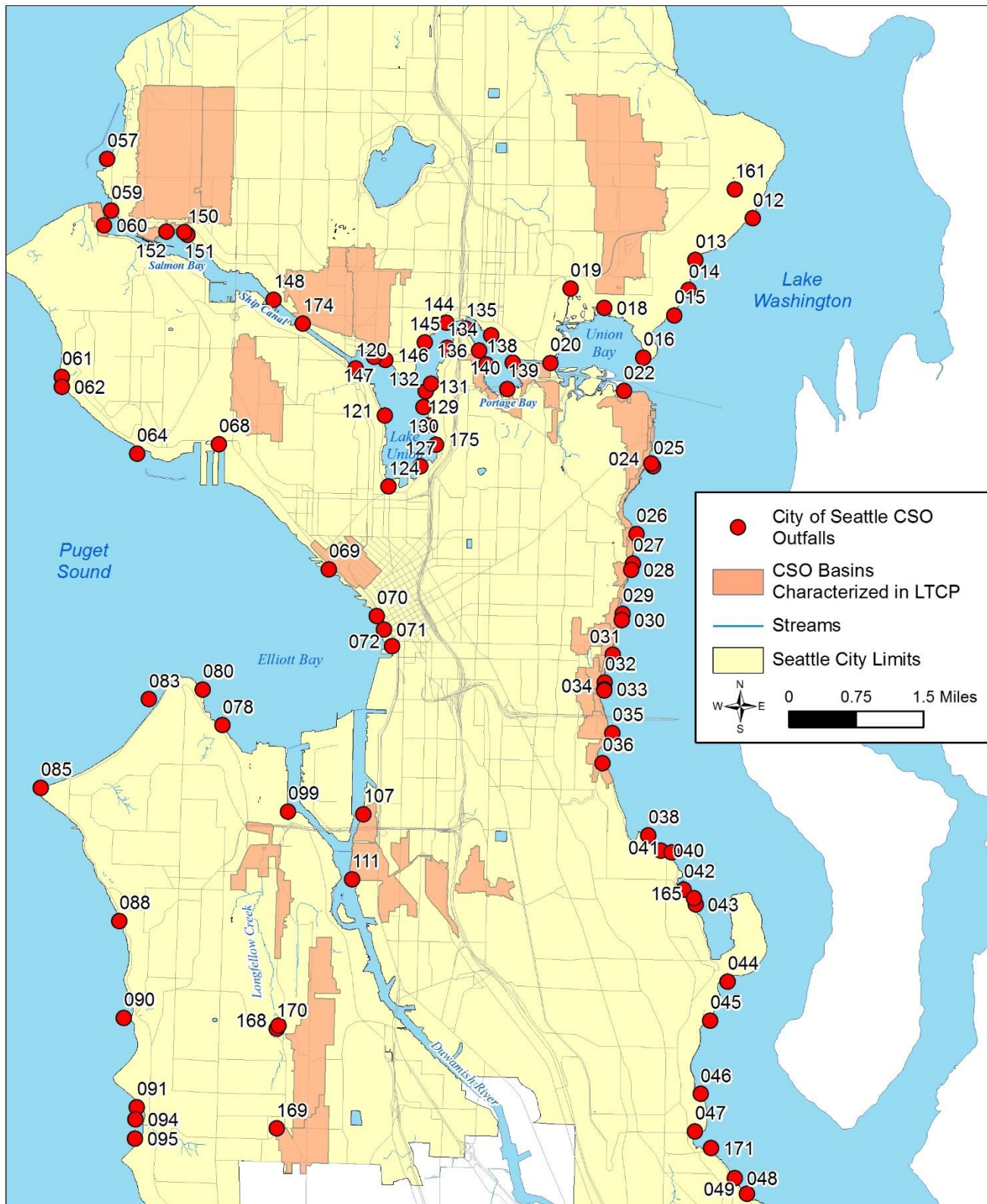


Figure 2-5. Locations of the City's CSO Outfalls

2.3.4 CSO Basin Delineation

The City's combined sewer system is divided into 19 CSO areas: Ballard, Central Waterfront, Delridge/Longfellow, Duwamish, East Waterway, Fremont/Wallingford, Genesee, Henderson, Interbay, Lake Union North, Lake Union West, Leschi, Madison Park/Union Bay, Magnolia, Montlake, North Union Bay, Portage Bay, West Seattle, and Windermere. These CSO areas are further subdivided into CSO basins that are delineated based on the tributary area to each individual CSO outfall. The 13 CSO areas included in the LTCP system characterization are presented in Figure 2-6.

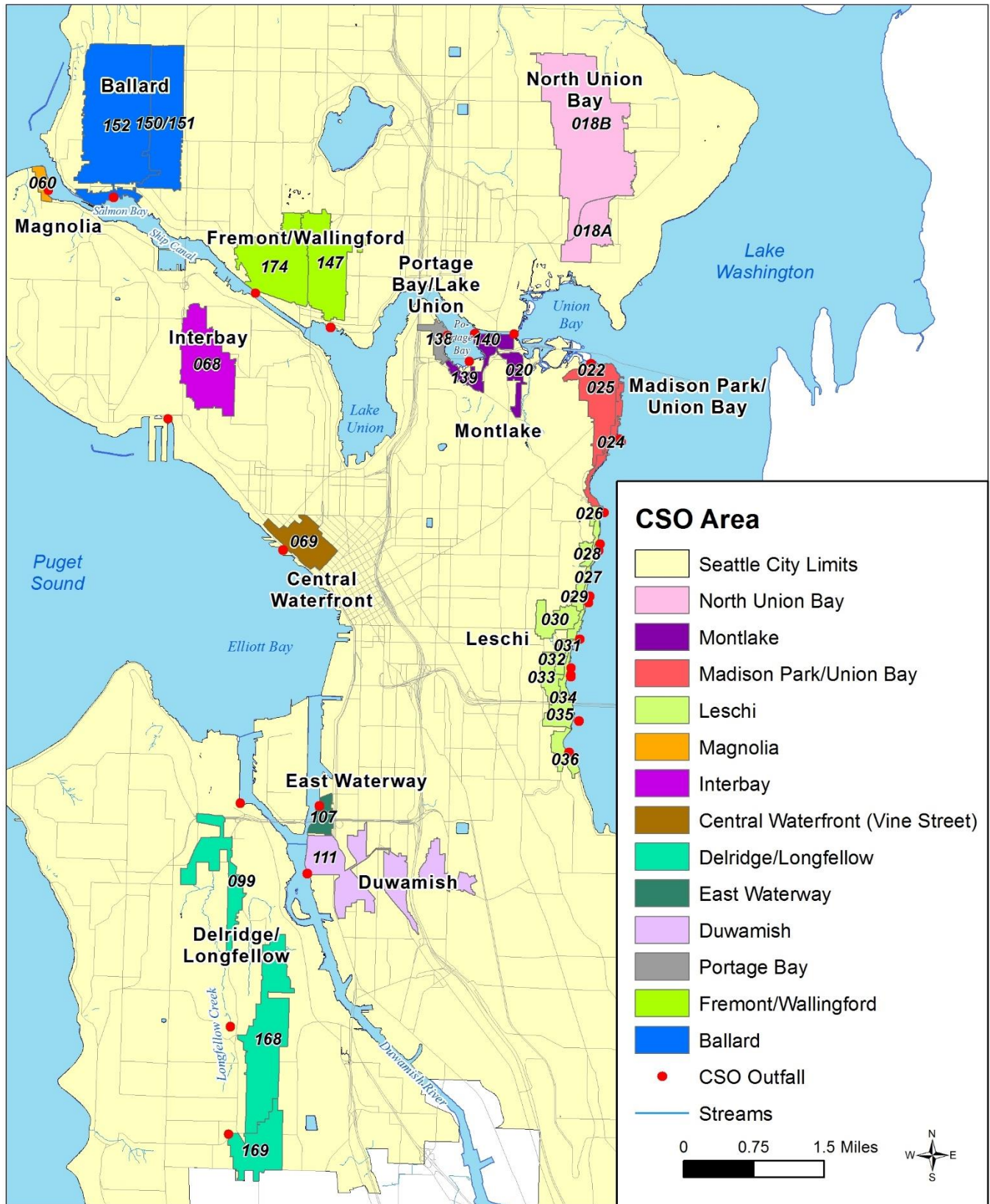


Figure 2-6. CSO Areas Included in the LTCP System Characterization

2.3.5 CSO Areas of LTCP Outfalls

Table 2-4 presents all of the LTCP CSO basins within each CSO area.

Table 2-4. Comparison of LTCP CSO Areas and LTCP CSO Basin Outfalls	
CSO area	CSO basins and outfalls
Ballard	2 basins: 150/151, 152
Central Waterfront	1 basin: 069
Delridge/Longfellow	3 basins: 099, 168, 169
Duwamish	1 basin: 111
East Waterway	1 basin: 107
Fremont/Wallingford	2 basins: 147, 174
Interbay	1 basin: 068
Leschi	11 basins: 026, 027, 028, 029, 030, 031, 032, 033, 034, 035, 036
Madison Park/Union Bay	3 basins: 022, 024, 025
Magnolia	1 basin: 060
Montlake	3 basins: 020, 139, 140
North Union Bay	1 basin: 018
Portage Bay/Lake Union	1 basins: 138

The following subsections describe the existing wastewater collection system in each of the 13 LTCP CSO areas.

2.3.6 LTCP CSO Areas

2.3.6.1 Ballard CSO Area

The Ballard CSO area covers 1,170 acres (1.8 square miles) in northwest Seattle; it is bounded approximately by 30th Avenue NW to the west, 15th Avenue NW to the east, NW 85th Street to the north, and the Lake Washington Ship Canal and Salmon Bay to the south (see Figure 2-7). The Ballard CSO area comprises CSO Basins 150/151 and 152 that drain from north to south toward the Lake Washington Ship Canal and Salmon Bay. The CSO Basin 150/151 has a single overflow point, but the outfall divides into two branches, each with its own designation. The wastewater generated in these basins flows by gravity to King County's Ballard siphon for conveyance to the West Point Wastewater Treatment Plant (WWTP).

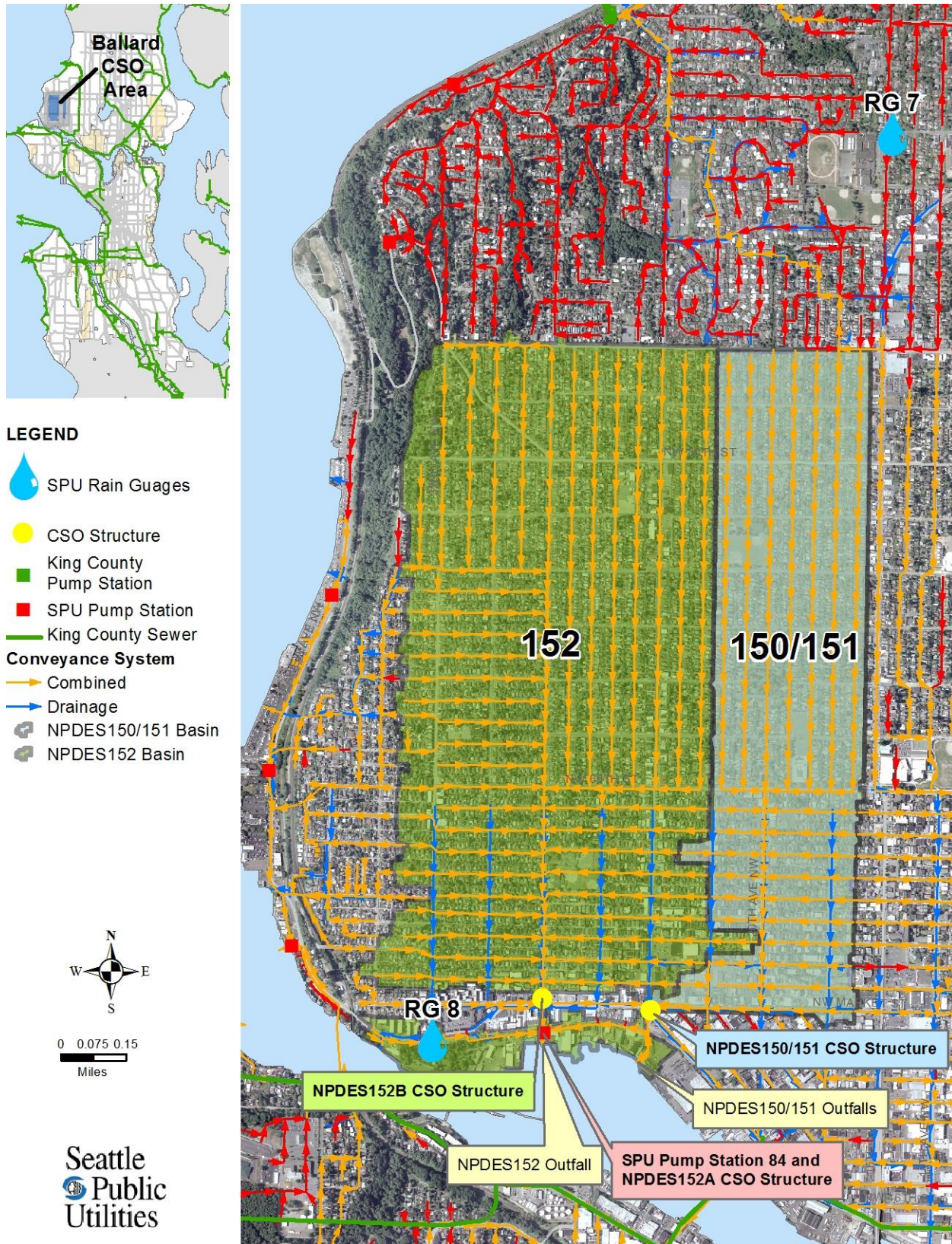


Figure 2-7. Overview of the Ballard CSO Area

The CSS in the Ballard CSO area conveys both sanitary and stormwater flow. The area to the north of NW 65th Street (about two-thirds of the total area) is fully combined. The area south of NW 65th Street is partially separated. Storm sewers collect and convey street runoff and a portion of private property runoff. Stormwater from partially separated areas of the Ballard CSO area is discharged into the ship canal and Salmon Bay. CSO Basins 150/151 and 152 contain permitted CSO structures that discharge overflows to Salmon Bay during large precipitation events when the capacity of the CSS is exceeded. Salmon Bay is located on the freshwater side of the Hiram M. Chittenden Locks.

Table 2-5 presents a summary of the key components of the wastewater collection system in the Ballard CSO area.

Table 2-5. Summary of Sewer Pipe in the Ballard CSO Area	
Component	Description
Length of pipe (LF)	186,000
Diameter range	6" to 48"
Number of connecting structures	750+
City pump stations	1 (PS84)
HydroBrakes	None
Storage facilities	None

2.3.6.2 Central Waterfront (Vine Street)

The Vine Street CSO area is located in the northern part of downtown Seattle near the waterfront. The area encompasses 150 acres (0.23 square mile) and is bounded approximately by Denny Way to the north, Bay Street to the northwest, 5th and 4th Avenues to the north and east, and Alaskan Way to the south and west (see Figure 2-8.). The Vine Street CSO area is included in the larger Central Waterfront CSO area, which includes four CSO outfalls and their respective CSO Basins: 069 (Vine), 070, 071, and 072. The LTCP focuses on CSO Basin 069. Note that the control of CSO Basins 070, 071, and 072 is being planned for as part of broader planning for the City of Seattle's central waterfront. Flow from CSO Basin 069 drains to the King County Elliott Bay Interceptor for conveyance, treatment, and discharge at the West Point WWTP.

The CSS in CSO Basin 069 conveys both sanitary and stormwater flow. Areas north and east of the BNSF Railroad tracks (adjacent to Alaskan Way) are fully combined. Storm sewers collect runoff from roadway areas along Alaskan Way and discharge into Elliott Bay, but these pipes are not included in the model. CSO Basin 069 contains a permitted CSO structure that discharges overflows to Elliott Bay in large precipitation events when the capacity of the CSS is exceeded.

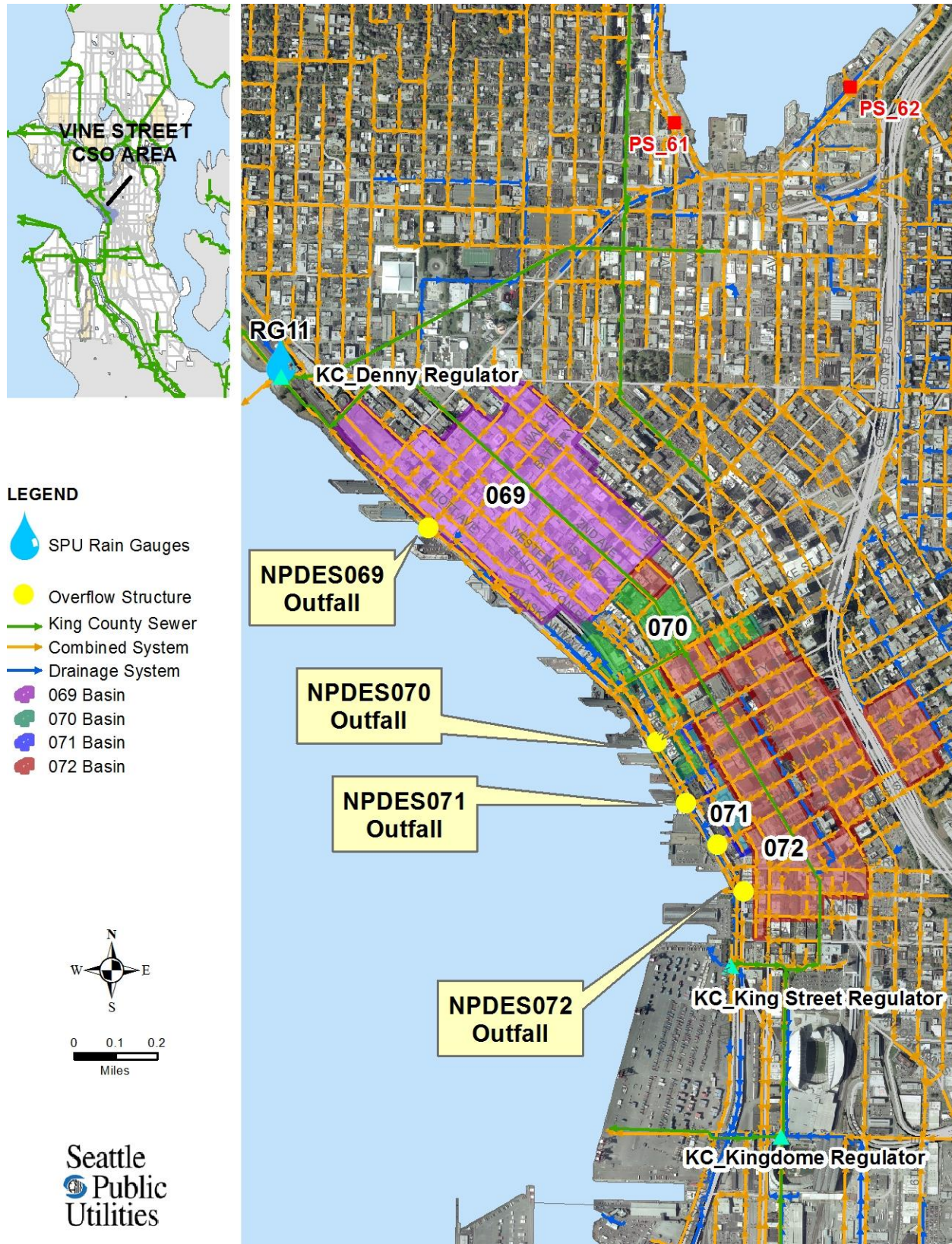


Figure 2-8. Overview of the Central Waterfront CSO Area

Table 2-6 presents a summary of the key components of the wastewater collection system in the 069 basin.

Table 2-6. Summary of Sewer Pipe in the Central Waterfront CSO Area	
Component	Description
Length of pipe (LF)	23,000
Diameter range	4" to 48"
Number of connecting structures	660+
City pump stations	None
HydroBrakes	None
Storage facilities	None

2.3.6.3 Delridge/Longfellow

The Delridge/Longfellow CSO area, located in West Seattle along Longfellow Creek, comprises CSO Basins 099, 168, 169, and 170, as shown in Figure 2-9. The total area is approximately 705 acres. The four basins are geographically separated and hydraulically independent. They individually discharge into the King County system through King County's Delridge trunk line along 26th Avenue SW, which runs from south to north through the basin. CSO Basin 170 is controlled and is not included in the LTCP.

The CSS in the Delridge/Longfellow Area conveys both sanitary and stormwater flow. CSO Basins 169 and 170 are nearly fully combined. CSO Basins 168 and 169 are partially separated. Storm sewers collect and convey street runoff and a portion of private property runoff in the combined areas. Stormwater from the partially separated areas is conveyed to Longfellow Creek for CSO Basins 168, 169, and 170. CSO Basin 99 stormwater from the partially separated areas discharges to the Duwamish River at the north end of the basin. All four CSO basins contain permitted CSO structures that discharge overflows to either Longfellow Creek or the Duwamish River during large precipitation events when the capacity of the CSS is exceeded.

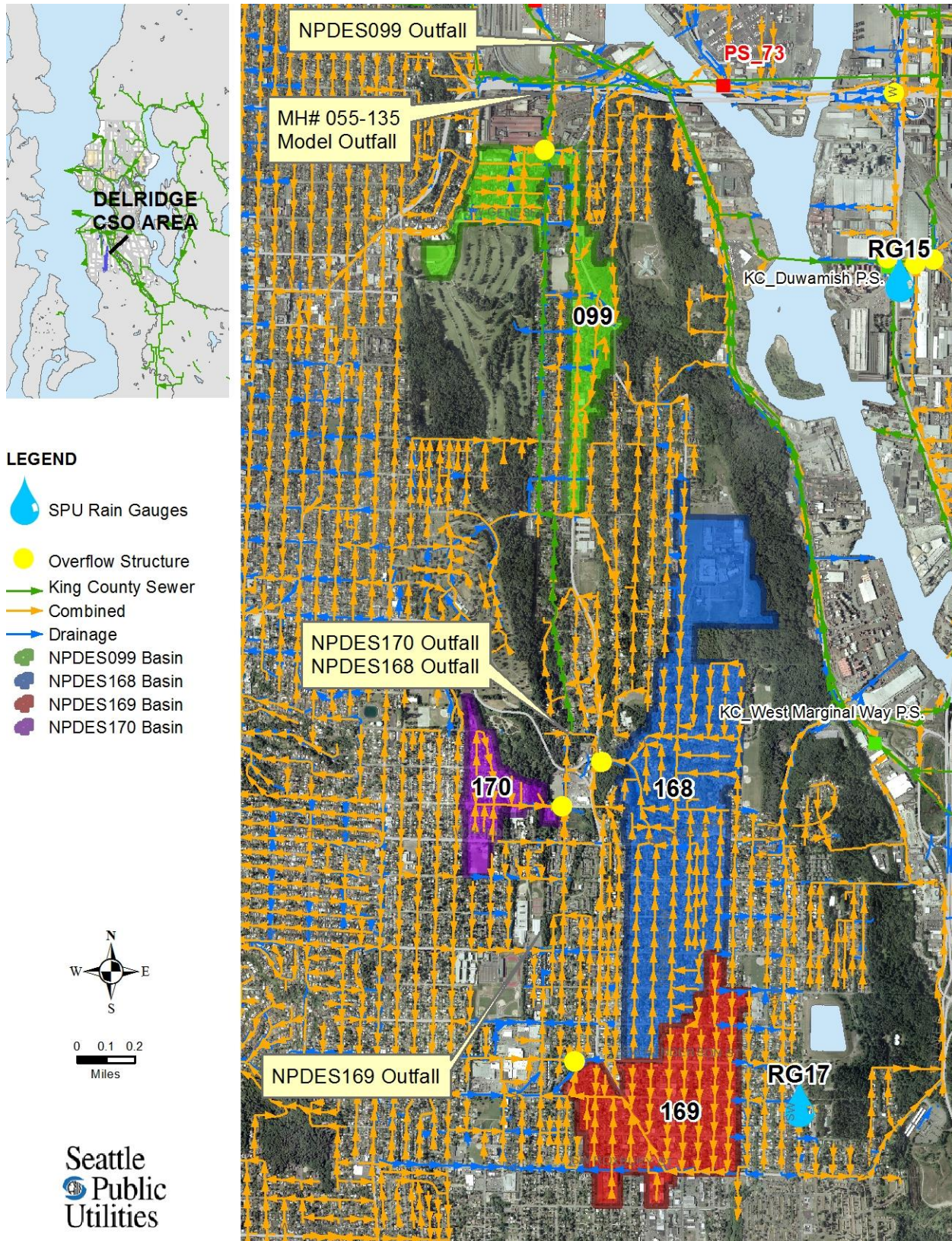


Figure 2-9. Overview of the Delridge/Longfellow CSO Area

Table 2-7 presents a summary of the key components of the wastewater collection system in the Delridge/Longfellow CSO area.

Table 2-7. Summary of Sewer Pipe in the Delridge/Longfellow CSO Area	
Component	Description
Length of pipe (LF)	114,000
Diameter range	8" to 96"
Number of connecting structures	710+
City pump stations	None
HydroBrakes	4 Basins (099, 168, 169, 170)
Storage facilities	CSO Basin 099 – 0.16 MG storage pipe CSO Basin 168 – 1.6 MG storage tank CSO Basin 169 – 1.6 MG storage tank CSO Basin 170 – 0.2 MG storage pipe

2.3.6.4 Duwamish

The Duwamish CSO area covers 487 acres (0.68 square mile) in southeast Seattle; it is bounded by S Hanford Street to the north, the Duwamish River to the west, S Hudson Street to the south, and Beacon Hill to the east (see Figure 2-10). The Duwamish CSO area comprises CSO Basin 111. Basin 111 drains from east to west toward the Duwamish River where there is a single overflow point. The wastewater generated in this basin flows by gravity to King County's Duwamish pump station (at the corner of Diagonal Avenue S and E Marginal Way S) for conveyance to the West Point WWTP.

The CSS in the Duwamish CSO area conveys both sanitary and stormwater flow. The area is partially separated. Storm sewers collect and convey street runoff and a portion of private property runoff. Stormwater from partially separated areas of the Duwamish CSO area is discharged into the Duwamish River. The single permitted outfall for CSO Basin 111 contains eight individual CSO structures (A–H), two of which (111E and 111F) have been plugged and no longer overflow. The remaining active CSO structures discharge overflows to the Diagonal Avenue storm drain and thence to the Duwamish River during large precipitation events when the capacity of the CSS is exceeded.

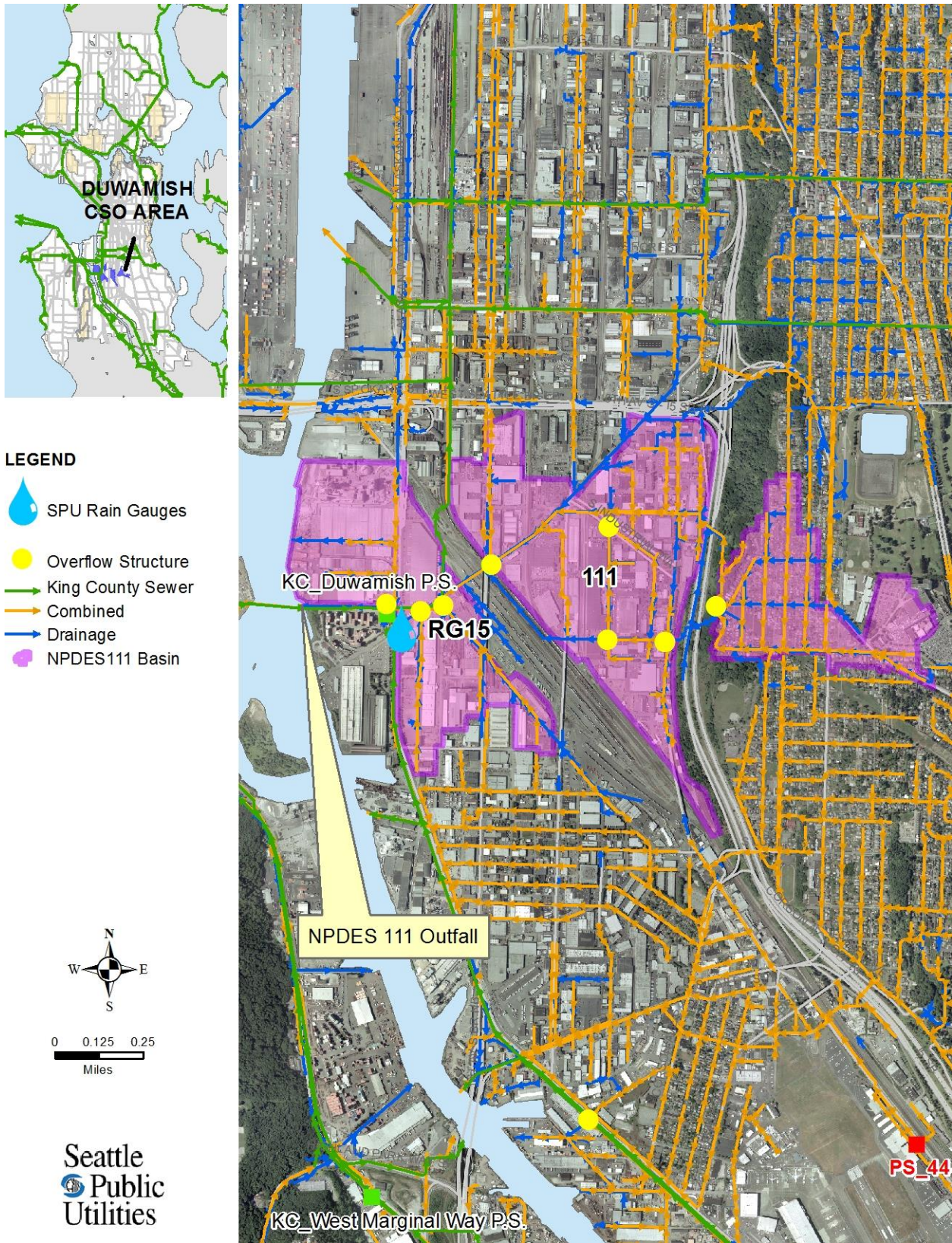


Figure 2-10. Overview of the Duwamish CSO Area

Table 2-8 presents a summary of the key components of the wastewater collection system in the Duwamish CSO area.

Table 2-8. Summary of Sewer Pipe in the Duwamish CSO Area	
Component	Description
Length of pipe (LF)	49,000
Diameter range	8" to 54"
Number of connecting structures	320+
City pump stations	None
HydroBrakes	1 Basin 111(H)
Storage facilities	CSO Basin 111(H) – 0.12 MG storage facility

2.3.6.5 Fremont/Wallingford

The Fremont/Wallingford CSO area covers 657 acres (1.0 square mile) in north Seattle; it is bounded approximately by Woodlawn Avenue N to the east, Lake Union and the Lake Washington Ship Canal to the south and west, and the Woodland Park Zoo to the north (see Figure 2-11). The Fremont/Wallingford CSO area comprises CSO Basins 147, 148, and 174, which drain from north to south toward Lake Union and the Lake Washington Ship Canal. CSO Basin 147 has two overflow points (147(A) and 147(B)), that discharge to a single outfall. Both CSO Basins 148 and 174 have an individual overflow point and outfall. CSO Basin 148 discharges via a pump station to CSO Basin 17. The wastewater generated in these basins flows by gravity to King County's North Interceptor for conveyance to the West Point WWTP. CSO Basin 148 is considered controlled and is not included in the LTCP.

The CSS in the Fremont/Wallingford CSO area conveys both sanitary and stormwater flow. The majority of the Fremont/Wallingford CSO area is partially separated. The area to the west of Stone Way N is mostly partially separated. Storm sewers collect and convey street runoff and a portion of private property runoff. Stormwater runoff from portions of CSO Basin 148 and a few localized areas of CSO Basin 174, (that are west of Stone Way N), and areas to the east of Stone Way N drain to the combined system. Stormwater from partially separated areas of the Fremont/Wallingford CSO area is discharged into the ship canal. CSO Basins 147 and 174 contain permitted CSO structures that discharge overflows to Lake Union and the Lake Washington Ship Canal during large precipitation events when the capacity of the CSS is exceeded or when the King County North Interceptor levels are high.

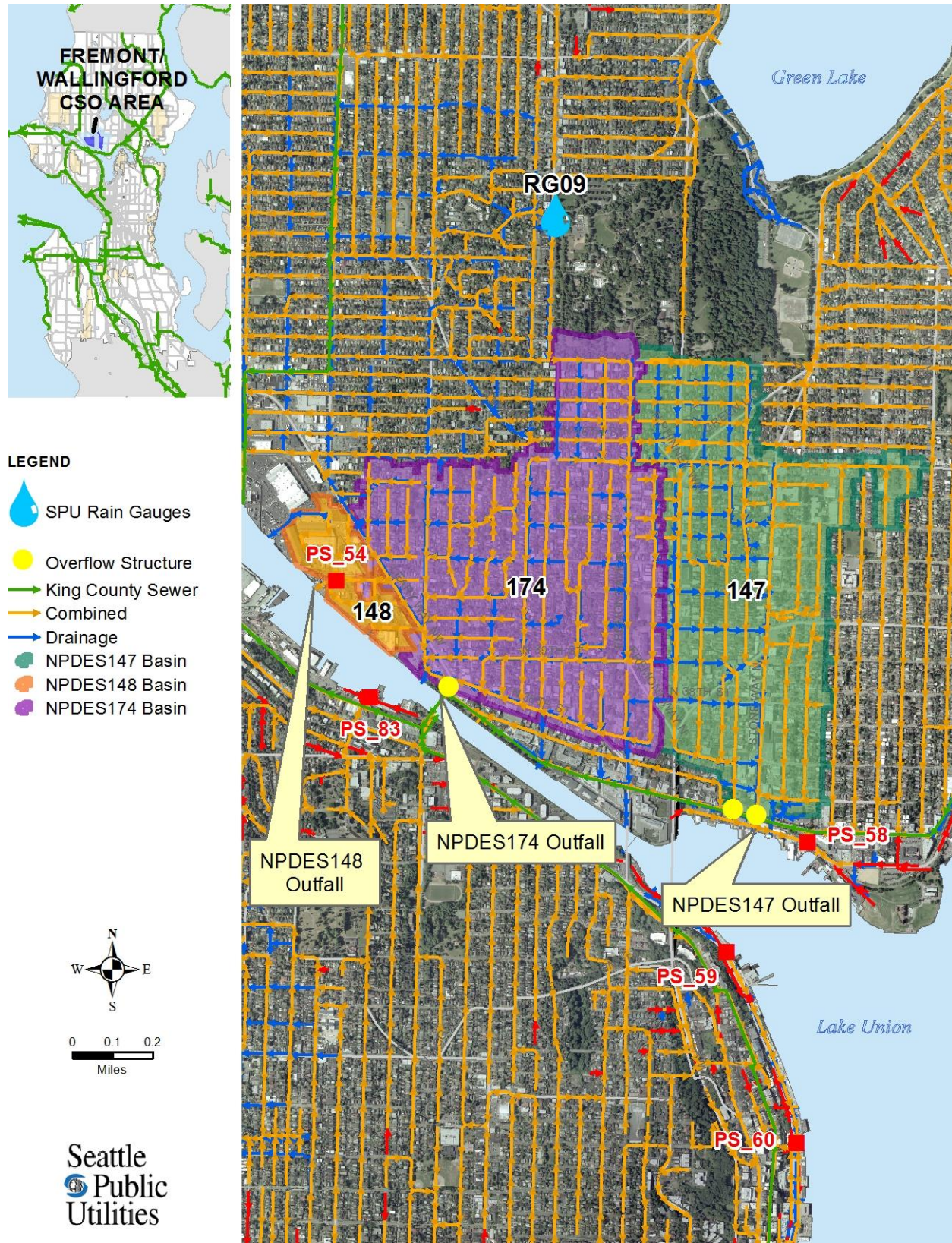


Figure 2-11. Overview of the Fremont/Wallingford CSO Area

Table 2-9 presents a summary of the key components of the wastewater collection system in the Fremont/Wallingford CSO area.

Table 2-9. Summary of Sewer Pipe in the Fremont/Wallingford CSO Area	
Component	Description
Length of pipe (LF)	125,000
Diameter range	8" to 54"
Number of connecting structures	640+
City pump stations	1 (PS54)
HydroBrakes	None
Storage facilities	None

2.3.6.6 Interbay

The Interbay CSO area covers 290 acres (0.45 square mile) in northwest Seattle; it lies on the west side of Queen Anne to the east of the Interbay railroad yards (see Figure 2-12). The wastewater generated in these basins flows by gravity to King County's North Interceptor for conveyance to the West WWTP. Each basin has a single overflow structure: CSO Basins 68(A) and 68(B). During large precipitation events, when the capacity of the CSS is exceeded, the flows discharge through these overflow structures into a storm drain and the combined flows overflow through CSO Outfall 068.

The CSS in the Interbay CSO area conveys both sanitary and stormwater flow. Just over three-fourths of the Interbay CSO area is partially separated. Storm sewers collect and convey street runoff and private property runoff. Stormwater from partially separated areas of the Interbay CSO area is discharged into Elliott Bay.

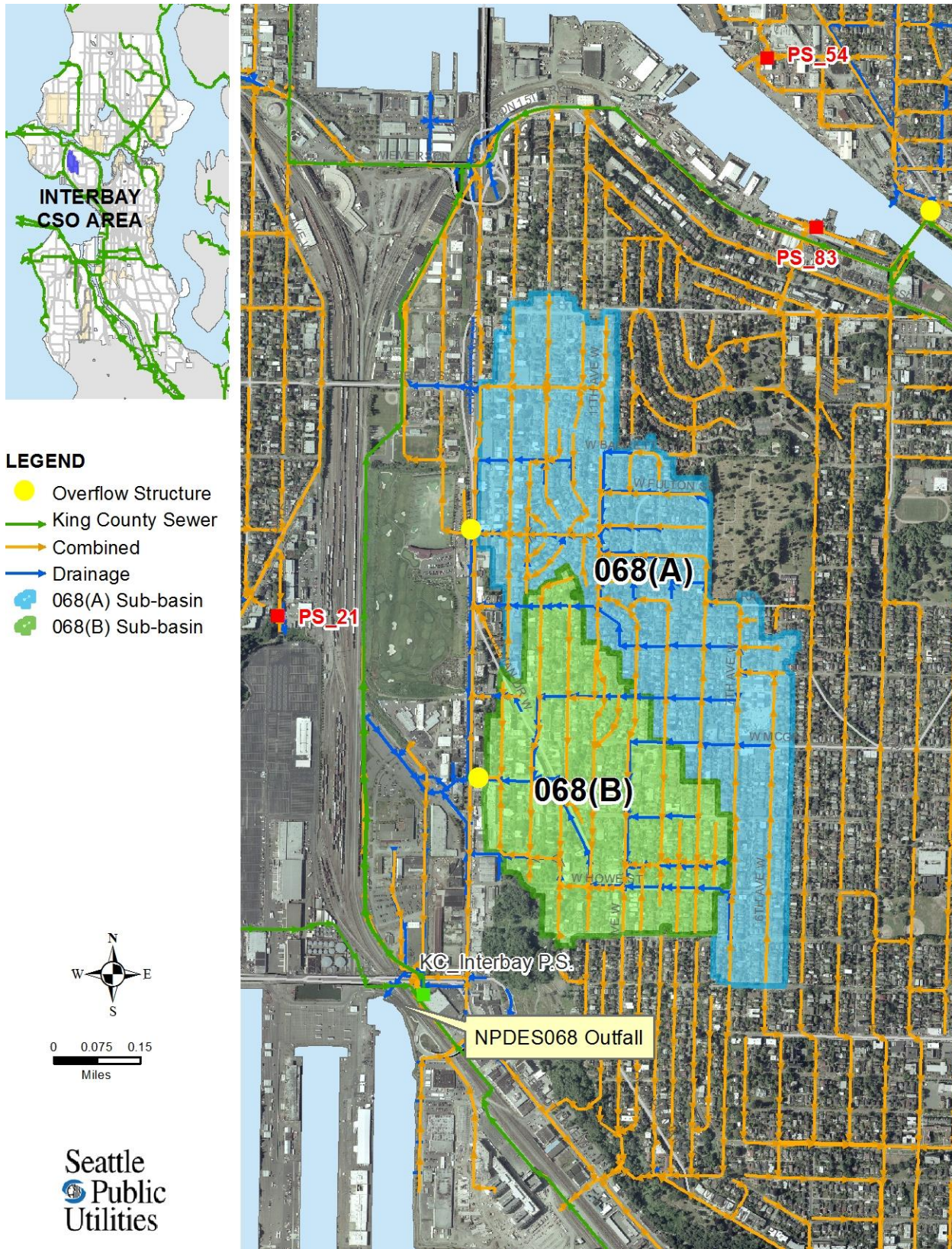


Figure 2-12. Overview of the Interbay CSO Area

Table 2-10 presents a summary of the key components of the wastewater collection system in the Interbay CSO area.

Table 2-10. Summary of Sewer Pipe in the Interbay CSO Area	
Component	Description
Length of pipe (LF)	65,000
Diameter range	8" to 72"
Number of connecting structures	500+
City pump stations	None
HydroBrakes	2 Basins 068(A) and (B)
Storage facilities	CSO Basin 068(A) - 0.30 MG storage pipe CSO Basin 068(B) – 0.12 MG storage pipe

2.3.6.7 Leschi

The Leschi CSO area covers 405 acres (0.63 square mile) in east Seattle; it is located on the western shore of Lake Washington along Lake Washington Boulevard from approximately S McClellan Street to E John Street (see Figure 2-13). The Leschi CSO area, comprised of CSO Basins 026 through 036, drains from south to north toward the King County East Pine Street pump station, with the exception of CSO Basin 026, which drains from north to south.

CSO Basin 032 has two overflow points; each has its own CSO designation (032(A) and 032(B)), but they share a common outfall. CSO Basins 33 and 34 have separate overflow points. The wastewater generated in all the Leschi basins flows by gravity to King County's East Pine Street PS for conveyance to the West Point WWTP.

The CSS in the Leschi CSO area conveys both sanitary and stormwater flow. The Leschi CSO area is partially separated. Storm sewers collect and convey street runoff and a portion of private property runoff. Stormwater from partially separated areas of the Leschi CSO area is discharged into Lake Washington. The basins within the Leschi CSO area contain permitted CSO structures that discharge overflows to Lake Washington during large precipitation events when the capacity of the CSS is exceeded.

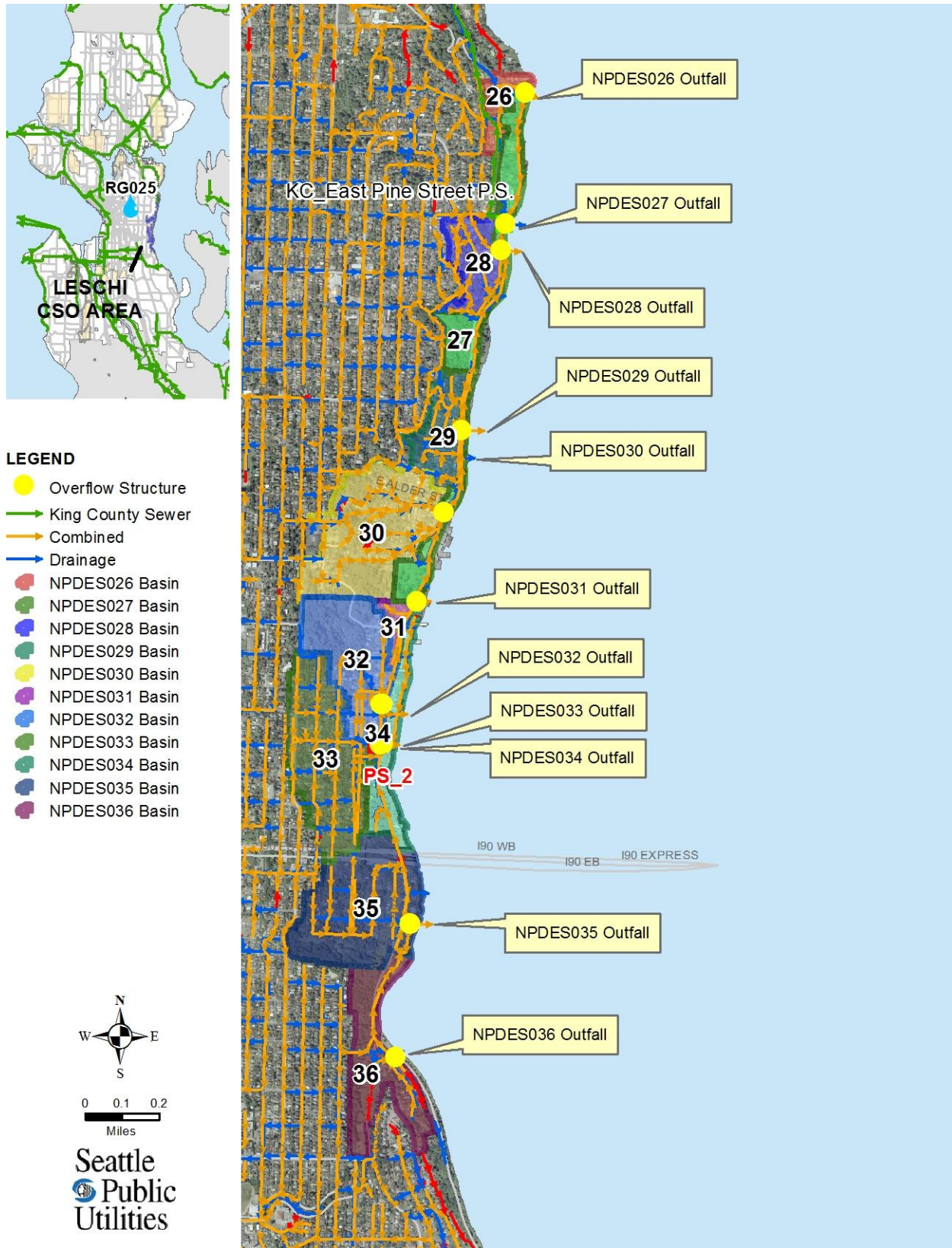


Figure 2-13. Overview of the Leschi CSO Area

Table 2-11 presents a summary of the key components of the wastewater collection system in the Leschi CSO area.

Table 2-11. Summary of Sewer Pipe in the Leschi CSO Area	
Component	Description
Length of pipe (LF)	72,000
Diameter range	8" to 48"
Number of connecting structures	450+
City pump stations	1 (PS2)
HydroBrakes or sluice gates	6 Basins (029, 032, 033, 030, 035, 036)
Storage facilities	CSO Basin030 – 0.02 MG in-line storage pipe CSO Basin034 – 0.04 MG offline storage pipe CSO Basin035 – 0.01 MG offline storage pipe

2.3.6.8 Madison Park/Union Bay

The Madison Park/Union Bay CSO area covers 240 acres (0.4 square mile) in east Seattle; it is bounded approximately by Lake Washington to the east, Union Bay to the north, and the Leschi CSO area to the south (see Figure 2-14). The Madison Park/Union Bay CSO area comprises CSO Basins 022, 024, and 025, which drain generally toward Union Bay and Lake Washington. The wastewater generated in these basins flows to the City's PS 7, and is then pumped to King County's South Lake Washington trunk line for conveyance to the West Point WWTP.

The CSS in the Madison Park/Union Bay CSO area conveys both sanitary and stormwater flow. Apart from a small area in the south of CSO Basin 024, the entire area is partially separated. Storm sewers collect and convey street runoff and a portion of private property runoff. Stormwater from partially separated areas of the Madison Park/Union Bay CSO area is discharged into Union Bay and Lake Washington. CSO Basins 022, 024, and 025 contain permitted CSO structures that discharge overflows to Union Bay and Lake Washington during large precipitation events when the capacity of the CSS is exceeded.

This CSO area is now controlled and is no longer a part of the LTCP.

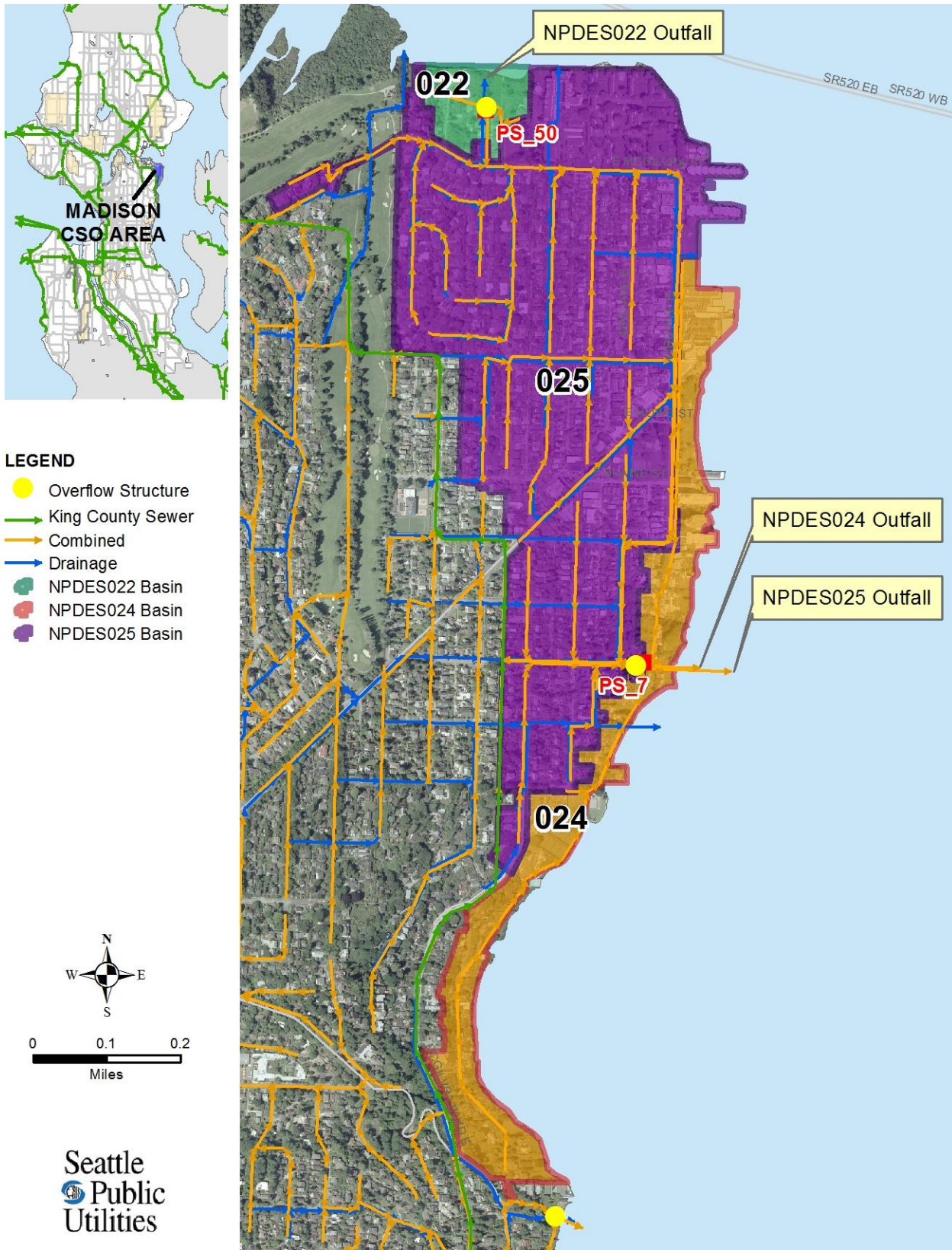


Figure 2-14. Overview of the Madison Park/Union Bay CSO Area

Table 2-12 presents a summary of the key components of the wastewater collection system in the Madison Park/Union Bay CSO area.

Table 2-12. Summary of Sewer Pipe in the Madison Park/Union Bay CSO Area	
Component	Description
Length of pipe (LF)	41,500
Diameter range	6" to 54"
Number of connecting structures	190+
City pump stations	2 (PS7, PS50)
HydroBrakes	None
Storage facilities	025 – 0.08 MG in-line storage pipe

2.3.6.9 Montlake CSO Area

The Montlake CSO area covers 140 acres (0.2 square mile) in east Seattle; it is bounded approximately by the Lake Washington Ship Canal to the north, Portage Bay to the north and west, Delmar Drive E and Boyer Avenue E to the south, and Lake Washington Boulevard E and Union Bay to the east (see Figure 2-15). The Montlake CSO area comprises CSO Basins 020, 139 and 140. The flows from CSO Basins 139 and 140 drain to the City's PS 25, from which they are pumped into the Montlake gravity system that then flows into the King County South Lake Washington trunk line. Flows from CSO Basin 020 drain to the City's pump station 13, from which they are pumped to King County's South Lake Washington trunk line for conveyance, treatment, and discharge at the West Point WWTP.

The CSS in the Montlake CSO area conveys both sanitary and stormwater flow. CSO Basin 140 and CSO Basin 020 north of Highway 520 (about 30 percent of the total area) are fully combined. CSO Basin 139 and CSO Basin 020 south of Highway 520 are partially separated. Storm sewers collect and convey street runoff and a portion of private property runoff. Stormwater from partially separated areas of the Montlake CSO area is discharged into the Ship Canal and Union Bay. The Montlake CSO area includes three permitted CSO outfalls that discharge overflows to the Ship Canal during precipitation events when the capacity of the CSS is exceeded.

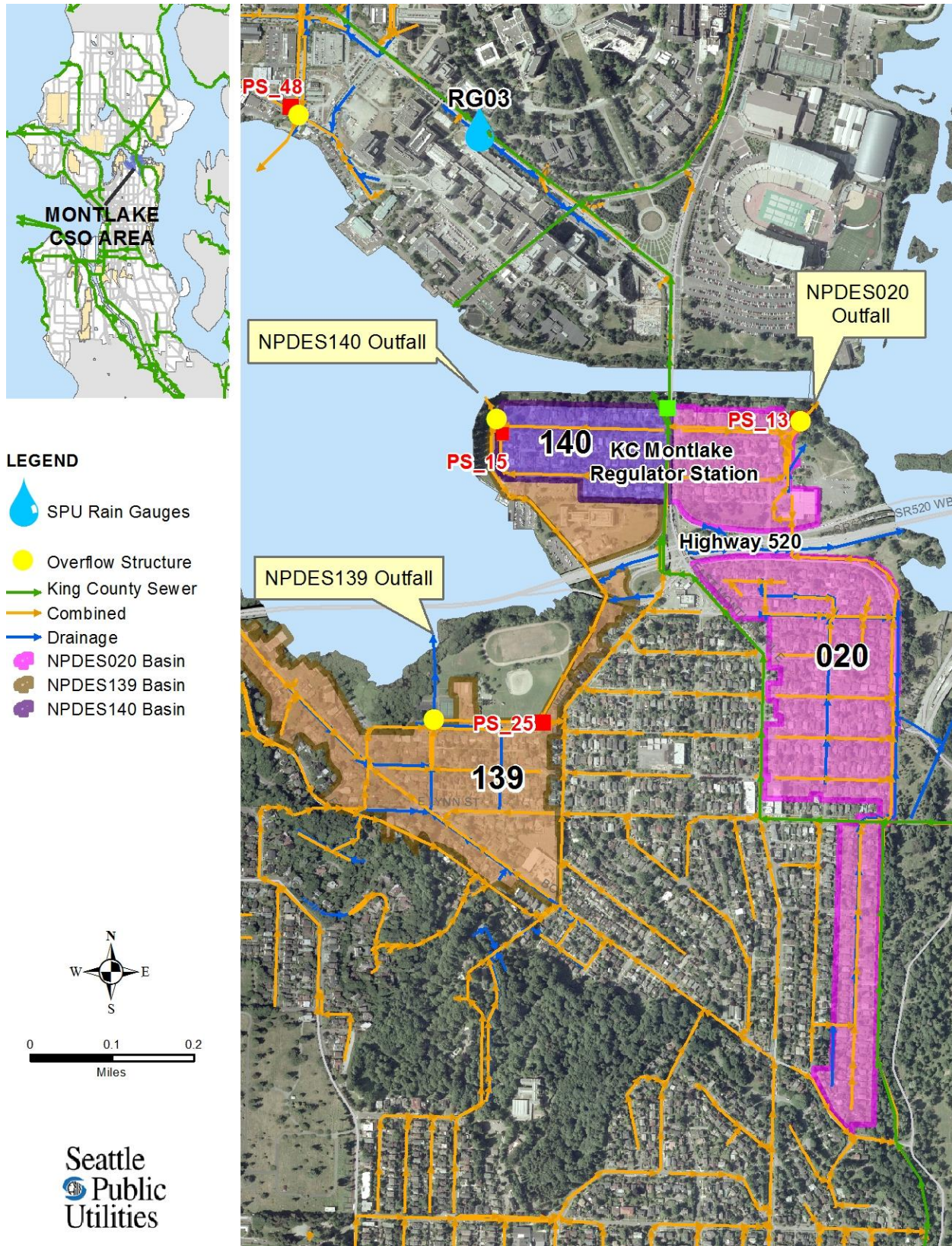


Figure 2-15. Overview of the Montlake CSO Area

Table 2-13 presents a summary of the key components of the wastewater collection system in the Montlake CSO area.

Table 2-13. Summary of Sewer Pipe in the Montlake CSO Area	
Component	Description
Length of pipe (LF)	26,600
Diameter range	4" to 120"
Number of connecting structures	150+
City pump stations	3 (PS13, PS15, PS25)
HydroBrakes	1 Basin (140)
Storage facilities	CSO Basin 020 – 0.12 MG offline storage pipe CSO Basin 140 – 0.02 MG offline storage pipe

2.3.6.10 North Union Bay

The North Union Bay CSO area covers approximately 900 acres (1.4 square miles) in northeast Seattle; it is bounded approximately by NE 85th Street to the north and NE 41st Street to the south. The western boundary generally runs between 30th and 35th Avenues NE and the eastern boundary runs between 45th and 50th Avenues NE (see Figure 2-16). The North Union Bay CSO area includes CSO Basin 018, which drains from north to south toward Union Bay and Lake Washington. CSO Basin 018 has two overflow points, designated 18(A) and 018(B). CSO Basin 018(B) overflows are conveyed downstream in the storm drainage system. Overflows from 18(A) enter the same storm drainage system and together the overflows are conveyed to a single outfall into Union Bay. The wastewater generated in these basins flows by gravity to King County's Laurelhurst trunk for conveyance to the West Point WWTP. The CSS in the North Union Bay CSO area conveys both sanitary and stormwater flow. Most of the basin contains storm sewers and is considered partially separated. The fully combined subcatchments are distributed in pockets throughout the area, with the largest concentration in the northern and northeastern parts of the area (i.e., north of NE 75th Street).

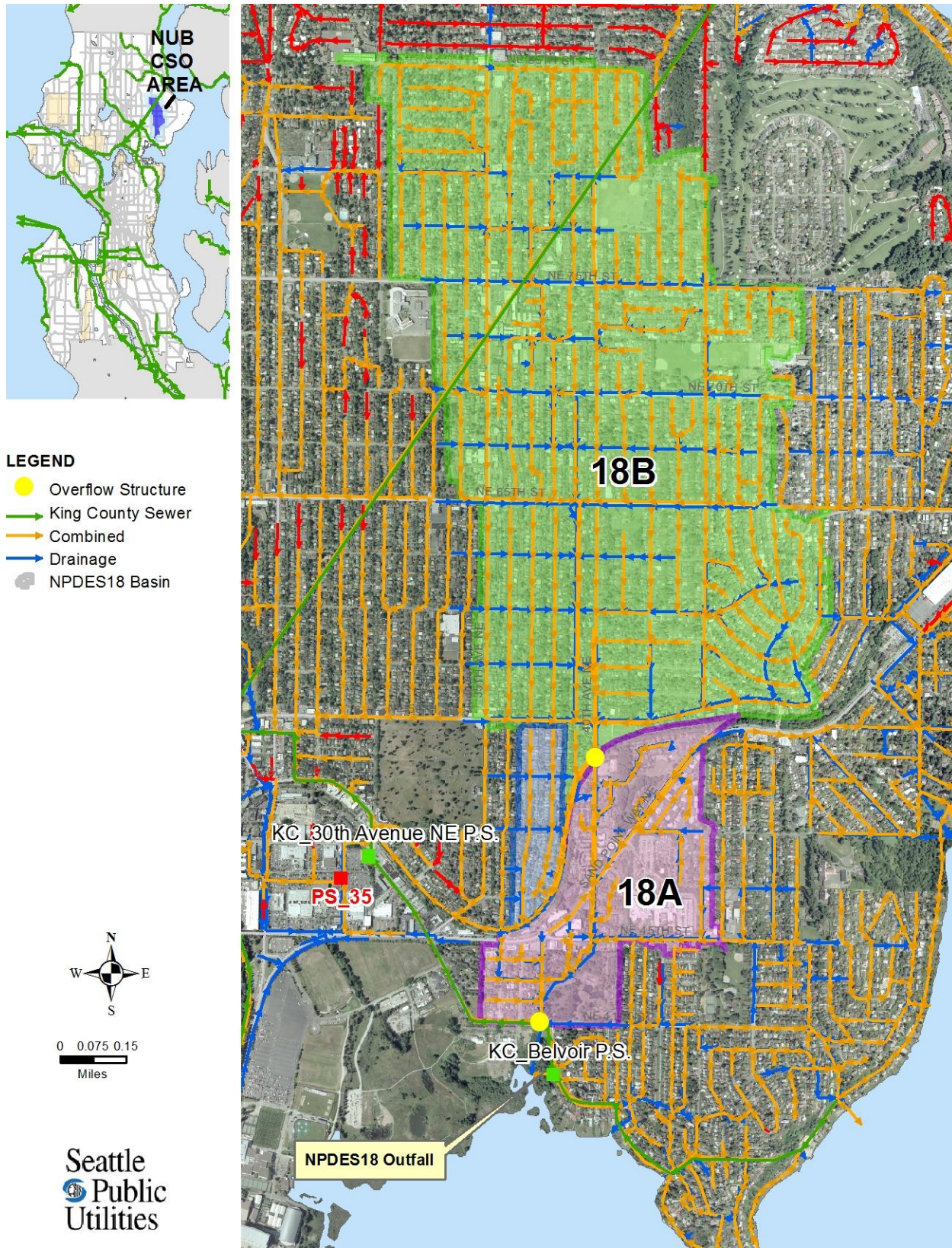


Figure 2-16. Overview of the North Union Bay CSO Area

Table 2-14 presents a summary of the key components of the wastewater collection system in the North Union Bay CSO area.

Table 2-14. Summary of Sewer Pipe in the North Union Bay CSO Area	
Component	Description
Length of pipe (LF)	164,000
Diameter range	8" to 72"
Number of connecting structures	850+
City pump stations	None
HydroBrake or sluice gate	Sluice Gate 018(A) HydroBrake 018(B)
Storage facilities	CSO Basin 018(A) – 0.15 MG in-line storage pipe CSO Basin 018(B) – 1.8 MG in-line and offline storage pipes

2.3.6.11 Portage Bay/Lake Union CSO Area

The Portage Bay/Lake Union CSO area covers 387 acres (0.6 square mile) in central Seattle. The Portage Bay/Lake Union CSO area is bounded by Portage Bay to the North, 11th Avenue E to the East, E Newton Street to the south, and Lake Union to the west (see Figure 2-17). The Portage Bay/Lake Union CSO area examined comprises CSO Basins 127, 129, 130, 131, 132, 134, 135, 136, 138, and 175. Of the CSO basins, only 138 is uncontrolled and included in the LTCP.

Five of the nine basins are partially separated and hydraulically dependent: 138, 135, 132, 130, and 175, listed from upstream to downstream. The Portage Bay/Lake Union CSO area generally drains from north to south along Eastlake Avenue E. Flow from CSO Basin 138 is pumped by PS20 into CSO Basin 135, and flows by gravity through CSO Basins 132, 130, and 175 to join the King County system farther south. Flows from house connections in CSO Basins 127, 129, 131, and 134 are pumped uphill by pump stations 62, 63, 64, and 65 to join the main sewer line. Flows from CSO Basin 136 are pumped to CSO Basin 138 by pump station 66. Stormwater from the partially separated areas of the Portage Bay/Lake Union CSO area is discharged directly into Lake Union and Portage Bay. All of the CSO basins contain permitted CSO structures that discharge overflows to Lake Union or Portage Bay during large precipitation events when the capacity of the CSS is exceeded.

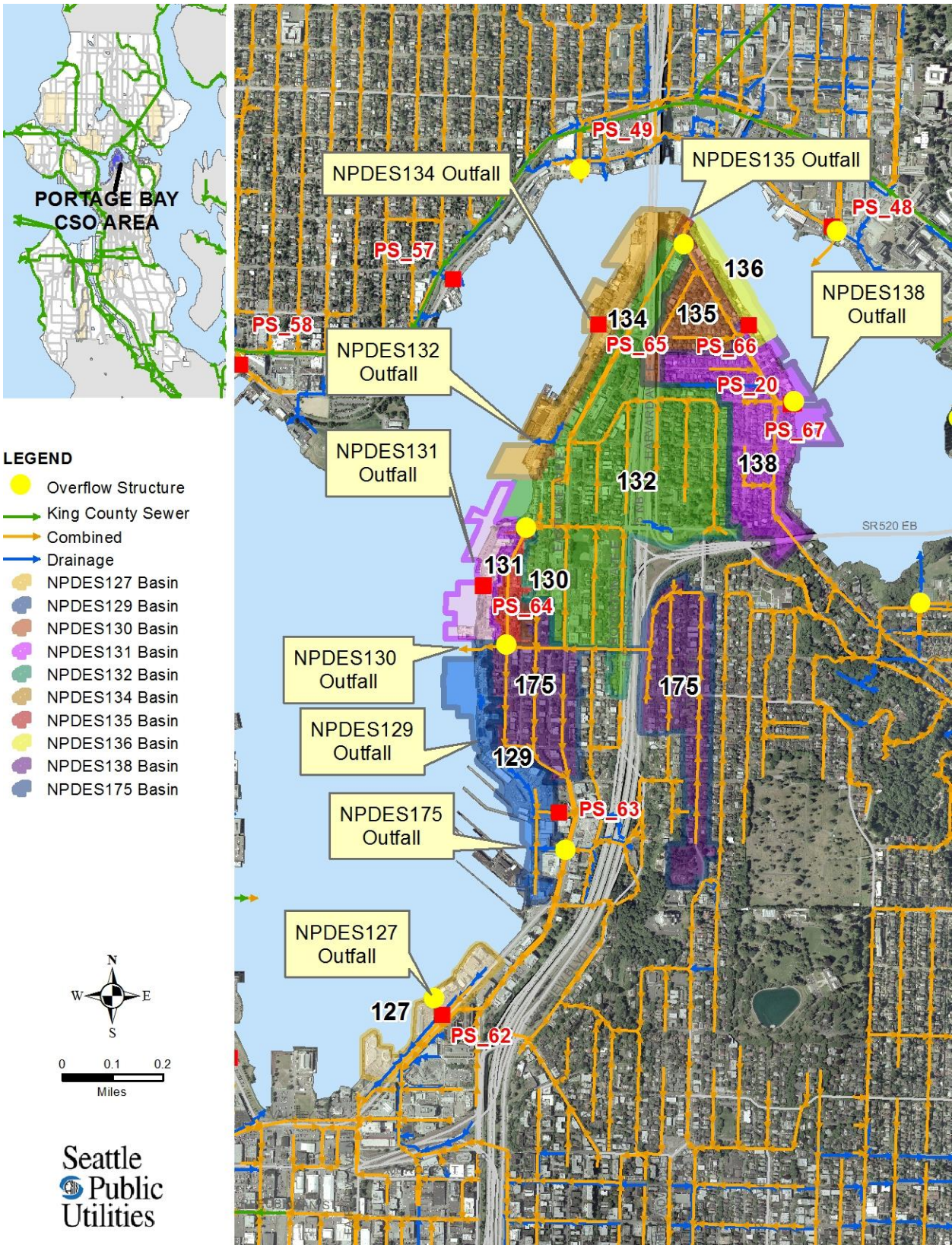


Figure 2-17. Overview of the Portage Bay/Lake Union CSO Area

Table 2-15 presents a summary of the key components of the wastewater collection system in the Portage Bay/Lake Union CSO area.

Table 2-15. Summary of Sewer Pipe in the Portage Bay/Lake Union CSO Area	
Component	Description
Length of pipe (LF)	65,000 ^a
Diameter range	8" to 54" ^a
Number of connecting structures	390 ^a
City pump stations	6 (PS20, PS62, PS63, PS64, PS65, PS66, PS67)
HydroBrakes	1 Basin (138)
Storage facilities	CSO Basin 138 – 0.13 MG storage pipes

^a Components from CSO Basin 127 not included in totals, basin was not included in the Portage Bay/Lake Union hydraulic model.

2.3.6.12 Magnolia

The Magnolia CSO area (CSO Basin 060) is located south of the ship canal, west of Salmon Bay, east of Discovery Park and north of West Commodore Way (see Figure 2-18). Topographically, the basin generally slopes from west to east. The 28-acre basin is served by a combined sewer system and consists of residential land use.

Flow within CSO Basin 60 is regulated by pump station 22 and by an overflow weir located within MH 010-159. Under normal conditions, sewage is routed toward pump station 22 and is pumped via an 8-inch force main to a 144-inch diameter King County North Interceptor, which conveys sewage toward the West Point WWTP. As flows increase, the wet well associated with pump station 22 fills and sewage backs up into the control structure (MH 010-159). At an elevation of 11.66 feet (NAVD88), sewage flows over the weir and enters a 20-inch diameter outfall pipe that discharges into Salmon Bay.

Table 2-16 presents a summary of the key components of the wastewater collection system in the Magnolia CSO area.

Table 2-16. Summary of Sewer Pipe in the Magnolia CSO Area	
Component	Description
Length of pipe (LF)	5,000
Diameter range	6" to 20"
Number of connecting structures	30+
City pump stations	1 (PS22)
HydroBrakes	None
Storage facilities	None



Figure 2-18. Overview of the Magnolia CSO Area

2.3.6.13 East Waterway CSO Area

The Duwamish River East Waterway CSO area comprises CSO Basin 107 and covers 58.7 acres (0.09 square mile) in southeast Seattle; it is bounded by S Hanford Street to the north, the East Waterway of the Duwamish River to the west, industrial properties to the south, and East Marginal Way S to the east (see Figure 2-19). Topographically, CSO Basin 107 is generally flat, and land use consists entirely of industrial property.

Flow in CSO Basin 107 drains toward a single overflow point near the intersection of East Marginal Way S and S Spokane Street (MH 056-097). The wastewater generated in this basin flows by gravity to the King County Elliot Bay Interceptor in Colorado Avenue S for conveyance to the West Point WWTP. Overflows at this location occur only when the water level in the King County interceptor is above the level of the overflow point.

Table 2-17 presents a summary of the key components of the wastewater collection system in the East Waterway CSO area.

Table 2-17. Summary of Sewer Pipe in the East Waterway CSO Area	
Component	Description
Length of pipe (LF)	9,000
Diameter range	6" to 36"
Number of connecting structures	80+
City pump stations	None
HydroBrakes	None
Storage facilities	None

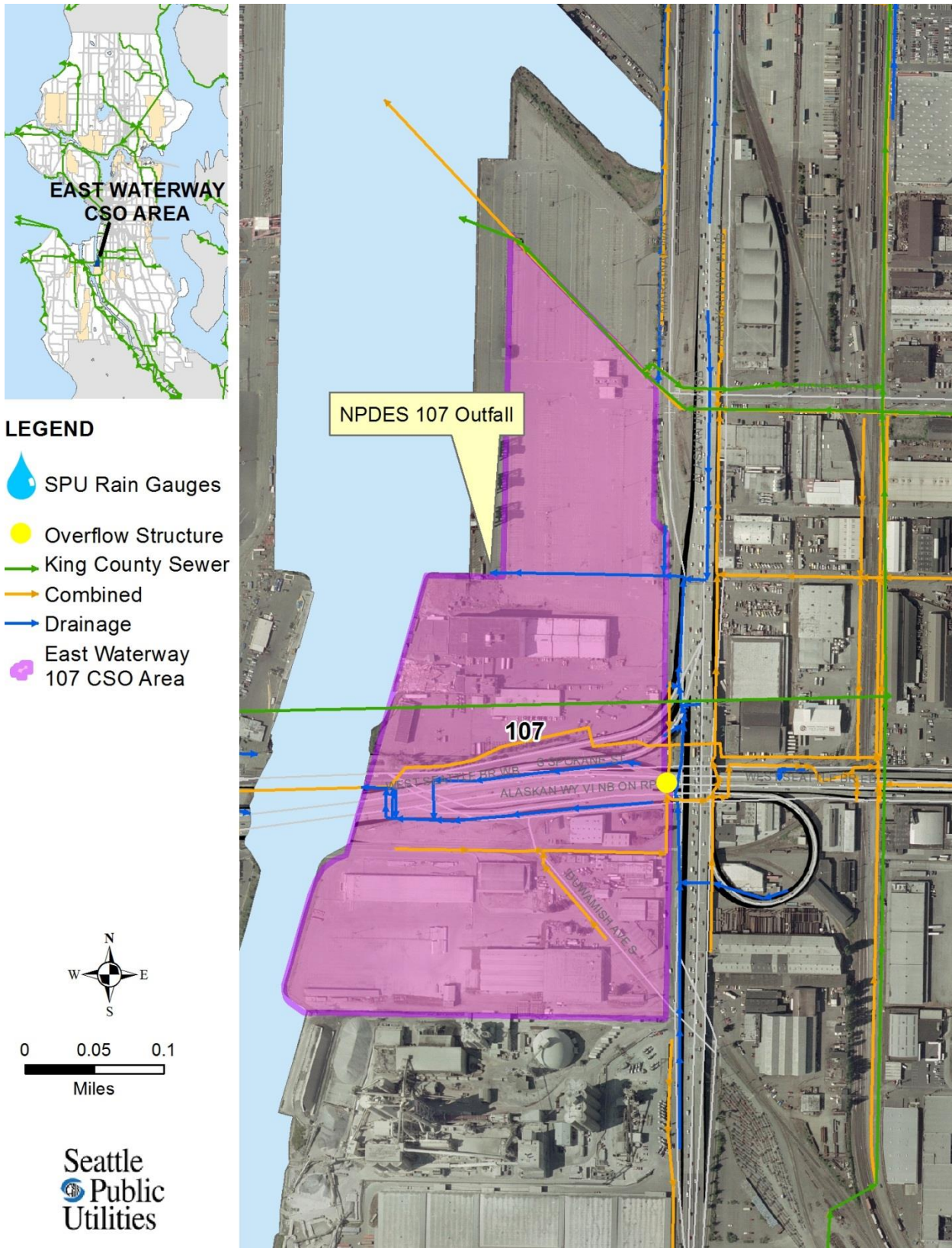


Figure 2-19. Overview of East Waterway CSO Area

2.3.7 Receiving Waters

The majority of Seattle is located within the Lake Washington/Cedar/ Sammamish Watershed (Watershed Resource Inventory Area (WRIA) 8). The Duwamish Waterway and Elliott Bay, located in south-western Seattle, are part of the Green/Duwamish and Central Puget Sound Watershed (WRIA 9). Seattle is characterized by a variety of surface water features including marine areas, rivers, lakes, and creeks. Each type is briefly summarized below:

Marine: Seattle's west side is situated adjacent to Puget Sound, a major marine embayment.

Rivers: Portions of south Seattle drain to the lower reaches of the Duwamish River (called the Duwamish Waterway). The river receives flow from the South Park basin, Norfolk basin, Longfellow Creek, and other smaller urban creeks and drains to Elliott Bay in south Puget Sound.

Lakes: Freshwater lakes and ponds, within or adjacent to the City, include the Portage Bay/Lake Union/Ship Canal system, linking Lake Washington and Puget Sound through the Hiram Chittenden Locks. Other freshwater lakes include Green, Haller, and Bitter lakes in the north portion of the City (also located in the Lake Union/Ship Canal drainage basin). Seattle also contains a many small ponds and wetlands.

Creeks: Runoff from Seattle's landscape drains to creek systems of varying size. Major creeks in the western regions of the City drain directly to Puget Sound and include Piper's and Fauntleroy creeks. Longfellow Creek is a main creek in the southwest portion of the City that drains to the Duwamish Waterway. Thornton Creek, Taylor Creek, and other smaller creeks drain the eastern portions of the City to Lake Washington.

Table 2-18 specifies the waterbody into which each CSO area included in the LTCP discharges. The following section describes the major waterbodies in the City in greater detail: Puget Sound, Elliott Bay, the Ship Canal, Lake Washington, the Duwamish River, and Longfellow Creek.

Table 2-18. Receiving Waterbody by CSO Area	
CSO area	Receiving waterbody
Ballard	Salmon Bay
Central Waterfront (Vine Street)	Elliott Bay
Delridge	Duwamish River (Basin 099) Longfellow Creek (Basin 168 and Basin 169)
Duwamish	Duwamish River
East Waterway	Duwamish River
Fremont/Wallingford	Lake Union
Interbay	Elliott Bay
Leschi	Lake Washington
Madison Park/Union Bay	Lake Washington (Basin 024 and Basin 025) Union Bay (Basin 022)
Magnolia	Salmon Bay

Table 2-18. Receiving Waterbody by CSO Area	
CSO area	Receiving waterbody
Montlake	Ship Canal
North Union Bay	Union Bay
Portage Bay	Lake Union (Basin 175) Portage Bay (all others)

Figure 2-20 presents a map showing the locations of the receiving waterbodies.

2.3.7.1 Lake Washington

Lake Washington is the second largest natural lake in Washington, with a surface area of 21,500 acres and a watershed of 472 square miles. The Lake Washington drainage system has been highly altered and now drains through the Lake Washington Ship Canal system rather than the Duwamish River. Most of the lake shoreline is highly developed and lake levels are regulated by the U.S. Corps of Engineers through operation of the Lake Washington Ship Canal system.

Union Bay is also considered part of Lake Washington and is located near the eastern end of the Ship Canal.

2.3.7.2 Puget Sound

Puget Sound is a fjord-like estuary that consists of four major interconnected basins that stretch from Hood Canal to north of Admiralty Inlet. The four basins include the Main (Admiralty Inlet and the Central basin), Whidbey, Southern, and Hood Canal basins. All of Seattle's marine CSOs discharge to the Central basin. Puget Sound borders the Ship Canal neighborhoods and Elliott Bay within the plan area. CSOs in the Ballard, Fremont and Wallingford area discharge to the Ship Canal and eventually drain to Puget Sound via the Hiram M. Chittenden Locks. Freshwater flows influence water circulation in this portion of Puget Sound with seasonal variation in the amount of freshwater input and an accompanying effect on water temperature, salinity, and density. The two main freshwater inputs to Puget Sound in the plan area are the Green/Duwamish River, which enters Elliott Bay, and the Cedar River (Lake Washington drainage basin), which flows into the Sound through the Lake Washington Ship Canal.

2.3.7.3 Ship Canal

The Lake Washington Ship Canal system is an 8.6-mile-long man-made navigable waterway connecting Shilshole Bay in Puget Sound to Union Bay in Lake Washington in Seattle. This system includes several interconnected waterways—Hiram M. Chittenden Locks (Ballard Locks), Salmon Bay, Salmon Bay Waterway, Fremont Cut, Lake Union, Portage Bay and Montlake Cut. Lake Union is a freshwater lake and receives most of its inflow from Lake Washington via the Montlake Cut and Portage Bay.



Figure 2-20. Receiving Water Bodies in the City of Seattle

2.3.7.4 Elliott Bay

Elliott Bay is a partially enclosed embayment that is bordered on the north, east, and south sides by urbanized areas and by Puget Sound on the west. The eastern shoreline borders the downtown neighborhoods and has been heavily modified from historical development. As a result, the shoreline along Elliott Bay is much steeper than a natural shoreline. The southern portion of the Bay is heavily altered through man-made port facilities including Harbor Island, completed in 1909. Elliott Bay is influenced by Green River freshwater flows through the heart of Seattle's industrial area and port facilities where the Green River becomes the Duwamish River.

2.3.7.5 Duwamish River

The Duwamish River originates at the confluence of the Green and Black Rivers near Tukwila and flows northwest for approximately 12 miles, splitting at the southern end of Harbor Island to form the East and West Waterways before discharging into Elliott Bay. The Duwamish River flows through the Delridge/Duwamish neighborhoods. The downstream portion of the Duwamish River serves as a major shipping route for bulk and containerized cargo, and the shoreline along the majority of the lower Duwamish has been developed for industrial and commercial operations. A portion of the lower Duwamish is maintained as a federal navigation channel by U.S. Army Corps of Engineers.

2.3.7.6 Longfellow Creek

Seattle's second largest watershed, the Longfellow Creek basin, is located in West Seattle in the Delridge area. The creek is 4.6 miles long and drains to the Duwamish River near Harbor Island through a 3,250-foot culvert. Approximately one third of the main channel length is piped. The watercourse is relatively flat compared to other major watercourses in Seattle, dropping 250 feet in elevation from its headwaters near the southern city limits to its mouth at the Duwamish River near Harbor Island. The watershed is highly developed.

2.4 Compilation and Analysis of Existing Data: Flow Monitoring

As described in the EPA guidance manual: Combined Sewer Overflows: Guidance for Monitoring and Modeling (Reference 26), the EPA CSO Control Policy identifies several possible objectives of a CSS monitoring program, including:

- To gain a thorough understanding of the sewer system
- To adequately characterize the system's response to wet-weather events, such as the volume, frequency and duration of CSOs
- To support a mathematical model to characterize the CSS
- To support development of the LTCP
- To evaluate the expected effectiveness of a range of CSO control options

The City has been gathering flow monitoring data at numerous locations within the CSS since 1998. The following sections describe the various flow monitoring programs undertaken by the City.

2.4.1 CSO Flow Monitoring Program (Prior to 2007)

The City's CSO flow monitoring program began in 1998, when flow monitors were installed at all of the City's pump station CSO overflow locations. These early flow monitors were able to measure only frequency and

duration, but not volume. By the end of 2000, flow monitors had been installed at all of the City's CSO overflow locations (pump station and non-pump station overflows), to measure frequency, duration, and volume of CSOs.

During this period, the City was using Supervisory Control and Data Acquisition (SCADA), telemetry, and Cellular Digital Packet Data (CDPD) systems in its CSO monitoring program. There were two sets of monitoring systems used to monitor overflows at pump stations. Permanent and temporary flow meters using the CDPD communications system were used for CSO overflow point sites. Overflow data (volume and duration), flow depth, and velocity at CSO sites were collected, analyzed, and archived for future use every five minutes. Monitoring data at the SCADA-based pump stations was collected every 15 seconds. The rainfall data was collected and archived every minute.

2.4.2 CSO Flow Monitoring Program (Post 2007)

In an effort to increase data quality, reduce monitoring down-time, and provide advance warning to prevent dry-weather overflows, the City revamped its permanent CSO and rainfall monitoring system in 2007. The City replaced its network of 17 rain gauges and 84 wastewater flow monitors with new, state-of-the-art instrumentation. In addition, the City established SOPs for monitor installation, maintenance, calibration, and data validation (quality assurance/quality control) to improve the quality of the flow monitoring data. Finally, the City implemented a real-time dry-weather overflow warning system to notify the City prior to the occurrence of a dry-weather overflow. The system has proven successful in reducing dry-weather overflows.

2.4.3 LTCP Flow Monitoring 2008-2012

A key element of the effort to reduce CSOs is the City's LTCP Flow Monitoring project. This project, a comprehensive effort to characterize flows and operational conditions in the City's combined sewer system, was divided into three phases comprising two years of data collection. Phase 1 (October 1, 2008 through May 31, 2009) was the wet season of the first year of monitoring. Phase 2 (June 1, 2009 through September 30, 2009) and Phase 3 (October 1, 2009 through May 31, 2010) were the dry and wet seasons, respectively, of the second year of monitoring.

The *December 2010 LTCP Flow Monitoring Report* (Reference 27) consisted of the following five volumes:

- Volume 1 summarizes the project objectives, the strategic methods used to identify and evaluate potential monitoring locations, the execution of the Flow Monitoring project, and the monitoring results. This information is presented in greater detail in Volumes 2–5.
- Volume 2 and Volume 3 are the Quality Assurance Project Plans, also known as the Flow Monitoring Plans, for the first year (Phase 1) and the second year (Phases 2 and 3) of the project, respectively. These volumes describe the project's goals and objectives, success criteria, and site selection methodology.
- Volume 4 summarizes the data collected during Phase 1 (October 1, 2008 through May 31, 2009). This volume also describes the suitability of the flow monitoring data for meeting the City's goals and objectives, suitability of rainfall data, and at-a-glance summaries of each monitoring site.
- Volume 5 summarizes the data collected during Phases 2 and 3 (June 1, 2009 through May 31, 2010) in a manner similar to Volume 4. This volume also summarizes the flow monitoring data collected during Phases 2 and 3 to support the City's system-wide model development effort.

The project targeted 12 CSO areas: Ballard, Delridge/Longfellow, Duwamish, Fremont/Wallingford, Interbay, Leschi, Madison Park/Union Bay, Magnolia, Montlake, North Union Bay, Portage Bay/Lake Union and West Seattle, which are subdivided into 38 smaller CSO basins. Each CSO basin represents one outfall, so the LTCP

Flow Monitoring project targeted about 43 percent of the City's total outfalls. In addition, rainfall data were collected from rain gauges installed citywide. During Phases 2 and 3, monitoring was also conducted at 53 system-wide monitoring locations across the City. Figure 2-21 and Figure 2-22 present the flow monitoring locations throughout the City during the 2008-2010 Flow Monitoring Program. The data obtained was used in calibration of a system-wide hydraulic model and to provide the foundation for the CSO control strategies to be implemented through the LTCP.

A Phase 4 monitoring effort was conducted following publication of the 2010 report. The goal of the LTCP Phase 4 Flow Monitoring project was to collect continuous rainfall; flow depth, level, and velocity; and operational data for refined model calibration in the Leschi and North Union Bay CSO basins during the wet season, (October 1, 2011 through March 31, 2012) to supplement data collected earlier in the program. The data were used to characterize the hydrologic and hydraulic performance of the CSS and support development of the LTCP. Detailed results of the Phase 4 program are documented in Appendix E.

In summary, the data collected from the 12 CSO basins and the system-wide flow monitoring locations, combined with the rainfall data also collected, provide a solid foundation for hydrologic and hydraulic model calibration and subsequent development of CSO reduction strategies. A brief summary of the flow and rainfall monitoring is presented in the following sections.

2.4.3.1 Flow Data

Data were collected over two wet seasons in order to gather sufficient rainfall, flow (depth, flow, velocity), and operational data (pump on-off data, run times, overflow structure behaviour, etc.) to allow accurate representation of conditions in the City's sewers. These data were used to characterize the hydrologic and hydraulic performance of the combined sewer system and support development of the LTCP.

Overall, the data collected in the 12 CSO areas and system-wide monitoring locations are reliable and representative and provide a solid foundation for hydrologic and hydraulic model calibration. For the 13 areas and the system-wide monitoring locations for which monitoring was conducted during the LTCP Flow Monitoring project, 96 percent of the data were classified as "Excellent," "Good," or "Some Limitations," meaning that they are valuable in varying degrees to calibrate and verify hydraulic models. Figure 2-23 shows the final overall flow monitoring data quality classifications for the 12 uncontrolled CSO basins and the system-wide meters that were monitored during the LTCP Flow Monitoring project.

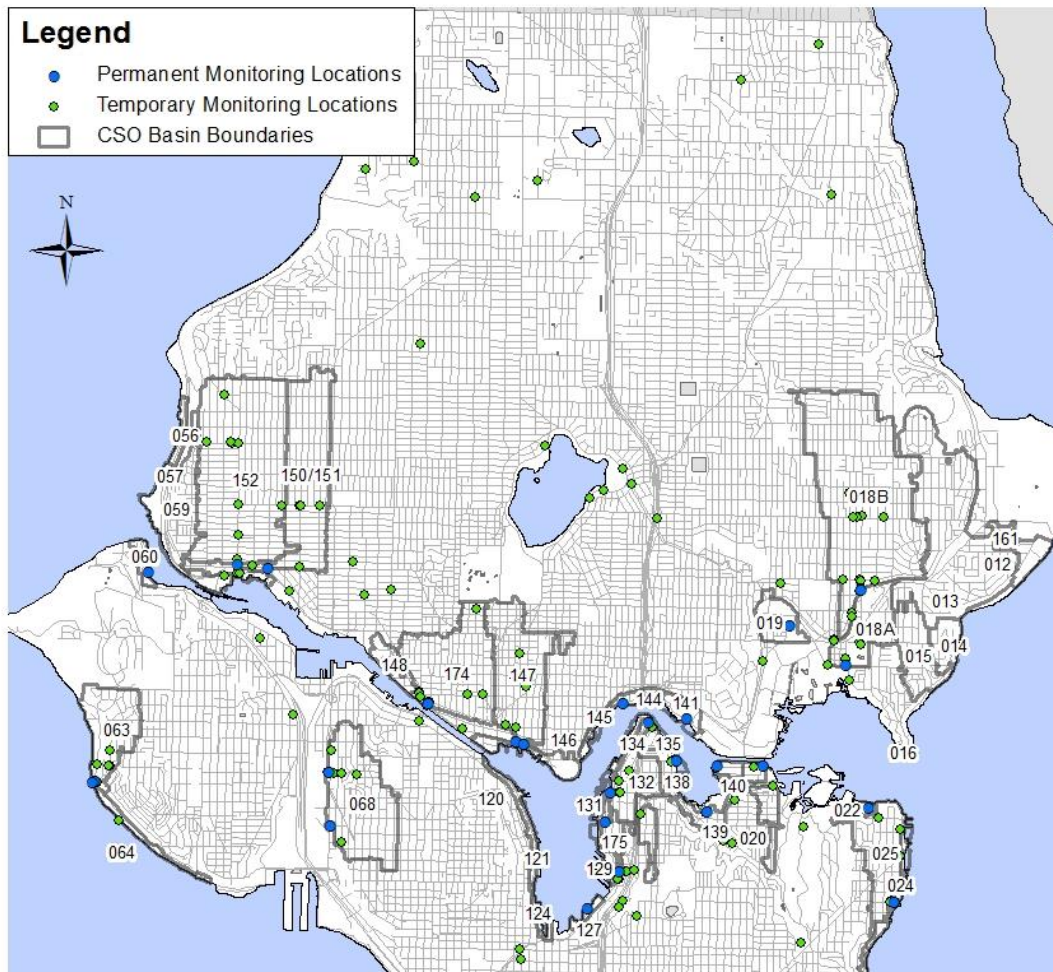


Figure 2-21. 2008-2010 Flow Monitoring Locations in Northern Seattle

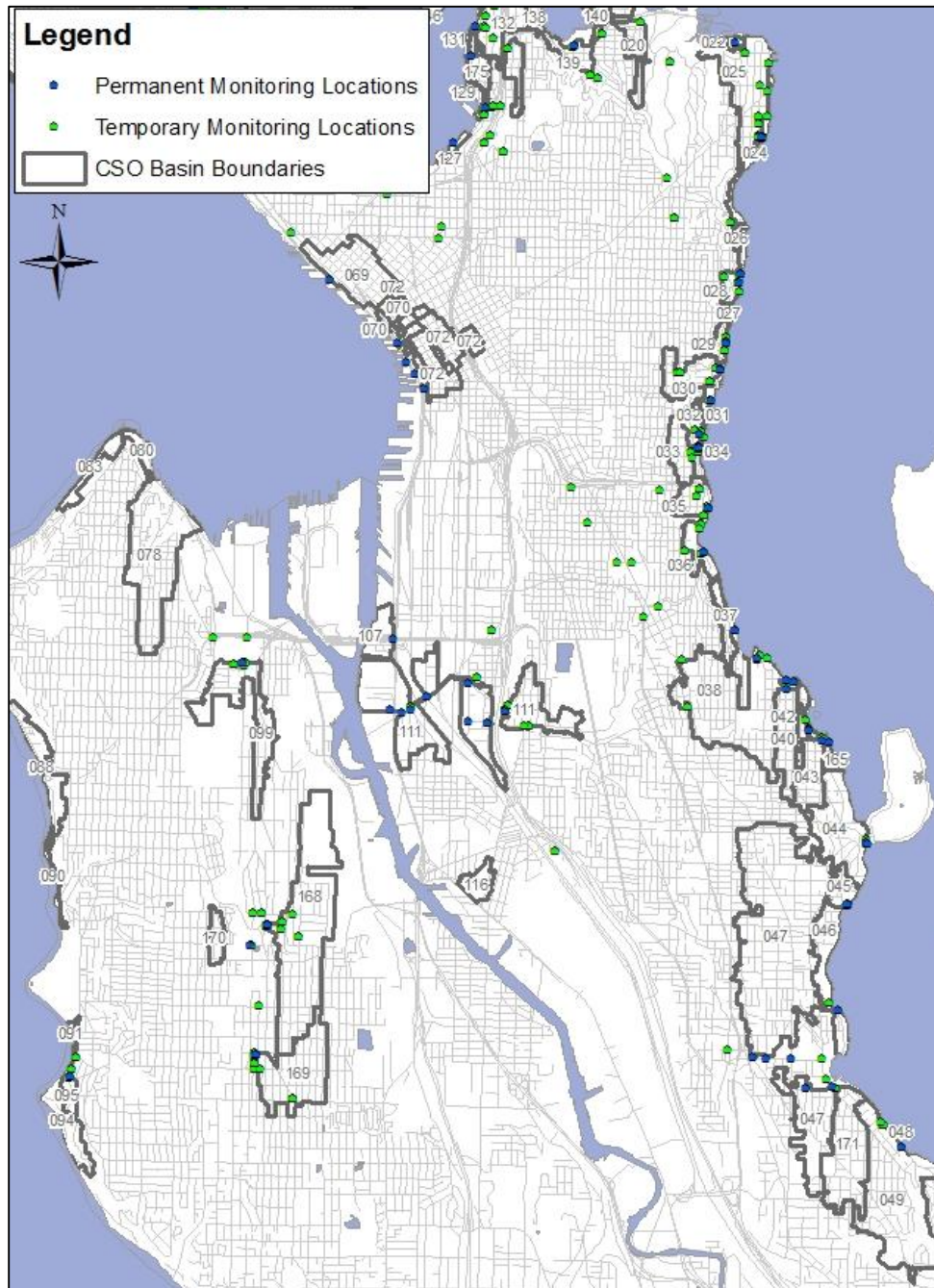


Figure 2-22. 2008-2010 Flow Monitoring Locations in Central and Southern Seattle

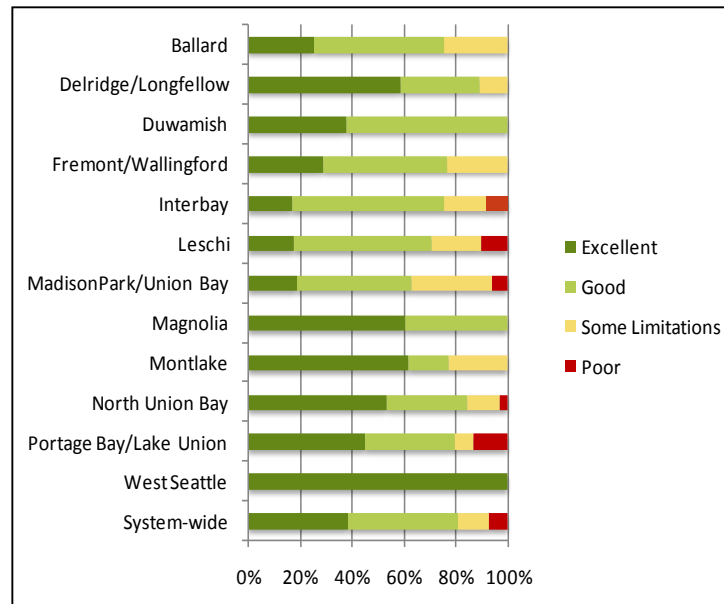


Figure 2-23. Overall Flow Monitoring Data Quality Classifications

2.4.3.2 Rainfall

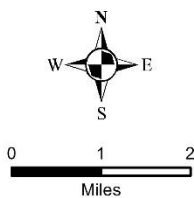
In addition to flow monitoring, the LTCP Flow Monitoring project included rainfall monitoring. The objectives for the rainfall monitoring component of the project were as follows:

- Capture data before, during, and after a wide range of storm events with a range of antecedent moisture conditions. In terms of recurrence intervals this objective was achieved by meeting both of the following criteria:
 - A minimum of three storm events of recurrence interval between 6 months and 1 year at any duration
 - A minimum of two storm events of recurrence interval between 1 year and 10 years at any duration spaced throughout the wet season.
- Recommend storm events for model calibration and future flow monitoring in the event that the desired storms do not occur during the project monitoring period.

Rainfall data were collected for the LTCP through the City's rain gauge network. Data from 9 of the 17 gauges were applicable to the CSO basins included in the LTCP. Each of these nine gauges was assigned with a CSO basin for review of flow monitoring results. Figure 2-24 presents the Thiessen polygons of the City's 17 rain gages.

LEGEND

-  SPU Rain Gauges
-  Thiessen Polygons
-  Ballard
-  Delridge/Longfellow
-  Duwamish
-  East Waterway
-  Fremont/Wallingford
-  Interbay
-  Leschi
-  Madison Park/Union Bay
-  Magnolia-NPDES060
-  Montlake
-  North Union Bay
-  Portage Bay/Lake Union
-  Vine Street
-  Water Body



Seattle
Public
Utilities

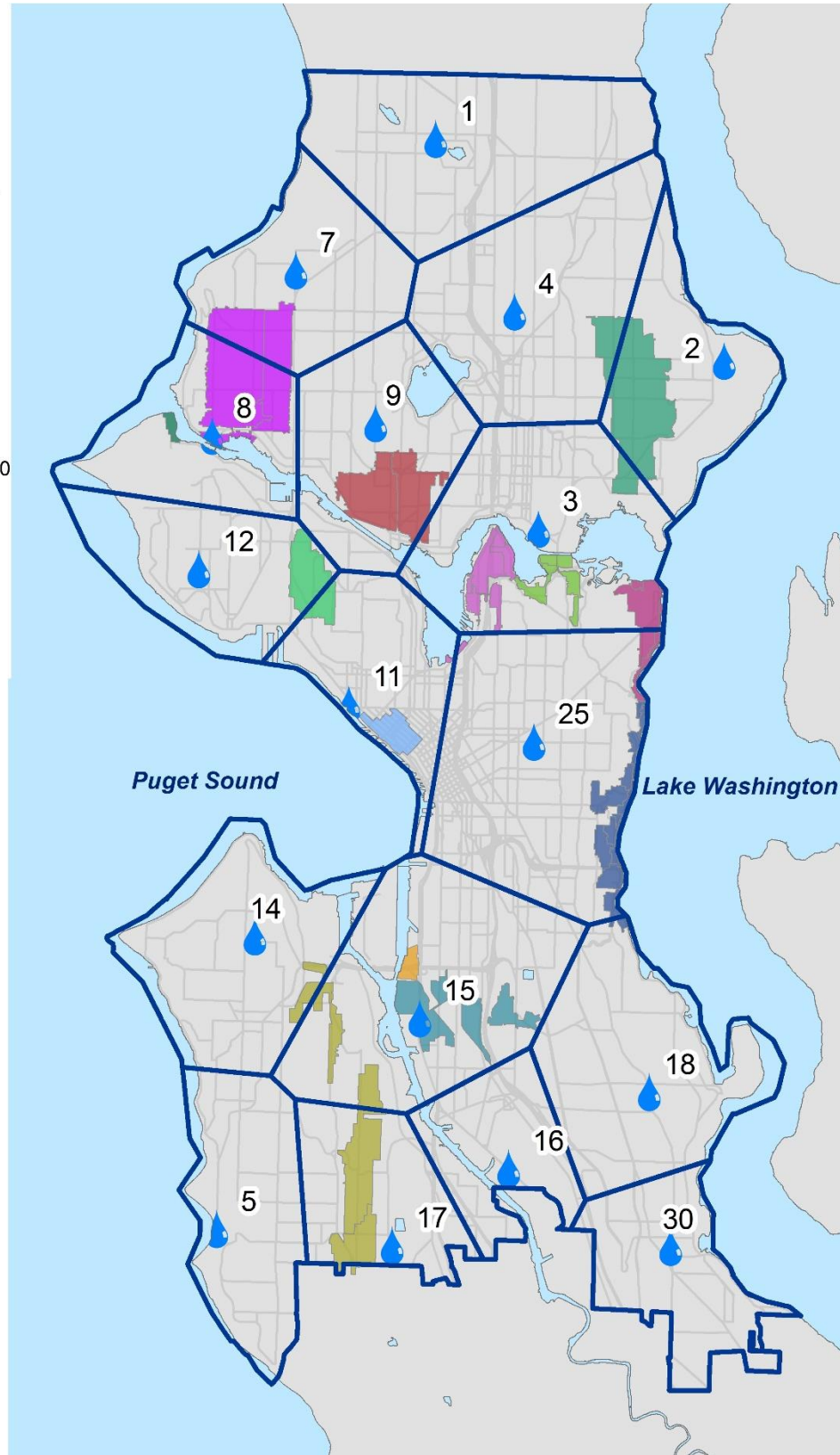


Figure 2-24. Thiessen Polygons for Each of the City's Rain Gauges

2.4.4 Continuing Flow Monitoring Efforts

The City continues to monitor each of its 87 CSO outfalls to detect sewage overflows. The City also tracks the performance of its flow monitors to ensure consistent, high quality measurements. In 2011, the cumulative average “up-time” of each flow monitor was over 99 percent. The City also continues to collect precipitation data from its network of 17 rain gages.

During 2011, the City continued monitoring at a total of 115 sites. During 2012 this number was reduced to 103 sites. Dedicated monitoring program staff frequently review the monitoring results from these locations and evaluate data quality and monitor performance. If emerging problems that might lead to or mask overflows are identified during these reviews (such as data showing slow storage tank drainage or missing data), the issues are rapidly addressed by requesting field service from the monitoring consultant or from the City’s Drainage and Wastewater crews. The consultant and City staff also perform on-site troubleshooting. For example, at a couple of monitoring sites, surface water was leaking around and through the maintenance hole lids and compromising the ultrasonic depth monitoring equipment. The solution was to install special sealed lids. These sites have since provided much improved overflow monitoring data.

Each month, the consultant's lead data analyst and senior engineer and the City monitoring staff meet to review and analyze any apparent overflows that occurred the previous month, taking into consideration rainfall, knowledge of site hydraulics, and the best available monitoring data. During these meetings a final determination is made regarding whether or not an overflow occurred and any necessary follow-up actions are documented.

In 2011, all non-pump station monitoring sites were converted to a two-minute recording interval from a five-minute recording interval as they approach overflow conditions. This allows for greater overflow quantity precision, particularly on the rising and falling limb of the overflow event. The City also had 15 temporary backup meters installed at pump station monitoring sites by a second flow monitoring consultant. This has reduced the risk of monitoring outages at these sites and provided a supplemental method of reporting overflows if the primary monitoring system suffers a loss of power or communication.

2.5 Sensitive Area Study

The following subsections present the preliminary sensitive area study based on information available for the 2013 Draft LTCP. This study was subsequently updated with new information in 2014. See Section 5.3.6 for the final results of the sensitive area study. The purpose of the sensitive area study is to prioritize CSO basins based on their environmental impacts to receiving water bodies and impacts to human health. The results of the study will be used to identify basins where CSO reduction projects are expected to provide the highest environmental and human health benefits.

This study was undertaken to satisfy the requirement of the EPA’s CSO Control Policy, which states the following principle:

EPA expects a permittee’s long-term CSO control plan to give the highest priority to controlling overflows to sensitive areas. Sensitive areas, as determined by the NPDES authority in coordination with State and Federal agencies, as appropriate, include designated Outstanding National Resource Water, National Marine Sanctuaries, waters with threatened and endangered species and their habitat, waters with primary contact recreation, public drinking water intakes or their designated protection areas, and shellfish beds.

2.5.1 Methodology

The Combined Sewer Overflows Guidance for Screening and Ranking Study (Reference 28) follows the guidelines established in the EPA policy documents providing guidance for screening and ranking. The purpose of the EPA screening and ranking document is to:

Give communities with multiple CSOs to multiple receiving water bodies a tool for ranking CSOs. Ranking CSOs will give the communities a basis for allocating resources to eliminate or control, in accordance with the CSO Control Policy, CSOs with the most significant impacts and to maximize the environmental benefits achieved for the resources expended.

CSO basins included in the study were ranked through a seven-criterion process using site-specific information. Each CSO basin received a score for each of the seven criteria. These scores were totalled, and the resulting total scores were used to rank the CSO basins.

Criteria one through six are established by the EPA screening and ranking document, while criterion seven is reserved for site-specific concerns that are not addressed in the other six criteria. For this study, points were scored for criterion seven based on the average annual CSO volume and frequency at the CSO outfall. From 0 to 100 points were scored for the average annual CSO frequency, and 0 to 100 points were scored for the average annual CSO volume. These scores were combined to come up with the total score for criterion seven. The average annual CSO frequencies and volumes are based on 32- or 34-year long-term simulations (LTS) using the LTCP hydraulic model that was developed for the City's wastewater system using EPA SWMM5 Build 5.0.022.

Criteria one through seven are summarized in Table 2-20, Sensitive Area Study Ranking Criteria. Refer to Appendix F for the Long Term Control Plan Sensitive Area Study. Results of the scoring are shown in Figure 2-25 and Figure 2-26.

2.5.2 Ranking Criteria

The ranking criteria used in the sensitive area study are based on the guidance provided in Reference 28, and are presented in Table 2-19.

Table 2-19. Sensitive Area Study Ranking Criteria

Criterion 1

If any CSOs pose a direct risk to public health or contribute to the non-attainment of designated uses on an ongoing basis, or if the potential impacts from CSOs are significant to areas designated under federal or state law as sensitive or protected resources, points are assigned as follows:

- Discharges to water experiencing beach closings or where there is a significant risk to public health from direct contact with pollutants in CSOs: Score 250 points
- Discharges to Outstanding National Resource Waters, National Marine Sanctuaries, or waters with threatened and endangered species and their habitat; public drinking water intakes or their designated protection areas; or shellfish beds: Score 200 points

Table 2-19. Sensitive Area Study Ranking Criteria

Criterion 2

If dry-weather overflows (DWOs) occur within the CSO basin, score the following points depending on the frequency of the DWOs:

- Chronic DWOs (i.e., they occur on a regular basis and are not caused by an occasional blockage of a regulator by debris): Score 150 points
- Infrequent DWOs caused by infrequent maintenance: Score 75 points

Criterion 3

Depending on the type of water body receiving the CSO, as well as the body's turbulence and mixing characteristics (energy), score points according to the table below:

Water Body Type	Low Energy	Medium Energy	High Energy
Estuarine and Wetland	100	N/A	N/A
Near-Shore Oceanic	60	40	20
Off-Shore Oceanic	30	15	10
Lakes and Ponds	100	N/A	N/A
River	40	20	10
Streams	60	40	20
N/A = Not Applicable			

Criterion 4

If the measured or estimated proportion of the flow rate(s) of all CSO outfalls to the receiving water flow rate (including CSO flow) in streams or rivers is:

- More than 50 percent: Score 50 points
- 25 to 50 percent: Score 30 points
- Less than 25 percent: Score 10 points

Note that since the proportion of CSO flow rate(s) to receiving water flow rate cannot be calculated for lakes and estuaries, they should automatically receive 30 points.

Table 2-19. Sensitive Area Study Ranking Criteria

Criterion 5

If a drinking water intake is within 10 miles (downstream in flowing water systems) of any CSO outfall, score the following points:

- Within 5 miles: Score 100 points
- Between 5 and 10 miles: Score 50 points

Criterion 6

If the composition of wastewater flows prior to any CSO outfall (based on dry-weather flows) includes:

- More than 50 percent industrial and commercial discharges or significant individual sources of potentially toxic materials: Score 50 points
- 30 to 50 percent industrial and commercial discharges or significant individual sources of potentially toxic materials: Score 25 points
- Less than 30 percent industrial and commercial discharges or significant individual sources of potentially toxic materials: Score 0 points

Criterion 7

Criterion 7 is reserved for site-specific concerns that are not addressed in the other six criteria. For this study, points were scored for Criterion 7 based on the average annual CSO volume and frequency at the CSO outfall. Points were scored as shown in the table below.

Average Annual CSO Frequency	Frequency Score	Average Annual CSO Volume (MG)	Overflow Volume Score
>= 20	100	>= 10	100
10 - 19.99	80	5 - 9.99	80
5 - 9.99	60	2 - 4.99	60
2 - 4.99	40	1 - 1.99	40
1.51 - 1.99	20	0.1 - 0.99	20
1 - 1.5	10	< 0.1	10
0 - 0.99	0	0	0

MG = millions of gallons

2.5.3 Ranking of Sensitive Areas

The CSO basins were scored based on the seven criteria and their results were ranked, as shown in Figure 2-25. The basins were divided into two categories:

- **LTCP Priority Basins – High Priority:** These basins are included in the LTCP and are not eligible for deferral as part of the Integrated Plan Alternative. Eight CSO basins from Ballard, Fremont, Delridge, North Union Bay, and Leschi CSO areas are included in this category.
- **Potential Integrated Plan Basins – Lower Priority:** These basins are included in the LTCP and are eligible for deferral as part of the Integrated Plan Alternative. Twenty CSO basins from the East Waterway, Duwamish, Leschi, Montlake, Portage Bay, Montlake, Madison Park, Central Waterfront, Magnolia, and Interbay CSO areas are included in this category.

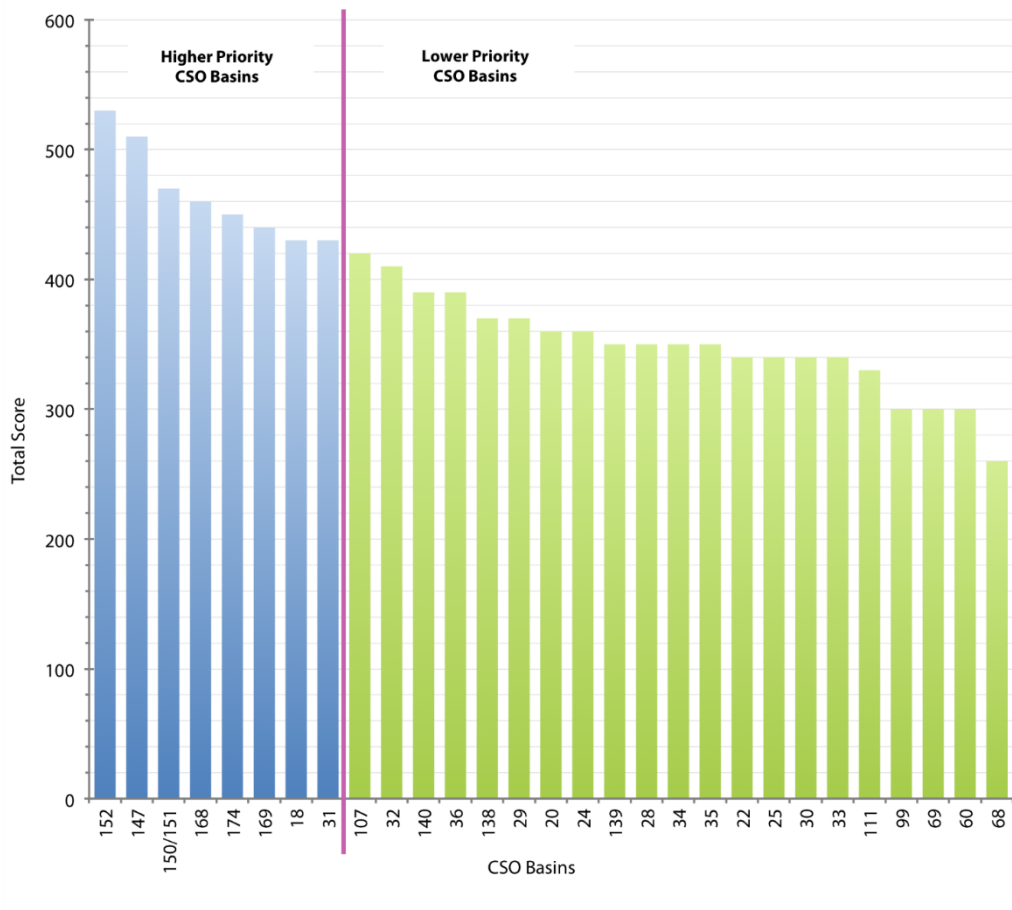


Figure 2-25. Ranking of LTCP CSO Basins Based on Sensitive Area Study

Figure 2-26 shows the locations of the higher and lower priority basins resulting from the Sensitive Area scoring.

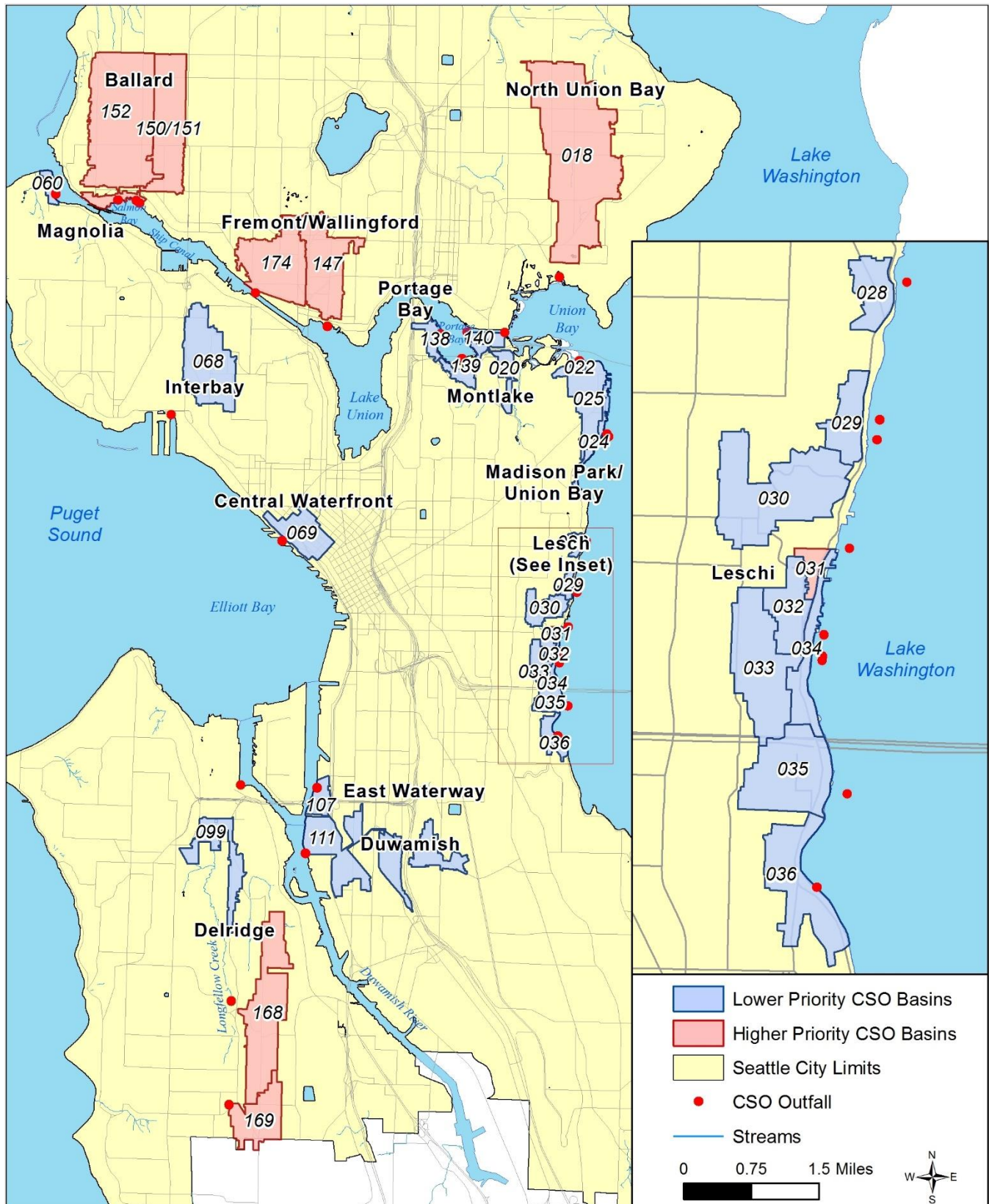


Figure 2-26. Prioritization of LTCP CSO Basins Based on Sensitive Area Study

2.6 Hydraulic Modeling and Baseline Characterization

The EPA's Combined Sewer Overflows Guidance for Long-Term Control Plan document indicates that the primary objective of CSS modeling is "to understand the hydraulic response of the CSS to a variety of precipitation and drainage area inputs." Hydraulic models of 13 CSO areas were developed to assess the performance of the existing wastewater collection system, predict wet-weather flows, estimate the frequency and volume of CSO events, and support the analysis of system modifications and new CSO control facilities that will meet the City's LTCP.

2.6.1 Combined Sewer System Modeling Objectives

The goals of hydraulic modeling were to estimate a baseline CSO frequency and volume and to develop a tool to support the evaluation of CSO control measures. The hydraulic model is also a valuable tool for understanding the sewer system hydraulics, the response of the sewer system to various precipitation events, and the characteristics of CSOs. To achieve these goals, modeling accomplished the following objectives:

- Characterize the hydrology of the LTCP basins
- Characterize the performance of the existing diversion structures, outfall structures, and conveyance pipes
- Represent the performance of City pump stations
- Simulate and evaluate hydraulic grade lines and flow rates throughout the LTCP basins under varying conditions based on historical precipitation and known boundary conditions
- Compute long-term CSO frequencies, volumes, and flow rates

2.6.2 Model Selection

The City chose the EPA's Stormwater Management Model Version 5 (EPA SWMM5) as its standard modeling platform and this software was used in development of the LTCP. The selection process and a description of the software are given below. This software satisfies the requirements of the Consent Decree.

In 2008, the City undertook a process to select a hydraulic modeling platform for use in various modeling projects, including the LTCP. This process included convening a panel of the City, local consultant, and King County staff involved with sewer modeling. The panel developed a list of needed features and attributes of a hydraulic model necessary to complete the most common type of modeling. From this, a list of available modeling software was developed that would satisfy the requirements. The various software products were obtained and tested on a common basin problem. The software products were then ranked by the panel based on performance, satisfaction of requirements, ease of use, special features, and cost. Based on this process, the City selected the EPA SWMM5 as the platform for use in the LTCP.

The project teams also utilized PCSWMM, a modeling interface to EPA SWMM5 with a robust geographic information system (GIS) module developed by Computational Hydraulics Institute to build hydraulic models for each basin. All modeling work was performed using Build 5.0.022 of EPA SWMM5.

2.6.3 Model Description

In general, each hydraulic model contains three essential components:

- the network of sewer infrastructure (pipes, pumps, and structures)
- tributary basins served by the sewer network (the source of flows to the network)
- boundary condition (i.e., flow and water levels that represent the system beyond the model boundaries)

Hydraulic models of the 13 modelled CSO basins contain all of the public pipes and maintenance holes in the system. These models also contain special hydraulic structures including pump stations, weirs, gates, orifices, storage tanks, and HydroBrakes.

Each model was subdivided into discrete subcatchment areas, based on different types of runoff-generating surfaces and land uses. Models generally have separate subcatchment categories for building rooftops, private parcels, and public rights-of-way. The boundary conditions were selected based on local hydraulic conditions and data availability. For some of the CSO areas, temporary flow monitors were installed to compute flow rates and water levels where wastewater exits the model.

SWMM is a dynamic rainfall-runoff simulation model used for single-event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of subcatchment areas that receive precipitation and generate runoff. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage, pumps, and regulators. SWMM tracks the quantity of runoff generated within each subcatchment, and the flow rate and flow depth in each pipe and channel during a simulation period comprising multiple time steps. The LTCP models used the following methodology for flow generation and flow routing. (More complete descriptions are available in the SWMM5 User's Manual.)

- Flow routing: Dynamic wave routing, which solves the complete one-dimensional Saint Venant equations, is used. This method allows accurate simulation of the hydraulics of any general network including storage, backwater, and pressurized flow, without resort to simplifications.
- Pervious surface infiltration: Infiltration of rainfall on pervious surfaces uses the Green-Ampt method. Infiltration is the source for groundwater inflow.
- Surface runoff: Surface runoff from impervious and pervious surfaces is generated using the standard SWMM5 nonlinear reservoir method.
- Groundwater infiltration to sewer system: Groundwater inflow to the sewer system is generated using the SWMM5 groundwater module. This module balances infiltration from the surface, evapotranspiration, percolation between layers and to deep groundwater, and inflow to the sewers.
- Dry-weather flows: Dry-weather flows from residences and businesses were estimated from flow monitoring and water use records. Diurnal variation in dry-weather flows was developed from flow monitoring records.

2.6.4 Model Calibration and Verification Summary

Calibration is the process of adjusting modeling input parameters so that the model output matches as closely as possible the monitored conditions within the system. Verification involves testing a calibrated model's predictions against field observations that are independent of the data used for calibration.

2.6.4.1 Procedures for Calibration

The LTCP hydraulic models were calibrated using an innovative automated process named Automated Calibration and Uncertainty Analysis for Storm Water Management Model (ACU-SWMM). ACU-SWMM is a software package created by MGS Engineering Consultants, Inc. for use with SWMM5. It was designed primarily for use with CSSs where uncertainties from multiple sources can make model calibration difficult and severely impact the reliability of sewer flow predictions.

ACU-SWMM randomly varies the set of input values between upper and lower boundaries established for each parameter and performs many model simulations (typically 500) using various combinations of the parameter values. For each set of model parameters, a simulation is performed and numerical goodness-of-fit (GOF)

measures are computed for sewer flow volume and peak flow rate based on comparison of simulated and recorded sewer flows. Model error is estimated by computation of the standard deviation of sewer flow volume GOF measures for the sewer flow hydrographs recorded at the various metering sites for multiple storm events encompassing both dry- and wet-weather events of varying magnitude.

Modeling parameter sets that produced the best combination of GOF measures were deemed candidate parameter sets. The best-fit model parameter set was selected based on visual comparison of simulated and recorded sewer-flow hydrographs for the candidate parameter sets together with the GOF statistics. In many cases, multiple ACU-SWMM runs were performed to narrow the range of parameters. The best-fit model parameter set was then locked into the SWMM model, and ACU-SWMM was repeated for the next downstream calibration basin. Figure 2-27 shows an example ACU-SWMM calibration plot for the Delridge CSO area.

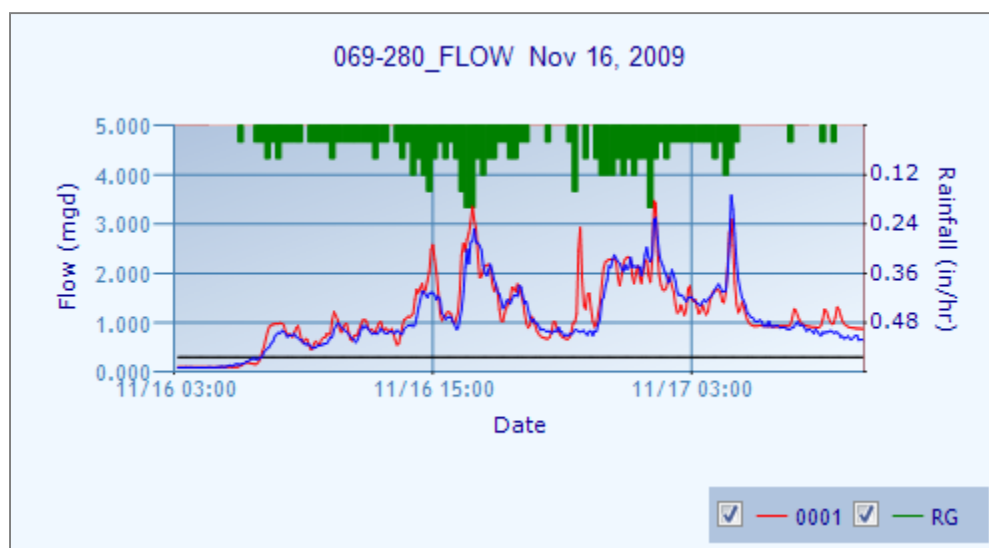


Figure 2-27. ACU-SWMM Calibration Plot for Monitoring Site in CSO Basin 168

After automated calibration was complete, the LTCP hydraulic model outputs were compared to water-level data collected at the permanent CSO monitoring sites. As needed, the hydraulic characteristics of these facilities were refined to achieve a better agreement between simulated and recorded water levels.

2.6.4.2 Model Verification

The automated calibration runs were conducted over a wide range of storm events representing a wide range of system responses. GOF was computed over the full range of these events, typically 6 to 10 events. The performance of the subcatchments was thus verified by arriving at parameter sets that optimized the model response over a wide range of storm conditions.

In addition, LTCP hydraulic model calibrations were verified by comparing the models' predictions of CSO events, depths at overflow structures, and overflow volumes to observed data. This method of verification is powerful, because it tests model capabilities to reproduce the very metrics required to control CSO events (i.e., event frequency and volume).

In this process, the models were shown to provide accurate estimates of CSO frequency, structure depth, and overflow volumes and to represent the observed data.

2.6.5 Model Application for Alternative Analysis

The models were built using the best available infrastructure data and then calibrated to flow monitoring data at more than 120 locations around the City across a diverse range of storm characteristics. The calibration included automated calibration procedures that resulted in robust calibration results that were evaluated by visual inspection and computing and goodness of fit statistics.

The models were verified by comparing simulated and recorded level data collected at the CSO structures and by comparing the simulated and reported frequency and volume of CSO events across a multi-year period. The models reproduced the character of CSO events. This indicates that the models are a suitable tool for the evaluation of LTCP CSO reduction alternatives.

2.6.6 LTCP Hydraulic Model Reports

The 2012 LTCP Hydraulic Model Report (Reference 29) was prepared to meet requirements of the Consent Decree, Appendix C, Item B.2, which establishes requirements for the development and documentation of hydraulic models. The report summarizes the project background, development, and calibration of computer models of the CSS in the 12 uncontrolled CSO areas listed above. These hydraulic models were developed to assess the performance of the existing system, predict wet-weather flows, estimate the frequency and volume of CSO events, and support the analysis of system modifications and new CSO control facilities that will make up the City's LTCP. The reports were submitted to EPA and Ecology for approval in December 2012 and were approved in April 2013.

The 2012 LTCP Hydraulic Model Report consists of the following 13 volumes:

- Volume 1 is this Executive Summary, which provides an overview of the modeling approach and documentation.
- Volumes 2–13 are the basin-specific Hydraulic Model Reports for 12 uncontrolled CSO areas. These volumes are organized to serve two purposes: to be an ongoing technical reference for the City staff and to clearly illustrate that the content of the volumes complies with the requirements of the Consent Decree.

The East Waterway CSO Basin 107, which is located near the Duwamish River, is also an uncontrolled CSO outfall. This small basin is hydraulically connected to King County's Elliott Bay Interceptor downstream of the Duwamish pump station. Overflows at this location are strongly correlated with wastewater levels in King County's Elliott Bay Interceptor. Based on the City King County Interceptor Hydraulic Model completed in 2012 (Reference 30), and flow data provided by King County, the City constructed a hydraulic model for CSO Outfall 107 in 2013; the report is included in Appendix B.

Table 2-20 lists the CSO areas modelled as part of the LTCP.

Table 2-20. Hydraulic Model Reports		
	CSO area	CSO outfall numbers
2012 LTCP hydraulic model report volume (December 2012)		
2	Ballard	150/151, 152
3	Delridge/Longfellow	099, 168, 169, 170
4	Duwamish	111

Table 2-20. Hydraulic Model Reports		
	CSO area	CSO outfall numbers
2012 LTCP hydraulic model report volume (December 2012)		
5	Fremont/Wallingford	147, 148, 174
6	Interbay	068
7	Leschi	026, 027, 028, 029, 030, 031, 032, 033, 034, 035, 036
8	Madison Park/Union Bay	022, 024, 025
9	Montlake	020, 139, 140
10	North Union Bay	018
11	Portage Bay/Lake Union	130, 132, 135, 138, 175
12	Magnolia	060
13	Central Waterfront	069
LTCP Appendix B – LTCP hydraulic model report		
	East Waterway	107

2.7 CSO Outfall Control Status

2.7.1 Consent Decree

Appendix A of the Consent Decree, List of Existing CSO outfalls, lists the control status of the City's CSO outfalls. Table 2-21 summarizes the Consent Decree appendix control status for the LTCP CSO outfalls (those outfalls to be controlled by an LTCP control measure rather than through other committed projects). This list was based on the 2010 CSO Reduction Plan Amendment and was prepared prior to completion of the LTCP CSO hydraulic models.

Table 2-21. Consent Decree – CSO Outfall Control Status		
LTCP CSO outfall number	CSO name	Status
018	38th Ave. NE at NE 41st St.	Uncontrolled
020	Shelby St. at E Park Dr.	Uncontrolled
022	39 th Ave NE at NE 41 st St.	Controlled
024	43rd Ave. E at E Lee St.	Controlled
025	43rd Ave. E at E Lee St.	Uncontrolled
026	Denny Blaine Pl. E	Controlled
027	Lake Washington Blvd.	Controlled

Table 2-21. Consent Decree – CSO Outfall Control Status		
LTCP CSO outfall number	CSO name	Status
028	Lake Washington Blvd. E at E Pike St.	Uncontrolled
029	Lake Washington Blvd. E at E James St.	Uncontrolled
030	Lake Washington Blvd. E at E Alder St.	Controlled
031	Lake Washington Blvd. S at S Main St.	Uncontrolled
032	Lake Washington Blvd. S at S Dearborn St.	Uncontrolled
033	Lake Washington Blvd. S at S Charles St.	Controlled
034	Lake Washington Blvd. S at S Charles St.	Uncontrolled
035	Lake Washington Blvd. S at S Massachusetts St.	Uncontrolled
036	Lake Washington Blvd. S at S College St.	Uncontrolled
060	W Cramer St. at 39th Ave. NW	Uncontrolled
068	W Garfield St. at 17th Ave. W	Uncontrolled
069	Alaskan Way at Vine St.	Uncontrolled
099	SW Hinds St. at Duwamish River West Waterway	Uncontrolled
107	SW Hinds St. at Alaskan Way S	Uncontrolled
111	S Oregon St. at East Duwamish	Uncontrolled
138	E Shelby St., Portage Bay	Uncontrolled
139	16th Ave. E at Louisa St.	Uncontrolled
140	E Shelby St. at W Park Dr.	Uncontrolled
147	Stone Way N at Northlake Way	Uncontrolled
150/151	24th Ave. NW and NW Market St.	Uncontrolled
152	28th Ave. NW and NW Market St.	Uncontrolled
168	Delridge Ave. SW at SW Myrtle St.	Uncontrolled
169	Between 24th and 25th Ave. SW north of SW Thistle St.	Uncontrolled
174	NW 36th Street at 2nd Ave. NW	Uncontrolled

2.7.2 NPDES Permit Annual CSO Report

The City's NPDES Permit (No. WA-003168-2) issued on October 27, 2010, requires that the City issue an Annual Combined Sewer Overflow Report as described under Section S6. Paragraph A. Specifically the Annual Combined Sewer Overflow Report must:

1. Include a summary of the number and volume of untreated discharge events per outfall for that year.
2. Determine and list which of the permitted CSO outfalls can be categorized as meeting the Performance Standard for Controlled CSOs as defined in Condition S8A, based on historical long-term discharge data (up to 20 years – past and present data), modeling, and/or other reasonable methods as approved by Ecology

The 2012 Annual CSO Report submitted on March 31, 2013, was the first to report CSO control status based on the historical long-term discharge data (20 years) using a combination of flow monitoring data and hydraulic modeling as required under the 2010 NPDES Permit. Completion of the LTCP hydraulic models in late 2010 enabled the City to perform long-term modeling using historical rainfall data to supplement the actual flow data to create a 20-year moving average.

The 2013 Annual CSO Report submitted in March 2014 lists four LTCP CSO outfalls included in Appendix A of the Consent Decree as uncontrolled that are now reported to be controlled. These are CSO Outfalls 025, 034, 035 and 068.

2.7.3 Final LTCP CSO Outfall Control Status

Table 2-22 lists the final status for the LTCP CSO outfalls that were evaluated for CSO control measures to bring the system into compliance with the moving 20-year performance criteria and the long-term overflow frequency based on flow data and long-term modeling.

The final number of uncontrolled LTCP CSO outfalls now total 22 after removing CSO Outfalls 025, 034, 035 and 068 as uncontrolled CSO outfalls based on the 2013 Annual CSO Report results. (Outfalls 150/151 and 152 are reported as separate outfalls.)

Table 2-22. LTCP Outfall Control Status					
CSO area	CSO outfall	Consent Decree control status note ^c	2013 Annual CSO Report control status note ^d	2013 Annual CSO Report moving 20-year average overflow frequency note ^d	LTCP control status
North Union Bay	018	Uncontrolled	Uncontrolled	4.1	Uncontrolled
Montlake	020	Uncontrolled	Uncontrolled	1.4	Uncontrolled
Madison Park/Union Bay	022	Controlled	Controlled	1.0	Controlled
Madison Park/Union Bay	024	Controlled	Controlled	1.0	Controlled
Madison Park/Union Bay	025	Uncontrolled	Controlled	0.8	Controlled
Leschi	026	Controlled	Controlled	0.2	Controlled
Leschi	027	Controlled	Controlled	0	Controlled

Table 2-22. LTCP Outfall Control Status

CSO area	CSO outfall	Consent Decree control status note ^c	2013 Annual CSO Report control status note ^d	2013 Annual CSO Report moving 20-year average overflow frequency note ^d	LTCP control status
Leschi	028	Uncontrolled	Uncontrolled	2.7	Uncontrolled See Note ^a
Leschi	029	Uncontrolled	Uncontrolled	2.7	Uncontrolled See Note ^a
Leschi	030	Controlled	Controlled	0.9	Controlled See Note ^a
Leschi	031	Uncontrolled	Uncontrolled	13.1	Uncontrolled See Note ^a
Leschi	032	Uncontrolled	Uncontrolled	5.4	Uncontrolled See Note ^a
Leschi	033	Controlled	Controlled	0.3	Controlled See Note ^b
Leschi	034	Uncontrolled	Controlled	1.0	Controlled See Note ^b
Leschi	035	Uncontrolled	Controlled	0.9	Controlled See Note ^b
Leschi	036	Uncontrolled	Uncontrolled	2.1	Uncontrolled See Note ^b
Magnolia	060	Uncontrolled	Uncontrolled	2.7	Uncontrolled
Interbay	068	Uncontrolled	Controlled	0.7	Controlled
Central Waterfront	069	Uncontrolled	Uncontrolled	1.6	Uncontrolled
Delridge	099	Uncontrolled	Uncontrolled	1.6	Uncontrolled
East Waterway	107	Uncontrolled	Uncontrolled	4.9	Uncontrolled
Duwamish	111	Uncontrolled	Uncontrolled	1.8	Uncontrolled
Portage Bay/Lake Union	138	Uncontrolled	Uncontrolled	1.5	Uncontrolled

Table 2-22. LTCP Outfall Control Status

CSO area	CSO outfall	Consent Decree control status note ^c	2013 Annual CSO Report control status note ^d	2013 Annual CSO Report moving 20-year average overflow frequency note ^d	LTCP control status
Montlake	139	Uncontrolled	Uncontrolled	1.2	Uncontrolled
Montlake	140	Uncontrolled	Uncontrolled	3.9	Uncontrolled
Fremont/ Wallingford	147	Uncontrolled	Uncontrolled	38.1	Uncontrolled
Ballard	150/151	Uncontrolled	Uncontrolled	17.1	Uncontrolled
Ballard	152	Uncontrolled	Uncontrolled	45.8	Uncontrolled
Delridge	168	Uncontrolled	Uncontrolled	2.6	Uncontrolled
Delridge	169	Uncontrolled	Uncontrolled	2.5	Uncontrolled
Fremont/ Wallingford	174	Uncontrolled	Uncontrolled	8.7	Uncontrolled

Notes

- a LTCP hydraulic modeling indicated that CSO Basins 28, 29, 30, 31, and 32 are all hydraulically “linked” and must be evaluated as a system in the LTCP.*
- b LTCP hydraulic modeling indicated that 33, 34, 35, and 36 are all hydraulically “linked” and must be evaluated as a system in the LTCP.*
- c July 3, 2013 Consent Decree, APPENDIX A: List of Existing CSO Outfalls*
- d 2013 CSO Annual Report Combined Sewer Overflow (CSO) Reduction Program, March 30, 2014, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling.*

Figure 2-28 shows the CSO outfall locations, control status, and the specific CSO program phase for each uncontrolled CSO outfall. The LTCP will address the uncontrolled CSO outfalls shown as LTCP Project on the figure. The other uncontrolled CSO outfalls will be corrected through the 2010 Plan Projects or the Early Action Projects.

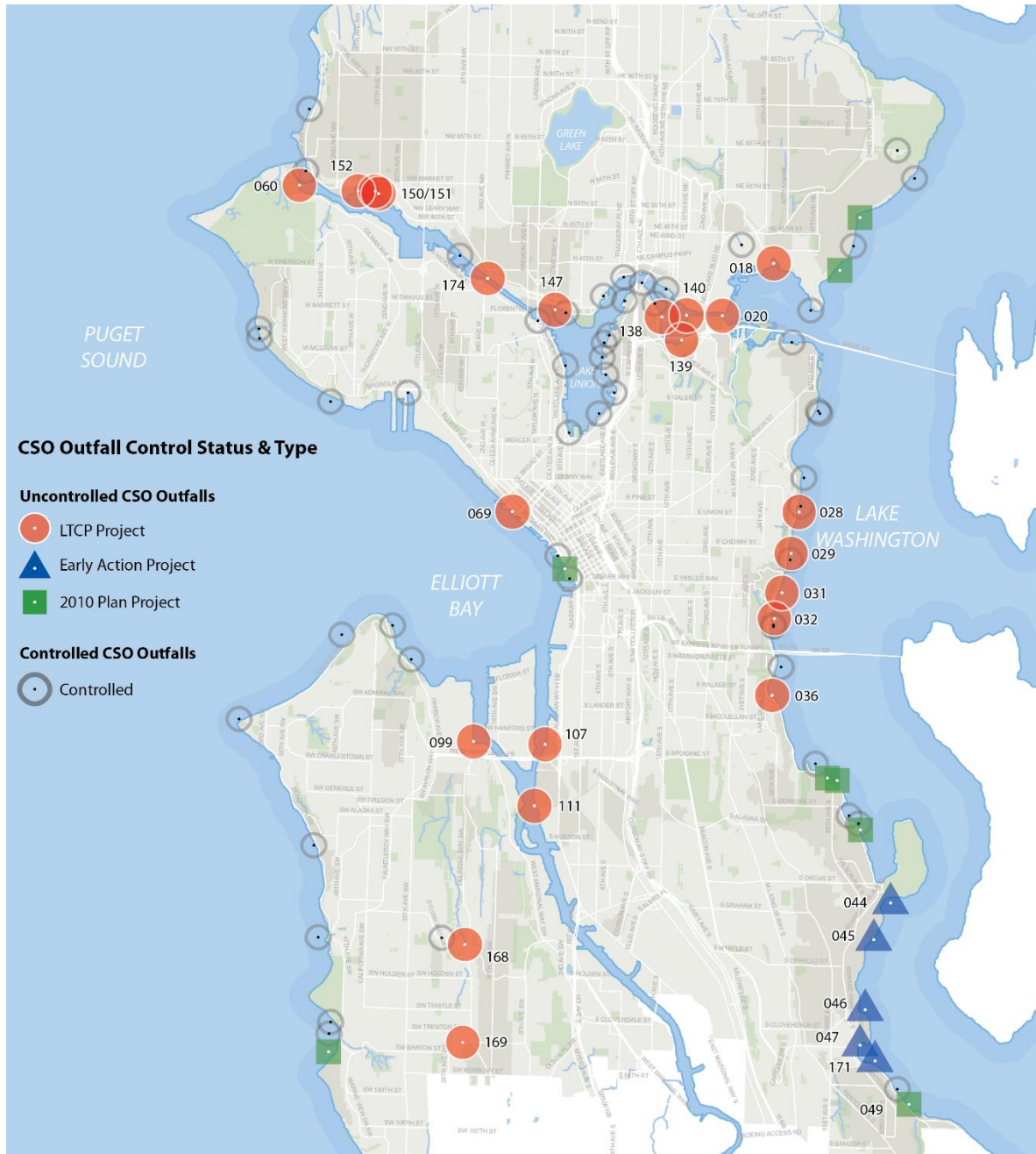


Figure 2-28. Controlled and Uncontrolled CSO Outfalls and CSO Implementation Program Phase

2.8 CSO Control Volumes

For the 22 uncontrolled LTCP CSO outfalls listed in Table 2-23, control volumes (CV) for each outfall were computed using hydraulic models re-calibrated or refined in EPA-SWMM5 Build 5.0.022. A CV is the amount of CSO storage required to limit annual CSO overflows to 1.0 or less events per year on a long-term simulation basis. A detailed description of the computation of CVs, average annual overflow frequency and average annual overflow volumes is included in Appendix G, Long Term Model Simulation Results

For each uncontrolled CSO outfall, hydraulic model long-term simulations were conducted using a 32- or 34-year precipitation time series (1978 through 2009 or 2011). A CSO CV with a once-per-year overflow frequency was determined by choosing the 32nd or 34th largest overflow volume from the time series of computer-simulated overflows. An uncertainty analysis was also performed where 11 separate LTSs were conducted in which the historical precipitation time series was scaled in a manner to reflect the magnitude of uncertainties from several sources. This approach yielded 11 plausible futures with regard to the manner in which uncertainties can affect the magnitude of sewer flows and overflow volumes. These 11 plausible futures allowed determination of the CSO best estimate CV and uncertainty bounds.

The four sources of uncertainty evaluated included:

1. Representativeness of historical precipitation time series: Use of the historical precipitation time series record to model the characteristics of future precipitation produces uncertainties in model-predicted flows for future conditions. Assuming a stationary climate, the longer the historical record is, the more likely it becomes that that record will be representative of future storm characteristics. Assessment of the precipitation record using the results from state-wide and Seattle-specific precipitation-frequency studies results in a standard error of estimation (standard deviation) for precipitation-frequency of 5 percent. Thus, using conventional sampling statistical theory, the range and distribution of future precipitation can be modeled as the historical long-term time series scaled by a precipitation scaling factor with a mean of 1.00 and a standard deviation of 0.05 drawn from a normal distribution.
2. Possible effects of climate change: Scientific consensus is that the climate is not stationary and that climate change is underway. The historical precipitation time series already contains any effects of climate change in the recent past (1978–2011). The primary interest for the future 30-year planning period is what additional changes may occur. A simplified probabilistic model was formulated that considers that precipitation in the future 30-year planning period may range from no change to an increase of 15 percent, with a most-likely value being a 5 percent increase. An empirical likelihood function was developed for use in conducting the uncertainty analysis. The range of effects of climate change are mimicked by scaling the historical precipitation time series by a precipitation scaling factor obtained from Monte Carlo selection from the climate change likelihood function. Including this factor provides an upper bound to CV values. Excluding it provides a lower bound.
3. Model uncertainties: Uncertainties exist in model-predicted flow values because of inaccuracies and uncertainties in the model inputs and imperfections in the structure and governing algorithms used to make predictions. The magnitude of uncertainties in model-predicted sewer flows, described in Section 5 of the LTCP Hydraulic Model Reports, was estimated using global GOF measures computed during the model calibration process. Ideally, uncertainties in prediction of sewer flows for the LTSs would be modeled by adjusting the predicted sewer flows at locations within the SWMM5 model. However, this approach is impractical in the SWMM5 model. Alternatively, precipitation scaling factors were used to re-scale the historical precipitation time series as a surrogate, forcing function to mimic changes in sewer flows. This was a practical approach recognizing the linearity of the response of stormwater runoff from impervious areas to small changes in precipitation.

4. **Residual uncertainties:** Residual uncertainties account for uncertainties that arise from sources other than the three categories described above. This includes the effect of the number of flow meters, quality of flow data, and representativeness of precipitation used in model calibration. It also includes uncertainties associated with hydraulic components such as HydroBrakes, pump stations, flap gates, overflow weirs, and storage tanks that add to the uncertainty of system performance in the long-term future. The effects of residual uncertainties were mimicked using precipitation scaling factors in the same manner as described above for model uncertainties.

Computer modeling estimated the volume and duration of each overflow event simulated during the 32-year period for each LTS and computed the average annual overflow frequency and overflow volume for each uncontrolled CSO outfall. The collection of overflows was ranked from largest to smallest and the once-per-year CV for each LTS is computed. The CSO best-estimate CV is computed as the mean of the 11 CVs for the 11 LTSs.

The long-term average annual overflow frequency, average annual overflow volume, and CVs for each uncontrolled CSO outfall are shown in Table 2-23. Control volumes were estimated with and without effects of future climate change. Frequency of overflow was computed assuming a minimum 24-hour period between overflows to define the beginning and ending of events. For the LTCP, the CVs including climate change was used for the basis of CSO control measure sizing and evaluation.

Table 2-23. LTCP Hydraulic Modeling Results

CSO area	CSO outfall structure number	Average annual overflow frequency ^a	Average annual overflow volume (MG) ^{a,c}	Control volume with climate change (MG) ^c	Control volume without climate change (MG) ^{b,c}
North Union Bay	018A	4.1	0.7	0.26	0.19
North Union Bay	018B	2.4	4.3	1.37	0.98
Montlake	020	1.1	0.64	0.16	0.12
Leschi	026	0.1	<0.01	0	0
Leschi	027	0	0	0	0
Leschi	028	1.2	0.03	< 0.01	< 0.01
Leschi	029	1.6	0.01	0.02	0.01
Leschi	030	0.6	0.06	< 0.01	< 0.01
Leschi	031	16	0.93	0.31	0.25
Leschi	032A	1.7	0.05	0.01	< 0.01
Leschi	032B	6.6	0.22	0.07	0.05
Leschi	033	0.1	<0.01	0	0
Leschi	034	0.9	0.3	0.03	< 0.01
Leschi	035	1.1	0.01	< 0.01	< 0.01
Leschi	036	2.1	0.12	0.03	0.017

Table 2-23. LTCP Hydraulic Modeling Results

CSO area	CSO outfall structure number	Average annual overflow frequency ^a	Average annual overflow volume (MG) ^{a,c}	Control volume with climate change (MG) ^c	Control volume without climate change (MG) ^{b,c}
Magnolia	060	3.1	0.26	0.11	0.09
Interbay	068A	0.5	0.18	0.02	< 0.01
Interbay	068B	0.6	0.09	0.01	< 0.01
Central Waterfront	069	1.4	0.54	0.07	0.05
Delridge/Longfellow	099	1.5	0.81	0.17	0.11
East Waterway	107	5.7	1.5	0.50	0.45
Duwamish	111B	1.1	0.2	< 0.01	< 0.01
Duwamish	111C	1.1	0.2	< 0.01	< 0.01
Duwamish	111H	0.7	0.21	0.01	< 0.01
Portage Bay/Lake Union	138	1.7	0.31	0.11	0.07
Montlake	139	1.2	0.04	0.01	< 0.01
Montlake	140	4.4	0.28	0.05	0.02
Fremont/Wallingford	147A	37.5	8.6	2.08	1.90
Fremont/Wallingford	147B	4.4	0.3	0.07	0.06
Ballard	150/151	16	2.9	0.62	0.45
Ballard	152	47.8	23.5	5.38	4.38
Delridge/Longfellow	168	2.3	4.42	2.00	1.45
Delridge/Longfellow	169	1.8	2.81	1.19	0.74
Fremont/Wallingford	174	8.6	3.8	1.06	0.99

Notes:

^a From 32 or 34 yr simulation with Rainfall scaling =1.0

^b Estimated control volume after removal of climate change uncertainty but keeping other uncertainties

^c Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

CHAPTER 3

Development and Evaluation Of Alternatives for CSO Control

3.1 Long-Term Control Plan Approach

The Long Term Control Plan uses a combination of three CSO control strategies to control CSO overflows:

- “Fix it First” to make sure that maximum capacity in the existing system is achieved and utilized
- “Keep Stormwater Out” to implement a variety of measures that use soil to absorb stormwater or slow the rate of flow of stormwater into the system
- “Store What’s Left” to temporarily hold combined sewage during a storm and gradually release it to a wastewater treatment facility when there is capacity available in the combined sewer system

The City’s strategy aligns with EPA’s guidance documents that recommend collection system controls (Fix it First), source controls (Keep Stormwater Out), and storage technologies (Store What’s Left).

This chapter presents an overview of the LTCP planning approach, including the integration of previous City CSO planning efforts and current CSO capital improvements into the overall LTCP, CSO control measure development and evaluation, shared CSO control measures between the City and King County, and the LTCP options.

Figure 3-1 summarizes the LTCP planning approach used for the Draft LTCP. A brief summary of the approach is presented below:

- The 2010 CSO Reduction Plan Amendment was the basis for the LTCP. Appendix C, Paragraph C.2 of the Consent Decree stated: “*The LTCP shall build upon the alternative analysis work that was performed as part of the development of the City’s 2010 CSO Reduction Plan Amendment (2010 Plan).*”
- The 2010 CSO Reduction Plan Amendment recommended CSO control measures for all CSO outfalls considered uncontrolled at that time. The 2010 CSO Reduction Plan Amendment identified two phases of CSO project implementation: 2010-2015 committed projects and future LTCP projects.
- A comprehensive system characterization was performed for the LTCP. LTCP flow monitoring was performed from 2008 through 2012 and SWMM Version 5 combined sewer modelling was performed for the LTCP CSO basins.
- The City’s Consent Decree defined a performance criterion based on a “*Twenty Year Moving Average*” to determine if a CSO outfall is “controlled”. The Consent Decree stated in Section IV, Paragraph 9(ee): “*For previously Controlled CSO Outfalls and where monitoring records exist for the past 20 consecutive years, the twenty year moving average shall mean the average number of untreated discharges per CSO Outfall over the 20 year record. On an annual basis, the twenty year moving average will be calculated and includes the current monitored year and each of the previous 19 years of monitored CSO data. For CSO reduction projects and Controlled CSO Outfalls where a complete twenty year record of monitored data does not exist, missing annual CSO frequency data will be generated based on the predicted CSO frequency for a given year as established in the approved engineering report or facility plan.*”
- The Consent Decree also identified Early Action CSO Control Programs and Measures in Section V,

Paragraph A for CSO Outfalls 044 and 045 (North Henderson) and CSO Outfalls 46, and 47/171.

- In the 2013 Annual CSO Report, the City determined the control status for all 87 CSO outfalls in accordance with the Twenty Year Moving Average criterion as described in Section 1.5.4.
- The 2013 Annual CSO Report determined that there are 35 uncontrolled City-managed CSO outfalls. CSO control is being provided in three phases as summarized below:
 - **2010 Plan Projects:** Eight outfalls will be controlled through capital projects completed during the years 2010-2018, including CSO reduction projects for Windermere, Genesee, West Seattle, and South Henderson CSO areas. CSO control for the Central Waterfront will be coordinated with the schedule for major changes in that neighborhood. Additional CSO reduction efforts were initiated through the Green Infrastructure (GI) program in Ballard, Magnolia, Montlake, North Union Bay, Fremont/Wallingford, and Delridge CSO areas. In addition, a storage project to control South Henderson CSO Outfall 049 will be completed during the years 2023-2025.
 - **Early Action CSO Programs and Measures:** The Consent Decree requires early action for the two North Henderson (044 and 045) and three South Henderson (046, 047 and 171) uncontrolled CSO outfalls. CSO Outfalls 044 and 045 will achieve controlled status by December 31, 2019, and CSO Outfalls 046, 047, and 171 will achieve controlled status by December 31, 2016.
 - **LTCP:** The remaining 22 uncontrolled CSO outfalls will be controlled through the implementation of the recommended CSO control measures on an implementation schedule to meet the Consent Decree construction completion milestone date of December 31, 2025, and the achievement of control status for each outfall as defined in the Consent Decree.
- The LTCP evaluated potential CSO control measures for the remaining uncontrolled CSO outfalls using the four major EPA categories of CSO control measures: Source Controls, Collection System Controls, Storage Technologies, and Treatment Technologies. Conceptual engineering and evaluation of these CSO control measures and the non-monetary factors screening indicated that storage technologies (tanks or tunnels) were the likely cost effective solution for most of the basins. Several CSO area-specific opportunities for flow diversion and Green Infrastructure were also feasible. The City will continue to implement source control measures (GI) and collection system control measures (retrofits) under the 2010 Plan Projects. The CSO reduction benefits of these control measures will ultimately be reflected in reduced sizes and scopes of constructed LTCP storage facilities.
- The LTCP provides a comprehensive solution for the remaining LTCP uncontrolled CSO outfalls to reduce overflows to one per outfall per year. The individual control measures for each uncontrolled outfall were combined into four aggregate or system-wide options that achieve this objective. For the LTCP, system-wide options were developed under two basic concepts: the City meets their consent decree-mandated control responsibilities through implementation of independent or neighborhood CSO control measures or the City participates in one or more shared projects with King County to take advantage of potential cost and impact reduction opportunities.
- A detailed evaluation was performed to evaluate and compare non-monetary factors against cost to rate and rank the system-wide options for the Draft LTCP. The system-wide options included two City independent (neighborhood) options and three shared City/King County options.

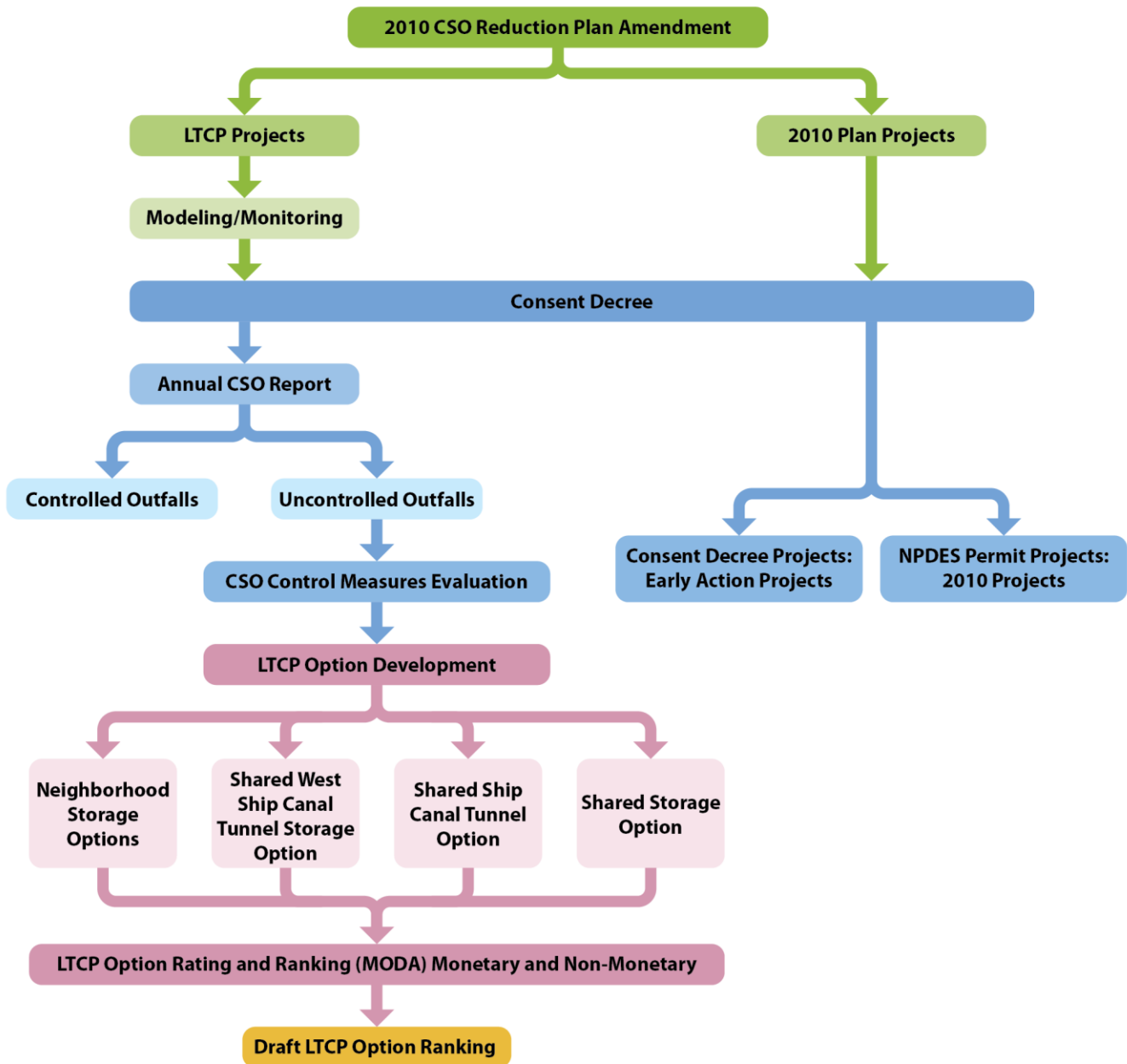


Figure 3-1. LTCP Option Decision Flow Chart

3.1.1 City and King County CSO Project Coordination

The City recognizes the importance of strong coordination with King County in controlling CSOs in the City. All of the proposed LTCP options have elements that may have an impact on King County's downstream wastewater system. Three of the proposed LTCP options include shared City/King County projects along the Ship Canal. Several of the proposed LTCP options include sewer system improvements that will convey additional wastewater volume to the downstream King County system. Regardless of which LTCP option is selected, coordination between the City and King County is critical to successfully designing, constructing, and eventually operating the proposed CSO control projects in the City.

The City and King County are continuing to work together closely to analyze and recommend shared LTCP options that are more cost-effective, produce better environmental outcomes, and minimize disruption to

communities than independent LTCP options. King County must also reach its own conclusions about the benefits of a shared project to the regional system and the implications of such a project to its own Long Term Control Plan (Reference 31) and Consent Decree (Reference 32). Selection of a shared City/King County project will depend on the City's and County's analytical results as well as a number of joint factors mutually agreed upon in a City/County coordination plan. These factors include such things as which agency will be responsible for the design, construction, and operation of the shared facility; each agency's project cost-share; operational and implementation roles and responsibilities; the process for dispute resolution; and the ability to fulfil regulatory and contractual obligations. If the City and King County choose to implement a shared City/King County project, then a shared project agreement between the two agencies will be necessary prior to designing and constructing the project. In addition, the City and King County will analyze the impacts of any recommended project on the downstream King County system and agree on an approach to addressing those impacts prior to constructing the project.

3.1.2 Performance Criteria

As described in Ecology regulations and the Consent Decree, CSOs must be limited to an average of one untreated discharge per year per outfall based on a 20-year moving average in order to be considered controlled. Additional details on control criteria are described in Sections 1.5.3 and 1.5.4.

3.1.3 CSO Control Measure Development

The 2010 CSO Reduction Plan amendment specified a series of projects for the most critical CSO overflow areas that were underway in various stages of design or construction. These were described in Table ES-1 of the 2010 Plan as 2010-2015 committed CSO control projects. The table lists the recommended control measure, estimated costs and the projected year of completion.

For those uncontrolled outfalls for which committed projects had not been identified, the 2010 Plan used a series of cost curves and estimated CVs to craft a cost-effective combination of potential control strategy solutions for each CSO control area.

In accordance with the direction of the Consent Decree, the LTCP alternative analysis process begins with the control measures recommended in the 2010 CSO Reduction Plan Amendment.

As a part of the LTCP planning process, the City reviewed and validated the recommendations of the 2010 Plan and simultaneously reconsidered basic CSO controls to develop a comprehensive list of component control measures. This list of existing and new alternatives was then subjected to evaluation incorporating refinements in system characterization, additional demonstration projects under the GI program, retrofit analysis and feasibility, interagency communication, regulatory input, public comment, and other factors to screen and focus on the optimal control measure for each basin and ultimately for the LTCP options.

3.1.4 Shared City and King County CSO Control Measures

Because of the interconnectedness of the City and King County wastewater collection systems, individual CSO control measures adopted by either agency can potentially exacerbate an overflow for the other. CSO control measures for long-term control of the City's CSOs affect, or are affected by, strategies and decisions related to the County's system.

King County began its CSO update planning in 2009. Because the two agencies were preparing similar documents during the same period and the two combined sewer systems were geographically and hydraulically linked, King County approached the City to identify potential collaborative opportunities.

The two agencies evaluated 40 potential shared projects and identified four feasible shared storage projects to evaluate in each agency's respective CSO plan: shared Fremont/Wallingford/3rd Avenue W Regulator storage, shared North Union Bay/University Regulator storage, shared Montlake/Montlake Regulator storage, and a deep tunnel along the Ship Canal.

These shared projects are more fully detailed in Section 3.5.2.

3.1.5 CSO Control Measure Evaluation Process

The feasibility of specific CSO control strategies within a specific basin varies depending on basin characteristics. The 2010 CSO Reduction Plan Amendment performed the initial development and screening of CSO control concepts for each of the uncontrolled CSO areas. As additional analysis and system characterization proceeded, new strategies were considered and analyzed. In some cases, executive decisions resulted in elimination of alternatives. Other measures were eliminated on the basis of site-specific issues (soil contamination), significant cost, or other factors. An intermediate screening process described in subsequent parts of this document was also used.

The goal of the screening and evaluation process was to reduce the list of potential control measures for each CSO area to the best solution so that system-wide combinations of control measures could be assessed in a more detailed triple bottom line evaluation process. A triple bottom line evaluation is used to consider the cost, environmental, and social impacts of various alternatives.

The technique used for this final analysis process is called multiple objective decision analysis (MODA). This technique incorporates a mechanism for considering non-monetary social and environmental issues as well as cost to create a structured comparison of competing solutions.

For additional detail, see Section 4.1.1 Evaluation of LTCP Alternative Options.

3.2 2010 CSO Reduction Plan Amendment Projects

3.2.1 Preliminary Recommended CSO Control Projects

Figure 2-28 is a map of the City's uncontrolled basins. The recommended control measures include 2010 Plan committed projects, Early Action projects, and LTCP Projects.

3.2.2 2010 Plan Committed Projects

Table 3-1 lists the 2010 committed projects and their current status including the continued existence of the project as a viable control measure.

Table 3-1. 2010 Plan CSO Reduction/Control Projects

Applicable CSO basins	Implementation status as of March 2015
Windermere	
013: Off-line storage 015: Retrofit	CSO Basin 013 construction began in October 2012 and construction completion is planned for 2015. CSO Basin 015 achieved construction completion in August 2012. Post project performance monitoring started Sept 2012 and continued until 2014.
Genesee	
040: Off-line storage 041: Off-line storage 043: Off-line storage 040, 041 and 043: GI	CSO Basins 040 and 041 storage has been combined into a single off-line storage project. CSO Basin 043 will be a separate off-line storage project. Both projects began construction in April 2013 and construction completion is planned for 2015 completion. Residential RainWise program is offered in these basins.
South Henderson	
049: Off-line storage	CSO Basin 049 is a storage project that will be constructed between by December 31, 2025.
Ballard	
150/151 and 152: GI	CSO Basin 152 pilot project constructed in 2011-12 and post-construction monitoring was performed in 2012-13. Additional GI right-of-way projects will start construction 2015. RainWise is offered in this basin.
Magnolia	
060: GI	Residential RainWise program is offered in CSO Basin 060. No other 2010 Plan projects are planned.
North Union Bay	
018: GI	Residential RainWise program is offered in this basin.
Interbay	
068: GI	This basin is now controlled based on the 2013 Annual CSO Report.
Montlake	
140: GI	Residential RainWise program is offered in this basin.
Fremont/Wallingford	
147 & 174: GI	Residential RainWise program is offered in this basin.

Table 3-1. 2010 Plan CSO Reduction/Control Projects

Applicable CSO basins	Implementation status as of March 2015
Central Waterfront	
069: Off-line storage	Since the northern portion of the Elliott Bay Seawall project (which includes CSO Basin 069) will not be constructed until after 2020, it was determined that CSO Basin 069 should be an LTCP project.
070 & 071: Off-line storage	During the SDOT's EBS and CWF Project design phases, it was determined that CSO Basins 070 and 071 should be coordinated and constructed with the first phase of the EBS construction as a 2010 Plan project. The anticipated completion date is 2018-2020.
West Seattle	
095: Retrofit	Basin 095 construction completed June 2013. Post project performance monitoring started July 2013 and continued for two years.
Delridge	
168: Retrofit	Bid in 2014. Construction completion is planned in 2015. Post project performance monitoring will start following construction and continue for 2 years. RainWise program is offered in these basins. GI roadside right-of-way project will start construction in 2015.
169: Retrofit	

3.2.3 Early Action Projects

The 2010 Plan identified CSO projects for the Windermere, Genesee, Henderson, Ballard, North Union Bay, Interbay, Montlake, Fremont-Wallingford, Central Waterfront, West Seattle and Delridge CSO areas. The July 2013 Consent Decree defined the Henderson CSO projects as "Early Action" including North Henderson and South Henderson projects with specific consent decree milestone completion dates. Consequently, the North and South Henderson projects are no longer part of the 2010-2015 phase and are considered Early Action Projects. Their project status is shown on Table 3-2.

Table 3-2. Early Action Projects

Applicable CSO basins	Implementation status as of May 2014
North Henderson	
044: Off-line storage 045: Off-line storage	CSO Basins 044 and 045 have been combined into a single off-line storage project. The project submitted 90% plans and specifications to EPA and Ecology in 2014. Planned completion date is December 31, 2018.
South Henderson	
046: Off-line storage 047/171: Off-line storage	CSO Basin 046 is a flow diversion project and submitted 90% plans and specifications to EPA and Ecology in December 2013. CSO Basin 047/171 is a storage project and started construction in late 2013.

3.2.4 2010 Plan Recommendations for LTCP CSO Reduction/Control Projects

For those uncontrolled outfalls for which committed projects had not been identified, the 2010 Plan used a series of cost curves and estimated CVs to craft a cost-effective combination of potential control strategy solutions for each CSO control area. The 2010 Plan recommendations for projects to be considered during preparation of the LTCP is shown in Table 3-3 along with pertinent comments regarding their continuing applicability. Additional clarification of the comments is included in subsequent portions of this document.

Table 3-3. 2010 Plan Preliminary LTCP CSO Reduction/Control Projects			
2010 CSO Reduction Plan		LTCP CSO control measure evaluation	
CSO basin	Proposed LTCP CSO control measure	Potential LTCP CSO control measure	Comments
Ballard			
150/151	In-line storage	Yes	The 2013 Annual CSO Report determined that this CSO outfall is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
152	Infiltration and inflow removal (I/I)	No	I/I analysis evaluation (See Appendix H) following issuance of the 2010 Plan Amendment indicated that I/I reduction is not a cost-effective solution compared to storage and thus will no longer be considered as a CSO control measure for this NPDES basin.
	Off-line storage	Yes	
Magnolia			
060	In-line storage	Yes	
North Union Bay			
018	In-line storage	No	Retrofit program design work indicated that a sewer system improvement CSO control measure (i.e., retrofit) will control CSO Basin 18 and is more cost-effective than in-line storage.
Interbay			
068	In-line storage	No	The 2013 Annual CSO Report determined that this CSO outfall is in control based on a moving 20-year average frequency. No LTCP project will be required.
Central Waterfront			
069	Off-line storage (2010 CSO Plan Amendment considered this CSO basin as a 2010-2015 committed project)	Yes	Since the northern portion of the Elliott Bay Seawall project (which includes CSO Basin 069) will not be constructed until after 2020, it was determined that CSO Basin 69 should be an LTCP project.

Table 3-3. 2010 Plan Preliminary LTCP CSO Reduction/Control Projects

2010 CSO Reduction Plan		LTCP CSO control measure evaluation	
CSO basin	Proposed LTCP CSO control measure	Potential LTCP CSO control measure	Comments
Fremont/Wallingford			
147	Off-line storage	Yes	The 2013 Annual CSO Report determined that this CSO outfall is uncontrolled based on a moving 20-year average frequency. An LTCP storage project will be required.
174	Off-line storage	Yes	The 2013 Annual CSO Report determined that this CSO outfall is uncontrolled based on a moving 20-year average frequency. An LTCP storage project will be required.
Duwamish			
111	Off-line storage	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
Delridge			
099	2010 CSO Plan Amendment considered this CSO basin as controlled.	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
168	Retrofit	Yes	Sewer system improvements are being constructed in 2015 that may control this outfall. A LTCP project will be constructed if the sewer system improvement cannot achieve full control of CSO Basin 168.
169	Retrofit	Yes	Sewer system improvements are being constructed in 2015 that may control this outfall. A LTCP project will be constructed if the sewer system improvement cannot achieve full control of CSO Basin 169.
Montlake			
020	Roof drain disconnects	No	The Consent Decree requires that the City identify measures to control all uncontrolled outfalls. The City must document the performance of GI in targeted CSO basins before EPA and Ecology will allow the City to reduce the size of any "grey" control measures. If the effectiveness is proven and approved, the City may implement smaller "grey" control measures and take credit for flow reductions associated with GI.

Table 3-3. 2010 Plan Preliminary LTCP CSO Reduction/Control Projects

2010 CSO Reduction Plan		LTCP CSO control measure evaluation	
CSO basin	Proposed LTCP CSO control measure	Potential LTCP CSO control measure	Comments
	Roadside rain gardens	No	The Consent Decree requires that the City identify measures to control all uncontrolled outfalls. The City must document the performance of GI in targeted CSO basins before EPA and Ecology will allow the City to reduce the size of any “grey” control measures. If the effectiveness is proven and approved, the City may implement smaller “grey” control measures and take credit for flow reductions associated with GI.
	I/I	No	I/I analysis evaluation following issuance of the 2010 Plan Amendment indicated that I/I reduction is not a cost-effective solution compared to storage and thus will no longer be considered as a CSO control measure for this NDPES basin.
	Off-line storage (not considered cost-effective in 2010 Plan Amendment)	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
139	2010 CSO Plan Amendment considered this CSO basin as controlled.	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
140	2010 CSO Plan Amendment considered this CSO basin as controlled.	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
Leschi			
028	Cisterns	No	RainWise program will be offered in this CSO basin. The Consent Decree requires that the City identify measures to control all uncontrolled outfalls. The City must document the performance of GI in targeted CSO basins before EPA and Ecology will allow the City to reduce the size of any “grey” control measures. If the effectiveness is proven and approved, the City may implement smaller “Grey” control measures and take credit for flow reductions associated with GI.
	In-line storage	Yes	
029	In-line storage	Yes	
030	Roof drain disconnects	No	The 2013 Annual CSO Report determined that this CSO basin is in control based on a moving 20-year average frequency. No LTCP project will be required.

Table 3-3. 2010 Plan Preliminary LTCP CSO Reduction/Control Projects

2010 CSO Reduction Plan		LTCP CSO control measure evaluation	
CSO basin	Proposed LTCP CSO control measure	Potential LTCP CSO control measure	Comments
	Roadside rain gardens	No	The 2013 Annual CSO Report determined that this CSO basin is in control based on a moving 20-year average frequency. No LTCP project will be required.
	I/I	No	The 2013 Annual CSO Report determined that this CSO basin is in control based on a moving 20-year average frequency. No LTCP project will be required.
031	Off-line storage	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
032	Off-line storage	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
034	Roof drain disconnects	No	The 2013 Annual CSO Report determined that this CSO basin is in control based on a moving 20-year average frequency. No LTCP project will be required.
	I/I reduction	No	The 2013 Annual CSO Report determined that this CSO basin is in control based on a moving 20-year average frequency. No LTCP project will be required.
035	Roof drain disconnects	No	The 2013 Annual CSO Report determined that this CSO basin is in control based on a moving 20-year average frequency. No LTCP project will be required.
036	In-line storage	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
Madison Park			
024	2010 CSO Plan Amendment considered this CSO basin as controlled.	No	The 2013 Annual CSO Report determined that this CSO basin is in control based on a moving 20-year average frequency. No LTCP project will be required.
025	Off-line storage	No	The 2013 Annual CSO Report determined that this CSO basin is in control based on a moving 20-year average frequency. No LTCP project will be required.
East Waterway			
107	Off-line storage	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
Portage Bay			

Table 3-3. 2010 Plan Preliminary LTCP CSO Reduction/Control Projects

2010 CSO Reduction Plan		LTCP CSO control measure evaluation	
CSO basin	Proposed LTCP CSO control measure	Potential LTCP CSO control measure	Comments
138	In-line storage	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.

3.3 Available CSO Control Measures

EPA guidance documents list four major categories of CSO control measures that can be used to bring combined systems into compliance. These categories were used to evaluate specific control measures for each LTCP CSO area.

3.3.1 Collection System Controls

Collection system controls focus on maximizing storage and conveyance within the existing CSS to reduce overflows. Examples include retrofits, sewer separation, weir adjustment, I/I, and flow diversion.

3.3.2 Source Controls

Source controls are aimed at reducing the total flow reaching the combined system. Examples include downspout separation and GI. These control techniques are the equivalent of “Keep Stormwater Out”. GI is a source control strategy that retards or retains stormwater flows for infiltration or subsequent treatment and thereby reduces CSOs.

GI feasibility analysis considers two factors that result in its estimated effectiveness. The first factor is the technical suitability of the combined sewer area (soils, topography, land use, density of development, etc.). The second factor is the anticipated level of public participation in the necessary GI projects. These two factors combine to produce a wide variety of potential GI effectiveness levels.

Potential GI applicability and feasibility for long-term CSO control is reported on in a report, Green Infrastructure Analysis for CSO Control, in Appendix I.

In all cases, some implementation of GI will provide a reduction in overflow volume.

There are two aspects to the City’s GI program:

- RainWise is a City program that pays property owners to mitigate the impacts of impervious roof surfaces by installing properly sized and constructed rain gardens or cisterns. The amount of the payment is based on the amount of roof area controlled.
- Roadside rain gardens are bioretention facilities constructed in public right-of-way.

The City is implementing a GI capital program in selected basins. Evaluations of the quantity of CSO reduction will be documented in an engineering report, and will be taken into account during the design phase of LTCP projects located in basins where GI is implemented. GI is a lead strategy in attaining control of CSOs. While it may not be technically suitable in some areas and may not have the capacity to be the sole CSO control technique, it is consistent with the concept of sustainability and is supported by a broad public constituency.

GI control measures are not being considered for the LTCP as a specific control measure because the Consent Decree requires a “grey” CSO control measure to be proposed for each uncontrolled outfall.

3.3.3 Storage Technologies

Storage solutions temporarily store enough CSO volume to prevent overflow from an overtaxed conveyance system. Examples of storage solutions include below-grade tanks, in-line or off-line enlarged pipes in the right-of-way, and deep tunnels. The City is currently constructing storage tanks for the Windermere and Genesee CSO projects and they will be operational in late 2015.

3.3.4 Treatment Technologies

Treatment technologies target specific removal or mitigation of pollutants at each outfall. Such technologies typically require construction of treatment and solids disposal facilities and their supporting structural, mechanical, electrical, and instrumentation systems.

3.3.5 Control Measure Application

Using a combination of the 2010 CSO Reduction Plan and EPA guidance documents, 75 independent and 40 shared control measures were identified and evaluated.

The evaluation made use of an intensive flow monitoring and modeling effort conducted by the City as a part of system characterization requirements.

During the evaluation period, the City’s ongoing retrofit efforts identified a number of potential system modifications and the City embarked on a program of modeling and analysis to define cost-effective CSO reduction opportunities.

Discussions with regulatory officials during the period also provided criteria for acceptable alternative control measures.

3.4 Screening of CSO Control Measures

3.4.1 2010 CSO Reduction Plan Recommended Projects

The 2010 CSO Reduction Plan represented the first screening of possible alternatives. The Consent Decree directs that the list of potential solutions described in the plan be the starting point for further alternative analysis. The feasibility of those measures is presented in Table 3-4.

An important result of the Consent Decree direction is the acknowledgement that the 2010 Plan evaluation of two potential control measures – sewer separation and point of discharge treatment – is sufficient to eliminate them from further consideration in the LTCP.

Table 3-4. CSO Control Measures to be Evaluated in the LTCP

2010 CSO Reduction Plan		LTCP	
2010 Proposed control measures	CSO outfall	Feasibility for LTCP after evaluation	LTCP CSO outfalls
Roadside rain gardens	150/151, 152, 060,020,140, 030	The Consent Decree requires that the City identify measures to control all uncontrolled outfalls. The City must document the performance of GI in targeted CSO basins before EPA and Ecology will allow the City to reduce the size of any “grey” control measures. If the effectiveness is proven and approved, the City may implement smaller “grey” control measures and take credit for flow reductions associated with GI.	150/151, 152, 099, 168, 169, 018, 020, 139, 140, 147,138
(RainWise) Residential rain gardens	060, 018, 068, 020, 140, 147, 174		099, 168, 169, 111, 028, 029, 031, 032, 036, 018, 020, 139, 140, 147, 174, 138
Cisterns	152, 140, 030		(see RainWise)
Permeable pavements	152, 140		
Bioretention swale	140		
I/I	152, 020, 034	Due to a lack of cost-effectiveness, will not be considered for any CSO basin	
Regulating devices and backwater gates or hydraulically operated sluice gates	168 & 169	Retrofit CSO control measures will provide partial control of these NDPES basins.	018, 111, 168, 169
Flow diversion	None	Although not considered in 2010 Plan, may be feasible for CSO Basin107 because of close proximity to King County treatment plant	060, 018, 028, 029, 031, 032, 036, 020, 139, 140, 107, 111, 099
In-line storage	049, 150/151, 060, 018, 028, 029, 036, 138,	Control volumes, hydraulic operations, and site-specific nature of this control measure make this CSO control measure inapplicable in any basin,	

Table 3-4. CSO Control Measures to be Evaluated in the LTCP

2010 CSO Reduction Plan		LTCP	
2010 Proposed control measures	CSO outfall	Feasibility for LTCP after evaluation	LTCP CSO outfalls
Off-line storage	152, 069, 147, 174, 111, 107, 031, 030, 032, 034, 035, 036, 025, 024, 138, 168, 169,	Will continue to be considered because of cost-effectiveness.	049, 060, 150/151, 152, 147, 174, 020, 139, 140, 138, 028, 029, 031, 032, 036, 069, 107, 111, 099, 168, 169
Storage in the right of way	None	Because of potential shared King County/City project opportunities, the LTCP will evaluate the cost-effectiveness of storage in the right of way.	150/151, 152, 147, 174, 018, 020, 139, 140, 138, 028, 029, 031, 032, 036
Treatment	None	2012 King County CSO Plan evaluated CSO treatment opportunities and determined that the King County Hanford, Lander, Kingdome, King St. (HLKK) CSO plant is the most cost effective shared treatment opportunity.	069, 107

3.4.2 Impact of Revised Performance Criteria (20 Year Moving Average)

Analysis of the controlled/uncontrolled status of each outfall has historically been based on a 5-year moving average of overflows until 2010. The Consent Decree revises the analysis period to a 20-year moving average using a combination of actual measured flows and modeled performance to establish that an outfall meets the control criteria. As shown in Table 2-21, LTCP Outfall Control Status, analysis of flow monitoring data and updated modeling under this new performance standard resulted in the shift of two CSO areas (Interbay and Madison Park) from uncontrolled to controlled status.

3.4.3 Impact of Hydraulic Model Results

The City has concurrently (with the LTCP) pursued an extensive program of flow monitoring and hydrologic and hydraulic model development in order to characterize the CSS response to anticipated rainfall conditions. The results of this modeling effort have been applied as they became available and incorporated into the ongoing control measure evaluation process. The net effect of updated model predictions has been refinement of CVs (both increases and decreases) and the adjustment of alternative details and costs.

3.4.4 Impact of Retrofit Program

The concurrent Retrofit Program has examined a prioritized list of the uncontrolled CSO areas in search of cost-effective, low-impact collection system modifications. As the results of the retrofit analysis of CSO areas have

become known, they have been incorporated into the alternative evaluation process. In some cases, potential retrofits have significantly reduced or eliminated the need for competing storage measures. It is anticipated that as retrofit opportunities are identified and successfully implemented in succeeding program years, they will be incorporated into the detailed planning and design of storage facilities to reduce the size and scope of those facilities.

Implementation of any retrofit project will require City coordination with King County. Specifically, the City and King County will need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.

3.4.5 Impact of Green Infrastructure

The City has a robust GI program. The 2010 Plan Amendment evaluated and recommended a number of GI techniques in several CSO areas. Further GI evaluation has refined the GI strategies within Seattle's CSO basins. Due to the nature of the City's CSO basins, which are primarily composed of drainage areas that have already undergone stormwater separation, significant GI opportunities do not exist in all CSO basins. Where appropriate, the City's concurrent GI programs applied in rights-of-way and private parcels, as well as companion stormwater code requirements to implement GI to the maximum extent feasible, will continue to be pursued. It is anticipated that the results of the GI engineering reports and analysis in several CSO basins will be incorporated into the detailed planning and design of storage facilities to reduce the size and scope of those facilities.

A GI feasibility evaluation is included as Appendix I to this document. The potential effectiveness of GI control measures (RainWise and roadside rain gardens) consider both the technical suitability of the area being evaluated as well as the range of public participation levels anticipated. Table 3-5 presents a summary of the feasibility evaluation.

3.4.6 Impact of Shared Project Negotiations

The 2010 Plan Amendment did not address the possibility of pursuing shared projects with King County. Collaboration between the City and King County staff have identified and evaluated several tank and tunnel projects. Prior to implementing any shared projects with King County and the City, a joint project agreement will need to be executed between the two agencies.

Table 3-5. Green Infrastructure Potential Effectiveness

CSO area	Basin	V22 CV	Practical participation		Maximum participation	
			CV reduction through GI	Percent of total	CV reduction through GI	Percent of total
Duwamish	111H	0.01	0.016	100.0%	n/a	
Leschi	028	0.01	0.002	20.0%	0.015	100.0%
Leschi	029	0.02	0.001	5.0%	0.008	40.0%
Leschi	031	0.31	0.0004	0.1%	0.003	1.0%
Leschi	032	0.08	0.001	1.3%	0.01	12.5%
Leschi	036	0.03	0.001	3.3%	0.011	36.7%

Table 3-5. Green Infrastructure Potential Effectiveness

CSO area	Basin	V22 CV	Practical participation		Maximum participation	
			CV reduction through GI	Percent of total	CV reduction through GI	Percent of total
North Union Bay	018	1.63	0.45	27.6%	0.79	48.5%
Montlake	020	0.16	0.021	13.1%	0.066	41.3%
Montlake	139	0.01	0.006	60.0%	0.025	100.0%
Montlake	140	0.05	0.019	38.0%	0.026	52.0%
Ballard	150/151	0.62	0.172	27.7%	0.273	44.0%
Ballard	152	5.38	1.07	19.9%	1.718	31.9%
Fremont/Wallingford	147	2.15	0.02	0.9%	0.484	22.5%
Fremont/Wallingford	174	1.06	0.054	5.1%	0.122	11.5%
Portage Bay	138	0.11	0.007	6.4%	0.011	10.0%
Delridge	099	0.17	0.017	10.0%	0.043	25.3%
Delridge	168	2.00	0.162	8.1%	0.266	13.3%
Delridge	169	1.19	0.152	12.8%	0.192	16.1%

3.4.7 Impact of the City's Infiltration and Inflow Removal Evaluation Report

The 2010 Plan Amendment proposed I/I projects in several CSO areas as a component solution. The City staff performed a detailed analysis of the feasibility of I/I in those CSO areas. In general, the report indicated that I/I is not a cost-effective method of achieving CSO reduction compliance and this control strategy has been eliminated from further consideration.

3.4.8 CSO Control Measures to be Considered for LTCP

Ongoing refinement, evaluation, and interim screening of the range of feasible control measures and the application of external factors and requirements described above resulted in a trend toward the use of storage technologies (tanks or tunnels) as the likely solution for most of the basins. Several CSO area-specific opportunities for flow diversion were also feasible and remain under consideration. Source control measures (GI) and collection system control measures (retrofits) will continue to be implemented because of their potential to reduce overflows at a lower cost per gallon than storage facilities. The positive effects of these control measures will ultimately be reflected in reduced sizes and scopes of constructed storage facilities.

3.5 Control Measure Definition and Application

The following subsections present the various control measures developed for this LTCP. Implementation of any neighborhood and shared project will require City coordination with King County. Specifically, the City and King

County will need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts. Prior to implementing any shared project with King County and the City, a joint project agreement will need to be executed between the two agencies.

3.5.1 Control Measures for Specific CSO Areas

3.5.1.1 Ballard CSO Area

The Ballard CSO area is the largest of the City's CSO contributing area and includes 1,170 acres (1.8 square miles) in northwest Seattle; The Ballard CSO area includes CSO Basins 150/151 and 152. CSO Basin 150/151 has a single overflow point, but the outfall divides into two branches, each with its own CSO outfall designation. The wastewater generated in these basins flows by gravity to King County's Ballard siphon for conveyance to the West Point WWTP. Figure 3-2 shows the Ballard CSO area boundaries, CSO outfall locations, and general area for potential CSO control measure implementation.

3.5.1.1.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-6 lists the Ballard CSO outfalls' long-term average annual overflow frequency, average annual overflow volume, and CV. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the Ballard CSO outfall CV including climate change were used as the basis for CSO control measure sizing and evaluation.



Figure 3-2. Ballard CSO Area Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

Table 3-6. Ballard CSO Outfall Control Volumes

CSO Outfall	Average annual overflow frequency ^a	Average annual overflow volume (MG) ^{b,c}	Control volume with climate change (MG) ^d	Control volume without climate Change (MG) ^{c, d}
150/151	17.1	2.67	0.62	0.45
152	45.8	21.38	5.38	4.38

^a 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling

^b From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0

^c Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties

^d Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

3.5.1.1.2 CSO Control Measure Evaluation

Section 3.4 described the screening performed to identify the CSO control measures for LTCP evaluation. Table 3-7 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-7. Ballard CSO Control Measures

CSO control measure	LTCP evaluation results
GI	Ballard is a primary opportunity for GI applications. As shown in Appendix I, GI approaches have an estimated CV reduction of as much as 1.99 MG. The City is implementing selected GI control measures in the Ballard CSO area and will evaluate the performance of GI in Ballard. If the effectiveness of GI is proven and approved, the City may implement smaller “grey” control measures and take credit for flow reductions associated with GI. For the LTCP, no Ballard CSO reduction credit will be associated with GI because the Consent Decree requires 100 percent “grey” CSO control measures be proposed in the LTCP to resolve all uncontrolled outfalls.
Off-line storage	Because the two Ballard CSO outfalls are so geographically close to each other, conceptual planning concluded that a single CSO control measure for both CSO outfalls was the most cost effective solution. Because of the large Ballard CSO area storage volumes (6 MG), the LTCP evaluated two off-line storage CSO control measure alternatives: a single off-line tank and parallel large-diameter storage pipes. Evaluation of the large diameter pipe control measure removed it from further consideration due to construction impacts, cost effectiveness, and long-term impacts on crossing utilities in a congested corridor.

Table 3-7. Ballard CSO Control Measures

CSO control measure	LTCP evaluation results
Deep tunnel storage	Because of the geographical proximity of the Ballard and Fremont-Wallingford CSO basins and the large combined storage volume of 9.2 MG, the LTCP evaluated the cost-effectiveness of deep tunnel storage between Ballard and Fremont-Wallingford CSO areas. The evaluation is presented in Section 3.5.1.12, Neighborhood West Ship Canal Tunnel. Because of potential shared King County/City project opportunities and the large Ballard CSO area storage volumes (6 MG), the LTCP evaluated the cost-effectiveness of deep tunnel storage as described in Section 3.5.2, Shared Project Control Measures.

3.5.1.1.3 Final Ballard CSO Control Measures

There are two final LTCP CSO control measures for the Ballard CSO area: Off-line storage and deep-tunnel storage. Figure 3-2 shows general area for potential CSO control measure implementation.

Since the basins connect to the same combined sewer and are adjacent to each other, the off-line storage CSO control measure combines the storage needs for both CSO Basins 150/151 and 152 in one off-line storage facility. The Ballard CSO control measure consists of the transferring of combined sewage overflow (CSO) volume to multiple collection system control structures, a new multi-cell underground storage tank, and the necessary infrastructure to divert and convey combined sewer flows to and from storage. In order to reduce the number of CSO occurrences in the Ballard basin to an average of one per year, an estimated storage volume of 6.00 MG is required. Control measure modelling confirmed the feasibility of the and estimated that this CSO control measure for CSO Outfalls 150/151 and 152 will reduce the annual overflow frequencies from 17.1 and 45.8 respectively to one or less events per year.

There are three potential deep-tunnel storage CSO control measures for the Ballard CSO area and they are more fully described in Section 3.5.2.2, Shared Tunnel Projects. One deep-tunnel option will provide CSO storage for both the Ballard and Fremont/Wallingford CSO areas. In addition, there are two shared tunnel projects with King County where the Ballard CSO area will be included in the storage capacity.

Implementation of any neighborhood and shared project will require City coordination with King County. Specifically, the City and King County will need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts. Prior to implementing any shared project with King County and the City, a joint project agreement will need to be executed between the two agencies.

3.5.1.2 Magnolia CSO Area

The Magnolia Basin (CSO Outfall 060) is located south of the Ship Canal, west of Salmon Bay, east of Discovery Park and north of West Commodore Way. Topographically, the basin generally slopes from west to east. The 28-acre basin is served by a combined sewer system and consists of residential land use. The wastewater generated in this basin flows to the 144-inch diameter King County North Interceptor, which conveys sewage toward the West Point WTP. Figure 3-3 shows the Magnolia CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.

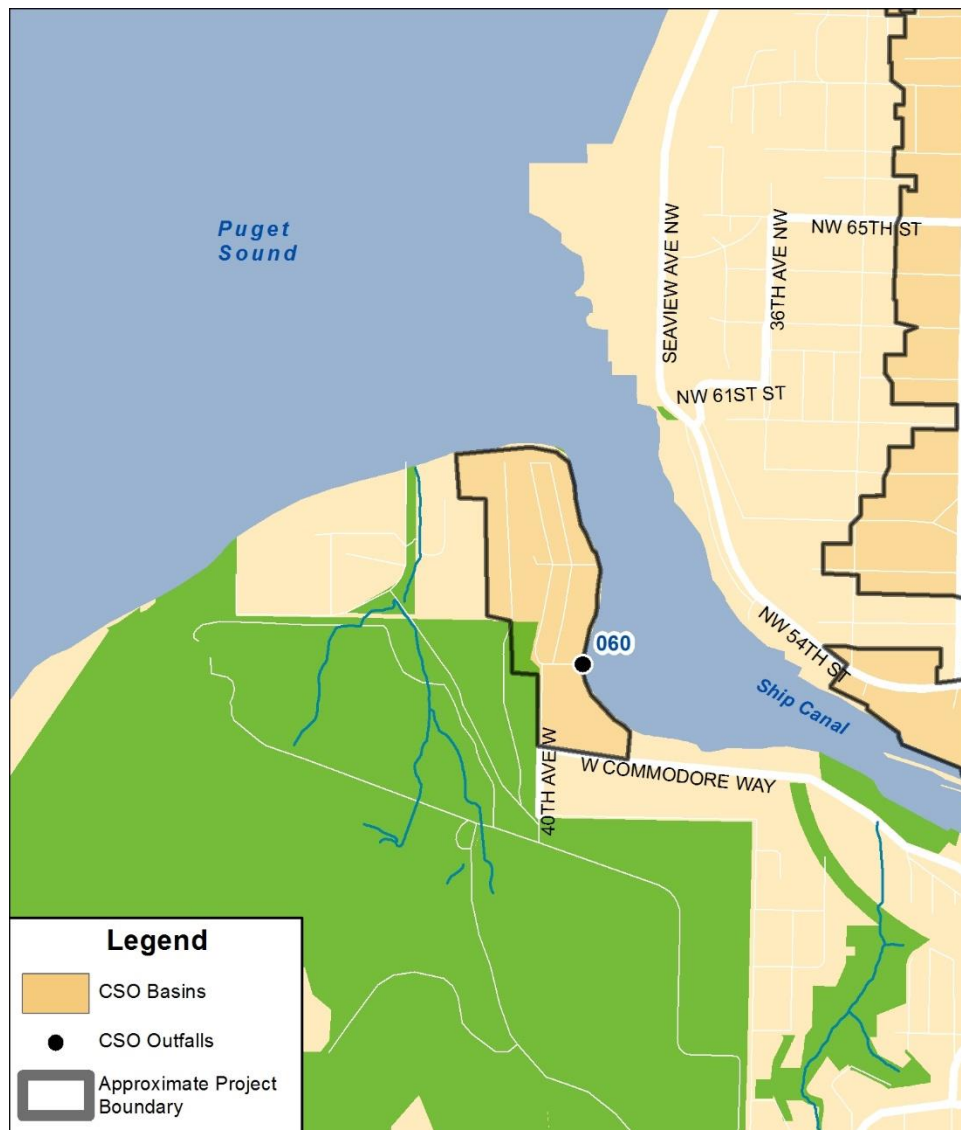


Figure 3-3. Magnolia CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.2.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-8 lists the Magnolia CSO outfall's long-term average annual overflow frequency, average annual overflow volume, and CV. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the Magnolia CSO outfall CV including climate change was used as the basis for CSO control measure sizing and evaluation.

3.5.1.2.2 CSO Control Measure Evaluation

Section 3.4 described the CSO screening performed to identify the CSO control measures for LTCP evaluation. Table 3-9 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-8. Magnolia CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency ^a	Average annual overflow volume (MG) ^{b,c}	Control volume with climate change (MG) ^d	control volume without climate change (MG) ^{c, d}
60	2.7	0.30	0.11	0.09

^a 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling

^b From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0

^c Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties

^d Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

Table 3-9. Magnolia CSO Control Measures

CSO control measure	LTCP evaluation results
Flow diversion	The City's Retrofit Program evaluated potential retrofit solutions to control CSO outfall 060 and identified a flow diversion option. CSO Outfall 060 control is achieved through transferring the peak storm flows out of the Magnolia CSO basin to the Fort Lawton Tunnel (operated by King County) via increased pumping and force main capacity.
Off-line storage	Three off-line storage options were evaluated: a tank in the street right-of way, a pipe in the street right-of way, and a tank on private property. The three off-line storage CSO control measures were equivalent in costs and impacts. The off-line storage pipeline in the street right-of way was selected as the Magnolia off-line CSO control measure for LTCP evaluation.

3.5.1.2.3 Final Magnolia CSO Control Measures

There are two final LTCP Magnolia CSO control measures: off-line storage and flow diversion. Figure 3-3 shows the general area for potential Magnolia CSO control measure implementation.

The Magnolia CSO basin off-line storage control measure consists of transferring combined sewage overflow to a new off-line storage pipe. This CSO control measure includes a storage pipe and the necessary infrastructure to divert and convey combined sewer flows to and from the pipe. The estimated storage volume required is 0.11 million gallons. Control measure modelling confirmed the feasibility of this CSO control measure and estimated that it will reduce the annual overflow frequencies from 2.7 to 1 or less events per year.

The Magnolia CSO basin flow diversion control measure includes transferring the peak storm flows out of the Magnolia CSO basin to the Fort Lawton Tunnel (operated by King County) by increasing the pump capacity at Pump Station No. 22 from 0.86 MGD to 3.3 MGD and constructing a new 12-inch diameter pipe. It is described in additional detail in Section 3.5.2.3, Flow Diversion Projects. Control measure modelling confirmed the feasibility of this concept for this CSO control measure and estimated that it will reduce the annual overflow frequency to one or less events per year.

3.5.1.3 North Union Bay CSO Area

The North Union Bay CSO area covers approximately 900 acres (1.4 square miles) in northeast Seattle. The North Union Bay CSO area includes CSO Basin 018, which drains from north to south toward Union Bay and Lake Washington. The basin has two overflow points, designated overflows 018(A) and 018(B). Overflows from both points are conveyed by the storm drainage system to a single outfall (CSO Outfall 018) into Union Bay. The wastewater generated in these basins flows by gravity to King County's Laurelhurst trunk for conveyance to the West Point WWTP. Figure 3-4 shows the North Union Bay CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.

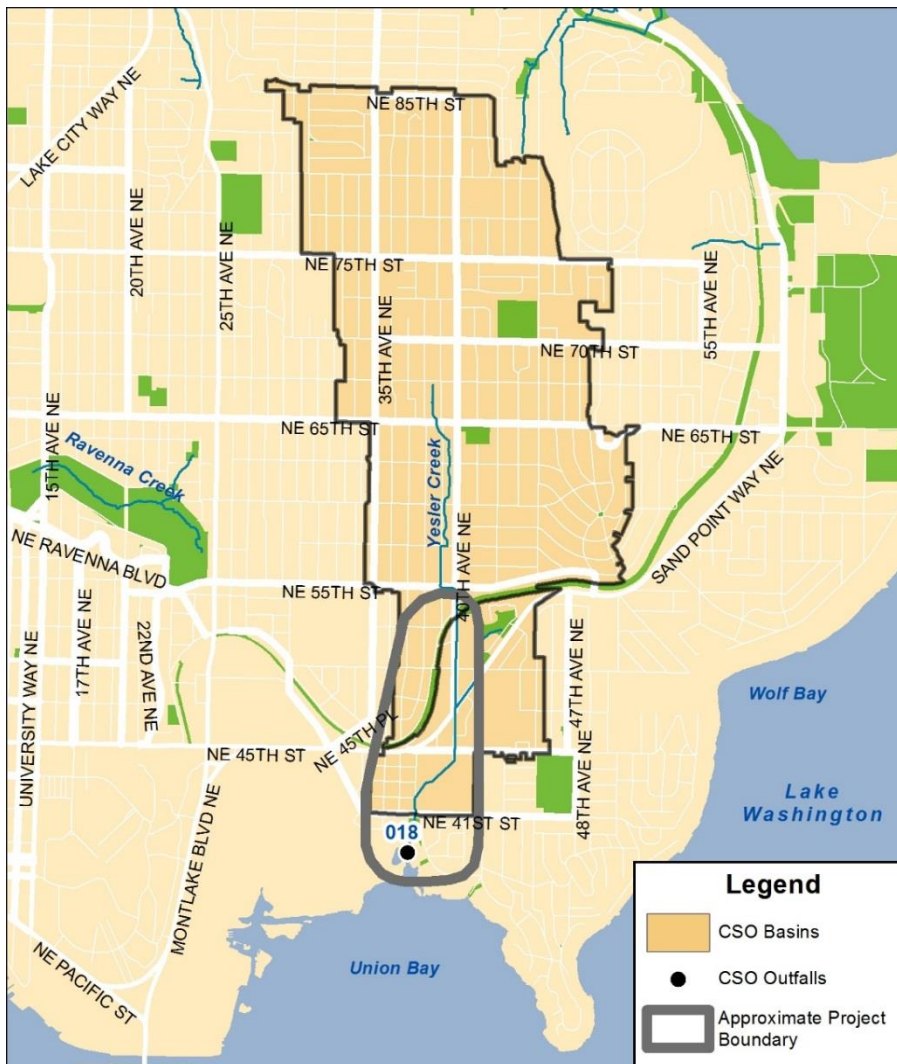


Figure 3-4. North Union Bay CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.3.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-10 lists the North Union Bay CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated for possible effects with and without future

climate change. For the LTCP, the North Union Bay CSO outfall CV including climate change was used as the basis for CSO control measure sizing and evaluation.

Table 3-10. North Union Bay CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency ^a	Average annual overflow volume (MG) ^{b,c}	Control volume with climate change (MG) ^d	Control volume without climate change (MG) ^{c, d}
18	4.1	5.1	1.63	1.17

^a 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling

^b From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0

^c Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties

^d Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

3.5.1.3.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-11 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measure evaluation for this CSO area.

Table 3-11. North Union Bay CSO Control Measures

CSO control measure	LTCP evaluation results
Flow diversion	The City's Retrofit Program identified a retrofit flow diversion project to the King County Laurelhurst Interceptor.
Off-line storage	Two types of off-line storage were evaluated: independent City storage and shared City/King County storage. For Independent City storage, two storage control measure options for the northern portion of the basin and five alternatives for the southern portion of the basin were evaluated. The northern control measures involved storage in street right-of-way and storage on private property. The southern control measures involved storage on private property. Because of the potential shared King County/City project opportunity, the LTCP evaluated the cost-effectiveness of shared storage with the King County University Regulator project which is described in Section 3.5.2, Shared Project Control Measures.
Deep tunnel storage	Because of potential shared King County/City project opportunities, the LTCP evaluated the cost-effectiveness of deep tunnel storage. North Union Bay is a tributary area to a deep tunnel storage option more fully described in Section 3.5.2, Shared Project Control Measures.

3.5.1.3.3 Final North Union Bay CSO Control Measures

The final LTCP North Union Bay CSO control measure is a flow diversion. Figure 3-4 shows the general area for potential North Union Bay CSO control measure implementation.

The North Union Bay CSO basin flow diversion control measure will involve modifying the existing City CSO storage facility's outflow structure to achieve the current HydroBrake manufacturer's design performance. It is described in additional detail in Section 3.5.2.3, Flow Diversion Projects. This CSO control measure will restore the original design capacity for storage and flows. Control measure modelling confirmed the feasibility of this CSO control measure and estimated that it will reduce the annual overflow frequencies from 4.1 to 1 or less events per year. This CSO control measure was selected based on cost-effectiveness compared to the off-line storage control measure.

There are two potential shared CSO control measures for the North Union Bay CSO area; they are described in Section 3.5.2, Shared Project Control Measures. The first is a shared storage CSO control measure and will include storage for the King County University Regulator and the City's North Union Bay CSO basin. The second, a ship canal tunnel shared with King County, will meet storage requirements for several King County CSO outfalls and City CSO areas.

3.5.1.4 Central Waterfront CSO Area

The Central Waterfront CSO area is located in the northern part of downtown Seattle, near the waterfront. The area encompasses 150 acres (0.23 square mile) and is bounded approximately by Denny Way to the north, Bay Street to the northwest, 5th and 4th Avenues to the north and east, and Alaskan Way to the south and west (see Figure 2-7.). The Vine Street CSO area is included in the larger Central Waterfront CSO area, which includes four CSO outfalls and their respective basins: 069 (Vine), 070, 071, and 072. The LTCP focused on the uncontrolled CSO outfall 069 and the 2010 CSO Reduction Plan projects will include control of CSO Outfall 071. Flow from CSO Basin 069 drains to the King County Elliott Bay Interceptor for conveyance, treatment, and discharge at the West Point WWTP. Figure 3-5 shows the Central Waterfront CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.

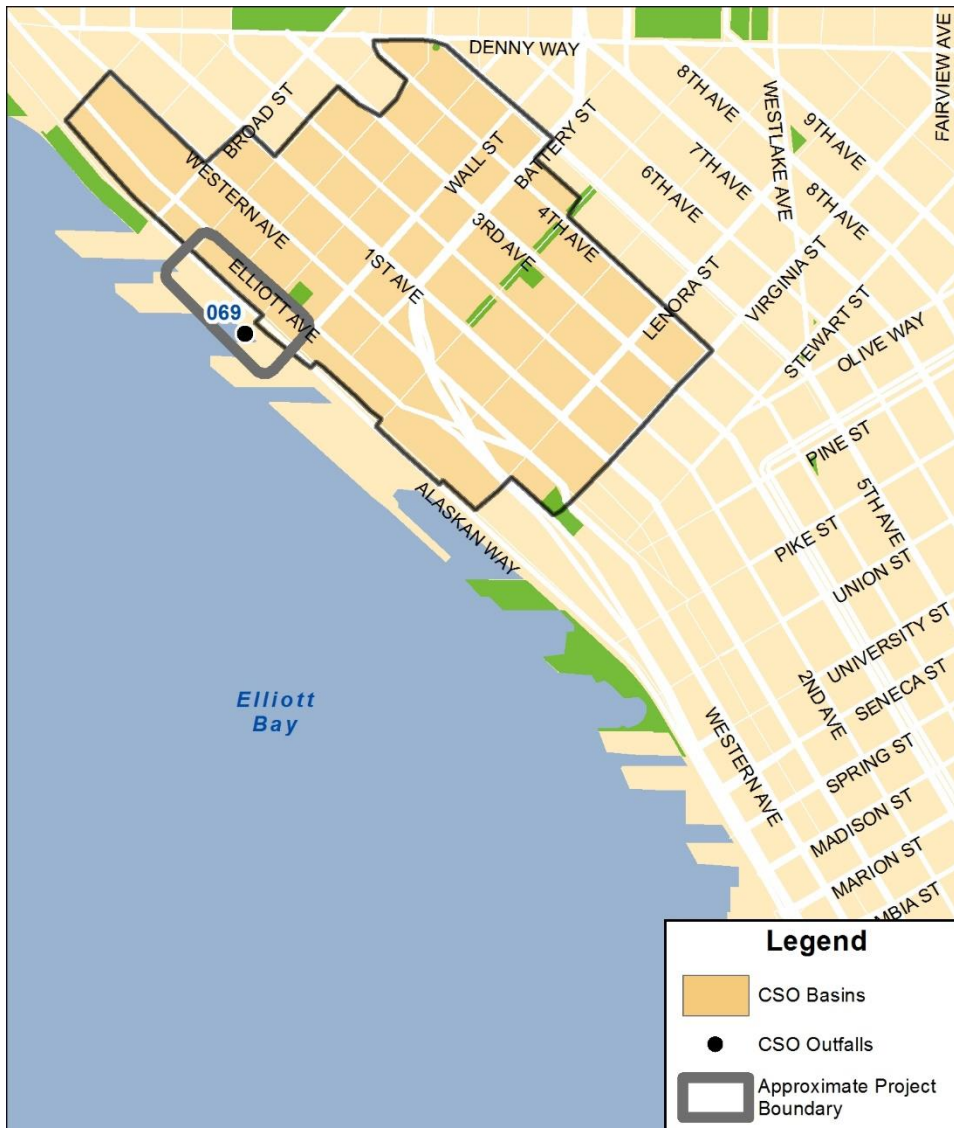


Figure 3-5. Central Waterfront CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.4.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-12 lists the Central Waterfront CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the Central Waterfront CSO outfall CV including climate change was used as the basis for CSO control measure sizing and evaluation.

Table 3-12. Central Waterfront CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency ^a	Average annual overflow volume (MG) ^{b,c}	Control volume with climate change (MG) ^d	Control volume without climate change (MG) ^{c, d}
069	1.6	0.82	0.07	0.05

^a 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling

^b From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0

^c Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties

^d Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

3.5.1.4.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-13 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-13. Central Waterfront CSO Control Measures

CSO control measure	LTCP evaluation results
Off-line storage	Two types of off-line storage were evaluated: storage tanks and pipe storage. Because of high groundwater and poor soils conditions, storage tank construction is not cost effective and will interfere with the final configuration of the City's Elliott Bay Seawall Replacement and Central Waterfront Projects. Off-line pipe storage was evaluated and was determined to be the most cost effective CSO control measure. It also minimizes impacts to the City's Elliott Bay Seawall Replacement and Central Waterfront Projects.

3.5.1.4.3 Final Central Waterfront CSO Control Measures

The Central Waterfront (Vine Street) CSO control measure consists of off-line CSO storage upstream of the King County Elliot Bay Interceptor, which directs flow to the King County West Point WWTP. The storage volume will be provided by an off-line storage pipe in the vicinity of CSO Outfall 069. Figure 3-5 shows general area for potential Central Waterfront CSO control measure implementation.

As shown in Table 3-12, Central Waterfront CSO Outfall Control Volume, the LTCP hydraulic modelling estimated a CV with climate change of 0.07 MG. Control measure modelling for the final off-line CSO storage indicated that a storage volume of 0.13 MG is required based on King County Elliot Bay Interceptor hydraulic limitations. With 0.13 MG of storage volume, the modelling confirmed the feasibility of this concept and estimated that it will reduce the annual overflow frequencies from 1.6 to 1 or less events per year.

Implementation of any neighborhood project will require City coordination with King County. Specifically, the City and King County will need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.

No shared King County/City storage opportunities were identified for this CSO area.

3.5.1.5 Fremont/Wallingford CSO Area

The Fremont/Wallingford CSO area covers 657 acres (1.0 square mile) in north Seattle and includes CSO outfalls 147, 148, and 174, which drain from north to south toward Lake Union and the Lake Washington Ship Canal. CSO Outfalls 147 and 174 are uncontrolled and are addressed in the LTCP. CSO Outfall 148 is controlled and is not evaluated in the LTCP. CSO Basin 147 has two overflow points (147(A) and 147(B)), that discharge to a single outfall (CSO Outfall 147). Both the CSO Basins 148 and 174 each have single overflow points and outfalls. Wastewater generated in these basins flows by gravity to King County's North Interceptor for conveyance to the West Point WWTP. Figure 3-6 shows the Fremont-Wallingford CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.



Figure 3-6. Fremont/Wallingford CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.5.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-14 lists the Fremont-Wallingford CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the Fremont-Wallingford CSO outfall CVs including climate change were used as the basis for CSO control measure sizing and evaluation.

Table 3-14. Fremont-Wallingford CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency ^a	Average annual overflow volume (MG) ^{b,c}	Control volume with climate change (MG) ^d	Control volume without climate change (MG) ^{c, d}
147	38.1	8.14	2.15	1.96
174	8.7	3.33	1.06	0.99

^a 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling

^b From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0

^c Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties

^d Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

3.5.1.5.2 CSO Control Measure Evaluation

Section 3.4 described the CSO Control Measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-15 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-15. Fremont-Wallingford CSO Control Measures

CSO control measure	LTCP evaluation results
Off-line storage	Seven independent storage control measures in which the two CSO outfalls were served by a common storage facility were evaluated, as well as seven additional storage control measures (four for CSO Outfall 147 and three for CSO outfall 174) that served each individual outfall were evaluated. Because the two Fremont-Wallingford CSO outfalls are so close to each another, conceptual planning concluded that a single control measure for both CSO outfalls was the most cost effective solution. Because of the large Fremont-Wallingford CSO area storage volumes (3.2 MG), the LTCP evaluated two off-line storage alternatives: a single off-line tank and a storage tunnel serving only the Fremont/Wallingford CSO area. City management concluded that a single off-line storage tank on City-owned property was the most cost-effective control solution for this CSO area. Evaluation of the large diameter pipe control measure removed it from further consideration due to construction impacts, cost effectiveness, and long-term impacts on crossing utilities in a congested corridor Because of the potential for shared King County/City storage and the large Fremont-Wallingford CSO area storage volumes (3.2 MG), the LTCP evaluated

Table 3-15. Fremont-Wallingford CSO Control Measures

CSO control measure	LTCP evaluation results
	the cost-effectiveness of off-line storage with King County's 3 rd Avenue West CSO area. This concept is described in Section 3.5.2, Shared Project Control Measures.
Deep tunnel storage	Because of the geographic proximity of the Ballard and Fremont-Wallingford CSO basins and the large combined storage volume of 9.2 MG, the LTCP evaluated the cost-effectiveness of deep tunnel storage between Ballard and Fremont-Wallingford CSO areas. The evaluation is presented in Section 3.5.1.12, Neighborhood West Ship Canal Tunnel. Because of the potential for shared King County/City storage and the large Fremont-Wallingford CSO area storage volumes (3.2 MG), the LTCP evaluated the cost-effectiveness of deep tunnel storage as described in Section 3.5.2, Shared Project Control Measures.

3.5.1.5.3 Final Fremont-Wallingford Control Measures

There are two final LTCP CSO control measures for the Fremont/Wallingford CSO area: Off-line storage and deep tunnel storage. Figure 3-6 shows the general area for potential Fremont/Wallingford CSO control measure implementation.

Since the basins connect to the King County North Interceptor and are adjacent to each other, the off-line storage CSO control measure combines the storage needs for both CSO Basins 147 and 174 in one off-line storage facility. The CSO control measure consists of transferring CSO volume to multiple collection system control structures, a new multi-cell underground storage tank, and the necessary infrastructure to divert and convey combined sewer flows to and from storage. In order to reduce the number of CSO occurrences in the Fremont/Wallingford CSO basin to an average of one per year, an estimated storage volume of 3.2 million gallons is required. Control measure modelling confirmed the feasibility of this concept and estimated that annual overflow frequencies for CSO Outfalls 147 and 174 will be reduced from 38.1 and 8.7, respectively, to 1 or less events per year.

The deep tunnel storage CSO control measure will provide CSO storage for both the Ballard and Fremont/Wallingford CSO areas. This evaluation is presented in Section 3.5.1.12, Neighborhood West Ship Canal Tunnel.

There are two potential shared CSO control measures involving the Fremont-Wallingford CSO area and they are described in Section 3.5.2, Shared Project Control Measures. The first is a shared storage CSO control measure that will include storage for the King County 3rd Avenue West Regulator and the City Fremont-Wallingford CSO outfalls. The second involves shared tunnel projects with King County where the Fremont-Wallingford CSO area will be included in the storage capacity.

3.5.1.6 Duwamish CSO Area

The Duwamish CSO area covers 487 acres (0.68 square mile) in southeast Seattle; it is bounded by S Hanford Street to the north, the Duwamish River to the west, S Hudson Street to the south, and Beacon Hill to the east.

The Duwamish CSO area comprises CSO Basin 111. CSO Basin 111 drains from east to west toward the Duwamish River where there is a single overflow point at CSO Outfall 111. The wastewater generated in this basin flows by gravity to King County's Duwamish pump station (at the corner of Diagonal Avenue S and East Marginal Way S) for conveyance to the West Point WWTP. The CSS in the Duwamish CSO area conveys both sanitary and stormwater flow. The area is partially separated. CSO Basin 111 contains eight permitted CSO structures (A–H) that discharge overflows to the Diagonal Avenue storm drain and then to the Duwamish River through CSO Outfall 111 during large precipitation events when the capacity of the CSS is exceeded. Figure 3-7 shows the Duwamish CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.



Figure 3-7. Duwamish CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Measure Implementation

3.5.1.6.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-16 lists the Duwamish CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CV. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the Duwamish CSO outfall CV including climate change was used as the basis for CSO control measure sizing and evaluation.

Table 3-16. Duwamish CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency ^a	Average annual overflow volume (MG) ^{b,c}	Control volume with climate change (MG) ^d	Control volume without climate change (MG) ^{c, d}
111	1.8	0.49	<0.01	<0.01

^a 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling

^b From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0

^c Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties

^d Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

3.5.1.6.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-17 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-17. Duwamish CSO Control Measures

CSO control measure	LTCP evaluation results
Flow diversion	The City's Retrofit Program identified a retrofit flow diversion project for the King County Duwamish Interceptor. The City Retrofit Program evaluated potential retrofit solutions to control CSO Outfall 111 and identified a flow diversion retrofit CSO control option.
Off-line storage	CSO Outfalls 111B and 111C are close together and may be considered a single CSO control measure. CSO Outfall 111H is significantly geographically separated from 111B and 111C. Conceptual planning developed four independent storage control measures for CSO Outfalls 111B and 111C. These included a tank in the right-of-way, tanks on one of two government-owned properties, and a tank on private property. Two storage control measures were developed for CSO Outfall 111H including one on City-owned property and one on a park site. There were two storage control measures developed for a combined CSO Outfall 111B, 111C, and 111H storage site. Evaluation of the CSO control measures concluded that three off-line storage tanks in the right-of-way were the optimal control solution for this CSO area.

3.5.1.6.3 Final Duwamish CSO Control Measures

There are two final LTCP CSO control measures for the Duwamish CSO area: off-line storage and flow diversion. Figure 3-7 shows the general area for potential Duwamish CSO control measure implementation.

The off-line storage concept includes two separate CSO storage facilities:

- The Duwamish 111B and 111C CSO control measure consists of off-line CSO storage upstream of the King County Duwamish pump station. The Duwamish pump station directs flow to the King County Elliott Bay Interceptor. The 0.02 MG storage volume will be provided by modifying two existing control structures and re-routing storm drainage piping to isolate the structures.
- The Duwamish 111H CSO control measure will include an off-line storage pipe adjacent to the existing CSO Control Facility 35 storage tank. During CSO events, excess combined sewer flows will be diverted to a new 0.01 MG off-line storage pipe and flow through both the new storage pipe and the existing CSO Control Facility 35 tank to the downstream sewer conveyance system.
- Control measure modelling confirmed the feasibility of the concept and estimated that these CSO control measures will reduce the Duwamish CSO outfall annual overflow frequencies from 1.8 to 1 or less events per year.

The Duwamish CSO basin flow diversion control measures will divert flows to the King County Duwamish Interceptor and is described in additional detail in Section 3.5.2.3, Flow Diversion Projects.

No shared King County/City storage opportunities were identified for this CSO area.

3.5.1.7 East Waterway CSO Area

The East Waterway CSO area (CSO Basin 107) covers 58.7 acres (0.09 square mile) in southeast Seattle; it is bounded by S Hanford Street to the north, the East Waterway of the Duwamish River to the west, industrial properties to the south, and East Marginal Way S to the east. Topographically, CSO Basin 107 is generally flat, and land use consists entirely of industrial property. The wastewater generated in this basin flows by gravity to the King County Elliot Bay Interceptor in Colorado Avenue S for conveyance to the West Point WWTP. Flow in CSO Basin 107 drains toward a single overflow point (CSO Outfall 107) near the intersection of East Marginal Way S and S Spokane Street. Overflows at this location occur only when the water level in the King County interceptor is above the level of the overflow point. Figure 3-8 shows the East Waterway CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.



Figure 3-8. East Waterway CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.7.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-18 lists the East Waterway CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the East Waterway CSO outfall CV including climate change was used as the basis for CSO control measure sizing and evaluation.

Table 3-18. East Waterway CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency ^a	Average annual overflow volume (MG) ^{b,c}	Control volume with climate change (MG) ^d	Control volume without climate change (MG) ^{c, d}
107	4.9	0.9	0.5	0.45

^a 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling

^b From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0

^c Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties

^d Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

3.5.1.7.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-19 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-19. East Waterway Basin CSO Control Measures

CSO control measure	LTCP evaluation results
Flow diversion	King County will be constructing a new CSO treatment plant, near the CSO outfall 107 location. The LTCP evaluated a flow diversion from CSO Outfall 107 to the new King County CSO treatment plant. This concept is described in Section 3.5.2.3, Flow Diversion Projects.
Off-line storage	A storage control measure was developed for CSO Outfall 107 consisting of an underground storage tank. Evaluation of the CSO control measure concluded that off-line storage tank was the optimal control solution for this CSO area.

3.5.1.7.3 Final East Waterway CSO Control Measures

There are two final LTCP CSO control measures for the East Waterway CSO area: off-line storage and flow diversion. Figure 3-8 shows the general area for potential East Waterway CSO control measure implementation.

The off-line storage CSO control measure concept consists of transferring CSO volume to collection system control structures, a new multi-cell underground storage tank, and the necessary infrastructure to divert and convey combined sewer flows to and from storage. In order to reduce the number of CSO occurrences in the East Waterway CSO basin to an average of one per year, an estimated storage volume of 0.5 million gallons is required. Control measure modelling confirmed the feasibility of this concept and estimated that the CSO Outfall 107 annual overflow frequency will be reduced from 4.6 to 1 or less events per year. The East Waterway CSO basin flow diversion control measure will divert flows to the King County Duwamish Interceptor and will consist of a new pumping station and force main to the proposed King County HLKK CSO plant. The flow diversion is described in additional detail in Section 3.5.2.3, Flow Diversion Projects.

No shared King County/City storage opportunities were identified for this CSO area.

3.5.1.8 Delridge/Longfellow CSO Area

The Delridge/Longfellow CSO area, located in West Seattle along Longfellow Creek, comprises Basins 099, 168, and 169. The total area is approximately 660 acres. The three basins are geographically separated and hydraulically independent. They individually discharge into the King County system through King County's Delridge trunk line along 26th Avenue SW, which runs from south to north through the basin.

All three CSO basins contain permitted CSO structures that discharge overflows to either Longfellow Creek or the Duwamish River during large precipitation events when the capacity of the CSS is exceeded. Figure 3-9 shows the Delridge/Longfellow CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.



Figure 3-9. Delridge/Longfellow CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.8.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-20 lists the Delridge/Longfellow CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the Delridge/Longfellow CSO outfall CVs including climate change were used as the basis for CSO control measure sizing and evaluation.

Table 3-20. Delridge/Longfellow CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency ^a	Average annual overflow volume (MG) ^{b,c}	Control volume with climate change (MG) ^d	Control volume without climate change (MG) ^{c, d}
099	1.6	0.82	0.17	0.11
168	2.7	4.57	2.00	1.45
169	2.7	2.78	1.19	0.74

^a 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling

^b From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0

^c Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties

^d Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

3.5.1.8.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-21 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-21. Delridge/Longfellow Basin CSO Control Measures

CSO control measure	LTCP evaluation results
Flow diversion	The LTCP evaluated a flow diversion from CSO Outfall 099 to the King County Harbor Ave. trunk. This concept is described in Section 3.5.2.3, Flow Diversion Projects
Off-line storage	The City is currently implementing a retrofit project for CSO Outfalls 168 and 169 that will replace the existing HydroBrakes with improved controls and new controllable gates. This project will reduce the CSO overflows significantly. To reduce CSO overflows to less than one per year after the retrofit is completed, storage control measures were developed that include storage pipelines and underground storage tanks to control the remaining volume. Evaluation of the CSO control measures concluded that off-line storage tanks were the optimal control solution for this CSO area.

3.5.1.8.3 Final Delridge/Longfellow CSO Control Measures

There are two final LTCP CSO control measures for the Delridge/Longfellow CSO area: off-line storage and flow diversion. Figure 3-9 shows the general area for potential Delridge/Longfellow CSO control measure implementation.

The off-line storage concept includes three separate CSO storage facilities:

- As shown in Table 3-19, the LTCP hydraulic modelling estimated a CV with climate change of 2.0 MG and 1.19 MG for CSO Outfalls 168 and 169, respectively. The City is currently replacing existing HydroBrakes with improved upstream diversion structures, actively controlled valves, and an upstream and downstream flow monitoring system. This project will optimize the performance of existing City CSO control facilities 2 and 3 and will reduce CSOs at CSO Outfalls 168 and 169. Project construction must be completed by November 1, 2015 to meet the NPDES Permit compliance date. Control measure modelling of the retrofit project indicated that the project will reduce the CV for CSO Basin 168 to 0.25 MG from 2.0 MG and for CSO Basin 169 to 0.25 MG from 1.19 MG. These revised CVs were used to develop the final CSO control measures for CSO Basins 168 and 169.
- The control measure for CSO Basin 169 consists of a 0.25 MG off-line CSO storage pipe adjacent to the existing City control facility 2 storage tank that will store excess CSO after the existing control facility 2 tank is full. The stored CSO flows will be discharged to the existing King County interceptor when capacity is available.
- The control measure for CSO Basin 169 consists of a 0.25 MG off-line CSO storage pipe adjacent to the existing City control facility 3 storage tank that will store excess CSO after the existing control facility 3 tank is full. The stored CSO flows will be discharged to the existing King County interceptor when capacity is available.
- CSO Basin 099 is geographically remote from the other two basins. The control measure for CSO Basin 099 consists of a 0.17 MG off-line CSO storage pipe. The stored CSO flows will be discharged to the existing King County interceptor when capacity is available.
- Control measure modeling confirmed the feasibility of the above CSO control measures and estimated they will reduce the CSO Outfall 099, 168 and 169 annual overflow frequencies to one or less events per year per outfall.

The Delridge/Longfellow CSO basin flow diversion control measure will divert flows from CSO Outfall 099 to the King County Harbor Avenue Interceptor and will consist of a new pumping station and force main. The flow diversion is described in additional detail in Section 3.5.2.3, Flow Diversion Projects.

No shared King County/City storage opportunities were identified for this CSO area.

3.5.1.9 Montlake CSO Area

The Montlake CSO area covers 140 acres (0.2 square mile) in east Seattle; it is bounded approximately by the Lake Washington Ship Canal to the north, Portage Bay to the north and west, Delmar Drive E and Boyer Avenue E to the south, and Lake Washington Boulevard E and Union Bay to the east. The Montlake CSO area comprises CSO Basins 020, 139, and 140. The flows from CSO Basins 139 and 140 drain to City Pump Station 25, from which they are pumped into the Montlake gravity system that flows into the King County South Lake Washington trunk line. Flows from CSO Basin 020 drain to City Pump Station 13, from which they are pumped to King County's South Lake Washington trunk line. The trunk line conveys the flows to the West Point WWTP for treatment and discharge.

The CSS in the Montlake CSO area conveys both sanitary and stormwater flow. The Montlake CSO area includes three permitted CSO outfalls that discharge overflows to the Ship Canal during precipitation events when the capacity of the CSS is exceeded. Figure 3-10 shows the Montlake CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.



Figure 3-10. Montlake CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.9.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-22 lists the Montlake CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the Montlake CSO outfall CVs including climate change were used as the basis for CSO control measure sizing and evaluation.

Table 3-22. Montlake CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency ^a	Average annual overflow volume (MG) ^{b,c}	Control volume with climate change (MG) ^d	Control volume without climate change (MG) ^{c, d}
020	1.4	0.61	0.16	0.12
139	1.2	0.03	0.01	<0.01
140	3.9	0.25	0.05	0.02

^a 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling

^b From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0

^c Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties

^d Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

3.5.1.9.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-23 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-23. Montlake CSO Control Measures

CSO control measure	LTCP evaluation results
Flow diversion	The City Retrofit Program evaluated potential retrofit solutions to control Montlake CSO basins and identified a flow diversion retrofit flow diversion option for the King County interceptor.
Off-line storage	Two types of off-line storage were evaluated: independent City storage and shared City/King County storage. For Independent City storage, separate off-line storage control measures were evaluated for CSO Basins 020, 139, and 140. The LTCP evaluated the cost-effectiveness of shared storage with the King County Montlake Regulator project which is described in Section 3.5.2, Shared Project Control Measures.
Deep tunnel storage	The LTCP evaluated the cost-effectiveness of shared deep tunnel storage. Montlake CSO area is a tributary area to a deep tunnel storage option more fully described in Section 3.5.2, Shared Project Control Measures.

3.5.1.9.3 Final Montlake CSO Control Measures

There are two final LTCP CSO control measures for the Montlake CSO area: off-line storage and flow diversion. Figure 3-10 shows the general area for potential Montlake CSO control measure implementation.

Because of the relatively small storage requirements, separate off-line storage CSO control measures have been developed.

- The CSO Basin 020 CSO control measure consists of a 0.16 MG off-line CSO storage pipe. The stored CSO flows will be discharged to the existing King County interceptor.
- The CSO Basin 139 CSO control measure consists of a 0.01 MG off-line CSO storage pipe. The stored CSO flows will be discharged to the existing King County interceptor.
- The CSO Basin 140 CSO control measure consists of a 0.05 MG off-line CSO storage pipe. The stored CSO flows will be discharged to the existing King County interceptor.
- Control measure modelling confirmed the feasibility of the above CSO control measures and estimated that the CSO control measures will reduce the CSO Outfall 020, 139 and 140 annual overflow frequencies to one or less events per year per outfall.

The Montlake CSO basin flow diversion control measure will divert flows to the King County interceptor and will consist of a new pumping station and force main. The flow diversion is described in additional detail in Section 3.5.2.3, Flow Diversion Projects.

There are two potential shared CSO control measures involving the Montlake CSO area and they are described in Section 3.5.2, Shared Project Control Measures. The first potential shared CSO control measure is a shared storage tank that will include storage for the King County Montlake Regulator and the City Montlake and Leschi CSO basins. The second potential shared CSO control measure involves a shared tunnel project with King County where the Montlake CSO area will be included in the storage capacity.

3.5.1.10 Leschi CSO Area

The Leschi CSO area covers 405 acres (0.63 square mile) in east Seattle; it is located on the western shore of Lake Washington along Lake Washington Boulevard from approximately S McClellan Street to E John Street. The Leschi CSO area comprises CSO Basins 026 through 036, which drain from south to north toward the King County East Pine Street pump station, with the exception of CSO Basin 026, which drains from north to south.

CSO Basin 032 has two overflow points; each has its own CSO designation (032(A) and 032(B)), but they share a common outfall. The wastewater generated in all the Leschi basins flows by gravity to King County's East Pine Street pump station for conveyance to the West Point WWTP. The Leschi CSO area is partially separated. The basins within the Leschi CSO area contain permitted CSO structures that discharge overflows to Lake Washington during large precipitation events when the capacity of the CSS is exceeded. Figure 3-11 shows the Leschi CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.



Figure 3-11. Leschi CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.10.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-24 lists the Leschi CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated for possible effects of climate change and without future climate change. For the LTCP, the Leschi CSO outfall CV including climate change was used as the basis for CSO control measure sizing and evaluation.

Table 3-24. Leschi CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency ^a	Average annual overflow volume (MG) ^{b,c}	Control volume with climate change (MG) ^d	Control volume without climate change (MG) ^{c, d}
028	2.7	0.87	<0.01	<0.01
029	2.7	0.13	0.02	0.01
031	13.1	0.93	0.31	0.25
032	5.4	0.27	0.08	0.05
036	2.1	0.11	0.03	0.017

^a 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling

^b From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0

^c Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties

^d Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

3.5.1.10.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-25 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-25. Leschi CSO Control Measures

CSO control measure	LTCP evaluation results
Flow diversion	The City Retrofit Program evaluated potential solutions to control Leschi CSO basins and identified a flow diversion retrofit option for the King County interceptor.
Off-line storage	Two types of off-line storage were evaluated: independent City storage and shared City/King County storage. For Independent City storage, the Leschi CSO area can be hydraulically divided into a north and south areas. The North Leschi area includes CSO Basins 028, 029, 031 and 032. The South Leschi area includes CSO Basin 036. Because of potential shared King County/City storage opportunity, the LTCP evaluated the cost-effectiveness of shared storage with the King County Montlake Regulator project which is described in 3.5.2, Shared Project Control Measures.
Deep tunnel storage	The LTCP evaluated the cost-effectiveness of deep tunnel storage shared with King County. The Leschi CSO area is a tributary area to a deep tunnel storage option more fully described in Section 3.5.2, Shared Project Control Measures.

3.5.1.10.3 Final Leschi CSO Control Measures

There are two final LTCP CSO control measures for the Leschi CSO area: off-line storage and flow diversion. Figure 3-11 shows the general area for potential Leschi CSO control measure implementation.

Because of the Leschi conveyance system configuration, the Leschi CSO area can be hydraulically divided into north and south areas. The North Leschi area includes CSO Basins 028, 029, 031 and 032. The South Leschi area includes CSO Basin 036.

The North Leschi area has three separate CSO control measures:

- The CSO Basin 028 control measure consists of a 0.01 MG off-line CSO storage pipe. The stored CSO flows will be discharged to the existing King County interceptor.
- The CSO Basin 029 control measure consists of a 0.02 MG off-line CSO storage pipe. The stored CSO flows will be discharged to the existing King County interceptor.
- The CSO Basin 031 and 032 control measure consists of a combined 0.39 MG off-line CSO storage pipe. The stored CSO flows will be discharged to the existing King County interceptor.

The South Leschi area will have a single CSO control measure for CSO Basin 036, a 0.03 MG off-line CSO storage pipe. The stored CSO flows will be discharged to the existing King County interceptor.

Control measure modelling confirmed the feasibility of these CSO control measures and estimated that the CSO control measures will reduce the Basins 028, 029, 031, 032, and 036 annual overflow frequencies to one or less events per year per outfall.

The Leschi CSO area flow diversion control measure will divert flows to the King County interceptor and will consist of a new pumping station and force main. The flow diversion is described in additional detail in Section 3.5.2.3, Flow Diversion Projects.

There are two potential shared CSO control measures involving the Leschi CSO area and they are described in Section 3.5.2, Shared Project Control Measures. The first is a shared storage tank that will include storage for the King County Montlake Regulator and the City Leschi and Montlake CSO areas. The second involves a shared tunnel project with King County where the Leschi CSO area will be included in the storage capacity.

3.5.1.11 Portage Bay/Lake Union CSO Area

The Portage Bay/Lake Union CSO area covers 387 acres (0.6 square mile) in central Seattle. The Portage Bay/Lake Union CSO area is bounded by Portage Bay to the north, 11th Avenue E to the east, E Newton Street to the south, and Lake Union to the west (see Figure 2-16.). The Portage Bay/Lake Union CSO area comprises CSO Basins 127, 129, 130, 131, 132, 134, 135, 136, 138, and 175. Of the CSO basins, only CSO Outfall 138 is uncontrolled and included in the LTCP.

The Portage Bay/Lake Union CSO area generally drains from north to south along Eastlake Avenue E. Flow from CSO Basin 138 is pumped by Pump Station 20 into CSO Basin 135 and flows by gravity through CSO Basins 132, 130, and 175 to join the King County system farther south. Flows from house connections in CSO Basins 129, 131, and 134 are pumped uphill by Pump Stations 63, 64, and 65 to join the main sewer line. Flows from CSO Basin 136 are pumped to CSO Basin 138 by Pump Station 66. All of the CSO basins contain permitted CSO structures that discharge overflows to Lake Union or Portage Bay during large precipitation events when the capacity of the CSS is exceeded. Figure 3-12 shows the Portage Bay/Lake Union CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.



Figure 3-12. Portage Bay/Lake Union CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.11.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-26 lists the Portage Bay/Lake Union CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the Portage Bay/Lake Union CSO outfall CV including climate change was used as the basis for CSO control measure sizing and evaluation.

Table 3-26. Portage Bay/Lake Union CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency ^a	Average annual overflow volume (MG) ^{b,c}	Control volume with climate change (MG) ^d	Control volume without climate change (MG) ^{c, d}
138	1.5	0.28	0.11	0.07

^a 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling

^b From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0

^c Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties

^d Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

3.5.1.11.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-27 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-27. Portage Bay/Lake Union CSO Control Measures

CSO control measure	LTCP evaluation results
Off-line storage	Conceptual planning developed two independent storage control measures. These included a storage pipe and an underground storage tank.
Deep tunnel storage	The LTCP evaluated the cost-effectiveness of deep tunnel storage shared with King County. The Portage Bay/Lake Union CSO area is a tributary area to a deep tunnel storage option more fully described in Section 3.5.2, Shared Project Control Measures.

3.5.1.11.3 Final Portage Bay/Lake Union CSO Control Measures

There is one final LTCP CSO control measure, off-line storage, for the Portage Bay/Lake Union CSO area: Figure 3-12 shows the general area for potential Portage Bay/Lake Union CSO control measure implementation.

The SPU Portage Bay CSO control measure consists of transferring the combined sewage overflow from the SPU NPDES138 basin to a storage pipe in the right-of-way. A total maximum storage volume of 0.11 million gallons is required to control the outfall overflows at NPDES138 basin. The proposed storage pipe would be located upstream of the existing storage facility 36.

Control measure modelling confirmed the feasibility of this control measure and estimated that it will reduce the Basin 138 annual overflow frequency from 1.5 to 1 or less events per year.

There is a potential shared CSO control measures for the Portage Bay/Lake Union CSO area: a shared tunnel project with King County where the Portage Bay/Lake Union CSO area will be included in the storage capacity. The deep tunnel storage option more fully described in Section 3.5.2, Shared Project Control Measures.

3.5.1.12 Neighborhood West Ship Canal Tunnel

During evaluation of shared tunnel opportunities with King County, the conceptual planning effort identified that the Ballard and Fremont/Wallingford areas were suitable for deep tunnel construction based on existing geological information and previous tunnel construction work. This information was developed for a joint King County and City tunnel constructability workshop in December 2011.

The Neighborhood West Ship Canal Tunnel would store CSO flows from CSO Basins 150/151, 152, 147 and 174. The tunnel would be aligned between Fremont/Wallingford and Ballard as shown on Figure 3-13.



Figure 3-13. Neighborhood West Ship Canal Tunnel CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.12.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. As described above, the Neighborhood West Ship Canal Tunnel would combine the storage requirements

for the Ballard and Fremont/Wallingford CSO area into a single deep storage tunnel. Table 3-28 lists the Neighborhood West Ship Canal Tunnel CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, a Neighborhood West Ship Canal Tunnel CSO outfall total CV of 9.2 MG, including climate change, was used as the basis for CSO control measure sizing and evaluation.

Table 3-28. Neighborhood West Ship Canal Control Volume				
CSO Outfall	Average annual overflow frequency ^a	Average annual overflow volume (MG) ^{b,c}	Control volume with climate change (MG) ^d	Control volume without climate change (MG) ^{c, d}
150/151	17.1	2.67	0.62	0.45
152	45.8	21.38	5.38	4.38
147	38.1	8.14	2.15	1.96
174	8.7	3.33	1.06	0.99
Total			9.21	

^a 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling

^b From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0

^c Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties

^d Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

3.5.1.12.2 CSO Control Measure Evaluation

The storage tunnel alignment is generally in the right-of-way from a site in the vicinity of the southern end of CSO Basin 147 toward CSO Basin 150/151 and 152 outfalls. There would be an effluent pump station at the west end of the tunnel and it would discharge to the King County Ballard Siphon. Hydraulic modeling of the tunnel indicates that 9.21 MG of combined Ballard and Fremont-Wallingford storage would be required to reduce overflow frequency to one or less annual overflows at the contributing outfalls.

The City employed an expert tunnel engineer and a tunnel contractor to validate the costs and schedule for the independent and shared West Ship Canal Tunnel control measures. Both costs and schedules were validated by the expert designer and contractor and several recommendations were provided that can be found in the two independent reports entitled LTCP Cost and Schedule Review Final Report, Jacobs Associates, February 21, 2014; and Cost Review Report LTCP Tunnel Construction Cost Estimate Validation & Schedule Review, Frank Coluccio Construction Co., January 10, 2014.

3.5.1.12.3 Final Neighborhood West Ship Canal Tunnel CSO Control Measure

Based on the expert review recommendations, a minimum tunnel diameter was recommended to accommodate spoils removal and intervention. Consequently, the tunnel volume for this control measure increased from 9.2 MG to 13 MG.

Control measure modeling estimated that the Neighborhood West Ship Canal Tunnel with a storage volume of 13 MG will reduce the CSO Basin 150/151, 152, 147, and 174 annual overflow frequencies to 0.5 events per year per outfall.

3.5.2 Shared Project Control Measures

King County began its CSO update planning in 2009. Because the City and the County were preparing similar documents during the same period and the two combined sewer systems were geographically and hydraulically linked, King County approached the City to identify potential collaborative opportunities.

The two agencies evaluated 40 potential shared projects and identified 4 feasible shared storage projects to evaluate in each agency's respective CSO plan: shared Fremont/Wallingford/3rd Avenue W Regulator storage, shared North Union Bay/University Regulator storage, shared Montlake/Montlake Regulator storage, and a deep tunnel along the Ship Canal.

During evaluation of the deep tunnel along the Ship Canal, an additional opportunity became apparent consisting of a deep tunnel serving the Ballard/Fremont/Wallingford/3rd Avenue W Regulator. This option was termed the Shared West Ship Canal Tunnel and is similar in concept to the Neighborhood West Ship Canal Tunnel described in an earlier section of this plan.

In addition to shared storage, the two agencies also looked at flow diversion opportunities for Montlake, Leschi, Magnolia, East Waterway, and Duwamish.

3.5.2.1 Shared Surface Tank Storage

Three of the City's largest CSO areas lie along the Ship Canal and are adjacent to King County regulators. The proximity of each agency's CSO control projects creates the opportunity for cost and environmental impact reductions through sharing facilities. These areas are depicted in Figure 3-14.



Figure 3-14. Shared Storage Projects Overview

3.5.2.1.1 City North Union Bay/King County University Regulator

Two shared alternatives were developed for CSO Basin 018 and King County's University Regulator. One was a tank on private property and the other a tunnel in the right-of-way. The private property alternative became the basis for the shared project and was subsequently recommended as a preferred alternative in the King County CSO Plan.

3.5.2.1.1.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-29 lists the NUB CSO outfall's long-term average annual overflow frequency, average annual overflow volume, and CVs. For the City outfalls, CVs were estimated with and without future climate change. For the LTCP, the CSO outfall CVs including climate change were used as the basis for CSO control measure sizing and evaluation except for King County.

Table 3-29. North Union Bay/University Regulator CSO Outfall Control Volumes				
CSO Outfall	Average annual overflow frequency	Average annual overflow volume (MG)	Control volume with climate change (MG)	Control volume without climate change (MG)
CSO Outfall 018	4.1 ^a	5.1 ^{b,c}	1.63 ^d	1.17 ^{c, d}
King County University Regulator	1.6 ^e	19.4 ^e	NA ^f	2.94 ^g

^a 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling

^b From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0

^c Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties

^d Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

^e Long-term average (LTA) value from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 3-3. Annual Average Frequency and Volume of Untreated CSOs: Monitored CSOs Compared to Modeled CSOs, November 2011). Reference 33

^f Climate change was not explicitly considered in King County modeling.

^g Estimated overflow volume from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 4-5. Key Results from October 2010 Modeling Run, November 2011).

3.5.2.1.1.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-30 lists the screened control measures for further evaluation and summarizes the results of the LTCP CSO control measures for the affected CSO outfalls.

Table 3-30. NUB/University Regulator CSO Control Measures	
CSO control measure	LTCP evaluation results
Off-line storage	Two types of off-line storage were evaluated: storage tanks and a short tunnel. The storage tank was determined to be the most cost-effective shared option.

3.5.2.1.1.3 Final Shared NUB/University Regulator Control Measure

The North Union Bay/University Regulator shared CSO control measure consists of transferring CSO overflow volume to multiple collection system control structures, a new multi-cell underground storage tank, and the necessary infrastructure to divert and convey combined sewer flows to and from storage. In order to reduce the number of CSO occurrences in the North Union Bay /University Regulator area to an average of one per year, an estimated storage volume of 4.57 million gallons is required.

3.5.2.1.2 City Montlake/City Madison Park/City Leschi Regulator

Diversion of all Montlake/Madison Park/Leschi flows to a proposed shared tank was evaluated as a potential shared project with King County. This tank was subsequently recommended as a preferred alternative in the King County CSO Plan.

3.5.2.1.2.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO Outfall. Table 3-31 lists the Montlake/Leschi CSO outfall's long-term average annual overflow frequency, average annual overflow volume, and CVs. City CVs were estimated with and without future climate change. For the LTCP, the Montlake/Leschi CSO outfall CVs including climate change were used as the basis of CSO control measure sizing and evaluation except for King County.

Table 3-31. Montlake/Leschi/Montlake Regulator CSO Outfall Control Volumes

CSO Outfall	Average annual overflow frequency	Average annual overflow volume (MG)	Control volume with climate change (MG)	Control volume without climate change (MG)
020	1.3 ^a	0.61 ^{b,c}	0.16 ^d	0.12 ^{c, d}
139	1.2 ^a	0.03 ^{b,c}	0.01 ^d	<0.01 ^{c, d}
140	3.7 ^a	0.25 ^{b,c}	0.05 ^d	0.02 ^{c, d}
028	2.6 ^a	0.87 ^{b,c}	<0.01 ^d	<0.01 ^{c, d}
029	2.4 ^a	0.13 ^{b,c}	0.02 ^d	0.01 ^{c, d}
031	13.8 ^a	0.93 ^{b,c}	0.31 ^d	0.25 ^{c, d}
032	5.5 ^a	0.27 ^{b,c}	0.08 ^d	0.05 ^{c, d}
036	2.0 ^a	0.11 ^{b,c}	0.03 ^d	0.017 ^{c, d}
King County Montlake Regulator	10.8 ^e	28.8 ^e	NA ^f	6.60 ^g

^a 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling

^b From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0

^c Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties

^d Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

^e Long-term average (LTA) value from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 3-3. Annual Average Frequency and Volume of Untreated CSOs: Monitored CSOs Compared to Modeled CSOs, November 2011).

^f Climate change was not explicitly considered in King County modeling.

^g Estimated overflow volume from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 4-5. Key Results from October 2010 Modeling Run, November 2011).

3.5.2.1.2.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-32 lists the screened control measures for further evaluation and summarized the results of the LTCP CSO control measures for the affected CSO outfalls.

Table 3-32. Montlake/Leschi/Montlake Regulator CSO Control Measures

CSO control measure	LTCP evaluation results
Off-line storage	A storage tank was the only alternative evaluated. The storage tank was determined to be the most cost-effective shared option.

3.5.2.1.2.3 Final Shared Montlake/Leschi/Montlake Regulator CSO Control Measure

The Montlake/Leschi/Montlake Regulator shared CSO control measure consists of transferring CSO overflow volume to multiple collection system control structures, a new multi-cell underground storage tank, and the necessary infrastructure to divert and convey combined sewer flows to and from storage. In order to reduce the number of CSO occurrences in the Montlake/Leschi/Montlake Regulator areas to an average of one per year, an estimated storage volume of 7.26 million gallons is required.

3.5.2.1.3 City Fremont/Wallingford/King County 3rd Avenue W Regulator

Four collaborative alternatives were developed by the City and one by King County. The City alternatives included storage within the right-of-way, a tank on a park site, and tanks on one of two private properties. King County developed a storage site on the south side of the Ship Canal. The storage within the right-of-way was recommended as a preferred alternative in the King County CSO Plan.

3.5.2.1.3.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-33 lists the Fremont/Wallingford/3rd Avenue W Regulator CSO outfall's long-term average annual overflow frequency, average annual overflow volume, and CVs. For the City outfalls, CVs were estimated with and without future climate change. For the LTCP, the Fremont/Wallingford CSO outfall CVs including climate change were used for the basis of CSO control measure sizing and evaluation except for King County.

Table 3-33. Fremont/Wallingford/3rd Ave W Regulator CSO Outfall Control Volumes

CSO Outfall	Average annual overflow frequency	Average annual overflow volume (MG)	Control volume with climate change (MG)	Control volume without climate change (MG)
147	38.1 ^a	8.14 ^{b,c}	2.15 ^d	1.96 ^{c, d}
174	8.4 ^a	3.33 ^{b,c}	1.06 ^d	0.99 ^{c, d}
King County 3 rd Ave W Regulator	16.6 ^e	17.1 ^e	NA ^f	4.18 ^g

^a 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling

^b From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0

^c Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties

^d Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

^e Long-term average (LTA) value from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 3-3. Annual Average Frequency and Volume of Untreated CSOs: Monitored CSOs Compared to Modeled CSOs, November 2011).

^f Climate change was not explicitly considered in King County modeling.

^g Estimated overflow volume from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 4-5. Key Results from October 2010 Modeling Run, November 2011).

3.5.2.1.3.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-34 lists the screened control measures for further evaluation and summarized the results of the LTCP CSO control measures for the affected CSO outfalls.

Table 3-34. Fremont/Wallingford/3rd Ave W Regulator CSO Control Measures

CSO control measure	LTCP evaluation results
Off-line storage	Two types of off-line storage were evaluated: storage tanks and a deep tunnel. The deep tunnel was determined to be the most cost-effective shared option.

3.5.2.1.3.3 Final Shared Fremont/Wallingford/3rd Ave W Regulator CSO Control Measure

The Fremont/Wallingford/3rd Ave W Regulator shared CSO control measure consists of transferring CSO overflow volume to multiple collection system control structures, storage within the right-of-way, and the necessary infrastructure to divert and convey combined sewer flows to and from storage. In order to reduce the number of CSO occurrences in the Fremont/Wallingford/3rd Ave W Regulator area to an average of one per year, an estimated storage volume of 7.39 million gallons is required.

3.5.2.2 Shared Tunnel Projects

3.5.2.2.1 Shared West Ship Canal Tunnel

During evaluation of shared tunnel opportunities with King County, the conceptual planning effort identified that the Ballard and Fremont/Wallingford areas were suitable for deep tunnel construction based on existing

geological information and previous tunnel construction work. This information was developed for a joint King County and City tunnel constructability workshop in December 2011.

The Shared West Ship Canal Tunnel would store CSO flows from City CSO Outfalls 150/151, 152, 147 and 174 and from King County's 3rd Avenue West Regulator.



Figure 3-15. Shared West Ship Canal Tunnel

3.5.2.2.1.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-35 lists the Fremont/Wallingford/Ballard/3rd Avenue W Regulator CSO outfall's long-term average annual overflow frequency, average annual overflow volume, and CVs. City CVs were estimated with and without future climate change. For the LTCP, the CVs including climate change were used as the basis of CSO control measure sizing and evaluation except for King County.

Table 3-35. Shared West Ship Canal Tunnel CSO Outfall Control Volumes

CSO Outfall	Average annual overflow frequency	Average annual overflow volume (MG)	Control volume with climate change (MG)	Control volume without climate change (MG)
147	38.1 ^a	8.14 ^{b,c}	2.15 ^d	1.96 ^{c, d}
174	8.4 ^a	3.33 ^{b,c}	1.06 ^d	0.99 ^{c, d}
150/151	17.1 ^a	2.67 ^{b,c}	0.62 ^d	0.45 ^{c, d}
152	45.8 ^a	21.38 ^{b,c}	5.38 ^d	4.38 ^{c, d}
King County 3 rd Avenue W Regulator	16.6 ^e	17.1 ^e	NA ^f	4.18 ^g

^a 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling

^b From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0

^c Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties

^d Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

^e Long-term average (LTA) value from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 3-3. Annual Average Frequency and Volume of Untreated CSOs: Monitored CSOs Compared to Modeled CSOs, November 2011).

^f Climate change was not explicitly considered in King County modeling.

^g Estimated overflow volume from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 4-5. Key Results from October 2010 Modeling Run, November 2011).

3.5.2.2.1.2 Control Measure Evaluation

The storage tunnel alignment is generally in the right-of-way from a site in the vicinity of the southern end of CSO Basin 147 (Fremont/Wallingford) toward the CSO Basin 150/151 and 152 outfalls (Ballard). There would be an effluent pump station at the west end of the tunnel that would discharge to the King County Ballard Siphon. A dual discharge system was evaluated that would direct flows to either the Ballard or Fremont siphons as operating hydraulic conditions required. Based on communications between the City and King County modelers, this control measure was modified to direct flows only to the Ballard siphon. Hydraulic modeling of the tunnel indicated that 13.39 MG of combined Ballard and Fremont-Wallingford and 3rd Avenue West Regulator storage would be required to reduce overflow frequency to one or less annual overflows.

The City employed an expert tunnel engineer and a tunnel contractor to validate the costs and schedule for the Shared West Ship Canal Tunnel control measure (as well as for the Ship Canal Tunnel and Neighborhood West Ship Canal Tunnel). Both costs and schedules were validated by the expert designer and contractor and several recommendations were provided that can be found in the two independent reports entitled LTCP Cost and Schedule Review Final Report, Jacobs Associates, February 21, 2014; and Cost Review Report LTCP Tunnel Construction Cost Estimate Validation & Schedule Review, Frank Coluccio Construction Co., January 10, 2014.

Investigation of this shared tunnel with King County is ongoing.

3.5.2.2.2 Final Shared West Ship Canal Tunnel Control Measure

Control measure modelling estimated that the Shared West Ship Canal Tunnel with a storage volume of 13.39 MG will reduce the CSO Outfall 150/151, 152, 147, and 174 and King County 3rd Avenue W Regulator annual overflow frequencies to less than 1.0 event per year per outfall. Appropriate odor control, surge control, redundancy, and maintenance facilities were included in the costs for the final control measure.

3.5.2.2.3 Ship Canal Tunnel

A separate collaborative storage control measure was developed consisting of a deep tunnel generally located beneath the Ship Canal and spanning from the University District to Fremont/Wallingford. This is called the Ship Canal tunnel.

Diversion of all Ballard, Fremont/Wallingford, North Union Bay, Montlake, Portage Bay, and Leschi flows to the Ship Canal Tunnel would be a part of the tunnel construction project. King County CSO flows from University Regulator, Montlake Regulator, and 3rd Avenue West Regulator would also be included. In its original form, the Ship Canal Tunnel did not include flows from Ballard, but conveyance lines were added to transport flows from the two Ballard basins to the tunnel. Figure 3-16 presents the Ship Canal Tunnel boundaries.

Tunnel workshops were conducted in 2011 with King County and several tunnel experts to review the opportunities and risks associated with this concept. Conclusions from the tunnel workshops are included in the report entitled: Joint City/King County CSO Tunnel Option Expert Panel Review, January 2012. In general, the assembled subject matter experts concluded that a tunnel would be feasible.



Figure 3-16. Shared Ship Canal Tunnel

3.5.2.2.3.1 Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-36 lists the Ship Canal Tunnel contributing CSO outfall's long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated with and without future climate change. For the LTCP, the contributing CSO outfall CVs including climate change were used for the basis of CSO control measure sizing and evaluation except for King County.

Table 3-36. Shared Ship Canal Tunnel CSO Outfall Control Volumes				
CSO Outfall	Average annual overflow frequency	Average annual overflow volume (MG)	Control volume with climate change (MG)	Control volume without climate change (MG)
150/151	17.1 ^a	2.67 ^{b,c}	0.62 ^d	0.45 ^{c, d}
152	45.8 ^a	21.38 ^{b,c}	5.38 ^d	4.38 ^{c, d}
147	38.1 ^a	8.14 ^{b,c}	2.15 ^d	1.96 ^{c, d}
174	8.4 ^a	3.33 ^{b,c}	1.06 ^d	0.99 ^{c, d}
138	1.4 ^a	0.28 ^{b,c}	0.11 ^d	0.07 ^{c, d}
018	4.1 ^a	5.1 ^{b,c}	1.63 ^d	1.17 ^{c, d}
020	1.3 ^a	0.61 ^{b,c}	0.16 ^d	0.12 ^{c, d}
139	1.2 ^a	0.03 ^{b,c}	0.01 ^d	<0.01 ^{c, d}
140	3.7 ^a	0.25 ^{b,c}	0.05 ^d	0.02 ^{c, d}
028	2.6 ^a	0.87 ^{b,c}	<0.01 ^d	<0.01 ^{c, d}
029	2.4 ^a	0.13 ^{b,c}	0.02 ^d	0.01 ^{c, d}
031	13.8 ^a	0.93 ^{b,c}	0.31 ^d	0.25 ^{c, d}
032	5.5 ^a	0.27 ^{b,c}	0.08 ^d	0.05 ^{c, d}
036	2.0 ^a	0.11 ^{b,c}	0.03 ^d	0.017 ^{c, d}
King County 3 rd Avenue W Regulator	16.6 ^e	17.1 ^e	NA ^f	4.18 ^g
King County University Regulator	1.6 ^e	19.4 ^e	NA ^f	2.94 ^g
King County Montlake Regulator	10.8 ^e	28.8 ^e	NA ^f	6.60 ^g

^a 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling

^b From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0

^c Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties

^d Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

^e Long-term average (LTA) value from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 3-3. Annual Average Frequency and Volume of Untreated CSOs: Monitored CSOs Compared to Modeled CSOs, November 2011).

^f Climate change was not explicitly considered in King County modeling.

^g Estimated overflow volume from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 4-5. Key Results from October 2010 Modeling Run, November 2011).

3.5.2.2.3.2 Control Measure Evaluation

The storage tunnel alignment is generally in the right-of-way from a site in the vicinity of CSO Basin 018 (University District) toward the CSO Outfall 174 (Fremont/Wallingford). An effluent pump station at the west end of the tunnel would discharge to the King County Ballard Siphon. Hydraulic modelling of the tunnel indicated that 27.39 MG of combined storage would be required to reduce overflow frequency to one or less annual overflows at each of the contributing outfalls.

The City employed an expert tunnel engineer and a tunnel contractor to validate the costs and schedule for the Ship Canal Tunnel control measure (as well as for the Shared West Ship Canal Tunnel and Neighborhood West Ship Canal Tunnel). Both costs and schedules were validated by the expert designer and contractor and several recommendations were provided that can be found in the two independent reports entitled LTCP Cost and Schedule Review Final Report, Jacobs Associates, February 21, 2014; and Cost Review Report LTCP Tunnel Construction Cost Estimate Validation & Schedule Review, Frank Coluccio Construction Co., January 10, 2014.

3.5.2.2.3.3 Final Ship Canal Tunnel Control Measure

Control measure modelling estimated that the Ship Canal Tunnel with a storage volume of 27.39 MG will reduce the CSO Outfall 150/151, 152, 147, and 174, 138, 018, 020, 139, 140, 028, 029, 031, 032, 036, , and King County 3rd Avenue W Regulator, University Regulator and Montlake Regulator annual overflow frequencies to less than 1.0 event per year per outfall.. Appropriate odor control, surge control, redundancy, and maintenance facilities were included in the costs for the final control measure.



Figure 3-17. Flow Diversion Projects Overview

3.5.2.3 Flow Diversion Projects

Flow diversions are projects that transfer flows (generally through constructed pipes and pump stations) from overflow points to other places in the system where capacity is available. These projects are shown in Figure 3-17.

Implementation of flow diversion projects will require coordination with King County. Specifically, the City and King County will need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.

3.5.2.3.1 Duwamish Flow Diversion

Two collaborative alternatives were developed for Duwamish. Both involved conveyance of flows to King County's Duwamish pump station as a flow diversion.

3.5.2.3.2 Magnolia Flow Diversion

Two collaborative alternatives were developed based on transfer of flows to the Fort Lawton tunnel. One replaced a pump station and the second added a new pump station to the existing one. Further analysis under the Retrofit Program returned this control measure to the list of potential opportunities.

3.5.2.3.3 Leschi Flow Diversion

Two collaborative diversion control measure alternatives were developed for Leschi. These involved conveyance of flows north into the King County system. The diversion concept is being refined under the Retrofit Program. Two collaborative alternatives were developed based on flow diversion control measures of flows north into the King County System. These flow diversion concepts are being refined under the Retrofit Program.

3.5.2.3.4 East Waterway Flow Diversion

The proximity of the outfall to the proposed King County HLKK wet-weather treatment plant suggested that a flow diversion to the plant might be a more cost-effective solution. This control alternative has been evaluated and would be considered under the strategy of shared City/King County projects.

3.5.2.3.5 Delridge Flow Diversion

During the Sewer System Improvement Program's analysis of the Delridge CSO area, a concept was developed that transferred flows from CSO Basin 099 to the Harbor Island trunk.

Table 3-37 summarizes CVs and CSO control measure options that are applicable to each basin.

Table 3-37. Summary of LTCP Control Volumes and Options			
CSO basin	LTCP control volume (MG)	LTCP CSO control measure options	Comments
Ballard			
150/151	0.622	Off-line storage Deep tunnel storage (shared City/King County) Deep tunnel (City only)	
152	5.375	Off-line storage Deep tunnel storage (shared City/King County) Deep tunnel (City only)	
Magnolia			
060	0.110	Off-line storage Collection system improvements (retrofit) Flow diversion to King County North Interceptor	
North Union Bay			
018	1.627	Off-line storage Collection system improvements (retrofit) Shared City/King County storage	

Table 3-37. Summary of LTCP Control Volumes and Options

CSO basin	LTCP control volume (MG)	LTCP CSO control measure options	Comments
Central Waterfront			
069	0.070	Off-line storage	
Fremont-Wallingford			
147	2.150	Off -line storage Shared City/King County storage Deep tunnel storage (shared City/King County) Deep tunnel (City only)	
174	1.060	Off -line storage Shared City/King County storage Deep tunnel storage (shared City/King County) Deep tunnel storage (City only)	
Duwamish			
111	0.012	Off-line storage (2) Collection system improvements (retrofit) Flow diversion to King County interceptor	
East Waterway			
107	0.500	Off-line storage Flow diversion to King County HLKK CSO plant	The approved King Co CSO Plan identified two opportunities for flow diversion projects related to the HLKK CSO plant. Because of the close proximity of the City CSO Basin 107 to the proposed King County HLKK CSO plant, it is potentially cost-effective to divert CSO Basin 107 flows to the new King County CSO plant.
Delridge/Longfellow			
099	0.171	Collection system improvements (retrofit) Off-line storage (3)	The proposed 2010-15 retrofits will significantly reduce the overflow frequencies for CSO Basin 168 and 169. Additional CSO Basin 168 and 169 CSO control measures will be evaluated to meet the CSO performance standard, and will be included as an LTCP project for this basin.
168	0.250		
169	0.250		

Table 3-37. Summary of LTCP Control Volumes and Options

CSO basin	LTCP control volume (MG)	LTCP CSO control measure options	Comments
Montlake			
020	0.163	Collection system improvements (retrofit) Off-line storage Shared City/King County storage Deep tunnel (shared City/King County)	
139	0.007	Collection system improvements (retrofit) Off-line storage Shared City/King County storage Deep tunnel (shared City/King County)	
140	0.058	Collection system improvements (retrofit) Off-line storage Shared City/King County storage Deep tunnel (shared City/King County)	
Leschi			
028	0.003	Collection system improvements (retrofit) Off-line storage Shared City/King County storage Deep tunnel storage shared City/King County)	LTCP hydraulic modelling indicated that CSO Outfalls 028, 029, 030, 031, 032, and 033 are hydraulically linked and must be evaluated as a system in the LTCP.
029	0.015	Collection system improvements (retrofit) Off-line storage Shared City/King County storage Deep tunnel storage shared City/King County)	
031	0.313	Collection system improvements (retrofit) Off-line storage Shared City/King County storage Deep tunnel storage shared City/King County)	
032	0.075	Collection system improvements (retrofit) Off-line storage Shared City/King County storage Deep tunnel storage shared City/King County)	
036	0.027	Collection system improvements (retrofit) Off-line storage Shared City/King County storage Deep tunnel storage shared City/King County)	LTCP hydraulic modelling indicated that CSO Outfalls 033, 034, 035, and 036 are hydraulically linked and must be evaluated as a system in the LTCP.

Table 3-37. Summary of LTCP Control Volumes and Options

CSO basin	LTCP control volume (MG)	LTCP CSO control measure options	Comments
Portage Bay			
138	0.106	Off-line storage Deep tunnel storage (shared City/King County)	

3.6 LTCP Alternative Option Definition

The long-term control plan must provide a comprehensive solution to overflows from the CSS. This means that the control measures for uncontrolled CSO area must as a whole meet the requirements of the Consent Decree in reducing overflows to one per outfall per year. The individual control measures detailed above have been combined into four groups of options that achieve this objective. The groups include an independent storage option (either neighborhood tanks or a neighborhood tunnel) and three shared City/King County options. These are graphically displayed in Table 3-38 and Figures 3-18 through 3-21.

For the LTCP, system-wide options were developed under one of two basic concepts: the City meets their consent decree-mandated control responsibilities through implementation of independent control measures, or the City participates in one or more shared projects with King County to take advantage of potential cost and impact reduction opportunities.

Individual control measures for each CSO area were developed by the City to support an independent (neighborhood) system-wide solution.

One option under the shared project strategy is to combine facilities when both agencies must construct storage facilities close to one another. This resulted in the Shared Storage option. CSO areas that are not part of the shared project will require implementation of the independent (neighborhood) control measure.

Another option under the shared project strategy is to consolidate CSO storage for six City uncontrolled CSO basins and three King County uncontrolled CSO basins in a deep tunnel. This resulted in the Ship Canal Tunnel Option. CSO areas that are not part of the shared project will require implementation of the independent (neighborhood) control measures.

During development of the Ship Canal Tunnel Option, the feasibility of another potentially cost-effective shared tunnel solution, the West Ship Canal Tunnel (combining volumes from Ballard, Fremont/Wallingford, and 3rd Avenue W Regulator) was identified and evaluated. This option became the Neighborhood and Shared West Ship Canal Tunnel options.

The Table 3-38 presents the LTCP basin areas and explains how they fit into the four CSO control options.

Table 3-38. Option Development

CSO areas	LTCP options			
	Neighborhood Storage	Shared storage	Shared West Ship Canal Tunnel	Shared Ship Canal Tunnel
Ballard	Off-line storage tank or deep tunnel with Fremont/Wallingford	Off-line storage tank	Shared deep tunnel with Fremont/Wallingford	Shared deep tunnel
Magnolia	Off-line storage pipe	Off-line storage pipe	Flow diversion to North Interceptor	Flow diversion to North Interceptor
North Union Bay	Collection system improvement	Shared off-line storage tank	Collection system improvement	Shared deep tunnel
Central Waterfront	Off-line storage pipe	Off-line storage pipe	Off-line storage pipe	Off-line storage pipe
Fremont/Wallingford	Off-line storage tank or shared deep tunnel with Ballard	Shared off-line storage tank	Shared deep tunnel with Ballard	Shared deep tunnel
Duwamish	2 off-line storage pipes	2 off-line storage pipes	2 off-line storage pipes	Flow diversion to Duwamish Interceptor
Delridge	3 off-line storage pipes	3 off-line storage pipes	3 off-line storage pipes	Flow diversion to Harbor trunk plus 2 off-line storage pipes
Montlake	3 off-line storage pipes	Shared off-line storage tank	3 off-line storage pipes	Shared deep tunnel
Leschi	3 off-line storage pipes plus 1 off-line storage tank	Shared off-line storage tank	3 off-line storage pipes plus 1 off-line storage tank	Shared deep tunnel
East Waterway	Off-line storage tank	Flow diversion to HLKK treatment plant	Flow diversion to HLKK treatment plant	Flow diversion to HLKK treatment plant
Portage Bay	Off-line storage pipe	Off-line storage pipe	Off-line storage pipe	Shared deep tunnel

The following figures show the component basin projects included in each of the four LTCP options. Additionally, attached to each area map is an explanation of the option itself and how the option plans to address the uncontrolled basins not immediately affected by the shared project.

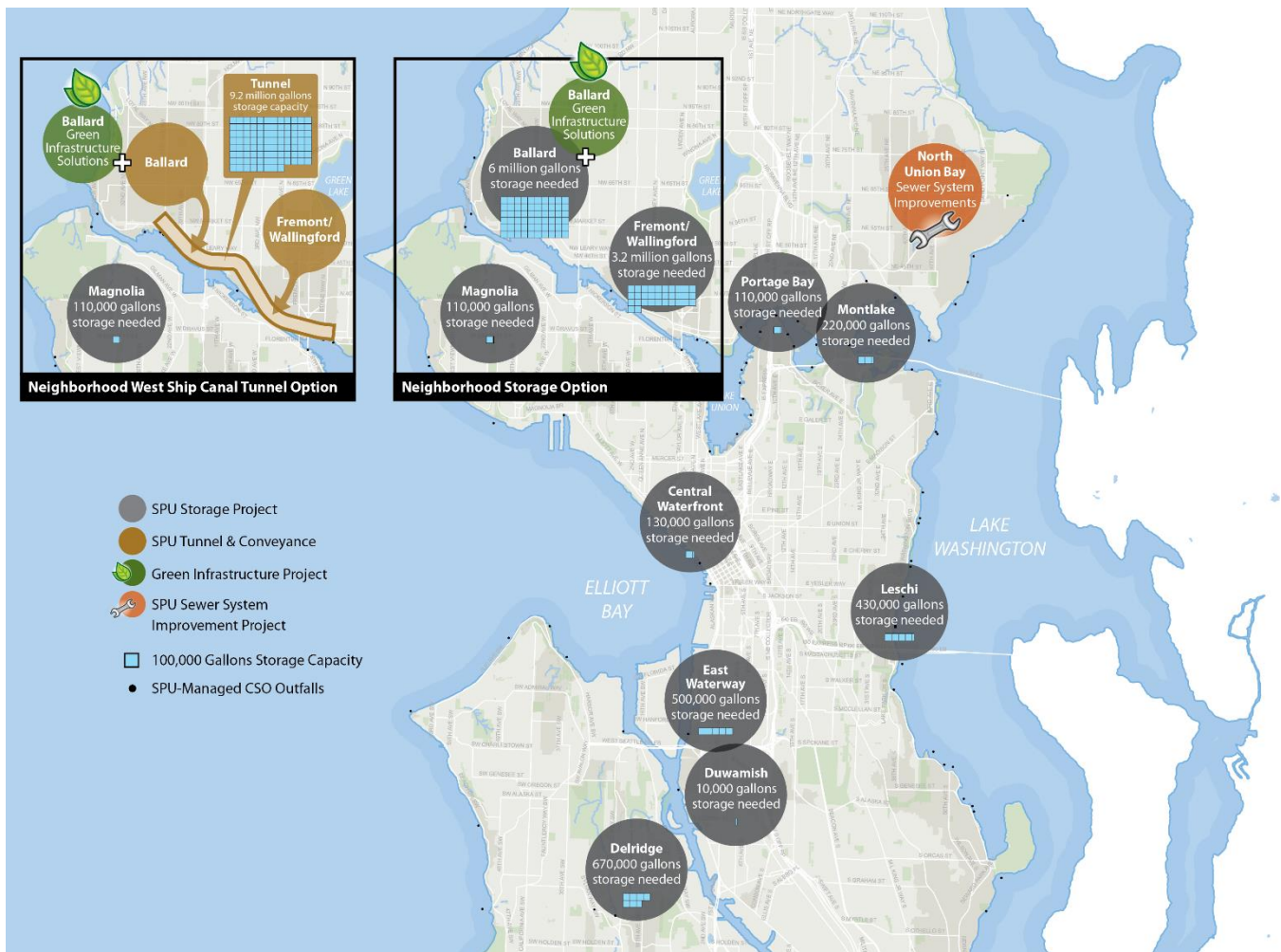


Figure 3-18. Neighborhood Storage Options

3.6.1 Neighborhood Storage Options

Under the Neighborhood Storage Option, the City would build underground storage facilities in Ballard, Fremont/Wallingford, Magnolia, Portage Bay, Montlake, Leschi, Central Waterfront, Duwamish, Delridge, and East Waterway CSO areas and sewer system improvements in the North Union Bay CSO area. This option involves building the largest number of storage facilities throughout the city.

There are two variations in the Neighborhood Storage Option: One would provide storage in tanks and pipes only, and the other would include a tunnel (Neighborhood West Ship Canal Tunnel) in combination with tanks and pipes. The storage tank/pipe option involves the greatest number of affected locations. The Neighborhood West Ship Canal Tunnel Option was developed because the two CSO areas with the largest storage volumes (Ballard and Fremont/Wallingford) are relatively close to one another. The Neighborhood West Ship Canal Tunnel Option likely reduces the number of facilities and neighborhood impacts.

Implementation of the North Union Bay sewer system improvements will require City coordination with King County because additional flows will be transferred to the King County system. Specifically, the City and King County will need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.



Figure 3-19. Shared West Ship Canal Tunnel Option

3.6.2 Shared West Ship Canal Tunnel Option

The Shared West Ship Canal Tunnel Option combines three of the largest CSO areas into a single deep tunnel. The West Ship Canal Tunnel is proposed as a shared option because the three CSO areas (two from the City and one from King County) with the largest CVs are relatively close to one another. The tunnel would extend from Fremont/Wallingford to Ballard and would provide the storage needed to address sewage overflows in Ballard, Fremont/Wallingford, and King County's 3rd Avenue West CSO basins. The tunnel would eliminate the need for a separate King County CSO project at an outfall near 3rd Avenue West.

Prior to implementing any shared projects between the City and King County, a shared project agreement would need to be signed between the two agencies.

Within this option, the remaining CSO areas would be controlled by their respective neighborhood control measures except for Magnolia and East Waterway, where flow diversions to King County's system are proposed. Any City flow diversion projects would require coordination with King County. Specifically, the City and King County would need to analyze the impacts of the proposed flow diversion projects on the downstream system and agree on an approach to address those impacts.

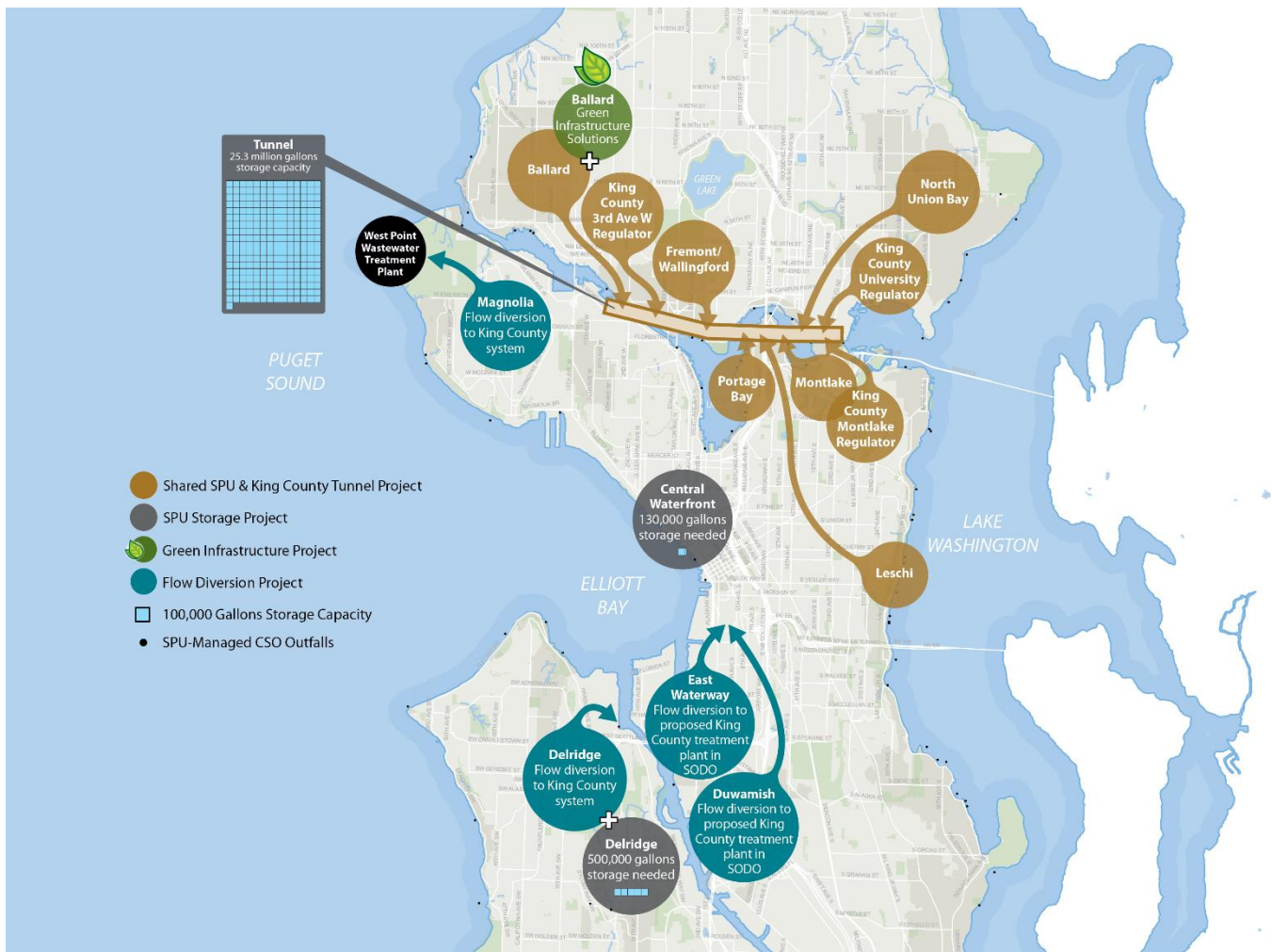


Figure 3-20. Shared Ship Canal Tunnel Option

3.6.3 Shared Ship Canal Tunnel Option

The Shared Ship Canal Tunnel Option combines the CVs from six of City CSO areas along the Ship Canal and Lake Washington, and three of the largest King County CSO areas along the Ship Canal in a deep tunnel extending from the University District to Fremont/Wallingford. The tunnel would provide the storage needed to address sewage overflows in the City's CSO areas of Ballard, Fremont/Wallingford, Portage Bay, Montlake, North Union Bay, and Leschi. The tunnel would also eliminate the need for three separate King County CSO projects at outfalls near Pacific Street (University Regulator), Montlake Avenue (Montlake Regulator), and 3rd Avenue West.

The remaining City CSO areas (Magnolia, Duwamish, East Waterway, and the northernmost Delridge CSO basin) would be diverted to King County under the assumption that flow diversions could be incorporated into mutual interagency agreements. The Central Waterfront and the southern Delridge CSO neighborhoods would continue to be served by their respective neighborhood control measures.

Prior to implementing any shared projects between the City and King County, a shared project agreement would need to be signed between the two agencies.

Specifically, the City and King County would need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.



Figure 3-21. Shared Storage Option

3.6.4 Shared Storage Option

Under the Shared Storage Option, the City and King County would jointly build larger but fewer storage tanks in three CSO areas:

- Fremont/Wallingford and King County 3rd Avenue W CSO
- North Union Bay and King County University Regulator CSO
- Montlake/Leschi and King County Montlake Regulator.

These three shared storage projects were recommended in the approved 2012 King County CSO plan. In the Duwamish CSO area, the City would divert flows to a treatment facility proposed by King County. All other LTCP CSO areas would have the same storage facilities as proposed under the Neighborhood Storage Option.

Prior to implementing any shared projects between the City and King County, a shared project agreement would need to be signed between the two agencies.

Specifically, the City and King County would need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.

3.6.5. Incorporating Green Infrastructure Control Measures

Green Infrastructure control measures were developed and evaluated in parallel with final grey control measures for uncontrolled CSO basins with potential for GI application. The GI program is currently being implemented in uncontrolled CSO basins where it is practicable. GI effectiveness will be evaluated during the implementation phase for individual LTCP projects and any potential reductions in the storage volume requirements for the grey control measure will be addressed in an engineering report which will be submitted to EPA and Ecology for approval, in accordance with the Consent Decree.

The proposed grey control measures presented in this LTCP meet 100 percent of the control requirements; possible contributions from GI are not included in meeting the requirement.

3.7 Project Cost Methodology

3.7.1 Capital Cost

Table 3-39 presents the capital cost of the proposed control measures that make up the LTCP options. The total project cost shown includes construction costs for major parts of each control measure (conveyance, storage, pump stations, special construction, etc.) as well as estimated soft costs such as project contingencies, management reserves, property costs, commissioning, and stabilization period costs.

A project contingency and management reserve fund allowance were included in the total project costs. These allowances typically include potential construction risks, permit conditions, and site-specific mitigation. During the design, the total project costs will be revised to include site specific conditions.

These costs were developed for the May 2014 Draft LTCP, submitted to Ecology and the EPA. See Section 5.7 for updated costs of the recommended LTCP option.

Table 3-39. Cost Summary of System Options (April 2013 Total Project Cost \$Millions)						
CSO area and CSO basins		Neighborhood Storage Tanks	Neighborhood West Ship Canal Tunnel	Shared West Ship Canal Tunnel	Shared Ship Canal Tunnel	Shared storage
Neighborhood Projects						
Leschi	028-036	\$ 25.6	\$ 25.6	\$ 25.6	0	0
Montlake	020/139/140	\$ 12.4	\$ 12.4	\$ 12.4	0	0
Portage Bay	138	\$ 8.0	\$ 8.0	\$ 8.0	0	\$ 8.0
Duwamish	111	\$ 3.7	\$ 3.7	\$ 3.7	\$ 9.7	\$ 3.7
East Waterway	107	\$ 29.1	\$ 29.1	\$ 13.5	\$ 13.5	\$ 13.5
Magnolia	060	\$ 5.7	\$ 5.7	\$ 5.0	\$ 5.0	\$ 5.7

Table 3-39. Cost Summary of System Options (April 2013 Total Project Cost \$Millions)

CSO area and CSO basins		Neighborhood Storage Tanks	Neighborhood West Ship Canal Tunnel	Shared West Ship Canal Tunnel	Shared Ship Canal Tunnel	Shared storage
Central Waterfront	069	\$ 9.6	\$ 9.6	\$ 9.6	\$ 9.6	\$ 9.6
Ballard	150/151/152	\$ 127.7			0	\$ 127.7
Fremont/Wallingford	147/174	\$ 81.9			0	0
Delridge	099	\$ 7.0	\$ 7.0	\$ 7.0	\$ 12.8	\$ 7.0
	168	\$ 8.1	\$ 8.1	\$ 8.1	\$ 8.1	\$ 8.1
	169	\$ 7.2	\$ 7.2	\$ 7.2	\$ 7.2	\$ 7.2
North Union Bay	018	\$ 1.3	\$ 1.3	\$ 1.3	0	0
Neighborhood West Ship Canal Tunnel			\$ 254.4			
Shared Projects						
Shared West Ship Canal Tunnel				\$ 257.8		
Shared Ship Canal Tunnel					\$ 617.0	
Shared University Tank						\$ 117.1
Shared Fremont/Wallingford/3 rd Ave Storage Facility						\$ 191.2
Shared Montlake Tank						\$ 166.8
Total Project Cost						
Total Project Cost of LTCP Option (City + King County Cost)		NA, see City cost below	NA, see City cost below	\$ 359.2	\$ 682.9	\$ 665.6
Total Project Cost of LTCP Option (City Cost) ^b		\$ 327.3	\$ 372.2	\$ 281.9	\$ 331.2	\$ 327.7

Notes:

^a Total Project Cost includes construction, engineering, property, SPU soft costs, sales tax, contingency, MRF, commissioning and stabilization (acceptance testing)

^b Based on preliminary cost shares developed for the Draft LTCP. See Section 5.7.4 for updated costs and details on the cost share used for the Final LTCP.

The initial conceptual development and evaluation of feasible control measures was completed using a cost model called Tabula (Reference 34), developed by King County. Use of this cost model provides a quick means to evaluate the cost effectiveness of the City's alternatives. Projects that could be shared with King County could

also be evaluated on a common basis. Tabula produces a Class 5 construction cost estimate (minus 50 percent to plus 100 percent accuracy).

To permit a more detailed and flexible evaluation of control measures, the City developed a new cost model called the LTCP Conceptual Cost Calculator (3C) (Appendix J). The tool was created in Microsoft Excel. The workbook consists of a number of Excel sheets serving one of three functions: model input, cost estimate, or schedule estimate. The tool combines features of both American Public Works Association (APWA) and Construction Specifications Institute (CSI) formats to allow estimates for linear and vertical construction elements and is set up in such a way that quantity or activity inputs can be fed into a Microsoft Project scheduler to generate a construction schedule. In addition, the model generates a summary of major material quantities and equipment hours for use in support of environmental analysis.

The cost estimating tool uses definitions and soft-cost values as presented in the City's Cost Estimating Guidelines to generate a total project cost. The level of detail in the 3C estimate is considered to approach a Class 4 estimate per the Association for the Advancement of Cost Engineering (AACE), with an accuracy of minus 20 percent to plus 30 percent.

The 3C tool has been updated using the April 2013 Engineering News Record (ENR) construction index and incorporates recent bid price updates based on construction bids received for the City's Windermere and Genesee CSO projects.

Validation of the 3C tool was completed in April 2013 using bid information from the Windermere and Genesee CSO projects that are currently in construction. The tool calculated a construction cost that was within four percent of the actual construction bid amounts.

A multi-agency tunnel evaluation workshop conducted in 2011 recommended that all deep tunnel control measures be evaluated using a "bottom up" (rather than a parametric) construction cost estimate. The "bottom up" estimate corresponded closely with the 3C tool estimate and provided additional detail in key areas.

For ease of comparison, the costs for all of the control measures presented in this LTCP have been estimated using the 3C tool only. This includes the various King County alternatives against which the shared options are compared.

3.7.2 Operating Cost

Non-capital costs include recurring annual operation and maintenance expenses, fees paid to King County for treatment of additional flows, ongoing flow monitoring for system control, and post-construction monitoring to demonstrate consent decree compliance.

An operation and maintenance cost model (Appendix K) was developed for comparing control measures. This cost model incorporated existing City operating experience with storage facilities and conveyance systems augmented by recent monitoring and construction commissioning data.

Facilities constructed under the LTCP will require commissioning costs beyond those typically encountered to complete construction. These include stabilization costs to ensure that the constructed facilities will perform as designed.

Table 3-40 presents information on the maintenance costs for the proposed control measures that are included in the LTCP options. The table includes anticipated annual costs for maintenance broken down by major activities for each control measure. The operating cost shown includes the expected cost of energy (both the "readiness to serve" and energy charge).

Table 3-40. Operating Cost Summary for System Options (April 2013 \$Millions) ^{a,b}

CSO area and CSO basins		Neighborhood Storage Tanks	Neighborhood West Ship Canal Tunnel	Shared West Ship Canal Tunnel	Shared Ship Canal Tunnel	Shared storage
Neighborhood projects						
Leschi	028-036	\$ 1.4	\$ 1.4	\$ 1.4	0	0
Montlake	020/139/140	\$ 0.8	\$ 0.8	\$ 0.8	0	0
Portage Bay	138	\$ 0.4	\$ 0.4	\$ 0.4	0	\$ 0.4
Duwamish	111	\$ 0.3	\$ 0.3	\$ 0.3	\$ 0.6	\$ 0.3
East Waterway	107	\$ 0.2	\$ 0.2	\$ 0.2	\$ 0.2	\$ 0.2
Magnolia	060	\$ 0.4	\$ 0.4	\$ 0.3	\$ 0.3	\$ 0.4
Central Waterfront	069	\$ 0.5	\$ 0.5	\$ 0.5	\$ 0.5	\$ 0.5
Ballard	150/151/152	\$ 0.7			0	\$ 0.7
Fremont/Wallingford	147/174	\$ 0.7			0	0
Delridge	099	\$ 0.4	\$ 0.4	\$ 0.4	\$ 0.7	\$ 0.4
	168	\$ 0.5	\$ 0.5	\$ 0.5	\$ 0.5	\$ 0.5
	169	\$ 0.5	\$ 0.5	\$ 0.5	\$ 0.5	\$ 0.5
North Union Bay	018	\$ 0.3	\$ 0.3	\$ 0.3	0	0
Neighborhood West Ship Canal Tunnel			\$ 1.8			
Shared projects						
Shared West Ship Canal Tunnel				\$ 1.4		
Shared Ship Canal Tunnel					\$ 2.4	
Shared University Tank						\$ 0.1
Shared FW/3rd Storage Facility						\$ 0.6
Shared Montlake Tank						\$ 0.6
Total project cost						
Total Operating Cost of LTCP Option (City + King County Cost)		NA, see City cost below	NA, see City cost below	\$ 7.0	\$ 5.7	\$ 5.2
Total Operating Cost of LTCP Option (City Cost) ^b		\$ 7.1	\$ 7.5	\$ 6.6	\$ 4.3	\$ 4.3

Notes:

^a System operating costs include maintenance labor and equipment, power and chemicals, odor control consumables, Post-construction monitoring, permanent flow monitoring, and treatment fees to King County

^b Based on preliminary cost shares developed for the Draft LTCP. See Section 5.7.4 for details on the cost share used for the Final LTCP.

CHAPTER 4

Evaluation of LTCP CSO Control Options

4.1 Overview of LTCP CSO Control Option Evaluation Process

The LTCP contains a rating and ranking of the LTCP options in accordance with the EPA requirements from the *"Combined Sewer Overflows Guidance for Long-Term Control Plan, 1995"*. In May 2014, the Draft LTCP was submitted to the EPA and Ecology for review and comment with this rating and ranking evaluation included. In addition, the City issued a public notice and held a public meeting and official public comment period for the Draft LTCP. After the comment period and receipt of EPA and Ecology comments, additional evaluation was performed, as described in Chapter 5, resulting in the selection of the recommended LTCP Option.

4.1.1 Rating and Ranking of LTCP Alternative Options

Based on the final LTCP options development work described in Chapter 3, an evaluation of the non-monetary factors was performed. The technique used for the LTCP option evaluation is called Multiple Objective Decision Analysis. This technique incorporates a mechanism for consideration of non-monetary, social, and environmental factors as well as cost to create a structured comparison of competing. The steps in the Multiple Objective Decision Analysis process are summarized as follows and described in detail below.

- Establish the decision goal
- Identify and specify fundamental objectives
- Develop performance measures to assess project performance against objectives
- Assign scores to the performance measures
- Assign weights to the objectives
- Score LTCP options and calculate total value scores
- Calculate total net present value costs for comparison with total value scores and conduct a sensitivity analysis

4.1.1.1 Decision Goal

The decision goal for the Draft LTCP is to perform an evaluation rating and perform a ranking (highest to lowest) of the LTCP options.

4.1.1.2 Objective Hierarchy

A series of objectives typically must be met to achieve the decision goal. Those objectives can be classified as fundamental, or main, objectives and sub-objectives. The main objectives are the singular factors that are most important to achieving the decision goal. Attributes that define the main objective that are referred to as sub-objectives. The objectives and sub-objectives are arranged in a hierarchy referred to as an objectives hierarchy or value hierarchy. The value hierarchy developed for this analysis is shown in Table 4-1.

Table 4-1. LTCP MODA Value Hierarchy

Main objectives	Sub-objectives
1. Technical complexity and performance risk	Does implementation require complex overall system controls? How many individual CSO facilities are needed to implement control strategy? How does the King County no-impact release rate affect City CSO operations?
2. Flexibility	Can the LTCP option meet changing control criteria and flow conditions?
3. Constructability	Are construction risks associated with the LTCP option significant? What are the expected permitting, regulatory, and land use compliance complexities and how difficult is it expected to be to obtain permits and approvals?
4. Consent Decree compliance schedule	Does the LTCP option meet the City Consent Decree Construction Completion Milestone Date of Dec 31, 2025? Does the LTCP shared option meet the King County Consent Decree Dates for the University, Montlake and 3 rd Avenue West CSO projects?
5. King County concurrence on shared projects	Has King County indicated their concurrence or objections to LTCP shared options to the City?
6. Construction impacts (short term)	What level of disruption will occur? Are the cumulative construction impacts significant?
7. Community impacts (long term)	Can the facility be designed to be compatible with the community? How will O&M activities impact the community?
8. Environmental and social justice	What are the LTCP option's overflow and operation impacts and benefits? Does the alternative result in unequal impacts and benefits to historically underserved communities and low-income populations during construction or operation of the facility?
9. Environmental	Will the construction impact wetlands, streams, shorelines, habitats, or endangered species?
10. Ease of Operation and Maintenance and Safety	What level of staffing is required for operation and shutdown (how often is the facility used, how long is the facility in use, how many operators are required, what level of operator experience is required, what are travel times)? What are peak staff required? Does the facility have access requirements in the right-of-way or require confined space entry? Are traffic control procedures required? Does access require a street use permit or lane closure?

4.1.1.3 Develop Performance Measures and Scoring

Once the objectives are fully developed and the decision makers agree that they fully represent the important issues in the problem, performance measures are required to determine how well the LTCP options perform against objectives. Performance measures may be quantitative or qualitative, depending upon the objective and the availability of data for each measure. All non-monetary objectives were scored using a 1 to 3 scale, where the worst potential outcome was given a score of 1 and the best possible outcome was given a score of 3. The performance measures are shown in Table 4-2.

Table 4-2. LTCP MODA Performance Measures

Criteria	Performance measures (high, medium, low)		
	High = 3.0 (best)	Medium = 2.0	Low = 1.0 (worse)
1. Technical complexity and performance risk	System operation is less complex because a large number of independent CSO outfall storages have been combined into fewer CSO control facilities... Reduces the requirements for coordinating operations of numerous independent CSO storage facilities for a large number of CSO outfalls. King County interceptor capacity does not impact City CSO facility release rates or increase City storage requirements. King County will not request additional capital costs to accommodate City CSO flows.	System operation is moderately complex because some CSO outfall storages have been combined into a single CSO control facility. (e.g., shared tanks or tunnels). Reduces the requirements for coordinating operations of several independent CSO storage facilities for a specific geographic area. King County interceptor capacity may impact City CSO facility release rates or increase City storage requirements. King County may request additional capital costs to accommodate City CSO flows.	System operation is very complex because each CSO outfall storage must control overflows independently (e.g., tanks at each outfall). Requires coordinating operations of numerous independent CSO storage facilities to achieve performance standard. King County interceptor capacity will significantly limit City CSO facility release rates or increase City storage requirements. King County will request major capital costs to accommodate City CSO flows.
2. Flexibility	Will require minimal modifications of controls and existing infrastructure. Significant space available for future expansion.	Will require moderate modifications to controls and infrastructure. Limited space for future expansion. e.g. Shared City/KC storage will rate medium	Will require significant modifications to controls and infrastructure. No Space for future expansion e.g. Neighborhood storage will rate lowest
3. Constructability	Site is not constrained; site is stable with low slope; groundwater elevations not affected during construction or operation. Adequate area for access; staging and operation of special equipment can be accommodated. There are several potential sites available for purchase including publicly and privately owned property. Property may be used for multiple benefit (meet regulatory needs and provide an amenity to the community). Multiple transport routes and modes are available.	Site may be constrained; site has low to moderate slope; site requires some dewatering and robust foundations including piles or tiebacks. Access and staging are not required for adequate construction sequencing. Contractor may have to provide offsite staging and operations. There are limited acceptable. Use of property may require mitigation to make construction feasible and the facility publically acceptable. Adequate transport routes are available.	Site is constrained; site has steep slopes with groundwater and soils conditions that increase instability if disturbed, requiring careful construction sequencing. Several move-in, move-out stages will be required to accommodate specialty contractors as well as conventional construction. Contractor must provide offsite staging and operations. Locating a site is difficult. (e.g., potential sites have cultural /or historical status, have binding covenants that preclude utility structures, or are not subject to condemnation by the City.) Condemnation may be required. Significant mitigation may be required to make the facility publically acceptable. Constrained transport routes are available.

Table 4-2. LTCP MODA Performance Measures

Criteria	Performance measures (high, medium, low)		
	High = 3.0 (best)	Medium = 2.0	Low = 1.0 (worse)
4. Consent Decree compliance schedule	All City facilities meet Consent Decree Construction Completion milestone of December 31, 2025. Shared King County/City facilities meet milestone dates stated in the King County Consent Decree.	Shared King County/City facilities do not meet the City Consent Decree Construction Completion milestone of December 2025 but is deferred based on approved King County Consent Decree without penalty from EPA or Ecology.	No Shared King County/City facilities meet the City Consent Decree Construction Completion milestone of December 31, 2025, and EPA or Ecology would impose penalties. Shared King County/City facilities do not meet milestone dates stated in the King County Consent Decree, and EPA/Ecology impose penalties.
5. King County concurrence on shared projects	King County participation is not needed or the King County Consent Decree requires King County to build shared storage with the City.	King County and the City are continuing discussion. (West Ship Canal)	King County CSO Plan does not recommend ship canal tunnel (Shared Tunnel)
6. Construction impacts (short term)	Disruption during construction is lowest in terms of number of sites, area affected, and construction duration and intensity. Mitigation options are available, potential public benefits and cumulative impacts are lowest (including King County facilities).	Disruption during construction is moderate in terms of area affected, number of sites, and construction duration and intensity. Mitigation options available which offset impacts. Cumulative impacts are moderate.	Disruption during construction is highest in terms of area affected, number of sites affected, and construction duration and intensity. Mitigation options are limited. Cumulative impacts are highest.
7. Community impacts (long term)	Facility is compatible with the surrounding community and minimal staff will be present infrequently. Traffic, odor, noise and visual impacts from the facility would require limited mitigation to be acceptable to the community.	Facility and grounds can be designed to screen facility and minimal staff visits are necessary. Traffic, odor noise and visual impacts from the facility would require mitigation to be acceptable to the community.	The facility will negatively impact the community and there would be staff on-site regularly. Traffic, odor, noise and visual impacts from the facility would require significant mitigation to be acceptable to the community.
8. Environmental and social Justice	The option provides social, environmental, health, and economic benefits to historically underserved communities and low-income populations at levels equal to or greater than those experienced by white middle- and high-income populations.	The option produces no net change in social, environmental, health, and economic impacts or benefits to historically underserved communities and low-income populations.	The option causes adverse and inequitable social, environmental, health, and economic impacts to historically underserved communities and low-income populations.

Table 4-2. LTCP MODA Performance Measures

Criteria	Performance measures (high, medium, low)		
	High = 3.0 (best)	Medium = 2.0	Low = 1.0 (worse)
9. Environmental	It is unlikely that the LTCP option would adversely impact wetlands, streams, shorelines, habitats, or endangered species. Mitigation options are available. City-wide cumulative impacts are lowest for most environmental resources.	It is likely that the LTCP option would impact wetland or stream buffers or streams, but endangered species, habitats and shoreline areas are unlikely to be impacted. Mitigation options are available. City-wide cumulative impacts are moderate for all environmental resources.	It is likely that the LTCP option would adversely impact a number of high value wetlands, streams, shorelines, habitats, or endangered species. Mitigation options are limited. City-wide cumulative impacts are high for a number of environmental resources.
10. Ease of O&M and safety	The facility requires no operating staff or can be remotely operated. Peak staff times require < 1 operator. The facility can be shut down with minimal staff time. Cleanup work is automated or can be scheduled to be integrated with other staff duties. The facility requires only annual preventive maintenance. The processes have minimal mechanical and instrumentation components (e.g., storage tank). The facility is reliable when used only intermittently. The facility does not have right-of-way access requirements or no permit is required for confined space entry. No traffic control procedures are required during operations and maintenance.	The facility can generally be remotely operated. An operator may need to be present periodically for sampling, chemical make-up, chemical delivery acceptance or other discrete tasks. Peak staff times require 1-2 operators. The facility can be shut down with minimal staff time. Cleanup work is generally automated; however, 1-2 personnel may be required. The facility requires monthly maintenance such as bumping pumps. The processes have an increased level of mechanical and instrumentation components (e.g., pump station). The facility has right-of-way access requirements or a permit is required for confined-space entry during non-routine operation and maintenance procedures. Traffic control procedures are required during non-routine operations and maintenance procedures. Work is in a moderately populated (residential or commercial) environment.	The facility requires operator attention during a storm. Peak staff times require 2 or more operators. The facility requires significant effort for shut down (e.g., vac/boom truck) and several days for cleanup. Cleanup work is generally manual with 2 or more personnel required for more than one day. Most procedures of shutdown need to be conducted immediately. The facility require monthly maintenance such as bumping pumps. The processes have an increased level of mechanical and instrumentation components (e.g., treatment facility). Equipment is prone to failure with intermittent use. The facility has right-of-way access requirements or a permit is required for confined space entry during routine operation and maintenance procedures. Traffic control procedures are required during routine operations and maintenance procedures. Work is in a densely populated (residential or commercial) environment.

4.1.1.4 Assign Scores to the Performance Measures

Rating or scoring the LTCP options is the process by which the performance scales are applied to the LTCP options. Each LTCP option is scored to determine the extent to which that option meets each objective (high, medium, or low). The scores and the rationale for each constructed scale are shown in Appendix D, LTCP Option Rating and Ranking Report. After scoring, each performance measure is normalized to a scale of zero to one by a

linear transformation of each score according to its distance from the scale endpoints. The results of the analysis is shown in Table 4-3.

Table 4-3. MODA Results					
Evaluation criteria	Scores				
	Neighborhood Storage Tanks	Neighborhood West Ship Canal Tunnel	Shared Storage	Shared Ship Canal Tunnel	Shared West Ship Canal Tunnel
1. Technical complexity and performance risk	1.0	2.0	2.5	1.0	1.0
2. Flexibility	1.0	2.5	2.0	1.0	1.0
3. Constructability	1.0	1.5	1.5	2.0	2.0
4. Consent Decree compliance schedule	3.0	3.0	1.0	1.0	1.0
5. King County concurrence on shared projects	3.0	3.0	2.0	1.0	1.0
6. Construction impacts (short term)	1.0	1.5	1.0	2.5	2.0
7. Community impacts (long term)	1.5	2.0	2.0	2.5	2.5
8. Environmental/ social justice	2.0	1.5	2.0	1.5	2.0
9. Environmental	1.5	1.5	2.0	2.5	2.0
10. Ease of O&M and safety	1.0	2.0	2.5	1.0	1.0

4.1.1.5 Assign Weights to the Objectives

Assigning weights to objectives is a subjective exercise based on the values of the stakeholders. Weighting was done after the performance measures were developed, so project team members could include in their consideration the extent to which the full set of LTCP options vary in performance. The weight assigned to an objective is a measure of that objective's relative contribution to the decision. Table 4-4 presents the weights developed for the objectives hierarchy.

Table 4-4. MODA Objective Weighting		
Evaluation criteria	Relative importance weight	% of total
1. Technical complexity and performance risk	100	12%
2. Flexibility	70	8%
3. Constructability	100	12%
4. Consent Decree compliance schedule	100	12%
5. King County concurrence on shared LTCP options	100	12%
6. Construction impacts (short term)	60	7%
7. Community impacts (long term)	80	9%
8. Environmental and social justice	80	9%
9. Environmental	80	9%
10. Ease of O&M and safety	80	9%

Weights were assigned in a two-step process. First, weights were assigned to establish the relative importance of the sub-objectives within each of the main objectives. The most important sub-objective was assigned an importance weight of 100, and the other sub-objectives were assigned weights proportional to the highest rated objective. After all sub-objectives were scored, the group assigned weights to the main objectives. Again, the most important objective was assigned a weight of 100 and the other objectives were assigned weights proportional to that objective.

4.1.1.6 Score LTCP options and Calculate Total Value Score

The total value score for each LTCP option was calculated using a weighted averaging process in which the total value score is the sum of the percentage-weighted, normalized scores (times 100) of each sub-objective. The results of the analysis are shown in Table 4-5.

Table 4-5. LTCP Option Rating

Evaluation criteria	Neighborhood-all tanks	Neighborhood-West Ship Canal Tunnel	Shared storage	Shared Ship Canal Tunnel	Shared West Ship Canal Tunnel
Total score	32.9	54.4	42.9	27.6	25.9
1. Technical complexity and performance risk	0.0	5.9	8.8	0.0	0.0
2. Flexibility	0.0	6.2	4.1	0.0	0.0
3. Constructability	0.0	2.9	2.9	5.9	5.9
4. Consent Decree compliance schedule	11.8	11.8	0.0	0.0	0.0
5. King County concurrence on shared projects	11.8	11.8	5.9	0.0	0.0
6. Construction impacts (short term)	0.0	1.8	0.0	5.3	3.5
7. Community impacts (long term)	2.4	4.7	4.7	7.1	7.1
8. Environmental and social justice	4.7	2.4	4.7	2.4	4.7
9. Environmental	2.4	2.4	4.7	7.1	4.7
10. Ease of O&M and safety	0.0	4.7	7.1	0.0	0.0

4.1.1.7 Compare Life Cycle Costs with Value Scores

All comparison of control measure costs used in the LTCP option rating and ranking process were made using a net present value (NPV) calculation based on a discount rate of three percent and a 100-year life cycle and include salvage value. In addition to initial capital costs and ongoing operating costs, the NPV calculation incorporated future replacements for metering equipment (5-year cycle), electrical and instrumentation components (10-year cycle), mechanical and odor control equipment (25-year cycle), and major structure upgrade (50-year cycle). Replacement values were extracted from construction cost estimates.

Preliminary cost shares for the various shared options were developed for the Draft LTCP, and were based on a cost allocation methodology developed by the City and King County. To calculate the cost shares, the existing King County recommended CSO project costs were estimated using the LTCP 3C cost model for comparison with the LTCP option costs. The NPV costs were calculated as 100-year life-cycle costs and are summarized in Table 4-6. See Section 5.7.4 for details on the cost share used in the Final LTCP.

Table 4-6. Cost Summary of System Options (April 2013 NPV (100-Year) \$Millions) ^a

CSO area and CSO basins		Neighborhood Storage Tanks	Neighborhood West Ship Canal Tunnel	Shared West Ship Canal Tunnel	Shared Ship Canal Tunnel	Shared Storage
Neighborhood projects						
Leschi	028-036	\$ 26.9	\$ 26.9	\$ 26.9	0	0
Montlake	020,139, 140	\$ 13.1	\$ 13.1	\$ 13.1	0	0
Portage Bay	138	\$ 8.7	\$ 8.7	\$ 8.7	0	\$ 8.7
Duwamish	111	\$ 3.9	\$ 3.9	\$ 3.9	\$ 8.4	\$ 3.9
East Waterway	107	\$ 27.4	\$ 27.4	\$ 14.5	\$ 14.5	\$ 14.5
Magnolia	060	\$ 5.6	\$ 5.6	\$ 5.5	\$ 5.5	\$ 5.6
Central Waterfront	069	\$ 9.0	\$ 9.0	\$ 9.0	\$ 9.0	\$ 9.0
Ballard	150/151 & 152	\$ 119.5			0	\$ 119.5
Fremont/Wallingford	147, 174	\$ 85.7			0	0
Delridge	099	\$ 7.8	\$ 7.8	\$ 7.8	\$ 12.2	\$ 7.8
	168	\$ 8.2	\$ 8.2	\$ 8.2	\$ 8.2	\$ 8.2
	169	\$ 7.4	\$ 7.4	\$ 7.4	\$ 7.4	\$ 7.4
North Union Bay	018	\$ 1.5	\$ 1.5	\$ 1.5	0	0
Neighborhood West Ship Canal Tunnel			\$ 223.6			
Shared projects						
Shared West Ship Canal Tunnel				\$ 231.1		
Shared Ship Canal Tunnel					\$ 542.0	
Shared University storage facility						\$ 95.5
Shared 3 rd Ave. W storage facility						\$ 170.0
Shared Montlake storage facility						\$ 139.2
Flow monitoring		\$ 48.6	\$ 44.8	\$ 44.8	\$ 56.1	\$ 56.1
Total Net Present Value		\$ 373.3	\$ 387.9	\$ 382.4	\$ 663.3	\$ 645.4

Table 4-6. Cost Summary of System Options (April 2013 NPV (100-Year) \$Millions) ^a

CSO area and CSO basins	Neighborhood Storage Tanks	Neighborhood West Ship Canal Tunnel	Shared West Ship Canal Tunnel	Shared Ship Canal Tunnel	Shared Storage
City Share total net present value	\$ 373.3	\$ 387.9	\$ 312.8	\$ 351.7	\$ 361.3

^a NPVs presented in Table 4-6 have been superseded. Updated NPVs are presented in Chapter 5, Sections 5.4 and 5.7.

The NPV costs are based in April 2013 dollars and includes the present-value cost of construction and operations, maintenance, and long-term replacement. The costs include factors such as land costs, contaminated soil mitigation, the potential for loans and grants, private and public park mitigation, and potential negotiated costs (or savings) with King County. It should be noted that the costs shown are planning level, conceptual costs (Class 4) that are expected to be accurate within minus 20 percent to plus 30 percent. Actual costs will vary depending on many factors. Note:

Table 4-7 shows the total value score for each LTCP option (as shown in Table 4-5, LTCP Option Rating) compared to its NPV (as shown in Table 4-6, Net Present Value, Class 4). The typical range of accuracy for a Class 4 estimate is also shown on Table 4-7.

Table 4-7. LTCP Value Score Comparison with Net Present Value ^a

LTCP option	Value score	City NPV cost share, \$M	Lower NPV cost range \$M (-20%)	Upper NPV cost range \$M (+30%)
Neighborhood West Ship Canal Tunnel	54.4	\$388	\$310	\$504
Shared Storage	42.9	\$361	\$289	\$469
Neighborhood Storage Tanks	32.9	\$373	\$298	\$485
Shared Ship Canal Tunnel	27.6	\$352	\$282	\$458
Shared West Ship Canal Tunnel	25.9	\$313	\$250	\$407

^a Note: NPV's presented in Table 4-6 have been superseded. Updated NPV's are presented in Chapter 5, Sections 5.4 and 5.7.

4.1.1.8 LTCP Option Rankings

The Draft LTCP performed a rating and ranking of the LTCP options in accordance with the EPA requirements from the Combined Sewer Overflows Guidance for Long-Term Control Plan, 1995. Section 4.1.1, Final LTCP Alternative Selection Decision Process, describes the LTCP final option selection process in detail. The Draft LTCP ranking results are presented below.

Because the NPVs for the LTCP options are within the accuracy range for a Class 4 estimate (minus 20 percent to plus 30 percent), the LTCP option NPV costs are essentially the same and all the LTCP options can be considered equivalent in costs.

The LTCP options were then ranked based on the total value scores shown on Table 4-5, LTCP Option Rating. The highest ranked LTCP option from the Draft LTCP was the Neighborhood West Ship Canal Tunnel Option. See Section 5.4, Development of Short List and Selection of Recommended Option, for details on how these options were further evaluated following the publishing of the Draft LTCP.

4.2 Public and Regulatory Agency Participation Program

4.2.1 Overview

The City has performed a comprehensive public and regulatory agency participation program for the LTCP in accordance with the Consent Decree. This section describes the City's program performed through the publishing of the Draft LTCP in May 2014. Section 5.2 describes the additional public and regulatory agency participation conducted since the publishing of the Draft LTCP.

4.2.2 Consent Decree Requirements

Specific requirements for a public and regulatory agency participation program for the LTCP are listed in Appendix C, paragraph A, Public and Regulatory Agency Participation Program, of the Consent Decree. The Consent Decree contains the following requirements:

A. Public and Regulatory Agency Participation Program.

The City shall implement a Public and Regulatory Agency Participation Program (the "Participation Program") designed to ensure that there is ample public participation and ample participation by the Plaintiffs, throughout all stages of development of the City's Long Term Control Plan. The Participation Program shall include, at a minimum, the following elements:

- 1. The means by which the City will make information pertaining to the development of the LTCP available to the public for review.*
- 2. The means by which the City will solicit comments from the public on the development of the LTCP.*
- 3. Summary of public hearings at meaningful times during the LTCP development process to provide the public with information and to solicit comments from the public regarding the components of the LTCP.*
- 4. Program for consideration of comments provided by the public as the City develops its LTCP.*
- 5. Measures that the City will employ to ensure that Plaintiffs are kept informed of the City's progress in developing its LTCP, including scheduling periodic meetings with Plaintiffs at meaningful times during the LTCP development process and regular submittal of reports to Plaintiffs summarizing the public comments received throughout implementation of the Program.*

4.2.3 Public Participation Process and Approach

A summary of the participation program activities is presented in Table 4-8.

Table 4-8. Public and Regulatory Agency Participation Program											
Consent Decree requirement (Appendix C, Section A)	City participation program activity										
	Community Guide updates briefings	Briefings	Website updates	Website animations, visualizations, and video	Updates to project listserv	Scoping meetings	On-Line questionnaires public hearing	Public hearing	Public meeting summary reports	Quarterly meetings with EPA and Ecology	Plaintiff webinars
A.1. The means by which the City will make information pertaining to the development of the LTCP available for public review.	•	•	•	•	•						
A.2. The means by which the City will solicit comments from the public on the development of the LTCP		•				•	•	•			
A.3. Summary of public hearings at meaningful times during the LTCP development process to provide the public with information and to solicit comments from the public regarding components of the LTCP									•		
A.4. Program for consideration of comments provided by the public as the City develops the LTCP.								•			
A.5. Measures that the City will employ to ensure that Plaintiffs are kept informed of the City's process in developing its LTCP development process and regular submittal of reports to Plaintiffs summarizing the public comments received throughout implementation of the Program										•	•

4.2.4 Public Participation and Review of Draft LTCP

Through May 2014, the City performed a comprehensive public and regulatory agency participation program to provide information pertaining to the development of the LTCP available for public review. Table 4-9 summarizes the work performed.

Table 4-9. LTCP Participation Program	
Consent Decree requirements (Appendix C, Section A.1-A.5)	Proposed public participation
How the City will make LTCP information available for public review	Prepared the Community Guide to the Plan to Protect Seattle's Waterways Issue 2 (Spring 2013) to provide an overview of the plan purpose and alternatives, environmental review process, and ways to provide comments during scoping. Placed an article about the plan in the summer 2013 edition of Seattle Public Utilities' Curb Waste newsletter, which is mailed to approximately 330,000 Seattle residents Developed a six-minute video about the plan and environmental review process, which is available online at www.seattle.gov/CSO. Approximately 120 people viewed the video since May 2013 Conducted briefings with 13 community organizations and environmental groups reaching approximately 136 stakeholders. Additional briefings will be offered Spring/Fall (Spring 2014 - Spring 2015) or if specifically requested by a stakeholder group Convened four meetings (July, September, October and November 2013) of the Stakeholder Advisory Group to inform decisions about elements of the plan that affect Ballard, Fremont and Wallingford Website updates to be completed Spring/Fall (Spring 2014 – Spring 2015) Maintained a real-time reporting website which alerts the public when sewage overflows occur. Reports are available at www.seattle.gov/CSO by clicking "Real Time Reports of Raw Sewage Overflows."
How the City will solicit public comments on the development of the LTCP	Completed EIS scoping by offering a 30-day public comment period from May 20 – June 20, 2013 and hosting a public scoping meeting on June 3, 2013 Seattle Public Utilities accepted comments by mail, email, in person at the scoping meeting, or via an online survey. Seattle Public Utilities received four comment letters and emails and 26 completed online surveys during the comment period. Online questionnaires in Spring 2014 LTCP/Integrated Plan public meeting June 24, 2014 Public hearing on the Draft LTCP/Integrated Plan/DEIS June 24, 2014
Summary of public hearings during LTCP development to provide public with information and to solicit public comments.	Draft EIS public hearing summary report LTCP/IP Public and Regulatory Agency Participation Summary Report
Program for consideration of comments provided by the public as the City develops the LTCP.	LTCP/Integrated Plan public meeting June 24, 2014

Table 4-9. LTCP Participation Program

Consent Decree requirements (Appendix C, Section A.1-A.5)	Proposed public participation
How the City will ensure that Plaintiffs are kept informed of the LTCP development. Regular report submittal to Plaintiffs summarizing public comments.	Quarterly meetings with EPA and Ecology (addresses both LTCP and Integrated Plan) • March 2013– Reviewed LTCP alternatives; LTCP outline; LTCP schedule; Integrated Plan Project status update. • June 2013 - Reviewed EPA Guidance Document/Consent Decree Crosswalk; LTCP Finance Plan Requirements; Updated LTCP outline; Integrated Plan briefing on expert panel meeting; Integrated Plan stormwater project selection process • August 2013 – LTCP status update; Reviewed Consent Decree deliverables; review/approval of CMOM Performance Program Plan, Floatables Observation Plan and Fog Control Program Plan; CMOM status update; Early Action Program status update. • December 2013 – Reviewed Consent Decree compliance matrix; Early Action items status update; Joint Operations and System Optimization Plan status update; Integrated Plan schedule and status update; LTCP schedule and status update; CMOM activities status update • April 2014 – Briefed EPA and Ecology on Draft LTCP and Draft Integrated Plan documents Webinars for plaintiffs at meaningful times. Webinar will report on public involvement activities and comments received at major milestones.

4.2.5 Final LTCP Public Process

In early 2015, the City Council will review and adopt the Final LTCP through a City ordinance process. The ordinance process will require open public council hearings and meetings to discuss and approve the ordinance. By May 30, 2015, the Final LTCP will be submitted to EPA and Ecology for final approval. By the end of 2015, the final plan is anticipated to be approved by EPA and Ecology and LTCP implementation will commence in late 2015 or early 2016.

4.3 Environmental Impact of LTCP Options

4.3.1 Overview

This section describes the type of social and environmental impacts that could occur within the plan area from any of the LTCP options, as presented in the Draft EIS. For the results presented in the Final EIS, see Section 5.5.

4.3.2 Construction Impacts

CSO reduction projects included under the LTCP options – and common to both the LTCP Alternative and the Integrated Plan Alternative –would involve construction of a combination of sewer system improvements, flow diversions, and underground storage. Because this is a plan-level evaluation, project details and construction methods have not yet been defined. However, the information in Table 4-10 provides a reasonable estimate of the nature, extent, and duration of anticipated construction activities for the types of projects being considered. Actual construction activities will vary and will be determined during subsequent project-specific review. It should be noted that for EIS purposes, CSO areas are described in terms of “neighborhoods,” to promote better familiarity with a broad audience. These neighborhoods are generally consistent with CSO basin areas.

Table 4-10. Summary of Construction Impacts**Resource****Earth**

Construction activities and equipment can cause temporary impacts to earth and groundwater during construction of major projects that require substantial excavation, trenching, or tunneling and removal of large quantities of soil. Any areas that are disturbed during construction would be subject to increased erosion and control measures would be required. Ground settlement from dewatering could cause settlement of nearby structures, roadways, and utilities. Vibration associated with tunneling operations could result in soil settlement along tunneling alignments.

The primary differences in potential effects of the LTCP options are related to the amount of surface disturbance and excavation potentially required.

The Neighborhood Storage Option (would likely result in the most geographically dispersed impacts, with the Ballard, Fremont/Wallingford, and East Waterway neighborhoods experiencing the most disturbance. Construction in the Leschi and Delridge neighborhoods could occur near steep slopes and known or potential landslide-prone areas. Impacts associated with nine additional King County facilities would add to the earth-related impacts. The Neighborhood West Ship Canal Tunnel Option would reduce the total number of facilities constructed, but would concentrate impacts at portal locations in Fremont and Ballard.

The Shared Storage Option reduces the total number of tanks, but concentrates impacts in the Fremont/Wallingford, North Union Bay, and Montlake neighborhoods. Dewatering could encounter contaminated groundwater.

The Shared West Ship Canal Tunnel Option has the potential to encounter liquefiable soils in Fremont and Ballard, which could result in soil settling. Vibration along the tunnel route would be a concern. The number of tanks would be lower than with the neighborhood option, resulting in reduced earthwork.

The Shared Ship Canal Tunnel Option would result in the highest amount of earthwork of all options, but would result in the fewest number of tanks being constructed. Impacts would be concentrated at the portal locations. Vibration and settlement along the tunnel route would be of concern to property owners along the route.

Air quality

Construction would not have a significant effect on air quality in the Seattle area, but may result in moderate localized impacts during the construction periods, largely related to vehicle emissions and dust.

The primary differences in potential air quality and odor effects of the LTCP options are related to the length of construction period and estimated number of truck trips.

The Neighborhood Storage Option has the most project locations, and therefore has the potential for short-term construction-related air and odor impacts in numerous neighborhoods. Storage tank construction in Ballard could last up to five years. The Shared Storage Option would affect fewer sites but would result in longer construction durations in the Fremont/Wallingford, North Union Bay, and Montlake neighborhoods. The Shared (and Neighborhood) West Ship Canal Options would result in fewer sites being potentially affected, but longer construction durations in the Ballard and Fremont/Wallingford neighborhoods. Overall, fewer facilities would be constructed because the City and King County would share some of their storage facilities. **The Shared Ship Canal Tunnel Option results in the lowest number of facilities but a longer duration of construction at the portal locations, likely in the Ballard/Fremont and Lake Washington neighborhoods.**

Surface water

Construction effects on surface water could include increased pollutants and sediments from site runoff and would require control measures. Construction of pipes, tanks, and portals could occur near sensitive receiving water bodies, including Lake Washington, the Ship Canal, and the Duwamish River. Discharges of dewatering water could introduce contaminants and sediments into local water bodies if not properly managed.

Table 4-10. Summary of Construction Impacts**Resource**

The primary differences in potential effects of the LTCP options are related to the amount of surface disturbance and the amount of excavation potentially required.

In general, the potential for construction-related impacts to surface waters in the plan area is low for all options because construction will comply with all applicable regulations and permit conditions. The greatest number of facilities would be constructed under the Neighborhood Storage Option with construction locations in up to 11 neighborhoods around the City. The Shared Storage Option reduces the total number of facilities constructed but increases the size of the facilities because they would be shared with King County. Potential for dewatering would occur with all options, but potential dewatering quantities are likely to be greatest for the tunnelling options, where construction durations would last between 3.5 and 7 years. In particular, the Shared (and Neighborhood) West Ship Canal and Shared Ship Canal Tunnel Options are likely to require substantial dewatering. Impacts to surface water would be avoided by compliance with applicable permit conditions.

Biological resources

No direct impacts to aquatic habitats, plants, and invertebrates would occur and no indirect impacts to fish, including federally listed salmonids, are anticipated because no in-water construction would occur. The potential for direct losses of terrestrial habitat associated with facility construction would be minimal under all plan alternatives because all construction will comply with applicable permit requirements. Indirect impacts to wildlife would be associated with increased level of noise and human activity during construction.

The primary differences in potential effects of the LTCP options are related to amount of construction activity (surface disturbance) and proximity to mapped priority habitats or species. CSO control projects would be constructed in urbanized areas.

The highest amount of surface disturbance would occur with the Shared Storage Option, which suggests a higher potential for habitat impacts. However, the total number of facilities is second to lowest, which would reduce the potential to cause indirect impacts to wildlife. The Shared Storage Option has the potential to impact priority species because construction would occur for up to five years in proximity to priority habitats along the Lake Washington Shoreline and Union Bay Natural Areas. The Neighborhood Storage Option affects the most neighborhoods. The Shared (and Neighborhood) West Ship Canal Tunnel Options result in lower overall disturbance but increase the duration of disturbance. The Shared Ship Canal Tunnel Option reduces the overall area disturbed, but results in construction activity lasting up to seven years in proximity to priority habitats.

Energy and climate change

None of the LTCP options would have a significant impact on energy resources in the Seattle area.

The primary difference in energy consumption and greenhouse gas (GHG) emissions between the options relates to the type of storage facility (e.g., tank or tunnel) and whether it is part of the Neighborhood Storage Option or one of the shared options. While the shared options would have higher energy consumption and GHG emissions per facility, there would be fewer new storage facilities built by the City and King County. Therefore, overall emissions would likely be lower.

Environmental health and public safety

Ground excavations and dewatering have the potential to encounter contaminated materials and may require special handling methods depending on the site and type of materials encountered. Discharges of dewatering water could introduce contaminants and sediments into local waterways if not properly managed. In general, environmental health risks associated with construction under all of the LTCP options are low and the potential for the public to encounter contaminated soils or groundwater is also low.

Larger projects, such as storage tanks and tunnels, have a greater potential for construction-related environmental health

Table 4-10. Summary of Construction Impacts**Resource**

and public safety impacts than smaller projects constructed in the right-of-way, such as storage pipes and flow diversions.

Noise and vibration

Construction of projects under the plan alternatives would result in short-term moderate to substantial increases in noise.

The primary differences in potential noise and vibration effects of the LTCP options are related to the amount of earthwork and the length of construction period. The Neighborhood Storage Option would have the most geographically dispersed noise and impacts throughout the plan area with the longest duration of impacts (up to five years) in Ballard.

Fremont/Wallingford, and East Waterway neighborhoods. The Shared Storage Option would concentrate higher intensity noise at fewer locations in the Fremont/Wallingford, North Union Bay and Montlake neighborhoods for up to five years. For the Shared (and Neighborhood) West Ship Canal Tunnel Options, the impacts would be concentrated at the portals, in the Ballard and Fremont/Wallingford neighborhoods for up to three and a half years. The Shared Ship Canal Tunnel Option would concentrate noise at the portal locations in the Ship Canal And Lake Washington neighborhoods for up to seven years, particularly at the launch portal site near the Fremont Cut.

Land use and visual quality

CSO control projects included under the LTCP range from those that would be located in the public right-of-way or streets and cause little or no land use or visual impact up to major infrastructure projects that could require acquisition of property or easements. The acquisitions and easements could be temporary, to accommodate access to a site or a location for project staging, or they could be permanent, for locating storage tanks or tunnels. Maintaining access to businesses and residences will be a key requirement. Impacts to visual quality during construction would be minor under all LTCP options. If public land is not available for facilities, acquisition of private property would likely be required.

The primary differences in potential effects of the LTCP options are related to the types of projects and their potential location and the length of construction.

The Neighborhood Storage Option has the largest number of CSO storage facilities and would have the greatest potential for temporary land use impacts. Access disruption could affect residences and businesses, as well as the University of Washington, for several years. The Shared Storage Option would reduce the total number of tanks but the construction would be concentrated at fewer, larger sites in the Ship Canal and Lake Washington neighborhoods of Fremont/Wallingford, North Union Bay, and Montlake. The Shared (and Neighborhood) West Ship Canal Tunnel Options would concentrate impacts in the Ballard and Fremont/Wallingford neighborhoods for up to three and a half years, although much of the area used for construction could be sold to private ownership following construction. The Shared Ship Canal Tunnel Option reduces the potential neighborhoods affected but concentrates potential impacts in the Ship Canal and Lake Washington neighborhoods, where construction could occur for up to seven years.

Historic, cultural, and archaeological resources

Construction under any of the LTCP options could have a potential adverse effect on historic, cultural, or archaeological resources in the plan area. The primary difference in impacts relates to the amount of excavation in geological layers and their potential to encounter cultural resources. All LTCP options include similar, minimal potential for impacts on aboveground historic resources. In general, storage tanks and pipes would have a greater amount of excavation in geological layers with potential to encounter cultural resources than the tunnel options, which would occur farther below the surface. There is minimal potential to affect aboveground resources although the potential to affect historic properties with vibration impacts will be a concern for the tunnelling options.

Transportation

Table 4-10. Summary of Construction Impacts**Resource**

Construction of projects under the LTCP options would result in moderate to substantial\, adverse transportation impacts for temporary periods ranging from one to six years. Potential construction-related transportation impacts would be highly visible and are of concern to local residents, business owners, and commuters. Transportation impacts would include increases in traffic volumes due to construction-generated truck trips and commute trips of construction workers as well as roadway lane and sidewalk closures where construction activities take place.

The primary differences in potential transportation impacts of the LTCP options are related to the length of construction period, estimated number of truck trips, and the road network in the affected neighborhood.

The Neighborhood Storage Option would have the most dispersed transportation impacts because it would require roadway lane and sidewalk closures throughout the city to accommodate construction from 18 City and 9 King County facilities. Some neighborhoods could be affected for up to five years. Localized impacts in the Leschi, Montlake and Magnolia neighborhoods could occur because limited route alternatives could require temporary lane closures. The Shared Storage Option would reduce or eliminate impacts in the Leschi neighborhood but would increase impacts in the Fremont/Wallingford, North Union Bay, and Montlake neighborhoods. The Shared (and Neighborhood) West Ship Canal Tunnel Options would concentrate transportation impacts at the portal locations in Ballard and Fremont/Wallingford. This option would result in substantially more truck trips over a longer period in Ballard compared to the Neighborhood Storage and Shared Storage Options. With expected construction duration of three and a half years, truck trips generated by the tunnelling are expected to average 60 per day. The increase in truck traffic is relatively low compared to background levels, and is not expected to adversely affect roadway conditions. Total construction trips are expected to be over 100,000 truck round trips for the Shared Ship Canal Tunnel Option, generated primarily on the south side of the Ship Canal at the launch portal. With estimated construction duration of up to seven years, truck trips generated by the tunnelling are expected to average 70 per day, which is not expected to adversely affect roadway conditions. This option would result in substantially more truck trips over a longer period south of the Ship Canal, where the launch portal would likely be located, compared to the other options.

Public utilities

Construction of storage tanks, pipes, tunnels, pump stations, and appurtenant facilities would occur in areas highly constrained by existing underground and overhead utilities and would require extensive coordination with existing utilities to avoid conflicts. The primary difference in impacts between the options relates to the number of new storage facilities construction and the amount of new conveyance (pipelines) required to transport flows to the new storage facilities. Several of the options include flow diversions to King County facilities, which would necessitate coordination and prior agreements with King County to ensure that there are minimal impacts to King County facilities during construction. Coordination with all potentially affected agencies and utilities would be required.

The Neighborhood Storage Option has the greatest potential for construction-related impacts to utilities due to the number of new storage tanks to be constructed and the amount of conveyance required to transport flows to storage facilities. Between the City and King County, a total of 27 facilities would be constructed, all located in areas with existing underground utilities. The Shared Storage Option would include three shared storage facilities with King County as well as a proposed flow diversion to a King County facility, which would require close coordination to ensure that there are minimal impacts to King County facilities during construction. The Shared West Ship Canal Tunnel Option involves the City and King County sharing a deep tunnel and two flow diversions to King County facilities, requiring a high level of coordination with King County to avoid potential construction-related impacts. Deep tunnels tend to be constructed below many underground utilities, reducing the potential for utility conflicts. However, temporary electrical substations to power the tunnel boring machine and construction of tunnel portals and other associated facilities would require utility coordination and reconfiguration. Construction impacts would be similar for the Neighborhood West Ship Canal Tunnel Option, but the tunnel would not be shared with King County. The Shared Ship Canal Tunnel Option involves the City and King County sharing a deep tunnel and includes four flow diversions to King County facilities. This option requires the highest level of coordination between the

Table 4-10. Summary of Construction Impacts**Resource**

City and King County to avoid potential construction-related impacts.

Socioeconomics and environmental justice

Construction of projects under the LTCP options could cause construction disturbance and modified access to community resources and businesses, resulting in temporary reduction in neighborhood cohesion. Temporary disruptions may be a particular hardship for some residents – particularly transit-dependent persons – due to disruptions to access and public transportation in project areas.

There could be short-term impacts on existing economic conditions in the construction areas due to construction disturbance and temporary changes in the use of the land during construction. In some cases, these changes would be permanent, while in other cases, economic activity would largely be restored following construction.

Although construction effects may be substantial, none of the LTCP options would cause disproportionately high and adverse effects on minority and low-income populations.

4.3.3 Operational Impacts

Table 4-11 describes the potential effects of the plan after construction has been completed and the plan projects are in operation. Both the LTCP Alternative and the Integrated Plan Alternative would implement one of the four LTCP options, although some of these CSO reduction projects would be deferred under the Integrated Plan Alternative. Because CSO reduction facilities under the LTCP options would largely be underground, few operational effects to the environment would result from plan implementation. As noted above, for purposes of the EIS, CSO areas are referred to as “neighborhoods.”

Table 4-11. Summary of Operational Impacts**Resource****Earth**

Overall, the operational effects from the LTCP Alternative are expected to be minor. With the implementation of site-appropriate design, potential adverse impacts would be avoided and minimized. All storage tanks, pipes and tunnels would be designed in accordance with seismic design standards, which are intended to minimize the long-term risks to the system.

Air quality

The net operational effects of the LTCP Alternative on air quality and odors would be minor in the plan area. All facilities would be designed and maintained to minimize emissions of odorous compounds and would include odor control components as necessary.

The Neighborhood Storage Option would have the highest number of potential odor-producing tanks and pipes located throughout the plan area, including in or near residential areas in the Ship Canal, Lake Washington, and Longfellow Creek/Duwamish Neighborhoods, which is expected to be of concern to area residents. All facilities would be designed and maintained to minimize emissions of odorous compounds. Therefore, operational effects of the CSO control facilities on air quality and odors would be minor in the plan area. The Shared Storage Option would reduce the total number of facilities implemented by the City and King County. The Shared (and Neighborhood) West Ship Canal Tunnel Option would reduce the number of potential odor-producing storage facilities in the Ballard and Fremont/Wallingford neighborhoods. The large tunnel would have the greatest potential for odors at the downstream tunnel portal (likely located along the Ship Canal in the

Table 4-11. Summary of Operational Impacts**Resource**

vicinity of Ballard), which would be controlled by an odor control facility. The Shared Ship Canal Tunnel Option would largely eliminate the potential for odor in the Lake Washington neighborhoods of Montlake, Portage Bay, and Leschi. The large tunnel would have the greatest potential for odors at the downstream tunnel portal (likely located along the south side of the Ship Canal), which would be controlled by an odor control facility. Additional flow diversions in Duwamish and Delridge would further reduce the number of potentially odor-producing storage facilities in those neighborhoods.

Surface water

The LTCP Alternative would result in substantial reduction of pollutant loading from existing uncontrolled CSO outfalls when compared with the No Action Alternative. All options of the LTCP Alternative would comply with Clean Water Act requirements and the Consent Decree. The Ship Canal/Lake Union, Lake Washington, Duwamish River, Longfellow Creek, Elliott Bay, and Puget Sound would receive reduced discharges from CSOs. Pollutant loadings from control of 22 currently uncontrolled CSOs would be substantively reduced and would come into compliance with Clean Water Act requirements.

Biological resources

All options for the LTCP Alternative would have negligible to minor operational effects in the plan area. There would be long-term beneficial effects on fish and aquatic life from reducing CSOs. Implementation of the LTCP would reduce the volume of untreated sewage and stormwater runoff, thereby reducing the potential for related adverse effects on aquatic life. The total volume of the City's current CSO discharge would be decreased by nearly 60 percent with full implementation of the LTCP and would comply with the Consent Decree as well as other federal and state requirements.

Energy and climate change

All options for the LTCP Alternative would have minor operational effects on energy use in the city. The GHG emissions produced by operating and maintaining CSO facilities are not expected to cause appreciable climate change impacts. The City has incorporated climate change modelling in its development of the LTCP options and would incorporate additional modelling in the design of individual CSO facilities to minimize risks from anticipated changes in precipitation and sea level rise. The Shared Storage Option would have somewhat higher electrical requirements than the Neighborhood Storage Option because of the greater energy requirements of the larger shared storage tanks. The Shared (and Neighborhood) West Ship Canal Tunnel Option would potentially have a higher electrical requirement than both the Neighborhood and Shared Storage Options because of the electricity needed to pump the deeply stored water. The Shared Ship Canal Tunnel Option would likely have the highest electrical energy requirements of all the LTCP options because of the greater energy requirements for pumping associated with the large deep tunnel. Overall impacts from both the City and King County projects would likely be reduced under all of the shared options because the shared facilities would reduce the number of City and King County independently constructed CSO control facilities.

Environmental health and public safety

Overall, the LTCP Alternative is expected to reduce environmental health risks associated with CSOs and stormwater by reducing untreated discharges. Reductions of CSO and stormwater discharges are to water bodies where water-contact recreation occurs, including Lake Union, the Ship Canal, Lake Washington, and the Duwamish Waterway.

Noise and vibration

The net operational effects of the LTCP Alternative would be minor in the plan area. Noise would be generated under all options by pump stations and odor control facilities. All facilities would be designed and maintained to reduce noise to permissible levels.

The Neighborhood Storage Option and the Shared Storage Option would include pump stations and other facilities located in residential areas, particularly in the Lake Washington, Longfellow Creek / Duwamish, and Ship Canal neighborhoods. The

Table 4-11. Summary of Operational Impacts**Resource**

Shared (and Neighborhood) West Ship Canal Tunnel and Shared Ship Canal Tunnel Options have fewer pump stations and noise-generating facilities so they would have a lower potential for noise impacts.

Land use and visual quality

Potential land use impacts associated with CSO control projects include conversion of land in residential, commercial, or industrial areas to public utility uses. These impacts differ between the options because of different property requirements of tanks as compared to tunnels. The completed facilities would largely be constructed below ground; aboveground facilities would have minimal visual impacts with the use of site-appropriate design and screening.

The Neighborhood Storage Option would have the most storage tanks located throughout the plan area with the potential to cause permanent land use changes. Current land uses would be permanently changed to become storage facilities, however, the tanks and associated equipment would largely be underground. The presence of underground storage tanks would restrict certain future uses on top of the facility. While there is the potential to redevelop the surface area into certain beneficial uses, the previous land use at the site could be permanently altered. Ballard would have the largest storage tank (occupying an estimated 60,000 square feet (SF)). The completed facilities would be designed to visually blend with the surroundings, but it is likely that they will have a different appearance from pre-construction conditions. Storage pipes would be constructed in street rights-of-way and would have less potential for land use changes.

The Shared Storage Option would result in fewer sites for storage tanks in the Ship Canal neighborhoods and no tank would be sited in the East Waterway area. Potential land use impacts from siting larger shared tanks could occur in the Lake Washington neighborhoods. These tanks would occupy an estimated 35,000 SF (North Union Bay) and 40,000 SF (Montlake).

The Shared (and Neighborhood) West Ship Canal Tunnel Option would have lower potential for long-term land use impacts because the tunnel would replace the need to site several storage tanks and less property would need to be retained following construction. The City would be able to sell or lease approximately 75 percent of the tunnel launch portal lands following construction, where it could be developed for zoned uses (e.g., industrial or commercial). Approximately one-half acre of the launch portal would be retained by the City to house the pump station, odor control, and permanent shaft for access and maintenance. All of the area used for the smaller, retrieval end of the tunnel in Fremont/Wallingford would be retained by the City. Some additional areas would be retained for permanent shafts. The Shared Ship Canal Tunnel Option would result in impacts similar to the Shared West Ship Canal Tunnel. All of the area used for the smaller, retrieval end of the tunnel in North Union Bay would be retained by the City. Compared to the Shared West Ship Canal Tunnel Option, the Ship Canal Tunnel would result in less potential for land use impacts in Ballard and more potential for land use impacts on the south side of the Ship Canal and in North Union Bay.

Recreation

Overall, the operational effects from the LTCP Alternative on recreational activities are expected to be minor. Reductions in pollutant loading would benefit long-term water quality and help maintain beneficial uses at area beaches. Water-contact recreation in area water bodies would be enhanced by improved water quality in Lake Washington, Portage Bay, and Lake Union, in particular. Locating storage facilities in a park would constrain certain future uses of that area for park purposes. However, there is a potential to provide recreational facilities on top of storage tanks following construction.

The Neighborhood Storage and Shared Storage Options would have the highest potential to cause park and recreation impacts because these options have the most tank facilities. Locating storage facilities in a park or its associated uses (such as parking) would constrain certain future uses of that area for park purposes. However, there is a potential to provide recreational facilities on top of storage tanks following construction.

The Shared (and Neighborhood) West Ship Canal Option would have less potential for long-term impacts to recreation than both the Neighborhood Storage and Shared Storage Options since the tunnel would replace the need to site several storage

Table 4-11. Summary of Operational Impacts**Resource**

tanks in the Ship Canal neighborhoods (Ballard and Fremont/ Wallingford). The Shared Ship Canal Tunnel Option would result in lower potential for recreation impacts in Ballard and more potential for impacts on the south side of the Ship Canal and in North Union Bay if the tunnel portals are sited in a park or recreation area, including university athletic fields, or the Burke Gilman Trail.

Historic, cultural, and archaeological resources

Operation of projects implemented under the LTCP Alternative is anticipated to have no effect on historic, cultural, and archaeological resources within the plan area.

Transportation

Overall, the operational effects from vehicle trips generated by facility maintenance under the LTCP Alternative are expected to be minor.

Utilities

Implementation of the LTCP would require close coordination with numerous utilities, particularly wastewater, stormwater, and water utilities within the service area. King County's West Point WWTP would receive additional sewage flows as a result of plan implementation. These additional flows could affect peak loading to West Point. Annual average flows would increase, resulting in greater operational and maintenance costs. Seattle and King County would address the incremental cost of these modified flows in a sewage disposal agreement. The potential implications to King County's combined sewer system vary depending upon the option implemented.

The Neighborhood Storage Option would generally have minimal operational impacts to utilities once construction is complete. However, this option would require the greatest length of sewer pipe construction, with accompanying maintenance requirements. Sewer system improvements in North Union Bay could have operational implications to King County, which would be resolved according to agreements negotiated with King County. Selection of this option would necessitate the need for King County to construct the largest number of independent storage facilities to meet regulatory requirements.

The Shared Storage Option would result in potential operational considerations for both King County and the City associated with flow diversion and shared storage projects. Potential operational implications would be coordinated with King County to ensure that detrimental impacts do not occur.

The Shared West Ship Canal Tunnel Option would result in a large joint tunnel and flow diversions to King County in the East Waterway and Magnolia neighborhoods. These joint projects would be implemented in accordance with operational agreements between the City and King County. This option may reduce the operational complexity of controlling neighborhood storage tanks or shared storage tanks as it provides one large storage facility for all flows to be managed through a single pump station discharging to the West Point WWTP. However, King County has acknowledged operational risks associated with fewer storage facilities.

The Shared Ship Canal Tunnel Option involves the City and King County sharing a deep tunnel, and includes four flow diversions to King County facilities. This option requires the highest level of coordination with King County, to reduce the potential for impacts. Extensive coordination between the City and King County would be conducted to develop operational agreements that are workable and efficient for both entities.

Socioeconomics and environmental justice

The operational effects of the LTCP Alternative would be minor to moderately beneficial, and there would be no adverse operational effects that would be predominantly borne by minority or low-income populations and underserved communities.

4.3.4 Summary

The construction impacts of the LTCP Alternative Options would be minor to moderate, assuming mitigation measures are implemented. Transportation impacts could be substantial in some neighborhoods. Long -term effects would be beneficial, particularly to water quality, biological resources, and environmental health, and there would be no adverse operational effects that would be predominantly borne by minority or low-income populations and underserved communities.

4.4 Implementation Plan Evaluation

4.4.1 Overview

The implementation schedule is the sequence and duration of design, construction and commencement of operations for the CSO control projects for each LTCP option. The implementation schedule will affect wastewater and drainage rates, employment, public and local businesses, agency resource allocation, and other agencies' projects.

The Consent Decree requires the LTCP to develop an expeditious schedule for the implementation of all CSO control measures. Appendix C Section C.8 of the Consent Decree stipulates that "if it is not possible for the City to design and construct all measures simultaneously, the LTCP shall include a phased schedule based on the relative importance of each measure with the highest priority given to those projects that most reduce the discharge of pollutants."

4.4.2 Prioritization and Scheduling Criteria

For each CSO control measure, the Consent Decree requires that the implementation schedule specify the critical milestone dates for the following project activities: engineering report, plans and specifications, construction start, construction completion, and achievement of controlled status. Because the CSO projects range in construction complexity and project costs, the CSO projects have project durations ranging from 3 years to 14 years based on the City's project implementation experience. The project duration assumptions are listed in Table 4-12.

The LTCP used two methods to determine the priority of projects that most reduce the discharge of pollutants. The first method followed the EPA guidelines for sensitive areas, which determines which basins have the largest impact on receiving water bodies and human health. The results of sensitive areas analysis was shown on Figure 2-26. The LTCP will give the highest priority to controlling overflows to the highest ranked sensitive areas. The second method is then used to rate the results as ranked by the first method to compare the relative cost-effectiveness of each CSO project on a total project cost per gallon of CSO discharge volume reduced. The LTCP will give the highest priority to controlling overflows to the CSO projects with the lowest cost per CSO discharge gallon reduced.

Table 4-12. Option Development (Months)

CSO control measure	Overall project duration	Engineering report	Plans and specifications	Construction start	Construction completion	Achievement of control status
Large CSO tanks (1 MG or larger)	148	36	36	6	54	16
CSO tanks	109	24	24	6	39	16
Pipe storage	73	12	12	6	27	16
Flow diversion	109	24	24	6	39	16
Collection system improvements (retrofits)	73	12	12	6	27	16
West Ship Canal Tunnel	148	36	36	6	54	16
Ship Canal Tunnel	184	36	36	6	90	16

4.4.3 LTCP Option Implementation Schedules

Figure 4-1 presents the overall schedule for the CSO control measure projects for each LTCP Option. The schedules show the project duration and two critical Consent Decree milestone dates: construction completion and achievement of controlled status. See Section 5.9.3 for the implementation schedule of the recommended LTCP option.



Figure 4-1. LTCP Option Implementation Schedules

Table 4-13 shows the Consent Decree milestone dates for the Neighborhood Storage Option.

Table 4-13. Neighborhood Storage (Tanks) Consent Decree Required Compliance Dates							
	Draft engineering report	Final engineering report	Draft plans and specs	Final plans and specs	Construction start	Construction completion	Achieve controlled status
Neighborhood CSO control measures							
Leschi	6/30/2017	12/31/2017	6/30/2019	12/31/2019	7/1/2020	9/30/2023	3/31/2025
Madison Park	9/30/2020	12/31/2020	9/30/2021	12/31/2021	7/1/2022	9/30/2023	3/31/2026
Montlake	9/30/2020	12/31/2020	9/30/2021	12/31/2021	7/1/2022	9/30/2023	3/31/2026
Portage Bay/Lake Union	9/30/2016	12/31/2016	9/30/2017	12/31/2017	7/1/2018	9/30/2020	3/31/2022
Duwamish	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2026
East Waterway	6/30/2017	12/31/2017	6/30/2019	12/31/2019	7/1/2020	9/30/2023	3/31/2025
Magnolia	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Central Waterfront	6/30/2018	12/31/2018	6/30/2020	12/31/2020	7/1/2021	9/30/2024	3/31/2026
Ballard	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	9/30/2025	3/31/2027
Fremont/Wallingford	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	9/30/2025	3/31/2027
Delridge 99	9/30/2017	12/31/2017	9/30/2018	12/31/2018	7/1/2019	9/30/2021	3/31/2023
Delridge 168	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Delridge 169	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
North Union Bay	n/a	n/a	6/30/2014	12/31/2014	7/1/2015	9/30/2017	3/31/2019

Table 4-14 shows the Consent Decree milestone dates for the Neighborhood West Ship Canal Tunnel Option.

Table 4-14. Neighborhood West Ship Canal Tunnel Consent Decree Required Compliance Dates

	Draft engineering report	Final engineering report	Draft plans and Specs	Final plans and Specs	Construction start	Construction completion	Achieve controlled status
Neighborhood CSO control measures							
Leschi	6/30/2017	12/31/2017	6/30/2019	12/31/2019	7/1/2020	9/30/2023	3/31/2025
Madison Park	9/30/2020	12/31/2020	9/30/2021	12/31/2021	7/1/2022	9/30/2023	3/31/2026
Montlake	9/30/2020	12/31/2020	9/30/2021	12/31/2021	7/1/2022	9/30/2023	3/31/2026
Portage Bay/Lake Union	9/30/2016	12/31/2016	9/30/2017	12/31/2017	7/1/2018	9/30/2020	3/31/2022
Duwamish	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2026
East Waterway	6/30/2017	12/31/2017	6/30/2019	12/31/2019	7/1/2020	9/30/2023	3/31/2025
Magnolia	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Central Waterfront	6/30/2018	12/31/2018	6/30/2020	12/31/2020	7/1/2021	9/30/2024	3/31/2026
Delridge 99	9/30/2017	12/31/2017	9/30/2018	12/31/2018	7/1/2019	9/30/2021	3/31/2023
Delridge 168	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Delridge 169	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
North Union Bay	n/a	n/a	6/30/2014	12/31/2014	7/1/2015	9/30/2017	3/31/2019
West Ship Canal Tunnel	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	9/30/2025	3/31/2027

Table 4-15 shows the Consent Decree milestone dates for the Shared West Ship Canal Tunnel Option.

Table 4-15. Shared West Ship Canal Tunnel Consent Decree Required Compliance Dates							
	Draft engineering report	Final engineering report	Draft plans and specs	Final plans and specs	Construction start	Construction completion	Achieve controlled status
Neighborhood CSO control measures							
Leschi	6/30/2017	12/31/2017	6/30/2019	12/31/2019	7/1/2020	9/30/2023	3/31/2025
Madison Park	9/30/2020	12/31/2020	9/30/2021	12/31/2021	7/1/2022	9/30/2023	3/31/2026
Montlake	9/30/2020	12/31/2020	9/30/2021	12/31/2021	7/1/2022	9/30/2023	3/31/2026
Portage Bay/Lake Union	9/30/2016	12/31/2016	9/30/2017	12/31/2017	7/1/2018	9/30/2020	3/31/2022
Duwamish	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2026
Central Waterfront	6/30/2018	12/31/2018	6/30/2020	12/31/2020	7/1/2021	9/30/2024	3/31/2026
Delridge 99	9/30/2017	12/31/2017	9/30/2018	12/31/2018	7/1/2019	9/30/2021	3/31/2023
Delridge 168	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Delridge 169	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
North Union Bay	n/a	n/a	6/30/2014	12/31/2014	7/1/2015	9/30/2017	3/31/2019
Shared CSO control measures							
Shared West Ship Canal Tunnel	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	12/31/2025	6/30/2027
East Waterway flow diversion	6/30/2017	12/31/2017	6/30/2019	12/31/2019	7/1/2020	9/30/2023	3/31/2025
Magnolia flow diversion	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027

Table 4-16 shows the Consent Decree milestone dates for the Shared Ship Canal Tunnel Option.

Table 4-16. Shared Ship Canal Tunnel Consent Decree Required Compliance Dates							
	Draft engineering report	Final engineering report	Draft plans and specs	Final plans and specs	Construction start	Construction completion	Achieve controlled status
Neighborhood CSO control measures							
Central Waterfront	6/30/2018	12/31/2018	6/30/2020	12/31/2020	7/1/2021	9/30/2024	3/31/2026
Delridge 168	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Delridge 169	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Shared CSO control measures							
East Waterway flow diversion	6/30/2017	12/31/2017	6/30/2019	12/31/2019	7/1/2020	9/30/2023	3/31/2025
Magnolia flow diversion	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Shared Ship Canal Tunnel	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	12/31/2028	3/31/2030
Leschi flow diversion	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	9/30/2025	3/31/2027
Duwamish flow diversion	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Delridge flow diversion	9/30/2017	12/31/2017	9/30/2018	12/31/2018	7/1/2019	9/30/2021	3/31/2023

Table 4-17 shows the Consent Decree milestone dates for the Shared Storage Option.

Table 4-17. Shared Storage Consent Decree Required Compliance Dates							
	Draft engineering report	Final engineering report	Draft plans and specs	Final plans and specs	Construction start	Construction completion	Achieve controlled status
Neighborhood CSO control measures							
Portage Bay/Lake Union	9/30/2016	12/31/2016	9/30/2017	12/31/2017	7/1/2018	9/30/2020	3/31/2022
Duwamish	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2026
Magnolia	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Central Waterfront	6/30/2018	12/31/2018	6/30/2020	12/31/2020	7/1/2021	9/30/2024	3/31/2026
Ballard	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	9/30/2025	3/31/2027
Delridge 99	9/30/2017	12/31/2017	9/30/2018	12/31/2018	7/1/2019	9/30/2021	3/31/2023
Delridge 168	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Delridge 169	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Shared projects							
East Waterway flow diversion	6/30/2017	12/31/2017	6/30/2019	12/31/2019	7/1/2020	9/30/2023	3/31/2025
Leschi flow diversion	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	9/30/2025	3/31/2027
Shared Fremont/Wallingford and 3rd Ave. W storage	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	12/31/2025	3/31/2027
Shared Montlake Sstorage	3/31/2023	12/31/2023	3/31/2025	12/31/2025	1/1/2026	12/31/2028	3/31/2030
Shared University storage	3/31/2023	12/31/2023	3/31/2025	12/31/2025	1/1/2026	12/31/2028	3/31/2030

The Shared West Ship Canal Tunnel option is estimated to take 11 years to design and construct and will meet the City Consent Decree construction completion milestone date (2025); however, it will not meet the County's construction completion milestone date for 3rd Avenue West (2023), unless the schedule can be compressed. Similarly, the Shared Ship Canal Tunnel Option will take 14 years to design and construct and will not meet the City's 2025 construction completion date nor the King County 3rd Avenue W completion date (2023). Two of the shared storage tank projects (North Union Bay and Montlake) proposed in King County's CSO Plan also will not meet the City's 2025 completion date.

4.4.4 LTCP Implementation Plan

As described in Section 4.1.1, Rating and Ranking of LTCP Alternative Options, the Draft LTCP has performed a rating and ranking of the LTCP options in accordance with the EPA requirements in the *Combined Sewer Overflows Guidance for Long-Term Control Plan, 1995*. The Draft LTCP was submitted in May 2014 for EPA and Ecology review and comment. The City issued a public notice and held a public meeting and official public comment period for the Draft LTCP. After the comment period and receipt of EPA and Ecology comments, additional evaluation was performed to refine and re-evaluate the options in order to select a preferred LTCP option. See Chapter 5.

4.4.5 Factors Potentially Affecting Schedule

The LTCP Implementation schedule is the sequence in which the LTCP options will be implemented. The implementation schedule will affect sewer rates, City resource workload, City resources, and local and regional projects. The following paragraphs describe major internal and external factors that may impact the timing and implementation decisions of the LTCP options and individual LTCP projects.

4.4.5.1 City Utility Rates

City drainage and wastewater rates will need to be increased to implement the LTCP options. In addition, the City rate payers will be paying for the implementation of the 2010 Plan CSO projects and the Consent Decree Early Action Projects during the same period (2015-2030). LTCP projects may need to be distributed throughout this period to reduce or "flatten" the rate increase. Rate impacts are discussed in detail in Section 4.5, Financial Plan.

4.4.5.2 King County Coordination on Shared Projects

There are three LTCP options that include shared projects with King County. The City and King County each have consent decrees and NPDES permits with varying compliance dates and priorities that make coordination of shared projects challenging. The City and King County are continuing to work together closely to analyze and recommend LTCP options that are more cost-effective, produce better environmental outcomes, and minimize disruption to communities. King County must also reach its own independent conclusions about the benefits of a shared project to the regional system and the implications of such a project to its own Long Term Control Plan and Consent Decree. Independent City-only neighborhood options have been developed that can also reduce impacts to communities if shared projects are not selected.

4.4.5.2.1 City Consent Decree Compliance Deadlines

The City Consent Decree requires "...Construction completion of all CSO control measures in the approved LTCP..." by December 31, 2025. For the neighborhood option, the City will be able to meet this consent decree deadline.

However, for the three shared LTCP options, the City and King County must agree on a mutual construction completion date for all shared projects and the City will need to obtain approval from EPA, Ecology, and the court if this date is different from their respective consent decrees. For example, for the Shared Storage Option, King County's Consent Decree has two of the shared projects (University Regulator and Montlake Regulator) with a required construction completion date of 2030. The City Consent Decree requires that all LTCP projects including shared projects have a construction completion date no later than December 31, 2025. If the City and County agree to implement these two shared projects, the City will need approval to implement these projects after the 2025 construction completion date. See Chapter 5, Section 5.4.2.2 and 5.9.5.2 for updated information regarding proposed Shared Projects and Consent Decree Milestone requirements.

4.4.5.3 Opportunities and Conflicts with other Projects

CSO Basin 107 (East Waterway) and CSO Basin 69 (Central Waterfront) may be impacted by the future King County Hanford-Lander-King St – Kingdome CSO Treatment Plant project. The proposed Hanford, Lander, Kingdome, King St. Project includes CSO treatment facility for up to 151-MGD (assuming the use of a ballasted sedimentation treatment process) near the Hanford St Regulator Station and modifications to the Elliott Bay Interceptor to divert flows to the CSO treatment facility. The flow diversion may result in decreased CSO control requirements for CSO Basins 107 and 069, depending on the final configuration of the HLKK flow diversion from the EBI to the new CSO plant. The City Consent Decree currently requires that CSO Basins 107 and 069 obtain construction completion by 2025. Close coordination of CSO Basins 107 and 069 projects with the County's HLKK project will be needed to identify the most cost-effective solution and implementation schedule.

4.4.5.4 Central Waterfront and Elliott Bay Seawall Projects

The proposed CSO Basin 069 (Central Waterfront) control measure for all LTCP options must be coordinated with the Elliott Bay Seawall (North) project. The CSO Basin 069 project location will be significantly impacted by the Elliott Bay Seawall (North) project construction which is currently scheduled for no earlier than 2018 to 2020. The specific construction schedule cannot be finalized until the City obtains funding for the Elliott Bay Seawall (North) project construction. Constructing the CSO Basin 069 project ahead of the Elliott Bay Seawall (North) project will result in significant additional construction costs for the seawall project to protect the CSO Basin 69 project in place.

4.5 Financial Plan

4.5.1 Overview

A financial analysis was performed for each of the options presented in the draft LTCP. See Chapter 5 Section 5.10 for the financial plan for the recommended LTCP option.

4.6 Operational Plan Evaluation

4.6.1 Overview

This section presents the City's operation and maintenance plan for the proposed LTCP options. The section includes proposed staffing requirements, and LTCP CSO operating strategies. Section 5.11 presents the operational plan for the recommended LTCP option, and provides a summary of the City and King County Joint Operations and System Optimization Plan.

4.6.2 Regulatory Requirements

4.6.2.1 EPA LTCP Requirements

The 1997 EPA LTCP Planning Guidance requirements for an operation plan are outlined in Section 4.6, Operational Plan Evaluation, and are summarized below:

As part of the implementation of the NMC, municipalities should be required to develop and document programs for operating and maintaining the components of their CSSs. Once an LTCP has been approved, however, the municipality's O&M program should be modified to incorporate the facilities and operating strategies associated with the LTCP controls. Typically, each facility constructed as part of the LTCP will have its own O&M manual detailing the equipment and features of the facility, including operating instructions, troubleshooting guides, and safety considerations. If the LTCP features multiple facilities, however, a master operating strategy should be developed to optimize the operation of the various LTCP components. Optimization might involve coordination of pump back timing, dynamic regulator operation, or other real-time operating strategies. Interim operating strategies might be required for phased projects and for construction-period operations and flow transitions.

Maintenance programs should consider the unique operating conditions of CSO facilities, particularly with regard to schedules for inspecting and exercising idle equipment. Aspects of the Post-Construction Monitoring Program might also be incorporated into the operational plan, as regular schedules for sampling and maintaining sampling equipment are developed.

If not addressed in the individual facility O&M manuals, the operational plan should identify staffing needs for CSO control facilities, both in terms of numbers of staff and specific positions necessary, with appropriate descriptions of responsibilities and minimum qualifications.

4.6.2.2 Ecology NPDES Permit Requirements

The City CSO NPDES permit describes project-specific requirements for operation and maintenance in NPDES Permit No. WA-003168-2, Section S4. Operations and Maintenance. The majority of these requirements will be completed during the LTCP implementation phase following the Final LTCP approval. Key NPDES operation and maintenance requirements included in the LTCP operation plan are:

- S4.A. O&M Program; 1. Institute an adequate Operation and Maintenance Program for the entire combined sewage system.
- S4.C. Electrical Power; The Permittee must ensure that adequate safeguards prevent the discharge of untreated wastes or wastes not conveyed in accordance with the requirements of this permit during electrical power failure at sewage lift stations. Adequate safeguards include, but are not limited to, alternate power sources, standby generator(s), or retention of inadequately treated wastes, bypass pumping (for example, pumping of combined sewer flows with a means other than the pump station's pumps), or other equally protective means.

4.6.3 Staffing

4.6.3.1 SPU Operation and Maintenance Staff Organization

SPU is organized into eight branches. The Operations and Maintenance functions of the Drainage and Wastewater Line of Business Branch are responsible for operating and maintaining the City's CSO facilities. The

Operations and Maintenance functions include more than 480 employees. Field crews respond to emergencies, locate and utilize appropriate resources, and carry out critical operations and maintenance programs and capital improvements to keep our infrastructure and assets working efficiently. Figure 4-2 presents the current overall SPU organization.

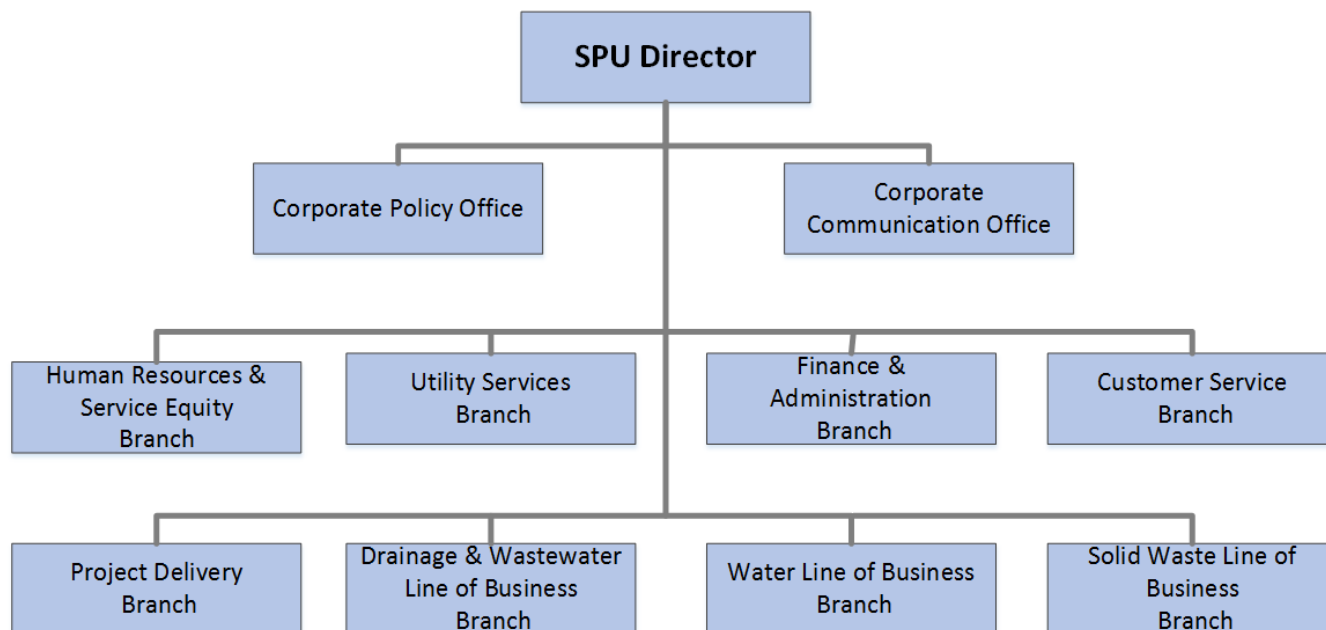


Figure 4-2. SPU Organization Chart

4.6.3.1.1 Drainage and Wastewater System Maintenance

The Drainage and Wastewater System Maintenance function includes managers, crew chiefs, and staff to maintain the drainage and wastewater assets within the City's service area. This group focuses on physical maintenance activities only and does not include any operations staff. There are separate crews for each of the following activities:

- Underground Storage Facilities
- Surface Water Management
- Line and Grade (Pipeline Maintenance)
- First Response (Responds to Customer Complaints and Emergencies)
- Closed Circuit TV (CCTV)
- Rehabilitation
- Ground Maintenance (Landscaping)

Figure 4-3 is an organization chart showing the division organization and its primary responsibility.

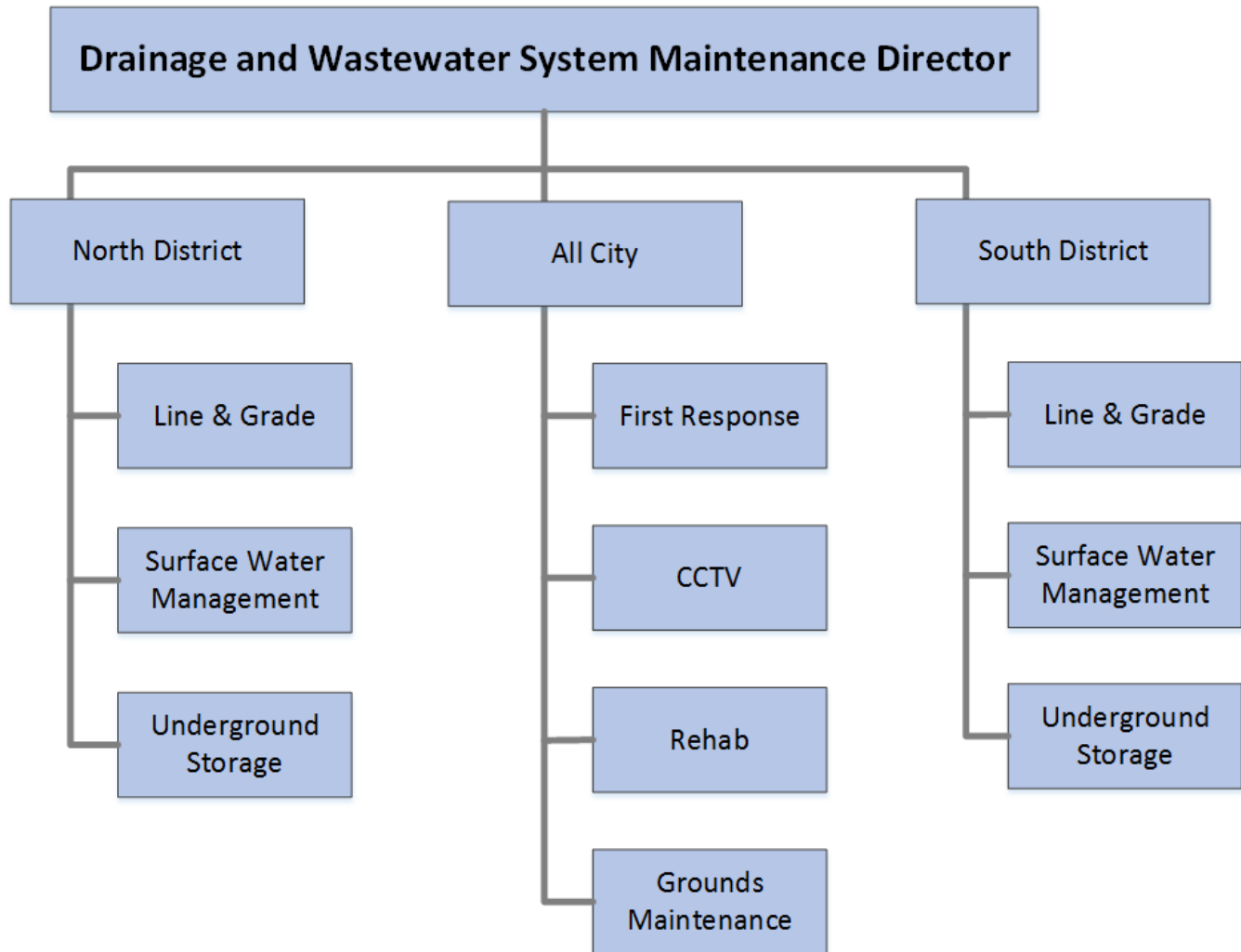


Figure 4-3. Drainage and Wastewater System Maintenance Organization Chart

4.6.3.1.2 Operations and Maintenance Function

There are four main sub-groups within the Operations and Maintenance function: Maintenance; Supervisory Control and Data Acquisition (SCADA); System Operations, Planning and Analysis (SOPA); and System Operations. The group contains a diverse set of skills including physical maintenance of electrical infrastructure, performance analysis, instrumentation and control engineering, and 24/7 control center operation. This organization allows the City to provide quality drainage and wastewater services to our customers under dry-weather and wet-weather conditions as well as unusual conditions such as flooding, SSOs or CSOs.

Figure 4-4 is an organization chart showing each sub-group and its primary responsibility.

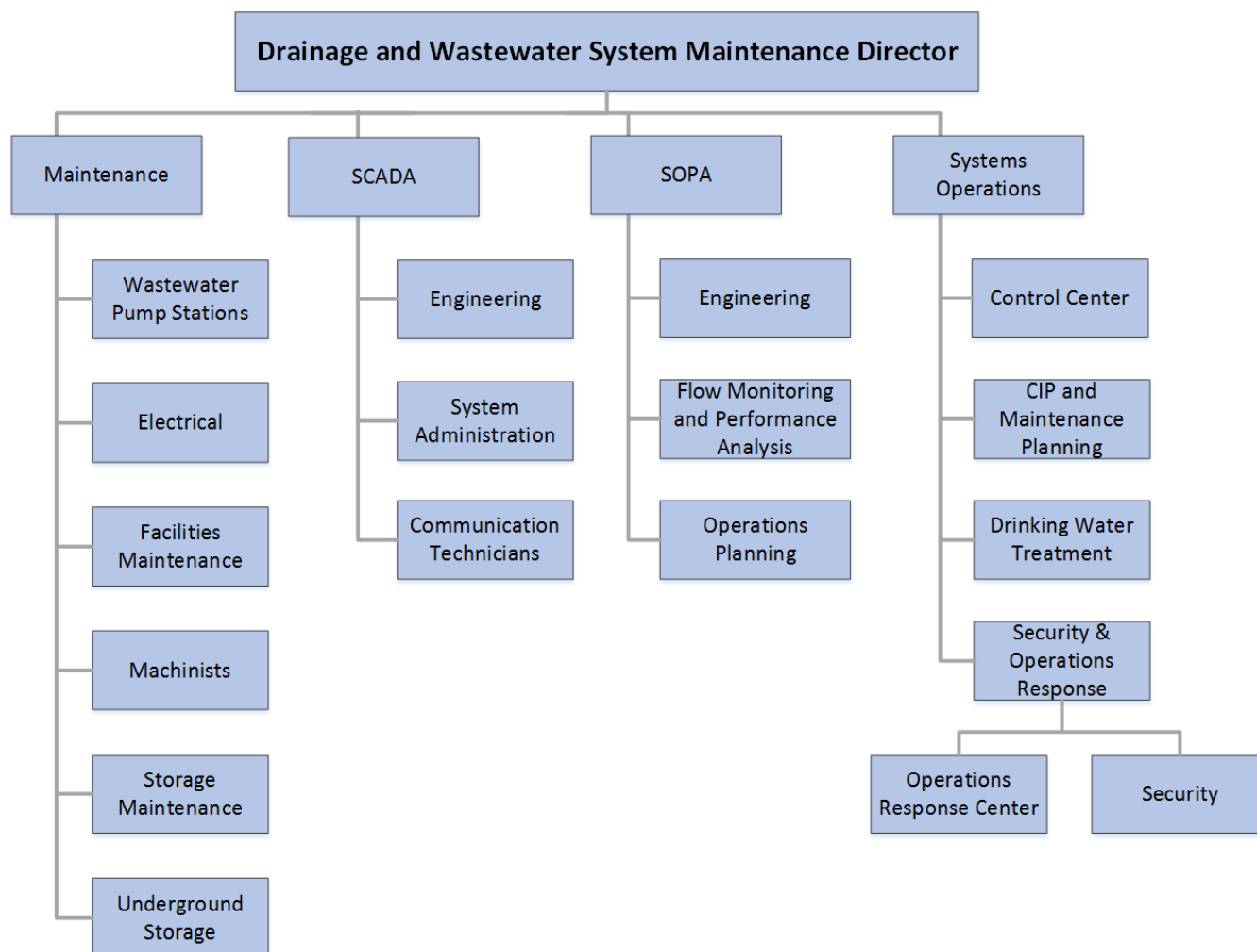


Figure 4-4. Operations and Maintenance Organization Chart

4.6.3.2 SPU Staffing Requirements

SPU has projected the additional operation and maintenance staffing requirements needed to commission, operate, and maintain the LTCP projects. Specific number of full-time-equivalent (FTE) employees and staff responsibilities for each LTCP options are summarized in Table 4-18 for current (2015), near-term (2020), construction completion (2025), and achievement of controlled status (2030).

Operation staff refers to Control Center operators (under the System Operations sub-group) and SOPA sub-group staff, who will conduct performance monitoring, modeling, post-construction monitoring reporting, facility configuration and control strategies management, and operations data stewardship. Maintenance staff refers to Maintenance sub-group staff, who will maintain pump stations, control structures, CSO storage and conveyance facilities.

Based on the LTCP Option Implementation schedules, the first additional LTCP operation and maintenance staff will be required for CSO facility commissioning and acceptance testing between 2018 and 2020. Depending on the final recommended LTCP option, the total number of additional operation and maintenance staff will be approximately 7 to 12 FTE employees after construction completion in 2025.

Table 4-18. Operations and Maintenance Staffing Needs for Proposed LTCP Options

LTCP option	LTCP staffing requirements (FTEs)			
	2015 (current)	2020 (near term)	2025 (construction completion)	2030 (controlled status)
Neighborhood Storage				
Operations	0.0	0.5	4.2	4.2
Maintenance	<u>0.0</u>	<u>0.7</u>	<u>7.4</u>	<u>7.4</u>
Total O&M staff	0.0	1.2	11.6	11.6
Neighborhood West Ship Canal Tunnel				
Operations	0.0	0.5	4.1	4.2
Maintenance	<u>0.0</u>	<u>0.7</u>	<u>7.1</u>	<u>7.1</u>
Total O&M staff	0.0	1.2	11.2	11.2
Shared Storage				
Operations	0.0	0.4	2.9	2.9
Maintenance	<u>0.0</u>	<u>0.4</u>	<u>6.1</u>	<u>6.1</u>
Total O&M staff	0.5	0.8	9.0	9.0
Shared West Ship Canal Tunnel				
Operations	0.0	0.5	4.1	4.1
Maintenance	<u>0.0</u>	<u>0.7</u>	<u>6.9</u>	<u>6.9</u>
Total O&M staff	0.0	1.2	11.0	11.0
Shared Ship Canal Tunnel				
Operations	0.0	0.2	2.0	2.0
Maintenance	<u>0.0</u>	<u>0.2</u>	<u>4.5</u>	<u>4.5</u>
Total O&M staff	0.0	0.4	6.5	6.5

See Chapter 5 Section 5.11 for additional details on the operational plan for the recommended LTCP option.

CHAPTER 5

Selection and Implementation Of Recommended LTCP CSO Control Option

5.1 LTCP Development and Implementation Timeline

On May 29, 2014, the Draft LTCP was issued for public and regulatory (EPA and Ecology) review and comment. Following the comment period and receipt of comments from the public, EPA, and Ecology, additional evaluation was performed to select a recommended option. The process for selecting the recommended option is documented in Section 5.4. Some of the smaller elements of the option have been modified from the Draft LTCP (flow transfers changed to small storage facilities), but the major elements (tanks and tunnels) have remained the same.

In early February 2015, a draft Final LTCP was submitted to EPA and Ecology for review. In March 2015, the Mayor and City Council reviewed and adopted the Final LTCP through a City ordinance process. The Final LTCP was submitted to EPA and Ecology along with an updated Post-Construction Monitoring Plan for approval on May 29, 2015. By the end of 2015, the Final LTCP is anticipated to be approved by EPA and Ecology and LTCP implementation will commence. Under the LTCP Alternative, construction completion of all LTCP CSO control projects will be achieved by December 31, 2025.

The overall LTCP development and implementation schedule is shown on Figure 5-1, along with a detailed schedule for adoption and approval of the Final LTCP.

5.2 Public and Regulatory Agency Participation Program

As part of the process for developing the Draft LTCP and selecting the recommended option, and in accordance with the Consent Decree, the City conducted a comprehensive public and regulatory agency participation program.

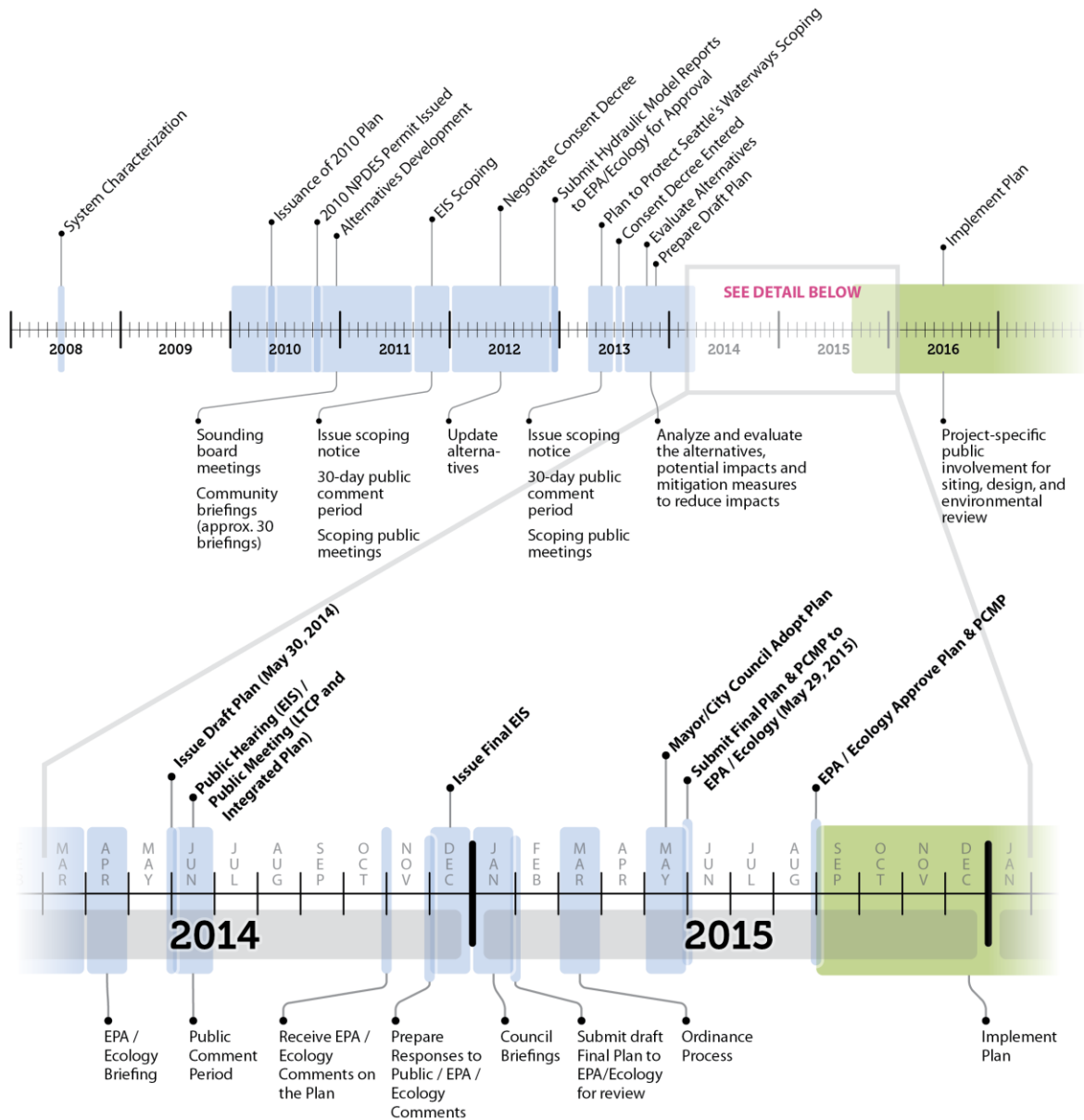


Figure 5-1. LTCP Schedule Summary of Public and Regulatory Participation Process and Approach

A summary of the overall public and regulatory agency participation program activities is presented in Table 5-1. Public and regulatory agency participation was performed jointly for the LTCP, the Integrated Plan, and the Programmatic EIS, which together comprise the City's overall Plan to Protect Seattle's Waterways.

Table 5-1. Final Public and Regulatory Agency Participation Program

Consent Decree requirements (Appendix C, Section A.1-A.5)	Public participation performed
How the City will make LTCP information available for public review.	► Prepared the Community Guide to the Integrated Plan to provide an overview of the three stormwater control projects the City proposes for the Integrated Plan Alternative. ► Placed an article about the Draft EIS release and public hearing in the summer 2014 edition of Seattle Public Utilities' Curb Waste newsletter, which is mailed to approximately 330,000 Seattle residents. Conducted briefings with 13 community organizations and environmental groups: • Ballard District Council (May 14, 2014) • Delridge Neighborhoods District Council (June 18, 2014) • Fremont Neighborhood Council (May 19, 2014) • Friends of Gasworks Park (May 13, 2014) • Groundswell NW (May 20, 2014) • Lake City Neighborhood Alliance (May 8, 2014) • Leschi Community Council (June 4, 2014) • North Seattle Industrial Association (May 27, 2014) • Northwest District Council (May 28, 2014) • Puget Soundkeeper Alliance (May 22, 2014) • South Park Neighborhood Alliance (June 10, 2014) • Sustainable West Seattle (May 5, 2014) • Thornton Creek Alliance (June 26, 2014) The following organizations declined the City's offer to provide a briefing: • Broadview Community Council • Central District Council • Duwamish River Cleanup Coalition • Georgetown Community Council • Greater Duwamish District Council • Madison Park Community Council • Meadowbrook Community Council • Montlake Community Council • North District Council • Puget Sound Partnership • Sustainable Seattle • Thornton Creek Oversight Committee

Table 5-1. Final Public and Regulatory Agency Participation Program

Consent Decree requirements (Appendix C, Section A.1-A.5)	Public participation performed
	• Wallingford Community Council. ▶ In coordination with the Ballard District Council, the City established the West Ship Canal Stakeholder Advisory Group to represent the interests of stakeholders in Ballard, Fremont, and Wallingford and provide focused input on aspects of the plan that affect these neighborhoods. The City convened two meetings of the West Ship Canal Stakeholder Advisory Group and the West Ship Canal Stakeholder Advisory Group met an additional six times. ▶ Maintained the CSO program website at www.seattle.gov/CSO. Information about the Plan to Protect Seattle's Waterways is available by clicking Long Term Control Plan.
How the City will solicit public comments on the development of the LTCP	• ▶ Issued the Draft Plan to Protect Seattle's Waterways and Draft EIS on May 29, 2014, and held a 30-day public comment period that ended on June 30, 2014. Hosted the Draft EIS public hearing and Long Term Control Plan/Integrated Plan public meeting on June 24, 2014. The City accepted comments by mail, email, and in person at the Draft EIS public hearing. The City received 13 sets of comments from the public and agencies. Held public Council Committee meetings in April and May 2015 for the Ordinance to approve the Plan to Protect Seattle's Waterways
Summary of public hearings during LTCP development to provide public with information and to solicit public comments.	▶ A summary of questions and comments received during the 30-day Draft EIS public comment period is available in the <i>Draft EIS Public Hearing and Long-Term Control Plan Public Meeting Summary Report</i> available at www.seattle.gov/CSO.
Program for consideration of comments provided by the public as the City developed the LTCP.	▶ Issued the Draft Plan to Protect Seattle's Waterways and Draft EIS on May 29, 2014, and held a 30-day public comment period that ended on June 30, 2014. Hosted the Draft EIS public hearing and Long Term Control Plan public meeting on June 24, 2014. The City accepted comments by mail, email, and in person at the Draft EIS public hearing. The City received 13 sets of comments from the public and agencies. ▶ Issued the Programmatic Final Environmental Impact Statement on December 4, 2014. • Distributed a Notice of Availability of the Programmatic Final EIS • Published a notice of Availability of the Programmatic Final EIS in <i>The Daily Journal of Commerce</i> and <i>the Seattle Times</i> • Transmitted the Notice of Availability and the Programmatic Final EIS to the Ecology's SEPA Unit • Filed the Programmatic Final EIS with the City's SEPA Public Information Center • Made copies of the Programmatic Final EIS and background materials available for public viewing at the Seattle Public Utilities office in the

Table 5-1. Final Public and Regulatory Agency Participation Program

Consent Decree requirements (Appendix C, Section A.1-A.5)	Public participation performed
	Seattle Municipal Tower, at the Seattle Central Library, and online at www.seattle.gov/CSO • Provided copies of the Programmatic Final EIS to all parties listed in the Programmatic Draft EIS distribution list and all parties that made comments on the Programmatic Draft EIS The appeal period closed without comment on December 19, 2014.
How the City ensured that EPA and Ecology were kept informed of the LTCP development.	► Communicated regularly with EPA and Ecology regarding the LTCP and the Integrated Plan, including the following: • April 23, 2014: Provided a summary presentation on the four volume Draft Plan to Protect Seattle's Waterways. -- Volume 1 Executive Summary -- Volume 2 The Long Term Control Plan -- Volume 3 The Integrated Plan -- Volume 4 Programmatic Environmental Impact Statement. Reviewed the Integrated Plan Post-Construction Monitoring Program and comments from EPA and Ecology on a preliminary draft of Volume 1 Executive Summary (which was provided in advance of the meeting). Reviewed the projected plan schedule. • November 13, 2014: Provided a summary presentation on the recommended CSO control measures and reviewed the schedule for development and submittal of a draft Final and Final Plan • February 2, 2015: Submitted draft Final Plan to EPA and Ecology for review • May 29, 2015: Submitted Final Plan and Post-Construction Monitoring Plan to EPA and Ecology for approval

5.2.1 Summary of Comments on the Draft LTCP

5.2.1.1 Public Comments

During the 30-day comment period for the Draft EIS, the City received several sets of comments:

- Six letters
- Six emails
- One comment form submitted at the Draft EIS public hearing

The following agencies and organizations submitted comment letters:

- Ballard Stormwater Consortium
- City of Seattle Parks and Recreation
- Duwamish River Cleanup Coalition

- King County Wastewater Treatment Division (King County)
- Washington State Department of Archaeology and Historic Preservation (DAHP)
- Washington State Department of Natural Resources (DNR)

A summary of questions and comments received during the 30-day Draft EIS public comment period is in the Draft EIS Public Hearing and Long Term Control Plan Public Meeting Summary Report available at www.seattle.gov/CSO.

5.2.1.2 King County Wastewater Treatment Division Comments

King County submitted comments during the 30-day Draft EIS comment period, including the following observations:

- The LTCP recognizes that all of the options have elements that may impact King County's system and that strong coordination is needed between the City and King County.
- King County will need to reach its own conclusions about the benefits of shared projects as well as implications for the regional wastewater system and to King County's LTCP and Consent Decree. Prior to implementing any shared projects with King County, joint project agreements need to be signed with the City.
- Both King County and the City need to be involved in analyzing the impacts of proposed projects on the downstream system and to agree on an approach to address impacts. Shared project agreements need to be negotiated and signed between the two agencies. Coordination is also necessary on City projects that aren't shared, such as projects that increase flows to King County facilities. The nature of those impacts will need to be analyzed and appropriate compensation to King County negotiated, where applicable. The Programmatic Draft EIS describes the City's commitment to work with King County and the importance of close coordination and shared agreements.

5.2.1.3 Regulatory Agency Comments

The City received 23 LTCP-related comments from Ecology on August 29, 2014. Responses were prepared and submitted to Ecology in February 2015.

The City received conditional approval of the May 2014 Draft LTCP from the EPA on October 31, 2014. On December 6, 2014, the City received a clarification letter that stated:

"EPA would like to clarify the letter sent to Seattle dated October 31, 2014. This letter approved the Draft Long Term Control Plan (LTCP) and provided conditional approval of the draft Integration Plan (IP). Both plans will only be considered completely approved when both EPA and Ecology have approved each as final documents. As such, approval of the final LTCP and final IP by the Agencies will require the City to address comments raised by both EPA and the Washington State Department of Ecology's in the next iteration of each."

5.2.2 Subsequent Public and Regulatory Agency Participation

On February 2, 2015, the City provided EPA and Ecology a draft Final Plan for Protecting Seattle's Waterways for review that identified the Recommended LTCP CSO Control Option and the Recommended Alternative for Protecting Seattle's Waterways. Comments were incorporated into the Final Plan. From March through May 2015, the City Council reviewed and adopted the Final LTCP through a City ordinance process. The ordinance process required open public Council hearings and meetings (April and May 2015) to discuss and approve the Ordinance.

On May 29, 2015, the Final LTCP was submitted to EPA and Ecology for Final Approval. By the end of 2015, the Final Plan is anticipated to be approved by EPA and Ecology and LTCP implementation will commence in late 2015 or early 2016.

Starting in 2016, the City will work with local neighborhoods to select specific sites at which facilities will be built. As part of each project siting process, the City will perform an appropriate, project-specific environmental review. The project-level environmental review will identify project-specific impacts and will help inform decisions regarding site and project-level details. Public meetings for siting, design, and environmental review will continue until the plan is fully implemented.

5.3 Refinement and Evaluation of CSO Control Options

This section describes the additional tasks that were performed between late May 2014 and December 2014 to refine and evaluate the CSO control options. Tasks included incorporating regulatory review comments, evaluating new hydraulic boundary conditions provided by King County for CSO storage release flow rates, performing a detailed evaluation of shared options with King County, preparing independent third-party cost estimates, issuing the Programmatic Final EIS, sponsoring an agency peer review, assessing the potential CSO reduction of proposed City retrofit and green infrastructure program projects, updating the CSO Sensitive Area Study, and reanalyzing the control status of outfalls previously thought to be controlled.

5.3.1 Evaluation of Additional King County Boundary Conditions (No Impact Release Rates)

The hydraulic models used for this analysis were based upon the calibrated Storm Water Management Model, Version 5 (SWMM5), engine update v22. These models were documented in the LTCP Hydraulic Model Reports (Refer to Chapter 2). The models were modified to incorporate the most likely CSO control measures to confirm that the measures would control discharges to an average of no more than one CSO event per year per outfall over a 20-year moving average.

All of the City's CSO basins discharge into the King County system through various facilities. To determine whether the City's CSO control measures would impact the operation of King County facilities, King County identified key locations in their system and, for each location and under varying conditions, specified the maximum flow that could be discharged from the City system without impacting operation of King County facilities. These data, called no-impact release rates (NIRR), provide durations and maximum flow rates for release of stored flow from the City CSO control facilities that would result in minimal or no impact on the operation of King County's facilities.

The City's most likely CSO control measures were also evaluated using the King County NIRR to confirm that the CSO control measures would allow the City to achieve compliance with the Consent Decree requirements. Where necessary, minor modifications were made to the City's CSO control measures to account for the King County NIRR, but the NIRR did not significantly impact any of the City's CSO control measures. The King County NIRR was available only for the period from 1978 through 2009 and thus the analysis was restricted to this period.

Section 5.8 summarizes the results of the evaluation. Appendix L includes the *January 2015 Long Term Control Plan CSO Control Measures Performance Modeling Report*, which provides additional detailed information on the CSO performance modeling.

5.3.2 Joint Evaluation of King County and City Shared Options

The City recognizes the importance of coordination with King County in controlling CSOs in Seattle. All City options have elements that may impact King County's downstream wastewater system. Three of the proposed options include shared City/King County projects along the Ship Canal. Several of the proposed options include sewer system improvements that would convey additional wastewater volume to the downstream King County system. All interagency coordination will be conducted in accordance with commitments included in the City and King County Coordination Plan, signed by both agencies on April 4, 2014. In the Coordination Plan, the City and King County agreed that specific factors will be considered in evaluating and making a recommendation on which CSO projects will be undertaken jointly or independently by either the City or King County. Section 5.4.2 discusses the evaluation factors and the process.

5.3.3 Issuance of Final Programmatic Environmental Impact Statement

The Final Programmatic EIS responded to comments received on the Draft Programmatic EIS, described changes to the alternatives that have occurred since the issuance of the Programmatic Draft EIS, and includes modification and revisions to the analysis as appropriate. Changes to the Draft Programmatic EIS in response to comments received are minor. Consistent with Washington Administrative Code 197-11-560(5) and Seattle Municipal Code 25.05.560.E, the City has prepared an updated fact sheet and an addendum to the Draft Programmatic EIS that includes the comments, responses, and changes to the document since its release. The Final Programmatic EIS was issued on December 4, 2014, and the appeal period closed without comment on December 19, 2014. The Final Programmatic EIS is Volume 4 of the Plan to Protect Seattle's Waterways.

The Final Programmatic EIS provides a comprehensive evaluation of potential impacts associated with implementation of the plan. Site-specific environmental reviews will be conducted during LTCP implementation, when additional information will be available. Environmental elements covered in the EIS include earth, groundwater, air quality, odors, surface water, biological resources, energy, climate change, and environmental health. Noise and vibration, land use, visual quality, recreation, historic and cultural resources, transportation, utilities, and socioeconomics and environmental justice were also evaluated.

Key issues associated with the alternatives and options include potential construction-related impacts, particularly traffic, noise, and other community impacts during construction periods that could range from roughly one year to as many as seven years, depending on the project size. Possible long-term impacts include a potential for odor and noise at storage facilities and potential operational implications for the region's wastewater system. Appropriate design, along with coordination with potentially affected agencies and organizations, will reduce the potential for significant impacts.

5.3.4 Assessment of Control Benefits from the Sewer System Improvement Program

The City has been conducting an ongoing program to identify, design, and construct sewer system improvement projects in CSS areas. These projects are typically small in scope and consist of modifications to existing infrastructure. Examples include raising an overflow or storage weir, removing an existing HydroBrake and replacing it with a motor-operated gate, increasing the capacity of a pump station by replacing the pumps, or modifying the hydraulics of an overflow control structure.

These sewer system improvements are an important part of the City's strategy to reduce CSOs. Each sewer system improvement project is coupled with the in-line or off-line storage projects described in Section 5.6, Development of Design Criteria for Recommended CSO Control Measures. Once the sewer system improvement is implemented, its performance will be evaluated for up to two years to determine what impact the project has had in reducing CSOs. It is expected that these projects will either eliminate the need for a storage project, or reduce the size of the storage project. Table 5-2 presents a summary of the various sewer system improvements being planned. For more details on these sewer system improvements see the Annual CSO Report.

Table 5-2 Summary of Planned Sewer System Improvements		
Sewer system improvement project	Description	Schedule
North Union Bay Basin 018	See Section 5.6.3.	See Section 5.9.3
Leschi Basins 026 through 036	Improved operation and maintenance activities, conveyance rehabilitations, weir adjustments, HydroBrake replacements, and a dry-weather flow bypass.	Package 1 completed in 2014 Package 2 to be completed by 2016
Magnolia Basin 060	Replace pumps and increase the capacity of pump station 22 from 0.9 MGD to 3.3 MGD.	To be completed by 2018
Delridge Basin 099	Details yet to be determined.	To be completed by 2017
East Waterway Basin 107	Installation of a check valve between the King County Elliott Bay Interceptor downstream of the Duwamish pump station and Basin 107, preventing backups in the interceptor from causing CSOs in Basin 107.	To be completed by 2018
Duwamish Basins 111B, 111C, and 111H	Overflow structure modifications and weir raises.	Basins 111B and 111C completed in 2014. Basin 111H was analysed, but no sewer system improvement project was identified
Montlake Basins 020, 139, and 140	Improvements for these basins have not yet been selected, but will likely include pump station upgrades.	To be completed by 2018
Portage Bay Basin 138	Details yet to be determined.	Completed by 2018
Delridge Basins 168 and 169	Upgrade existing 1.6 MG storage facilities and associated conveyance infrastructure. Updates include new diversion structures, HydroBrake removal, motor-operated gate installation, and modifications to the hydraulic control chambers.	Construction completion by November 1, 2015 (NPDES wastewater permit requirement)

5.3.5 Assessment of Control Benefits from Green Infrastructure Program

The term green infrastructure describes systems and practices that use or mimic natural processes to infiltrate, evapotranspire, or harvest stormwater on or near the site where it is generated. The City's use of GI may include,

but is not limited to, rain gardens, permeable pavement, bioretention facilities, rainwater harvesting, vegetated roofs, detention cisterns, and the retaining and planting of trees. These GI solutions control the sources of pollution by slowing, detaining, or retaining stormwater so that it does not carry runoff into nearby waterways. This reduces the volume and timing of flows into the system. GI facilities are also referred to as natural drainage systems (NDS) and they are a type of low impact development. Examples of GI currently being implemented by the City include:

- Stormwater code – the City requires GI as part of new and replaced development.
- RainWise – City program that provides property owners with rebates for mitigating the impacts of impervious roof surfaces on private property by installing properly sized and constructed GI facilities.
- Roadside rain gardens – Deep-rooted native plants and grasses planted in a shallow depression in the public right-of-way, such as the planting strip adjacent to homes.

The City's goal is to use green solutions to the maximum extent feasible to reduce CSOs. The RainWise program is offered in all of the uncontrolled CSO basins as part of the approach to manage the precipitation uncertainty associated with climate change. The roadside rain garden program focuses on basins with suitable soils where large areas of impervious roadway are connected to the combined sewer, and thus large scale implementation of GI can substantially reduce CSO control volumes as well as help alleviate localized sewer capacity issues. The primary CSO areas where roadside rain gardens can be used to offset CSO control volumes are Ballard, Delridge, Montlake, and North Union Bay.

Toward that goal, several GI projects were identified for early implementation: RainWise, Ballard NDS 2015, and Delridge NDS 2015. The City's 2010-2015 NPDES Waste Discharge Permit includes requirements to begin construction of roadside rain garden projects in the Ballard and Delridge CSO areas by October 31, 2015. Plans for additional future GI projects in the roadside right-of-way and the associated potential for downsizing of storage facilities within any of these basins will be documented in the engineering reports of individual CSO control projects, as discussed in Section 3.6.5.

5.3.5.1 Rainwise Program

Since 2010, RainWise has offered rebates to residents living in prioritized combined sewer areas of Seattle. As of 2014, RainWise rebates are offered in all of the City's uncontrolled CSO basins. Eligible property owners are alerted through mailings, public meetings, and media events. By logging onto the RainWise website at www.rainwise.seattle.gov, property owners can learn about green stormwater technologies and are presented with solutions appropriate to their property. Through this site, they are also able to contact trained contractors. Since program inception, over 500 contractors, landscape designers, and similar professionals have been trained in the program.

Upon completion, installations are inspected by a RainWise inspector and homeowners apply for rebates. RainWise rebates for rain gardens are currently \$3.50 per square foot of roof area controlled. The average RainWise installation controls runoff from 1,270 square feet of roof area.

The RainWise program has rebated 584 installations, controlling an impervious roof area of 17 acres.

In spring 2013, a memorandum of agreement with King County made RainWise rebates available to CSO basins within the City of Seattle under King County's jurisdiction. To date King County has rebated 185 installations.

5.3.5.2 Ballard Roadside Raingardens

The City has installed one roadside rain garden project, Ballard Roadside Raingardens Phase 1, and is currently in the design phase for a second project, Ballard Natural Drainage System 2015 (Ballard NDS 2015). The potential for future projects will be evaluated during preliminary engineering of the CSO storage project for the basin.

Ballard Roadside Raingardens Phase 1 built numerous rain gardens in the planting strip area of street rights-of-way and also reduced the amount of impervious surface in the project area by narrowing roadways and replacing that pavement with vegetation. Some of the Phase 1 rain gardens did not drain as quickly as designed because they were built over till soils with infiltration rates lower than the rate generally considered feasible for infiltration as a sole removal strategy. During the construction phase, the City retrofitted the slower-draining rain gardens by installing an underdrain with an orifice to allow any water that couldn't infiltrate fast enough a pathway out of the cell and back to the combined sewer system.

The City completed post project flow monitoring for Ballard Roadside Raingardens Phase 1. The monitoring work had two components: controlled flow tests and continuous flow monitoring. The controlled flow tests, which occurred in September of 2012 and again in the spring of 2013, involved hooking up to a fire hydrant, sending a simulated storm down the streets, and monitoring how well the bioretention facilities perform. The flow going into the rain gardens is known and the amount that leaves them is captured by flow monitors located in the pipe system immediately downstream.

These flow monitors continued to collect data until the middle of 2013. The results of the flow monitoring showed that the infiltrating rain gardens along 30th Ave NW are working as designed and are able to provide the desired reduction in combined sewage volume. The rain gardens along 28th Ave NW, which were retrofitted with an underdrain, demonstrated that they still could provide significant flow reduction. The monitoring showed that they reduced peak flow rates of CSO-size events by 80 to 90 percent, delayed discharge to the combined sewer by 50 to 60 percent, and infiltrated 40 to 50 percent of the annual flow volume to the rain garden.

The second roadside rain garden project in Ballard, Ballard NDS 2015, was initiated in August of 2012, and construction is planned to begin in fall of 2015. Ballard NDS 2015, building on the experience from the first Ballard NDS project, will provide roadside rain gardens on up to 20 blocks. The design includes bioretention within the planting strip and in curb extensions (see Figure 5-2 below). Ballard NDS 2015 is estimated to reduce the total



amount of stormwater reaching the City's combined sewer system by 6.5 MG each year and reduce the downstream storage control volume by 150,000 gallons. The project is also improving aesthetics, safety, and walking and biking mobility by overlapping with Seattle Department of Transportation's (SDOT's) proposed Neighborhood Greenway routes and community goals for improving the neighborhood.

Figure 5-2 Proposed Curb Extension Swale Configuration

5.3.5.3 Delridge Roadside Raingardens

The City began developing and analyzing alternatives for the Delridge NDS 2015 project in August 2012. This project will use roadside rain gardens in the public right-of-way to protect the water quality of Longfellow Creek by reducing CSO volumes discharging to the creek. The City has coordinated with SDOT to integrate locations for roadside rain gardens with neighborhood greenways within the Longfellow Creek basin. Neighborhood greenways are residential streets generally one street over from main arterials. These streets have low volumes of auto traffic and low speeds where people who walk and ride bicycles are given priority.

The City and SDOT conducted joint community engagement to identify the most technically and socially feasible neighborhood greenway east of Delridge Way. The City conducted a survey, worked with a community-based organization and community ambassadors to canvass residents, held three community meetings to identify the best locations for the roadside rain gardens on the neighborhood greenway, and assessed the most promising sites for their geotechnical feasibility.

The Delridge NDS 2015 project is anticipated to provide roadside rain gardens on up to 15 blocks, reduce the total amount of stormwater reaching the City's combined sewer system by 4.4 MG each year, and reduce downstream storage control volume needs by approximately 200,000 gallons. Delridge NDS 2015 performance modeling will be integrated into the Delridge sewer system improvement modeling optimization efforts planned for 2015. The project is currently in design and construction is expected to begin in fall 2015. Additional benefits of the project include improved pedestrian and bicycle safety along the greenway route, improved ADA access, traffic calming, improved vehicular sightlines, and increased tree canopy cover.

5.3.6 Update of CSO Sensitive Area Study

Section 2.5 described an initial prioritization of the assumed uncontrolled CSO basins following the guidelines for screening and ranking in the EPA policy documents. CSO basins included in the initial study were ranked on seven criteria using site-specific information available in December 2012. Each CSO basin received a score for each of the seven criteria. These scores were totalled and the resulting total scores were used to rank the CSO basins.

Subsequent to the April 2013 study, the hydraulic models for the CSO areas and the 20-year moving average overflow frequencies were determined. The 20-year moving average calculations indicated that eight of the CSO basins that were initially considered uncontrolled are now controlled as reported in the 2013 Annual CSO Report. A revised Sensitive Area Study was performed for the remaining uncontrolled CSO basins using the same seven criteria and 2013 Annual CSO Report statistics for the 20-year moving average annual overflow frequency and CSO volumes.

The CSO basins were scored based on the seven criteria and their results were ranked as shown in Figure 5-3. The basins were divided into two categories:

- **LTCP Priority Basins (higher priority):** These basins are included in the LTCP and are not eligible for deferral as part of the Integrated Plan Alternative. Seven CSO basins from Ballard, Fremont/Wallingford, Delridge, and North Union Bay CSO areas are included in this category.

- Potential Integrated Plan Basins (lower priority): These basins are included in the LTCP and are eligible for deferral as part of the Integrated Plan Alternative. Fourteen CSO basins from the East Waterway, Duwamish, Leschi, Montlake, Portage Bay, Central Waterfront, and Magnolia CSO areas are included in this category.

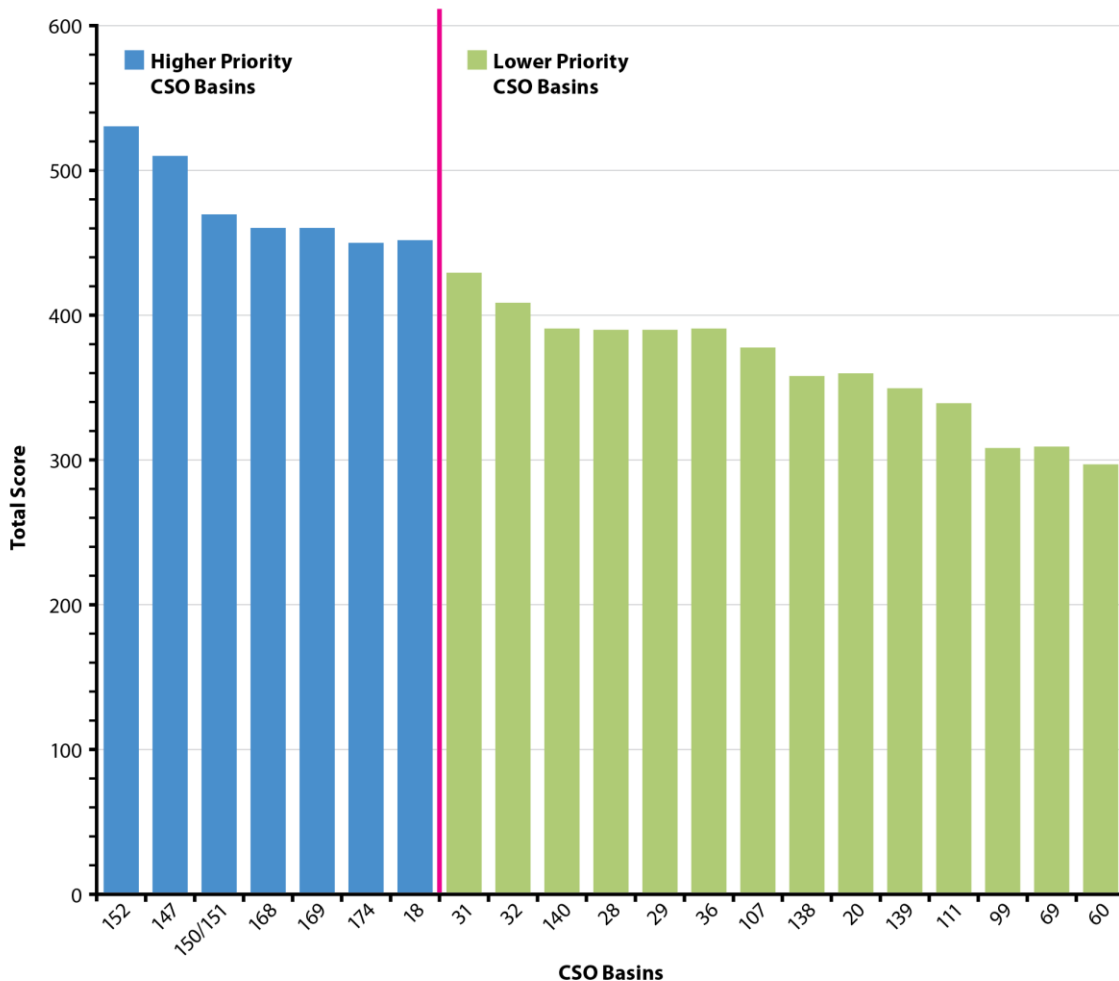


Figure 5-3 Updated Ranking of CSO Basins Based on Sensitive Area Study

5.3.7 Outfall Abandonment

On September 9, 2014, the City formally abandoned Leschi Outfall 026. This reduced the total of managed outfalls to 86.

5.3.8 Reanalysis of Control Status of Outfalls Previously Thought to be Controlled

As required by its NPDES permit, the City monitors all of its 86 CSO outfalls and prepares an annual report describing their performance relative to the once per year discharge standard. It is possible that CSO basins that are currently controlled may in the future become uncontrolled due to changing weather patterns, modifications

elsewhere in the system, or other causes. In these cases the City will determine the cause of the exceedance and will develop and implement a supplemental CSO control measure to bring the basin into control. The CSO control measure will depend on the basin and the cause of the exceedance. Supplemental measures may include sewer system improvements, GI, operational changes, or other CSO control measures.

As part of completing the LTCP, the City reanalysed flow monitoring and modeling data for each of the outfalls identified as controlled in the May 2014 Draft LTCP. The reanalysis indicated that Leschi (Basin 034) did not meet the controlled performance standard. Leschi (Basin 034) is hydraulically linked with the other Leschi basins and will be controlled by the North Leschi control measure described in the LTCP. No further action is required.

5.4 Development of Short List and Selection of Recommended Option

5.4.1 Short List of Final Options

Section 4.1.1 described a Multiple Objective Decision Analysis (MODA) process for rating and ranking the Draft LTCP options in accordance with the requirements from the EPA *Combined Sewer Overflows Guidance for Long-Term Control Plan*. The net present values of the costs for the options are Class 4 estimates with an accuracy of minus 20 percent to plus 30 percent, so it is difficult to differentiate among the options based on cost alone. The MODA process considered non-monetary factors as well. The Neighborhood West Ship Canal Tunnel was the highest ranked LTCP alternative option based on the MODA process.

After the May 2014 Draft LTCP was issued for public and regulatory comment, the City and King County commenced detailed evaluation of the three shared options (Shared Storage, Shared West Ship Canal Tunnel, and Shared Ship Canal Tunnel) and the City performed additional evaluation of the Neighborhood Storage (Tanks and Tunnel) options. King County provided hydraulic boundary conditions for the City to determine the allowable CSO storage release rates into the King County sewer system. Additional conceptual engineering was performed, that resulted in the elimination of two shared options and modifications to the third shared option.

The coordination between the sewer system improvement program and the LTCP options was also clarified following the May 2014 Draft LTCP. Several of the storage projects included in the LTCP options were coupled with planned sewer system improvements, as described in Section 5.3.4. Once the sewer system improvements are implemented their performance will be evaluated for up to two years to determine what impact the sewer system improvements have had in reducing CSOs. It is expected that the sewer system improvements will either eliminate the need for storage projects, or reduce the size of the storage projects.

A summary of the additional evaluation process is presented below.

5.4.1.1 Neighborhood Storage Tank Option

This option was retained as a Final LTCP option. There were no changes to the description provided in Section 3.6.1 for the Neighborhood Storage Tank Option.

5.4.1.2 Neighborhood West Ship Canal Tunnel

This option was eliminated for final evaluation because King County indicated an interest in evaluating and potentially pursuing the Shared West Ship Canal Tunnel option. A neighborhood tunnel would present the same challenges and community impacts as a shared tunnel, but the community would face additional construction

impacts if the agencies pursued separate projects. There would also be increased operational impacts from having three facilities instead of one. Although cost was not a significant determining factor in selection, this option was the most expensive.

5.4.1.3 Shared Storage

This option was eliminated for final evaluation because it will not meet the Consent Decree completion deadlines of December 31, 2025 for the North Union Bay CSO Basin 018 (King County University Regulator storage) and Montlake CSO Basins 020, 139, and 140 (King County Montlake Regulator). The King County University and Montlake Regulator CSO control measures would not be completed until December 31, 2028.

In addition, the City identified a sewer system improvement project for North Union Bay CSO Basin 018 that utilizes existing storage more effectively and eliminates the need to build additional storage for the basin. The sewer system improvement project has less impact on the community than building a new storage facility. In the Montlake area, joining in a shared project would require construction of extensive conveyance system improvements throughout the basin with their associated community impacts.

The third shared storage CSO control measure was the Fremont/Wallingford and King County 3rd Ave. West project. This project was eliminated for final evaluation because a Shared West Ship Canal Tunnel option as described below presented significantly fewer community impacts for both construction and operation than did building multiple storage tanks.

5.4.1.4 Shared West Ship Canal Tunnel

This option was retained as a Final LTCP option. The City evaluated a Shared West Ship Canal Tunnel including both King County 3rd Ave W and 11th Ave. NW CSO flows. The addition of storage for 11th Ave NW flows and King County's desire to collaborate on a shared project resulted in a significant increase in this option's ranking. Although this option may not be completed until 2025, King County's Consent Decree provides the opportunity to request a modification to the 3rd Ave. W construction completion date (December 31, 2023) to coordinate with the City on a shared project. The joint project analysis resulted in adding conveyance to divert 11th Ave. NW CSO flows into the tunnel and to divert 3rd Ave W flows into the tunnel from the south side of the Ship Canal instead of the north side. The impact of these changes will result in a reduction of the number of constructed facilities and associated community impacts.

Flow diversion for the East Waterway CSO control measure was revised to a neighborhood storage CSO control measure because the King County Hanford, Lander, Kingdome, King St. CSO plant will not be completed until December 31, 2030. Without an operating HLKK CSO plant, the City will not meet its Consent Decree construction completion date of December 31, 2025. Constructing a neighborhood storage CSO control measure will allow the City to meet that date.

Flow diversion for the Magnolia CSO control measure was revised to a neighborhood storage pipe because of hydraulic capacity limitations of the existing King County North Interceptor at the Magnolia CSO discharge location. Constructing a neighborhood storage CSO control measure will allow the City to discharge its CSO flows to the King County interceptor without impacting the King County interceptor hydraulic capacity.

There were no other changes to the option descriptions provided in Section 3.6.2.

5.4.1.5 Shared Ship Canal Tunnel

This option was eliminated from consideration because a third-party review documented in the L, 2014 Cost Review Report LTCP Tunnel Construction Cost Estimate Validation and Schedule Review, Frank Coluccio Construction Co.) of the Shared Ship Canal Tunnel schedule indicated that the tunnel would require six to eight years for construction and it would not meet the City Consent Decree construction completion date of December 31, 2025. In addition, King County, in their 2012 CSO Plan, rated the Shared Ship Canal Tunnel as the lowest ranked option.

5.4.1.6 Final Options for Evaluation

Two options were retained for final evaluation: Neighborhood Storage Tank and Shared West Ship Canal Tunnel. Table 5-3 summarizes the CSO areas and the specific CSO control measures for each option.

Table 5-3. Final Option Descriptions and CSO Control Measures		
CSO area	Options	
	Neighborhood Storage Tank	Shared West Ship Canal Tunnel
Ballard	Off-line storage tank	Shared deep tunnel with Fremont/ Wallingford and King County 3 rd Ave. W and 11 th Ave. NW
Magnolia	Off-line storage pipe	Off-line storage pipe
North Union Bay	Collection system improvement	Collection system improvement
Central Waterfront	Off-line storage pipe	Off-line storage pipe
Fremont/ Wallingford	Off-line storage tank	Shared deep tunnel with Ballard and King County 3 rd Ave. W and 11 th Ave. NW
Duwamish	2 off-line storage pipes	2 off-line storage pipes
Delridge	3 off-line storage pipes	3 off-line storage pipes
Montlake	3 off-line storage pipes	3 off-line storage pipes
Leschi	3 off-line storage pipes plus 1 off-line storage tank	3 off-line storage pipes plus 1 off-line storage tank
East Waterway	Off-line storage tank	Off-line storage tank
Portage Bay	Off-line storage pipe	Off-line storage pipe

Figures 5-4 and 5-5 show the CSO control measures and control volumes for the two final options.

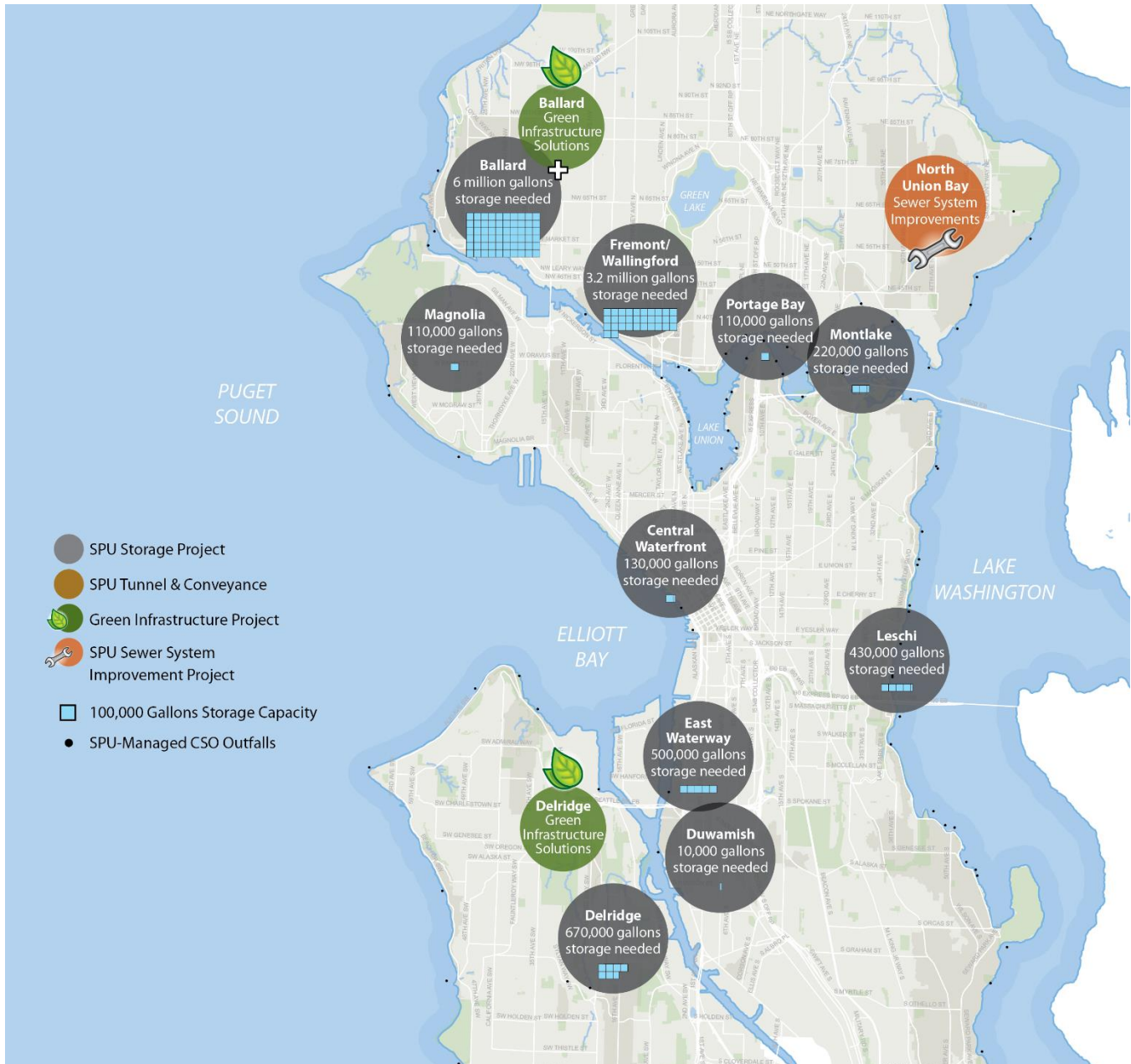


Figure 5-4 Neighborhood Storage Tank Option



Figure 5-5 Shared West Ship Canal Tunnel Option

5.4.2 Evaluation of Final Two Options

As described in Section 5.3.2, the Coordination Plan between the City and King County identifies factors to be considered in evaluating and recommending which CSO projects will be undertaken jointly or independently by either the City or King County. These evaluation factors are applied to the two final options as described in the subsections below.

5.4.2.1 Financing

In accordance with the agreed-on principles, financial benefits are to be shared by both agencies. Benefits will be realized through economies of scale and other efficiencies from replacing a larger number of independently designed and constructed storage projects with a smaller number of jointly developed storage projects. Financial risks and rewards are to be apportioned for each joint project.

The final two options were compared using an NPV calculation based on a discount rate of 3 percent and a 100-year life cycle that includes salvage value. In addition to initial capital costs and ongoing operating costs, the NPV calculation incorporated future replacements for metering equipment (5-year cycle), electrical and instrumentation components (10-year cycle), mechanical and odor control equipment (25-year cycle), and major structure upgrade (50-year cycle). Replacement values were extracted from construction cost estimates.

A preliminary breakdown of how cost will be shared between the City and King County was developed based on a cost allocation methodology developed by the City and King County, as described in Section 5.7.4. This cost share may change and will be finalized during the development of the Shared West Ship Canal Tunnel project.

The NPV costs are based in August 2014 dollars and include the present-value cost of construction and operations, maintenance, and long-term replacement. The costs include factors such as land costs, contaminated soil mitigation, the potential for loans and grants, private and public park mitigation, and potential negotiated costs (or savings) with King County. It should be noted that the costs shown are planning-level, conceptual costs (Class 4) that are expected to be accurate within minus 20 percent to plus 30 percent. Actual costs will vary depending on many factors. Table 5-4 and Figure 5-6 show the net present values and accuracy range for the two final options.

Table 5-4 Final Option Net Present Values

Option	Total Project NPV, \$M	City NPV cost share, \$M	City share lower NPV cost range \$M (-20%)	City share upper NPV cost range \$M (+30%)
Neighborhood storage tanks	\$401	\$401	\$321	\$521
Shared West Ship Canal Tunnel	\$491	\$386 ^a	\$309	\$502

Notes:

NPV = Net Present Value

^a As a shared project, King County would also contribute funding for the Shared West Ship Canal Tunnel. The cost shown in this table is limited to the City's share of the NPV. See Section 5.7.4 for details on the cost share methodology.

Although cost is of great importance, the level of accuracy of Class 4 estimates makes it difficult to distinguish between the two final options on the basis of cost.

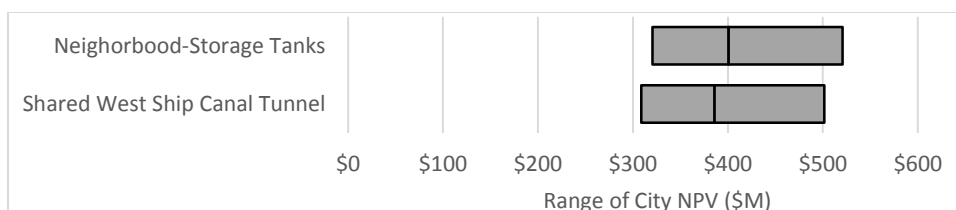


Figure 5-6 Comparison of Cost Range for Final LTCP Options

5.4.2.2 Scheduling

Both the City and King County are subject to consent decrees that set a schedule for completing CSO control projects identified in each agency's LTCP. King County must complete their CSO control projects by 2030; the City by 2025. Additionally, King County's LTCP includes a project sequence that establishes the order in which projects are to be completed. The effect of implementing joint projects on the City's or King County's ability to meet their respective completion schedules and King County's approved project sequence must be considered. Both utilities must agree that a joint project can be managed within their respective schedules before they proceed with it.

Table 5-5 presents the relevant consent decree milestones for the City LTCP CSO basins and the King County 3rd Ave. W and 11th Ave. NW CSO basins. (See Table 5-34 for proposed milestone dates for all projects. When approved, these dates will become the City's milestone dates.)

Table 5-5 Relevant Consent Decree Milestones for the City and King County CSO Basins

Agency	CSO basin	Relevant Consent Decree milestone		
		Facilities plan submittal	Completion of bidding	Construction completion
City	All LTCP CSO basins	TBD	TBD	December 31, 2025
King County	3 rd Ave. W	December 31, 2018	December 31, 2020	December 31, 2023
	11 th Ave. NW	December 31, 2026	December 31, 2028	December 31, 2030

Both agencies' consent decrees further stipulate that uncontrolled CSO basins must achieve controlled status within one year of the construction completion milestone.

As indicated in Table 5-5, the King County 3rd Ave. W CSO basin has the earliest consent decree milestones of the CSO basins being considered. An assessment was conducted to determine whether the Shared West Ship Canal Tunnel option could meet the Consent Decree milestones for the King County 3rd Ave. W CSO basin. To develop a prudent engineering and construction schedule, the agencies are working together to clarify schedule and project delivery risks to further assess the degree of variance in this schedule. As described in King County's Consent Decree (paragraph 23):

WTD may request a modification of the critical milestones set forth in Appendix B for the sole purpose of revising the priority and sequencing of its CSO control measures if WTD demonstrates that the requested modification (1) reflects good engineering practice, (2) is required to coordinate or align with the City of Seattle's stormwater or CSO infrastructure projects, (3) is necessary to attain cost effective and technically sound CSO control measures and (4) will not change, modify, or extend in any way WTD's final Construction Completion of December 31, 2030.

Since the Shared West Ship Canal Tunnel option deviates from King County's recommended control measures for 3rd Ave W and 11th Ave NW, it may be necessary for King County to request modification to its Consent Decree.

The City will work with King County, EPA, and Ecology to support the modification of King County's Consent Decree.

Although King County's 3rd Ave W facility will be delayed, it should be recognized that the 11th Ave. NW CSO outfall would achieve control status approximately five years earlier than required in King County's Consent Decree if the Shared West Ship Canal Tunnel option is approved.

The Neighborhood Storage Tank Option would allow both agencies to meet all of their consent decree milestones.

5.4.2.3 Community Impacts

Construction of CSO control projects can have temporary adverse impacts on host communities. Once constructed, CSO control facilities can have ongoing community impacts associated with their operation and maintenance. Development of shared CSO control projects presents the opportunity for the City and King County to reduce the total number of CSO control facilities, which can reduce the number of communities impacted by their construction, operation, and maintenance. Conversely, larger shared CSO control facilities could result in larger-scale impacts to host communities. A recommendation regarding whether or not to develop shared CSO control projects in lieu of independent projects needs to consider the number of affected communities and the scale of larger shared CSO control facilities on host communities.

The City evaluated a wide range of community impacts during the course of developing the LTCP and recognized four key factors that make a difference between the Neighborhood Storage Tank Option and the Shared West Ship Canal Option. A summary of the comparison between each option is presented in Table 5-6. As is noted in Table 5-3, the only difference between the Neighborhood Storage Tank Option and the Shared West Ship Canal Option is related to the projects that are to be constructed in the Ballard and Fremont/Wallingford CSO areas. As such, the community impacts described below focus on the impacts to those neighborhoods.

Table 5-6 Comparison of Community Impacts

Community impact	Neighborhood Storage Tank Option	Shared West Ship Canal Tunnel Option
Traffic and air pollution	This option has the most project locations, with dispersed short-term, construction-related air and odor impacts in numerous neighborhoods throughout the city. Impacts are likely to be most noticeable in residential areas. Storage tank construction in the largely residential Ballard and Fremont/Wallingford neighborhoods could last up to five years (Ballard) and three and one-half years (Fremont/ Wallingford). Transportation impacts would be highly visible and would be of concern to local residents, business owners, and commuters in affected neighborhoods. This option would have the most dispersed transportation impacts because it would require roadway lane and sidewalk closures at a number of locations throughout the city.	Construction-related air quality impacts would occur at fewer sites than under the Neighborhood Storage Tank Option but the impacts would be more concentrated at those sites. Construction of the tunnel would require a substantially higher number of truck trips and associated emissions than smaller, independently constructed CSO control facilities in Ballard and Fremont/Wallingford, resulting in more concentrated and longer duration impacts at the tunnel portal sites in these neighborhoods. Overall, this option would result in substantially more truck trips over a longer period in Ballard compared to the Neighborhood Storage Tank Option. The expected construction duration is three and one-half years. However, this option would eliminate construction truck trips associated with a separate King County 3rd Ave. W CSO

Table 5-6 Comparison of Community Impacts

Community impact	Neighborhood Storage Tank Option	Shared West Ship Canal Tunnel Option
		control project and a separate, independent King County 11 th Ave. NW CSO control project between Ballard and Fremont/Wallingford areas. These truck trips and traffic disruptions would be less than what would likely be experienced with independent CSO control projects. Thus, overall impacts would be reduced with this option.
Land use and visual quality	Due to the larger number of distributed CSO storage facilities, this option has the greater number of areas that would experience temporary land use impacts. Construction could intermittently disrupt access to residences, businesses, and institutions. Temporary easements would be needed from some private landowners, depending on the project. Acquisition-related impacts would potentially be greater under this option because it would require the greater number of project locations.	This option would concentrate construction-related land use impacts at fewer but larger project sites in Ballard and Fremont /Wallingford. The tunnel is estimated to require three and one-half years to construct and up to four acres for construction staging. Much of this area could be sold back to private ownership following construction. In addition to land use and visual quality impacts from tunnel portal activity, dispersed impacts and disrupted access from construction of drop shafts and microtunnels and from open-cut construction in roadways throughout the Ship Canal neighborhoods would occur. In addition, the new flow diversion (conveyance line) would introduce minor and temporary land use and visual quality impacts to the 3rd Ave. W area on the south side of the Ship Canal.
Noise and vibration	Construction of projects would result in short-term moderate to substantial increases in noise. This option would have more dispersed noise and vibration impacts throughout the Plan area. Construction would occur in every CSO neighborhood, but would last longest in Ballard, Fremont/Wallingford, and East Waterway, where construction durations would range from one to five years.	Potential construction-related impacts would largely be concentrated at the tunnel portals in the Ballard and Fremont/Wallingford neighborhoods. After initial tunnel portal site construction, most work would occur underground, which would not produce noticeable street-level noise or vibration other than from trucks hauling tunnel spoils on roadways. Potential for vibration impacts along the tunnel routes is likely to be a concern to property owners. Potential impacts in other neighborhoods, including those associated with construction of the new flow diversion (conveyance line) near the 3rd Ave. W CSO area on the south side of the Ship Canal, would be similar to those described for the Neighborhood Storage Tank Option.

5.4.2.4 Regulatory Considerations

All CSO control projects must meet the control standard of no more than one CSO event per outfall per year. As described in the City and King County Coordination Plan, recommendations about whether or not to develop a shared City and King County CSO control project should consider which type of project is most likely to meet compliance standards. The ability to adapt to changing regulations or other external factors like climate change should also play a part in the decision-making.

When considering the overflow frequency requirement, the planning team evaluated the flexibility of the tunnel to control the variability of volumes that will occur in the seven CSO basins from year to year versus the static control volume associated with discrete tanks for each CSO basin under the Neighborhood Storage Tank Option.

An analysis of the 20-year historical record ending with 2014 indicated that both the tunnel and the Neighborhood Storage Tank Option would meet the CSO control standard. However, since weather patterns vary across the City and the Shared West Ship Canal Tunnel is almost three miles long, the tunnel outfalls would not always overflow at the same time. As a result, the tunnel has flexible storage volume that can be used to reduce overflows compared to individual storage tanks.

5.4.2.5 Lead Agency Designation and Responsibilities

Efficient implementation of a shared CSO project may require that either King County or the City is designated as project lead, responsible for leading project design, construction, ownership, and operation. Alternatively, a shared project management structure can be developed for managing the project. The decision to designate a lead agency or create a joint project management structure will be reached collaboratively on a project-by-project basis. In either case, responsibilities of the lead agency or joint management team will be spelled out when the decision is made.

The final recommendation on a joint project will be documented in a joint project agreement. The agencies will need to agree on a schedule that meets each agency's compliance schedules and project goals.

The City would be the lead agency for the Shared West Ship Canal Tunnel. A draft Term Sheet spelling out the terms of an agreement to be executed between King County and the City has been developed. A joint project agreement is being prepared to define all roles and responsibilities for the construction and operation of the Shared West Ship Canal Tunnel.

5.4.3 Recommended LTCP Option

Based on the evaluations described in Section 5.4.2, the environmental impact statement prepared for the LTCP, and cooperative agreements with King County, the City selected the Shared West Ship Canal Tunnel option as the recommended option.

The Shared West Ship Canal Tunnel option is recommended because, on balance, it is a more flexible means of controlling CSOs in the area of the West Ship Canal and should result in the least long-term impacts to the neighborhoods where the tunnel would be located. Cost difference is not a determining factor in the recommendation because the options considered are within the same cost range. The determining factors in support of the recommendation are as follows:

- The Shared West Ship Canal Tunnel option allows the City and King County to work together to build a single facility to serve multiple common needs. Opportunities to achieve economies of scale and operational flexibility are greater with the shared tunnel than with separate neighborhood storage tanks.
- The West Ship Canal Tunnel option is consistent with terms contained in each jurisdiction's consent decree requiring coordination of the planning, implementation, and operation of CSO control within the Seattle area.
- The Shared West Ship Canal Tunnel option will likely have greater impacts to neighborhoods during construction than the Neighborhood Storage Tank Option. However, once constructed, the Shared West Ship Canal Tunnel will largely be underground. The impact to neighborhoods resulting from hosting permanent facilities is less than the Neighborhood Storage Tank Option.

A summary of the comparison between the two options is presented in Table 5-7, below.

Table 5-7 Comparison of Final Options

Evaluation factors		Option	
Factor	Items to be considered	Neighborhood Storage Tank Option	Shared West Ship Canal Tunnel Option
Financing	Financial benefits are to be realized and shared by both agencies through economies of scale and other efficiencies from replacing a larger number of independently designed and constructed storage projects with a smaller number of jointly developed storage projects.	The construction and long-term operating costs of the two alternatives for the City ratepayers are very similar. The total project cost and NPV of the two alternatives, given the accuracy of project development phase cost estimates, does not indicate a significant cost difference between the two options.	
Scheduling	The effect of implementing joint projects on either the City's or King County's ability to meet their respective consent decree milestone dates and King County's approved LTCP project implementation sequence will be considered. Both utilities must agree that a shared project can be managed within their respective schedules before recommending shared project implementation.	More complicated permitting/regulatory compliance requirements from dispersed large tank construction and operation.	The City's and King County's consent decrees contain identical language requesting the agencies to work together for a regional solution. The tunnel option requires a partnership for a joint project with King County that independent tanks do not require. The Consent Decree milestone for completion of construction for King County's 3rd Ave W facility will have to be changed from December 31, 2023, to December 31, 2025. The agencies are working together to confirm the schedule for construction completion.

Table 5-7 Comparison of Final Options

Evaluation factors		Option	
Factor	Items to be considered	Neighborhood Storage Tank Option	Shared West Ship Canal Tunnel Option
Community impacts	The evaluation of whether to develop shared CSO control projects in lieu of independent City and King County projects needs to consider the number of affected communities and the scale of larger joint CSO control facilities on host communities. Shared CSO control projects present the opportunity for the City and King County to reduce the total number of CSO control facilities to be constructed, which can reduce the number of communities impacted by their construction, operation, and maintenance. Conversely, larger joint CSO control facilities could result in larger-scale impacts to host communities.	There are significantly more short-term construction impacts from major tank construction and more long-term community impacts from land use restrictions and loss of property for dedicated major tank sites.	Community impacts from construction noise, traffic disruption, property consumed and removed from potential other uses, and street disruptions are lower with this option. A large portion of the tunnel construction sites could be sold for private use following the completion of construction.
Regulatory considerations	All CSO control projects must meet the control standard of no more than one CSO event per year. The evaluation of shared or independent CSO control projects should consider which type(s) of project are most likely to meet compliance standards.	The Neighborhood Storage Option will meet the control standards.	The Shared West Ship Canal Tunnel provides greater flexibility to control all seven outfalls due to the ability to optimize storage for each basin depending on the variability of rainfall and flows in each basin. The Shared West Ship Canal Tunnel CSO control measure is estimated to have a 20-year moving average CSO overflow frequency of 0.5 events per year and an annual CSO volume reduction of 80%.

Table 5-7 Comparison of Final Options

Evaluation factors		Option	
Factor	Items to be considered	Neighborhood Storage Tank Option	Shared West Ship Canal Tunnel Option
Local agency designation and responsibilities	Efficient implementation of a joint CSO control project may require the designation of a lead agency or the creation of a joint project management structure will be considered. Key evaluation decisions include which agency will act as lead, and what responsibilities are inherent in a lead agency, or whether a joint project management structure is appropriate and what responsibilities are inherent in a joint project management structure. The final recommendation on a joint project will be documented in a joint project agreement.	Both agencies have recent experience in the construction of large storage tanks. King County has extensive experience in the operation of facilities off-site from their treatment works and has dedicated operators and maintenance staff. The City has constructed and operated numerous pipe storage facilities and two large cylindrical storage tanks. The City is currently constructing new state of the art rectangular tank storage facilities. The Windermere and Genesee CSO storage facilities will be complete in 2015. The City is also performing final design of the Henderson CSO storage facilities which will be completed by 2018.	The City will be the lead agency for a Shared West Ship Canal Tunnel. King County and the City will enter a project-specific agreement to construct and operate the Shared West Ship Canal Tunnel.

5.4.4 Peer Review of Analysis and Recommendations

The City engaged a peer review team to assess the evaluation of the Neighborhood Storage Tank Option and the Shared West Ship Canal Tunnel option that was done by City staff and consultants and to provide their observations on the thoroughness of the monetary and non-monetary evaluation. The peer review members were senior public agency engineering, construction, and operations managers from the following agencies:

- City of Edmonton, Canada: The City of Edmonton is unique in that it operates its own tunnel construction company and currently owns multiple tunnel boring machines.
- Milwaukee Metropolitan Sewerage District (MMSD): MMSD provides wholesale conveyance and treatment services to 28 municipalities, similar to the services King County provides to its wholesale customers. MMSD also operates 21 miles of deep tunnels (15 to 30 feet in diameter), at depths of approximately 300 feet in solid dolomite rock.
- City of Portland, Oregon: The City of Portland has recently completed implementation of its LTCP. There are several operating storage tanks, as well as a tunnel system with vortex drop shafts and a 200-MGD pump station. The tunnels take dry-weather flow as well as wet-weather overflow and have had no

significant odor problems. Tunnel construction involved 10 miles of soft-ground tunnel and several mined tunnels.

- City of Omaha, Nebraska: The City of Omaha is currently involved in implementing its CSO LTCP. Omaha has \$300 million of its \$2 billion program currently under contract. The LTCP includes the concept of a deep tunnel and also includes two additional tanks. Omaha is now at 90 percent complete on design of a 14-foot-diameter stormwater tunnel that will convey separated stormwater to the Missouri River.

The peer team conclusion was: “The planning and analyses to date have been very good. The three options presented are common techniques and are technically viable. Continued cooperation between the City and King County could lead to a shared tunnel option that may be the best overall long-term, cost-effective solution to significantly reduce overflows and impacts to the area.”

5.5 Environmental Impact of Recommended Option

This section describes the types of social and environmental impacts that could occur within the plan area from the recommended option.

5.5.1 Construction Impacts

CSO reduction projects included under the recommended option – and common to both the LTCP Alternative and the Integrated Plan Alternative – would involve construction of sewer system improvements, flow diversions, and underground storage. Because this is a planning-level evaluation, project details and construction methods have not yet been defined. However, the information in Table 5-8 provides a reasonable estimate of the nature, extent, and duration of anticipated construction activities for the types of projects being considered. Actual construction activities would vary and would be determined during subsequent, project-specific review. It should be noted that for EIS purposes, CSO areas are described in terms of “neighborhoods” to promote better understanding within a broad audience. EIS neighborhoods are generally consistent with CSO basin areas.

Table 5-8. Summary of Recommended Option Construction Impacts

Resource
Earth
Construction of tunnel portals and movement of the tunnel boring machine could result in vibration and ground subsidence. The location of the portals, drop shafts, conveyance lines, and tunnel near liquefiable soils in Fremont, Ballard, and the south side of the Ship Canal could result in soil settling. Geotechnical exploration and testing would be conducted during project design to identify potential hazards along the tunnel alignment. Overall impacts would be reduced under this option because the shared tunnel would reduce the number of City and King County independently constructed CSO control facilities.
Air Quality
Construction of the tunnel would not have a significant impact on air quality in the Seattle area, but may result in moderate localized impacts largely related to vehicle emissions and dust. Impacts under the recommended option would be concentrated at fewer locations. Overall impacts would be reduced under this option because the shared tunnel would replace a number of City and King County independently constructed CSO control facilities with a single, large tunnel.
Surface Water
Construction could include increased pollutants and sediments from site runoff, requiring control measures. The shared tunnel would have reduced potential for impacts associated with site runoff compared to independently constructed City (Ballard and Fremont/Wallingford) and King County (3rd Ave W and 11th Ave NW regulators) CSO control facilities. Portal locations, due to their larger construction footprint, would be the focal point for potential surface water runoff impacts. Deep tunnels have less

Table 5-8. Summary of Recommended Option Construction Impacts

Resource
surface disruption than storage tanks and pipes, but would likely have dewatering impacts. Dewatering water could include contaminants and sediments that could be discharged into local water bodies if not properly managed.
Biological Resources
No direct impacts to aquatic habitats, plants, and invertebrates would occur and only minor indirect impacts are anticipated. Only minor impacts to terrestrial habitat are anticipated because projects are typically located in areas with low habitat value. In general, impacts would potentially be lower with the tunnel because construction will be concentrated at fewer locations with less surface disturbance than other options.
Energy and Climate Change
Construction would not have a significant impact on energy resources in the Seattle area. Construction-related energy consumption and greenhouse gas emissions would be lower than those estimated for the other options. Overall impacts would be reduced under this option because the shared tunnel replaces a number of City and King County independently constructed CSO control facilities.
Environmental Health and Public Safety
Ground excavations and dewatering have the potential to encounter contaminated materials and may require special handling methods. In general, environmental health risks are low, and the potential for the public to encounter contaminated soils or groundwater is low. Potential construction-related impacts would be concentrated at the tunnel portals in the Fremont/Wallingford and Ballard neighborhoods.
Noise and Vibration
Construction would result in short-term moderate to substantial increases in noise, lasting from one to as many as five years, depending on the control project. Potential construction-related impacts would largely be concentrated at the tunnel portals in the Ballard and Fremont/Wallingford neighborhoods (for approximately three and one-half years). After the portals are built, most work would occur underground, which would not produce noticeable street-level noise or vibration other than from trucks hauling tunnel spoils on roadways. The potential for vibration along the tunnel route is likely to be a concern to property owners.
Land Use and Visual Quality
This option would require the acquisition of easements or property for construction access facilities and staging areas. Property might need to be acquired for storage tank locations, although public property would be preferred when available. For storage pipes and flow diversions, construction would occur primarily in street rights-of-way. For the tunnel, property would need to be acquired for tunnel portals. This option would reduce the number of areas affected by construction, but would concentrate construction-related land use impacts at fewer, larger project sites in Ballard and Fremont/Wallingford. The tunnel is estimated to require three and one-half years to construct and up to four acres for construction staging. Much of this area could be sold following construction.
Recreation
Temporary impacts to recreation could occur if a facility is sited within a park, although the City would attempt to avoid siting facilities in parks. If construction or staging areas are located near or adjacent to a park, recreational use of the park could be disrupted by restricted access, noise, dust, and truck trips during peak construction periods.
Historic, Cultural, and Archaeological Resources
Construction could have a potential adverse effect on historic, cultural, or archaeological resources. Because excavation for the tunnel portals would be deeper than geological layers that might contain cultural resources, the tunnel options would have less potential to encounter cultural resources than storage tanks or storage pipes. This option has the potential for temporary impacts to historic properties along the proposed tunnel alignment (vibration, dust, noise, and visual integrity). Historic structures may be more susceptible to damage from vibration.

Table 5-8. Summary of Recommended Option Construction Impacts

Resource
Transportation
Transportation impacts would include increases in traffic volumes due to construction-generated truck trips, commute trips of construction workers, and roadway lane and sidewalk closures where construction activities take place. Impacts from tunnel construction would be concentrated at two tunnel portal locations in Ballard and Fremont/Wallingford. Total truck trips for tunnel construction are expected to be over 34,000 truck round trips (average 33 per day for 3.5 years) for the tunnel, generated primarily in Ballard. Additional truck trips would be generated by construction of conveyance and connection elements (e.g., drops shafts and conveyance lines). This option would eliminate construction truck trips associated with separate King County 3rd Ave. W and 11th Ave. NW CSO control projects. In addition, this option would avoid the need for substantial in-road construction for a storage pipe project, which could result in traffic disruptions in the Fremont/Wallingford area. While construction truck trips and traffic disruptions from separate, independent CSO control projects would be avoided under this option, conveyance and connection elements needed to deliver 3rd Ave. W and 11th Ave. NW flows to the tunnel (drop shafts and a conveyance line) would bring some additional construction truck trips and traffic disruptions to these areas. However, these truck trips and traffic disruptions would be less than what would likely be experienced for independent CSO control projects. Anticipated increase in truck traffic during tunnel construction is relatively low compared to typical background traffic on city arterials and is not expected to adversely affect roadway operations. However, at peak construction times, the truck trips could be noticeable to the public.
Public Utilities
Construction would occur in areas highly constrained by existing underground and overhead utilities, requiring extensive coordination with utilities to avoid conflicts. Deep tunnels tend to be constructed below many underground utilities, reducing the potential for utility conflicts. However, temporary electrical substations to power the tunnel boring machine and construction of tunnel portals and other associated facilities would require utility coordination and reconfiguration.
Socioeconomics and Environmental Justice
Construction could cause a hardship for some residents due to disruptions to access to community resources, businesses, and public transportation in project areas. There could be short-term impacts on existing economic conditions due to construction disturbance and temporary changes in the use of the land during construction. The shared tunnel would replace City (and King County) independently constructed storage facilities in the Ship Canal neighborhoods with a single, large tunnel, and therefore fewer areas would experience construction disturbance and modified access to community resources or businesses. However, it would concentrate impacts at fewer locations in the Ship Canal neighborhoods. The neighborhoods that have the highest potential to be affected include Ballard and Fremont/Wallingford. Disproportionate impacts to minority or low income populations are not expected.

5.5.2 Operational Impacts

Table 5-9 describes the potential effects of the plan after construction has been completed and the plan projects are in operation. Both the LTCP Alternative and the Integrated Plan Alternative would implement one of the four options, although some of these CSO reduction projects would be deferred under the Integrated Plan Alternative. Because CSO reduction facilities under the options would largely be underground, few operational effects to the environment would result from plan implementation. As noted above, for purposes of the EIS, CSO areas are referred to as “neighborhoods.”

Table 5-9. Summary of Recommended Option Operational Impacts

Resource
Earth
With the implementation of site-appropriate design, potential adverse impacts would be avoided and minimized. With the tunnel, there would be fewer storage tanks and pipes potentially at risk during a seismic event. Tunnels are generally designed to avoid other underground utilities and take advantage of stable glacial till layers. Operational effects are anticipated to be minor.
Air Quality
The net operational impacts on air quality and odors would be minor. All facilities would be designed and maintained to minimize emissions of odorous compounds. The large tunnel would replace the need for a number of potential odor-producing storage facilities in the Ballard and Fremont/Wallingford neighborhoods. The large tunnel's greatest potential for odors would be at the downstream tunnel portal (likely located along the Ship Canal in the vicinity of Ballard), which would be controlled by an odor control facility.
Surface Water
The recommended option would substantially reduce pollutant from existing uncontrolled CSO outfalls when compared with the No Action Alternative. Pollutant loadings would be substantially reduced and the outfalls would come into compliance with the Clean Water Act and the requirements of the Consent Decree. The Ship Canal/Lake Union, Lake Washington, Duwamish River, Longfellow Creek, Elliott Bay, and Puget Sound would receive reduced discharges from CSOs.
Biological Resources
The recommended option would result in negligible to minor impacts to biological resources. Instead, there would be long-term beneficial effects on fish and aquatic life from reducing CSOs. Implementation of the LTCP would reduce the volume of untreated sewage and stormwater runoff, thereby reducing the potential for related impacts on aquatic life. Implementation of the LTCP would comply with the Consent Decree as well as other federal and state requirements.
Energy and Climate Change
The recommended option would potentially have a higher electrical requirement than storage tanks because of the electricity needed to pump the deeply stored water. However, overall energy use would still be minor and would be further reduced as this option replaces the need for four City and two King County independently constructed CSO facilities. The GHG emissions produced by operating and maintaining CSO facilities are not expected to cause appreciable climate change. The City has incorporated climate change modeling in its development of the LTCP and would incorporate additional modeling in the design of individual CSO facilities to minimize risks from anticipated changes in precipitation and sea level rise.
Environmental Health and Public Safety
Overall, the recommended option is expected to reduce environmental health risks associated with CSOs by reducing untreated discharges. Reduction of CSO discharges to recreational water bodies, including Lake Union, the Ship Canal, Lake Washington, and the Duwamish Waterway, would reduce the potential for CSO-related environmental health risks in those water bodies.
Noise and Vibration
The net operational effects would be minor. Noise would be intermittently generated by pump stations and odor control facilities. All facilities would be designed and maintained to reduce noise to permissible levels.
Land Use and Visual Quality
Potential land use impacts include conversion of land in residential, commercial, or industrial areas to public utility uses. The tunnel would have less potential for long-term land use impacts than storage tanks since the tunnel would replace the need to site several storage tanks in the Ship Canal neighborhoods (Ballard and Fremont/Wallingford) and less property would need to be retained following construction. In contrast to storage tanks, the City would be able to sell or lease approximately 75 percent of the land needed for construction of the tunnel portal in Ballard for other uses. Approximately one half acre of the launch portal would be retained by the City to house the pump station, odor control, and a permanent shaft for access and

Table 5-9. Summary of Recommended Option Operational Impacts

Resource
maintenance. All of the area used for the smaller, recovery end of the tunnel in Fremont/Wallingford would be retained by the City. Some additional areas would be retained for permanent drop shafts as required to accept flows from each contributing City and King County CSO area.
Recreation
Overall, the operational effects on recreational activities are expected to be minor. Reductions in pollutant loading would benefit long-term water quality and help maintain beneficial uses at area beaches. Water contact recreation in Lake Washington, Portage Bay, the Duwamish River, and Lake Union, in particular, would be enhanced by improved water quality. Locating storage facilities in a park would constrain certain future uses of that area for park purposes. However, there is a potential to provide recreational facilities on top of storage tanks following construction. The tunnel would replace the need to site several storage tanks in the Ship Canal neighborhoods (Ballard and Fremont/Wallingford), thus reducing the potential for recreation impacts.
Historic, Cultural, and Archaeological Resources
Operation of projects implemented under the recommended option is anticipated to have no effect on historic, cultural, and archaeological resources.
Transportation
Overall, the operational effects from vehicle trips generated by facility maintenance under the recommended option are expected to be minor.
Public Utilities
Implementation of the recommended option will require close coordination with numerous utilities, in particular, wastewater and stormwater utilities within the service area. Because the City's collection system network sends wastewater to King County for treatment, coordination with King County will be particularly important. King County's West Point WWTP would receive additional sewage flows as a result of plan implementation. The high variability in flow rates within the sewer system associated with heavy storms could be challenging to manage at the King County West Point WWTP. Based on City modeling, these additional flows will have little effect on the peak loading to King County's West Point WWTP and may potentially reduce peak loading. However, annual average flows will increase, resulting in greater operational and maintenance costs. The City and King County will address the incremental cost of these flows in their sewage disposal agreement. The large shared tunnel under the recommended option would be implemented in accordance with operational agreements between the City and King County. The shared tunnel may reduce the operational complexity of controlling neighborhood storage tanks or shared storage tanks, as it provides one large storage facility for all flows to be managed through a single pump station discharging to King County's West Point WWTP. Close coordination with King County would be needed to optimize operational benefits.
Socioeconomics and Environmental Justice
The operational effects would be minor to moderately beneficial associated with improved water quality in area receiving waters, and there would be no adverse operational effects that would be predominantly borne by minority or low-income populations and underserved communities.

5.5.3 Summary

The construction impacts of the recommended option would be minor to moderate, assuming mitigation measures are implemented. Transportation impacts could be substantial in some neighborhoods. Long-term effects would be beneficial, particularly to water quality, biological resources, and environmental health, and there would be no adverse operational effects that would be predominantly borne by minority or low-income populations and underserved communities.

5.6 Development of Design Criteria for Recommended CSO Control Measures

5.6.1 Shared West Ship Canal Tunnel

5.6.1.1 CSO Control Measure Description

The recommended CSO control measure for the Ballard and Fremont/Wallingford areas is a Shared West Ship Canal Tunnel that will store CSO flows for two City and two King County CSO areas. Off-line storage will be provided with a deep storage tunnel constructed between the Ballard and Fremont/Wallingford CSO areas, on the north side of the Ship Canal. The Shared West Ship Canal Tunnel will control the Ballard CSO basins (Basins 150, 151, and 152), the Fremont/Wallingford CSO basins (Basins 147 and 174), the King County 3rd Ave. West Regulator (Basin 008), and the 11th Ave. NW Regulator (Basin 004). The total control volume for both the City and King County CSO basins is 15.24 MG. Figure 5-7 provides an overview of the project location and components.

The main components of the Shared West Ship Canal Tunnel include the storage tunnel and appurtenances, facilities to convey City and County CSO flows into the tunnel, and a tunnel pumping station effluent line to drain flows away from the tunnel. A description of each component is as follows:

The storage tunnel and appurtenances will include:

- A bored 15.24-MG off-line storage tunnel, 14,000 feet long, with a nominal 14-foot inside diameter
 - The stored volume in the storage tunnel will flow from the Fremont/Wallingford CSO Outfall 147 westward to an effluent pump station located near the Ballard CSO Outfall 152.
 - The tunnel route is planned to be generally in street rights-of-way along the north side of the Ship Canal.
- Six diversion structures for diverting influent CSO flow away from outfalls to the tunnel
- Four drop structures to convey influent CSO flow into storage
- An east tunnel portal housing odor control equipment

A west tunnel portal housing an effluent pump station with a peak capacity of 32 MGD to empty the storage tunnel in approximately 12 hours. Conveyance facilities from City and County CSOs will include:

- Approximately 2,200 linear feet (lf) of 36- to 72-inch diameter gravity sewer line to convey flows from the City's Ballard and Fremont/Wallingford CSO areas (Basins 150/151, 152, 147, and 174 respectively),
- Approximately 900 lf of 48- to 60-inch diameter gravity sewer line to convey flows from the County's 3rd Ave. W. and 11th Ave. NW CSO to tunnel drop structures. Approximately 800 lf of the gravity sewer line will be under the Ship Canal to connect the 3rd Ave. W. diversion structure to the tunnel.

The tunnel pumping station effluent line will consist of an approximately 1,900 lf force main to discharge the stored tunnel CSO flows directly into the existing Ballard Siphon wet-weather barrel forebay.

A new flow diversion structure will be constructed at the 3rd Ave. W CSO Regulator. In addition, an underwater flow diversion conveyance will be constructed beneath the Ship Canal from King County's 3rd Ave. W CSO Regulator north to a new tunnel drop structure located near the Fremont-Wallingford CSO Outfall 174. A new diversion structure near the 11th Ave. NW CSO Regulator and new gravity conveyance pipe to connect to a new tunnel drop structure will also be constructed.

The City will operate the shared CSO tunnel and will be responsible for achieving the CSO control performance standard for the following seven CSO outfalls: Ballard 150, 151 and 152; Fremont/Wallingford 147 and 174; King County 3rd Ave W and King County 11th Ave NW.

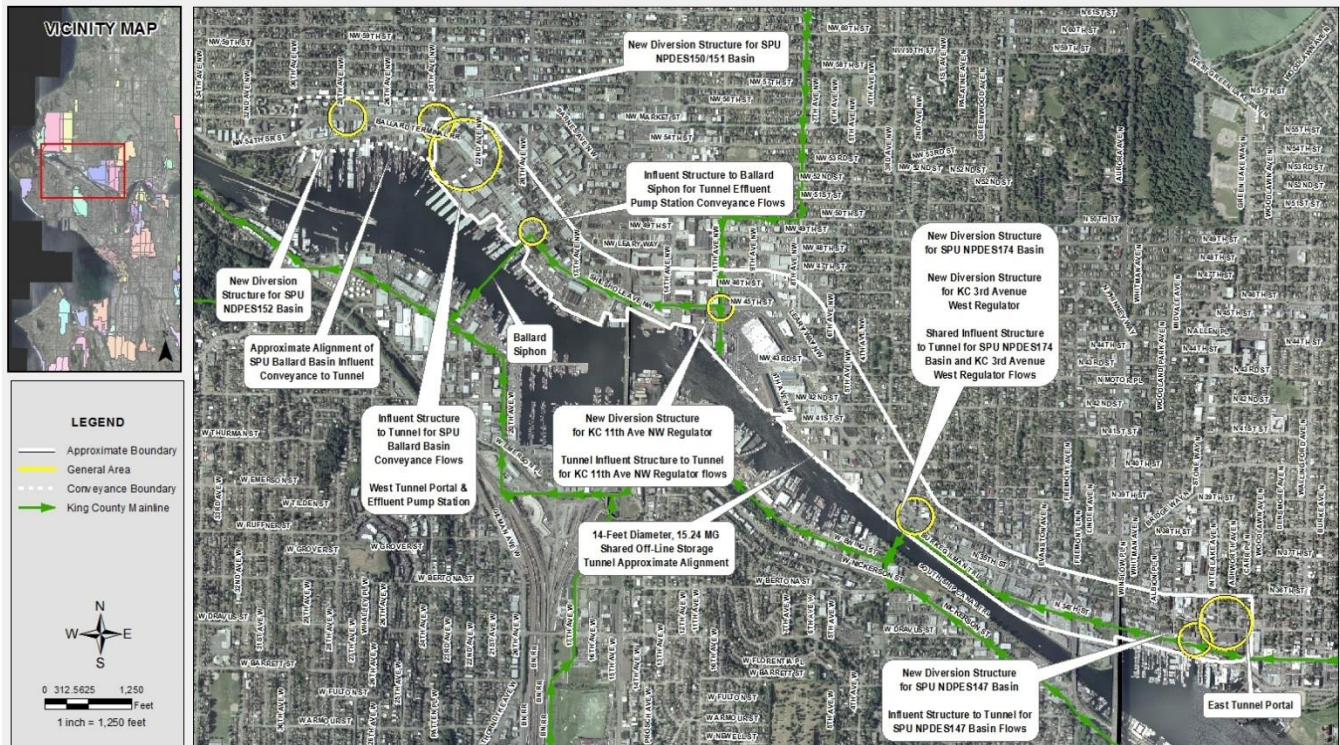


Figure 5-7. Shared West Ship Canal Tunnel Recommended Control Measure

5.6.1.2 CSO Control Measure Design Criteria

The design criteria for the Shared West Ship Canal Tunnel CSO control measures are listed in Table 5-10.

Table 5-10. Shared West Ship Canal Tunnel CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation ^a	Peak storage release rate with no impact (MGD) after CSO control measure implementation ^a	Average annual overflow volume after CSO control measure implementation (MG) ^a	Control volume with climate change (MG)
147 (City Fremont-Wallingford)	Shared West Ship Canal Tunnel	0.5	See Storage Release Rate below	1.5	2.15
174 (City Fremont-Wallingford)	Shared West Ship Canal Tunnel	0.5	See Storage Release Rate below	1.0	1.06

Table 5-10. Shared West Ship Canal Tunnel CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation a	Peak storage release rate with no impact (MGD) after CSO control measure implementation a	Average annual overflow volume after CSO control measure implementation (MG)a	Control volume with climate change (MG)
150/151 (City Ballard) ^b	Shared West Ship Canal Tunnel	0.4	See Storage Release Rate below	1.0	0.62
152 (City Ballard)	Shared West Ship Canal Tunnel	0.5	See Storage Release Rate below	3.6	5.38
11 th Ave NW (King County CSO Outfall 004)	Shared West Ship Canal Tunnel	0.4	See Storage Release Rate below	3.9	4.18 (without Climate Change)
3 rd Ave W (King County CSO Outfall 008)	Flow Diversion to Shared West Ship Canal Tunnel	0.5	See Storage Release Rate below	3.1	1.85 (without Climate Change)
Total Tunnel		Not applicable	32 (Storage release rate)	Not applicable	15.24

Notes:

^a Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0

^b These outfalls are served by a common discharge pipe and are considered a single point for control volume and frequency purposes.

Additional project design considerations to be evaluated during the design phase are shown on Table 5-11.

Table 5-11. Shared West Ship Canal Tunnel Additional Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
150, 151, 152, 147. 174	Validate final CSO control volume based on Annual CSO Reports, additional flow monitoring data, and final design modeling. Determine grit management scheme for flow diverted to storage.
King County 3rd Ave W	Validate final CSO control volume based on future Annual CSO Reports, additional flow monitoring data, and final design modeling. Determine grit management scheme for flow diverted to storage. King County to obtain approval for extending Consent Decree milestone for completion from 2023 to 2025.
King County 11th Ave NW	Validate final CSO control volume based on future Annual CSO Reports, additional flow monitoring data, and final design modeling. Determine grit management scheme for flow diverted to storage.

5.6.2 Magnolia

5.6.2.1 CSO Control Measure Description

The recommended CSO control measure for Magnolia CSO Outfall 060 is shown on Figure 5-8 and includes a new 0.11 MG buried storage pipe that is 6-feet in diameter and approximately 530 feet long. A possible location for the new storage pipe is within the City right-of-way. A new 10-foot diversion structure and approximately 50 feet of influent gravity pipeline will connect to a new 10-foot diameter access structure at the inlet end of the new storage pipe. A new effluent pump station (peak capacity of 0.22 MGD), sized to empty the storage facility within 12 hours, is required and will discharge through approximately 50 feet of force main. A new below-ground facility will house the electrical and standby power generation equipment. A new flap gate will be installed in the existing Magnolia CSO control structure to prevent tidal inflow.



Figure 5-8. Magnolia CSO recommended CSO Control Measure

5.6.2.2 CSO Control Measure Design Criteria

The Final LTCP project definition criteria for the Magnolia CSO control measure are listed in Table 5-12.

Table 5-12. Magnolia CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation ^a	Peak storage release rate with no impact (MGD) after CSO control measure implementation ^a	Average annual overflow volume after CSO control measure implementation (MG) ^a	Control volume with climate change (MG)
060	Off-line storage pipe	0.5	0.22	0.15	0.11

Notes:

^a Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0

Additional project design considerations to be evaluated during the design phase are shown on Table 5-13.

Table 5-13. Magnolia Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
107	Validate final CSO control volume based on Annual CSO Reports and flow monitoring data after Magnolia CSO sewer system improvement project implementation.

5.6.3 North Union Bay

5.6.3.1 CSO Control Measure Description

The recommended CSO control measure for North Union Bay CSO Outfall 018 is shown on Figure 5-9 and includes modifying the existing City CSO storage facility (CSO Facility 24) overflow structure to restore the original design capacity for storage and flows. The existing HydroBrake will be replaced with a motor-operated gate (or valve) for CSO Facility 24 to divert additional CSO flows to the downstream King County interceptor.

The motor-operated gate will have the ability to adjust to downstream conditions and upstream storage needs. Both the City and King County have downstream system constraints (capacity of the City's system between CSO Facility 24 and King County's Laurelhurst Trunk and the King County North Interceptor) that an active system will be able to meet by adjusting the discharge. An active system will result in the existing storage capacity being used efficiently to achieve the optimal balance between conveyance and storage.

The new motor-operated gate between the City and King County systems can be adjusted automatically to control flows. King County is planning a large University Regulator CSO project (storage and potential pump station) downstream of CSO Facility 24. Flows from Basin 018 will impact King County's design criteria and it will be advantageous to have the ability to control flows from the City's storage facility.

However, the recommended CSO control measure may result in an increase in the required storage volume for the King County University Regulator CSO storage project. The City performed pre-construction flow monitoring and will be performing up to five years of post-construction flow monitoring to determine the actual impacts upon the future King County University Regulator CSO project. Based on the flow monitoring data, King County and the

City will coordinate conveyance and storage design and operations for both the North Union Bay CSO and King County University Regulator CSO projects.

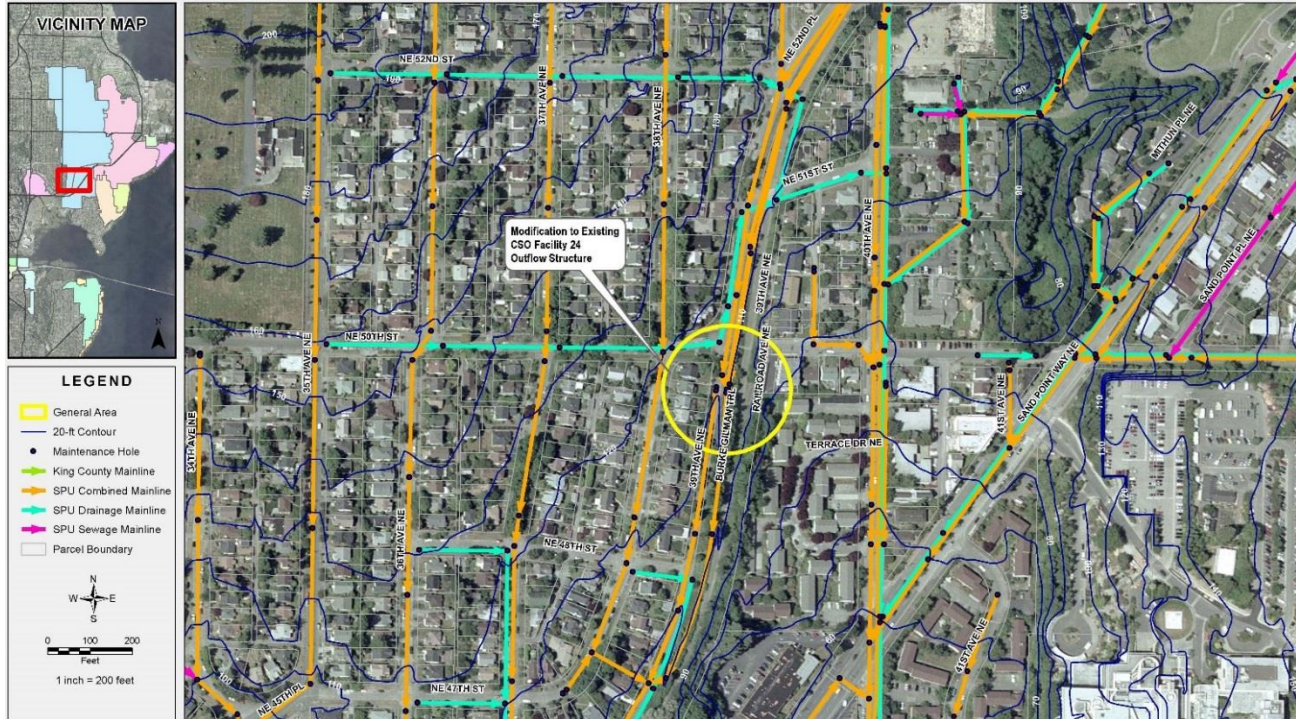


Figure 5-9. North Union Bay CSO Outfall 018 Recommended Control Measure

5.6.3.2 CSO Control Measure Design Criteria

The Final LTCP design criteria for the North Union Bay CSO control measure are listed in Table 5-14. Additional design considerations to be evaluated during the design phase are shown on Table 5-15.

Table 5-14. North Union Bay CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation ^a	Peak storage release rate with No Impact (MGD) after CSO control measure implementation ^a	Average annual overflow volume after CSO control measure implementation (MG) ^a	Control volume with climate change (MG)
018	Sewer system improvement (retrofit)	0.8	Peak flow will increase from 5.5 MGD to 9 MGD to King County	1.6	Not applicable.

Notes:

^a Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0

Table 5-15. North Union Bay Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
018	Validate control status after North Union Bay CSO sewer system improvement project implementation. After implementation, the City may convey additional CSO flows to the proposed King County University Regulator CSO storage tank. If the additional City flows impact the King County CSO storage tank sizing, the City and King County will evaluate the impacts and adjust the King County tank size to accommodate City flows.

5.6.4 Central Waterfront

5.6.4.1 CSO Control Measure Description

The recommended Central Waterfront CSO Outfall 069 control measure is shown on Figure 5-10 and includes a new 0.13 MG buried storage pipe that is 6 feet in diameter and approximately 600 feet long. A possible location for the new storage pipe, which will be located upstream of the existing CSO Outfall 069 control structure, is the existing street right-of-way. A new storage diversion weir will be installed in the existing City CSO facility in MH039-521. Approximately 50 feet of new gravity influent conveyance pipe will be required and will connect to a 10-foot diameter inlet structure of the new storage pipe. Stored CSO flows will be released by a new adjustable control gate installed in a 10-foot diameter outlet structure that will discharge into the existing combined sewer system. A level sensor in the new outlet structure will signal the automatic control gate to open when there is capacity in the existing combined sewer system.

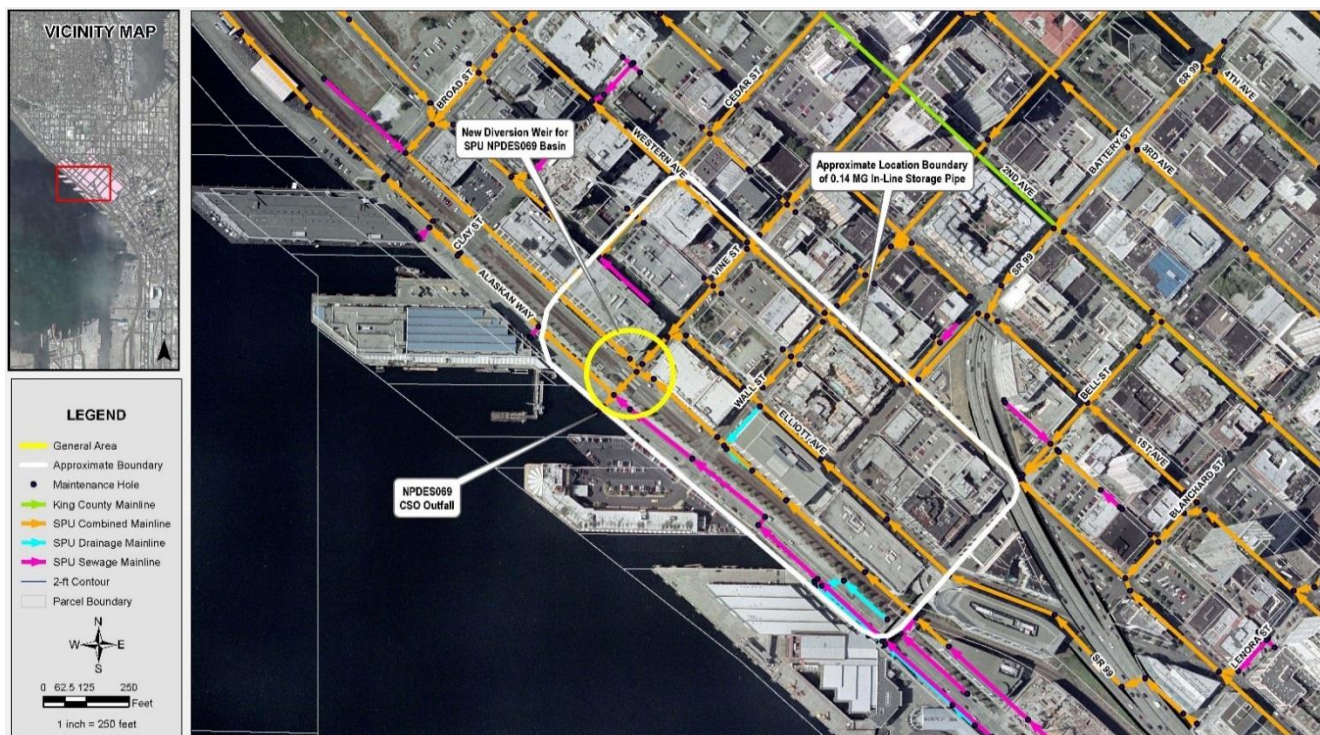


Figure 5-10. Central Waterfront CSO Outfall 069 Recommended Control Measure

5.6.4.2 CSO Control Measure Design Criteria

The design criteria for the Central Waterfront CSO control measure are listed in Table 5-16.

Table 5-16. Central Waterfront CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation ^a	Peak storage release rate with No Impact (MGD) after CSO control measure implementation ^a	Average annual overflow volume after CSO control measure implementation (MG) ^a	Control volume with climate change (MG)
069	Off-line storage pipe	0.7	0.26	0.5	0.13

Notes:

^a Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0

Additional project design considerations to be evaluated during the design phase are shown on Table 5-17.

Table 5-17. Central Waterfront Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
069	Validate final CSO control volume based on future Annual CSO Reports, additional flow monitoring data, and final design modeling. Coordinate construction with the north portion of the Elliott Bay Seawall Project.

5.6.5 Duwamish

5.6.5.1 CSO Control Measure Description

The recommended CSO control measure for Duwamish CSO Outfall 111 is shown on Figures 5-11 and 5-12 and includes improvements to control overflow structures 111B, 111C, and 111H.

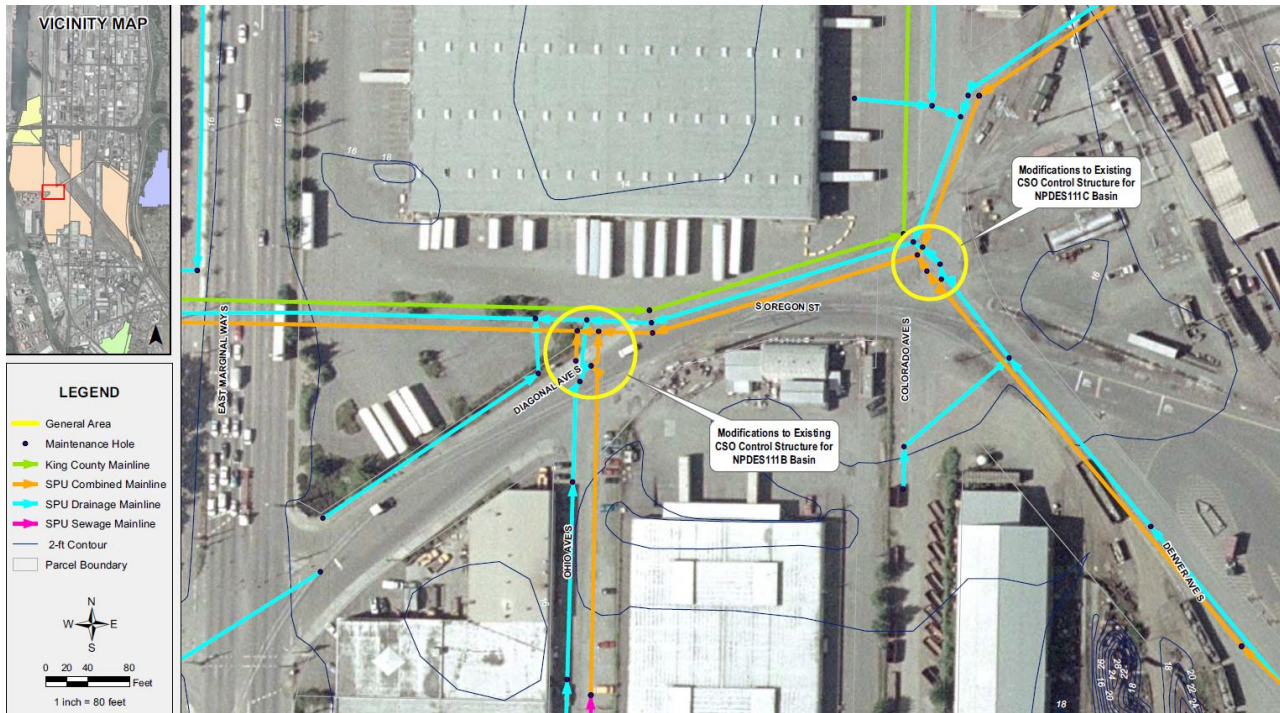


Figure 5-11. Duwamish CSO Sub-basin 111B and 111C Recommended Control Measure



Figure 5-12. Duwamish CSO Sub-basin 111H Recommended Control Measure

The Duwamish 111B and 111C CSO control measure consists of off-line CSO storage upstream of the King County Duwamish pump station which directs flow to the King County Elliott Bay Interceptor. The 0.02 MG storage volume will be provided by modifying two existing control structures and rerouting storm drainage piping to isolate the structures. Two new effluent pump stations (peak capacity of 0.02 MGD), sized to empty the storage facilities within 12 hours, are required as well as approximately 75 feet of force main. A new below-ground facility will house the electrical standby power generation equipment. The storm drainage conveyance system will be rerouted to bypass the overflow control structures for 111C and 111B, and the flap gate currently controlling the outlet of each control structure will be replaced by a new motor-operated control gate. Because the modified storm drainage conveyance system will bypass the control structure, both the storm drainage and CSO control chambers in each control structure will be used to store excess combined sewer flow.

The Duwamish 111H CSO control measure will include a new off-line storage pipe adjacent to the existing CSO Control Facility 35 storage tank. The new 60-inch diameter storage pipe will be approximately 100 feet long. During CSO events, excess combined sewer flows will be diverted from existing CSO Control Facility 35 storage to a new 0.01 MG off-line storage pipe and flow through both the new storage pipe and the existing CSO Control Facility 35 tank to the downstream sewer conveyance system. After a storage event, both the new storage pipe and existing tank will drain together through the existing gravity effluent pipes.

5.6.5.2 CSO Control Measure Design Criteria

The design criteria for the Duwamish CSO control measure are listed in Table 5-18.

Table 5-18. Duwamish CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation ^a	Peak storage release rate with no Impact (MGD) after CSO control measure implementation ^a	Average annual overflow volume after CSO control measure implementation (MG) ^a	Control volume with climate change (MG)
111B	Off-line storage pipe	0.4	See 111 (all sub-basins)	0.03	<0.01
111C		0.3		0.03	<0.01
111H		0.5		0.03	<0.01
111 (all sub-basins)	N/A	0.7	0.04	0.09	0.01

Notes:

^a Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0

Additional project design considerations to be evaluated during the design phase are shown on Table 5-19.

Table 5-19. Duwamish Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
111	Validate final CSO control volume based on Annual CSO Reports and flow monitoring data after Duwamish CSO sewer system improvement project implementation.

5.6.6 East Waterway

5.6.6.1 CSO Control Measure Description

The recommended CSO control measure for East Waterway CSO Outfall 107 is shown on Figure 5-13 and includes a new 0.5 MG storage tank with approximate dimensions of 50 feet wide by 90 feet long with a side water depth of 15 feet. Flows will enter the storage facility during a storm event through a new diversion structure and approximately 500 feet of gravity influent conveyance pipe. The tank will be buried and divided into chambers so that only those chambers required to store the storm event volume will be used. Storage of flows will start in the first chamber. When that chamber reaches capacity, flows will be transferred into subsequent chambers until either the storm event ends or the capacity of the storage facility is reached. The tank will need to be maintained on a scheduled basis and cleaned manually to ensure proper function. A new effluent pump station (peak capacity of 1.0 MGD), sized to empty the storage facility within 12 hours, is required and will discharge into the King County Elliott Bay Interceptor through approximately 1,380 feet of force main. A new below-ground facility will house the electrical, standby power generation, and odor control equipment.

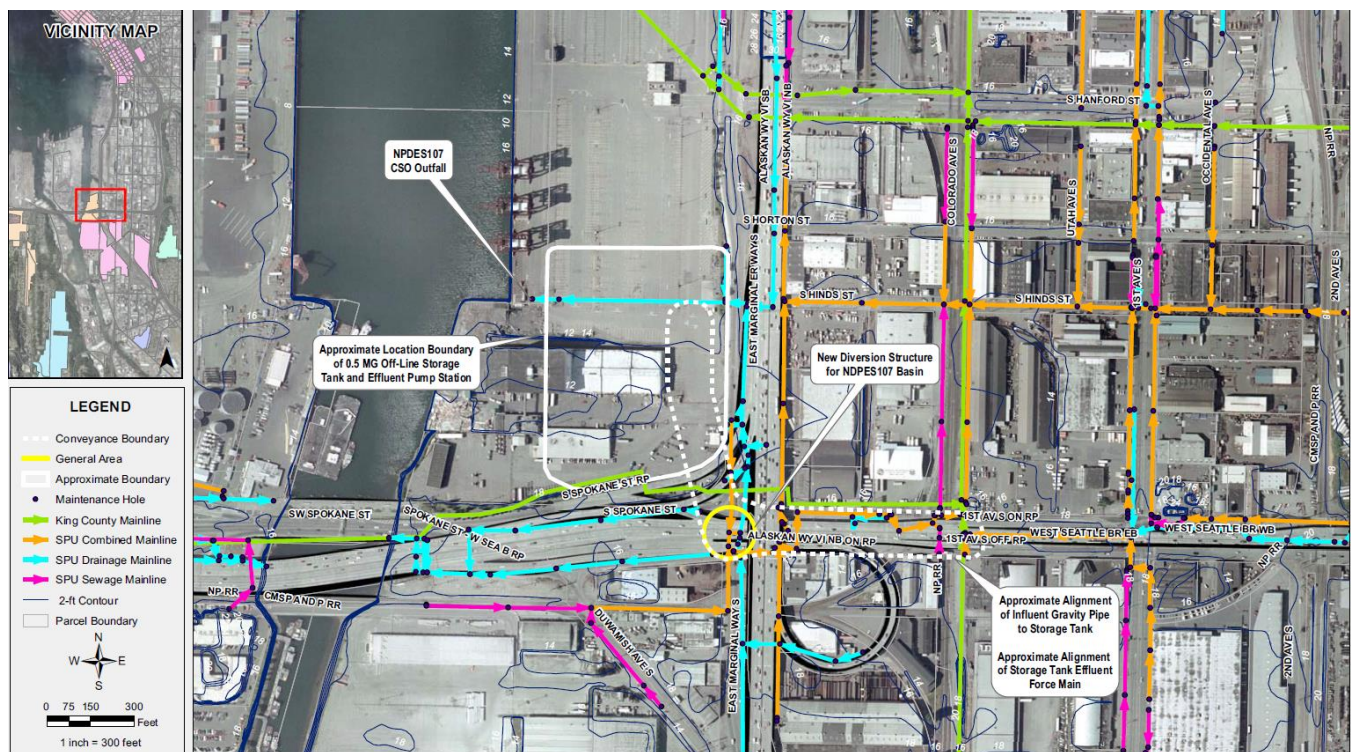


Figure 5-13. East Waterway CSO Outfall 107 Recommended Control Measure

5.6.6.2 CSO Measure Design Criteria

The design criteria for the East Waterway CSO control measure are listed in Table 5-20.

Table 5-20. East Waterway CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation ^a	Peak storage release rate with no impact (MGD) after CSO control measure implementation ^a	Average annual overflow volume after CSO control measure implementation (MG) ^a	Control volume with climate change (MG)
107	Off-line storage tank	0.7	1.0	0.01	0.5

Notes:

^a Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0

Additional design considerations to be evaluated during the design phase are shown on Table 5-21.

Table 5-21. East Waterway Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
107	Validate final CSO control volume based on Annual CSO Reports and flow monitoring data after the East Waterway CSO sewer system improvement project implementation. Re-evaluate CSO performance after construction of the King County HLKK CSO Plant.

5.6.7 Delridge/Longfellow

5.6.7.1 CSO Control Measure Description

The recommendations for the Delridge CSO area include three separate CSO control measures for uncontrolled CSO Outfalls 099, 168, and 169 as described below.

5.6.7.1.1 Delridge/Longfellow CSO Outfall 099

The recommended CSO control measure for the Delridge/Longfellow CSO Outfall 099 is shown on Figure 5-14 and includes a new 0.17 MG storage pipe that is 12 feet in diameter and approximately 210 feet long. The new storage pipe will be buried underground within the City right-of-way. Modifications to the existing CSO structure (MH055-447) will be required to divert flow to the new storage pipe. Approximately 80 feet of new gravity influent conveyance pipe will be required and will connect to the inlet end of new storage pipe. A new effluent pump station (peak capacity of 0.34 MGD), sized to empty the storage facility within 12 hours, is required and will discharge through approximately 30 feet of force main. A new below-ground facility will house the electrical, standby power generation, and odor control equipment.

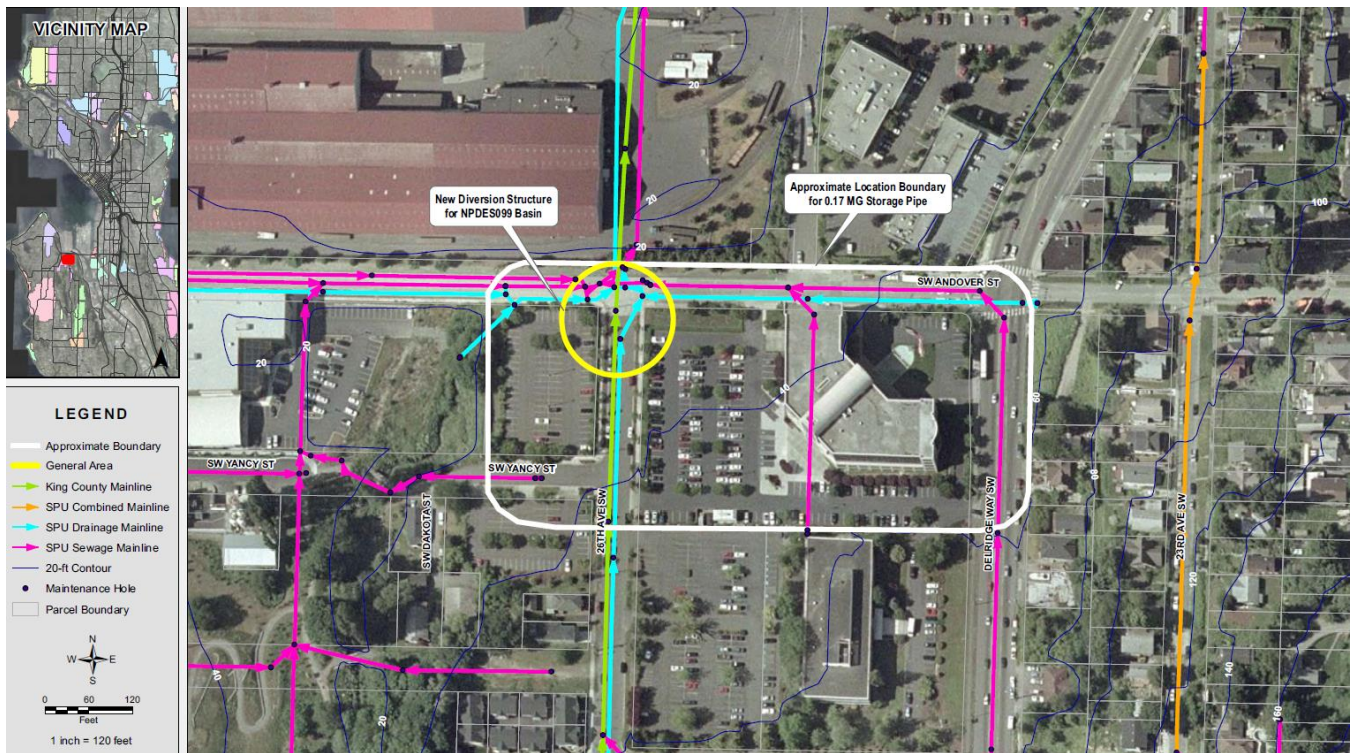


Figure 5-14. Longfellow CSO Outfall 099 Recommended Control Measure

5.6.7.1.2 Delridge/Longfellow CSO Outfall 168

As previously described in Section 5.3.4, the Delridge sewer system improvement project will be operational by October 2015 and is expected to significantly reduce the annual frequency and volume of CSOs discharged from Outfall 168. However, the Delridge sewer system improvement project hydraulic modeling indicated approximately 0.25 MG of additional CSO storage may be required to fully control CSO Outfall 168. The City will conduct post construction flow monitoring and modeling to determine the control volume required for the CSO control measure.

The recommended CSO control measure for Delridge/Longfellow CSO Outfall 168 is shown on Figure 5-15 and includes a new 0.25 MG storage pipe that is 10 feet in diameter and approximately 450 feet long. The new storage pipe will be buried underground within the City right-of-way. Modifications to the existing CSO structure (MH069-428) will be required to divert flow to the new storage pipe. Approximately 100 feet of new gravity influent conveyance pipe will be required and will connect to the inlet end of new storage pipe. A new effluent pump station (peak capacity of 0.50 MGD), sized to empty the storage facility within 12 hours, is required and will discharge through approximately 500 feet of force main. A new below-ground facility will house the electrical, standby power generation, and odor control equipment.

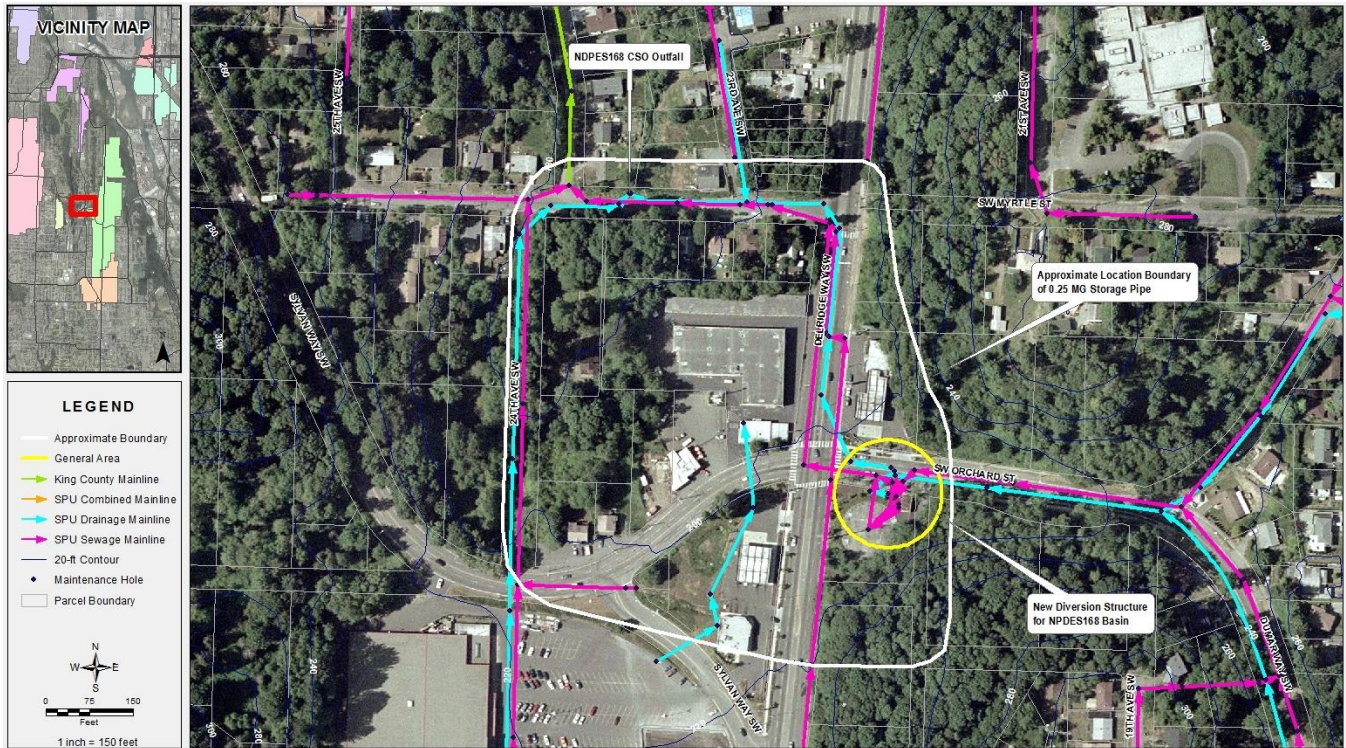


Figure 5-15. Longfellow CSO Outfall 168 Recommended Control Measure

5.6.7.1.3 Delridge/Longfellow CSO Outfall 169

As previously described in Section 5.3.4, the Delridge sewer system improvement project will be operational by October 2015 and is expected to significantly reduce the annual frequency and volume of CSO discharges from Outfall 169. However, the Delridge sewer system improvement project hydraulic modeling indicated approximately 0.25 MG of additional CSO storage may be required to fully control CSO Outfall 169. The City will conduct post construction flow monitoring and modeling to determine the control volume required for the CSO control measure.

The recommended CSO control measure for Delridge/Longfellow CSO Outfall 169 is shown on Figure 5-16 and includes a new 0.25 MG storage pipe that is 9 feet in diameter and approximately 550 feet long. The new storage pipe will be buried underground within the City right-of-way. Modifications to the existing CSO structure (MH076-367) will be required to divert flow to the new storage pipe. Approximately 50 feet of new gravity influent conveyance pipe will be required and will connect to the inlet end of new storage pipe. A new effluent pump station (peak capacity of 0.50 MGD), sized to empty the storage facility within 12 hours, is required and will discharge through approximately 50 feet of force main. A new below-ground facility will house the electrical, standby power generation, and odor control equipment.

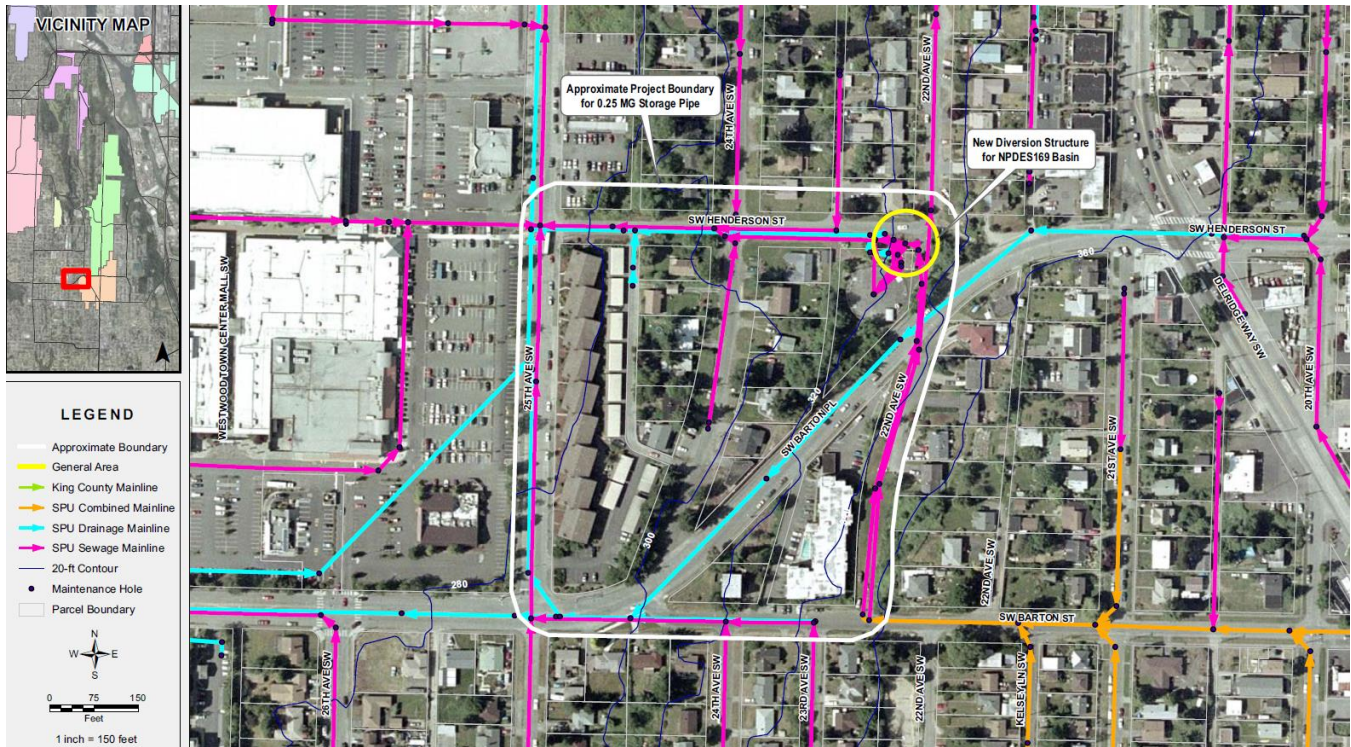


Figure 5-16. Longfellow CSO Outfall 169 Recommended Control Measure

5.6.7.2 CSO Measure Design Criteria

The design criteria for the Delridge/Longfellow CSO control measure are listed in Table 5-22.

Table 5-22. Delridge/Longfellow CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation ^a	Peak storage release rate with no impact (MGD) after CSO control measure implementation ^a	Average annual overflow volume after CSO control measure implementation (MG) ^a	Control volume with climate change (MG)
099	Off-line storage pipe	0.8	0.34	0.55	0.17
168	Off-line storage pipe	1.0	Peak outflow rate not increased	2.50	0.25
169	Off-line storage pipe	0.5	Peak outflow rate not increased	0.80	0.25

Notes:

^a Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0

Additional project definition considerations to be evaluated during the implementation phase are shown on Table 5-23.

Table 5-23. Delridge/Longfellow Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
099	Validate final CSO control volume based on future Annual CSO Reports, additional flow monitoring data, and final design modeling.
168	Validate final CSO control volume based on Annual CSO Reports and flow monitoring data after the Delridge CSO sewer system improvement project implementation.
169	Validate final CSO control volume based on Annual CSO Reports and flow monitoring data after the Delridge CSO sewer system improvement project implementation.

5.6.8 Montlake

5.6.8.1 CSO Control Measure Description

Three separate CSO control measures are recommended for Montlake CSO Outfalls 020, 139, and 140, as described below.

5.6.8.1.1 Montlake CSO Outfall 020

The recommended Montlake CSO Outfall 020 control measure is shown on Figure 5-17 and includes a new 0.16 MG buried storage pipe that is 12 feet in diameter and approximately 200 feet long. A possible location for the new storage pipe is within the existing street right-of-way upstream of Pump Station 13. One new diversion structure with two fixed weirs, a motor-operated gate, and approximately 50 feet of new gravity influent conveyance pipe will be required and will connect to the inlet end of new storage pipe. A new effluent pump station (peak capacity of 0.32 MGD), sized to empty the storage facility within 12 hours, is required and will discharge through approximately 50 feet of force main. A new below-ground facility will house the electrical, standby power generation, and odor control equipment.

5.6.8.1.2 Montlake CSO Outfall 139

The recommended Montlake CSO Outfall 139 control measure is shown on Figure 5-18 and includes a new 0.01 MG buried storage pipe that is 5 feet in diameter and approximately 75 feet long. A possible location for the new storage pipe is within the existing street right-of-way upstream of Pump Station 25. One new diversion structure and approximately 25 feet of new gravity influent conveyance pipe will be required and will connect to the inlet end of new storage pipe. After a CSO storage event, a new automatic gate in existing MH031-313 will open and allow the stored CSO flows to be released by gravity into the existing combined sewer conveyance system.

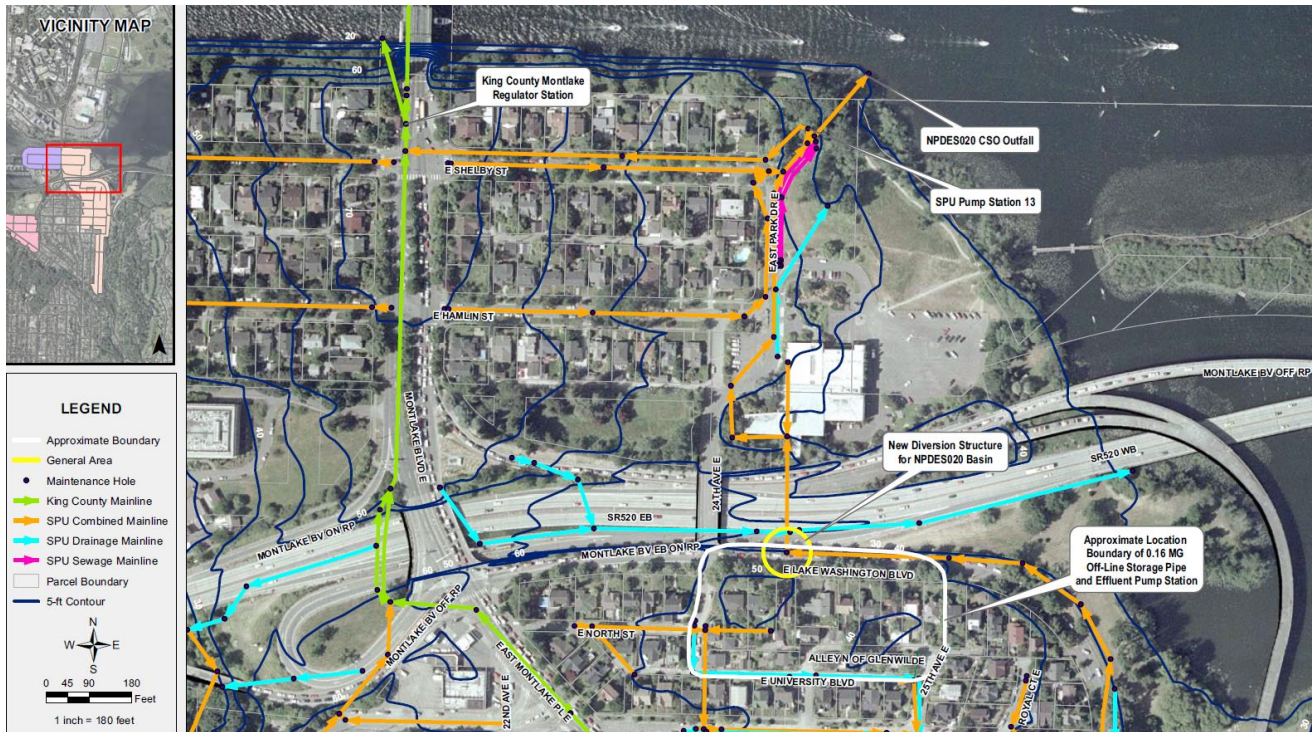


Figure 5-17 CSO Outfall 020 Recommended Control Measure



Figure 5-18 CSO Outfall 139 Recommended Control Measure

5.6.8.1.3 Montlake CSO Outfall 140

The recommended Montlake CSO Outfall 140 control measure is shown on Figure 5-19 and includes a new 0.05 MG buried storage pipe that is 8 feet in diameter and approximately 150 feet long. A possible location for the new storage pipe is within the existing street right-of-way, upstream of Pump Station 15 and its existing detention pipe. One new diversion structure and approximately 60 feet of new gravity influent conveyance pipe will be required and will connect to the inlet end of new storage pipe. After a CSO storage event, both the new and existing storage pipe will be emptied by the existing Pump Station 15.

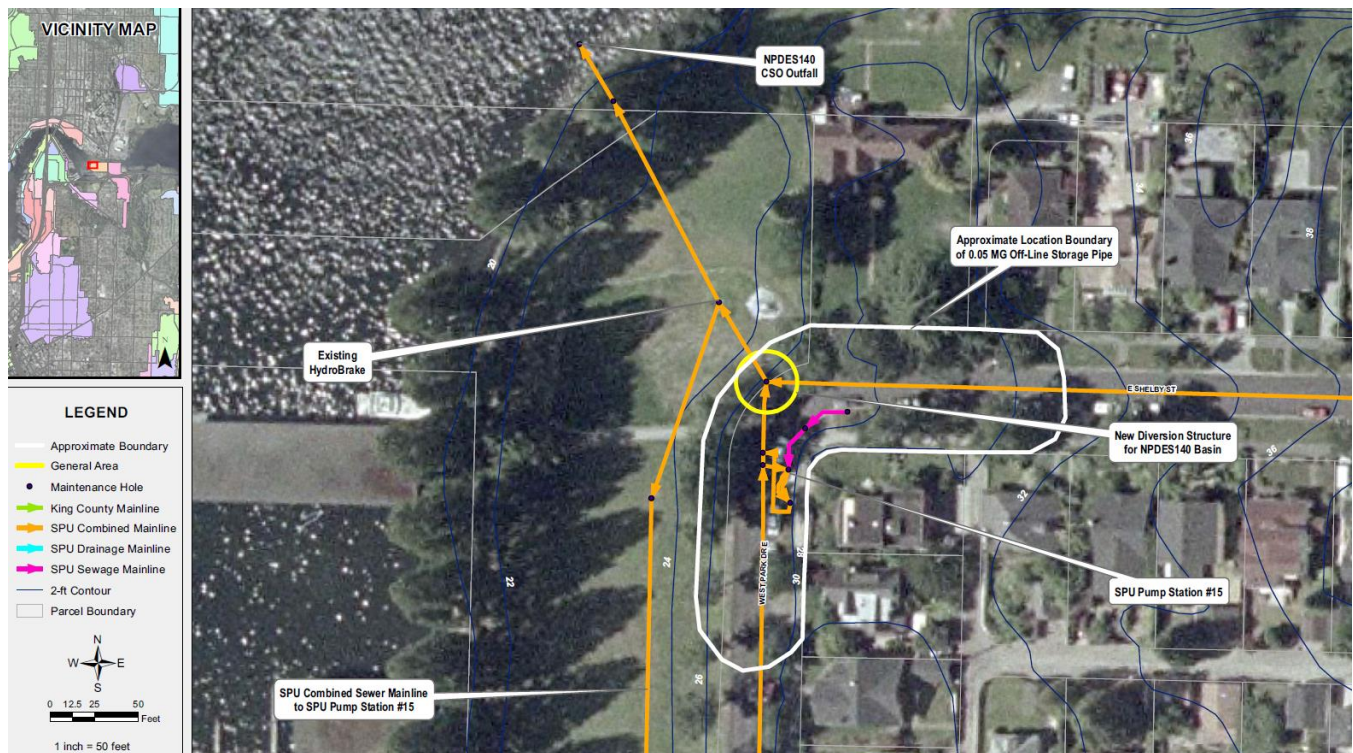


Figure 5-19 CSO Outfall 140 Recommended Control Measure

5.6.8.2 CSO Measure Design Criteria

The design criteria for the Montlake CSO control measures are listed in Table 5-24.

Additional design considerations to be evaluated during the design phase are shown on Table 5-25.

Table 5-24. Montlake CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation ^a	Peak storage release rate with no impact (MGD) after CSO control measure implementation ^a	Average annual overflow volume after CSO control measure implementation (MG) ^a	Control volume with climate change (MG)
020	Off-line storage pipe	0.6	Peak outflow rate not increased	0.40	0.16
139	Off-line storage pipe	0.5	Peak outflow rate not increased	0.02	0.01
140	Off-line storage pipe	0.4	Peak outflow rate not increased	0.08	0.05

Notes:

^a Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0

Table 5-25. Montlake Considerations for Design Phase

CSO outfall	Project definition considerations to be evaluated during design phase
020	Validate final CSO control volume based on future Annual CSO Reports, additional flow monitoring data, and final design modeling.
139	Validate final CSO control volume based on future Annual CSO Reports, additional flow monitoring data, and final design modeling.
140	Validate final CSO Control Volume based on future Annual CSO Reports, additional flow monitoring data, and final design modeling.

5.6.9 Leschi

5.6.9.1 CSO Control Measure Description

Based on the hydraulic model development work described in Chapter 2, System Characterization, and the Leschi conveyance system configuration, the Leschi CSO area can be hydraulically divided into north and south areas. The north Leschi area includes CSO Basins 026, 027, 028, 029, 030, 031, 032, and 033. The south Leschi area includes CSO Basin 034, 035, and 036. Figure 5-20 shows the Leschi CSO outfall locations and the general area of the recommended CSO control measures. Pumping Station 2 divides the north from the south groups. Basins south of Pump Station 2 drain to Pump Station 2 which pumps flows to the King County East Pine pump station. North of Pump Station 2, all flows drain by gravity to the King County East Pine pump station.

The Leschi basin is an isolated area with no upstream or downstream hydraulic relationship to other City NPDES basins; however, all of the Leschi basins are connected and each basin flows through the numerically lower basin and into the Leschi trunk sewer. All the collected flows discharge from the Leschi CSO area to King County's East Pine pump station for conveyance to the West Point WWTP.

Table 2-23, LTCP Outfall Control Status, indicated that 6 of the 11 NPDES basins in the Leschi CSO area (028, 029, 031, 032, 034, and 036) are uncontrolled and will require action to achieve the performance standard.

Because the basins are hydraulically linked, however, an action to control a single basin runs the risk of forcing adjacent basins out of control.

The recommended CSO control measure for the Leschi CSO area consists of four separate facilities to provide storage volume for the five uncontrolled basins as shown on Figure 5-20 and described in the following sections.



Figure 5-20. CSO Recommended Control Measure

5.6.9.1.1 North Leschi

The recommended measures for the north Leschi area have three separate CSO control measures for uncontrolled CSO Outfalls 028, 029, and 031/032 as described below.

The recommended Outfall 28 CSO control measure is shown on Figure 5-21 and includes a new 0.01 MG buried storage pipe that is 3 feet in diameter and approximately 210 feet long. A possible location for the new storage pipe is within the right-of-way of Lake Washington Blvd. One new diversion weir will be installed in the existing Outfall 028 control structure. Approximately 80 feet of new gravity influent conveyance pipe will be required and will connect to a new 8-foot diameter access structure at the inlet end of the new storage pipe. A new 12-foot diameter access structure at the outlet end of the new storage pipe with a motor-operated gate to allow drainage of the new storage pipe will also be required.

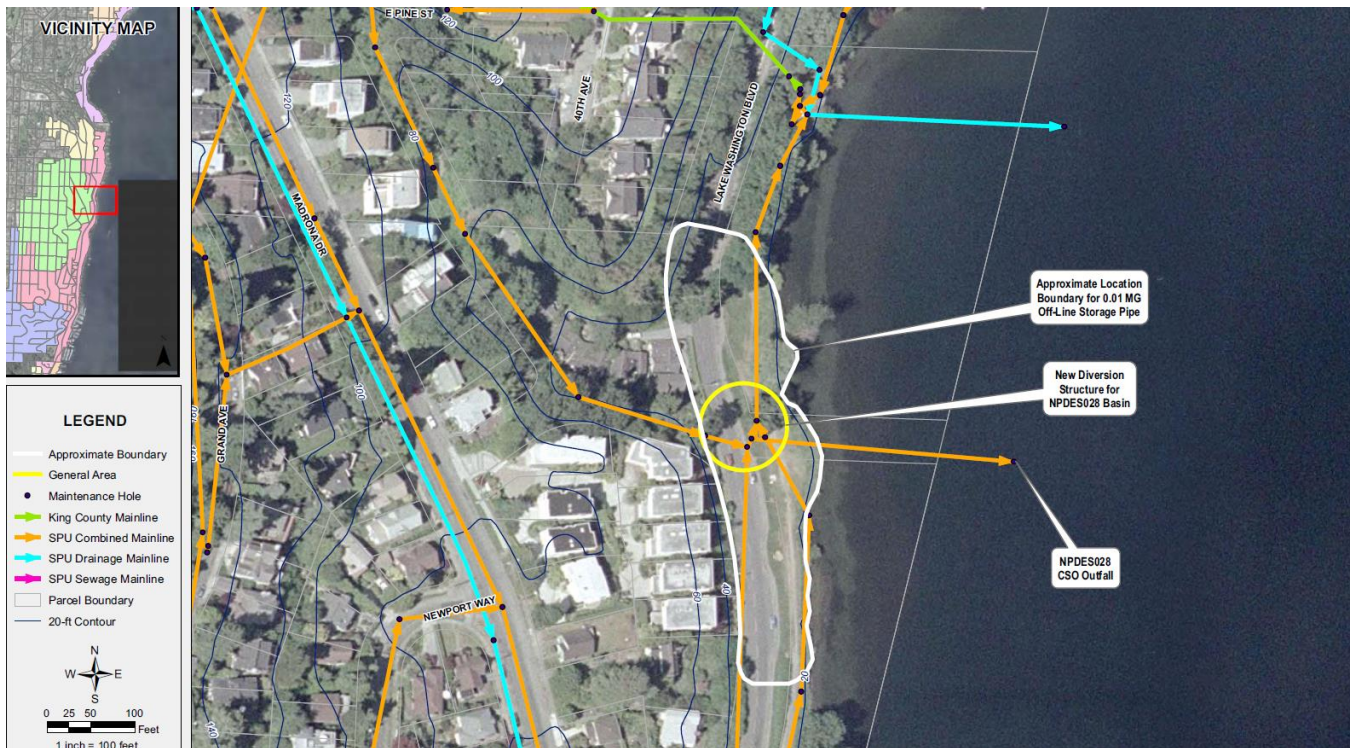


Figure 5-21. CSO Outfall 028 Recommended Control Measure

The recommended Outfall 029 CSO control measure is shown on Figure 5-22 and includes a new 0.02 MG buried storage pipe that is 5 feet in diameter and approximately 150 feet long. A possible location for the new storage pipe is within the right-of-way of Lake Washington Blvd. A new 4-foot diversion structure and approximately 20 feet of influent gravity pipeline will connect to the inlet end of the new storage pipe. A new effluent pump station (peak capacity of 0.04 MGD), sized to empty the storage facility within 12 hours, is required and will discharge through approximately 70 feet of force main. A new below-ground facility will house the electrical and standby power generation equipment. The existing outfall overflow weir will be raised.



Figure 5-22. CSO Outfall 029 Recommended Control Measure

The recommended CSO control measure for Basins 031 and 032 is shown on Figure 5-23 and includes a new 0.33 MG storage tank with approximate dimensions of 60 feet wide by 65 feet long with a side water depth of 15 feet. Based on hydraulic and hydrologic modeling, the storage volume estimates for Basins 031 and 032 are 0.31 MG and 0.08 MG, respectively – a sum of 0.39 MG. However, modeling of the design concept for Basins 031 and 032 indicated that a single 0.33 MG storage facility will be sufficient to control CSOs at Outfalls 031 and 032 to an average of one per year. Flows will enter the storage facility during storm events through a new diversion structure and approximately 50 feet of gravity influent conveyance pipe. The tank will be buried underground and divided into chambers so that only those chambers required to store the storm event volume will be used. Storage of flows will start in the first chamber. When that chamber reaches capacity, flows will be transferred into subsequent chambers until either the storm event ends or the capacity of the storage facility is reached. The tank will need to be maintained and cleaned manually to ensure proper function. A new effluent pump station (peak capacity of 0.66 MGD), sized to empty the storage facility within 12 hours, is required and will discharge through approximately 50 feet of force main. A new below-ground facility will house the electrical, standby power generation, and odor control equipment. Approximately 50 feet of existing 8-inch diameter gravity pipe will need to be increased to 12-inch diameter gravity pipe between MH046-033 and MH046-031. The CSO control measure for Basins 031 and 032 would also control Basin 034.



Figure 5-23. CSO Outfall 031 and 032 Recommended Control Measure

5.6.9.1.2 South Leschi

The recommended CSO control measure for the south Leschi area (Outfall 036) is shown on Figure 5-24 and includes a new 0.03 MG storage pipe that is 7 feet in diameter and approximately 120 feet long. A possible location for the new storage pipe is within the right-of-way of Lake Washington Blvd. One new diversion structure will be constructed upstream of the existing outfall control structure. Approximately 50 feet of new gravity influent conveyance pipe will be required and will connect to a new 8-foot diameter access structure at the inlet end of the new storage pipe. A new 12-foot diameter access shaft to accommodate the effluent pump station (peak capacity of 0.06 MGD), sized to empty the storage facility within 12 hours, is required and will discharge through approximately 50 feet of force main. A new below-ground facility will house the electrical, standby power generation, and odor control equipment.



Figure 5-24. CSO Outfall 036 Recommended Control Measure

5.6.9.2 CSO Measure Design Criteria

The design criteria for the Leschi CSO control measures are listed in Table 5-26.

Table 5-26. Leschi CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation ^a	Peak storage release rate with no impact (MGD) after CSO control measure implementation ^a	Average annual overflow volume after CSO control measure implementation (MG) ^a	Control volume with climate change (MG)
026	Outfall is controlled. No CSO control measure required	0.2	Not applicable	<0.01	Not applicable
027	Outfall is controlled. No CSO control measure required	0	Not applicable	0	Not applicable
028	Off-line storage pipe	0.5	0.02	0.02	<0.01
029	Off-line storage pipe	0.5	0.04	0.03	0.02

Table 5-26. Leschi CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation ^a	Peak storage release rate with no impact (MGD) after CSO control measure implementation ^a	Average annual overflow volume after CSO control measure implementation (MG) ^a	Control volume with climate change (MG)
030	Outfall is controlled. No CSO control measure required	0.8	Not applicable	0	Not applicable
031	Combined 031/032 Off-line storage pipe/tank	0.5	0.66	0.17	0.31
032		0.4		0.01	0.08
033	Outfall is controlled. No CSO control measure required	0.2	Not applicable	0	Not applicable
034	Outfall is uncontrolled, but will be brought into control from the CSO control measures being implemented in other basins	0.4	Not applicable	0.15	Not applicable
035	Outfall is controlled. No CSO control measure required	0.5	Not applicable	0.01	Not applicable
036	Off-line storage pipe	0.5	0.06	0.06	0.03

Notes:

^a Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0 Additional design considerations to be evaluated during the design phase are shown on Table 5-27.

Table 5-27. Leschi Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
026	Outfall is currently controlled. Validate CSO control status based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.
027	Outfall is currently controlled. Validate CSO control status based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.

Table 5-27. Leschi Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
028	Validate final CSO control volume based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.
029	Validate final CSO control volume based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.
030	Outfall is currently controlled. Validate CSO control status based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.
031	Validate final CSO control volume based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.
032	
033	Outfall is currently controlled. Validate CSO control status based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.
034	Outfall is currently controlled. Validate CSO control status based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.
035	Outfall is currently controlled. Validate CSO control status based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.
036	Validate final CSO control volume based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.

5.6.10 Portage Bay/Lake Union

5.6.10.1 CSO Control Measure Description

The recommended CSO control measure for Portage Bay/Lake Union (Outfall 138) is shown on Figure 5-25 and includes a new 0.12 MG buried storage pipe that is 10 feet in diameter and approximately 210 feet long. A possible location for the new storage pipe is within the City right-of-way. A new diversion structure and approximately 210 feet of influent gravity pipeline will connect to a new 12-foot diameter access structure at the inlet end of new storage pipe. A new non-return valve will be installed in the new 12-foot diameter access structure at the south end of the new storage pipe so storage can be emptied by gravity back into the existing the City sewer system within 12 hours of a wet-weather event. A new below-ground facility will house the electrical and odor control equipment.



Figure 5-25. Portage Bay/Lake Union CSO Outfall 138 Recommended Control Measure

5.6.10.2 CSO Measure Design Criteria

The design criteria for the Portage Bay CSO control measure are listed in Table 5-28.

Table 5-28. Portage Bay/Lake Union CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation ^a	Peak storage release rate with no impact (MGD) after CSO control measure implementation ^a	Average annual overflow volume after CSO control measure implementation (MG) ^a	Control volume with climate change (MG)
138	Off-line storage pipe	0.6	0.22	0.15	0.11

Notes:

^a Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0

Additional considerations to be evaluated during the design phase are shown on Table 5-29.

Table 5-29. Portage Bay Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
138	Validate final CSO Control Volume based on future Annual CSO Reports, additional flow monitoring data, and final design modeling.

5.7 Estimated Costs of Recommended LTCP Option

5.7.1 Overview of Project Costs

The project costs and their net present values were presented in Chapters 3 and 4. Section 5.4 described the process used to identify two final options for long-term CSO control: the Neighborhood Storage Tank Option and the Shared West Ship Canal Tunnel option. Following the short-listing of these two options, the costs of each were updated to reflect the results of ongoing refinement and evaluation. Major areas of cost revision were:

- Previous estimates (expressed in 2013 dollars) were escalated to August 2014 dollars.
- Final control measure modeling resulted in minor changes to control measure sizes and volumes.
- Project schedules were adjusted as appropriate to allow sewer system improvement projects to be completed prior to final design of the control measures. This will allow the City to optimize the size of final control measures, and it resulted in changes to NPVs.
- More detailed analysis of pre- and post-construction monitoring affected that portion of the cost.
- Substitution of storage projects for the proposed flow diversions in the Magnolia and East Waterway neighborhoods affected the overall cost estimates.

For all control measures except Ballard and Fremont/Wallingford, the City used its Conceptual Cost Calculator (3C) to develop estimates of construction cost. Details of the 3C cost model can be found in Section 3.7.1.

Because Ballard and Fremont/Wallingford are the largest basins and are included in a shared project with King County, further refinement of the costs was deemed to be appropriate. King County and the City engaged a third-party cost estimator who was not involved in the development of the conceptual designs of the City's or King County's CSO facilities. This estimator provided an independent project cost estimate for the Shared West Ship Canal Tunnel, the City's Ballard Storage Tank, the City's Fremont/Wallingford Storage Tank, King County's 3rd Ave. W storage tank, and King County's 11th Ave. NW conveyance.

This was done for two primary purposes: to update King County project costs that were dated and prepared under different methods and to ensure that the estimates used to compare the agencies' projects were done on an equivalent basis (the "apples to apples" factor).

5.7.2 Capital Cost

Table 5-30 presents the capital cost of the recommended CSO control measures that are included in the Shared West Ship Canal Tunnel option.

The total project cost shown includes construction costs for major parts of each control measure (conveyance, storage, pump stations, special construction, etc.) as well as estimated soft costs, project contingencies, management reserves, property costs, commissioning, and stabilization period costs. All costs are expressed in August 2014 dollars based on an Engineering News Record Construction Cost Index (CCI) value of 10161.68.

Table 5-30. Recommended CSO Control Measures Total Project Cost (August 2014 \$Millions)								
CSO area	CSO outfall	Total project cost ^a	Construction cost	Property cost	Soft costs	Project contingency and reserves	Commissioning and stabilization	Baseline flow monitoring
Leschi	028-036	\$28.1	\$12.0	\$1.7	\$5.9	\$6.8	\$1.2	\$0.5
Montlake	020/139/140	\$13.6	\$6.3	-	\$3.1	\$3.3	\$0.6	\$0.3
Portage Bay	138	\$8.7	\$4.1	-	\$2.0	\$2.1	\$0.4	\$0.1
Duwamish	111	\$4.4	\$1.9	-	\$0.9	\$1.0	\$0.2	\$0.4
East Waterway	107	\$31.1	\$13.0	\$3.3	\$6.4	\$7.9	\$0.4	\$0.1
Magnolia	060	\$6.3	\$2.9	-	\$1.4	\$1.6	\$0.3	\$0.1
Central Waterfront	069	\$10.5	\$4.9	-	\$2.4	\$2.6	\$0.5	\$0.1
	099	\$7.7	\$3.6	-	\$1.7	\$1.9	\$0.4	\$0.1
Delridge	168	\$8.9	\$4.2	-	\$2.0	\$2.1	\$0.4	\$0.2
	169	\$8.0	\$3.7	-	\$1.8	\$1.9	\$0.4	\$0.2
North Union Bay	018	\$1.6	\$0.6	-	\$0.3	\$0.3	\$0.2	\$0.2
Shared West Ship Canal Tunnel	City: 150, 151, 152, 147 and 174; King County: 3rd Ave W and 11th Ave NW	\$374.1 ^b	\$210.0	\$2.8 ^c	\$76.7	\$75.2 ^d	\$8.8	\$0.6
Total cost of control measures		\$503.0	\$267.2	\$7.8	\$104.6	\$106.7 ^d	\$13.8	\$2.9
Anticipated King County contribution ^d		\$116.0	\$65.1	\$0.9	\$23.8	\$23.3	\$2.7	\$0.2
City share of total cost of control measures		\$387.0	\$202.1	\$6.9	\$80.8	\$83.4	\$11.1	\$2.7

Notes:

^a Total Project Cost includes construction, engineering, property, soft costs, sales tax, contingency, management reserve fund, commissioning, stabilization, and baseline flow monitoring.

^b Includes \$1.2 M for Art and Sustainability.

^c Property cost of Shared West Ship Canal Tunnel is shown as net capital cost assuming 80 percent of property sold after construction.

^d See Section 5.7.4 for details on the cost share between the City and King County. City and King County negotiations have been conducted using a preliminary total project cost of \$366 M (in August 2014 \$'s) for the Shared West Ship Canal Tunnel. The difference in cost is due to the inclusion of commissioning, stabilization, and flow monitoring costs, which are assumed to be capitalized instead of operating expenses. The total project cost estimate for the project will continue to be refined as the project is developed.

Facilities constructed under the LTCP will require commissioning costs beyond those the City typically encounters when completing construction. These include stabilization costs to ensure that the constructed facilities will perform as designed. A project contingency and management reserves were included in the total project costs. These allowances are intended to address the costs of potential construction risks, permit conditions, and site-specific mitigation. During the design, the total project costs will be revised to include site-specific conditions.

The cost estimates for the control measures presented in this LTCP are considered to be Class 4 estimates, as defined by the Association for the Advancement of Cost Engineering (AACE), with an accuracy range of minus 20 percent to plus 30 percent.

The construction costs for the recommended CSO control measures have been reviewed and validated by third-party engineering and construction firms as follows:

- Tunnel construction costs were reviewed by three independent cost reviewers. The tunnel construction schedule was reviewed by a construction contractor.
- Large CSO storage tank cost estimates (3 MG and larger) were reviewed by an independent cost reviewer.
- Smaller pipe and tank storage and conveyance cost estimates were based on recent City construction costs.
- Major conveyance costs were reviewed in an independent cost review.

5.7.3 Operating Cost

The City's non-capital costs include recurring annual operation and maintenance expenses, fees paid to King County for treatment of additional flows, ongoing flow monitoring for system control, and post-construction monitoring to demonstrate consent decree compliance.

An operation and maintenance cost model (Appendix K) was developed for comparing control measures. This cost model incorporated existing City operating experience with storage facilities and conveyance systems augmented by recent monitoring and construction commissioning data.

Table 5-31 presents information on the maintenance costs for the proposed control measures that are included in the options. The table includes anticipated annual costs for maintenance broken down by major activities for each control measure. The operating cost shown includes the expected cost of energy (both the readiness to serve and energy charges).

Table 5-31. Recommended CSO Control Measures Operation and Maintenance Costs (August 2014 \$Millions)

CSO area	CSO basins	Annual O&M ^a	Post-construction monitoring
Leschi	028-036	\$0.31	\$1.20
Montlake	020/139/140	\$0.22	\$0.64
Portage Bay	138	\$0.05	\$0.41
Duwamish	111	\$0.16	\$0.19

Table 5-31. Recommended CSO Control Measures Operation and Maintenance Costs (August 2014 \$Millions)^c

CSO area	CSO basins	Annual O&M ^a	Post-construction monitoring
East Waterway	107	\$0.11	\$0.13
Magnolia	060	\$0.08	\$0.30
Central Waterfront	069	\$0.05	\$0.49
Delridge	099	\$0.11	\$0.36
	168	\$0.13	\$0.42
	169	\$0.14	\$0.37
North Union Bay	018	\$0.09	\$0.19
Shared West Ship Canal Tunnel	The City: 150/151, 152, 147 and 174 King County: 3 rd Ave W and 11 th Ave NW	\$0.82	\$1.76
Annual operating cost		\$2.27	\$6.46
Anticipated King County contribution ^b		\$0.25	\$0.55
City share of annual operating cost		\$2.02	\$5.91

Notes:

^a Annual system operating and maintenance costs include maintenance labor, power and chemicals, odor control consumables, meter maintenance costs for permanent flow monitoring, and treatment fees to King County.

^b Based on a preliminary cost share for the Shared West Ship Canal Tunnel. See Section 5.7.4 for details.

5.7.4 Shared Project Costs

A cost sharing methodology for shared projects was agreed upon by King County and the City. In general, the approach is to share the savings. Each jurisdiction's share of the selected project is based on each jurisdiction's proportionate share of the avoided cost of projects that would otherwise have been built.

This cost sharing approach is applicable to the Shared West Ship Canal Tunnel project for the City (Ballard and Fremont/Wallingford) and King County (3rd Ave. W and 11th Ave. NW) CSO basins. Table 5-32 presents the planning-level cost share that was used for the development of this LTCP based on the methodology agreed to by King County and the City. The actual cost shares will be developed as part of the project-specific agreement to be developed by the agencies.

Table 5-32: Breakdown of Costs Between King County and the City

Agency	Project	NPV of costs	Percent of total NPV of costs
City	Ballard Tank	\$135M ^a	69%
	Fremont/Wallingford Tank	\$106M ^a	
King County	3rd Ave. W Tank	\$90M	31%
	11th Ave W Conveyance	\$20M	
Combined		\$352M	100%

Note:

^a For comparison with King County projects, the cost of pre-construction and permanent flow monitoring not included in NPV.

5.8 Performance Evaluation of Recommended Option

5.8.1 CSO Performance Standard

This section was prepared in accordance with Appendix C of the July 3, 2013, Consent Decree. The specific requirement is listed in Paragraph C.5(a) as follows:

Assessment of CSO Control Measures: In developing the LTCP, the City must conduct or document prior analysis of alternatives for reducing the City's CSOs. The assessment must include, at a minimum, (a) an evaluation of the annual performance capabilities and effectiveness, measured in terms of CSO activation frequencies and overflow volumes, of various CSO control alternatives to meet performance criteria for controlling CSOs, pursuant to WAC 173-245 and RCW 90.48.48.

5.8.2 Recommended CSO Control Measures Performance

Based on the CSO control measures described in Section 5.6 and the King County No Impact Release Rates described in Section 5.3, the LTCP hydraulic models were used to estimate the 20-year moving average annual overflow frequency and volume for each CSO outfall control measure. The results are shown in Table 5-33, Projected Annual Performance (20-year Moving Average Overflow Frequency and Volume) After Implementation of Recommended CSO Control Measures. All recommended CSO control measures will reduce the annual CSO overflow frequencies to less than one event per outfall per year based on a 20-year moving average.

Table 5-33 Projected Annual Performance (20-year Moving Average Overflow Frequency and Volume) After Implementation of Recommended CSO Control Measures

CSO area	CSO outfall number	Recommended CSO control measure	20-year moving average annual overflow frequency ^a	Average annual overflow volume (MG) ^b	Peak no impact release rate (MGD) ^c	Comments
Shared West Ship Canal (Joint City and King County)						
Fremont/Wallingford	147	15.24 MG deep tunnel storage located north of the Ship Canal	0.5	1.5	n/a	Overflows diverted to tunnel until tunnel is full
Fremont/Wallingford	174		0.5	1.0	n/a	Overflows diverted to tunnel until tunnel is full
Ballard	150/151		0.5	1.0	n/a	Overflows diverted to tunnel until tunnel is full
Ballard	152		0.5	3.6	n/a	Overflows diverted to tunnel until tunnel is full
King County 3 rd Ave. W	008		0.5	3.1	n/a	Overflows diverted to tunnel until tunnel is full
King County 11 th Ave. NW	004		0.4	3.9	n/a	Overflows diverted to tunnel until tunnel is full
Tunnel performance and Effluent pump station flow rate			Not Applicable	Not Applicable	32	Tunnel Effluent PS discharge rate based on Ballard wet weather siphon NIRR
Off-Line Storage						
Montlake	020	0.16 MG off-line storage pipe	0.6	0.40	0.32	Flows released from storage are passed through existing City Pump Station 13 so that peak outflow from the basin is not increased
Leschi	028	0.01 MG off-line storage pipe	0.5	0.02	0.02	
Leschi	029	0.02 MG off-line storage pipe	0.5	0.03	0.04	
Leschi	031	0.33 MG off-line storage tank/pipe	0.5	0.17	0.66	Outflow from common storage tank
Leschi	032		0.4	0.01		

Table 5-33 Projected Annual Performance (20-year Moving Average Overflow Frequency and Volume) After Implementation of Recommended CSO Control Measures

CSO area	CSO outfall number	Recommended CSO control measure	20-year moving average annual overflow frequency ^a	Average annual overflow volume (MG) ^b	Peak no impact release rate (MGD) ^c	Comments
Leschi	036	0.03 MG off-line storage pipe	0.5	0.06	0.06	
Magnolia	060	0.11 MG off-line storage pipe	0.5	0.15	0.22	
Central Waterfront	069	0.13 MG off-line storage pipe	0.7	0.50	0.26	
Delridge/Longfellow	099	0.17 MG off-line storage pipe	0.8	0.55	0.34	
East Waterway	107	0.5 MG off-line storage tank	0.7	0.01	1.0	
Duamish	111	0.01 MG off-line storage pipe	0.7	0.09	0.02	
Portage Bay/Lake Union	138	0.11 MG off-line storage pipe	0.6	0.15	n/a	Flows released from storage are passed through the existing City Pump Station 20 so that outflow from the basin is not increased
Montlake	139	0.01 MG off-line storage pipe	0.5	0.02	n/a	Flows released from storage are passed through the existing City Pump Station 25 so that outflow from the basin is not increased
Montlake	140	0.05 MG off-line storage pipe	0.4	0.08	n/a	Flows released from storage are passed through the existing City Pump Station 25 so that outflow from the basin is not increased

Table 5-33 Projected Annual Performance (20-year Moving Average Overflow Frequency and Volume) After Implementation of Recommended CSO Control Measures

CSO area	CSO outfall number	Recommended CSO control measure	20-year moving average annual overflow frequency ^a	Average annual overflow volume (MG) ^b	Peak no impact release rate (MGD) ^c	Comments
Delridge/ Longfellow	168	0.25 MG off-line storage pipe	1.0	2.50	n/a	Peak outflow rate not increased
Delridge/ Longfellow	169	0.25 MG off-line storage pipe	0.5	0.80	n/a	Peak outflow rate not increased
Flow Diversion						
North Union Bay	018	Modifications to CSO control structure 018B	0.8	1.8	n/a	Increase peak flow from 5.5 MGD to 9 MGD to King County

Notes:

^a 20-year moving average overflow frequency with Rainfall scaling factor of 1.0

^b Estimated volumes less than 5,000 gallons are shown as < 0.01 MG. Volumes of 5,000 to 10,000 gallons are rounded up to 0.01 MG.

^c Maximum discharge rates from storage facilities based on King County provided "no-impact release rates"

5.9 Implementation Plan for Recommended Option

5.9.1 Overview

The implementation plan describes the approach the City will take to meet design, construction, and operational compliance milestones for each of the CSO control projects. The implementation schedule will affect rates, employment, public and local businesses, agency resource allocation, and other agency projects.

The Consent Decree requires the LTCP to develop an expeditious schedule for the design, construction, and implementation of all CSO control measures. If it is not possible for the City to design and construct all measures simultaneously, the LTCP will include a phased schedule based on the relative importance of each measure with the highest priority given to those projects which most reduce the discharge of pollutants.

5.9.2 Prioritization and Scheduling Criteria

5.9.2.1 Project Scheduling Approach

Project scheduling takes into consideration task durations as well as the relative priorities of the projects. Project duration assumptions are listed in Table 4-12.

The LTCP used two methods to determine the priority of projects which most reduce the discharge of pollutants. The first method followed the EPA guidelines for sensitive areas, which determines which basins have the largest impact on receiving water bodies and human health. The results of the revised sensitive areas analysis were summarized in Figure 5-3. The LTCP will give the highest priority to controlling overflows to the highest ranked sensitive areas.

The second method was then used to rate the results as ranked by the first method to compare the relative cost-effectiveness of each CSO project on a total project cost per gallon of CSO discharge volume reduced. The LTCP will give the highest priority to controlling overflows to the CSO projects with the lowest cost per CSO discharge gallon reduced.

5.9.2.2 Project Phasing

Because the CSO projects vary in construction complexity and project costs, their durations range from 5 years to 11 years based on the City's project implementation experience. In addition, project funding will influence the implementation schedule and require a phased construction approach.

5.9.2.3 Consent Decree Required Milestone Dates

For each CSO control measure, the Consent Decree requires the implementation schedule to specify milestone dates for the following project activities: draft and final engineering report, draft and final plans and specifications, construction start, construction completion, and achievement of controlled status. These required milestone dates have been identified for each recommended CSO control measure and are summarized in Table 5-34 below.

5.9.3 LTCP Option Implementation Schedules

Figure 5-26 presents the overall schedule for the recommended CSO control measure projects. The schedules show the project duration and the Consent Decree milestone dates for construction completion and achievement of controlled status.

In most CSO areas the overall strategy is to first implement sewer system improvements prior to implementing storage facilities. The sewer system improvements are expected to either reduce the need for an additional storage facility, or at the least to reduce the required size of the facility. Once the sewer system improvements have been constructed their ongoing performance will be evaluated, and any impacts on the sizing of required CSO facilities will be assessed.

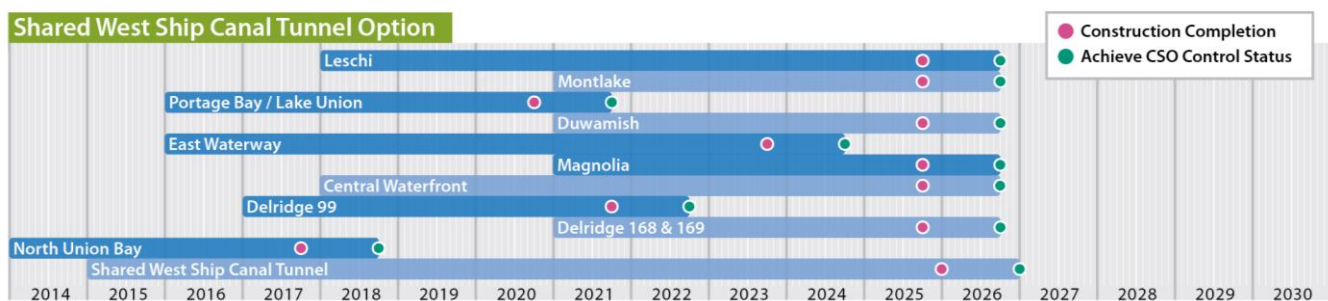


Figure 5-26. Recommended Option Implementation Schedule

The EPA CSO Control Policy indicates that the implementation of CSO projects should be prioritized based on the results of the Sensitive Area Study (see Section 5.3.6). The high priority CSO basins from the City Sensitive Area Study include the following:

- Ballard Basins 150, 151, and 152
- Fremont/Wallingford Basins 147 and 174

- Delridge Basins 168 and 169
- North Union Bay Basin 018

The uncontrolled CSO basins in the Ballard and Fremont/Wallingford CSO areas will be controlled with the completion of the Shared West Ship Canal Tunnel. This CSO control measure is one of the first projects to begin, due to its long duration.

A sewer system improvement project is currently being implemented in Basins 168 and 169 in Delridge, with an NPDES permit deadline to complete construction by November 1, 2015. If post-project performance monitoring indicates that these sewer system improvement projects do not bring the basins into control, an additional CSO control measure will be implemented beginning in 2021.

The CSO control measure for Basin 018 in North Union Bay is currently being implemented, with a scheduled construction completion date of September 30, 2017.

The implementation schedule for the lower-priority CSO basins was based on budget availability and coordination with the sewer system improvement program. In basins where sewer system improvements are being implemented, the CSO control measure is not scheduled to begin until the corresponding retrofit project has been completed and the impact of the sewer system improvement on the control volume has been evaluated.

Table 5-34 shows the Consent Decree milestone dates for the Shared West Ship Canal Tunnel as well as the milestones for the remaining 2010 Plan projects and Consent Decree Early Action Projects that will be completed after 2015.

Table 5-34. Milestone Compliance Dates							
	Draft engineering report	Final engineering report	Draft plans and specs	Final plans and specs	Construction start ^a	Construction completion ^b	Achieve controlled status ^c
City-only CSO control measures							
Leschi	6/30/2019	12/31/2019	6/30/2021	12/31/2021	7/1/2022	9/30/2025	9/30/2026
Montlake	6/30/2021	12/31/2021	6/30/2022	12/31/2022	7/1/2023	9/30/2025	9/30/2026
Portage Bay/Lake Union	6/30/2016	12/31/2016	6/30/2017	12/31/2017	7/1/2018	9/30/2020	9/30/2021
Duwamish	6/30/2021	12/31/2021	6/30/2022	12/31/2022	7/1/2023	9/30/2025	9/30/2026
East Waterway	6/30/2017	12/31/2017	6/30/2019	12/31/2019	7/1/2020	9/30/2023	9/30/2024
Magnolia	6/30/2021	12/31/2021	6/30/2022	12/31/2022	7/1/2023	9/30/2025	9/30/2026
Central Waterfront	6/30/2019	12/31/2019	6/30/2021	12/31/2021	7/1/2022	9/30/2025	9/30/2026
Delridge 99	6/30/2017	12/31/2017	6/30/2018	12/31/2018	7/1/2019	9/30/2021	9/30/2022
Delridge 168	6/30/2021	12/31/2021	6/30/2022	12/31/2022	7/1/2023	9/30/2025	9/30/2026
Delridge 169	6/30/2021	12/31/2021	6/30/2022	12/31/2022	7/1/2023	9/30/2025	9/30/2026

Table 5-34. Milestone Compliance Dates

	Draft engineering report	Final engineering report	Draft plans and specs	Final plans and specs	Construction start ^a	Construction completion ^b	Achieve controlled status ^c
North Union Bay	Completed	Completed	Completed	Completed	7/1/2015	9/30/2017	9/30/2018
Shared City/King County West Ship Canal Tunnel CSO control measure							
Shared West Ship Canal Tunnel	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	12/31/2025	12/31/2026

Notes:

^a Construction Start is defined in the Consent Decree, Section IV. Definitions, Paragraph 9 (j).

^b Construction Completion is defined in the Consent Decree, Section IV. Definitions, Paragraph 9 (i).

^c Achieve Control Status will be documented in the City's Annual Report, submitted to EPA and Ecology by March 31 of each year.

5.9.4 LTCP Implementation Plan

5.9.4.1 LTCP CSO Program Management Approach

Implementation of the recommended CSO control measures will be managed by the City in coordination with King County. Figure 5-27 provides a preliminary organizational structure for LTCP implementation that describes the roles and functional responsibilities for City and King County staff as well as outside resources.

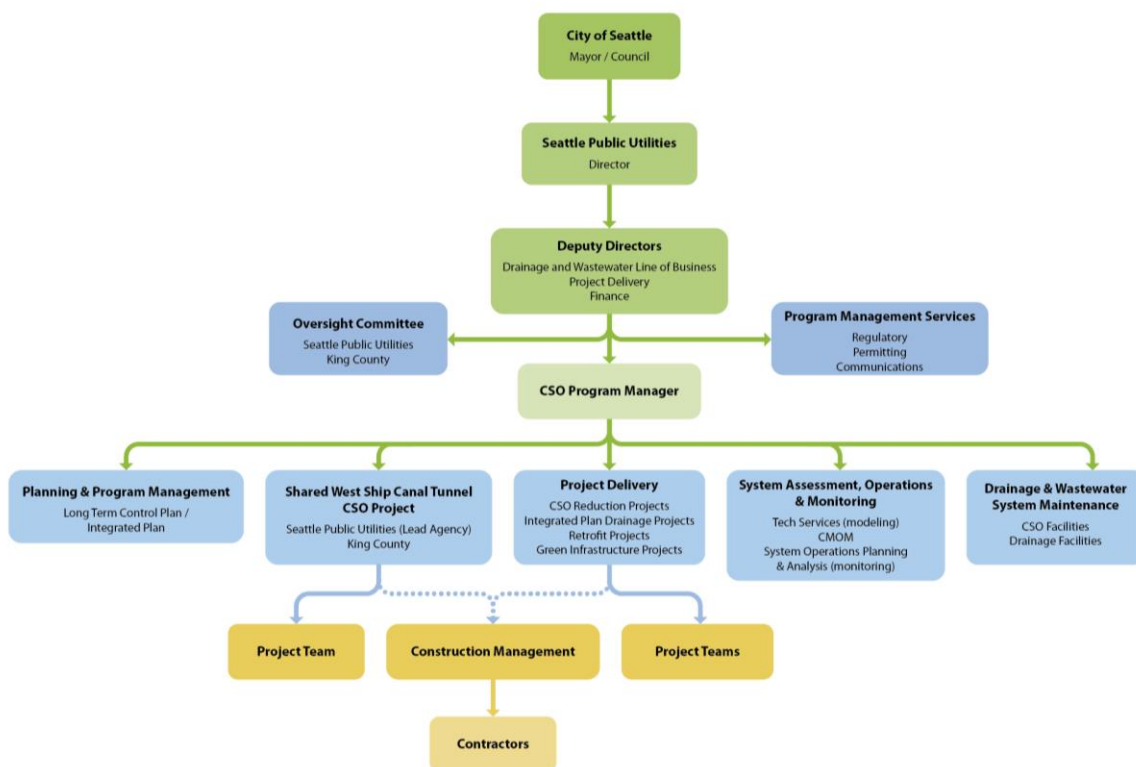


Figure 5-27. Preliminary Organization Structure for LTCP Implementation

5.9.4.2 Shared West Ship Canal Tunnel

The City is the lead agency for the Shared West Ship Canal Tunnel and will be the responsible for project management, design, construction, start-up, and operation. King County and the City will establish a joint project management team with specific roles and responsibilities defined and agreed upon. An oversight committee of the appropriate agency executives will be established to oversee the budget, schedule, configuration, and change management of the project. Roles and responsibilities will be defined by the project-specific agreement to be signed by the agencies.

5.9.4.3 City-Only Neighborhood CSO Control Measures

The City will be responsible for the project management, design, construction, start-up, and operation for all other CSO control measures.

5.9.5 Factors Potentially Affecting Schedule

The LTCP implementation schedule shows the order in which the CSO control measures will be implemented between 2015 and the achievement of control status. The implementation schedule will affect sewer rates, City resource workload, City resources, and local and regional projects. The following major internal and external factors that impact the timing and implementation decisions of the options or individual projects were identified for the LTCP.

5.9.5.1 City Rates

City drainage and wastewater rates will need to be increased to implement the LTCP options. In addition, the City rate payers will also be paying for the implementation of the 2010 Plan CSO projects and the Consent Decree Early Action Projects during the same period (2015 to 2025). LTCP projects may need to be distributed throughout this period to reduce or “flatten” the rate increase. Rate impacts are discussed in detail in Section 4.5, Financial Plan.

5.9.5.2 King County Coordination

5.9.5.2.1 Coordination Strategy

The City and King County both have CSO consent decrees and NPDES Permits with varying compliance dates and priorities that make coordination of shared projects challenging. The City and King County have entered into an agreement for working together on plans, projects, and activities that have the potential to affect both agencies. The City/King County project coordination strategy addresses projects having the potential to impact both agencies and it includes factors for determining joint or independent projects, project coordination levels, and tiered project management and oversight levels. It is expected that this plan will be updated and modified periodically.

King County and the City are each implementing Capital Improvement Programs within the City of Seattle, including independent and joint CSO control, capacity improvements, sanitary sewer overflow control, drainage improvement, and asset management projects. King County has an approved LTCP. The City has prepared a Final LTCP. King County and the City are developing and will implement a Joint System Optimization and Operations Plan. Both agencies will also implement post-construction monitoring plans in the same water bodies. Both agencies agree to assess the cost-efficient level of coordination on all of these projects, and where coordination seems useful, both agencies will work together to develop joint project agreement or detail sheets for each project with the appropriate coordination activities for each project phase.

5.9.5.2.2 Coordination Principles

The purpose of these coordination principles is to provide a foundation for the City and King County to work together on plans, projects, and activities. The principles are summarized below.

- The City and King County will work together on plans, projects, and activities when one agency's plan, project, or activity has the potential to impact the other or when such collaboration benefits the discharge environments, the communities near facilities or discharges each utility serves, or each agency's customers. If either agency identifies potential adverse impacts to the others' systems, projects, operations, community relations, or compliance with regulations, both agencies commit to work together to promptly determine causes and develop preventive actions.
- The relationship of the agencies will be as partners with individual obligations, contracts, and responsibilities.
- Projects and activities will be coordinated with the intent of meeting applicable regulatory standards for treatment, CSO control, and SSO control and drainage.
- Plans, projects, and activities will meet the intent of each agency's Consent Decree and NPDES permit project sequences, schedules, and requirements. Where implementation of plans, projects, or activities would result in conflicts with either agency's Consent Decree and NPDES permit project sequences, schedules, and requirements, the agencies will negotiate together with regulators to resolve the conflict.
- Evaluation of the benefits of plans, projects, and activities to the community and customers will include consideration of financial, social, and environmental criteria.
- Cost sharing opportunities will be determined and reviewed for joint projects. Cost sharing details will be identified for each project and will be consistent with a joint City and King County cost sharing method for joint capital projects.
- Payments or credits for changes in operation and maintenance costs resulting from increased or decreased flows between the City and King County systems will be identified for each project.
- Project scheduling will consider each agency's sequencing and financing priorities.
- Collaboration on projects and activities will consider each agency's unique governmental structures, authorities, legal obligations, and responsibilities, including council structures and processes, financial goals (sewer rates, capacity charge and funding), customers (the City's customers are a subset of King County's customers), the City's drainage responsibilities, and King County's wastewater treatment responsibilities.
- This coordination plan will be reviewed and modified as needed in conjunction with review and amendment of each agency's long-range plans and more frequently by request of either agency.
- Project communications will be developed and agreed upon by the City and King County and will include a discussion of the benefits of joint projects to each agency's customers and stakeholders.
- Decisions on plans, projects, and activities will be made by a joint oversight committee as described in the coordination plan. Conflicts between King County and the City will be resolved in a timely manner by elevating the issues to the joint oversight committee.

5.9.5.3 Opportunities and Conflicts with Other Projects

CSO Basin 107 (East Waterway) will be impacted by the future King County HLKK Project. The proposed HLKK project includes a CSO treatment facility of up to 151-MGD (assuming the use of a ballasted sedimentation treatment process) near the Hanford St Regulator Station and modifications to the Elliott Bay Interceptor to divert wet-weather flows to the CSO treatment facility. The flow diversion may result in decreased CSO control requirements for CSO Basins 107 depending on the final configuration of the HLKK flow diversion from the Elliott

Bay Interceptor to the new CSO plant. The City Consent Decree currently requires that CSO Basin 107 reach construction completion by 2025. Close coordination of the CSO Basin 107 project with King County's HLKK project will need to occur to identify the most cost-effective solution and implementation schedule.

5.9.5.4 Central Waterfront and Elliott Bay Seawall Projects

The proposed CSO Basin 069 (Central Waterfront) control measure for all options must be coordinated with the Elliott Bay Seawall (North) Project. The CSO Basin 069 project location will be significantly impacted by the Elliott Bay Seawall (North) project construction which is currently scheduled for 2018 to 2020. The specific construction schedule cannot be finalized until the City obtains funding for the Elliott Bay Seawall (North) project construction. Constructing the CSO Basin 069 project before the Elliott Bay Seawall (North) project would result in additional disruption to the community and significant additional construction costs for the Seawall project to protect the CSO Basin 069 project in place.

5.10 Financial Plan for Recommended Option

5.10.1 Overview

Significant financial investment in CSO control is necessary for the City to comply with regulatory requirements and improve water quality in the City's surrounding receiving waters. This section describes the projected costs for the LTCP from 2015 through 2045 and the associated incremental rate increases that will be necessary to fund the LTCP.

5.10.2 Financial Capability Matrix

A Financial Capability Matrix combines the Residential Indicator (first phase) and Permittee Financial Capability Indicators (second phase) to give an overall assessment of the City's financial capability (Table 5-35). This assessment can be used to help establish an appropriate and reasonable CSO control implementation schedule. Appendix C contains details on the City's financial capability assessment.

Table 5-35. EPA Financial Capability Matrix			
Permittee financial capability indicator score	Residential indicator (cost per household as a % of MHI)		
	Low (below 1.0%)	Mid-Range (between 1.0% and 2.0%)	High (above 2.0%)
Weak (below 1.5)	Medium burden	High burden	High burden
Mid-range (between 1.5 and 2.5)	Low burden	Medium burden	High burden
strong (above 2.5)	Low burden	Low burden	Medium burden

5.10.3 Baseline Wastewater and Drainage Rates

The monthly baseline rates, not including the costs of the LTCP or Integrated Plan Alternatives, were estimated. The monthly wastewater and drainage rates for the current City Strategic Business Plan were used to estimate the baseline rates from 2015 through 2030. The King County Treatment Wholesale baseline rates also include the King County treatment cost increases provided by King County in June 2013 and the rate impact estimates provided in the King County Executive's Recommended Combined Sewer Overflow Control Plan June 2012. The baseline monthly rates are listed in Table 5-36.

Table 5-36. Baseline Monthly City Wastewater and Drainage Rate Estimate (with Inflation)

Baseline rates	2015	2020	2025	2030
Wastewater ^a	\$17.85	\$26.84	\$35.89	\$42.51
Drainage ^b	\$29.15	\$42.38	\$52.65	\$58.12
King County treatment wholesale rate ^c	\$33.31	\$41.42	\$39.26	\$39.82
Total baseline rate	\$80.31	\$110.64	\$127.80	\$140.46

Notes:

^a The wastewater baseline rate represents the typical residential monthly system rate based on 4.3ccf (100 cubic feet) drinking water consumption per month. All LTCP-related capital costs have been removed.

^b The drainage baseline rate represents the typical residential monthly rate for the average parcel, which is a residential lot between 5,000-6,999 square feet (Small Residential Tier 3). All LTCP-related capital costs have been removed.

^c King County charges a wholesale treatment rate to cities and local wastewater districts that send flows to the regional system. The City of Seattle passes through this rate to customers via the treatment component of the sewer rate. This analysis assumes the typical residential monthly bill with drinking water consumption of 4.3ccf.

5.10.4 Project Revenue Requirements and Rate Impacts

5.10.4.1 Assumptions

The assumptions used in this analysis include budget estimates used for the Strategic Business Plan and inflation rates for both capital and non-capital projects. The non-capital projects assume the inflation rate utilized in the Strategic Business Plan through 2020 and then an average for later years. Capital projects utilized the national construction inflation forecast provided by the consulting firm of HIS Global Insight.

King County treatment cost increases assume the most recent forecast (2015 to 2019) provided by King County in June 2013 and the rate impact estimates provided in the King County Executive's Recommended Combined Sewer Overflow Control Plan, June 2012.

5.10.4.2 Projected Rates and Rate Impacts

Based on the planning-level cost estimates and the implementation schedules for each option, the City analyzed how the recommended option may affect monthly City wastewater and drainage rates between 2015 and 2045. Table 5-37 shows the total monthly estimated rates (baseline and including the costs of the recommended option) between 2015 and 2030.

Table 5-37. Monthly Wastewater and Drainage Rates for LTCP Implementation (with Inflation)

Option	2015	2020	2025	2030
Total baseline rate only	\$80.31	\$110.64	\$127.80	\$140.46
Recommended shared West Ship Canal Tunnel Option	\$81.36	\$115.44	\$133.15	\$145.57

Figure 5-28, Monthly Wastewater and Drainage Rates for Baseline and LTCP Implementation, shows the total monthly rate (Total Baseline Rate and additional LTCP Rates).

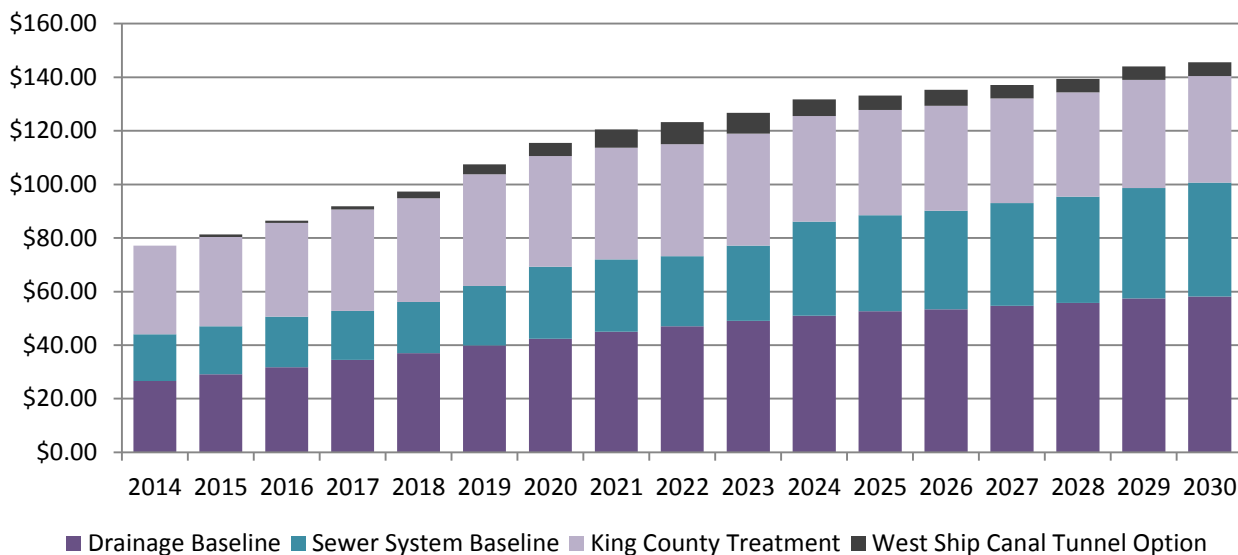


Figure 5-28. Monthly Wastewater and Drainage Rates for Baseline and LTCP Implementation

Given the recommended option, the monthly City wastewater and drainage rates are estimated to increase an additional \$5.11 by 2030 as shown in Table 5-37. By comparison, the current baseline City rates without implementing any LTCP projects are estimated to increase by \$60.15 during the same period.

5.10.5 Recommended Financial Plan

The estimated costs of the plan will be funded with a combination of additional borrowing and cash funds. The City is recommending funding the LTCP with 75 percent revenue bond funds and 25 percent cash as per the Financial Policies for the Drainage and Wastewater Fund. The line of business maintains a strong rating of Aa/AA with both Moody's and Standard and Poor's rating agencies, and as such, receives favorable interest rates in the bond market. The tax-exempt bonds are backed solely by the revenues of the fund and are typically issued for a term of 30 years. As projected earlier, increases in both the sewer and drainage rates will be used to fund the cost of borrowing and the 25 percent cash contribution.

When available, the City will apply for grant dollars and low-cost loans. These will typically be from the Washington State Revolving Fund or Public Works Trust Fund. However, given the uncertainty regarding availability of grants and loans from these sources, no funds from these sources have been assumed in the rate impact analysis.

5.11 Operation Plan

This section presents the City's general approach to operating the recommended option. The section includes proposed staffing requirements, CSO operating strategies, and system operation coordination with King County.

5.11.1 City and King County Joint Operations and System Optimization Plan

Implementation of the recommended option follows directly from terms of each jurisdiction's Consent Decree which requires coordination of the planning, implementation, and operation of CSO controls within the combined system. The City's Consent Decree includes the following requirement in paragraph 31:

No later than March 1, 2016, the City shall submit to EPA and the State for their approval a Joint Operations and System Optimization Plan ("Joint Plan") that the City will work with King County in jointly developing and which satisfies the requirements of Appendix F. This Joint Plan shall be applicable to the City's and King County's respective CSO systems, and (a) be consistent with each entity's operational objectives, (b) ensures the optimal level of coordination and information sharing is maintained, and (c) optimizes system and joint operations.

During 2014, the City and King County Joint Plan team developed and evaluated operational alternatives in CSO basins where there is the greatest opportunity for operation and system optimization. The second required progress report was submitted to EPA and Ecology in December 2014. The Final Joint Plan to be submitted in March 2016 will include detailed information on the operation of recommended City CSO control measures. For example, the City will design and operate the tunnel in coordination with King County to satisfy the following operating conditions:

- The City CSO facilities will operate within the King County NIRR to protect down-stream King County facilities and ensure regulatory compliance.
- Upgrades to the system, including options analysis and design, to respond to changes in flow from the basins, future regulatory changes, or errors in control volume estimates will be shared in accordance with the cost sharing agreement.
- The design and operation of the tunnel will include grit and debris control to avoid downstream settling and the compromising of system capacity.

Table 5-38 presents an accomplishment matrix summarizing the status and completion date for each of the Joint Plan requirements listed in the Consent Decrees for both agencies.

Table 5-38. Operations and Maintenance Status	
Consent Decree item ^a	Status
(a) Overview of those interdependent portions of the King County's regional wastewater, conveyance, and treatment system and the City's wastewater collection system	Completed Q4 2013
(b) Methods to accommodate each agency's operational objectives while complying with their contractual obligations	In progress, anticipated completion date Q4 2015

Table 5-38. Operations and Maintenance Status	
Consent Decree item ^a	Status
(c) Shared operational objectives for the King County and the City's combined sewer systems	Completed Q2 2013
(d) Organizational structure	Completed Q3 2013
(e) Modes of operation (dry, wet, transition) for identified CSO facilities	In progress, anticipated completion date Q4 2015
(f) Each agency's operational decision hierarchy	In progress, anticipated completion date Q4 2015
(g) Identified CSO facilities, if any, that may be beneficial to jointly operate and/or monitor	In progress, anticipated completion date Q4 2015
(h) Real-time communication plans/protocols	In progress, anticipated completion date Q4 2015
(i) Emergency and special operations protocols	In progress, anticipated completion date Q4 2015
(j) A process for incorporating the Joint Plan into the design of new capital projects for the combined system, including the King County and City's CSO long-term control plans	In progress, anticipated completion date Q4 2015
(k) A process for updating the Joint Plan every three years	In progress, anticipated completion date Q4 2015

Notes:

^a Joint Plan components are listed in Appendix D of King County's Consent Decree and in Appendix F of the City's Consent Decree.

5.11.2 Recommended Shared West Ship Canal Tunnel Option Staffing

The City has projected the additional operation and maintenance staffing needed to commission, operate, and maintain the LTCP projects. Specific numbers of full-time equivalent (FTE) employees and staff responsibilities for the recommended option are summarized in Table 5-39 for current (2015), near-term (2020), construction completion (2025), and achievement of controlled status (2030).

The City Operations staff refers to control center operators in the System Operations and System Operations Planning and Analysis (SOPA) sub-groups who will conduct performance monitoring, modeling, post-construction monitoring reporting, facility configuration and control strategies management, and operations data stewardship. Maintenance staff refers to Maintenance sub-group staff who will perform maintenance of the CSO control measure facilities including pump stations, control structures, and CSO storage and conveyance facilities.

Based on the implementation schedules for the recommended option, the first additional LTCP operation and maintenance staff will be required for CSO facility commissioning and acceptance testing by 2020. The total number of additional operations and maintenance staff will be up to 11 FTEs after construction completion in 2025.

Table 5-39. Operations and Maintenance Staffing Needs for Recommended Option

Recommended option	LTCP staffing requirements (FTEs)			
	2015 (current)	2020 (near term)	2025 (construction completion)	2030 (controlled status)
Shared West Ship Canal Tunnel Option	0.0	0.5	4.1	4.1
	<u>0.0</u>	<u>0.7</u>	<u>6.9</u>	<u>6.9</u>
Operations	0.0	1.2	11.0	11.0
Maintenance				
Total O&M staff				

5.11.3 Maintenance of CSO Control Measures

In general, routine inspection and cleaning activities are established for each asset class and assigned to the appropriate skilled craft as part of the City asset on-boarding process. Conditions are assessed and follow-up activities (such as supplemental cleaning, adjustments, repair, replacement, etc.) are initiated based on internal service-level requirements and industry best practices. Frequency of routine scheduled and event-driven maintenance activities are adjusted according to condition assessment findings and anticipated weather events. The goal is to apply the appropriate, timely, and necessary levels of maintenance that ensure assets perform as designed. Detailed maintenance strategies will be prepared during the LTCP implementation phase for the preventative, corrective, and emergency maintenance procedures.

The City established maintenance procedures for the new Windermere and Genesee CSO storage facilities. These CSO storage facilities are scheduled for startup and commissioning in 2015 and the City maintenance experience will be used to update the procedures for the following CSO facilities:

- Storage pipes and tanks
- Pump systems
- Conveyance pipelines
- Gates, valves, and weirs
- Odor control systems
- SCADA systems
- Automated wash down systems

5.11.4 Facilities and Grounds Operation of CSO Control Measures

Master operating strategies are intended to define protocols for optimizing the operation of multiple CSO facilities. Operating strategies presented in this plan are presented in general planning-level detail. Project specific operating strategies will be prepared during the LTCP implementation phase.

Storage will be provided through new in-line storage pipelines, off-line storage tanks, or an off-line deep tunnel storage facility. Existing CSO storage facilities also may need to be used to achieve the CSO performance

standard. The general CSO master system operating approach is to provide sufficient real-time flow monitoring for each CSO facility to determine the influent flows, CSO facility performance, CSO overflow, and CSO storage release flows back into the City or King County interceptor system. General operating strategies will be developed for operation between, during, and after CSO events:

- Inter-CSO events occur between CSO storage events. During these periods, operating procedures such as weather forecasting, operational preparation, and control revisions can be performed to prepare the CSO facility for an upcoming CSO storage event.
- During-CSO events are the actual storage events when a storm occurs and the CSO facility receives CSO flows for storage. During these events, operating procedures for flow monitoring, equipment monitoring, CSO storage, and pumping control will be required.
- Post-CSO events include the release of the stored CSO flows into the King County interceptor system. Detailed flow monitoring will be required to not exceed the King County NIRR for each City CSO control facility to minimize downstream impacts to the King County interceptor and West Point WWTP.

5.11.4.1 Automation and SCADA

All LTCP projects will be monitored in real time using the City SCADA system, and each project will be operated by on-site Programmable Automation Controllers. PACs will be programmed to operate gates, pumps, and other mechanical devices. The City Control Center operators will have 24/7 real-time remote access via the SCADA system to monitor and, if needed under unusual circumstances, to override the local PAC control.

5.11.4.2 Monitoring

Each LTCP project will have real-time monitoring instrumentation to monitor levels, mechanical devices, and flows. Data will be available through the City SCADA system in real time to the Control Center and in near real time to other users of the data.

5.11.4.3 Storage Control Strategy

The LTCP projects will generally use automated sluice gates or valves to constrict flow and direct it into storage. Automated control of these devices can be overridden if necessary by a local or remote operator. Flows will be released from storage either by opening flow control gates or valves or by pumping from the storage facility back into the conveyance system.

The City CSO facilities will operate within the King County NIRR to protect down-stream King County facilities and ensure regulatory compliance. Generally, storage flow release will be controlled by the PAC and will take place when monitoring equipment indicates that there is available capacity in the downstream system. Downstream conditions that are assessed in real time may be restricted to just the immediate project vicinity or may include City and King County facilities farther downstream or in nearby basins.

5.11.4.4 Storage Performance Monitoring

Continuous evaluation of the CSO system and each LTCP project will be performed by the City SOPA group. All operational and metrological data is gathered by the SOPA group, and CSO control performance will be closely evaluated after significant CSO and storm events.

Downstream hydraulic limitations resulting from King County interceptor and treatment plant capacity will impact City CSO storage operations and need to be evaluated as part of the overall City operating strategy.

Figure 5-29. Illustrates how the recommended Shared West Ship Canal Tunnel will operate. The tunnel is a 15.24 MG storage facility that will release its stored flows into the King County North Interceptor. King County has provided NIRR for the tunnel effluent pumping to avoid impacting the downstream King County North Interceptor.

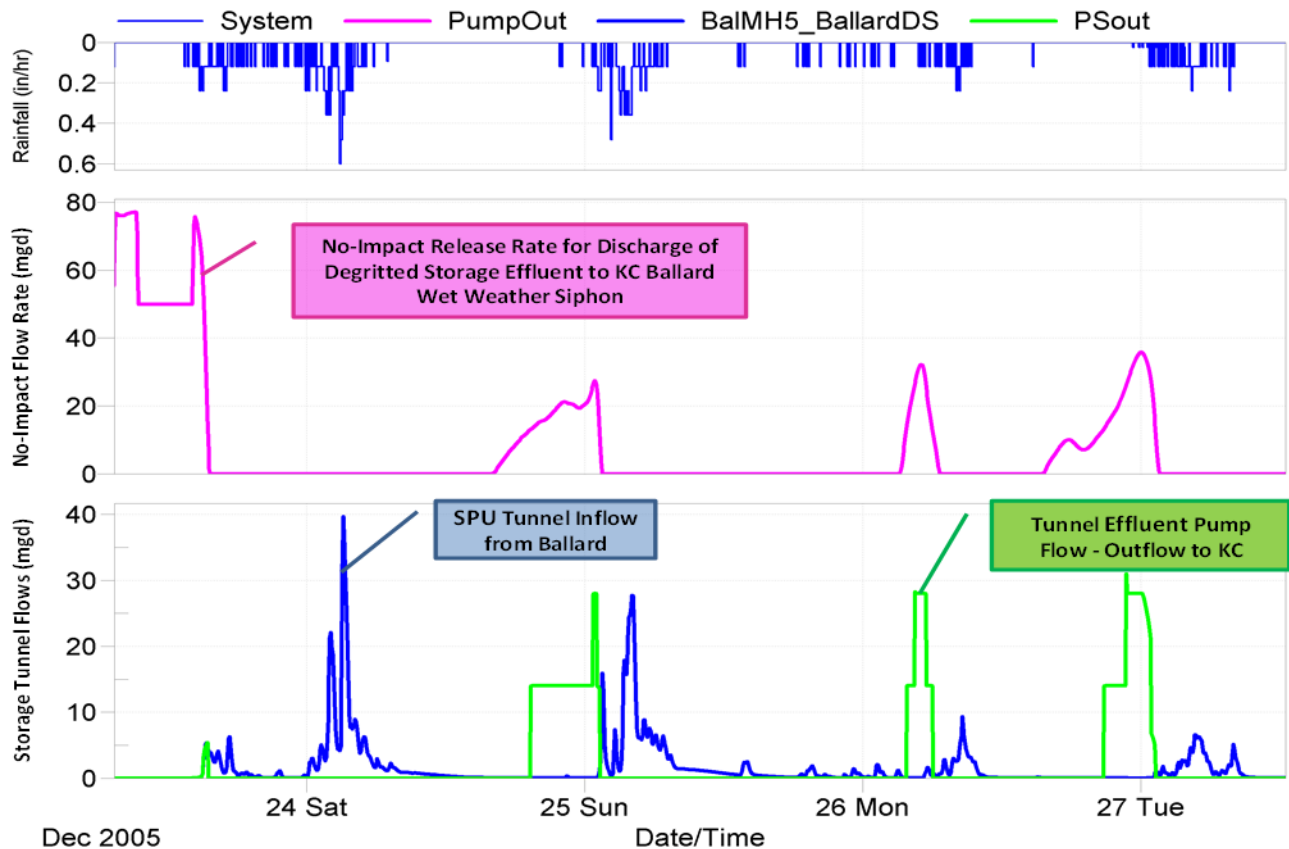


Figure 5-29. Example of Shared West Ship Canal Tunnel Storage Operation During CSO Event

As the rainfall increases (top row, blue column), CSO flows will increase in both the King County and City sewer systems. To prevent CSOs, rain-induced CSO flows (bottom row, blue line) will be diverted into the proposed tunnel to prevent overflows. As rainfall subsides and interceptor capacity is available, stored CSO flows can be released (bottom row, green line) back into the sewer system.

However, since all City stored flows will be released into the King County interceptor system, the King County interceptor and treatment plant capacity are major factors in how the City CSO facilities operate and when the City CSO facilities can release stored CSO flows. This limitation is called the NIRR (middle row, pink line).

The proposed facility will need to release stored CSO flows multiple times during a prolonged CSO event such as the example storm shown. Sufficient flow monitoring and real-time control systems must be provided to determine when and how much CSO flows need to be diverted into storage and when the stored flows can be released to the King County interceptor system.

5.12 Measures of Success

The measure of success for the City CSO program will be the successful construction and operation of the recommended LTCP projects by the required critical milestone dates and demonstration, through post-construction monitoring, that the CSO control status is in accordance with the Consent Decree.

5.12.1 Overview

The EPA *Combined Sewer Overflows Guidance for Long-Term Control Plan*, 1995 recommends in Section 1.6.8, *Measures of Success*, that

As municipalities, NPDES permitting authorities, and the public embark on a coordinated effort to address CSOs, serious consideration should be given to “measures of success.” For purposes of this discussion, measures of success are objective, measurable, and quantifiable indicators that illustrate trends and results over time. Measures of success generally fall into four categories:

- 1. Administrative measures that track programmatic activities;*
- 2. End-of-pipe measures that show trends in the discharge of CSS flows to the receiving water body, such as reduction of pollutant loadings, the frequency of CSOs, and the duration of CSOs;*
- 3. Receiving water body measures that show trends of the conditions in the water body to which the CSO occurs, such as trends in dissolved oxygen levels and sediment oxygen demand; and*
- 4. Ecological, human health, and use measures that show trends in conditions relating to the use of the water body, its effect on the health of the population that uses the water body, and the health of the organisms that reside in the water body, including beach closures, attainment of designated uses, habitat improvements, and fish consumption advisories. Such measures would be coordinated on a watershed basis as appropriate.*

The Consent Decree also states that the performance criteria is the 20-year moving average, which is defined in Section IV. Definitions, paragraph (ee):

(ee). “Twenty Year Moving Average” shall mean the average number of untreated discharge events per CSO Outfall over a twenty year period for purposes of compliance with WAC 173-245-020(22). For previously Controlled CSO Outfalls and where monitoring records exist for the past 20 consecutive years, the twenty year moving average shall mean the average number of untreated discharges per CSO Outfall over the 20 year record. On an annual basis, the twenty year moving average will be calculated and includes the current monitored year and each of the previous 19 years of monitored CSO data. For CSO reduction projects and Controlled CSO Outfalls where a complete twenty year record of monitored data does not exist, missing annual CSO frequency data will be generated based on the predicted CSO frequency for a given year as established in the approved engineering report or facility plan. For each CSO reduction project, the engineering report or facility plan shall predict the CSO frequency for each CSO Outfall (s) based on long-term simulation modeling using a 20-year period of historical rainfall data, the hydraulic model,

the CSO control project design and assuming the CSO control project existed throughout the 20-year period. For CSO reduction projects, the level of control is the number of discharge events per CSO Outfall per year that are estimated to occur based on the designed CSO control project over a 20-year period. The level of control will be estimated for each year for a period of 20 years in the engineering report or facility plan. For the time period between the approval of the engineering report and the CSO reduction project's Construction Completion date, the City shall use the same model for the approved design along with the corresponding rainfall data for this period of time to derive CSO frequencies. This information will be submitted as an amendment to the engineering report or facility plan. For CSO reduction projects, the 20-year moving average will use the approved level of control, on an annual basis, for each of the preceding years for which monitored data does not exist in conjunction with monitored data after the CSO control project has been constructed.

5.12.2 Post-Construction Monitoring Program

The Consent Decree outlines the requirements of a post-construction monitoring program. The Consent Decree outlines three key components of the post-construction monitoring program, as summarized below:

- **Achieving Controlled Status:** The Consent Decree stipulates that “one year following Construction Completion of each CSO control measure, the City shall document that the associated CSO Outfall has been controlled.” In order to determine whether a CSO outfall has achieved controlled status, each completed CSO control measure will undergo post-project performance monitoring. This term, which is not contained in the Consent Decree, is used to describe the flow monitoring, modelling, and analysis that must be conducted by the City in order to determine whether a CSO outfall has achieved controlled status. In general, post-project performance monitoring consists of the following steps:
 - Monitoring flows of the constructed CSO control measure to obtain actual operating and CSO frequency information
 - Revising the approved hydraulic model to incorporate the as-constructed CSO control measure project
 - Calibrating the as-constructed model with actual performance and flow data
 - Calculating the moving 20-year average annual overflow frequency analysis using a combination of flow monitoring data supplemented with computer simulations that assume the constructed CSO control measure has been in operation for 20 years.

The control measure must meet a performance standard of no more than one untreated discharge per CSO outfall per year on a 20-year moving average. The results of each control project's post-project performance monitoring will be included in the following year's annual report submitted to EPA and Ecology in compliance with the consent decree and the NPDES permit.

- **Implement the Post-Construction Monitoring Plan (PCMP):** As described in the Consent Decree, the City is required to “implement the Post-Construction Monitoring Plan... as conditionally approved by the State... by developing and implementing Quality Assurance Project Plans for each CSO control measure, in accordance with the schedule identified in the LTCP.” The purpose of the PCMP is to demonstrate achievement and compliance with the State's water quality standard. This will include the development of sediment sampling and analysis plans for each of the 14 representative outfalls identified in the

conditionally approved PCMP. The PCMP was submitted as a separate document for approval on May 29, 2015.

- Submit the PCMP report: As described in the consent decree, the City is required to submit a PCMP report within 120 days after complete implementation of the PCMP.

The PCMP report will:

- Summarize the data collected pursuant to the PCMP
- Analyze whether the completed CSO control measures have met and continue to meet the design criteria and performance criteria specified in the LTCP
- Show that the City's operation of its CSS complies with the CSO control policy, the CWA and its implementing regulations, all applicable state law and regulations, and the City's NPDES permit.

EPA and Ecology approval of the PCMP report will confirm that the CSO control measure has satisfied the consent decree requirements for post-construction monitoring.

In summary, the City's PCMP consists of two primary components, as summarized in Table 5-40 below.

Table 5-40. Summary of the Post-Construction Monitoring Program		
Component	Description/purpose	Applicable deadlines
Post-project performance monitoring	Determine whether an uncontrolled CSO outfall has been brought into control due to the construction of CSO control measures. This program is implemented on a project-by-project basis.	Achieve controlled status one year following construction completion.
Post-project construction monitoring	Demonstrate achievement/compliance with the State's water quality standard. This program is implemented at 14 surrogate outfalls: 013, 018, 028, 047, 063, 068, 071, 095, 099, 111, 147, 151, 169, and 174.	Complete post-construction monitoring for all CSO outfalls except 071, 099, 111, 147, 174, and 151 by December 31, 2028, and the report by December 31, 2029. Complete post-construction monitoring of CSO Outfalls 071, 099, 111, 147, 174, and 151 by December 31, 2035, and the report by April 30, 2036.

5.12.3 City/King County Monitoring and Modeling Memorandum of Agreement

The City and King County have developed flow monitoring and modeling requirements for the purpose of quantifying how much impact, if any, the completed CSO control measures have on downstream King County facilities. In general, these requirements include several years of pre-construction flow monitoring to establish baseline conditions followed by a minimum of five years of post-construction flow monitoring. This data is then used to determine what payments the City will be required to make to King County for increased capital and operational expenses at downstream locations.

These requirements will be finalized with the approval by each agency of the term and detail sheets for each shared project.

5.12.4 Coordination with Other Programs

The Joint Operations Plan is discussed in Section 5.11, Operation Plan. In conformance with the Consent Decree, the final Joint Plan will be issued March 1, 2016.

5.12.5 Data Evaluation and CSO Performance Report

The City is required under its NPDES permit to submit an annual report to Ecology for review and approval by March 30 of each year. The annual report must cover the previous calendar year and report the frequency and volume of all CSO overflows and determine the control status for all permitted CSO outfalls.

The City is also required under the Consent Decree to submit an annual report to EPA and Ecology until the Consent Decree terminates. The first Consent Decree annual report was submitted to EPA and Ecology in October 2013. The second Consent Decree annual report was combined with the annual NPDES permit report and submitted in March 2014. Each subsequent annual Consent Decree report will be submitted by March 30 of the following year as a combined report with the Annual Report.

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Protecting Seattle's Waterways

Volume 3

Integrated Plan

Final | May 29, 2015



**Volume 3
Integrated Plan**

Final
May 29, 2015

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List of Abbreviations

Term	Definition	Term	Definition
µg/L	microgram(s) per liter	O&M	operations and maintenance
303(d)	list of impaired water bodies	PAH	polycyclic aromatic hydrocarbon
As	arsenic	PBDE	polybrominated diphenyl ether
AVL	Automated Vehicle Location	PCB	polychlorinated biphenyl
AWQC	ambient water quality criteria	PLM	pollutant load model
BMP	best management practice	PM	particulate matter
BOD	biochemical oxygen demand	PSP	Puget Sound Partnership
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act	RCOC	Representative Constituent of Concern
CESF	chitosan-enhanced sand filtration	RCW	Revised Code of Washington
CFU	colony forming unit(s)	RF	receptor factor
CI	confidence interval	RfD	reference dose
City	City of Seattle	ROS	regression on order statistics
cPAH	carcinogenic polycyclic aromatic hydrocarbon	SCADA	supervisory control and data acquisition
COC	Constituent of Concern	sdt	short dry ton(s)
CSO	combined sewer overflow	SF	slope factor
Cu	copper	SS4WQ	Street Sweeping for Water Quality program
CWA	Clean Water Act	SSI	Sewer System Improvements
DO	dissolved oxygen	State	Washington State
Ecology	Washington State Department of Ecology	SWMM5	EPA Storm Water Management Model, Version 5
EIV	exposure index value	T&E	threatened and endangered
EMC	event mean concentration	TSS	total suspended solids
EPA	U.S. Environmental Protection Agency	UCL	upper confidence limit
GIS	geographic information system	UIC	underground injection control
kg	kilogram(s)	USACE	U.S. Army Corps of Engineers
LCL	lower confidence limit	WAC	Washington Administrative Code
LTCP	Long-Term Control Plan	WQ	water quality
MCLG	maximum contaminant level goal	WTD	(King County) Wastewater Treatment Division
MG	million gallon(s)	WWHM	Western Washington Hydrology Model
mg/L	milligram(s) per liter	WWPCA	Washington Water Pollution Control Act
MG/yr	million gallons per year	WWTP	wastewater treatment plant
mL	milliliter(s)	yr	year(s)
MODA	Multiple Objective Decision Analysis	Zn	zinc
MTCA	Model Toxics Control Act		
N/A	not applicable		
NDS	Natural Drainage Systems		
NPDES	National Pollutant Discharge Elimination System		

Integrated Plan Summary

Background

The City of Seattle (City) is committed to protecting and enhancing water quality to sustain and improve the environment and Seattle's quality of life, while providing critical sewer and drainage services for Seattle residents, businesses, and visitors. The City operates a sewer system and a municipal separate storm sewer system, both of which are permitted under the National Pollutant Discharge Elimination System (NPDES) by the Washington Department of Ecology (Ecology).

The storm sewer system serves approximately two-thirds of the city, discharging approximately 13 billion gallons of stormwater to the receiving water bodies in and around the city during an average year. The combined sewer system serves approximately one-third of the city, conveying stormwater and sewage to regional wastewater treatment plants (WWTPs) owned and operated by King County. During heavy rainfall events, the combined sewer system is designed to allow discharge at designated relief points (outfalls) in order to avoid sewage overflows into streets, homes and businesses. These discharges are called combined sewer overflows (CSOs). CSOs are a mixture of untreated stormwater (about 90 percent) and wastewater that can adversely affect receiving water bodies.

The City is taking a number of actions to reduce water pollution reaching the receiving water bodies in and around Seattle. Those actions include implementing stormwater pollution reduction programs and constructing structural stormwater controls and CSO control projects. The City has completed numerous CSO control projects during the past 50 years, resulting in substantial reductions in CSO discharges. Despite these efforts, roughly 154 million gallons (MG) of stormwater and sewage were discharged during CSO events in 2012. Further reductions in CSOs are needed to protect our water bodies.

The City is developing a Long-Term Control Plan (LTCP) to achieve further reductions in CSO discharges. The LTCP focuses on the areas of the city that have not yet attained compliance with Washington state (State) and federal requirements for CSO discharges. The City is developing the LTCP under a Consent Decree agreement with the U.S. Environmental Protection Agency (EPA), U.S. Department of Justice, and Ecology, filed on April 16, 2013, and lodged on July 3, 2013, under Civil Action 2:13-cv-00678 (USA, 2013). The LTCP prescribes a number of CSO control projects (referred to herein as "LTCP projects") that must be constructed by December 31, 2025, in order to comply with the Consent Decree.

The City has devoted substantial resources to CSO controls over the past 50 years but only limited resources have been available to address the water quality impacts of discharges from the City's municipal separate storm sewer system. Ecology has found that stormwater runoff is the main pathway through which toxic pollutants enter Puget Sound (Ecology, 2011a), and the Puget Sound Partnership has identified stormwater pollution prevention as a top priority (PSP, 2013). Ecology estimates that stormwater contributes more than 50 times as much flow and 30 times as much solids loading as the CSO discharges to the Lower Duwamish Waterway (Ecology, 2013b).

To address this need, the City negotiated an "Integrated Plan" alternative in the Consent Decree. This alternative allows the City to implement stormwater control projects that will significantly benefit water quality in receiving water bodies, while deferring lower-benefit LTCP projects. For Ecology and EPA to accept the alternative proposal, the City must demonstrate that the stormwater projects provide water quality benefits beyond those that would be achieved by the LTCP projects alone. Deferred LTCP projects will still be implemented; however, the projects would be operational by 2030, as compared to 2025 under the LTCP alternative. Under the Integrated Plan alternative, LTCP projects with relatively high water quality benefits will not be deferred.

Controlling CSOs, complying with our state and federal requirements for CSO discharges is a top priority for the City and important for protecting the receiving water bodies in and around Seattle. The Integrated Plan allows the City to address pollution from stormwater as well as from CSOs. The Integrated Plan will cost more than the LTCP projects alone. However, the Integrated Plan will provide greater pollutant load reductions, water quality benefits, and protection of public health and safety and the environment than the LTCP projects alone.

Integrated Plan Development

The City prepared this Integrated Plan in accordance with the Consent Decree as well as with EPA guidance for integrated planning. The objective of the Integrated Plan is to propose stormwater projects that will provide significant benefits to water quality beyond those provided by the LTCP projects alone. The Integrated Plan identifies LTCP projects to be deferred until after 2025 so that the City can focus available resources on implementing the proposed stormwater projects.

To develop this Integrated Plan, the City completed the steps listed below:

1. Ranked local receiving water bodies and drainage basins based on the Consent Decree requirements (Chapter 2).
2. Engaged the public and regulatory agencies during development of the plan (Chapter 4).
3. Identified potential candidate stormwater projects for implementation and potential candidate LTCP projects for deferral based on the water body and drainage basin ranking and EPA guidance (Chapter 5).
4. Performed a screening evaluation to select candidate LTCP and stormwater projects for further evaluation (Chapter 5).
5. Compiled existing data relevant to the candidate projects and their potential impacts on pollutant loads and exposures for human and ecological receptors (Chapter 6).
6. Developed methods for evaluating and comparing the candidate projects based on the Consent Decree requirements (Chapter 6).
7. Obtained guidance from an independent Expert Panel on the methodology developed for evaluating and comparing the candidate projects (Chapter 6).
8. Estimated pollutant load reductions and exposure reductions for the candidate LTCP and stormwater projects (Chapter 7).
9. Identified the candidate stormwater projects that contribute significant water quality benefits compared to the candidate LTCP projects (Chapter 8).
10. Used Multiple Objective Decision Analysis (MODA) to score the candidate stormwater projects and compare the benefits of each project (Chapter 8).
11. Selected a combination of stormwater projects that would provide significantly more water quality benefits than the candidate LTCP projects proposed for deferral until after 2025. The Integrated Plan alternative to the LTCP consists of these selected LTCP and stormwater projects (Chapter 8).
12. Prepared the Integrated Plan document in accordance with relevant Consent Decree requirements and EPA guidance.
13. Included the Integrated Plan as Volume 3 in the City's Protecting Seattle's Waterways Plan, which consists of the following four volumes:
 - Volume 1: Executive Summary
 - Volume 2: Long-Term Control Plan
 - Volume 3: Integrated Plan
 - Volume 4: Programmatic Environmental Impact Statement

Selected Integrated Plan Projects

The City followed the steps listed above to develop this Integrated Plan, which is designed to provide significantly greater water quality benefits than the LTCP projects alone. The Integrated Plan consists of implementing three stormwater projects by 2025 and deferring construction completion of six candidate LTCP projects until 2030. The three stormwater projects are as follows:

- Natural Drainage Systems (NDS) Partnering
- South Park Water Quality (WQ) Facility
- Street Sweeping Expansion Arterials

NDS Partnering would entail reconstructing City rights-of-way to manage flow and provide water quality treatment for urban runoff using primarily the green infrastructure practice of bioretention (i.e., engineered rain gardens). The South Park WQ Facility would provide active basic treatment for roughly 74 million gallons per year (MG/yr) of stormwater runoff from a largely industrial area that discharges to the Lower Duwamish Waterway, thereby reducing the potential for recontamination of sediment remediation areas. The Street Sweeping Expansion Arterials would expand the area, frequency, and duration of the City's current arterial street sweeping efforts.

Under the Integrated Plan, LTCP Neighborhood Storage projects to control the following six CSO outfalls would be completed by 2030¹:

- CSO Outfall 99
- CSO Outfall 107
- CSO Outfall 111
- CSO Outfall 138
- CSO Outfall 139
- CSO Outfall 140

All six LTCP projects involve detention of combined sewer flows. The detention facilities will be sized to reduce the frequency of CSO discharges to no more than once per year per outfall over a 20-year period. The six deferred LTCP projects are small relative to the largest non-deferred CSO projects included in the LTCP and the three stormwater projects in the Integrated Plan alternative.

Figure IPS-1 shows the locations of the stormwater projects to be implemented and the CSO outfalls whose control will be deferred under the Integrated Plan. Table IPS-1 summarizes these projects.

¹ Prior to 2025, SPU will implement Sewer System Improvements (SSI) designed to reduce overflows from the CSO outfalls associated with the six deferred LTCP Neighborhood Storage projects. After the SSI have been completed, SPU will monitor the six affected outfalls to assess compliance with the state CSO control standard. SPU will then determine whether some or all of the deferred LTCP Neighborhood Storage projects can be downsized or eliminated.

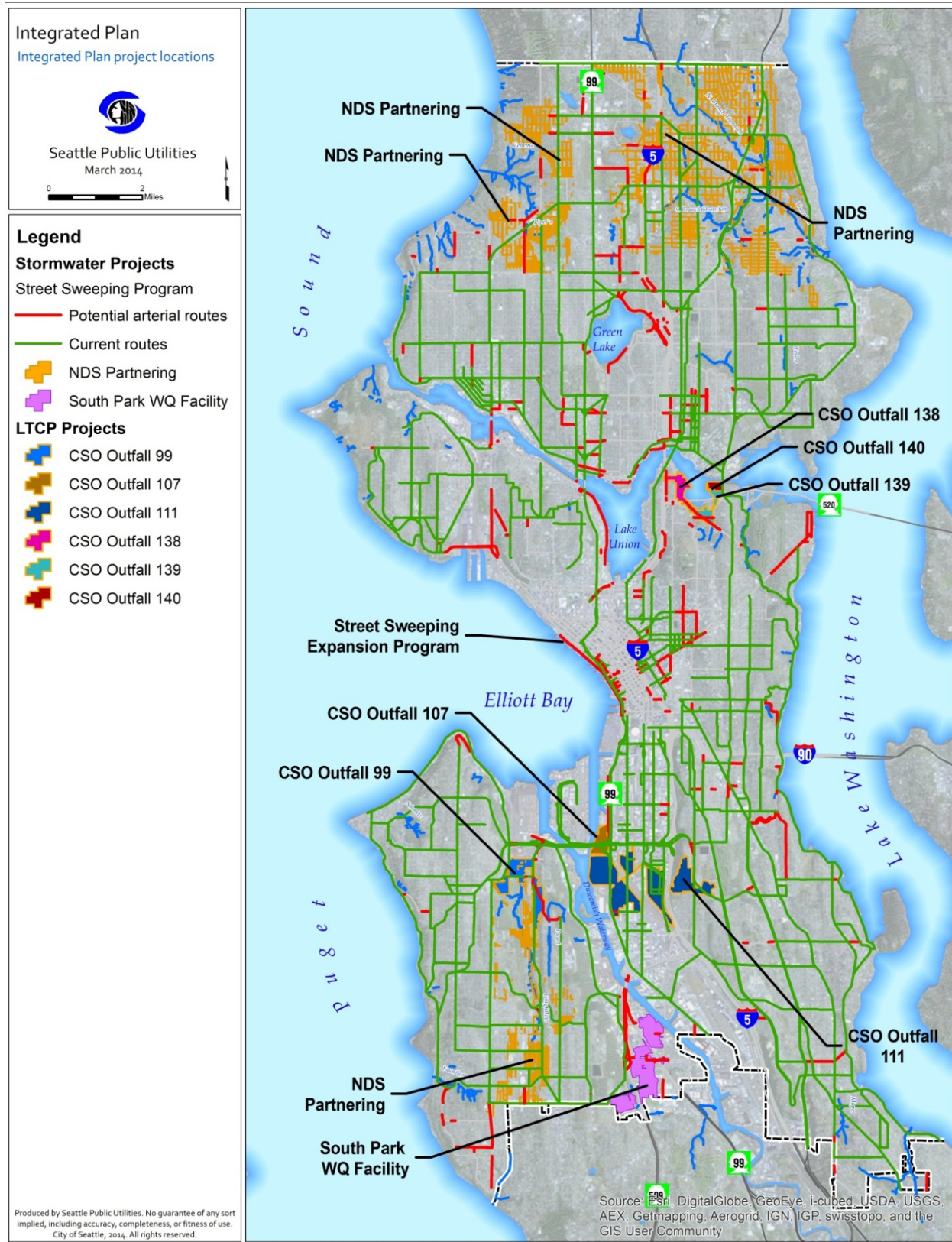


Figure IPS-1. Integrated Plan project locations

Table IPS-1. Summary of Integrated Plan Projects

Project name	Project type	Receiving water body	Average existing discharge frequency (average no. events/ yr) ^{a,b}	Average volume treated or removed (MG/yr) ^c	Life-cycle cost ^d (M\$)	Construction completed (yr)
LTCP projects to be completed during 2028–30^e						
CSO Outfall 99	Offline storage pipe	West Waterway of the Duwamish River	1.5	0.17	\$8.2	2030
CSO Outfall 107	Offline storage tank	East Waterway of the Duwamish River	4.6	1.1	\$24.2	2030
CSO Outfall 111	Offline storage pipes	Duwamish River	1.7	0.01	\$7.3	2030
CSO Outfall 138	Offline storage tank	Portage Bay	1.4	0.09	\$7.5	2030
CSO Outfall 139	Offline storage pipes	Portage Bay	1.2	0.01	\$1.9	2030
CSO Outfall 140	Offline storage pipes	Portage Bay	3.7	0.05	\$4.4	2030
Stormwater projects/programs to be implemented by 2025^f						
NDS Partnering	Bioretention	Longfellow Creek, Piper's Creek, Thornton Creek	119	35	\$27.2	2025
South Park WQ Facility	Basic, active treatment (e.g., CESF ^g)	Duwamish Waterway	119	74	\$34.8	2025
Street Sweeping Expansion Arterials	Street sweeping (weekly arterial sweeping)	Multiple	119	1,527 ^h	\$26.1	N/A ⁱ

- a. For stormwater projects, the existing discharge frequency was estimated using data from 10 years' worth of recorded rainfall data from a City rain gauge. A discharge event was considered as an "event" if, on that particular day, the precipitation depth was at a minimum of 0.03 inch. Based on collected flow monitoring data, a rainfall depth of 0.03 inch generates flow in the storm sewer system.
- b. The existing discharge frequencies for the candidate LTCP projects can be found in the 2012 Annual CSO Report.
- c. The estimated annual average volume removed by the candidate LTCP projects was calculated using the moving 20-year average simulated volumes, without the consideration of climate change. This means that the precipitation data used for modeling were not modified to account for potential effects of climate change on rain; therefore, a scaling factor of 1 was assumed. See Volume 2 of the LTCP report on a more detailed discussion of the hydraulic modeling conducted.
- d. Present value in 2014 dollars assuming 100-year project life and 3% discount rate based on Integrated Plan schedule.
- e. Prior to 2025, SPU will implement Sewer System Improvements (SSI) designed to reduce overflows from the CSO outfalls associated with the six deferred LTCP Neighborhood Storage projects. After the SSI have been completed, SPU will monitor the six affected outfalls to assess compliance with the state CSO control standard. SPU will then determine whether some or all of the deferred LTCP Neighborhood Storage projects can be downsized or eliminated.
- f. SPU anticipates that the South Park and NDS Partnering projects will have a life span of 50 years. Street Sweeping Expansion for the Integrated Plan will be conducted up to 2030 or until all six of the deferred CSOs have been controlled. At that time, SPU will determine whether to continue the Street Sweeping Expansion program.
- g. CESF is chitosan-enhanced sand filtration.
- h. Volume is based on estimated runoff from swept streets.
- i. The Street Sweeping Expansion Arterials program will begin in 2015. The purchase of sweepers and program implementation will be complete by 2016. Post-construction monitoring will occur between 2016 and 2019.

The Integrated Plan will result in significant benefits to water quality beyond those that would be achieved by the candidate LTCP projects alone. Figure IPS-2 shows that the three stormwater projects selected for the Integrated Plan would treat much larger volumes than the six deferred LTCP projects would control.

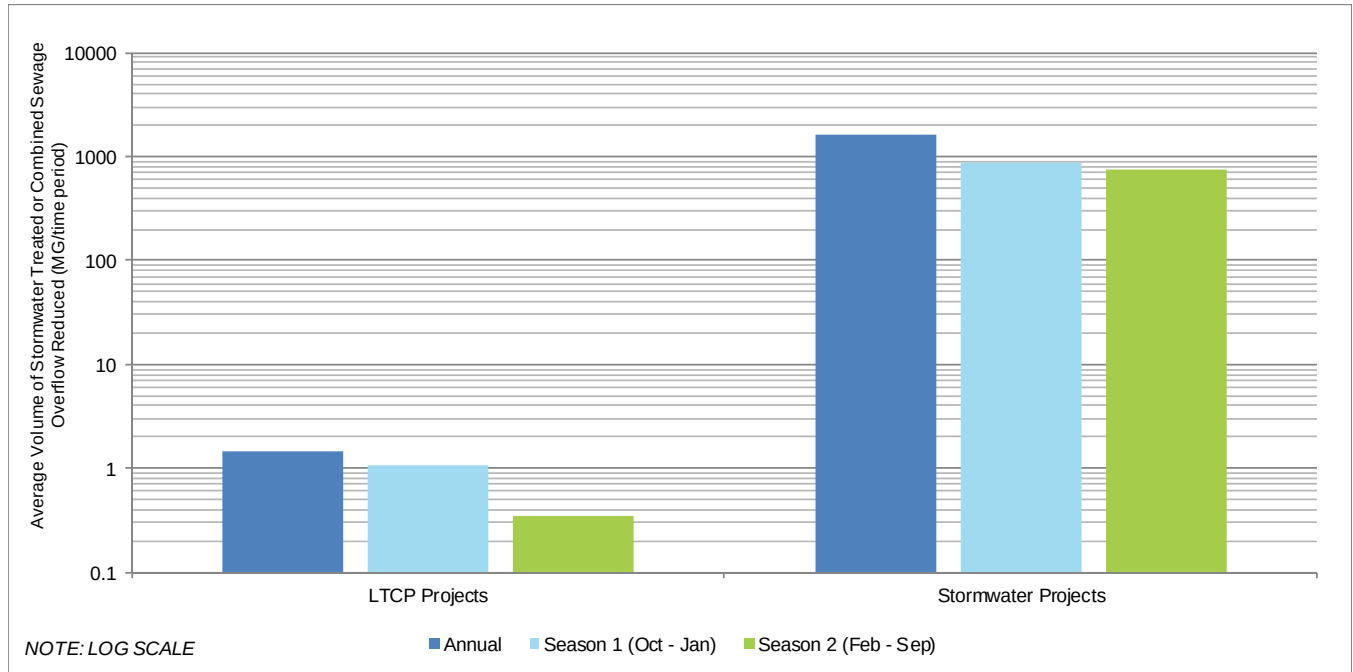


Figure IPS-2. Volume treated or reduced by Integrated Plan projects

Average volumes for Season 1 and Season 2 are shown to illustrate variations in seasonality. Season 1 is considered "wet," whereas Season 2 is considered "dry." Modeling of LTCP project discharges has shown that 65% of the CSOs occur during the "wet" season with their associated overflow volume at about 85% of the total simulated CSO volume.

Table IPS-2 lists the average projected pollutant load reduction benefits of each Integrated Plan project. Figure IPS-3 shows the cumulative load reduction of the selected Integrated Plan stormwater projects relative to the cumulative load reduction of the deferred LTCP projects. As shown in Figure IPS-3, the three stormwater projects would remove approximately 35 times as much dissolved copper, 100 times as much dissolved zinc, and 130 times as much total suspended solids (TSS) as the six deferred LTCP projects. As noted above, the six deferred LTCP projects are small relative to the largest non-deferred projects included in the LTCP.

Table IPS-2. Average Annual Pollutant Load Reduction Benefits from Each Project Included within the Integrated Plan

Project	Average volume treated or removed (MG/ yr)	Ammonia-N (kg)	Biochemical oxygen demand (kg)	Bis(2-ethylhexyl) phthalate (kg)	Dichlobenil (kg)	Dissolved copper (kg)	Dissolved zinc (kg)	Fecal coliform bacteria (billion CFU)	H+ (kg)	Oil and grease (kg)	PBDEs (kg)	PCBs (kg)	Phosphorus (kg)	Total copper (kg)	Total suspended solids (TSS) (kg)	Total zinc (kg)
Candidate LTCP projects																
CSO Outfall 99	0.17	0.78	12	0.0015	0.000070	0.0032	0.012	651	0.000073	2.2	0.000038	0.000032	0.37	0.0084	20	0.026
CSO Outfall 107	1.1	19	82	0.035	0.00029	0.027	0.14	4346	0.00049	15	0.00025	0.00046	6.6	0.22	494	0.57
CSO Outfall 111	0.0086	0.15	0.64	0.00027	0.000003	0.00021	0.0011	34	0.0000038	0.11	0.0000020	0.0000036	0.05	0.0017	4	0.0044
CSO Outfall 138	0.091	0.43	6.8	0.00081	0.000041	0.0018	0.0067	360	0.000040	1.2	0.000021	0.000018	0.21	0.0046	11	0.015
CSO Outfall 139	0.0057	0.027	0.42	0.000050	0.000003	0.00011	0.00042	22	0.0000025	0.075	0.0000013	0.0000011	0.013	0.00029	0.69	0.00090
CSO Outfall 140	0.051	0.24	3.8	0.00045	0.000023	0.0010	0.0038	201	0.000023	0.67	0.000012	0.000010	0.12	0.0026	6	0.0081
Total	1.4	21	106	0.038	0.00043	0.034	0.16	5,614	0.00063	19	0.00032	0.00053	7.3	0.24	536	0.63
Candidate stormwater projects																
NDS Partnering	35	9.2	684	0.22	0.0048	0.46	3.2	17,910	0.015	396	0.0029	0.0018	14	1.3	7,704	11
South Park WQ Facility	74	0.0	1,088	0.29	0.0	0.71	14	52,700	0.0	702	0.0047	0.0069	46	4.5	24,741	29
Street Sweeping Expansion Arterials	1,527 ^a	N/A	337	0.14	N/A	N/A	N/A	2,100	N/A	69	0.0096	0.0033	24	5.2	36,200	10
Total	1,636	9.2	2,109	0.64	0.0048	1.17	17	72,710	0.015	1,167	0.017	0.012	83	10.9	68,645	51

N/A = not applicable.

- a. The average annual runoff volume treated for the street sweeping program was estimated based on street area swept, mean annual rainfall, the fraction of annual rainfall events that produces runoff, and a runoff coefficient. Refer to Appendix G, Section 2.2.3 for additional details.

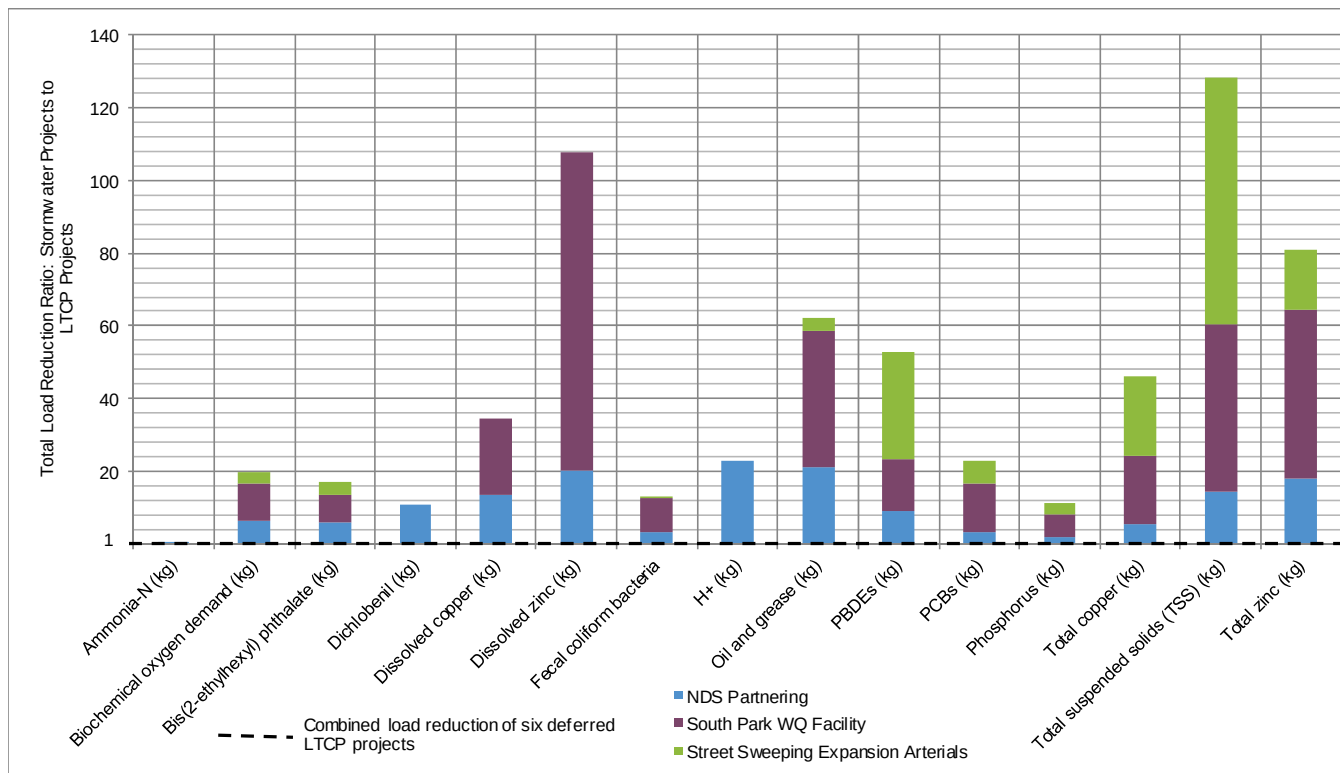


Figure IPS-3. Significant pollutant load reduction benefits of Integrated Plan

The Integrated Plan will provide pollutant load reductions to a number of receiving water bodies that the LTCP projects would not otherwise address, including impaired water bodies and water bodies that provide salmonid habitat. Moreover, the Integrated Plan will provide hydrologic benefits to several small creeks that have been adversely affected by hydromodification.

Integrated Plan Implementation Schedule

Table IPS-3 contains the schedule for implementing the LTCP projects and stormwater projects that compose the Integrated Plan. The City will implement all of the proposed stormwater projects by December 31, 2025. The City will begin designing the LTCP projects in 2024 and complete construction by 2030.

Table IPS-3. Implementation Schedule							
Project name	Draft engineering report ^a	Final engineering report	Draft plans and specs	Final plans and specs	Construction start	Construction completion/project completion ^b	Achieve controlled status/post-construction monitoring completed ^c
LTCP outfalls to be controlled during 2028-30							
CSO Outfall 99	6/30/2017	12/31/2026	6/30/2018	12/31/2027	7/1/2028	9/30/2030	3/31/2031
CSO Outfall 107	6/30/2017	12/31/2024	6/30/2019	12/31/2026	7/1/2027	9/30/2030	3/31/2031
CSO Outfall 111	6/30/2021	12/31/2026	6/30/2022	12/31/2027	7/1/2028	9/30/2030	3/31/2031
CSO Outfall 138	6/30/2016	12/31/2026	6/30/2017	12/31/2027	7/1/2028	9/30/2030	3/31/2031
CSO Outfall 139	6/30/2016	12/31/2026	6/30/2017	12/31/2027	7/1/2028	9/30/2030	3/31/2031
CSO Outfall 140	6/30/2016	12/31/2026	6/30/2017	12/31/2027	7/1/2028	9/30/2030	3/31/2031
Stormwater projects/programs to be implemented by 2025							
NDS Partnering	NA	NA	NA	NA	7/17/2019	12/28/2025	9/30/2029
South Park WQ Facility	NA	NA	NA	NA	12/31/2023	12/31/2025	9/30/2028
Street Sweeping Expansion Arterials	NA	NA	NA	NA	2015 ^d	N/A	9/30/2019

a. SPU will submit the draft engineering report to Ecology for review.

b. "Construction Completion" dates apply to the LTCP projects and that "Project Completion" dates apply to the Stormwater projects/programs.

c. "Achieve Controlled Status" dates apply to the LTCP projects and that "Post-Construction Monitoring Completed" dates apply to the Stormwater projects/programs.

d. The "Construction Start" for Street Sweeping Expansion Arterials is the notice to proceed date for SDOT to initiate the program.

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CHAPTER 1

Introduction

On July 3, 2013, a Consent Decree addressing the control of sewage discharges from the City of Seattle (City)'s combined sewer system was entered in U.S. District Court under Civil Action 2:13-cv-00678 (USA, 2013). The Consent Decree agreement between the City, the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) requires the City to develop a Long-Term Control Plan (LTCP) and implement measures for controlling combined sewer overflows (CSOs) by the end of 2025. Section V.B. paragraph 20 of the Consent Decree allows the City to propose an Integrated Plan alternative that would allow certain stormwater quality improvements to be implemented prior to implementing the CSO control measures that provide the least water quality benefit. The City prepared this Integrated Plan in accordance with the Consent Decree and applicable EPA guidance (EPA, 2012).

1.1 Project Background

The City owns and operates a sewer system that conveys sewage to regional wastewater treatment plants (WWTPs) owned and operated by King County. Approximately one-third of the city is served by combined sewers, which convey both stormwater and sewage. The combined sewer system is designed to overflow at permitted relief points during heavy rainfall events. CSOs help the City avoid serious operational, environmental, and public-safety concerns, such as sewage overflowing into streets or basements. CSO discharges contain untreated wastewater and stormwater that can adversely affect receiving water bodies. The City is required to reduce these discharges to no more than one overflow per outfall per year on a long-term basis. Figure 1-1 shows the areas of the city (also referred to as the locations of the CSO basins) that currently do not meet this requirement. The City is developing an LTCP (Volume 2: Long-Term Control Plan) to address these CSO basins. The LTCP identifies CSO control projects that will meet the performance requirement by December 31, 2025, as required by the Consent Decree.

In addition to the sewer system, the City owns and operates a municipal separate storm sewer system. The storm sewer system discharges approximately 13 billion gallons during an average year. Stormwater is the main pathway through which toxic pollutants enter Puget Sound (Ecology, 2011a), and the Puget Sound Partnership has identified stormwater pollution prevention as a top priority (PSP, 2013).

Seattle has devoted substantial resources toward CSO reduction over the past 50 years. As a result, current CSO discharges are a small fraction of historical flows. The City's CSO discharge volume of 154.2 million gallons (MG) in 2012 was many times lower than the average annual discharge volume from the City's storm sewer system. Ecology has estimated that stormwater contributes more than 50 times the flow and 30 times the solids loading of the CSO discharges to the Lower Duwamish Waterway (Ecology, 2013b).

The Consent Decree allows the City to propose an Integrated Plan as an alternative to the LTCP. EPA and Ecology approval of the Integrated Plan would allow the City to defer certain CSO control projects so that stormwater quality improvements providing greater water quality benefit could be implemented sooner. The City would still be required to meet the CSO performance standard, but would have longer to complete the last few CSO control projects.

If approved by EPA and Ecology, the Integrated Plan would allow the City to (1) defer implementation of selected CSO control projects (referred to herein as “candidate LTCP projects”) until after 2025 and (2) implement stormwater projects by 2025 that would provide significant benefits to water quality beyond those that would be achieved by implementing the LTCP projects alone. All CSO basins would still achieve the CSO performance standard but the City would defer completion of the last few CSO control projects to 2030.

In order to meet the 2025 deadline for controlling all CSO outfalls, the City would need to focus its resources on CSO control measures. Approval of the Integrated Plan would allow the City to defer some of the smallest LTCP projects and devote resources to stormwater quality projects that provide substantially greater water quality benefits.

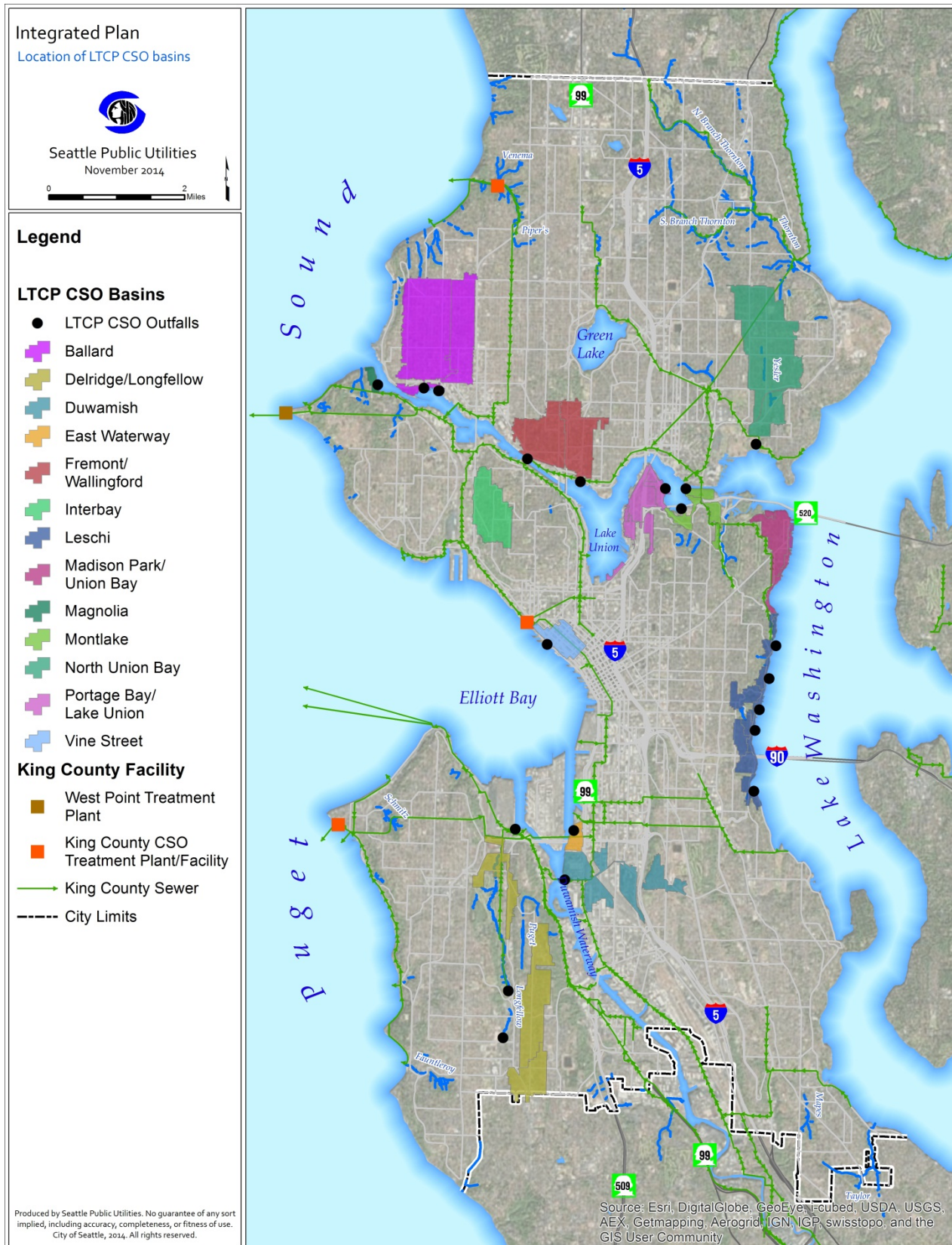


Figure 1-1. Location of LTCP CSO basins

1.2 Integrated Planning Objectives

The objective of the Integrated Plan is to propose a mix of stormwater improvements and LTCP projects that together will provide significantly more benefit to water quality than the LTCP projects alone. This Integrated Plan will allow the City the opportunity to prioritize its investments in water quality and provide more benefits to the city's receiving water bodies.

1.3 Seattle's Approach to Integrated Planning

The City developed its integrated planning approach based on the Consent Decree Section V.B. paragraph 20 (USA, 2013), recent EPA guidance (EPA, 2012), and input provided by an independent Expert Panel. Figure 1-2 shows the basic steps that were used to create this plan. Section 5.3.1 provides a more detailed discussion of this approach.

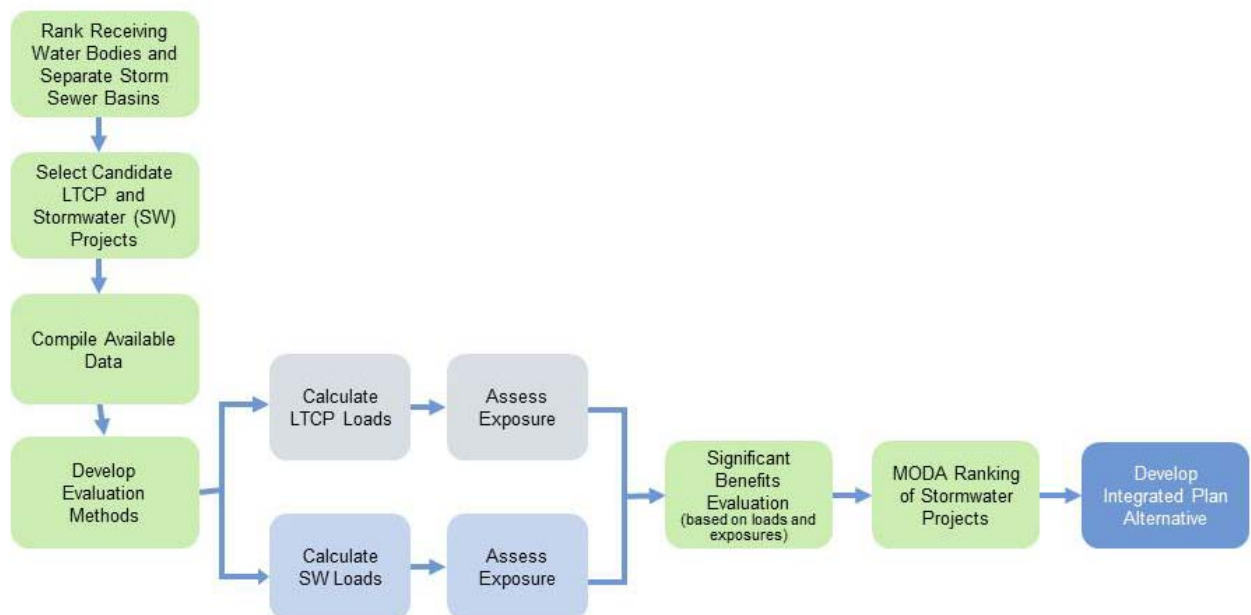


Figure 1-2. Integrated planning approach

The City ranked local receiving water bodies and drainage basins based on the Consent Decree requirements and estimated stormwater total suspended solids (TSS) loads, which were used as an initial indicator, from stormwater basins. While not required by the Consent Decree, the ranking was done to focus planning on water bodies that have the characteristics identified by the Consent Decree as important. The City then developed an initial list of stormwater projects for potential inclusion in the Integrated Plan and conducted a screening evaluation to select candidate stormwater projects for further evaluation.

To identify candidate LTCP projects for potential deferral, the City ranked the LTCP projects in the LTCP based on EPA criteria (EPA, 1995). The City selected six low-frequency, low-volume LTCP projects, also called LTCP Neighborhood Storage projects, as candidates for deferral under the Integrated Plan.

The City compiled existing data relevant to the candidate LTCP and stormwater projects and their potential impacts on pollutant loads and exposures for human and ecological receptors. Based on review of the existing data and input from an independent Expert Panel, the City developed methods for evaluating and comparing the candidate projects. The City then applied these methods to estimate pollutant load reductions and exposure reductions for the candidate LTCP and stormwater projects. These results were used to identify candidate stormwater projects that appeared to provide significant water quality benefits compared to the candidate LTCP projects. The next steps involved scoring the projects using a Multiple Objective Decision Analysis (MODA) and conducting a cost-benefit analysis.

The City used the results of the preceding steps to select a combination of stormwater projects that would provide significantly more water quality benefits than the six candidate LTCP projects alone. The Integrated Plan alternative to the LTCP consists of these three stormwater projects and six LTCP projects.

1.4 Supporting Documentation

The City developed this Integrated Plan using the reports and documents listed below:

- Long-Term Control Plan Hydraulic Modeling Reports (Brown and Caldwell, 2012). Volume 1 is the Executive Summary. CSO basins assessed in this Integrated Plan are described in Volume 3, Delridge/Longfellow; Volume 4, Duwamish; Volume 9, Montlake; and Volume 11, Portage Bay.
- Calibrated Storm Water Management Model (SWMM) hydrologic/hydraulic models for the six candidate LTCP CSO basins. (SPU, 2014a; in progress). (Hydraulic models of the uncontrolled LTCP CSO areas contain all of the public pipes and maintenance holes in the system. These models also contain special hydraulic structures, including pump stations, weirs, gates, orifices, storage tanks, and HydroBrakes. All modeling work was performed using Build 5.0.022 of EPA SWMM5.)
- Integrated Plan: CSOs for Potential Deferral Technical Memorandum. Prepared by Seattle Public Utilities. April 9, 2013 (SPU, 2013b).
- Integrated Plan: Stormwater Treatment Project Screening Technical Memorandum. Prepared by Seattle Public Utilities. April 10, 2013 (SPU, 2013c).
- Briefing Memorandum for April 29, 2013, Expert Panel Meeting. Briefing Memorandum on Stormwater and CSO Project Evaluation and Exposure Assessment Methods. Prepared by Seattle Public Utilities. April 22, 2013, revised May 23, 2013 (SPU, 2013e).
- Geographic information system (GIS)-based models for estimating TSS loads and flows for various land covers in Seattle. (The GIS-based model was developed by Seattle Public Utilities. It is described in Appendix C.)
- Western Washington Hydrology Models (WWHM) for the candidate stormwater project drainage areas. (WWHM was developed by Ecology. The most recent update was in 2012.)
- Pollutant load models (PLM). (These models were developed for the Integrated Plan. Refer to Appendices F and G.)

Most of these documents are included in the appendices to this Integrated Plan. The remainder are available from Seattle Public Utilities.

1.5 Conformance with Consent Decree Requirements and EPA Guidance

This Integrated Plan document was prepared to meet requirements of the Consent Decree, Section V.B. paragraph 20, which establishes requirements for the development and documentation of the evaluation of the candidate LTCP (CSO reduction) and stormwater projects for inclusion within the Integrated Plan. This plan summarizes the process used in developing the proposed Integrated Plan and serves as Volume 3 of the four reports to be submitted to Ecology and EPA. The following four volumes will be submitted in accordance with the Consent Decree requirements:

- Volume 1: Executive Summary
- Volume 2: Long-Term Control Plan
- Volume 3: Integrated Plan
- Volume 4: Programmatic Environmental Impact Statement

A summary of the Consent Decree items and EPA guidance references is provided below. Table A-1 in Appendix A provides a crosswalk that describes where the Consent Decree requirements and EPA guidance suggestions are addressed.

1.5.1 Consent Decree Item Summary

This Integrated Plan addresses a number of criteria or requirements described in Section V.B. paragraph 20 of the Consent Decree, including the following:

- stormwater quality project(s) that result in significant benefits to water quality beyond those that would be achieved by implementation of the LTCP (CSO reduction) projects alone
- a schedule for implementation of the Integrated Plan projects and the candidate LTCP projects that would be completed after 2025

All LTCP projects in the LTCP will be completed, but some would be deferred beyond 2025 under an approved Integrated Plan.

The Consent Decree cites specific elements that must be included within the Integrated Plan. Appendix A contains a brief description of each element required by the Consent Decree.

CHAPTER 2

Receiving Waters Characterization

This chapter describes the key receiving water bodies in the city. As shown in Figure 2-1, the key water bodies include the Lower Duwamish Waterway, Lake Washington, Puget Sound, Elliott Bay, Lake Washington Ship Canal/Lake Union, Thornton Creek, Longfellow Creek, and Piper's Creek. Appendix B contains additional information about each water body.

2.1 Lower Duwamish Waterway

The Duwamish Waterway originates at the confluence of the Green and Black rivers near Tukwila, Washington, and flows northwest for approximately 12 miles, splitting at the southern end of Harbor Island to form the East and West waterways before discharging into Elliott Bay. The downstream portion of the Duwamish Waterway is brackish and serves as a major shipping route for bulk and containerized cargo, and most of the shoreline along the lower Duwamish has been developed for industrial and commercial land uses. A portion of the lower Duwamish is maintained as a federal navigation channel by the U.S. Army Corps of Engineers (USACE).

According to State water quality standards, the Lower Duwamish Waterway is designated for secondary contact recreation uses. This designation is intended to protect people engaged in boating, wading, and others uses where contact with the water is likely to be limited. There are no monitored swimming beaches on the Duwamish and therefore no information on beach closures.

The Lower Duwamish Waterway is listed as a Superfund Site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (EPA, 2013a) and as a Model Toxics Control Act (MTCA) site (Ecology, 2013b). The CERCLA and MTCA listings are for bottom sediments that contain elevated concentrations of polychlorinated biphenyls (PCBs), carcinogenic polycyclic aromatic hydrocarbons (cPAHs), arsenic (As), dioxins, and furans.

The Lower Duwamish Waterway is listed as having critical habitat for proposed, threatened, and endangered species (City of Seattle, 2012).

2.2 Lake Washington

Lake Washington is the second-largest natural lake in Washington, with a surface area of 21,500 acres and a watershed of 472 square miles. The Lake Washington drainage system has been highly altered and now drains through the Lake Washington Ship Canal system rather than the Green/Duwamish River (Chrastowski, 1983). Most of the lake shoreline is highly developed and lake levels are regulated by the USACE through operation of the Hiram M. Chittenden Locks (Chrastowski, 1983; USACE, 2012a, 2012b).

Union Bay is also considered part of Lake Washington, and is located near the eastern end of the Ship Canal.

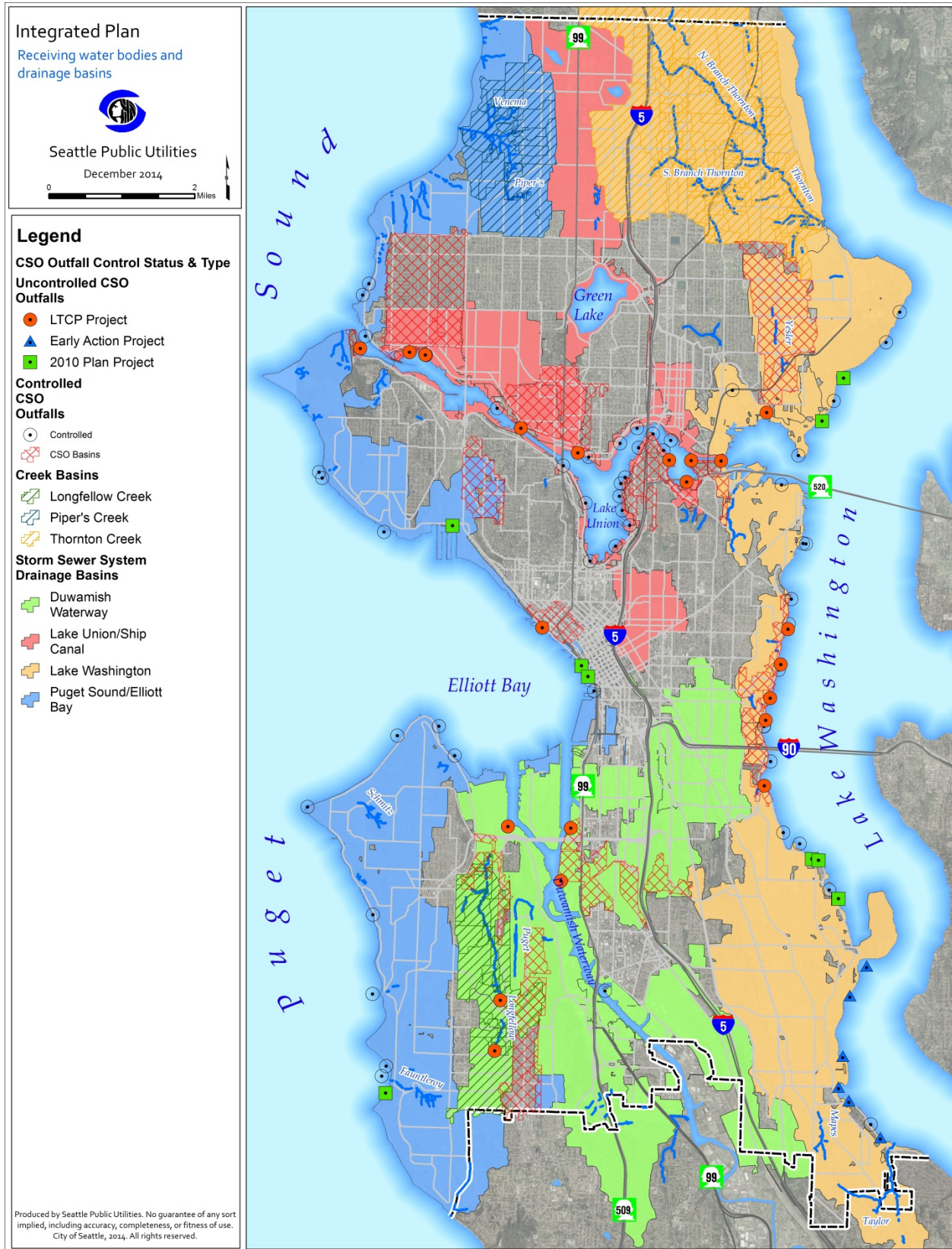


Figure 2-1. Receiving water bodies and drainage basins

King County (2013b) monitors swimming beaches on Lake Washington once per week from May through September to determine the fecal coliform levels and informs the public of potential risks to swimmers. There are seven monitored beaches in the city. During 1996–2012, there were 39 beach closures.

At present, there are no CERCLA or MTCA listings for Lake Washington adjacent to Seattle (EPA, 2013a and Ecology, 2013b).

Lake Washington is listed as having critical habitat for proposed, threatened, and endangered species (City of Seattle, 2012).

2.3 Puget Sound

Puget Sound is a fjord-like estuary that consists of four major interconnected basins that stretch from Hood Canal to north of Admiralty Inlet. The four basins include the Main (Admiralty Inlet and the Central Basin), Whidbey, Southern, and Hood Canal basins. All of Seattle's marine CSOs discharge to the Central Basin. Puget Sound borders the Ship Canal neighborhoods and Elliott Bay within the Integrated Plan area. CSOs in the Ballard, Fremont, and Wallingford area discharge to the Ship Canal and eventually drain to Puget Sound via the Hiram M. Chittenden Locks. Freshwater flows influence water circulation in this portion of Puget Sound with seasonal variation in the amount of freshwater input and an accompanying effect on water temperature, salinity, and density. The two main freshwater inputs to Puget Sound in the Integrated Plan area are the Green/Duwamish River, which enters Elliott Bay, and the Cedar River (Lake Washington drainage basin), which flows into Puget Sound through the Lake Washington Ship Canal.

The city encompasses 21 official beach/water access locations on Puget Sound. The State monitors four of these locations between Memorial Day and Labor Day each year. There were 13 beach closures for the period of 2004–10 (Ecology, 2013a).

At present, there are no CERCLA or MTCA listings for Puget Sound in the waters adjacent to Seattle (EPA, 2013a and Ecology, 2013b).

Puget Sound is listed as having critical habitat for proposed, threatened, and endangered species occurring within Puget Sound adjacent to Seattle (City of Seattle, 2012).

2.4 Elliott Bay

Elliott Bay is a partially enclosed embayment that is bordered on the north, east, and south sides by urbanized areas and by Puget Sound on the west. The eastern shoreline borders the Downtown neighborhoods and has been heavily modified from historical development. As a result, the shoreline along Elliott Bay is much steeper than a natural shoreline. The southern portion of Elliott Bay is heavily altered through man-made port facilities including Harbor Island, which was completed in 1909. Elliott Bay is influenced by Green River freshwater flows through the heart of Seattle's industrial area and port facilities, where the Green River becomes the Duwamish Waterway.

Information on beach closures for Elliott Bay is included in Section 2.3 above. At this time there are no CERCLA or MTCA listings for Elliott Bay in the waters adjacent to Seattle (EPA, 2013a and Ecology, 2013b).

Like Puget Sound, Elliott Bay is listed as having critical habitat for proposed, threatened, and endangered species occurring within Puget Sound adjacent to Seattle (City of Seattle, 2012).

2.5 Lake Washington Ship Canal/Lake Union

The Lake Washington Ship Canal system is an 8.6-mile-long, man-made navigable waterway connecting Shilshole Bay in Puget Sound to Union Bay in Lake Washington in Seattle. This system includes several interconnected waterways: the Hiram M. Chittenden Locks, Salmon Bay, Salmon Bay Waterway, Fremont Cut, Lake Union, Portage Bay, and Montlake Cut. Lake Union is a freshwater lake and receives most of its inflow from Lake Washington via the Montlake Cut and Portage Bay.

There are no monitored swimming beaches on the Lake Washington Ship Canal/Lake Union water body. Consequently, there is no information on beach closures.

Gas Works Park, a City of Seattle park, is located on the north shore of Lake Union and is listed by Ecology as a MTCA site (Ecology, 2013b). It is the former location of a plant that converted coal and oil into manufactured gas. The sediments off the shore of Gas Works Park contain polycyclic aromatic hydrocarbons (PAHs). The sediments are currently being studied to determine the best cleanup remedy.

The Lake Washington Ship Canal/Lake Union is listed as having critical habitat for proposed, threatened, and endangered species (City of Seattle, 2012).

2.6 Thornton Creek

Thornton Creek and its many tributaries flow through the northeast part of Seattle, forming the city's largest watershed. The watercourse is the longest in Seattle with nearly 20 miles of main stream channel and 20 tributaries. The headwaters of Thornton Creek start in the city of Shoreline, Washington, and the creek discharges to Lake Washington at Matthews Beach Park in Seattle.

There are no monitored swimming beaches on Thornton Creek and therefore no information on beach closures. At this time there are no CERCLA or MTCA listings for Thornton Creek in Seattle (EPA, 2013a and Ecology, 2013b). Thornton Creek is listed as having critical habitat for select proposed, threatened, and endangered species (City of Seattle, 2012).

2.7 Longfellow Creek

The Longfellow Creek basin encompasses approximately 1,504 acres within the Delridge area of West Seattle. The creek is 4.6 miles long and flows into the Duwamish River near Harbor Island through a 3,250-foot-long culvert (City of Seattle, 2007). Approximately one-third of the main channel length is piped. The watercourse is relatively flat compared to other major watercourses in Seattle, dropping 250 feet in elevation from its headwaters near the southern city limits to its mouth at the Duwamish River near Harbor Island.

There are no monitored swimming beaches on Longfellow Creek and therefore no information on beach closures. Currently, there are no CERCLA or MTCA listings for Longfellow Creek in Seattle (EPA, 2013a and Ecology, 2013b). Longfellow Creek does not contain any critical habitat for threatened or endangered species.

2.8 Piper's Creek

Piper's Creek basin encompasses approximately 1,578 acres in the northwest portion of Seattle. The mainstem of the creek is approximately 2 miles long, including the major tributary, Venema Creek. The headwaters of the creek watershed are located in developed neighborhoods, including Broadview and Greenwood. The mainstem flows through a steep ravine in Carkeek Park before discharging into Puget Sound.

There are no monitored swimming beaches on Piper's Creek and therefore no information on beach closures. At present there are no CERCLA or MTCA listings for Piper's Creek in Seattle (EPA, 2013a and Ecology, 2013b). Piper's Creek does not contain any critical habitat for threatened or endangered species.

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CHAPTER 3

Existing Combined and Separated Systems Characterization

The City's sewer and drainage infrastructure includes combined, fully separated, and partially separated systems, each serving approximately one-third of the city (Figure 3-1). These systems are described below.

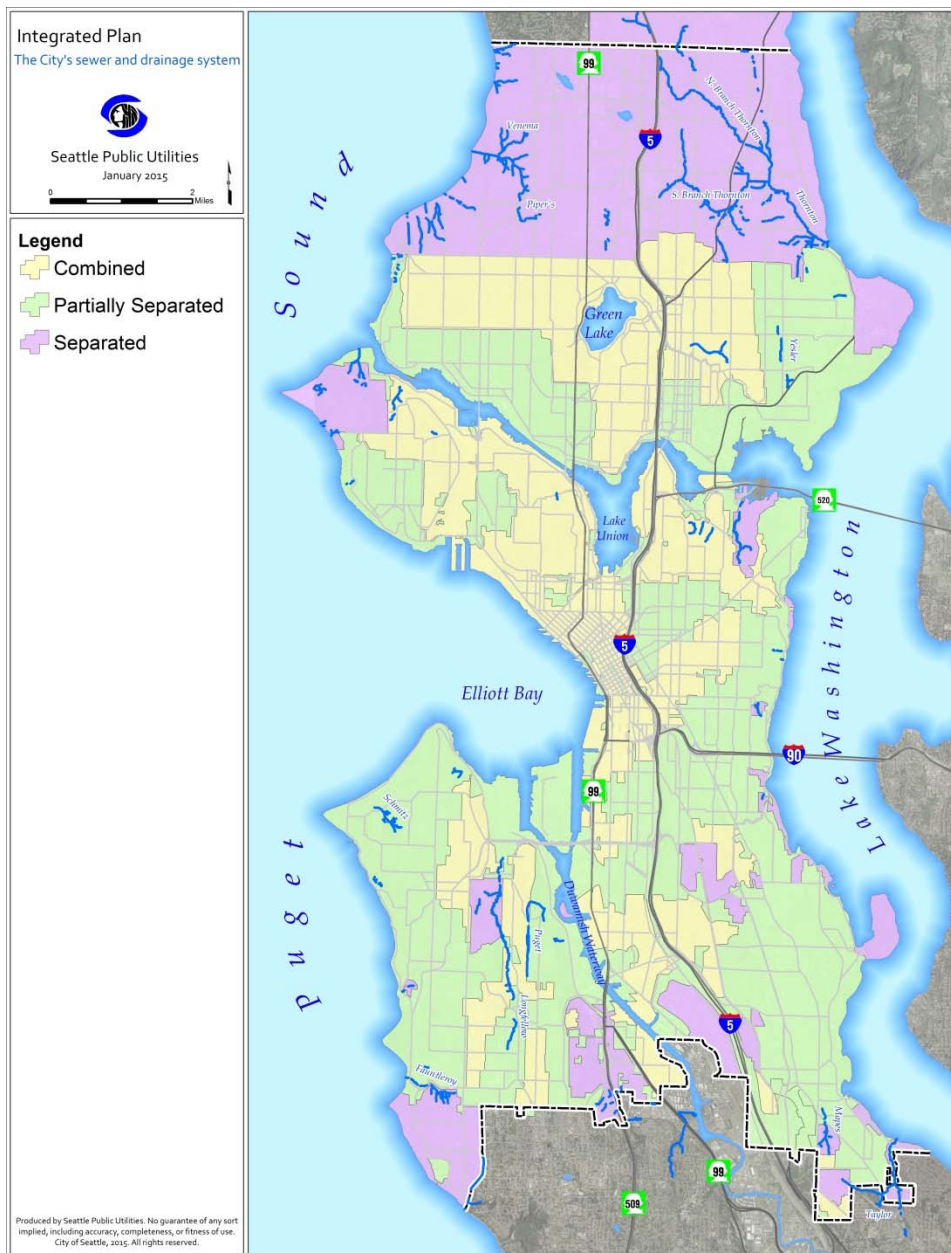


Figure 3-1. The City's sewer and drainage system

3.1 Description of the Combined System

King County and the City own and operate combined sewer systems that serve about one-third of the city. Each combined sewer system is a piped system that carries both sewage and stormwater to a wastewater treatment plant (WWTP). Figure 3-2 shows the key components of a typical combined sewer system.

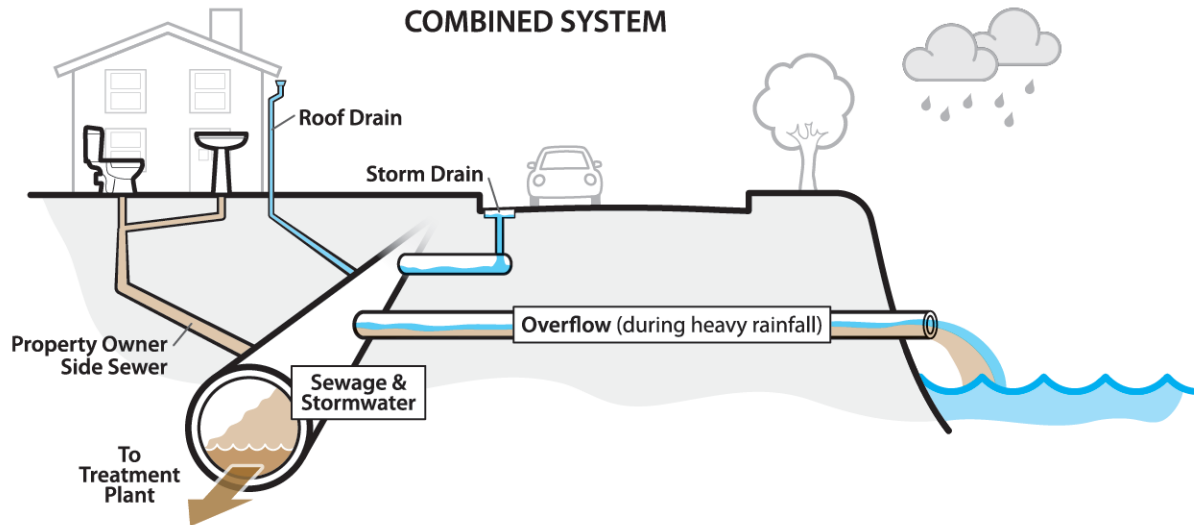


Figure 3-2. Combined sewer system

King County currently operates three secondary WWTPs (West Point WWTP, South WWTP, and Brightwater WWTP) and four combined sewage wet weather treatment facilities (Alki, Carkeek, Elliott West, and Henderson/MLK). These facilities discharge treated wastewater to Puget Sound, Elliott Bay, and the Lower Duwamish Waterway.

The combined sewer systems overflow at designed relief points during heavy rain events. CSO discharges consist of stormwater, wastewater, and groundwater in varying proportions. King County and the City manage CSOs based on the size of the sewer system basin served by each CSO outfall, with the City managing basins smaller than 1,000 acres and the County managing basins larger than 1,000 acres. The City manages 86 CSO outfalls and the County manages 38 CSO outfalls. However, parts of King County's system are interconnected with the City's and the operations of one may impact the operations of the other. Some of the City-owned CSO outfalls are located upstream and in close proximity to King County-owned CSO outfalls.

During the 1980s, increasing the storage capacity of the system became the City's preferred solution to controlling CSOs, resulting in construction of 38 facilities for overflow control. Currently, 34 CSO basins are still uncontrolled, and 12 of the uncontrolled basins are being addressed under the City's current state and federal requirements for CSO discharges. The LTCP is focused on the 22 remaining uncontrolled CSO basins, which are located in the Ballard, Delridge/Longfellow, Duwamish, Fremont/Wallingford, Interbay, Leschi, Montlake, North Union Bay, Portage Bay, Magnolia, and Central Waterfront (Vine Street) areas.

3.2 Description of the Separated System

Beginning in the 1950s, additions to the sewer system were designed as separated systems, with separate networks of pipes for sewage and stormwater. In the areas served by the City's municipal separate storm sewer system, runoff is collected and conveyed in a storm drain system. Wastewater is collected in a separate sanitary sewer and conveyed to a WWTP (Figure 3-3). Some portions of the City's municipal separate storm sewer system are piped while others have an informal system of ditches and culverts, most of which drain to creeks or larger receiving waters. For example, the area north of NE 85th Street, which the City annexed in 1954, is served primarily by ditch-and-culvert drainage systems (City of Seattle, 2009).

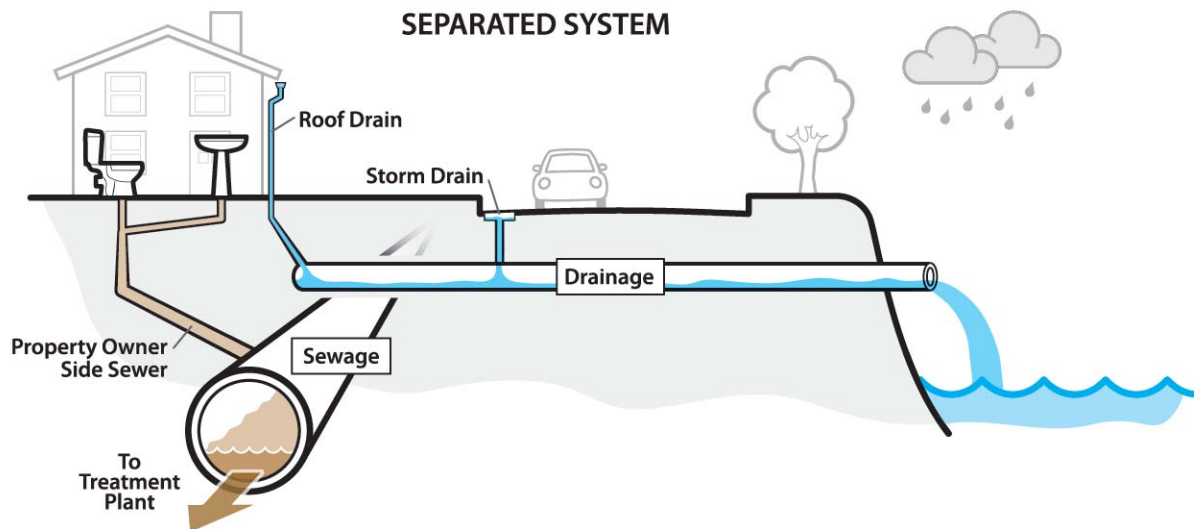


Figure 3-3. Separated storm sewer system

3.3 Description of the Partially Separated System

During the 1960s, some combined sewer system areas were retrofitted with storm drain separation projects that diverted street runoff in pipes to the municipal separate storm sewer system and receiving waters but did not collect runoff from rooftops or private properties outside the road rights-of-way (Figure 3-4). The primary objective of separation projects was to reduce CSOs. In these partially separated areas, runoff from rooftops and other private-property areas is still collected and conveyed to wastewater treatment plants (City of Seattle, 2009). Some of the candidate LTCP projects are in areas with partially separated storm drainage systems.

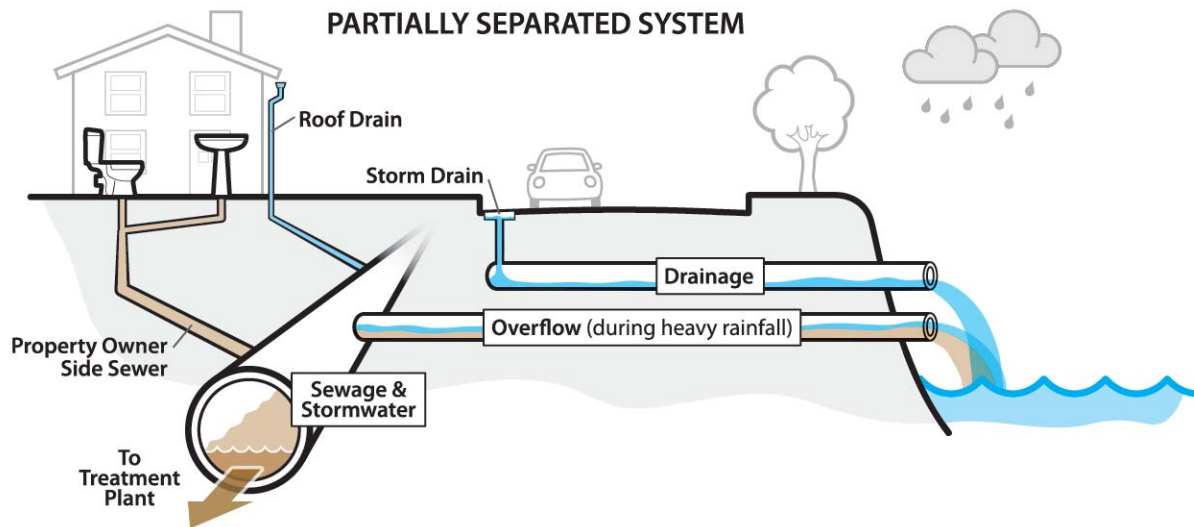


Figure 3-4. Partially separated system

CHAPTER 4

Public and Regulatory Agency Participation Plan

The Consent Decree specifies that the Integrated Plan shall include a public and regulatory agency participation program. The purpose of this program is to ensure that there is ample public participation throughout all stages of development of the City's Integrated Plan. Table 4-1 lists the public and regulatory agency participation requirements of the Consent Decree and the corresponding activities performed by the City during development of the Integrated Plan. The City is using the same public participation process for the LTCP.

Table 4-1. Description of Public and Regulatory Agency Participation Program	
Requirement	Activities
The means by which the City will make information pertaining to the development of the Integrated Plan available for public review	The City will provide updates on the LTCP/Integrated Plan and Programmatic EIS through: • Community Guide updates • Animations • Visualizations • Video for Web site • Briefings • Web site updates • Updates to the project listserv
The means by which the City will solicit comments from the public on the development of the Integrated Plan	• Scoping meetings (October 2011) • Online questionnaires • Re-scoping meetings (May 2013) • Briefings • Public meeting/hearing on the Draft Plan/DEIS Spring 2014 • Comments and questions can be submitted anytime to the City via e-mail at CSO_LTCP@seattle.gov
Summary of public hearings at meaningful times during the Integrated Plan development process to provide the public with information and to solicit comments from the public regarding components of the Integrated Plan	• Draft EIS public hearing summary report
Program for consideration of comments provided by the public as the City develops the Integrated Plan	• Summary reports to be prepared for all public meetings. The following summary reports will include a comment response section: • Scoping Summary Report (2011) • Re-scoping summary report (spring 2013) • Final EIS comment response • LTCP/Integrated Plan Public and Regulatory Agency Participation Final Summary Report

Table 4-1. Description of Public and Regulatory Agency Participation Program

Requirement	Activities
Measures that the City will employ to ensure that EPA and Ecology are kept informed of the City's progress in developing its Integrated Plan development process and regular submittal of reports to EPA and Ecology summarizing the public comments received throughout implementation of the Program	• Quarterly meetings with EPA/Ecology (addresses both LTCP and Integrated Plan) • Webinars for EPA and Ecology at meaningful times: emphasis of webinar will be to report on public involvement activities and comments received at major milestones • June/July 2013: Re-scoping recap • May 2014 Draft LTCP/Integrated Plan/DEIS rollout • October/November 2014: LTCP/Integrated Plan/DEIS public hearing recap

CHAPTER 5

Selection of Candidate LTCP and Stormwater Projects

This chapter provides an overview of the methods the City used to identify candidate LTCP and stormwater projects.

5.1 Identification of Candidate LTCP Projects

The City developed its approach for identifying and ranking candidate LTCP projects for deferral based on the document, *Integrated Municipal Stormwater and Wastewater Planning Approach Framework* (EPA, 2012) and consultations with the LTCP project team. The City's approach and results are summarized below (see Volume 2 for additional details).

The candidate LTCP projects were selected for deferral by ranking the CSO basins using site-specific information together with criteria recommended in EPA document 832-B-95-004, *Combined Sewer Overflows Guidance for Screening and Ranking* (EPA, 1995). This approach, as well as a list of the selected LTCP projects, is described in Volume 2 and summarized below.

The City used two guiding principles from EPA's integrated planning guidance (EPA, 2012) to identify candidate LTCP projects:

- The Integrated Plan should allow the City to balance Clean Water Act (CWA) requirements in a manner that addresses the most pressing public-health and environmental protection issues first.
- The Integrated Plan should describe the relative priorities of the selected projects and how those priorities reflect the relative importance of adverse impacts on public health and water quality along with the permittee's financial capability.

5.1.1 Consultation with LTCP Team: Ranking and Scoring Process

The City's Integrated Plan team consulted with the LTCP team in order to identify, score, and rank the candidate LTCP projects. The CSO basins were scored based on seven criteria using site-specific information. The CSO basins were ranked from highest to lowest score and divided into two categories: higher-priority CSO basins and lower-priority CSO basins. In keeping with EPA guidelines, the City selected a group of potential candidates for deferral from the lower-priority CSO basins.

Next, the City screened out some of the LTCP projects that likely would be controlled by constructing sewer system retrofits rather than Neighborhood Storage Projects. The City further refined its deferral candidate list based on opportunities for partnering with King County to build projects that jointly address the agencies' CSO outfalls.

Through this process, the City identified six LTCP CSO control projects, each of which would control basins that experience a low frequency and volume of CSOs, for potential deferral until after 2025. The City will implement the other LTCP CSO control projects by 2025, in accordance with the LTCP. The LTCP document (Volume 2) provides additional details regarding selection of candidate LTCP projects for deferral.

5.2 Candidate LTCP Projects

The candidate LTCP projects will reduce CSO discharges to the Lower Duwamish Waterway and Lake Washington Ship Canal/Lake Union. All six LTCP projects will store excess flows and release the stored flows back to the combined sewer when conveyance and treatment capacity becomes available. Water released from LTCP storage facilities in CSO Outfalls 99, 111, 138, 139, and 140 will be treated at King County's West Point Treatment Plant and discharged via a deep-water outfall in Puget Sound. For the candidate project controlling flows from CSO Outfall 107, the stored water may be either conveyed to the West Point Treatment Plant or pumped from the storage facility back to the interceptor and conveyed to a King County CSO wet weather treatment facility.

Table 5-1 lists the estimated average annual overflow frequency and overflow volume for each of the six candidate LTCP projects. Figure 5-1 shows the drainage areas and outfalls associated with each project. For a detailed discussion on each of these CSO basins, including the basin characteristics and predictive tools used for estimating overflow frequency and volumes, refer to the respective LTCP Hydraulic Modeling Report for that particular basin (Brown and Caldwell, 2012 [Volumes 2–10]).

Table 5-1. Candidate LTCP Projects				
CSO area	CSO outfall and basin number	Receiving water body	Average existing discharge frequency (average events/yr) ^a	Average volume treated or removed (MG/yr) ^b
Delridge/Longfellow	99	West Waterway of the Duwamish River	1.5	0.17
East Waterway	107	East Waterway of the Duwamish River	4.6	1.11
Duwamish	111 (B, C, and H)	Duwamish River	1.7	0.01
Portage Bay	138	Portage Bay	1.4	0.09
Montlake	139	Portage Bay	1.15	0.01
Montlake	140	Portage Bay	3.7	0.05

a. Average annual overflow frequency for 1993–2012 from Table 5-8 of the 2012 Annual Report, CSO Reduction Program.

b. The volume treated for each approved candidate LTCP project is the moving 20-year average simulated volume without climate change (scaling factor = 1).

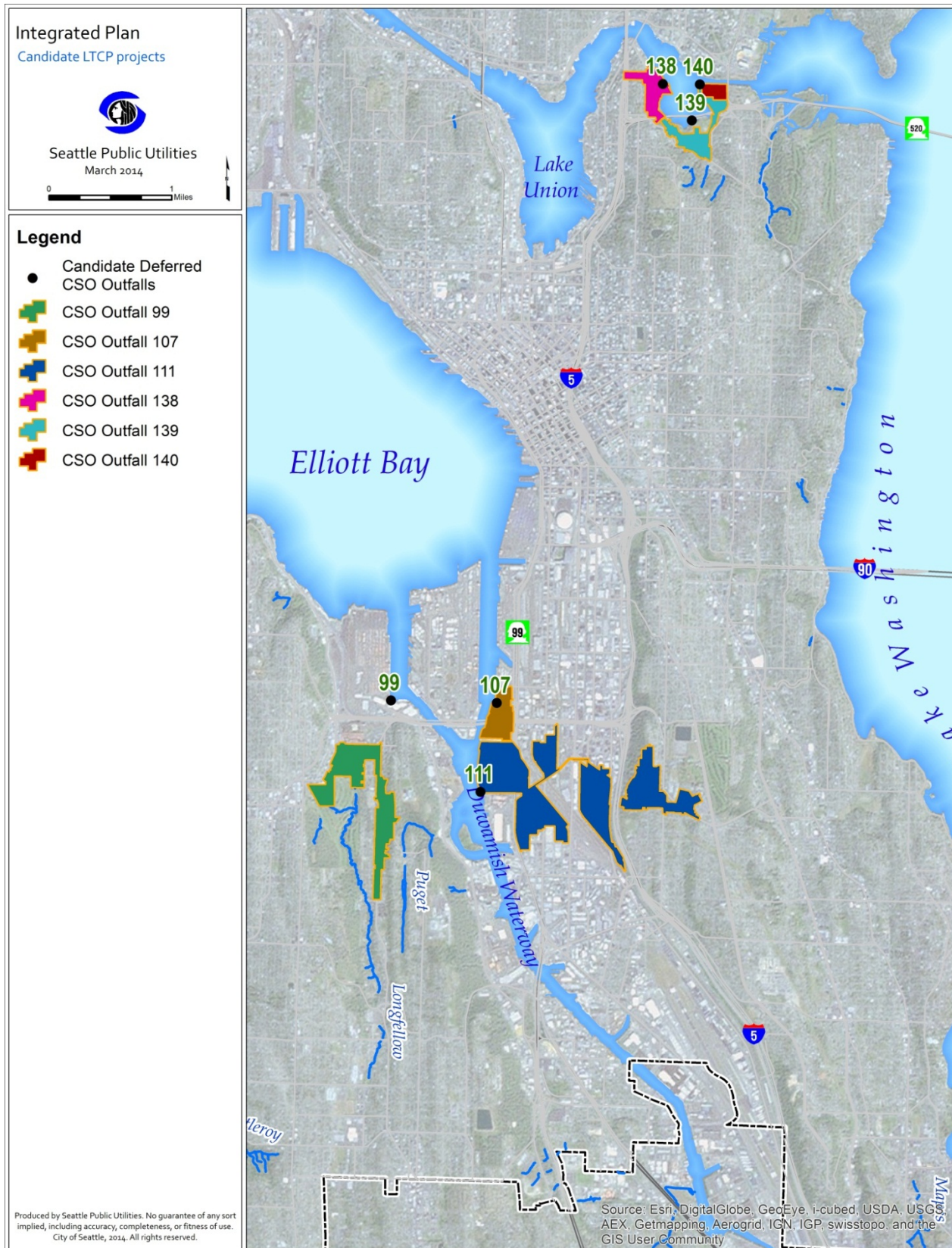


Figure 5-1. Candidate LTCP projects

5.3 Identification of Candidate Stormwater Projects

The City followed a systematic approach to select candidate stormwater projects for potential inclusion in this Integrated Plan, as summarized below.

5.3.1 Approach

Identification of candidate stormwater projects entailed the general steps listed below:

1. Rank receiving water bodies and identify their pollutants of concern
2. Develop TSS loads for each stormwater basin based on estimates of average annual volumes and pollutant concentrations
3. Rank each stormwater basin and characterize priority basins
4. Identify potential project locations and stormwater projects
5. Screen project list
6. Develop a planning-level cost estimate for potential projects
7. Conduct initial ranking of potential stormwater projects based on estimated cost per kilogram (kg) of TSS removed per year

The City's approach is documented in Appendix C to this Integrated Plan and the following technical memoranda:

- Integrated Plan: Stormwater Priority Basins Technical Memorandum (Draft), March 22, 2013; (Final), April 9, 2013 (SPU, 2013a)
- Integrated Plan: Stormwater Treatment Project Screening Technical Memorandum (Final), April 10, 2013 (SPU, 2013c)
- Integrated Plan: Stormwater Project Selection Process for Further Consideration (Final), May 15, 2013 (SPU, 2013d)
- Integrated Plan-Briefing Memorandum on Stormwater and CSO Project Evaluation and Exposure Assessment Methods. Revised May 23, 2013 (SPU, 2013e)

These memoranda describe the tools used and the results obtained from these analyses, including the identification of the City's high-priority drainage basins for stormwater treatment.

5.3.2 Candidate Stormwater Projects

The City initially identified 15 stormwater projects as candidates for potential inclusion in the Integrated Plan. Thirteen of the candidate projects were structural measures such as media filters, swirl concentrators, bioretention, biofiltration, and "active" treatment. The two candidate programmatic stormwater measures both involved street sweeping.

The City subsequently removed five of the candidate structural projects from further consideration. Two projects were removed because the City is already installing a large stormwater quality project in the same basin. Two pretreatment projects were removed because the City decided that the Integrated Plan should focus on treatment projects rather than pretreatment projects, which are intended primarily to reduce maintenance needs and ensure performance of downstream treatment facilities. The Joint Hanford-Lander-Kingdom-King (HLKK) Wet Weather Treatment project was screened out based on timing with King County and costs.

The candidate structural stormwater projects would affect the Lower Duwamish Waterway, Lake Washington, Lake Washington Ship Canal/Lake Union, Longfellow Creek, Piper's Creek, and Thornton Creek. The street sweeping programs would reduce pollutant loads to all of these water bodies as well as Elliott Bay and Puget Sound.

Table 5-2 contains a brief summary of the candidate stormwater projects and programs. Figure 5-2 shows the drainage basins where the eight structural candidate stormwater projects would be located. Figures 5-3 and 5-4 show the areas encompassed by the two street sweeping programs.

Table 5-2. Candidate Stormwater Treatment Projects and Programs, Tributary Areas, and Project Types			
Project name	Receiving water body	Total drainage tributary area ^a	Project type
Longfellow Cascades	Longfellow Creek	68 acres	Bioretention receiving runoff from multiple upstream blocks
NDS Partnering	Longfellow Creek Piper's Creek Thornton Creek	Longfellow Creek: 557 Piper's Creek: 684 Thornton Creek: 2,703 ^b	Bioretention receiving runoff from adjacent block
Piper's Cascades	Piper's Creek	160 acres	Bioretention receiving runoff from multiple upstream blocks
South Myrtle St. Shoulder Stabilization	Duwamish Waterway	3.2 acres	Biofiltration swale
South Myrtle St. StormFilter Vault	Duwamish Waterway	8.5 acres	Cartridge media filter
South Park Water Quality (WQ) Facility	Duwamish Waterway	254 acres	Active treatment (CESF) ^c
Street Sweeping Expansion Arterials	Multiple	10,600 annual curb miles (approx. 1,736 acres)	Street sweeping (weekly arterial sweeping)
Street Sweeping Expansion Residential	Multiple	11,500 annual curb miles (approx. 1,120 acres)	Street sweeping (residential biweekly)
SW Hinds SD StormFilter Vault	Duwamish Waterway	29.45 acres	Cartridge media filter
U Village Filterrras	Lake Washington	5.4 acres	Media filter

a. A complete discussion of the areas included in each pollutant load model (PLM) is provided in Appendix F.

b. See Appendix J, Project Sheet for NDS Partnering, for a thorough discussion on the impervious and pervious areas included within the tributary areas for each watershed.

c. CESF = chitosan-enhanced sand filtration.

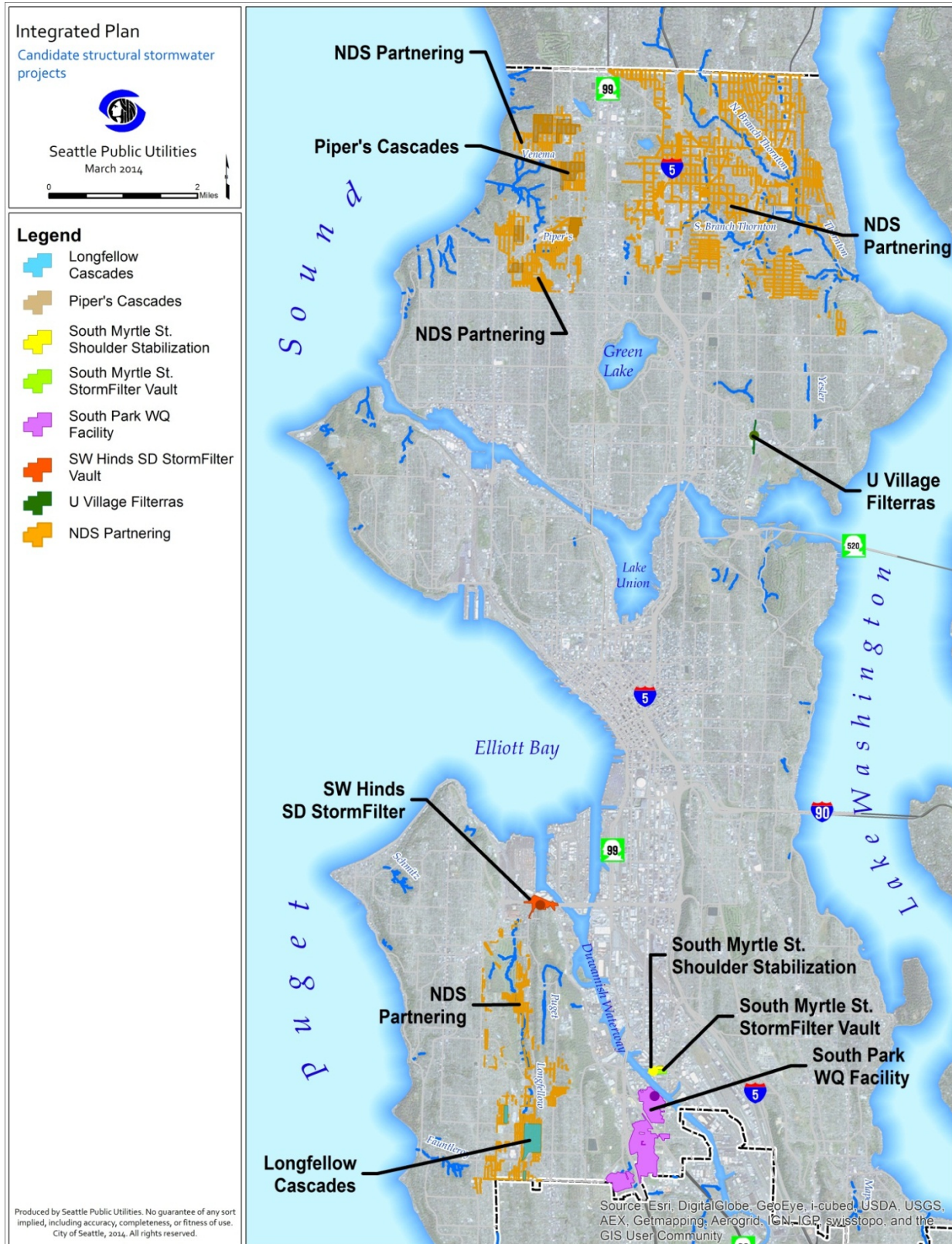


Figure 5-2. Candidate structural stormwater projects, not including the street sweeping program expansions

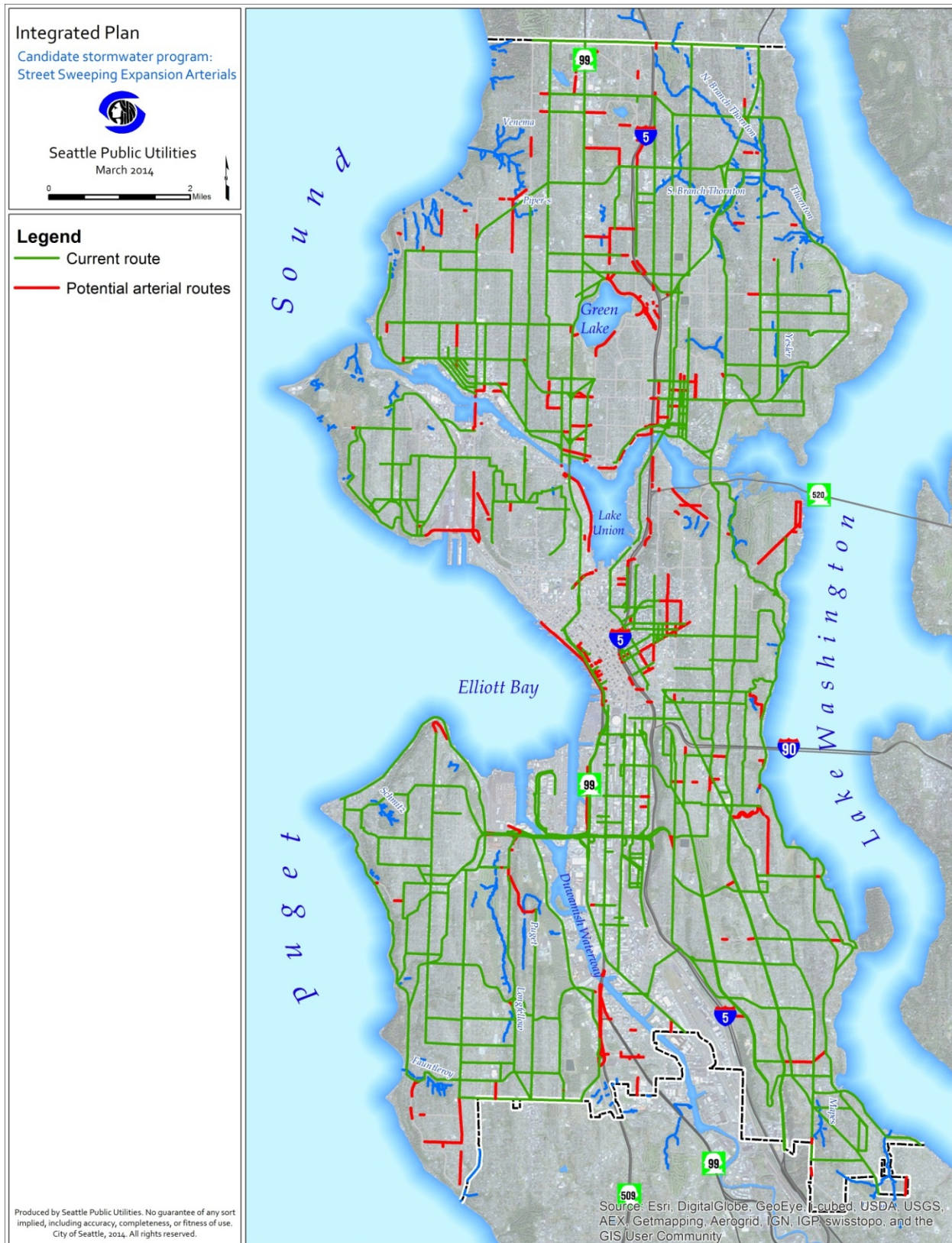


Figure 5-3. Candidate stormwater program: Street Sweeping Expansion Arterials

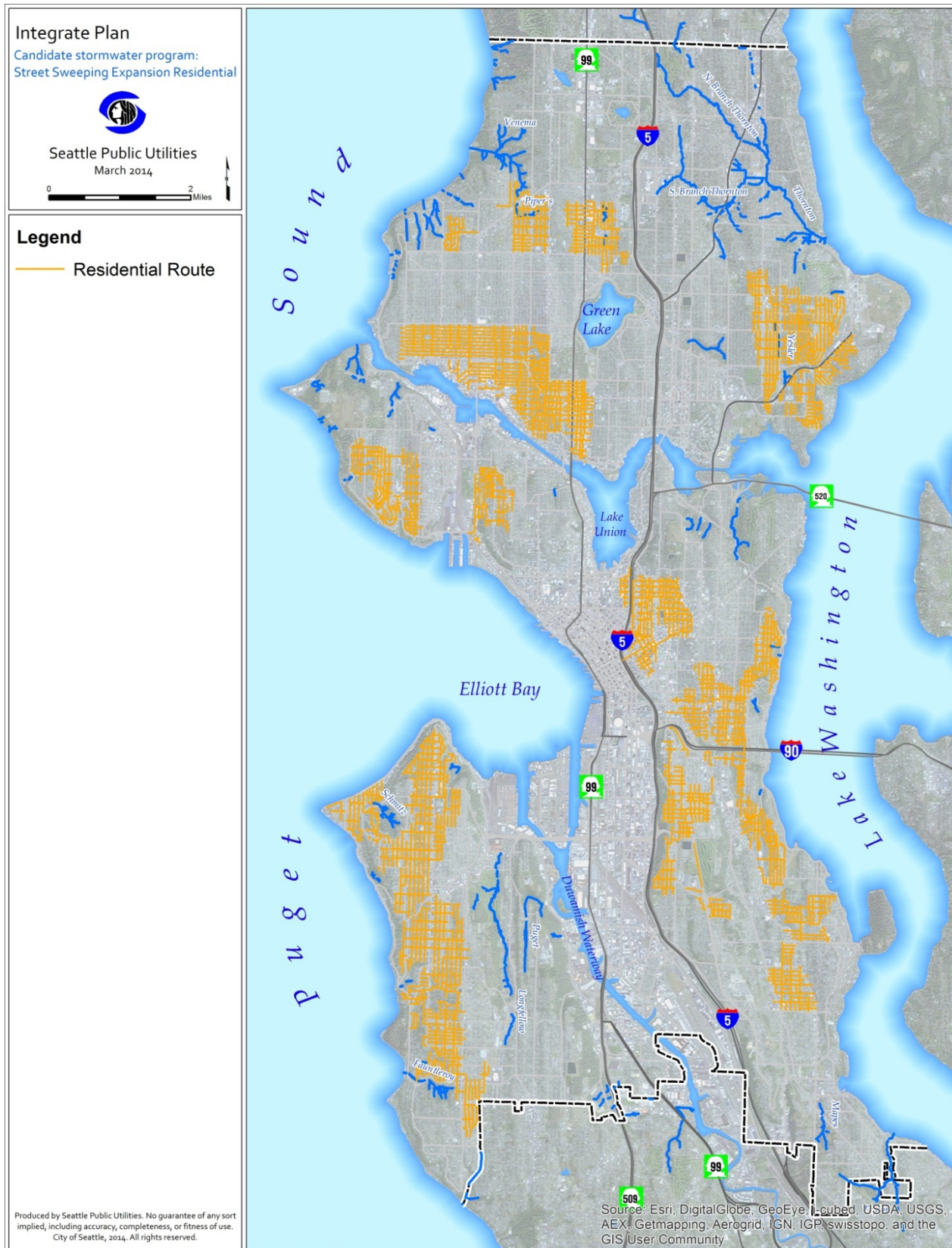


Figure 5-4. Candidate stormwater program: Street Sweeping Expansion Residential

A brief description of each candidate project is provided below. Appendix C contains additional details about each candidate project.

5.3.2.1 Longfellow Cascades

The Longfellow Cascades project is a green infrastructure project that would provide treatment and flow control/volume reduction for a portion of the stormwater runoff from approximately 68 acres. The project entails constructing bioretention elements along four to seven blocks along 22nd and 24th Avenues SW and constructing pipe or ditch improvements to collect and convey runoff from several blocks upstream of the project to treat a portion of the Longfellow Creek storm sewer system basin. Stormwater treatment would be provided by bioretention and volume reduction through infiltration.

5.3.2.2 NDS Partnering

The Natural Drainage Systems (NDS) Partnering project is a regional green infrastructure project that would construct bioretention facilities (i.e., engineered rain gardens) in the storm sewer system basins that drain to Longfellow, Piper's, and Thornton creeks. In addition to providing stormwater treatment and flow control/volume reduction, the NDS Partnering project would provide community benefits such as mobility, traffic calming, and beautification, and would increase community awareness around the stormwater quality impacts generated by impervious surfaces.

The NDS Partnering project would entail reconstructing the City rights-of-way to manage flow and provide water quality treatment for urban runoff primarily using bioretention. It would focus on managing runoff generated on a given block with green infrastructure approaches on that block. As noted above, the right-of-way improvements may include curbs, sidewalks, and other community amenities.

The City would work in partnership with local residents or community groups to identify candidate blocks within each basin. Candidate blocks must be among the potential blocks identified by the City as potentially feasible for bioretention. The City anticipates that most of the candidate blocks will be in areas that currently lack curbs and gutters. The project locations would be prioritized based primarily on stormwater management goals, but factors such as community support and overlapping City priorities will be included in the project prioritization.

5.3.2.3 Piper's Cascades

The Piper's Cascades project is a localized green infrastructure project that would provide stormwater treatment and flow control/volume reduction. The project would install bioretention elements as well as pipe or ditch improvements to collect and convey runoff from several blocks upstream of the project site. The project would provide treatment and flow control within high-priority subbasins of Piper's Creek as well as subbasins that overlap with the Broadview Sewer and Drainage Improvement Project.

5.3.2.4 South Myrtle St. Shoulder Stabilization

The South Myrtle St. Shoulder Stabilization project is a localized project that would provide stormwater source control and flow control/volume reduction. The project site is an unpaved gravel/dirt road shoulder on a heavily traveled industrial roadway that drains to the Duwamish Waterway. Currently, stormwater runoff is collected in a series of catch basins located along the south edge of the street. The site is the subject of an adaptive management response under Special Condition S4F of the City's municipal stormwater discharge permit due to contaminants (PCBs and metals) discharged to the roadway from an adjacent industrial property. Ecology is concerned that the unpaved shoulder could contribute contaminated sediment to the Duwamish Waterway.

This project would involve paving a wide strip along the north side of S Myrtle Street in order to widen the traveled surface; installing a gravel-surface, angled parking area on the north side of the street; and installing a biofiltration swale in the remainder of the shoulder to treat runoff from the parking area and the adjacent properties to the north, which currently drain to the City right-of-way.

5.3.2.5 South Myrtle St. StormFilter Vault

The South Myrtle St. StormFilter Vault project is a localized project that would provide stormwater treatment. The project entails installation of a cartridge media filter and stabilization of the unpaved shoulder with biofiltration. The 40-foot-wide shoulder on the north side of S Myrtle Street would be paved to reduce erosion and a StormFilter unit would be installed to treat runoff from the entire 8.5-acre drainage basin.

5.3.2.6 South Park Water Quality Facility

The South Park Water Quality (WQ) Facility would treat stormwater runoff from approximately 254 acres in the 7th Avenue S drainage system. The City would install a basic, active treatment system, such as a chitosan-enhanced sand filtration (CESF) system, prior to discharge into the Duwamish Waterway. The treatment facility would be co-located with a new stormwater pump station that the City plans to build in order to reduce flooding in the 7th Avenue S drainage system. The proposed project would take advantage of the opportunity to integrate water quality treatment with flood control.

5.3.2.7 Street Sweeping Expansion Arterials

The Street Sweeping Expansion Arterials program would entail increased sweeping of arterials to remove potential stormwater pollutants from storm sewer system basins. This program includes the following three expansions:

- increase the route coverage from 83 percent to approximately 85 percent of curbed arterials (for a total 10,600 curb-miles), by adding 1 route, for a total of 25 routes
- increase the sweeping season from 40 to 48 weeks per year
- increase the sweeping frequency from biweekly to weekly for some routes: 21 routes will be swept on a weekly basis and 4 routes will be swept on a biweekly basis

5.3.2.8 Street Sweeping Expansion Residential

The Street Sweeping Expansion Residential program would focus on the storm sewer system basins and would cover 11,500 curb-miles (approximately 65 percent of the curbed local streets within the city). This street sweeping program would be an expansion of the City's current street sweeping efforts. Streets would be swept biweekly during the day over a 46-week period. The street sweeping would take place within various basins that affect all of the receiving water bodies in the city.

5.3.2.9 SW Hinds SD StormFilter Vault

The SW Hinds SD StormFilter Vault project is a localized project that would provide stormwater treatment. The project entails installing a cartridge media filter within the Duwamish River Basin, along W Marginal Way SW, for stormwater treatment. Runoff from the eastern 29.45 acres of the SW Hinds Street drainage basin is conveyed along W Marginal Way SW in a 36-inch-diameter pipe, before connecting with the 96-inch-diameter outfall pipe. A diversion structure would be installed to route stormwater underneath the existing 48-inch-diameter sanitary sewer owned by King County to the Port of Seattle property on the south side of W Marginal Way SW. If the City can obtain an easement from the Port, the StormFilter vault would be installed underneath the Port's parking lot.

5.3.2.10 U Village Filtreras

The U Village Filtreras project is a localized project that would treat stormwater runoff from approximately 5.4 acres that drains to Lake Washington. The project consists of installing Filterra media filters in the right-of-way for water quality treatment of runoff from 25th Avenue NE between NE Blakely Street and NE 44th Street.

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CHAPTER 6

Methods for Evaluation of Candidate Projects

This chapter discusses the methods the City used to evaluate the candidate LTCP and stormwater projects.

6.1 Introduction

The Consent Decree requires a pollutant load reduction analysis for each stormwater project proposed for implementation and each candidate LTCP project. In addition, the Consent Decree requires an assessment of the potential reductions in pollutant exposure for human and ecological receptors. The Consent Decree lists a range of water quality constituents that the Integrated Plan must address.

The City developed methods for evaluating pollutant load and exposure reductions from the candidate LTCP and stormwater projects based on the following: Consent Decree requirements, review of the available relevant data, and input from an independent Expert Panel. Section 6.2 summarizes the Expert Panel's involvement. Section 6.3 describes climate change considerations. Section 6.4 describes how the City identified the "Representative Constituents of Concern" (RCOCs) to be evaluated for each candidate project. Sections 6.5 and 6.6, respectively, summarize the pollutant load evaluation methods for the candidate LTCP (CSO) and stormwater projects and Section 6.7 outlines exposure assessment methods applied.

6.2 Expert Panel

The City worked with a five-member Expert Panel during the development of the Integrated Plan. The primary role of the Expert Panel was to provide input on the data, methods, and assumptions used to develop the Integrated Plan. The Expert Panel acted as a technical sounding board for the City, reviewing and commenting on technical questions and issues relevant to the methodology. The Expert Panel was not involved in the selection of the stormwater projects included in the Integrated Plan. Appendix D contains information on the Expert Panel members and summaries of the Expert Panel meetings.

6.3 Climate Change

The LTCP Volume 2 modeling reports discuss the modeling conducted on each of the LTCP (CSO) projects. As discussed in each of these modeling reports, climate change factors were taken into consideration for determining long-term overflow estimates. The LTCP models were run both with and without "scaling factors," which were intended to allow the City to factor climate change and other uncertainties into the design of the LTCP control projects. (Scaling factors are multipliers for the rainfall time series.) A scaling factor of 1.0, which represents no climate change, was used for estimating the pollutant loads for the candidate LTCP projects. A scaling factor of 1.0 was used for two reasons:

- Climate change was not factored into the pollutant load reduction estimates for the candidate stormwater projects. For the Integrated Plan candidate project evaluations, the load reduction estimates for the candidate LTCP projects need to be directly comparable to the candidate stormwater project pollutant load reduction estimates.

- The candidate stormwater projects and LTCP projects would all be built within the next 16 years. The climate change portion of the scaling factors is based on the physics associated with a 1-degree Celsius rise in the surface temperature of the north Pacific, which is expected to occur over a longer time frame.

See Volume 2: LTCP, of the City's Protecting Seattle's Waterways Plan, for additional details on the incorporation of climate change and scaling factors used for the hydraulic models.

6.4 Representative Constituents of Concern

Section V.B. paragraph 20 of the Consent Decree lists a number of specific constituents that the Integrated Plan must address. These include fecal coliform bacteria, TSS, biochemical oxygen demand (BOD), ammonia, phosphorus, oil and grease, and pH. The Consent Decree also lists several general categories of constituents (e.g., metals, pesticides, semi-volatile organic compounds).

Due to the very tight schedule for developing the Integrated Plan, it was not possible to collect new water quality data. Therefore, the City compiled and reviewed existing stormwater, CSO, and receiving water data in light of the Consent Decree requirements to develop a list of RCOCs. In some cases, the City identified surrogates to represent a category of constituents (e.g., dissolved and total copper [Cu] and dissolved and total zinc [Zn] for metals; PCBs and polybrominated diphenyl ethers [PBDEs] for toxic organic compounds).

To help develop this list of RCOCs, the City reviewed its existing stormwater sampling data and receiving water data to identify representative data sets to link pollutant concentrations (and their inherent variability) with different land uses. To supplement the local stormwater data, additional data were used such as from the City of Tacoma, King County, Oregon Association of Clean Water Agencies, and other suitable regional and/or national databases.

The Consent Decree listed numerous specific constituents as well as categories of constituents. For some of these constituents, little or no data were available for an adequate evaluation. Also, it was not feasible to model each Constituent of Concern (COC) given the available data and schedule. Therefore, the Integrated Plan team selected RCOCs with input from the Expert Panel. RCOCs were selected based on Consent Decree requirements, data availability, and professional judgment. Table 6-1 lists the COCs listed in the Consent Decree and the recommended RCOCs to be used in the pollutant load and exposure reduction evaluations.

Table 6-1. COCs Identified in the Consent Decree and Recommended RCOCs Used for Project Evaluations	
Constituents of Concern (COCs) identified in the Consent Decree	Recommended Representative Constituents of Concern (RCOCs)
Biochemical oxygen demand (BOD)	BOD
Semi-volatile organic compounds	Bis(2-ethylhexyl)phthalate
Pesticides	Dichlobenil
Pathogens (fecal coliform bacteria)	Fecal coliform bacteria
pH	H+
Nitrogen ammonia	Ammonia-N
Oil and grease	Oil and grease
Polybrominated diphenyl ethers (PBDEs)	PBDEs ^a
Projected dissolved oxygen (DO)	Projected DO

Table 6-1. COCs Identified in the Consent Decree and Recommended RCOCs Used for Project Evaluations

Constituents of Concern (COCs) identified in the Consent Decree	Recommended Representative Constituents of Concern (RCOCs)
Polychlorinated biphenyls (PCBs)	PCBs ^a
Phosphorus	Phosphorus ^a
Total suspended solids (TSS)	TSS
Metals	Dissolved copper
	Dissolved zinc
	Total copper
	Total zinc

a. Total phosphorus, total PCBs, and total PBDEs were used as RCOCs.

6.5 Pollutant Load Evaluation Methods for Candidate LTCP Projects

The City estimated pollutant load reductions from the candidate LTCP projects based on the expected reductions in overflow volumes and available information on RCOC concentrations in City and King County CSO discharges.

6.5.1 Overflow Volume Reduction

The reduction in CSO discharge volumes from the candidate LTCP projects was estimated using results from calibrated hydrologic and hydraulic models. The City developed hydrologic and hydraulic models (EPA-SWMM 5 Build 5.0.022) for the currently uncontrolled CSO basins to support development of the LTCP. The models were developed to assess the performance of the existing system, predict wet weather flows, and estimate the frequency and volume of CSO events. The models were calibrated to flow monitoring data collected within each CSO basin. In addition, the model for CSO Outfall 107 used supervisory control and data acquisition (SCADA) data to supplement the available flow monitoring data. A full discussion of the modeling conducted for each of these CSO basins is provided within the LTCP reports Volumes 2–10 (Brown and Caldwell, 2012).

These calibrated models provide simulated, long-term time series of CSO events (including discharge volumes and duration). They also allow estimation of the groundwater, stormwater, and sanitary contributions to overflows. In addition, the models were used to develop estimates of control volumes (i.e., required storage) to limit CSOs to one or fewer overflow per outfall per year.

The control volume estimates and simulated CSO event volumes were used to generate pre- and post-project CSO frequencies and volumes. The difference between pre- and post-project CSO event volumes was the expected reduction in overflow volume, which was used in estimating pollutant load reductions for the candidate LTCP projects.

6.5.2 RCOC Concentrations

The City sampled CSO water quality at 16 locations between 2007 and 2010. Sites were sampled from one to four times. In addition, King County sampled CSO water quality at two locations in the Duwamish area between 2007 and 2009. These sites were sampled from three to five times. The samples were analyzed for most of the RCOCs. Only one of the six candidate LTCP projects (CSO Outfall 99) was sampled.

The City evaluated the land use data for the sampled and unsampled CSO locations. The tributary areas for the 16 CSOs sampled by the City were primarily residential. The tributary areas for four of the six candidate LTCP projects (CSO Outfalls 99, 138, 139, and 140) are mostly residential. Therefore, the data from the 16 sampled CSOs were pooled together to estimate RCOC concentrations for CSO Outfalls 99, 138, 139, and 140.

CSO Outfalls 107 and 111 serve largely industrial areas. As noted above, the City's CSO data were collected from residential areas. Therefore, the City used water quality data collected from two King County CSOs that are located near CSO Outfalls 107 and 111 and have tributary areas with industrial land uses. The data from the two King County CSOs were pooled to estimate RCOC concentrations for CSO Outfalls 107 and 111.

Data for PCBs, PBDEs, and pesticides were not available from the City sampling data. Data from a King County report describing PCBs and PBDEs (King County, 2011) were used to fill these data gaps.

The herbicide dichlobenil was used as a surrogate for pesticides. Local stormwater sampling provided data on dichlobenil concentrations for runoff from residential, commercial, and industrial land uses. However, no data on dichlobenil or other pesticides were available for City CSO discharges. Therefore, median dichlobenil concentrations for stormwater from each land use type were used to estimate a weighted concentration based on the land use of each CSO basin. This weighted concentration was factored by the percentage of flow attributable to groundwater and stormwater within each CSO basin, as indicated by the CSO models.

The King County sampling data did not include BOD, fecal coliform bacteria, oil and grease, or H⁺. The City sampling data were used to fill this data gap. The City and King County water quality data are discussed in more detail in Appendix E.

The RCOC concentrations used in the CSO analysis were the mean of the data set, and included both the upper confidence limit (UCL) and lower confidence limit (LCL) as calculated by the bootstrap method (Singh et al., 1997). The bootstrap method samples from the data set with replacement several thousand times and calculates the desired descriptive statistics from the sampled data; it is fundamentally a procedure based on the Central Limit Theorem, which suggests that even when the underlying population distribution is non-normal, averaging produces a distribution more closely approximated with normal distribution than the sampled distribution (Devore, 1995). A comprehensive description of the bootstrap method is provided in Appendix F, which discusses the pollutant reduction estimation method applied to the stormwater projects.

Table 6-2 lists the RCOC concentrations used for the CSO load evaluations. This bootstrap method that was used for deriving the mean, LCL, and UCL of the CSO water quality data set was also applied to the data set used for the stormwater project evaluation, as discussed in Section 6.6.

Table 6-2. Mean, LCL, and UCL of RCOCs Applied to the CSO Volumes for Estimating Pollutant Reductions

Constituents of concern	Units	Residential/commercial			Industrial		
		Bootstrap mean	Bootstrap 95% lower confidence limit (LCL)	Bootstrap 95% upper confidence limit (UCL)	Bootstrap mean	Bootstrap 95% lower confidence limit (LCL)	Bootstrap 95% upper confidence limit (UCL)
Ammonia-N	mg/L	1.2	1.0	1.6	4.6	2.8	7.0
BOD	mg/L	19	15	24	19	15	24
Bis(2-ethylhexyl) phthalate	mg/L	0.0023	0.0018	0.0030	0.0083	0.0025	0.019
Dichlobenil	mg/L	Residential: 0.00012	N/A	N/A	0.000070	N/A	N/A
		Commercial: 0.000098					
Dissolved copper	mg/L	0.0051	0.0046	0.0057	0.0065	0.0041	0.011
Dissolved zinc	mg/L	0.019	0.018	0.021	0.032	0.022	0.046
Fecal coliform bacteria	CFU/100 mL	103,885	72,200	140,048	103,885	72,200	140,048
H+	mg/L	0.00012	0.000088	0.00017	0.00012	0.000088	0.00017
Oil and grease	mg/L	3.5	2.8	4.4	3.4	2.8	4.4
PBDEs	mg/L	0.000060	N/A	N/A	0.000060	N/A	N/A
PCBs	mg/L	0.000052	0.000040	0.000067	0.00011	0.000063	0.00020
Phosphorus	mg/L	0.60	0.44	0.75	1.6	1.2	2.1
Total copper	mg/L	0.013	0.011	0.016	0.053	0.034	0.068
TSS	mg/L	32	26	39	118	78	179
Total zinc	mg/L	0.042	0.038	0.048	0.14	0.10	0.19

6.5.3 Pollutant Load Reduction Estimation

Pollutant load reductions were estimated as the product of the RCOC concentrations and simulated CSO volume reductions for each candidate LTCP project. Appendix E contains a more detailed discussion of the predicted volumes and RCOC concentration used for estimating the pollutant load reductions from the LTCP projects.

6.5.4 Projected DO Estimation

A simplified approach was used to calculate the potential impact of each candidate LTCP project on dissolved oxygen (DO). The Streeter-Phelps equation was used to calculate the maximum DO deficit based on the change

in nitrogen and carbonaceous BOD concentrations. The deficit value was used to estimate the percent change from DO at saturation. The same method was used to estimate potential DO impacts from the candidate stormwater projects. Appendix F contains a detailed description of the method.

6.6 Pollutant Load Evaluation Methods for Candidate Stormwater Projects

The City estimated the potential pollutant load reductions for each candidate stormwater project. The City used the loads modeling results to help determine which stormwater projects should be included in the Integrated Plan. This section summarizes the pollutant loads modeling methods for the candidate stormwater projects. Appendix F provides a detailed description of the stormwater project loads evaluations and results.

6.6.1 Model Overview

The City used existing information and a relatively simple spreadsheet pollutant load model (PLM) to estimate pollutant load reductions for the candidate stormwater projects. Although the PLM was not calibrated to site-specific conditions, local information provided by the City (e.g., local stormwater runoff study data and local precipitation data) were used where possible. Information from literature and the International Stormwater Best Management Practice (BMP) Database (Geosyntec Consultants and Wright Water Engineers, Inc., 2011) was also used for parameterizing the PLM.

The pre-project component of the model was based on observed and literature-developed rainfall/runoff relationships and estimated pollutant concentrations in stormwater runoff. The volume of stormwater runoff was estimated using a simple volumetric runoff coefficient, an empirical expression that relates runoff volume to the rainfall depth and the basin characteristics, such as imperviousness and soil infiltration characteristics. The pollutant concentration in stormwater runoff was represented by an expected average pollutant concentration, developed based on analysis of event mean concentrations (EMCs). The EMCs used in this analysis were obtained from available monitoring data from other studies and are dependent on the land-use type. See Appendix F for additional details on the data used and the methodology applied for this analysis.

The post-project component of the model utilizes the pre-project concentrations and runoff volumes and applies stormwater project performance estimates to each of the candidate stormwater projects. The modeled performance of each project depends on the following three factors:

- the fraction of average long-term stormwater runoff volume receiving treatment (referred to hereafter as “capture efficiency”)
- the pollutant removal achieved in the stormwater project by virtue of surface runoff reduction via infiltration and/or evapotranspiration (generically referred to as “volume reduction”)
- the pollutant removal achieved in the stormwater project by virtue of improved water quality of treated runoff

The flow chart in Figure 6-1 provides an overview of the post-project modeling component. See Appendix F for additional details on the data used and the methodology applied for this analysis.

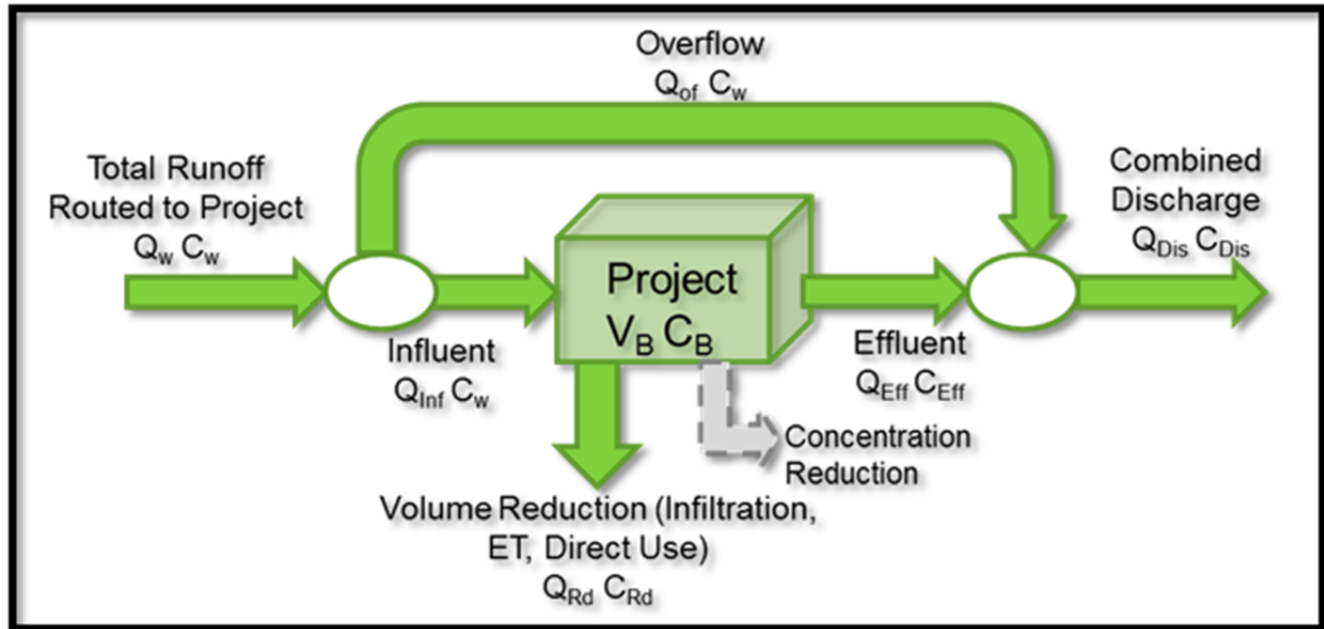


Figure 6-1. Flow chart used for stormwater project evaluation

6.6.2 Uncertainty in Input Parameters

There is an inherent level of uncertainty in the stormwater sampling data, watershed characteristics, GIS data, stormwater project performance data, and other data sets that were used to help understand the water quality benefits of stormwater projects. Therefore, understanding and quantifying these sources of uncertainty and incorporating them into the PLM created a more robust analysis. A statistical modeling approach (Monte Carlo Analysis) was employed to allow the uncertainty in input parameters to be reflected in model inputs and provide an indication of the average characteristics and variability of the stormwater concentrations and loadings in model results. For each Monte Carlo iteration, the PLM randomly selected a value between the lower and upper bounds for each key parameter to develop a unique estimate of average long-term conditions. The calculation was repeated for a large number of iterations, resulting in a large distribution of different estimates of potential long-term runoff volume, pollutant concentrations, and pollutant loadings results from each of the project tributary areas (see Appendix F for a complete discussion of the uncertainty in the input parameters as well as a description of the Monte Carlo Analysis).

The first step was to develop a lower and upper bound for each of the parameters that is sensitive in the analysis and can be meaningfully quantified. When possible, the model expressed these input parameters in terms of a 95 percent confidence interval (CI) on the long-term average (i.e., bounded by the LCL and the UCL). CIs were developed for the land use runoff concentrations, project effluent concentrations, and street sediment concentrations using the bootstrap method approach, as defined in Section 6.5.2 above, in combination with regression on order statistics (ROS). Additionally, when the underlying data sets did not allow for the explicit estimation of CIs, the LCL and UCL for each key model input parameter were estimated using other methods, such as modeling calculations, data analysis, literature, or best professional judgment (see Appendix F for a comprehensive discussion of this methodology).

The PLM was intended to estimate long-term average annual conditions for a given location and project. It did not seek to describe the temporal variability that is inherent in stormwater pollutant loading. Additionally, the PLM was not intended to predict conditions for a given storm event or monitoring period.

6.6.3 Street Sweeping Model Overview

The City developed a separate model to characterize long-term average pollutant loading reductions and concentration reductions for the candidate street sweeping stormwater projects. This model uses a rate of pollutant removed by sweeping per curb-mile (pick-up rate) calculated from data measured during the City's current street sweeping program. The pick-up rate is then applied to the area that will receive additional sweeping to generate the total pollutant mass removed. Adjustments were applied to the total pollutant mass removed to convert this mass into a portion that would have been expected to be washed off the street during rain events and discharged at stormwater outfalls. A detailed discussion of the street sweeping analysis is included in Appendix G. The methodology and data provided by the City were then used to characterize the uncertainty inherent in the street sweeping data, as described below, and run with the Monte Carlo iterations.

6.6.4 Model Input Parameters

The PLM input parameters for the pre-project pollutant loadings included precipitation, stormwater project drainage area, runoff coefficients, and land use runoff concentrations. PLM input parameters for the post-project pollutant loadings included candidate stormwater project performance parameters, including capture efficiency, volume reduction, and effluent quality and/or other expressions of treatment efficiency. Appendix F provides a detailed discussion on all of the model input parameters and includes a discussion on the precipitation characteristics, stormwater project drainage areas, including the effective drainage area adjustments and their degree of project implementation, runoff coefficients, land use runoff concentrations, and project performance metrics. As noted in Appendix F (section 3.2.3), the "degree of project implementation" is the ratio of the constraints that will limit the treatment area size to the overall area that may be available. Additional model input parameters for street sweeping include ranges of uncertainty and seasonal variations in street sweeping load reductions. Appendix G contains a detailed description of the street sweeping analysis.

6.6.5 Model Methodology

The application of the PLM involved several calculation steps, as summarized below:

1. Calculate the implemented effective drainage area for each land use type within the stormwater project drainage area, based on degree of project implementation, GIS land use (e.g., residential, commercial, industrial), surface type (e.g., street, building, sidewalk, landscaped area), and drainage system connection factors (parameters selected from within CIs).
2. Estimate the runoff coefficient for each land use type within the stormwater project drainage, based on GIS land use and pervious surface type data, and source type runoff coefficients (parameters selected from within CIs).
3. Select the rainfall depth for the time period (from CIs) to calculate the stormwater runoff volume from each land use type within the stormwater project drainage area and then sum volumes for the pre-project runoff volume.
4. Select a pollutant concentration in stormwater runoff for each land use type and each RCOC (from respective CIs), and multiply by runoff volume to calculate the pre-project load from each discrete contributing area.
5. Sum load and volume contributions from each contributing area and use these sums to calculate the pre-project concentration for each RCOC.

6. Route the pre-project load through the candidate stormwater project to estimate the post-project pollutant load and volume associated with candidate stormwater project bypass, volume reduction, and change in concentration via treatment (each selected from within CIs). Sum each element to compute the composite load, volume, and resultant average concentration discharged downstream of the candidate stormwater project.
7. Calculate the post-project average volume reduction, concentration reduction, and load reduction for each RCOC based on the difference between pre-project and post-project results.
8. To calculate the distribution of results, repeat steps 1–7 a total of 1,000 times for each RCOC and time period, recording the pre-project and post-project, and reduction model results for each iteration.

Appendix F of this plan provides a complete discussion on the methodology used by the City for evaluation of the pollutant load reductions for each of the stormwater projects, excluding the street sweeping stormwater programs. Appendix G of this plan describes the City's recent street sweeping monitoring and how the results were used to estimate pollutant load reductions for the two candidate street sweeping programs.

6.7 Exposure Assessment Methods

The City developed a conceptual model to estimate the relative exposure reduction associated with each candidate LTCP project and structural stormwater project. The model used metrics for potential hazard and exposure to calculate an exposure index value (EIV) for each structural project. Section 6.7.1 summarizes the EIV calculation methods. Appendix H contains a more detailed description of the EIV methods.

It was impractical to calculate EIVs for the candidate street sweeping programs. Therefore, the City performed a more qualitative exposure assessment for street sweeping. After tentatively selecting the projects for the Integrated Plan, the City performed a qualitative assessment to compare the selected stormwater projects to the selected LTCP projects. Section 6.7.2 summarizes the qualitative exposure assessment methods.

6.7.1 Exposure Index Value Method

The City developed a conceptual model that used metrics for potential hazard and exposure to calculate an EIV for each structural project. The EIV was designed to compare and rank candidate projects based on their relative reductions in human and ecological exposures. The EIVs were used to help compare the candidate projects and select projects to be included in the Integrated Plan.

The EIV model included three basic components:

- characterization of the RCOCs
- identification of potential human and ecological receptors in the receiving water body affected by each candidate project
- identification of potential exposure pathways and exposure rates for the receptors near each discharge location

Based on input from the Expert Panel, the City calculated the following three separate EIV metrics for each candidate structural project:

- human receptors exposed to toxic constituents, based on chronic water quality criteria
- human receptors exposed to fecal coliform, based on acute water quality criteria
- ecological receptors exposed to toxics and nutrients, based on chronic water quality criteria

The EIV calculation was based on the following parameters:

- pre-project RCOC concentration
- water quality criterion for each RCOC
- change in RCOC load resulting from project implementation
- exposure potential for each receptor type and at each project location

EIVs were calculated as follows:

$$EIV_{Human\ or\ Eco-RCOC} = \frac{C_{Pre}}{WQC_{Human\ or\ Eco}} \times relative\ change\ in\ load \times RF_{Human\ or\ Eco}$$

Where:

C_{pre} = concentration in effluent discharged pre-project (mg/L, or CFU/100 mL for fecal coliform)

WQC = human or ecological water quality criterion (mg/L, or CFU/100 mL for fecal coliform)

Relative change in load = (pre-project load – post-project load for a specific RCOC) / total change in load across all projects (candidate LTCP and stormwater projects) for this RCOC

RF = receptor factor (unitless)

The EIV calculations require information about receptors at each affected outfall location. As noted above, EIVs were not calculated for the candidate street sweeping programs because they would affect more than 100 outfalls and numerous water bodies throughout the city.

6.7.1.1 Hazard Potential

The hazard potential is calculated based on the ratio of the pre-project RCOC concentration from the candidate LTCP or stormwater project outfall to the applicable water quality criterion for the RCOC, which can vary depending on the receptor.

$$Hazard\ potential = \frac{C_{Pre}}{WQC_{Human\ or\ Eco}}$$

Tables 6-3 and 6-4 show the water quality criteria for human receptors and ecological receptors, respectively.

Table 6-3. Water Quality Criteria for Human Receptors

RCOC	Criterion (mg/L)	Basis	Health impact basis	Source
Bis(2-ethylhexyl) phthalate	0.0012	Assuming ingestion of water and fish consumption	Chronic, cancer (liver cancer in rodents, EPA SF)	EPA AWQC (EPA, 2002b)
Copper	1.3	EPA drinking water MCLG	Chronic, non-cancer (gastrointestinal effects in humans, EPA RfD)	EPA AWQC (EPA, 2013b)
Dichlobenil	0.44	Assuming ingestion of water and fish consumption	Chronic, non-cancer (decreased body weight in dogs, EPA RfD)	Derived using EPA AWQC equation (EPA, 2000)
Fecal coliform	50 CFU/100 mL 100 CFU/100 mL 200 CFU/100 mL	Extraordinary primary contact (Ship Canal, Portage Bay, Piper's Creek, Thornton Creek) Primary contact (Longfellow Creek) Secondary contact (Duwamish Waterway)	Acute infection	Ecology, 2011b
PBDEs	0.000088	Assuming ingestion of water and fish consumption	Chronic, non-cancer (neurobehavioral effects in rats, EPA RfD)	Derived using EPA AWQC equation (EPA, 2000)
PCBs	0.000000064	Assuming ingestion of water and fish consumption	Chronic, cancer (liver cancer in rats, EPA SF)	EPA AWQC (EPA, 2013b)
Zinc	7.4	Assuming ingestion of water and fish consumption	Chronic, non-cancer (enzyme activity in humans, EPA RfD)	EPA AWQC (EPA, 2013b)

AWQC = ambient water quality criteria.

CFU = colony forming unit(s).

MCLG = maximum contaminant level goal.

RfD = reference dose.

SF = slope factor.

Table 6-4. Water Quality Criteria for Ecological Receptors

RCOC	Chronic criterion: freshwater (mg/L)	Chronic criterion: marine (mg/L)	Basis	Source
Ammonia-N	Location-specific; see Appendix H	8.21 (Oct–Jan) 5.52 (Feb–Sep)	Calculated as un-ionized ammonia and converted to total ammonia, as N, assuming salmonids present; see Appendix H	Ecology, 2011b
Bis(2-ethylhexyl) phthalate	0.003	0.003	No criteria, based on data suggesting chronic toxicity to aquatic life as low as 3 µg/L	EPA, 1980
Dichlobenil	0.33	0.33	Chronic criteria for fisheries	Ecology, 2013c
Dissolved copper	0.0041 (mesotrophic) 0.011 (streams)	0.0031	For freshwater, based on water-body-specific hardness assumptions using EPA equation. For marine, equal to EPA value; see discussion below.	EPA, 2007
Dissolved zinc	0.054 (lakes) 0.14 (streams)	0.081	Based on water-body-specific hardness assumptions; see Appendix H of this plan.	EPA, 2007
PCBs	0.000014	0.00003	Total PCBs	Ecology, 2011c
Phosphorus	0.00875 (lakes) 0.010 (streams)	No value	Total phosphorus, Ecoregion II	EPA, 2002a

6.7.1.2 Change in Load

Pre-project and post-project pollutant loads were estimated as described in Sections 6.5 and 6.6. The change in load for each project was normalized (taken as a ratio) to the total estimated load reductions of all of the candidate LTCP and stormwater projects combined. Data were normalized to allow for a comparison of load reduction for RCOCs with different units and the EIVs for the candidate projects.

6.7.1.3 Receptor Factor

The receptor factor (also known as exposure potential) is a function of the receptor type (human or ecological) and project location (or receiving water body). The City identified potential receptor exposure pathways for the following receiving water bodies:

- Duwamish River
- Lake Washington
- Puget Sound/Elliott Bay
- Lake Washington Ship Canal/Lake Union
- Thornton Creek
- Longfellow Creek
- Piper's Creek

Human Receptor Factor

The exposure potential for humans was estimated based on the following three factors:

- relative dose of the RCOC
- relative distance from outfall to the activity location (or length of the exposure pathway)
- likelihood of the activity

The City evaluated the following five potential activities in the receiving water bodies affected by each candidate project:

- swimming
- wading
- recreational boating
- fishing
- shellfishing

The analysis considered the following three potential pathways for exposure during the activities listed above:

- incidental ingestion of surface water
- dermal contact with surface water
- ingestion of fish or shellfish

The likelihood of an activity was estimated as a range from 1 to 5 (5 = most likely), based on the frequency and duration of the activity by season.

Ecological Receptor Factor

The ecological receptor factor considers the presence and sensitivity of three specific life stages (egg/breeding, juvenile, and adult) for eight fish species (bull trout, Chinook salmon, chum salmon, coho salmon, cutthroat trout, pink salmon, sockeye salmon, and steelhead).

For the ecological receptor, pathways include:

- ingestion of water
- contact with water

The likelihood of the life-stage presence was estimated as a range from 1 to 5, where 5 indicates the most presence. The following values were assigned based on estimated duration of presence:

- 1: if present during 1 month
- 3: if present during 2–3 months
- 5: if present for greater than 3 months

The relative distance from the outfall to the receptor was estimated by direct measurements at the site or with GIS. Appendix H of this plan provides a detailed discussion of the methodology used to calculate EIVs.

6.7.2 Qualitative Exposure Assessment

EIVs were not calculated for the two candidate street sweeping programs because the EIV calculations require information on potential receptors near each affected outfall. Runoff from the swept streets would affect more than 100 outfalls and numerous receiving water bodies throughout the city. It was not feasible to assess the potential receptors at each location. Therefore, potential exposure reductions from sweeping were evaluated using a more qualitative approach based on load reductions and the frequency and timing of runoff from the swept streets. Section 8.2.3 describes the potential reductions in exposure that would result from the candidate street sweeping programs.

After the City had tentatively selected projects and programs for the Integrated Plan, a qualitative evaluation was performed to compare the selected stormwater projects to the LTCP projects in terms of overall exposure reduction benefits. This comparative assessment considered pollutant loads, discharge frequency, discharge timing, potential human and ecological receptors, and hydromodification benefits of the Integrated Plan. Section 8.4.3.2 describes the exposure reduction benefits assessment.

CHAPTER 7

Project Evaluation Results

This chapter discusses the pollutant load reduction results and exposure assessment results for each of the evaluated candidate LTCP and stormwater projects.

7.1 Introduction

The City used the methods described in Chapter 6 to estimate pollutant load reductions for the candidate LTCP and stormwater projects considered for potential inclusion in this Integrated Plan. The pollutant loads results were then used with other existing data to calculate EIVs for the candidate projects.

Section 7.2 summarizes the results from the pollutant load reduction evaluations of the LTCP projects identified as candidates for deferral under the Integrated Plan. Section 7.3 presents the pollutant load reduction results for the candidate stormwater projects and programs. Section 7.4 summarizes the EIV results for the candidate LTCP and stormwater projects. Appendices E, F, and G contain additional information on the pollutant loads modeling results for the candidate LTCP projects, stormwater projects, and street sweeping programs, respectively. Appendix H provides additional details regarding the EIV results.

7.2 Pollutant Load Reductions for Candidate LTCP Projects

The City used the methods described in Chapter 6 to estimate the pollutant load reductions associated from implementing each of the candidate LTCP projects. Table 7-1 lists maximum and minimum annual RCOC reductions that would be provided by the candidate LTCP projects. For example, the largest of the six candidate LTCP projects (CSO 107) would reduce the average annual flow volume by 1.1 MG/yr, while the smallest project (CSO 138) would reduce the annual flow volume by only 0.0057 MG/yr. (Note that this is not directly comparable to Table IPS-1, which lists the average annual load reductions for each LTCP project.) See Appendix E for a more comprehensive discussion of these results.

Table 7-1. Range of Volume and RCOC Load Reduction Results for the Six Candidate LTCP Projects

Evaluated metric	Units	Maximum annual reduction ^a	Minimum annual reduction ^b
Volume ^c	MG/yr	1.1	0.0057
Ammonia-N	kg/yr	19	0.027
BOD	kg/yr	82	0.42
Bis(2-ethylhexyl)phthalate	kg/yr	0.035	0.000050
Dichlobenil	kg/yr	0.00029	0.0000025
Dissolved copper	kg/yr	0.027	0.00011
Dissolved zinc	kg/yr	0.14	0.00042
Fecal coliform bacteria	billion CFU/yr	4,346	22

Table 7-1. Range of Volume and RCOC Load Reduction Results for the Six Candidate LTCP Projects

Evaluated metric	Units	Maximum annual reduction ^a	Minimum annual reduction ^b
H+	kg/yr	0.00049	0.0000025
Oil and grease	kg/yr	15	0.075
PBDEs	kg/yr	0.00025	0.0000013
PCBs	kg/yr	0.00046	0.0000011
Phosphorus	kg/yr	6.6	0.013
Total copper	kg/yr	0.22	0.00029
TSS	kg/yr	494	0.69
Total zinc	kg/yr	0.57	0.00090

a. The largest average annual reduction that would be provided by one of the six candidate LTCP projects.

b. The smallest average annual reduction that would be provided by one of the six candidate LTCP projects.

c. The maximum and minimum annual volume reductions for the candidate LTCP projects were estimated from the moving 20-year (through 2012) average simulated CSO volumes without climate change (scaling factor = 1).

CSO Outfall 107 is predicted to have the greatest reduction in all of the evaluated RCOC concentration loads. The CSO Outfall 139 project would result in the least pollutant load reductions.

Figure 7-1 shows the estimated reductions in volume for each of the six candidate LTCP projects. Figures 7-2 through 7-6 show the estimated load reductions for key RCOCs (i.e., TSS, fecal coliform, dissolved copper, PCBs, and ammonia-N). Appendix E of this plan contains the data for all of the RCOCs evaluated.

Figures 7-1 through 7-6 show results for three time periods: annual, Season 1, and Season 2. These three types of results are shown to illustrate the variation in seasonality. A review of CSO discharges and modeling results show that most CSO discharges occur during Season 1 (October through January). More specifically, modeling of the candidate LTCP locations indicates that about 65 percent of the CSOs occur during Season 1, with the associated overflow volume at about 85 percent of the total simulated CSO volume from the candidate LTCP locations. During Season 2 (February through September), CSO discharge frequencies and volumes are relatively low.

7.2.1 Dissolved Oxygen

As discussed in Section 6.5.4, in order to characterize the impact of pollutant load reductions on receiving water dissolved oxygen (DO) concentrations, a simplified approach based on the Streeter-Phelps equation was used to estimate the change in projected DO concentration associated with each candidate LTCP project. The Streeter-Phelps equation calculates the average daily DO deficit (i.e., difference between DO at saturation and actual DO).

The Streeter-Phelps equation does not implicitly account for flow. As LTCP project improvements are quantified by reductions in flow and not by decreases in pollutant concentrations, improvements in BOD concentrations are first normalized to account for changes in loading. Using a common normalizing volume, equal to the maximum flow from all the stormwater and LTCP projects (e.g., 140.457 MG/yr), allowed for a comparison between stormwater and LTCP projects.

Reductions in the normalized DO deficit between pre- and post-project implementation were calculated for each of the LTCP projects. Table 7-2 provides a summary of the annual DO load reduction results from each LTCP project (see Appendix F for a more comprehensive discussion of these results).

Table 7-2. Normalized DO Deficit Results from the Six Candidate LTCP Projects (mg/L)			
LTCP project	Maximum annual reduction	Minimum annual reduction	Median annual reduction
CSO Outfall 99	0.0035	0.0022	0.0028
CSO Outfall 107	0.034	0.018	0.025
CSO Outfall 111	0.0003	0.0001	0.0002
CSO Outfall 138	0.0019	0.0012	0.0015
CSO Outfall 139	0.0001	0.0001	0.0001
CSO Outfall 140	0.0011	0.0007	0.0009

7.2.2 Variability and Uncertainty in the LTCP Project Evaluation

The pollutant load reduction estimates derived from the candidate LTCP projects were based on predicted volumes from calibrated hydraulic models. These models are discussed in Volume 2: Long-Term Control Plan. The pollutant loads estimates for this Integrated Plan used the central tendency flow volumes from the LTCP hydraulic models. Although these models were calibrated, there is uncertainty associated with any model. The LTCP Hydraulic Modeling Reports contain a detailed discussion of the uncertainties associated with the predicted volumes generated from the LTCP hydraulic models.

Uncertainties are also associated with the RCOC concentrations that were used to estimate the pollutant load reductions for the candidate LTCP projects. These uncertainties were characterized by establishing a UCL and an LCL using the statistical analysis bootstrap method. Appendix F of this plan contains a detailed discussion of the statistical analysis conducted on all of the RCOC data used for assessing the candidate LTCP and stormwater projects. The UCL and LCL values are shown in the RCOC-related figures below via error bars.

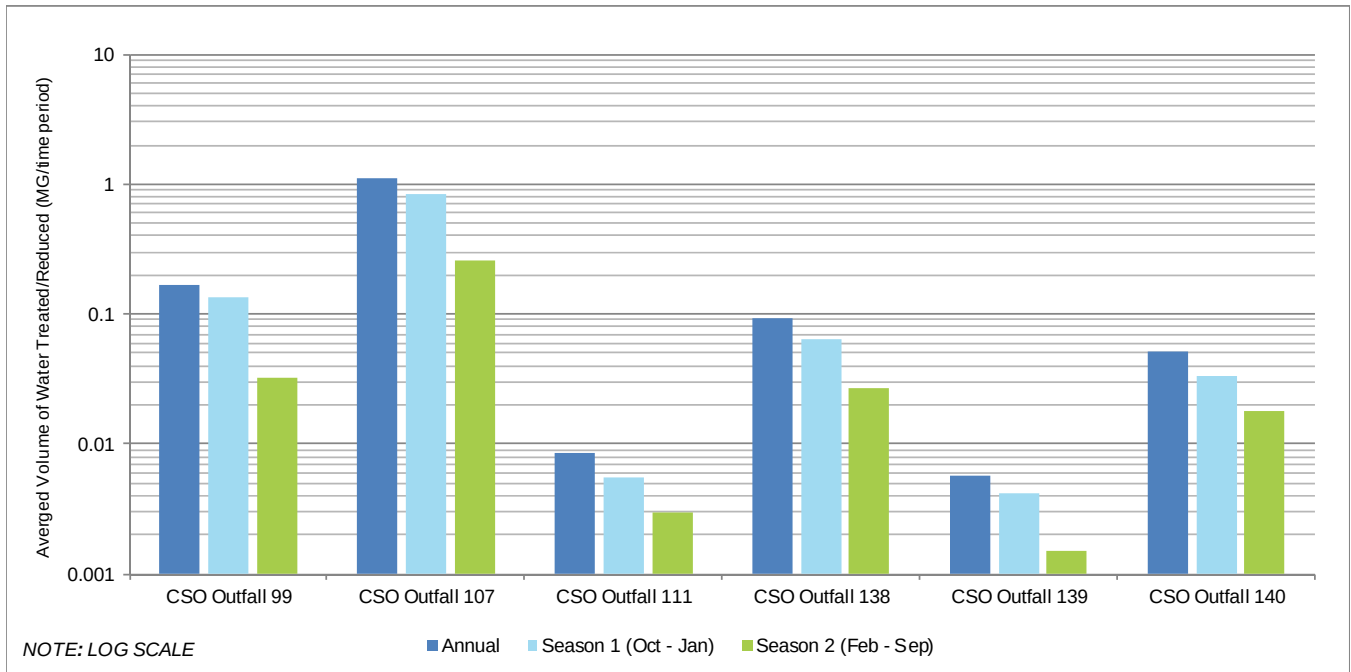


Figure 7-1. Average volume of water treated or reduced by the candidate LTCP projects

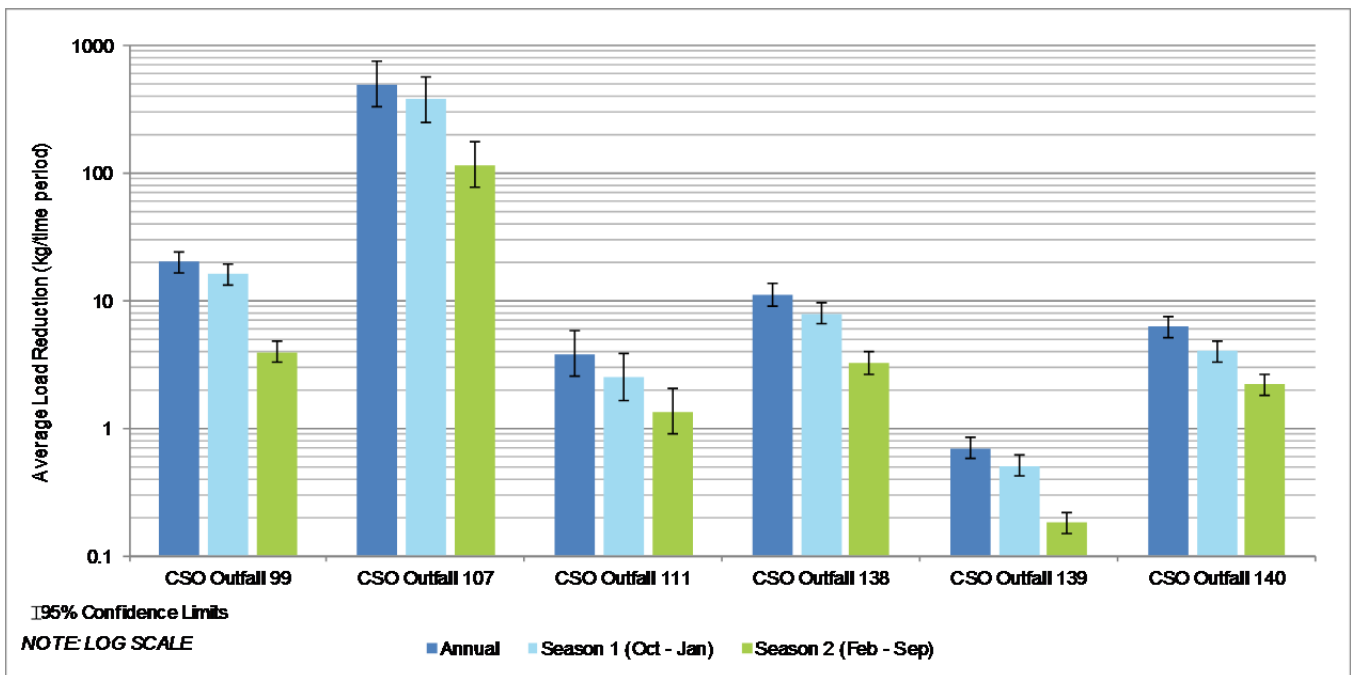


Figure 7-2. Average TSS load reduction from the candidate LTCP projects

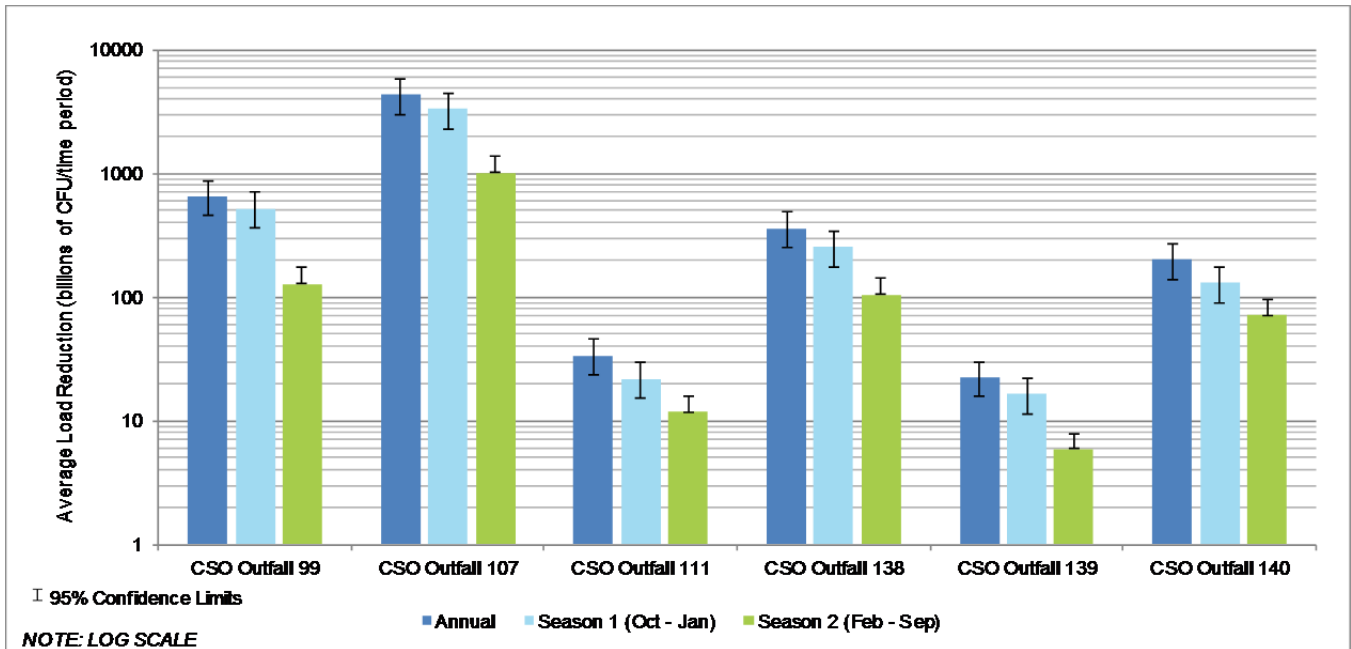


Figure 7-3. Average fecal coliform load reductions from the candidate LTCP projects

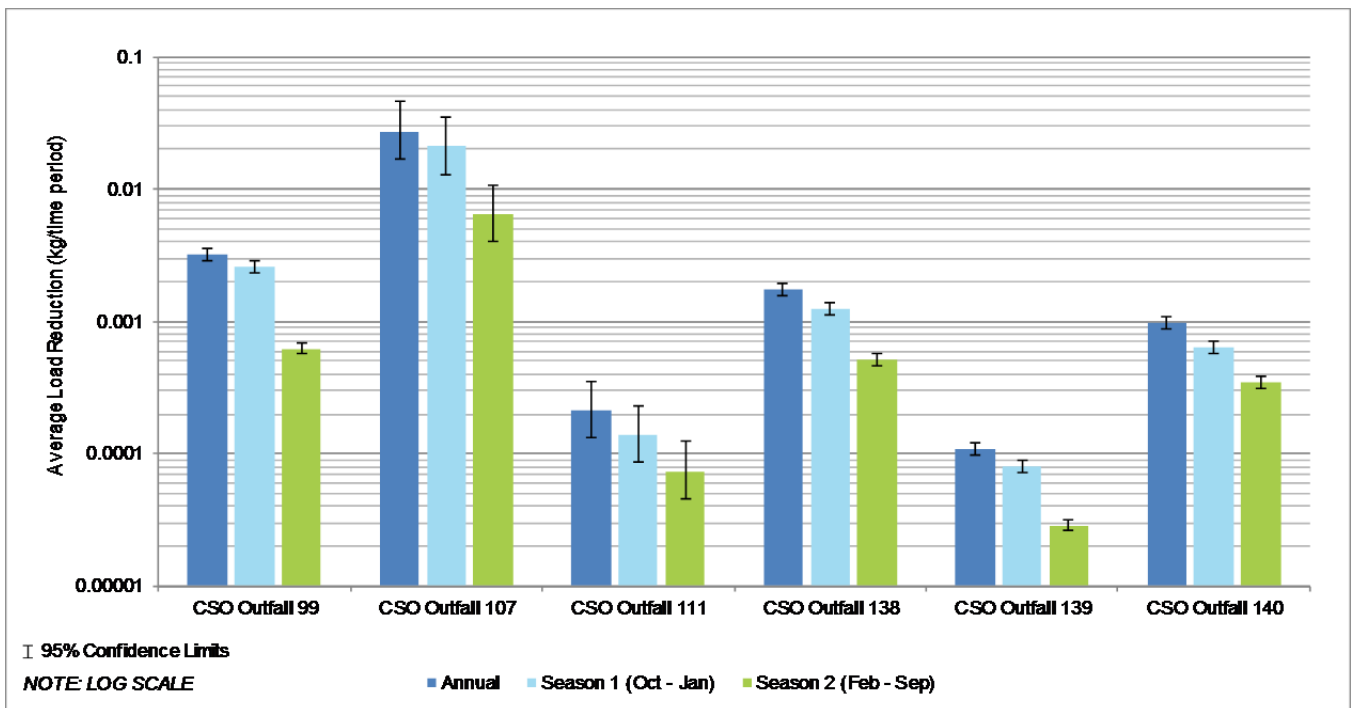


Figure 7-4. Average dissolved copper load reductions from the candidate LTCP projects

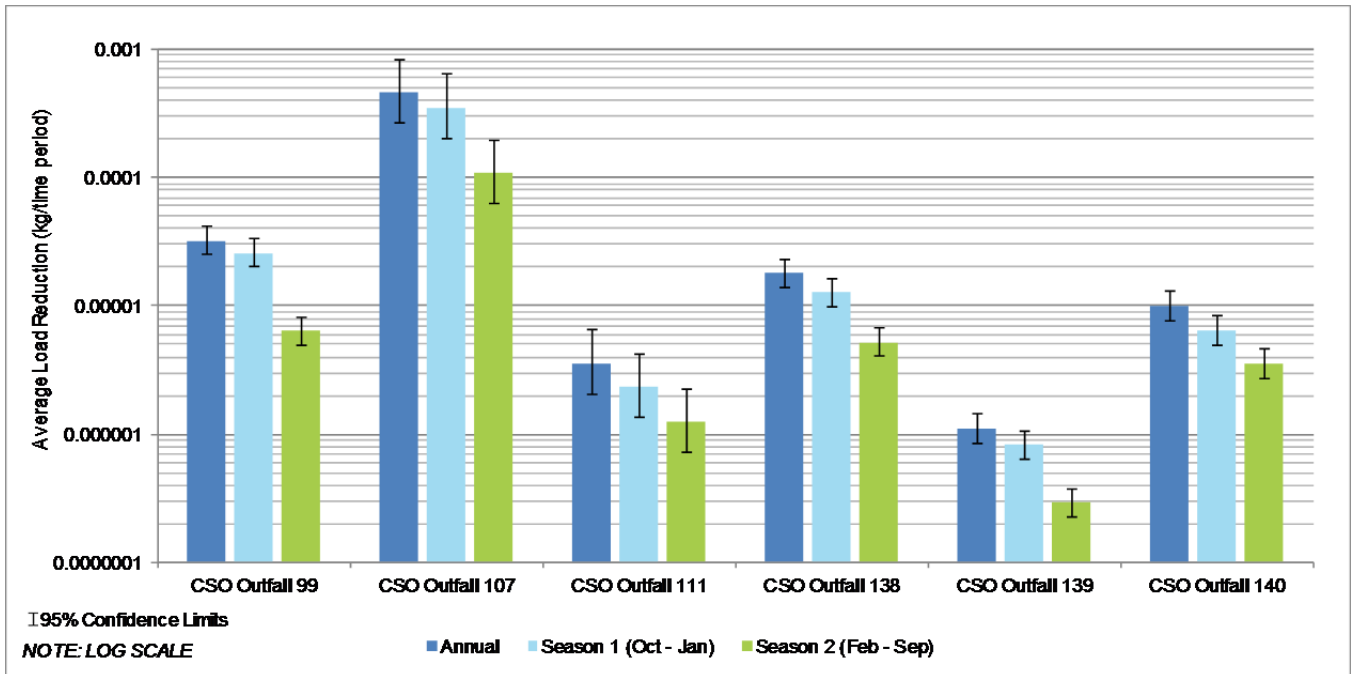


Figure 7-5. Average PCB load reductions from the evaluated candidate LTCP projects

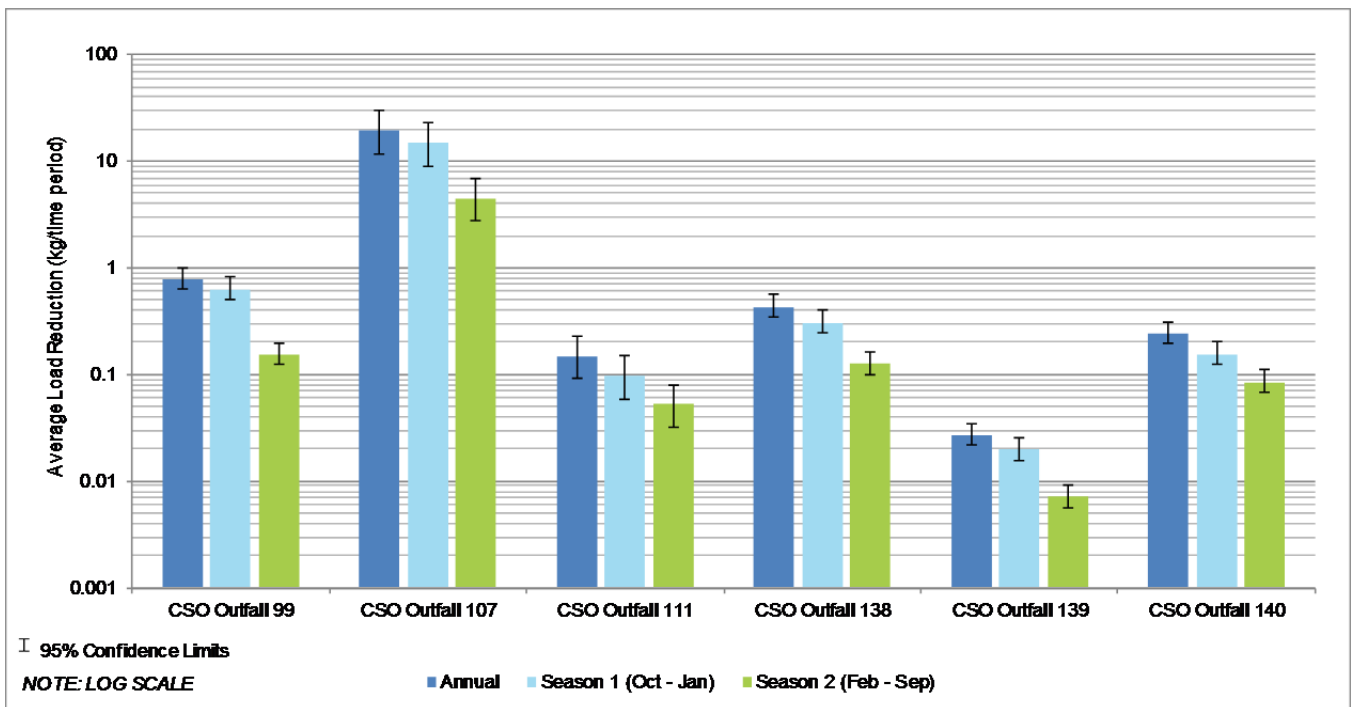


Figure 7-6. Average ammonia-N load reduction from the candidate LTCP projects

7.3 Pollutant Load Reductions for Candidate Stormwater Projects

The pollutant load reduction estimates for the candidate stormwater projects were based on City conceptual designs of the stormwater projects, performance data (i.e., effluent concentrations and volume reductions) from the International Stormwater BMP Database (Geosyntec Consultants and Wright Water Engineers, Inc., 2011), data from stormwater projects or treatment facilities recently piloted (SPU, 2012a; SPU, 2012b; City of Tacoma and Taylor Associates, 2008; North Boeing Field, 2013; CDM, 2010), and best professional judgment in the cases of the RCOCs where data were unavailable (Bis(2-ethylhexyl)phthalate, total PCBs, and total PBDEs) or where data were limited (BOD, fecal coliform, oil and grease, and dissolved copper). Changes in conceptual designs and associated changes in load reduction estimates will be reflected in Version 3 of this plan. Table 7-3 lists the overall capture efficiency for the candidate stormwater projects. Table 7-4 shows the range of volume and RCOC load reductions estimated for the 10 candidate stormwater projects. See Appendix F for a more comprehensive discussion of these results.

Table 7-3. Project Capture Efficiency for Candidate Stormwater Projects	
Stormwater project	Capture efficiency ^a
Longfellow Cascades	80%
NDS Partnering	80%
Piper's Cascades	80%
South Myrtle St. Shoulder Stabilization	91% ^b
South Myrtle St. StormFilter Vault	91% ^b
South Park WQ Facility	83%
Street Sweeping Expansion Arterials	N/A
Street Sweeping Expansion Residential	N/A
SW Hinds SD StormFilter Vault	91% ^b
U Village Filterrras	91% ^b

a. Capture efficiency is defined as the percentage of the annual runoff volume a stormwater project will be capable of treating/managing.

b. The design criteria level was provided by the City: structural projects are designed to treat up to 91% of the average annual runoff volume.

Table 7-4. Range of Volume and RCOC Load Reduction Results for the 10 Candidate Stormwater Projects^a

Evaluated metric	Units	Maximum annual reduction ^a	Minimum annual reduction ^b
Volume treated	MG/yr	1,527 ^c	0.108 ^c
Ammonia-N	kg/yr	9.2	0.0
BOD	kg/yr	1,088	8.72
Bis(2-ethylhexyl)phthalate	kg/yr	0.29	0.002
Dichlobenil	kg/yr	0.0048	0.0
Dissolved copper	kg/yr	0.71	0.0
Dissolved zinc	kg/yr	14	0.0
Fecal coliform bacteria	billion CFU/yr	52,700	125
H+	kg/yr	0.021	0.0
Oil and grease	kg/yr	702	0.0
PBDEs	kg/yr	0.011	0.000033
PCBs	kg/yr	0.0069	0.000069
Phosphorus	kg/yr	46	0.093
Total copper	kg/yr	6.3	0.027
TSS	kg/yr	41,900	142
Total zinc	kg/yr	29	0.24

a. The largest average annual reduction that would be provided by 1 of the 10 candidate stormwater projects.

b. The smallest average annual reduction that would be provided by 1 of the 10 candidate stormwater projects.

c. The maximum and minimum results refer to the stormwater project treatment volumes (i.e., not stormwater project reductions in runoff volumes).

Figure 7-7 shows the estimated treatment volumes for each of the candidate stormwater projects. Figures 7-8 through 7-12 show the estimated load reductions for key RCOCs. Appendix F of this plan contains the data for all of the RCOCs evaluated for the structural stormwater projects. As shown in Figure 7-8, Street Sweeping Expansion Residential, Street Sweeping Expansion Arterials, South Park WQ Facility, and NDS Partnering would provide the largest reductions in annual TSS loads. Figures 7-9 and 7-10, respectively, show that the South Park WQ Facility would provide the greatest load reductions in fecal coliform and dissolved copper, while NDS Partnering would provide the second-greatest reductions. Figure 7-11 shows that the South Park WQ Facility and sweeping projects would provide the greatest reductions in PCB loads. Figure 7-12 shows that the NDS Partnering project would provide the greatest reduction in ammonia-N. Several of the projects would have little or no load reduction for some of the RCOCs.

7.3.1 Dissolved Oxygen

Reductions in the normalized DO deficit between pre- and post-project implementation were calculated for each of the candidate stormwater projects, using the same method described in Section 7.2.1. Table 7-5 provides a summary of the annual DO load reduction results from each candidate stormwater project (see Appendix F for a more comprehensive discussion of these results).

Table 7-5. Normalized DO Deficit Results from the Candidate Stormwater Projects (mg/L)			
Stormwater project	Maximum annual reduction	Minimum annual reduction	Median annual reduction
Longfellow Cascades	0.08	0.02	0.05
NDS Partnering	0.15	0.01	0.02
Piper's Cascades	0.13	0.03	0.08
South Myrtle St. Shoulder Stabilization	0.0036	0.0003	0.0018
South Myrtle St. StormFilter Vault	0.02	0.00	0.01
South Park WQ Facility	0.39	0.05	0.21
SW Hinds SD StormFilter Vault	0.08	0.01	0.04
U Village Filterrras	0.03	0.00	0.01

7.3.2 Variability and Uncertainty in the Stormwater Project Evaluation

An inherent level of uncertainty comes with using sampling data, GIS data, and stormwater project performance data to estimate the water quality benefits of stormwater projects. The variability of stormwater quality and volume are widely recognized. For the Integrated Plan, the analysis method was intended to estimate long-term averages, and any inherent uncertainty in the data and input parameters. When possible, the model expressed these input parameters in terms of a 95 percent CI on the long-term average (i.e., bounded by the LCL and the UCL).

Sources of uncertainty also arise from spatial variability of processes, the stochastic nature of stormwater, limited data, monitoring techniques, and more. As a result, uncertainty is associated with PLM inputs such as runoff characteristics, pollutant load estimates per land use or source area, and spatial variability. As discussed in Section 6.6.2, Monte Carlo Analysis was used to quantify the uncertainty in long-term estimates of land use runoffs and stormwater project performance. A detailed discussion of the uncertainties associated with the stormwater project evaluations is provided in Appendix F.

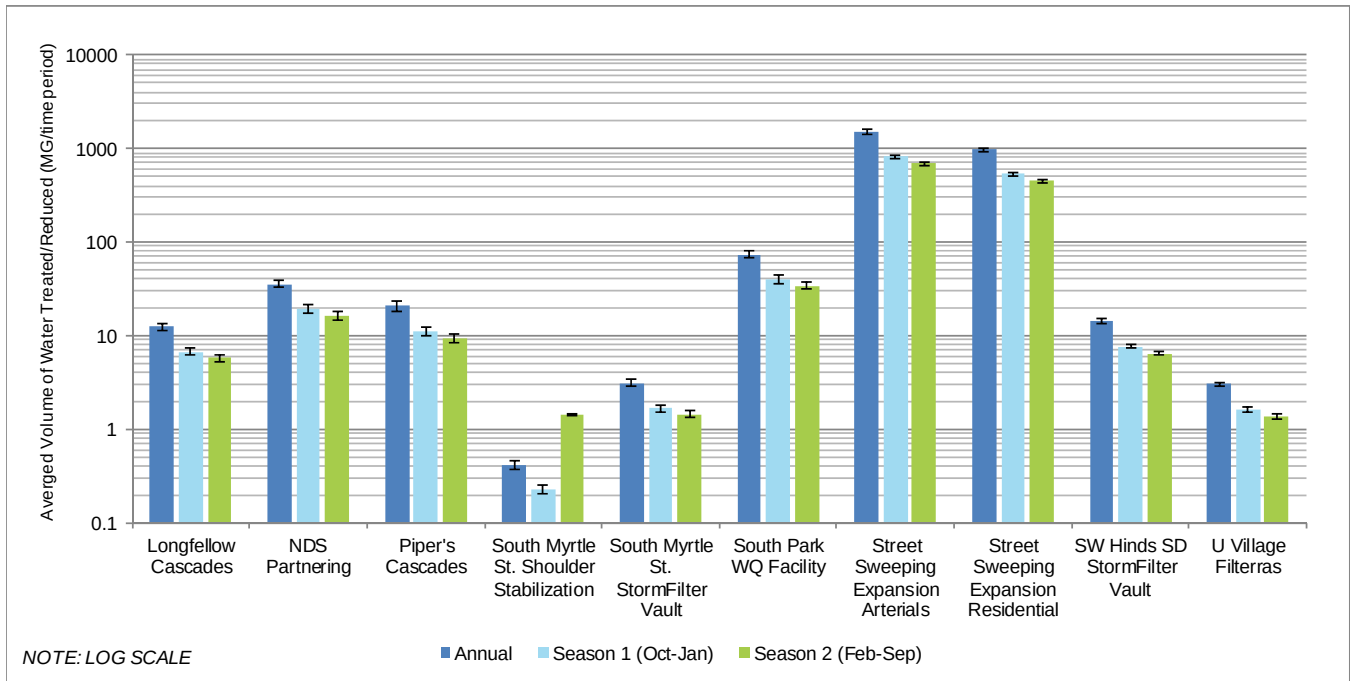


Figure 7-7. Long-term average volume of water treated or reduced by the candidate stormwater projects

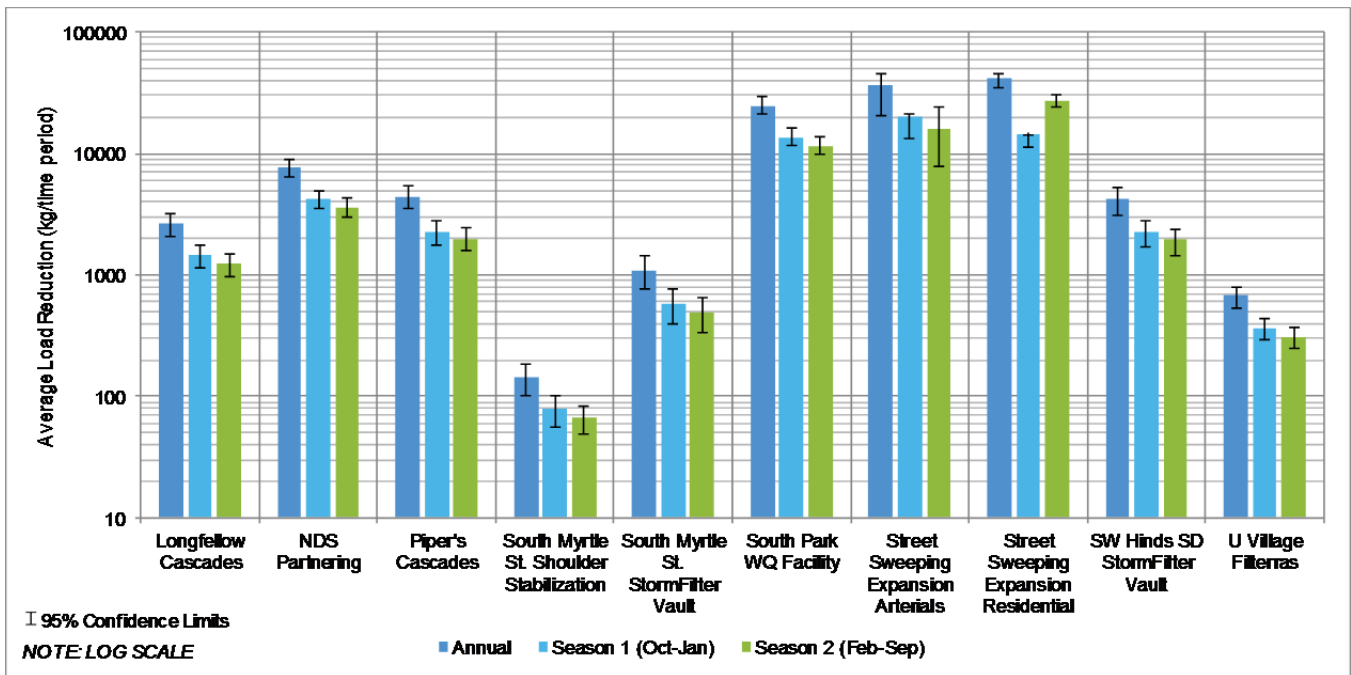


Figure 7-8. Long-term average TSS load reduction from the candidate stormwater projects

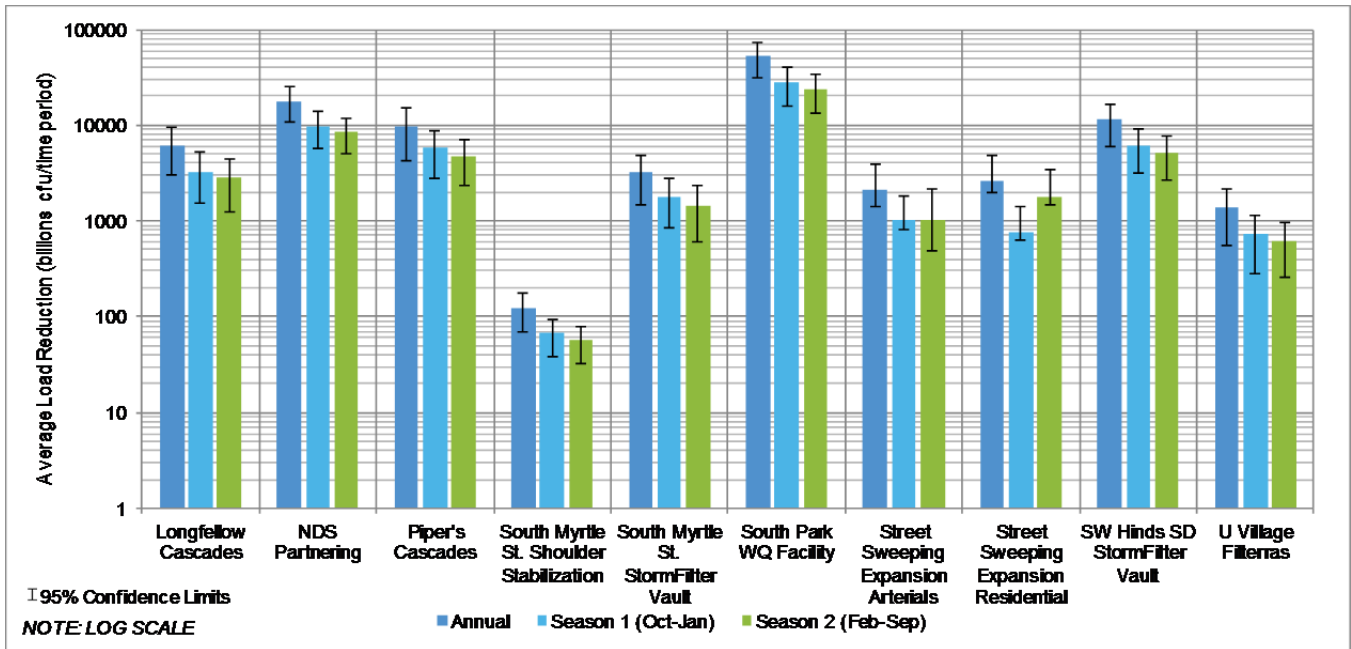


Figure 7-9. Long-term average fecal coliform load reduction from the candidate stormwater projects

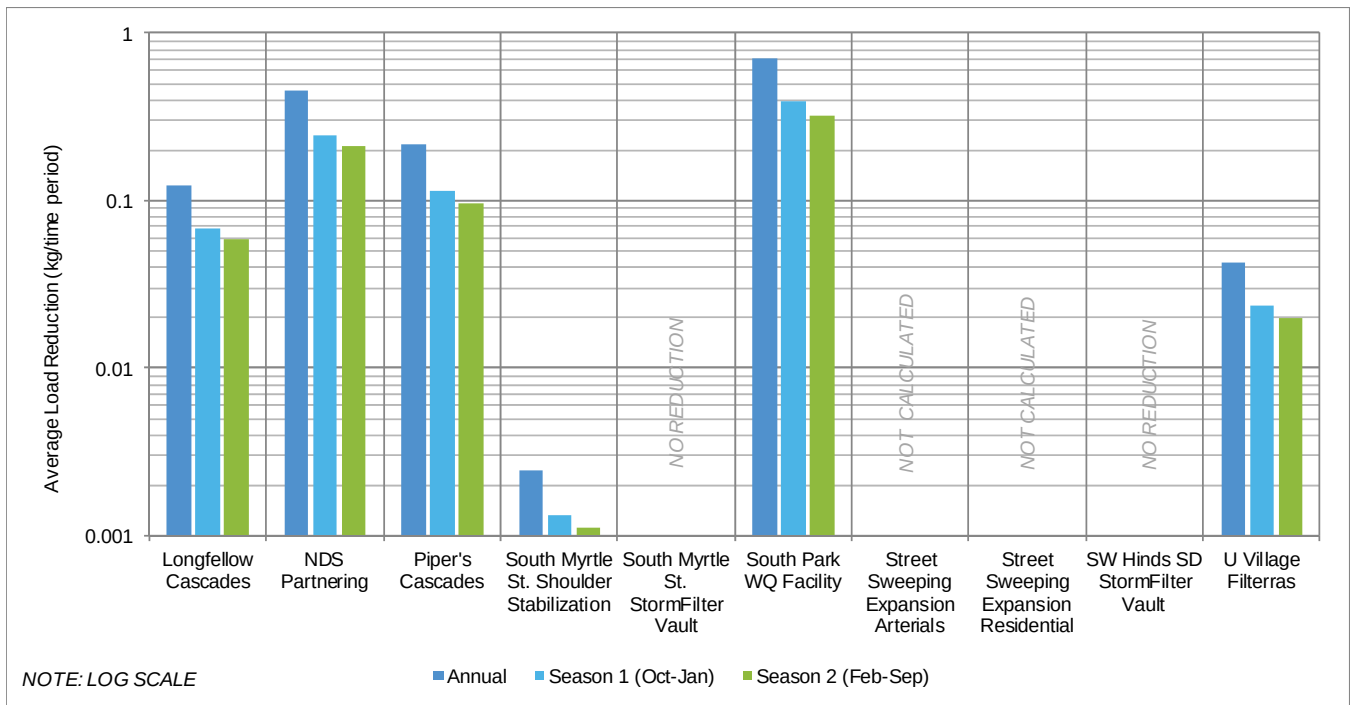


Figure 7-10. Long-term average dissolved copper load reduction from the candidate stormwater projects

Note that UCL and LCL values are not shown because they could not be calculated for selected projects due to limited data availability.

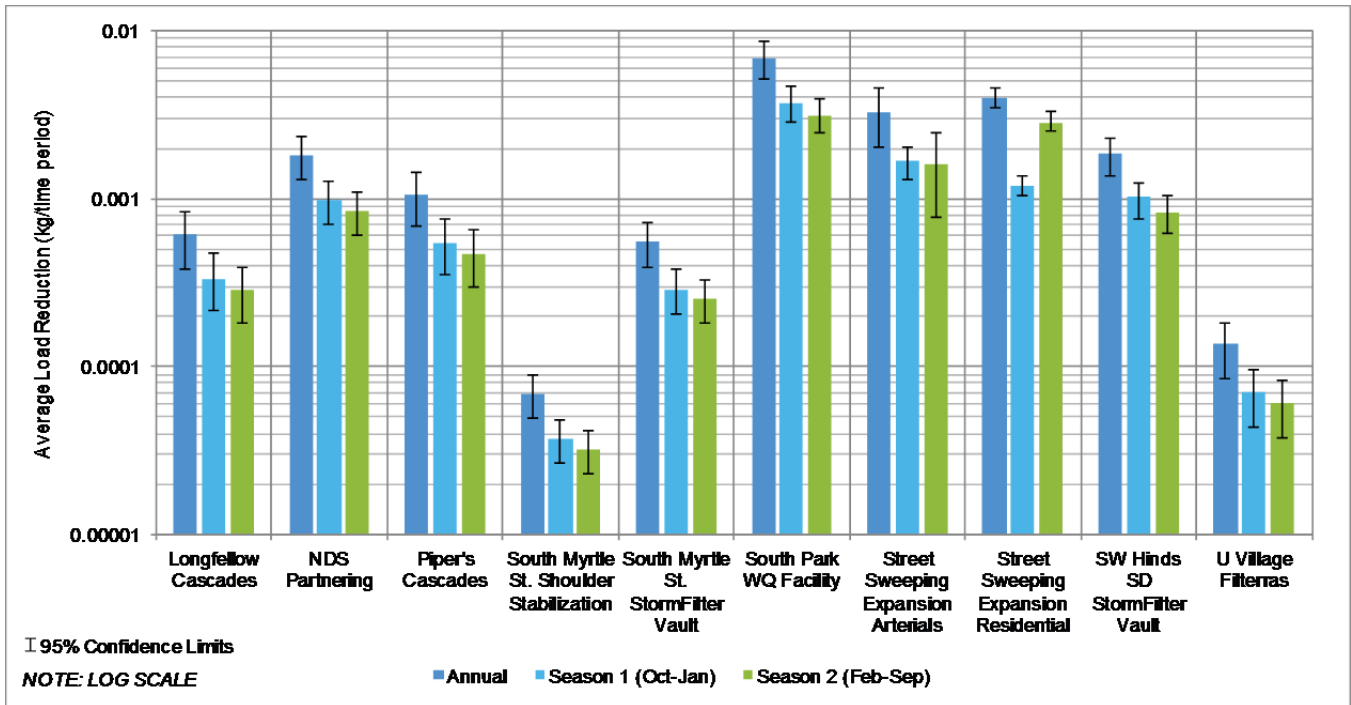


Figure 7-11. Long-term average PCB load reduction from the candidate stormwater projects

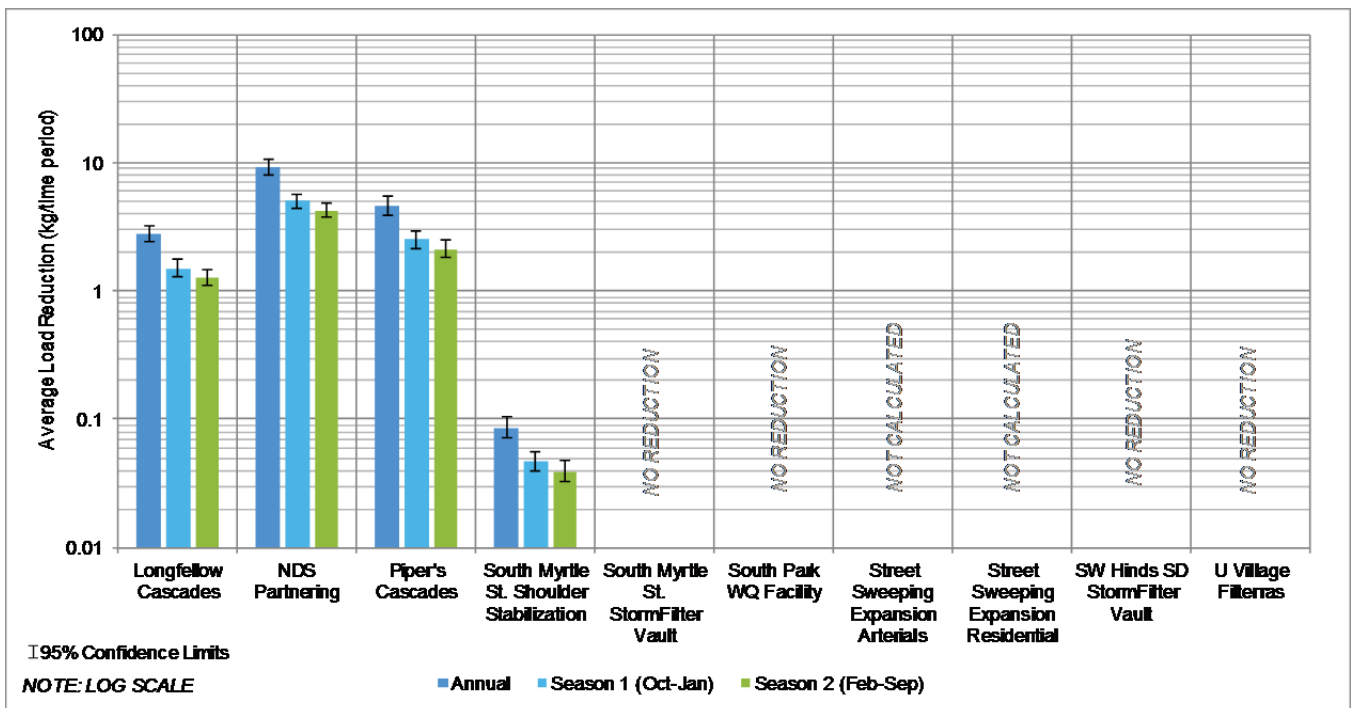


Figure 7-12. Long-term average ammonia-N load reduction from the candidate stormwater projects

7.4 Exposure Assessment Results

The City calculated exposure index values (EIVs) for each candidate LTCP and structural stormwater project. As described in Section 6.7, the following three EIVs were calculated for each project:

- human receptors exposed to toxics
- human receptors exposed to fecal coliform
- ecological receptors exposed to toxics and nutrients

Tables 7-6 through 7-8 list the EIVs for each candidate LTCP and structural stormwater project. The EIVs indicate the relative exposure reduction benefit provided by each project. Projects with higher EIVs provide more exposure reduction benefits than projects with lower EIVs.

Table 7-6. Human EIVs for Toxics (Annual)		
Candidate project	Receiving water body	Human EIV: toxics (chronic)
CSO Outfall 99	West Waterway of the Duwamish River	0.39
CSO Outfall 107	East Waterway of the Duwamish River	13
CSO Outfall 111	Duwamish River	0.16
CSO Outfall 138	Portage Bay	0.13
CSO Outfall 139	Portage Bay	0.0061
CSO Outfall 140	Portage Bay	0.080
Longfellow Cascades	Longfellow Creek	0.27
NDS Partnering: Thornton Creek	Thornton Creek	3.8
NDS Partnering: Piper's Creek	Piper's Creek	0.89
NDS Partnering: Longfellow Creek	Longfellow Creek	0.12
Piper's Cascades	Piper's Creek	3.8
South Myrtle St. Shoulder Stabilization	Lower Duwamish Waterway	1.6
South Myrtle St. StormFilter Vault	Lower Duwamish Waterway	14
South Park WQ Facility	Duwamish Waterway	117
Street Sweeping Expansion Arterials	Multiple	Not calculated ^a
Street Sweeping Expansion Residential	Multiple	Not calculated ^a
SW Hinds SD StormFilter Vault	Lower Duwamish Waterway	36.2
U Village Filterrras	Lake Washington Ship Canal/ Lake Union	2.0

a. EIVs were not calculated for street sweeping because the receptor factors are based on the outfall location, and runoff from the swept streets would enter many outfalls throughout the city.

Table 7-7. Human EIVs for Fecal Coliform (Annual)		
Candidate project	Receiving water body	Human EIV: fecal coliform (acute)
CSO Outfall 99	West Waterway of the Duwamish River	0.18
CSO Outfall 107	East Waterway of the Duwamish River	1.3
CSO Outfall 111	Duwamish River	0.019
CSO Outfall 138	Portage Bay	2.0
CSO Outfall 139	Portage Bay	0.093
CSO Outfall 140	Portage Bay	1.4
Longfellow Cascades	Longfellow Creek	1.1
NDS Partnering: Thornton Creek	Thornton Creek	7.0
NDS Partnering: Piper's Creek	Piper's Creek	1.2
NDS Partnering: Longfellow Creek	Longfellow Creek	0.52
Piper's Cascades	Piper's Creek	5.3
South Myrtle St. Shoulder Stabilization	Lower Duwamish Waterway	0.024
South Myrtle St. StormFilter Vault	Lower Duwamish Waterway	0.67
South Park WQ Facility	Duwamish Waterway	8.3
Street Sweeping Expansion Arterials	Multiple	Not calculated ^a
Street Sweeping Expansion Residential	Multiple	Not calculated ^a
SW Hinds SD StormFilter Vault	Lower Duwamish Waterway	1.9
U Village Filterrras	Lake Washington Ship Canal/ Lake Union	3.2

a. EIVs were not calculated for street sweeping because the receptor factors are based on the outfall location, and runoff from the swept streets would enter many outfalls throughout the city.

Table 7-8. Ecological EIVs for Toxics and Nutrients (Annual)		
Candidate project	Receiving water body	Ecological EIV: toxics/nutrients (chronic)
CSO Outfall 99	West Waterway of the Duwamish River	0.0057
CSO Outfall 107	East Waterway of the Duwamish River	0.35
CSO Outfall 111	Duwamish River	0.0038
CSO Outfall 138	Portage Bay	0.039
CSO Outfall 139	Portage Bay	0.0031
CSO Outfall 140	Portage Bay	0.035
Longfellow Cascades	Longfellow Creek	0.61
NDS Partnering: Thornton Creek	Thornton Creek	2.5
NDS Partnering: Piper's Creek	Piper's Creek	0.54
NDS Partnering: Longfellow Creek	Longfellow Creek	0.24
Piper's Cascades	Piper's Creek	1.8
South Myrtle St. Shoulder Stabilization	Lower Duwamish Waterway	0.019
South Myrtle St. StormFilter Vault	Lower Duwamish Waterway	0.14
South Park WQ Facility	Duwamish Waterway	1.9
Street Sweeping Expansion Arterials	Multiple	Not calculated ^a
Street Sweeping Expansion Residential	Multiple	Not calculated ^a
SW Hinds SD StormFilter Vault	Lower Duwamish Waterway	0.36
U Village Filterrras	Lake Washington Ship Canal/ Lake Union	0.32

a. EIVs were not calculated for street sweeping because the receptor factors are based on the outfall location, and runoff from the swept streets would enter many outfalls throughout the city.

Figures 7-13 and 7-14 show the three EIVs for each candidate LTCP and stormwater project: Figure 7-13 shows the human-toxics EIVs and Figure 7-14 shows the human-fecal coliform and ecological EIVs. Note that EIV scores should be compared only within each category because the EIVs were calculated differently for each exposure category (i.e., human-toxics, human-fecal coliform, and ecological). Therefore, EIV scores for human-toxics are not directly comparable to EIV scores for human-fecal coliform or ecological receptors.

As indicated in Figures 7-13 and 7-14, most of the candidate LTCP projects have low EIVs compared to the candidate stormwater projects. Several of the stormwater projects have substantially higher EIVs than the LTCP projects.

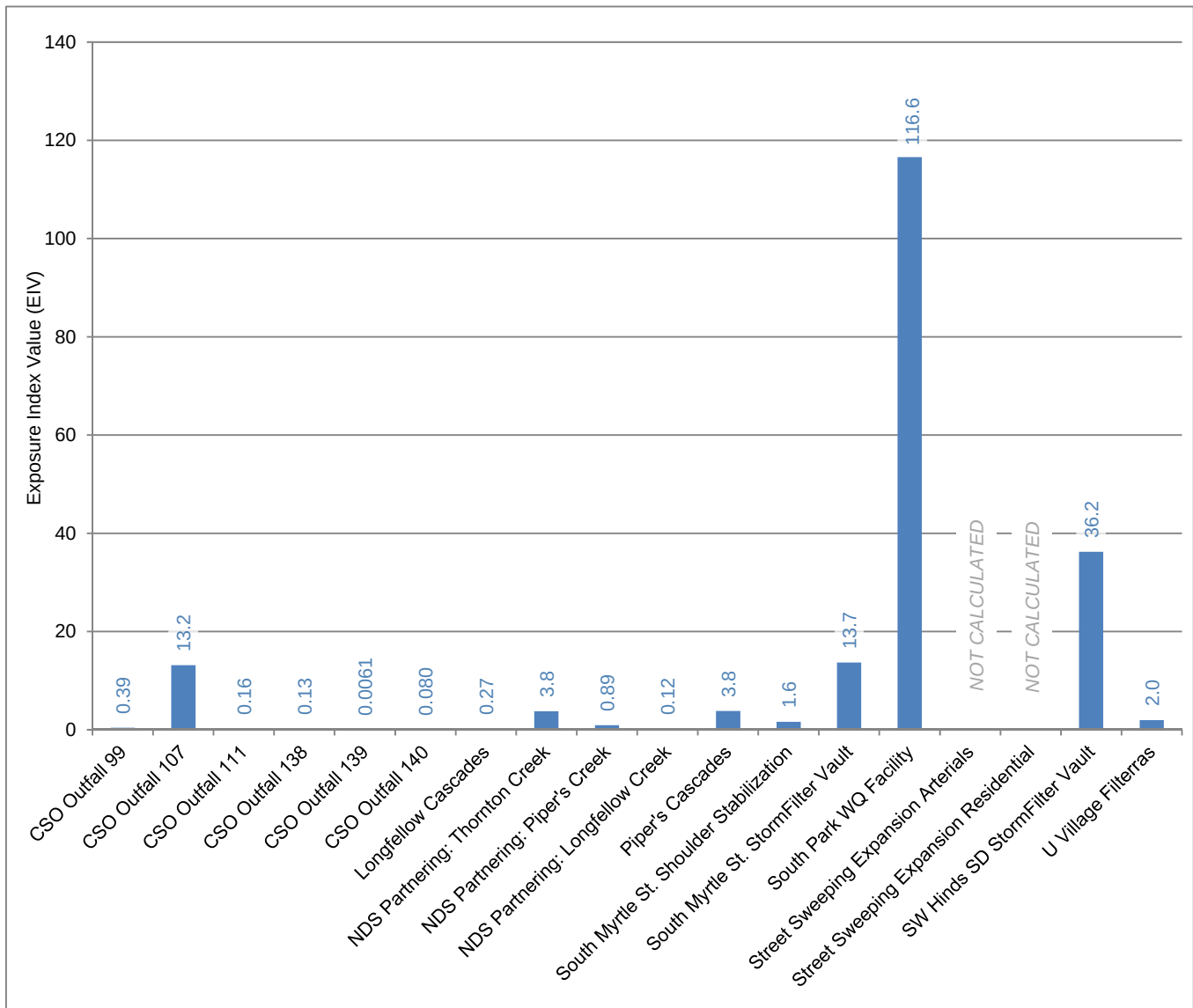


Figure 7-13. EIVs for human receptors: toxics

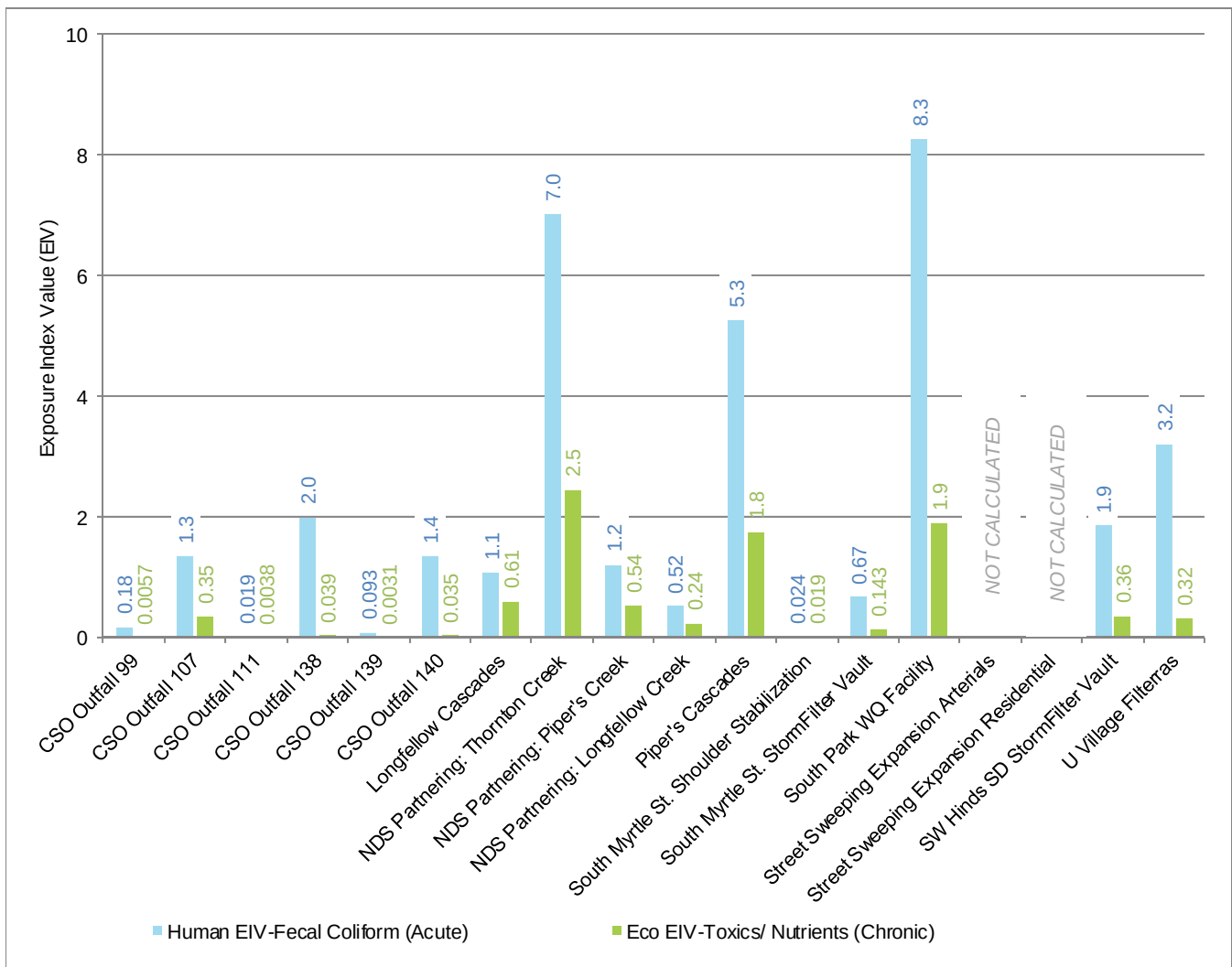


Figure 7-14. EIVs for human receptors: fecal coliform and EIVs for ecological receptors—toxics and nutrients

Figures 7-15 and 7-16 show which RCOCs dominate or drive the human-toxics and ecological EIVs. As shown in Figure 7-15, PCBs drive the human-toxics EIV scores.

Figure 7-16 shows that phosphorus is a key driver for ecological EIVs at most freshwater locations. At the saltwater/brackish locations, a variety of RCOCs contribute to the ecological EIVs.

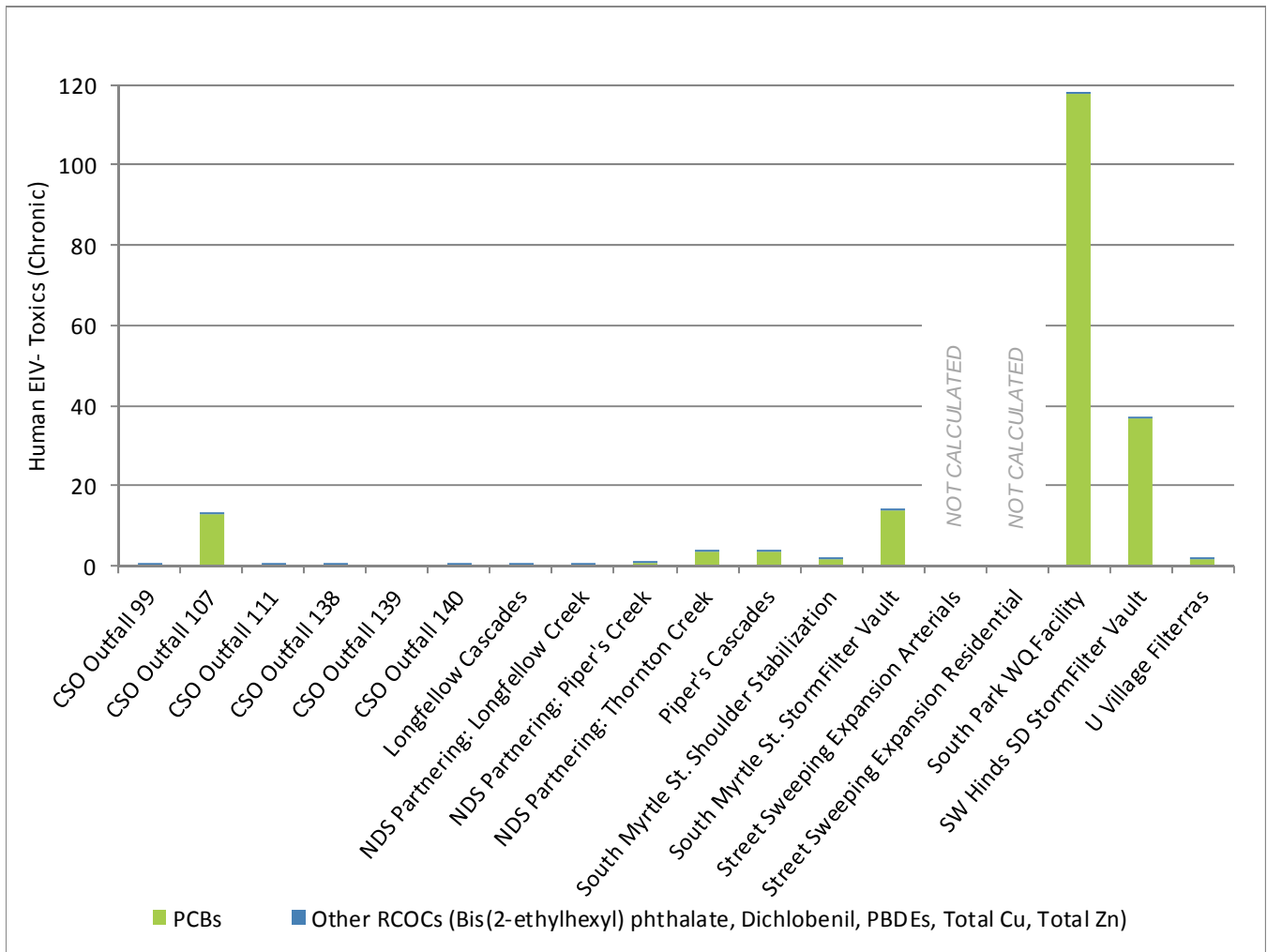


Figure 7-15. Relative contribution of specific RCOCs to human toxics EIVs

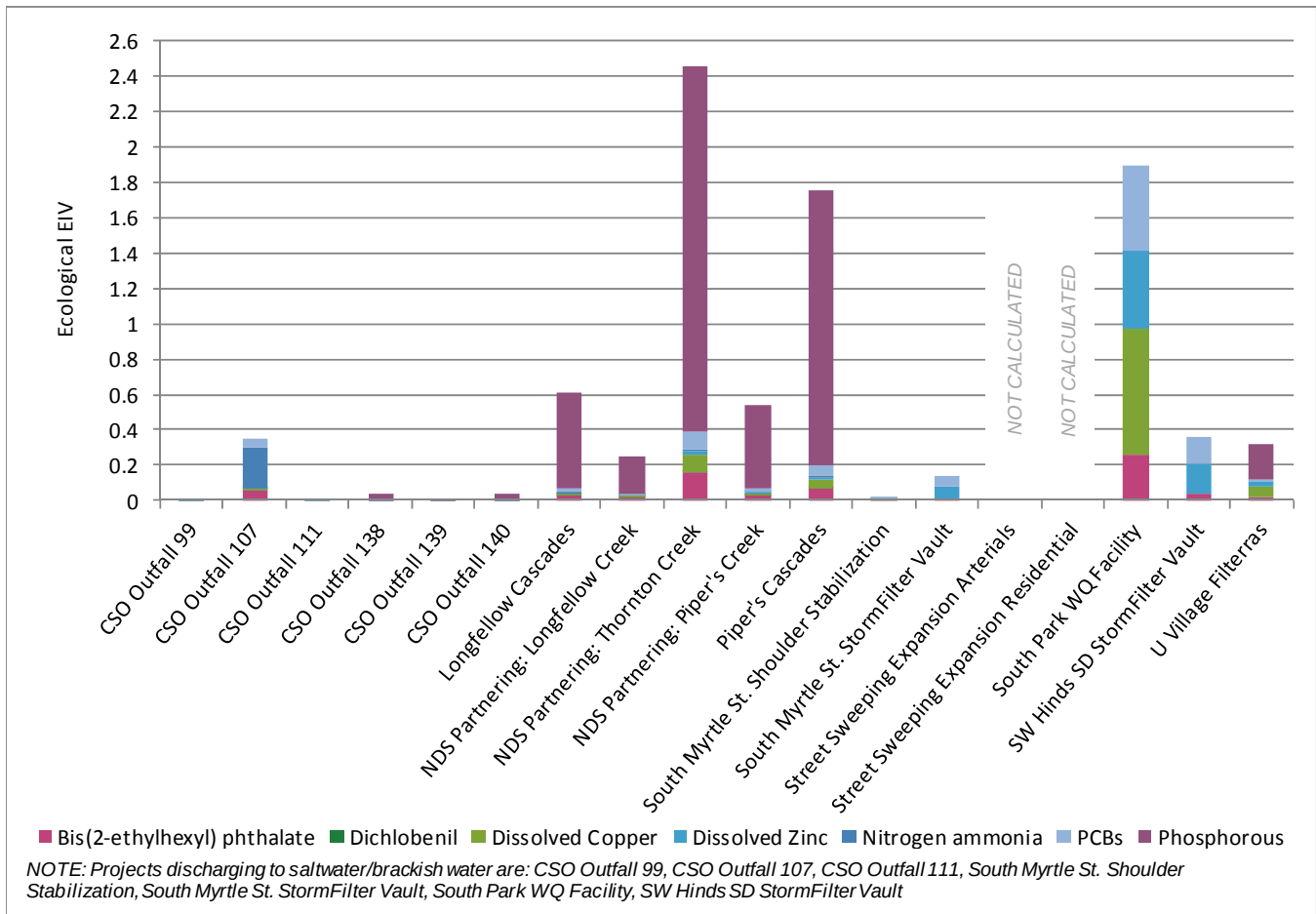


Figure 7-16. Relative contribution of specific RCOCs to ecological EIVs

7.4.1 Relative Exposure Reductions for Candidate Street Sweeping Programs

EIVs were not calculated for the candidate street sweeping programs because the EIV receptor factors are based on the outfall location, and runoff from the swept streets would affect numerous outfalls and water bodies throughout the city. Therefore, a more qualitative approach was used to compare the potential reductions in exposure that would result from the candidate street sweeping programs to the potential exposure reductions from the deferred LTCP projects.

Table 1-1 in Appendix I indicates that the candidate street sweeping programs would provide much larger reductions in PCBs and phosphorus than the candidate LTCP projects. PCBs were found to be the key driver for human-toxics EIVs at all locations. Phosphorus was the key driver for ecological EIVs at freshwater locations, while PCBs were an important contributor to ecological EIVs at several saltwater/brackish locations. These results suggest that the candidate street sweeping programs would provide substantial reductions in human exposure to toxics and ecological exposure to nutrients and toxics as compared to the candidate LTCP projects.

The pollutant loads modeling results (Table 1-1 in Appendix I) indicate that neither of the candidate street sweeping programs would provide as much fecal coliform load reduction as CSO Outfall 107. However, both street sweeping programs would provide more fecal coliform load reduction than any of the other candidate LTCP projects. The loads modeling results also indicate that the candidate street sweeping programs would provide appreciable reductions in human exposure to fecal coliform. Moreover, the loads reductions from sweeping would benefit water bodies throughout the city.

CHAPTER 8

Development of Integrated Plan

This chapter describes the development of the Integrated Plan, which consists of stormwater projects to be implemented by 2025 and LTCP projects to be deferred until after 2025.

8.1 Introduction

The Consent Decree allows the City the opportunity to prepare an Integrated Plan as an alternative to the LTCP. According to Section V.B. paragraph 20 of the Consent Decree, the Integrated Plan must propose water quality improvement project(s) “that will result in significant benefits to water quality beyond those that would be achieved by implementation of the approved CSO Control Measures only.”

The Consent Decree requires that the City describe the benefits of the proposed projects in terms of reductions in pollutant loads and exposure to human and ecological receptors. In addition, the Consent Decree requires a cost-benefit analysis for the proposed projects.

The City developed its Integrated Plan alternative based on these Consent Decree requirements. The City first compared the water quality benefits of the candidate stormwater projects with the water quality benefits of the candidate LTCP projects for potential deferral. This provided the information needed to identify the candidate stormwater projects that would contribute significant benefits to water quality over and above the projected benefits of the deferred LTCP projects. The City also evaluated the candidate stormwater projects based on other factors, such as proximity to other planned stormwater quality projects and level of treatment (pretreatment, basic, or enhanced). Based on these evaluations, the City decided to retain 10 of the candidate stormwater projects for further evaluation.

The City then scored and ranked the candidate stormwater projects using Multiple Objective Decision Analysis (MODA). In keeping with the Consent Decree, MODA gave primary consideration to the expected water quality benefits of each project. MODA also considered other City priorities and community values so that the City could compare the candidate projects based on their overall benefits.

Based on the water quality comparisons and MODA, the City selected a suite of stormwater projects for implementation by 2025 and LTCP projects for deferral until 2028–30. The Integrated Plan comprises these projects.

The City performed a cost-benefit analysis of the Integrated Plan. The City compared the present-value costs of the selected projects to their respective benefits as indicated by MODA scores and costs per unit of pollutant load reduction.

Sections 8.2 and 8.3, respectively, describe the water quality comparisons and MODA. Section 8.4 presents the stormwater and LTCP projects that compose the Integrated Plan, and the significant benefits provided by the Integrated Plan.

8.2 Comparison of Candidate LTCP and Stormwater Projects

The City selected candidate stormwater projects that would take advantage of opportunities in key drainage basins and receiving water bodies, as discussed in Chapter 5. In contrast, the City identified relatively small LTCP projects in the LTCP as potential candidates for deferral. The intent was to identify candidate stormwater projects that would provide significant water quality benefits as compared to the deferred LTCP projects.

Section 8.2.1 compares the estimated pollutant load reductions for the candidate LTCP and stormwater projects. Section 8.2.2 compares the candidate LTCP and stormwater projects based on their relative reductions in exposure to human and ecological receptors. Load and exposure reductions were estimated based on stormwater project conceptual designs that may continue to evolve. Appendix I of this plan contains more detailed information on the estimated load reductions for the candidate stormwater and LTCP projects.

8.2.1 Pollutant Load Reduction

The City compared the projected pollutant load reductions for the candidate stormwater projects with the projected load reductions for the candidate LTCP projects. Table 8-1 lists the estimated annual RCOC load reductions for the candidate projects. For all RCOCs except ammonia-N, the highest-ranked candidate projects are all stormwater projects. CSO Outfall 107 would provide the largest ammonia-N load reduction of the candidate projects, followed by the NDS Partnering, Piper's Cascades, and Longfellow Cascades stormwater projects. The latter are green infrastructure projects that involve infiltration.

Figure 8-1 compares the estimated RCOC load reductions for each candidate stormwater project with the estimated load reductions for the largest of the candidate LTCP projects. As shown in the figure, most of the stormwater projects provide greater load reductions for most RCOCs. The primary reason for this is that these candidate stormwater projects would treat larger volumes than the candidate LTCP projects (see Figure 8-2).

The top-performing candidate stormwater projects provide larger load reductions for the key drivers for human exposure (PCBs and fecal coliform) and ecological exposure (phosphorus and PCBs). In contrast, three stormwater projects (South Myrtle St. Shoulder Stabilization, South Myrtle St. StormFilter Vault, and U Village Filtreras projects) provide less load reduction for most RCOCs compared to the largest candidate LTCP project because these stormwater projects treat relatively small volumes of stormwater.

Appendix I contains charts comparing the estimated pollutant loads reductions for each RCOC for the candidate stormwater and LTCP projects.

Table 8-1. Average Pollutant Load Reductions for Candidate LTCP and Stormwater Projects

Candidate project	Volume treated/reduced		Ammonia-N		BOD		Bis(2-ethylhexyl) phthalate		Dichlobenil		Dissolved copper		Dissolved zinc		Fecal coliform		H+		Oil and grease		PBDEs		PCBs		Phosphorus		Total copper		Total suspended solids		Total zinc	
	MG/yr	Rank	Reduction (kg/yr)	Rank	Reduction (kg/yr)	Rank	Reduction (kg/yr)	Rank	Reduction (kg/yr)	Rank	Reduction (kg/yr)	Rank	Reduction (kg/yr)	Rank	Reduction (billion CFU/yr)	Rank	Reduction (kg/yr)	Rank	Reduction (kg/yr)	Rank	Reduction (kg/yr)	Rank	Reduction (kg/yr)	Rank	Reduction (kg/yr)	Rank	Reduction (kg/yr)	Rank	Reduction (kg/yr)	Rank	Reduction (kg/yr)	Rank
CSO Outfall 99	0.17	11	0.78	5	12	11	0.0015	12	0.000070	5	0.0032	7	0.012	10	651	11	0.000073	9	2.2	9	0.000038	11	0.000032	12	0.37	11	0.0084	12	20	12	0.026	12
CSO Outfall 107	1.1	10	19	1	82	8	0.035	8	0.00029	4	0.027	6	0.14	9	4,346	6	0.00049	8	15	7	0.00025	8	0.00046	9	6.6	6	0.22	8	494	10	0.57	10
CSO Outfall 111	0.0086	15	0.15	8	0.64	15	0.00027	15	0.000003	9	0.00021	11	0.0011	13	34	15	0.0000038	12	0.11	13	0.0000020	15	0.0000036	15	0.05	15	0.0017	15	4	15	0.0044	15
CSO Outfall 138	0.091	13	0.43	6	6.8	13	0.00081	13	0.000041	6	0.0018	9	0.0067	11	360	12	0.000040	10	1.2	11	0.000021	13	0.000018	13	0.21	12	0.0046	13	11	13	0.015	13
CSO Outfall 139	0.0057	16	0.027	10	0.42	16	0.00005	16	0.000003	10	0.00011	12	0.00042	14	22	16	0.0000025	13	0.075	14	0.0000013	16	0.0000011	16	0.013	16	0.00029	16	0.69	16	0.0009	16
CSO Outfall 140	0.051	14	0.24	7	3.8	14	0.00045	14	0.000023	7	0.0010	10	0.0038	12	201	13	0.000023	11	0.67	12	0.000012	14	0.000010	14	0.12	13	0.0026	14	6	14	0.0081	14
Longfellow Cascades	5.0	7	2.8	4	237	6	0.063	6	0.0019	3	0.12	4	0.71	6	6,212	5	0.00510	5	129	4	0.0010	7	0.00062	7	5.1	8	0.34	7	2,645	7	3.4	7
NDS Partnering	35	4	9.2	2	684	2	0.22	2	0.0048	1	0.46	2	3.2	3	17,910	2	0.015	2	396	2	0.0029	4	0.0018	5	14	4	1.3	4	7,704	4	11	3
Piper's Cascades	8.3	6	4.7	3	370	3	0.11	5	0.0031	2	0.22	3	1.2	5	9,734	4	0.0081	3	204	3	0.0017	5	0.0010	6	8.4	5	0.58	5	4,382	5	6	5
South Myrtle St. Shoulder Stabilization.	0.10	12	0.086	9	8.7	12	0.0021	11	0.000015	8	0.0024	8	0.16	8	125	14	0.00062	7	3.4	8	0.000033	12	0.000069	11	0.09	14	0.027	11	142	11	0.24	11
South Myrtle St. StormFilter	3.1	8	0.0	13	56	10	0.0098	10	0.0	13	0.0	14	1.29	4	3,232	7	0.0064	4	1.3	10	0.00025	9	0.00056	8	1.4	9	0.13	10	1,092	8	1.4	8
South Park WQ Facility	74	3	0.0	13	1,088	1	0.29	1	0.0	13	0.71	1	14	1	52,700	1	0.0	14	702	1	0.0047	3	0.0069	1	46	1	4.5	3	24,741	3	29	1
Street Sweeping Expansion Arterials	1527	1	N/A	N/A	337	5	0.14	4	N/A	N/A	N/A	N/A	N/A	N/A	2,100	9	N/A	N/A	69	6	0.0096	2	0.0033	3	24	3	5.2	2	36,200	2	10	4
Street Sweeping Expansion Residential	986	2	N/A	N/A	366	4	0.16	3	N/A	N/A	N/A	N/A	N/A	N/A	2,560	8	N/A	N/A	84	5	0.011	1	0.0040	2	28	2	6.3	1	41,900	1	12	2
SW Hinds SD/ StormFilter	14	5	0.0	13	213	7	0.045	7	0.0	13	0.0	14	4.1	2	11,496	3	0.021	1	0.0	16	0.0011	6	0.0019	4	6.0	7	0.44	6	4,191	6	5	6
U Village/Filtreras	3.0	9	0.0	13	64	9	0.014	9	0.0	13	0.043	5	0.54	7	1,395	10	0.0014	6	0.0	16	0.00022	10	0.00014	10	0.87	10	0.18	9	676	9	1	9

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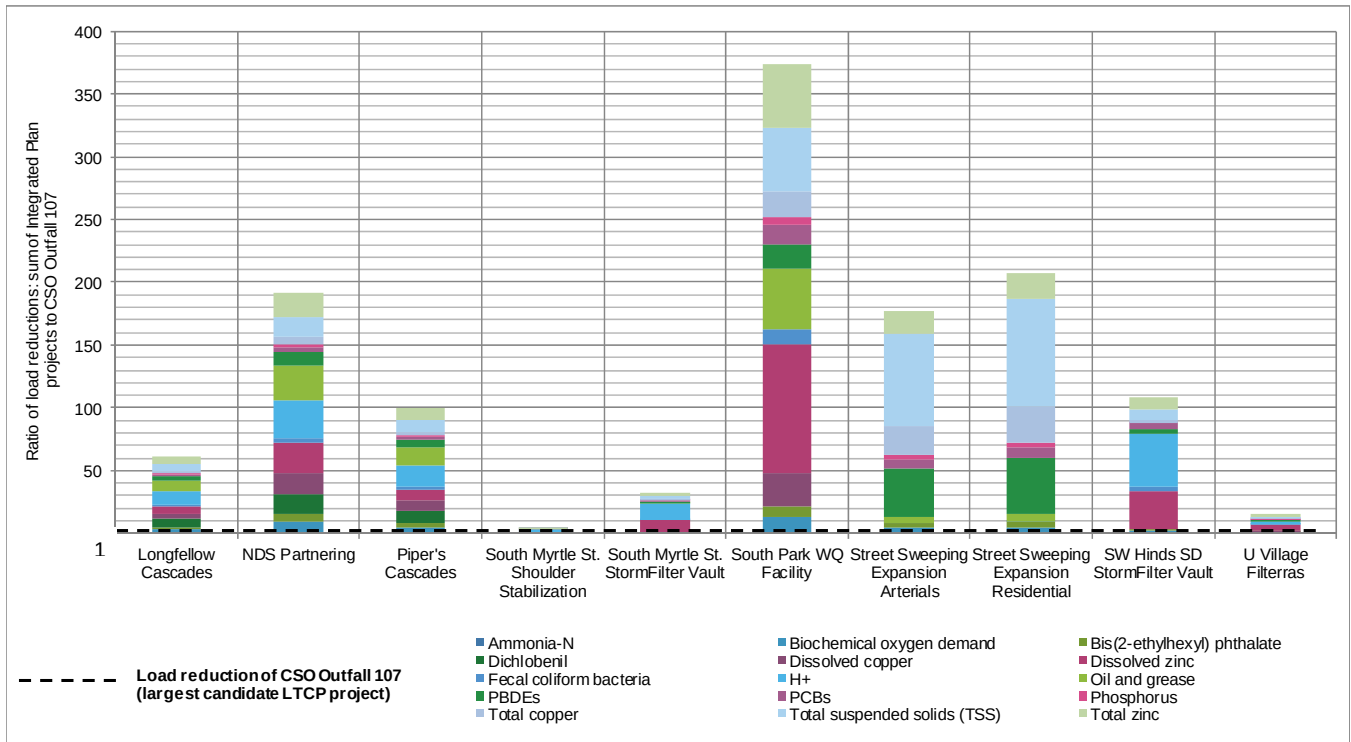


Figure 8-1. Comparison of candidate stormwater projects to largest candidate LTCP project load reductions

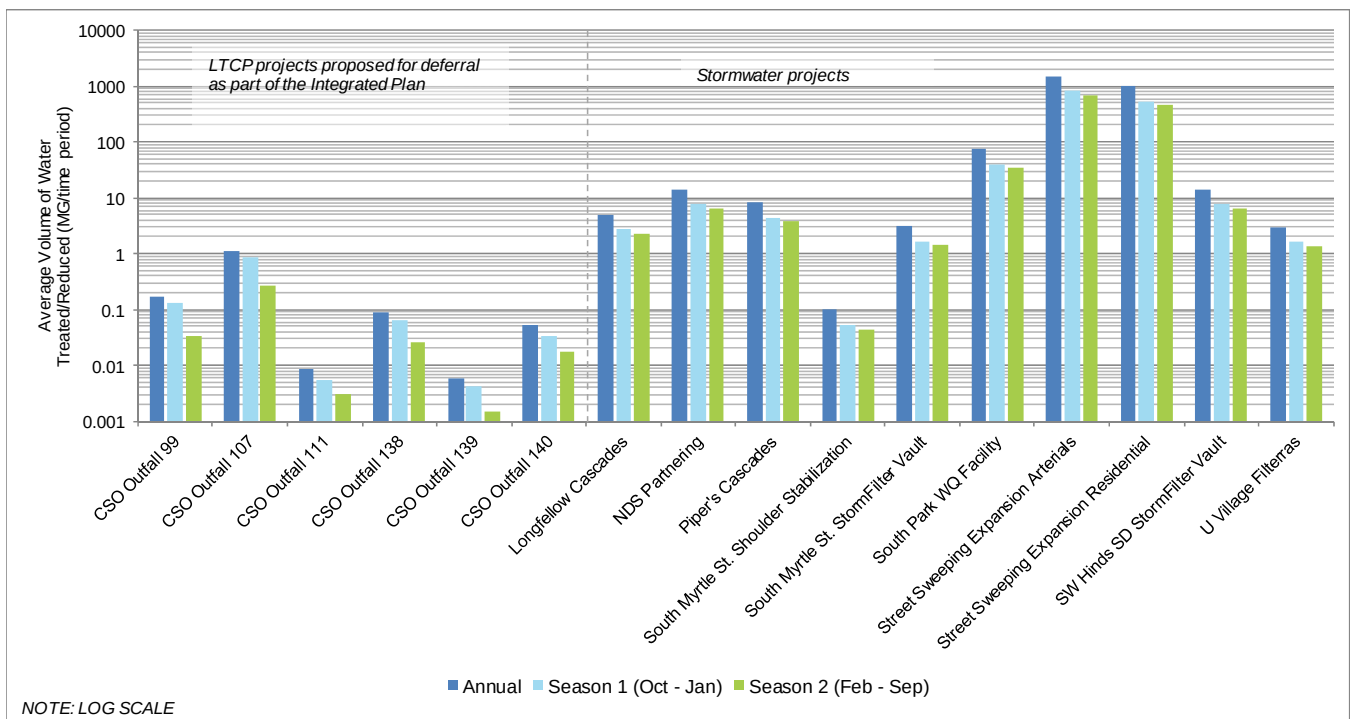


Figure 8-2. Average volumes treated or reduced by candidate LTCP and stormwater projects

8.2.2 Relative Exposure Reductions for Candidate Projects

The City used the pollutant loads reduction results, together with information on local receiving water bodies, to calculate human and ecological exposure index values (EIVs) for the candidate LTCP and structural stormwater projects. The EIVs were calculated to help the City compare the candidate projects and to select the projects to include in the Integrated Plan. Appendix H of this plan provides a detailed description of the EIV methods and results. EIVs were not calculated for the candidate street sweeping programs because the EIV receptor factors are based on the outfall location, and runoff from the swept streets would affect numerous outfalls and water bodies throughout the city. Section 8.2.3 explains the approach used to evaluate the potential reductions in exposure that would result from the candidate street sweeping programs.

Table 8-2 lists the EIVs for the candidate stormwater and LTCP projects. The highest (best) EIVs were associated with candidate stormwater projects. The South Park Water Quality Facility had the highest EIVs for human receptors while the NDS Partnering: Thornton Creek project had the highest EIV for ecological receptors among all of the candidate stormwater and LTCP projects. Note that Table 8-2 lists three sets of EIVs for NDS Partnering because EIVs depend in part on discharge location and NDS Partnering would include projects in three creek basins. Of the LTCP projects, CSO Outfall 107 had the highest human-chronic (toxics) and ecological EIVs, and CSO Outfall 138 had the highest fecal coliform EIV.

Figure 8-3 compares the EIVs for the candidate stormwater projects to the highest EIVs for the candidate CSO projects (CSO Outfall 107 and CSO Outfall 138). As shown in the figure, the human and ecological EIVs for the South Park Water Quality Facility are many times higher than the highest EIVs for the candidate CSO projects. The ecological EIVs for the NDS Partnering: Thornton Creek and Piper's Cascades projects were several times higher than the ecological EIVs for the highest candidate CSO project (CSO Outfall 107).

Table 8-2. Comparison of EIVs for Candidate LTCP and Stormwater Projects, by Project							
Candidate project	Receiving water body	Human				Ecological	
		Toxics		Fecal coliform		Toxics/nutrients	
		EIV	Rank	EIV	Rank	EIV	Rank
CSO Outfall 99	West Waterway of the Duwamish River	0.39	10	0.18	13	0.0057	14
CSO Outfall 107	East Waterway of the Duwamish River	13.2	4	1.3	8	0.35	7
CSO Outfall 111	Duwamish River	0.16	12	0.019	16	0.0038	15
CSO Outfall 138	Portage Bay	0.13	13	2.0	5	0.039	11
CSO Outfall 139	Portage Bay	0.0061	16	0.093	14	0.0031	16
CSO Outfall 140	Portage Bay	0.080	15	1.4	7	0.035	12
Longfellow Cascades	Longfellow Creek	0.27	11	1.1	10	0.61	4
NDS Partnering: Thornton Creek	Thornton Creek	3.8	6	7.0	2	2.5	1
NDS Partnering: Piper's Creek	Piper's Creek	0.89	9	1.2	9	0.54	5
NDS Partnering: Longfellow Creek	Longfellow Creek	0.12	14	0.52	12	0.24	9

Table 8-2. Comparison of EIVs for Candidate LTCP and Stormwater Projects, by Project

Candidate project	Receiving water body	Human				Ecological	
		Toxics		Fecal coliform		Toxics/nutrients	
		EIV	Rank	EIV	Rank	EIV	Rank
Piper's Cascades	Piper's Creek	3.8	5	5.3	3	1.8	3
South Myrtle St. Shoulder Stabilization	Duamish Waterway	1.6	8	0.024	15	0.019	13
South Myrtle St. StormFilter Vault	Duamish Waterway	13.7	3	0.67	11	0.14	10
South Park WQ Facility	Duamish Waterway	116.6	1	8.3	1	1.9	2
Street Sweeping Expansion Arterials	Multiple	N/A ^a					
Street Sweeping Expansion Residential	Multiple	N/A ^a					
SW Hinds SD StormFilter Vault	Duamish Waterway	36.2	2	1.9	6	0.36	6
U Village Filterrras	Union Bay/Lake Washington	2.0	7	3.2	4	0.32	8

a. EIVs were not calculated for street sweeping because the receptor factors are based on the outfall location, and runoff from the swept streets would enter >100 outfalls throughout the city.

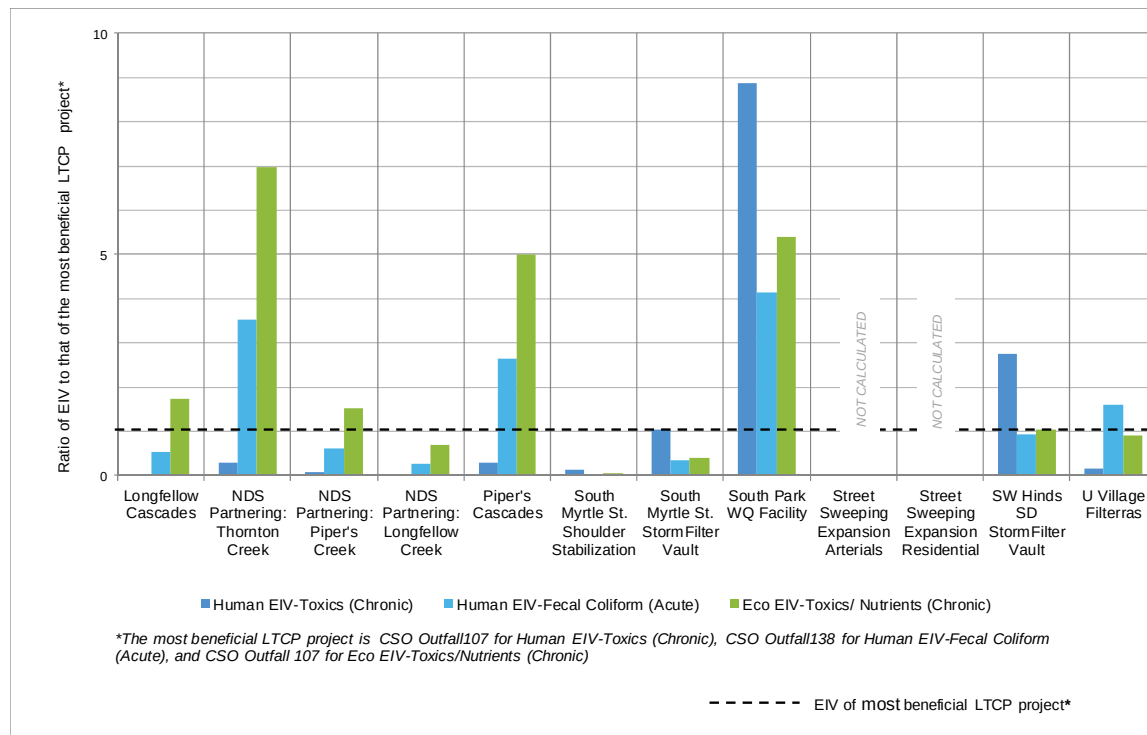


Figure 8-3. Ratio of candidate stormwater project EIVs to most beneficial candidate LTCP project EIVs

8.2.3 Relative Exposure Reductions for Candidate Street Sweeping Programs

EIVs were not calculated for the candidate street sweeping programs because the EIV receptor factors are based on the outfall location, and runoff from the swept streets would affect numerous outfalls and water bodies throughout the city. Therefore, a more qualitative approach was used to evaluate the potential reductions in exposure that would result from the candidate street sweeping programs.

Table 8-1 above and Figures 1-3 and 1-6 in Appendix I show that the candidate street sweeping programs would provide much larger reductions in PCBs and phosphorus than the candidate LTCP projects. PCBs were found to be the key driver for human-toxics EIVs at all locations, as shown in Figure 7-15 above. Phosphorus was the key driver for ecological EIVs at freshwater locations, while PCBs were an important contributor to ecological EIVs at several saltwater/brackish locations (see Figure 7-16). These results suggest that the candidate sweeping programs would provide substantial reductions in human exposure to toxics and ecological exposure to nutrients and toxics as compared to the candidate LTCP projects.

The pollutant loads modeling results indicate that neither of the candidate street sweeping programs would provide as much fecal coliform load reduction as CSO Outfall 107. However, both sweeping programs would provide more fecal coliform load reduction than any of the other candidate LTCP projects. The pollutant loads modeling results also indicate that the candidate sweeping programs would provide appreciable reductions in human exposure to fecal coliform. Moreover, the loads reductions from sweeping would benefit water bodies throughout the city.

8.3 Multiple Objective Decision Analysis

The pollutant loads modeling and exposure assessments described above indicated that multiple combinations of the candidate stormwater projects and programs could provide significantly greater water quality benefits beyond those that would be achieved by implementation of the combined six CSO reduction projects alone. Therefore, the City believes that it is appropriate to defer all six CSO reduction projects. Implementation of the preferred option for the LTCP and the candidate stormwater projects by 2025, and the remaining six CSO reduction projects by 2030, will result in significant benefits to the receiving water bodies in and around Seattle beyond what could be achieved with the six CSO reduction projects alone. Therefore, the City decided that the Integrated Plan should include deferral of all six of the candidate LTCP projects.

To help select the candidate stormwater projects for the Integrated Plan, the City used MODA to compare the candidate stormwater projects and programs for potential inclusion in the Integrated Plan. This section summarizes the MODA methods and results.

8.3.1 Methodology Overview

The City often uses MODA to help make decisions regarding projects or programs. For the Integrated Plan, the City used MODA to compare candidate stormwater projects based on their expected water quality benefits as well as other criteria important to the community.

The MODA methodology for the Integrated Plan involved the following steps:

1. Establish evaluation criteria
2. Develop measurement scales and assign draft scores
3. Establish relative value weights

4. Normalize scores and calculate results
5. Perform sensitivity analysis

These steps are described below. Appendix I contains additional details on the MODA process.

8.3.2 Establish Evaluation Criteria

The Integrated Plan team developed evaluation criteria during a series of workshops facilitated by the same MODA specialists who supported the LTCP decision-making process. Through these workshops the team developed criteria that represent the City values and objectives relevant to making decisions about the Integrated Plan. The MODA criteria used to rank the candidate stormwater projects are summarized below. Appendix I contains additional details on these criteria and their measurement scales.

1. **Performance risk:** *How flexible is the project in terms of responding to varying flow and pollutant characteristics above and below the project location?*
2. **Flexibility:** *What are the intervention opportunities to address under-performance, changes in rainfall patterns, and/or increases in temperature and drought situations?*
3. **Relationship with other agencies (tribes, King County):** *To what extent does the project enhance long-term relationships with Puget Sound area tribes and King County Wastewater Treatment Division (WTD)?*
4. **Water quality:** *To what extent does the candidate project contribute water quality benefits beyond those that would be achieved by the deferred LTCP projects? As described in Appendix I, the project score for this criterion was calculated based on pre-project RCOC concentrations, relevant water quality criteria, and estimated load reductions.*
5. **Other positive environmental outcomes:** *Does the project help meet the City's Green Goal by reducing stream flow rates, and/or does the project add green space and habitat?*
6. **Construction impacts (short-term):** *What level of disruption will occur during project construction?*
7. **Community impacts (long-term):** *What lasting impact will the project and its operations and maintenance (O&M) activities have on the neighborhood, either positive (culturally relevant, sidewalks, water access, bike paths, traffic calming, visual appeal), or negative (odor, noise, visual)? Note: This is not meant to include construction impacts.*
8. **Environmental/social justice:** *Who and where? Will the location of the project address the historical inequity (e.g., address problems that were historically "underreported")? Will the project protect a current use by socioeconomic class (e.g., fishing in Duwamish/Green Lake)? Will facility siting affect an already heavily impacted area (e.g., South Park has transfer station)?*
9. **Ease of operations and maintenance (O&M) and safety:** *The score for this criterion was the average of the scores given for three sub-criteria: operations, maintenance, and safety.*

8.3.3 Develop Measurement Scales and Assign Draft Scores

A measurement scale describes the extent to which a project meets each evaluation criterion. The Integrated Plan team developed measurement scales of 1 to 5 for each criterion (except water quality). The worst potential outcome was given a score of 1 and the best possible outcome was given a score of 5. The MODA team then assigned scores for each criterion (except water quality) using the 1–5 measurement scale. Scores for each criterion (except water quality) were assigned based on each team member's knowledge of the project.

The water quality score for each candidate stormwater project was calculated based on estimated pre-project (i.e., existing) concentrations and the estimated load reductions that would result from implementation of the project. The existing concentrations were used to indicate the potency of the existing discharge and the load reductions were used to account for the magnitude of change. The water quality score was calculated as described below.

First, a weight was calculated as the ratio of the pre-project concentration to the water quality criteria for each RCOC:

$$Weight_{RCOC} = \frac{Pre\text{-}project\ concentration_{RCOC}}{Water\ quality\ criteria_{RCOC}}$$

Next, the load reduction for each RCOC was normalized to the largest LTCP project (CSO Outfall 107):

$$Normalized\ load\ reduction_{RCOC} = \frac{Load\ reduction\ project_{RCOC}}{Load\ reduction\ LTCP\ NPDES\ 107_{RCOC}}$$

The weight was then multiplied by the normalized load reduction and summed to provide the water quality score for the candidate project or program.

$$Water\ quality\ score_{project} = \sum (weight * normalized\ load\ reduction)_{RCOC}$$

Appendix I provides more details on the evaluation criteria, measurement scales, and scoring rationales.

8.3.4 Establish Relative Value Weights

The City assigned weights to each criterion to reflect the relative value of each criterion within the context of the decision being made. Weights were determined at a MODA team meeting where a trained facilitator led City senior managers using a modified Delphi process in which managers provided weights, the weights were shown to the group, and the differences were discussed. Weights were assigned based on the relative importance of the criterion and the extent to which the scores for the criterion varied among the candidate projects. The discussion resulted in a consensus set of weights that were used in the evaluation. Table 8-3 presents the consensus weights used for the MODA evaluation of the candidate stormwater projects. The water quality criterion was given the greatest weight.

Table 8-3. Criteria Weights		
Evaluation criterion	Relative value weight	Percent of total
1. Performance risk	18	10%
2. Flexibility	12	7%
3. Relationship with other agencies	4	2%
4. Water quality	100	54%
5. Other positive environmental outcomes	8	4%
6. Construction impacts (short-term)	8	4%
7. Community impacts (longer-term)	8	4%
8. Environmental/social justice	8	4%
9. Ease of O&M and safety	18	10%

8.3.5 MODA Results

Total MODA scores ranged from 0 to 100. All scores were normalized to a 0–1 scale using linear transformation. The normalized scores were multiplied by the relative value weight for each criterion, then multiplied by 100 (a scalar for presentation), and summed over all criteria, resulting in a total value score for each project.

Table 8-4 lists the MODA scores and ranks for the candidate stormwater projects. The results of the analysis are also shown on Figure 8-4 as a stacked bar chart where each bar represents the contribution to the score from each criterion. As shown, the South Park WQ Facility provides the highest overall score. Water quality and performance risk impacts contributed the most value to the South Park WQ Facility project.

Table 8-4. MODA Results		
Candidate project/program	Total score	Rank
South Park WQ Facility	79	1
Street Sweeping Expansion Arterials	64	2
Street Sweeping Expansion Residential	57	3
NDS Partnering	41	4
SW Hinds SD StormFilter Vault	40	5
Piper's Cascades	37	6
Longfellow Cascades	35	7
U Village Filtreras	30	8
South Myrtle St. StormFilter Vault	30	9
South Myrtle St. Shoulder Stabilization	27	10

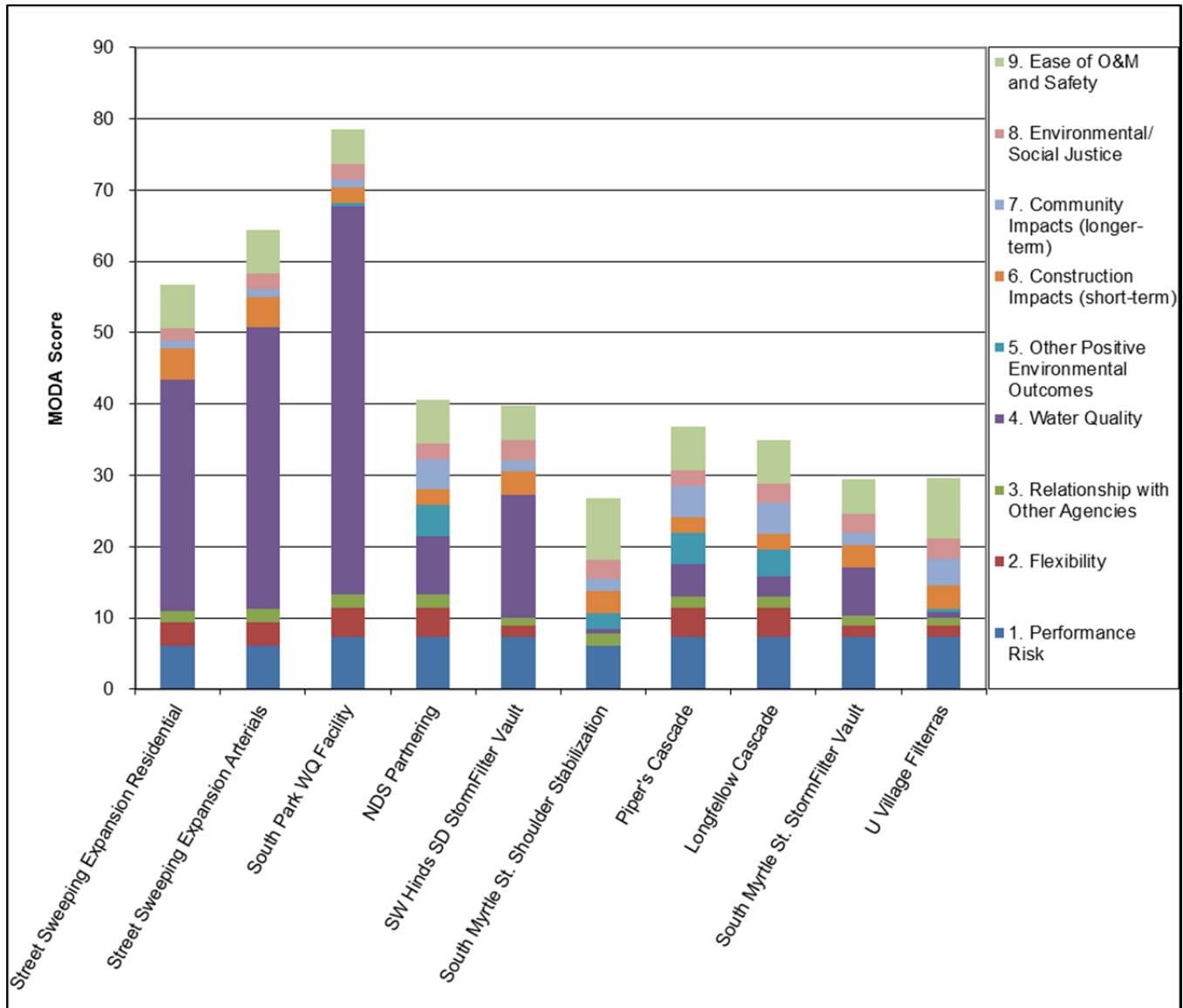


Figure 8-4. MODA results

8.4 Integrated Plan Projects

In keeping with the Consent Decree requirements, the City selected projects for the Integrated Plan based on their anticipated pollutant load reductions, human and ecological exposure reductions, and overall benefits to water bodies with special circumstances. The City added the MODA evaluations to the selection process to acknowledge the economic, social, and environmental benefits of the projects beyond the Consent Decree requirements.

The City found that a number of the candidate stormwater projects would provide significant benefits beyond those of the LTCP projects alone, as described in Sections 8.1 through 8.3 above. The City ultimately selected three of these candidate stormwater projects for the Integrated Plan based on their significant water quality benefits, high value per the MODA evaluations, and life-cycle costs. The City selected the South Park Water

Quality Facility project, Street Sweeping Expansion Arterials and NDS Partnering project for implementation under the Integrated Plan alternative.

The South Park Water Quality Facility received the highest significant benefits and MODA score of the candidate stormwater projects. Street Sweeping Expansion Arterials received the fourth-highest significant benefit score and the second-highest MODA score. NDS Partnering received the second-highest significant benefit score and the fourth-highest MODA score. The City selected NDS Partnering instead of the third-ranked project (Street Sweeping Expansion Residential) in order to have a combination of green, gray, and programmatic stormwater measures in the Integrated Plan, consistent with EPA's "Integrated Municipal Stormwater and Wastewater Planning Approach Framework." Moreover, the residential sweeping program would have required development and enforcement of a no-parking program in areas with little or no off-street parking.

The three stormwater projects would provide citywide source control (Street Sweeping Expansion Arterials Program), active treatment of stormwater runoff to the high-priority Lower Duwamish Waterway (South Park WQ Facility Project), and green infrastructure to reduce flows and pollutants discharging into salmon-bearing streams (NDS Partnering Project). These stormwater projects would be fully implemented by 2025.

The City selected six LTCP CSO control projects for deferral under the Integrated Plan alternative. Projects to control CSO Outfalls 99, 107, 111, 138, 139, and 140 would be constructed by 2030 instead of 2025. As discussed in Sections 8.1 through 8.3 above, the six deferred LTCP projects would provide much smaller water quality benefits than the three selected stormwater projects.

8.4.1 Selected Stormwater Projects

This section provides a brief summary of the three stormwater projects selected for the Integrated Plan. Appendix J contains detailed fact sheets for these projects.

8.4.1.1 NDS Partnering Project

The NDS Partnering project is a regional green infrastructure project that would construct bioretention facilities (i.e., engineered rain gardens) in separated storm sewer system basins that drain to Piper's, Thornton, and Longfellow creeks. These would entail modifications to about 4 miles of rights-of-way to manage flow and provide water quality treatment for stormwater runoff. Attachment J, Figures J-1 through J-3 show the general project locations and receiving water bodies.

The bioretention facilities would be designed to reduce geomorphically significant flows and loads of PCBs, metals, bacteria, and other pollutants to Piper's, Thornton, and Longfellow creeks. Two types of bioretention facilities would be constructed depending on site-specific conditions. In areas with low infiltration rates, the facilities would be equipped with underdrains (perforated pipes) to collect stormwater that passes through the bioretention media but does not infiltrate into the underlying soil within an acceptable time frame. The underdrains would convey the treated stormwater to a City stormwater conveyance system or an engineered underground injection control (UIC) structure, such as a pit drain (<12 feet deep), a vertically drilled drain (25-35 feet deep), or a gravity injection well (35-80 feet deep). Injection wells would be used only where pit drains and drilled drains are found to be infeasible based on geotechnical analysis and groundwater monitoring.

The City recently completed a GIS study to map the areas within each watershed that appear feasible for NDS projects. The NDS Partnering project would require only about 4 percent of the potentially feasible area within the Piper's, Thornton, and Longfellow creek watersheds. Thus, the City should have significant flexibility in finding bioretention facility locations with appropriate site conditions and community support.

The City will select specific NDS project sites using a “partnering” approach. The City will work in partnership with local residents and community groups to identify candidate blocks within areas deemed potentially feasible for bioretention. To encourage local partnerships, the NDS Partnering project will include community amenities such as mobility, traffic calming, and beautification. The City anticipates that most of the candidate blocks will be in areas that currently lack curbs and gutters. In addition to providing water quality, flow control, and community benefits, NDS Partnering project should also increase community awareness of urban stormwater quality issues.

NDS Partnering locations will be prioritized based primarily on stormwater management goals, but factors such as community support and overlapping City priorities will be included in the site prioritization. The site selection process will involve information exchange with neighborhood groups and other public agencies about the program, and selection of project sites based on input from these groups. South Park WQ Facility Project

As briefly described in Section 5.3.2, the South Park WQ Facility would treat runoff in the 7th Avenue S drainage system. The current South Park drainage area is approximately 238 acres, about 145 acres (61 percent) of which is impervious. In the future, the drainage area could be expanded to encompass up to 278 acres including approximately 219 acres of impervious surfaces (SPU, 2014b). The South Park project would involve installation of a basic, active treatment system, such as a CESF system, near the outlet to the 7th Avenue S drainage system. The facility would treat runoff prior to discharge into the Duwamish Waterway. The treatment facility would be designed in conjunction with a new stormwater pump station that the City plans to build in order to reduce flooding in the 7th Avenue S drainage basin. The proposed project would take advantage of the opportunity to integrate water quality treatment with flood control.

The primary objective of this project would be to reduce loads of total PCBs, metals, bacteria, and other pollutants to the Duwamish Waterway. This project would be designed to treat an average annual runoff volume of approximately 74 MG/yr and remove about 80 percent of the TSS load (approximately 24,741 kg) in an average year. See Appendix J for additional information on this project.

8.4.1.2 Street Sweeping Expansion Arterials Program

The Street Sweeping Expansion Arterials program would focus on the separated storm sewer system basins. It would entail increased sweeping of arterials to remove potential stormwater pollutants from a tributary area of approximately 1,736 acres (10,600 annual curb-miles), including streets and adjacent sidewalks. This program includes the following three expansions:

- increase the route coverage from 83 percent to approximately 85 percent of curbed arterials (for a total 10,600 curb-miles), by adding 1 route, for a total of 25 routes
- increase the sweeping season from 40 to 48 weeks per year
- increase the sweeping frequency from biweekly to weekly for some routes: 21 routes would be swept on a weekly basis and 4 routes would be swept on a biweekly basis

The primary objective of this program would be to reduce loads of TSS, PCBs, metals, bacteria, and other particulate-bound pollutants to multiple receiving water bodies. This program would remove pollutants from approximately 1,736 acres with an average annual runoff volume of approximately 1,527 MG/yr. See Appendix J for additional information on this program.

8.4.2 Selected LTCP Projects

The City selected six LTCP projects (those that would control CSO Outfalls 99, 107, 111, 138, 139, and 140) for deferral under the Integrated Plan. These six projects were selected for deferral because (1) they are located in CSO basins that the LTCP team deemed lower priority based on ranking per EPA guidelines and consideration of potential partnering opportunities with King County, and (2) the projects would provide considerably smaller reductions in pollutant loads and exposures than the selected stormwater projects. The LTCP (Volume 2) provides additional details regarding the six LTCP projects to be deferred.

Figure 8-5 shows the locations of the stormwater projects/programs that would be implemented and the LTCP projects that would be deferred under the Integrated Plan alternative. Table 8-5 summarizes the stormwater projects/programs to be implemented and the LTCP projects to be deferred.

Table 8-5. Integrated Plan Alternative

Project name	Project type	Receiving water body	Average existing discharge frequency (average events/yr) ^{a,b}	Average volume treated or removed (MG/yr) ^c	Life-cycle cost ^d (M\$)	Construction completed (yr)
LTCP projects to be completed during 2028–30^e						
CSO Outfall 99	Offline storage pipe	West Waterway of the Duwamish River	1.5	0.17	\$8.2	2030
CSO Outfall 107	Offline storage tank	East Waterway of the Duwamish River	4.6	1.1	\$24.2	2030
CSO Outfall 111	Offline storage pipes	Duwamish River	1.7	0.01	\$7.3	2030
CSO Outfall 138	Offline storage tank	Portage Bay	1.4	0.09	\$7.5	2030
CSO Outfall 139	Offline storage pipes	Portage Bay	1.2	0.01	\$1.9	2030
CSO Outfall 140	Offline storage pipes	Portage Bay	3.7	0.05	\$4.4	2030
Stormwater projects/programs to be implemented by 2025^f						
NDS Partnering	Bioretention	Longfellow Creek, Piper's Creek, Thornton Creek	119	35	\$27.2	2025
South Park WQ Facility	Basic, active treatment (e.g., CESF ^g)	Duwamish Waterway	119	74	\$34.8	2025
Street Sweeping Expansion Arterials	Street sweeping (weekly arterial sweeping)	Multiple	119	1,527 ^h	\$26.1	N/A ⁱ

a. For stormwater projects, the existing discharge frequency was estimated using data from 10 years' worth of recorded rainfall data from a City rain gauge. A discharge event was considered as an "event" if, on that particular day, the precipitation depth was at a minimum of 0.03 inch. Based on collected flow monitoring data, a rainfall depth of 0.03 inch generates flow in the storm sewer system.

b. The existing discharge frequencies for the candidate LTCP projects can be found in the 2012 Annual CSO Report.

c. The estimated average volume removed for the candidate LTCP projects was calculated using the moving 20-year average simulated volumes, without the consideration of climate change. This means that the precipitation data used for modeling was not modified to account for potential effects of climate change on rain; therefore, a scaling factor of 1 was assumed. See the LTCP Hydraulic Monitoring Reports for a more detailed discussion of the hydraulic modeling conducted.

d. Present value in 2014 dollars assuming 100-year project life and 3% discount rate based on current IP schedule.

e. Prior to 2025, SPU will implement Sewer System Improvements (SSI) designed to reduce overflows from the CSO outfalls associated with the six deferred LTCP Neighborhood Storage projects. After the SSI have been completed, SPU will monitor the six affected outfalls to assess compliance with the state CSO control standard. SPU will then determine whether some or all of the deferred LTCP Neighborhood Storage projects can be downsized or eliminated.

f. SPU anticipates that the South Park and NDS Partnering projects will have a life span of 50 years. Street Sweeping Expansion for the Integrated Plan will be conducted up to 2030 or until all six of the deferred CSOs have been controlled. At that time, SPU will determine whether to continue the Street Sweeping Expansion program. CESF is chitosan-enhanced sand filtration.

g. Volume is based on estimated runoff from swept streets.

h. The Street Sweeping Expansion Arterials program will begin in 2015. The purchase of sweepers and program implementation will be complete by 2016. Post-Construction Monitoring will occur between 2016 and 2018.

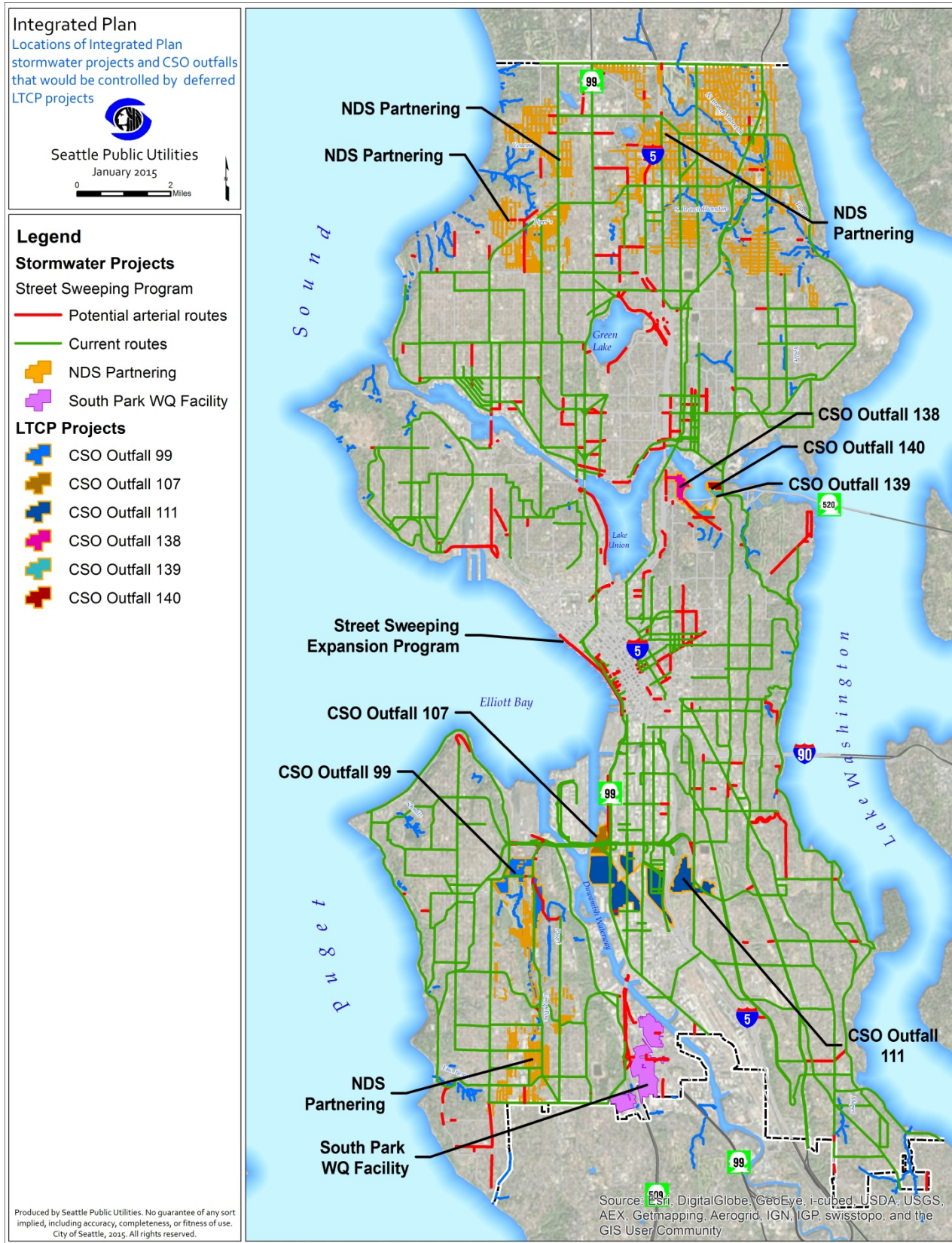


Figure 8-5. Locations of Integrated Plan stormwater projects and CSO outfalls that would be controlled by

deferred LTCP projects**8.4.3 Water Quality Benefits of the Integrated Plan**

The Consent Decree requires that the Integrated Plan must result in significant water quality benefits beyond the benefits that would be achieved by implementing the LTCP control measure projects alone. This section summarizes the additional water quality benefits of the Integrated Plan.

8.4.3.1 Pollutant Load Reduction Benefits

Table 8-6 shows that the three stormwater projects selected for the Integrated Plan would result in substantially greater load reductions than the deferred LTCP projects for all RCOCs except ammonia-N. For the RCOCs aside from ammonia-N, the Integrated Plan stormwater projects would achieve load reductions from 10 to more than 100 times greater than the six deferred LTCP projects and the LTCP projects not deferred (see Figure 8-6).

Table 8-6. Average Annual Pollutant Load Reductions for Preferred Alternative for the Integrated Plan

Project	Ammonia-N (kg)	Biochemical oxygen demand (kg)	Bis(2-ethylhexyl) phthalate (kg)	Dichlobenil (kg)	Dissolved copper (kg)	Dissolved zinc (kg)	Fecal coliform bacteria (billion CFU)	H+ (kg)	Oil and grease (kg)	PBDEs (kg)	PCBs (kg)	Phosphorus (kg)	Total copper (kg)	Total suspended solids (TSS) (kg)	Total zinc (kg)
LTCP projects to be completed during 2028–30															
CSO Outfall 99	0.78	12	0.0015	0.000070	0.0032	0.012	651	0.000073	2.2	0.000038	0.000032	0.37	0.0084	20	0.026
CSO Outfall 107	19	82	0.035	0.00029	0.027	0.14	4346	0.00049	15	0.00025	0.00046	6.6	0.22	494	0.57
CSO Outfall 111	0.15	0.64	0.00027	0.000003	0.00021	0.0011	34	0.0000038	0.11	0.0000020	0.0000036	0.05	0.0017	4	0.0044
CSO Outfall 138	0.43	6.8	0.00081	0.000041	0.0018	0.0067	360	0.000040	1.2	0.000021	0.000018	0.21	0.0046	11	0.015
CSO Outfall 139	0.027	0.42	0.000050	0.000003	0.00011	0.00042	22	0.0000025	0.075	0.0000013	0.0000011	0.013	0.00029	0.69	0.00090
CSO Outfall 140	0.24	3.8	0.00045	0.000023	0.0010	0.0038	201	0.000023	0.67	0.000012	0.000010	0.12	0.0026	6	0.0081
Total load reduction	21	106	0.038	0.00043	0.034	0.16	5,614	0.00063	19	0.00032	0.00053	7.3	0.24	536	0.63
Stormwater projects/programs to be implemented by 2025															
NDS Partnering	9.2	684	0.22	0.0048	0.46	3.2	17,910	0.015	396	0.0029	0.0018	14	1.3	7,704	11
South Park WQ Facility	0.0	1,088	0.29	0.0	0.71	14	52,700	0.0	702	0.0047	0.0069	46	4.5	24,741	29
Street Sweeping Expansion Arterials	N/A	337	0.14	N/A	N/A	N/A	2,100	N/A	69	0.0096	0.0033	24	5.2	36,200	10
Total load reduction	9.2	2,109	0.64	0.0048	1.17	17	72,710	0.015	1,167	0.017	0.012	83	10.9	68,645	51

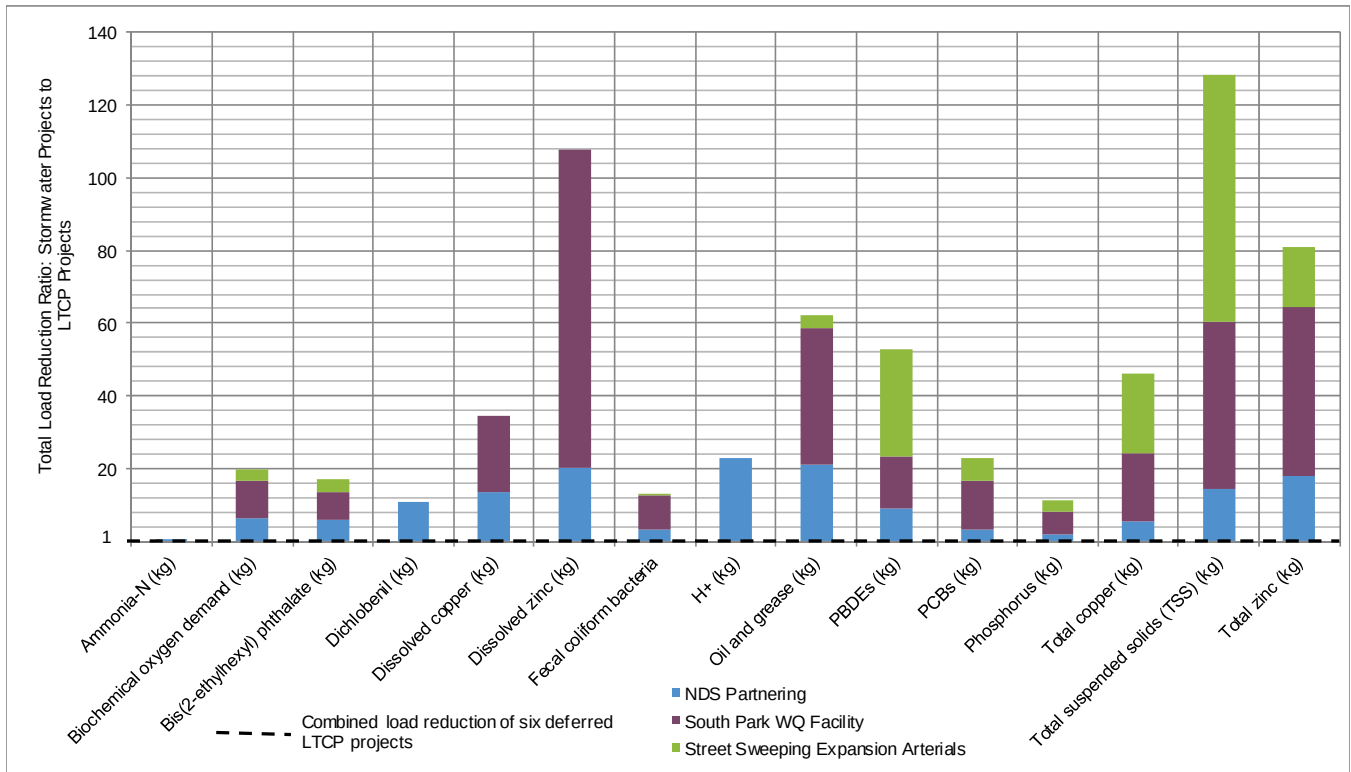


Figure 8-6. Significant pollutant load reduction benefits of Integrated Plan stormwater projects

The bars show how much more estimated pollutant load reduction would be provided by the proposed stormwater projects than by the six deferred LTCP projects, which is represented by the black dashed line.

The six LTCP projects listed in Table 8-5 would be deferred but not eliminated under the Integrated Plan. After the deferred LTCP projects are completed during 2028–30, their water quality benefits will add to the water quality benefits of the stormwater projects. The Integrated Plan stormwater and LTCP projects are long-term measures (100-year life cycle). Consequently, the Integrated Plan will result in significantly greater long-term water quality benefits compared to the deferred LTCP projects alone.

Figures 8-7, 8-8, and 8-9 show the long-term load reductions for TSS, PCBs, and fecal coliform, respectively, with and without the Integrated Plan. As shown in these figures, the Integrated Plan would result in much larger reductions in TSS, PCBs, and fecal coliform loads than the deferred LTCP projects.

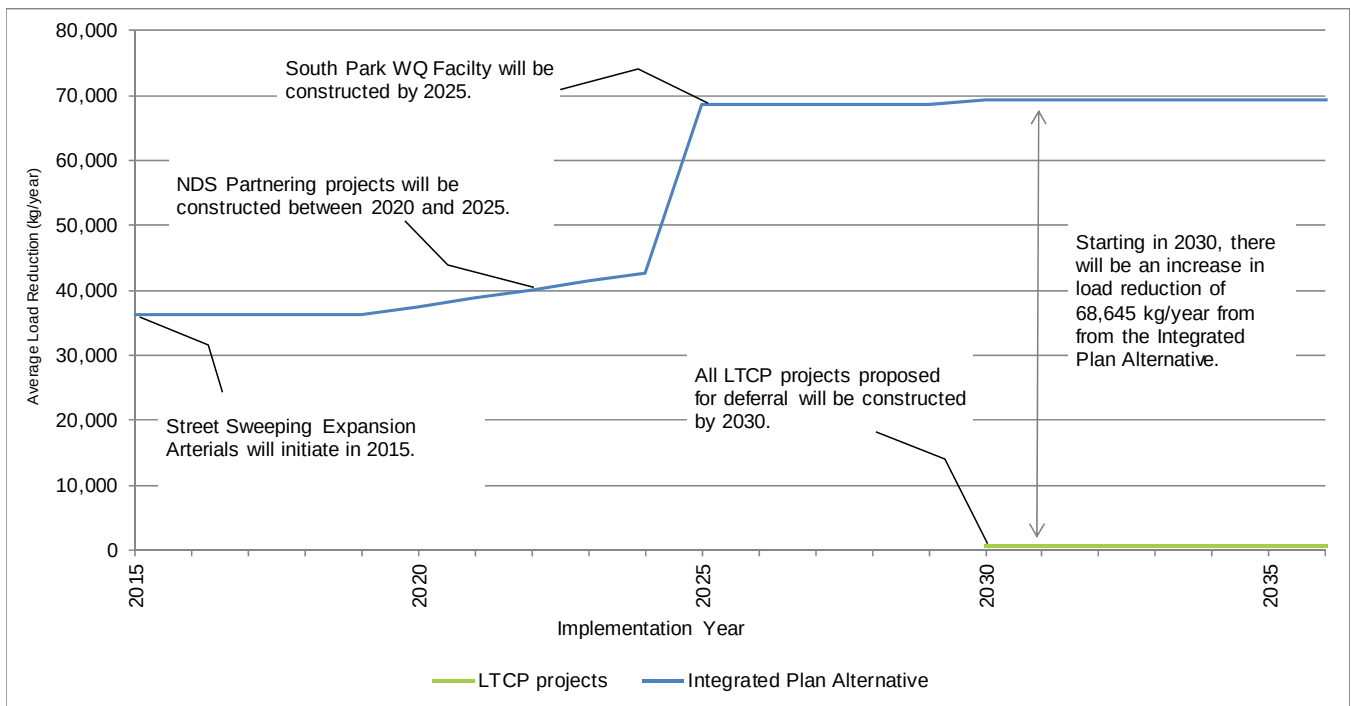


Figure 8-7. Cumulative water quality benefits of the Integrated Plan: TSS load reduction

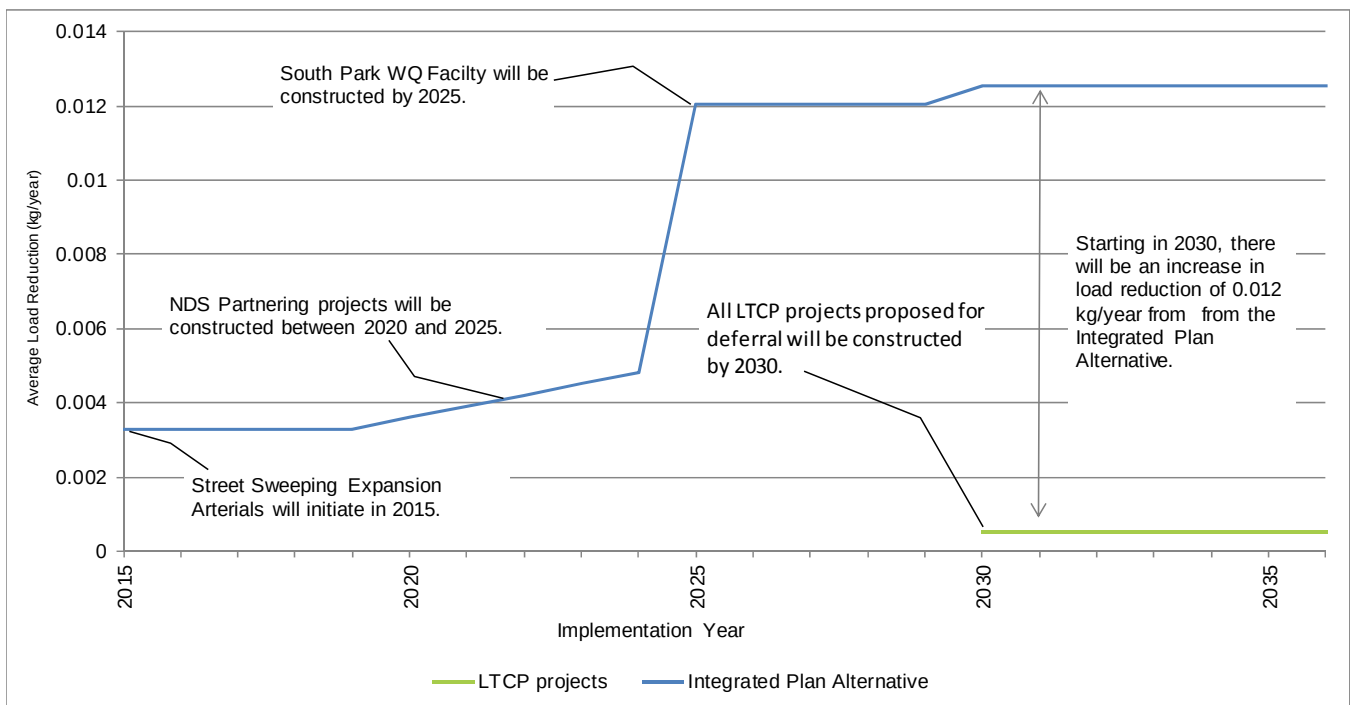


Figure 8-8. Cumulative water quality benefits of the Integrated Plan: PCBs load reduction

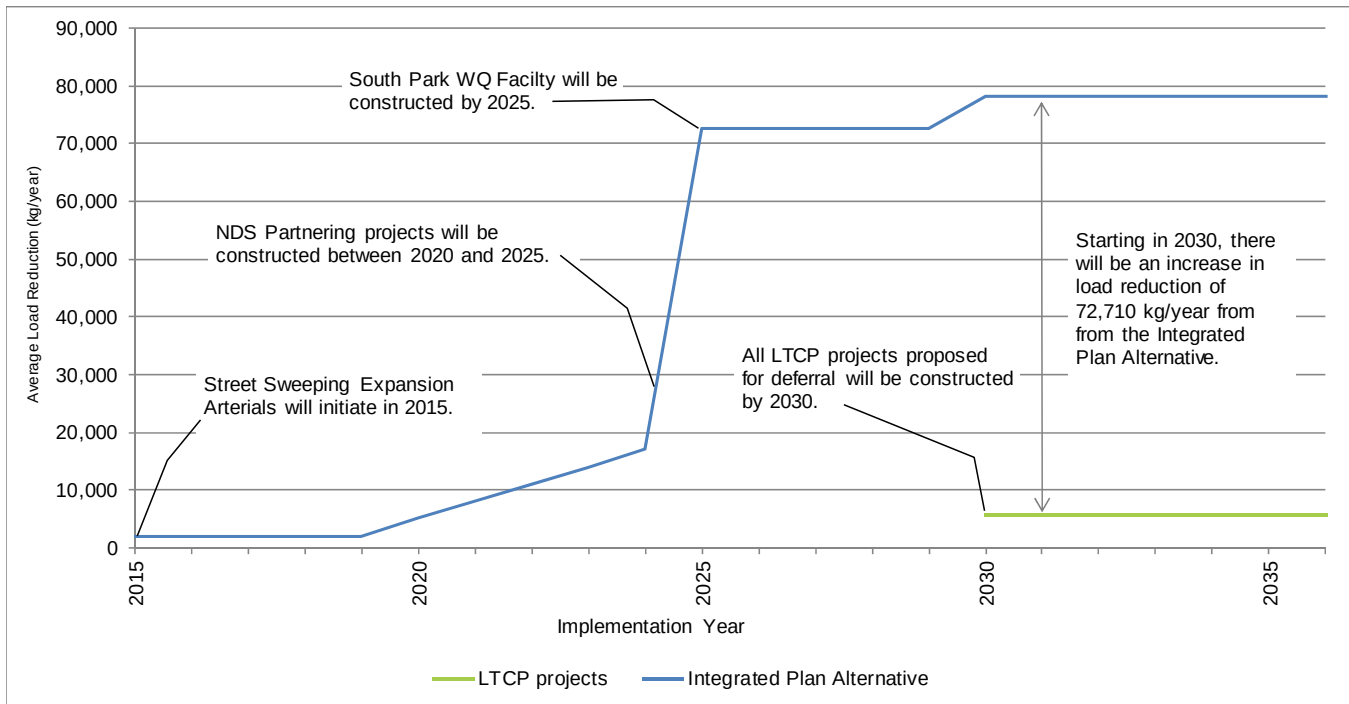


Figure 8-9. Cumulative water quality benefits of the Integrated Plan: fecal coliform load reduction

Under the Integrated Plan, both the stormwater projects and the deferred LTCP projects would reduce pollutant loads to water bodies listed as impaired, water bodies with contaminated sediments, water bodies with spawning grounds, and water bodies where listed species may be present (see Table 8-7). However, the deferred LTCP projects would benefit only the Duwamish Waterway and the Ship Canal while the stormwater projects would benefit additional water bodies throughout the city.

8.4.3.2 Exposure Reduction Benefits

The Integrated Plan would reduce pollutant exposures for human and ecological receptors beyond the reductions that would occur due to the deferred LTCP projects alone. The reduced exposures would result from reductions in the following four factors:

- pollutant loads
- discharge frequency
- discharges when human and ecological receptors are more likely to be present
- geomorphically significant flows to creeks

The following paragraphs discuss each factor.

Pollutant Loads

The Integrated Plan would result in substantially larger reductions in pollutant loads than the LTCP projects alone. These large reductions in loads should bring large reductions in pollutant exposures for human and ecological receptors, including threatened or endangered species.

The exposure assessment (Section 7.4) indicated that PCBs were by far the most important driver for human-toxics EIVs at all locations, as well as an important contributor to ecological EIVs at several locations. PCBs are also a key concern with regard to recontamination of sediments in the Duwamish Waterway. As shown in Figure 8-6 above, the Integrated Plan stormwater projects would result in PCB load reductions more than 20 times larger than the deferred LTCP projects. Human and ecological exposure to PCBs will be further reduced after the deferred LTCP projects are completed in 2028–30.

Human exposure to fecal pathogens is a key concern for CSOs as well as stormwater discharges. The Integrated Plan stormwater projects would result in fecal coliform load reductions more than 10 times greater than the deferred LTCP projects (see Figure 8-6 above). After the deferred LTCP projects are completed in 2028–30, fecal coliform loads and potential exposure will be further reduced.

The exposure assessment indicated that phosphorus, copper, and zinc were important contributors to the ecological EIVs, while dichlobenil, bis(2-ethylhexyl)phthalate, and ammonia-N also contributed to the EIVs. Figure 8-6 shows that the Integrated Plan stormwater projects should provide 10 to 100 times the deferred LTCP load reductions for all of those pollutants except ammonia-N.

As noted in Table 8-7, due to its relatively large load reductions for PCBs and other key pollutants, the human and ecological EIVs for the South Park WQ Facility project are far higher (better) than the EIVs for any of the deferred LTCP projects. The human-fecal coliform and ecological EIVs for the NDS Partnering project are higher than the respective EIVs for the deferred LTCP projects. Although EIVs were not calculated for the candidate street sweeping programs, the pollutant load modeling results suggest that the Street Sweeping Expansion Arterials program would provide substantial reductions in human exposure to toxics and ecological exposure to nutrients and toxics as compared to the candidate LTCP projects. The exposure reduction benefits of the Integrated Plan will increase when the deferred LTCP projects are completed in 2028–30.

Discharge Frequency

The Integrated Plan stormwater projects would treat discharges that are far more frequent than the existing discharges from the deferred LTCP projects. As noted in Table 8-7, the stormwater projects would treat more than 100 runoff events in an average year. The City selected the deferred LTCP projects largely because these LTCP basins are already close to meeting the one discharge per outfall per year standard. The current average discharge frequencies for the outfalls that would be controlled by the deferred LTCP projects range from 1.4 to 5 times per year. Because the stormwater discharges are much more frequent, they are more likely to affect human and ecological receptors.

Discharge Timing

The stormwater projects would treat flows that occur during much of the year. The deferred LTCP projects would control CSOs that discharge primarily during October through January. As shown in Figure 8-10, human and ecological receptors are less likely to be present in the affected receiving water bodies during the peak CSO discharge season. Therefore, the Integrated Plan should reduce exposures beyond the reductions that would be achieved by the deferred LTCP projects alone.

Geomorphically Significant Flows

The Integrated Plan includes the NDS Partnering project, which will increase stormwater infiltration and reduce direct stormwater discharges to Piper's, Thornton, and Longfellow creeks in addition to providing water quality benefits. Initial modeling indicates that NDS Partnering would reduce stormwater discharges in the Piper's, Thornton, and Longfellow basins by about 3, 12, and 2 MG/yr, respectively. These flow reductions should

incrementally reduce the frequency and duration of channel-disturbing flows and could increase base flows in the creeks.

Numerous creeks in the Puget Sound lowlands have been adversely affected by hydrologic changes associated with urban development. Urbanization involves replacing native vegetation and topsoil with impervious surfaces, which reduces infiltration and evapotranspiration, and construction of artificial drainage networks designed to quickly convey runoff to receiving water bodies. These landscape alterations can reduce base flows and increase the frequency and duration of geomorphically significant flows, stream channel erosion, down-cutting, and instability problems, particularly in small streams.

The Integrated Plan would also defer six LTCP projects that discharge directly into the Duwamish Waterway and the Lake Washington Ship Canal. The small flow reductions resulting from the deferred LTCP projects are unlikely to affect channel morphology or physical habitat conditions in those large water bodies.

Table 8-7. Summary of Stormwater and LTCP Projects Included in the Integrated Plan

Project	Receiving water body	Receiving water conditions				Average existing discharge frequency (average events/yr) ^{a,b}	Average volume treated or removed (MG/yr) ^c	Exposure index value		
		303(d)/impairments	Contaminated sediments	Spawning grounds	T&E species			Human EIV: toxics (chronic)	Human EIV: fecal coliform (acute)	Eco EIV: toxics/nutrients (chronic)
LTCP projects to be completed during 2028–30										
CSO Outfall 99	West Waterway of the Duwamish River	✓	✓		✓	1.5	0.17	0.39	0.18	0.0057
CSO Outfall 107	East Waterway of the Duwamish River	✓	✓		✓	4.6	1.1	13	1.3	0.35
CSO Outfall 111	Duwamish River	✓	✓		✓	1.7	0.01	0.16	0.019	0.0038
CSO Outfall 138	Portage Bay					1.4	0.09	0.13	2.0	0.039
CSO Outfall 139	Portage Bay	✓	✓		✓	1.2	0.01	0.0061	0.093	0.0031
CSO Outfall 140	Portage Bay	✓	✓		✓	3.7	0.05	0.080	1.4	0.035
Stormwater projects/programs to be implemented by 2025										
NDS Partnering	Thornton Creek	✓			✓	119	24 (12) ^d	3.8	7.0	2.5
	Piper's Creek	✓		✓		119	6 (3) ^d	0.89	1.2	0.54
	Longfellow Creek	✓		✓		119	5 (3) ^d	0.12	0.52	0.24
South Park WQ Facility	Duwamish Waterway	✓	✓		✓	119	74	117	8.3	1.9
Street Sweeping Expansion Arterials	Multiple	✓				119	1,527	N/A ^e	N/A ^e	N/A ^e

a. For stormwater projects, the existing discharge frequency was estimated from a 10-year rainfall record from a City rain gauge, where a discharge event was any day on which precipitation depth was at least 0.03 inch. Based on flow monitoring data, a rainfall depth of 0.03 inch generates flow in the storm sewer system.

b. The existing discharge frequencies for the deferred LTCP neighborhood storage projects are those reported in the 2012 Annual CSO Report.

c. The volume removed for the deferred LTCP neighborhood storage projects is the moving 20-year average simulated volumes without climate change (scaling factor = 1).

d. Numbers in parentheses are volumes infiltrated.

e. EIVs were not calculated for street sweeping because the receptor factors are based on the outfall location, and runoff from the swept streets would enter >100 outfalls throughout the city.

Project	Receiving water body	Species or activity	January	February	March	April	May	June	July	August	September	October	November	December	P.P.
Street Sweeping Expansion Arterials	Puget Sound	Listed Salmonid Rearing													
		Listed Salmonid Adult Migration													
		Listed Rockfish Rearing													
		Listed Rockfish Adult Migration													
		Listed Birds Rearing													
		Listed Birds Adult Migration/Foraging													
		Listed Mammals Adult Migration													
		Listed Mammals Rearing													
		NL Salmonid Rearing													
		NL Salmonid Adult Migration													
		Swimming/Wading													
		Kayaking/Paddle Boarding													
		Shellfishing													
		Fishing													
Street Sweeping Expansion Arterials	Elliot Bay	Listed Salmonid Rearing													
		Listed Salmonid Adult Migration													
		Listed Rockfish Rearing													
		Listed Rockfish Adult Migration													
		Listed Birds Rearing													
		Listed Birds Adult Migration/Foraging													
		Listed Mammals Adult Migration													
		Listed Mammals Rearing													
		NL Salmonid Rearing													
		NL Salmonid Adult Migration													
		Swimming/Wading													
		Kayaking/Paddle Boarding													
		Shellfishing													
		Fishing													
South Park WQ Facility Street Sweeping Expansion Arterials NPDES 99 NPDES 107 NPDES 111	Lower Duwamish Waterway	Listed Salmonid Rearing													
		Listed Salmonid Adult Migration													
		NL Salmonid Rearing													
		NL Salmonid Adult Migration													
		Swimming/Wading													
		Kayaking/Paddle Boarding													
		Shellfishing													
		Fishing													
															X
															X
Street Sweeping Expansion Arterials	Lake Washington	Listed Salmonid Rearing													
		Listed Salmonid Adult Migration													
		NL Salmonid Rearing													
		NL Salmonid Adult Migration													
		Listed Birds Rearing													
		Listed Birds Adult Migration/Foraging													
		Swimming/Wading													
		Kayaking/Paddle Boarding													
		Fishing													
															X
Street Sweeping Expansion Arterials NPDES 138 NPDES 139 NPDES 140	Lake Washington Ship Canal/Lake Union	Listed Salmonid Rearing													
		Listed Salmonid Adult Migration													
		NL Salmonid Rearing													
		NL Salmonid Adult Migration													
		Swimming/Wading													
		Kayaking/Paddle Boarding													
		Fishing													
NDS Partnering Street Sweeping Expansion Arterials	Longfellow Creek	NL Salmonid Rearing													
		NL Salmonid Adult Migration													
		NL Salmonid Spawning													X
		Swimming/Wading													
NDS Partnering Street Sweeping Expansion Arterials	Pipers Creek	NL Salmonid Rearing													
		NL Salmonid Adult Migration													
		NL Salmonid Spawning													X
		Swimming/Wading													X
NDS Partnering Street Sweeping Expansion Arterials	Thornton Creek	NL Salmonid Rearing													
		NL Salmonid Adult Migration													
		NL Salmonid Spawning													
		Swimming/Wading													
		Fishing													

Species are lumped together in listed or non-listed groups. Some or all of the species may be observed in the receiving waters at any given time.

Listed species may include: Salmonids: Chinook salmon, Steelhead trout, Bull trout; Rockfish: three species; Birds: Marbled murrelet; Mammals: Killer whale, Steller sea lion, Humpback whale.

Non-listed species may include: Salmonids: Coho salmon, Sockeye salmon, Chum salmon, Pink salmon, Cutthroat trout, Rainbow trout.

NL: non-listed.

P.P.: presumed present.

X: Activity or species is presumed present (P.P.) but no specific date range was available.

Thicker bar: Indicates peak timing for the species and associated life history use or human activities.

Shading: November to February is peak timing for discharges from CSO basins.

Figure 8-10. Human and ecological receptors at each discharge location

8.4.4 Cost-Benefit Analysis

This section presents the cost-benefit analysis of the Integrated Plan in accordance with the Consent Decree requirement that the plan shall include “a cost-benefit analysis for implementation of the Integrated Plan”. The City prepared this analysis consistent with generally accepted guidance applicable to the Integrated Plan, using readily available, relevant data.

A cost-benefit analysis is an analytical tool for comparing the positive and negative effects of a proposed action on the value of goods and services available to society for other uses. A cost is a reduction in value; a benefit is an increase in value. Either may involve a change (decrease or increase, respectively) in the supply of a good or service, a change in its per-unit value, or both.

This analysis compares two scenarios. One describes what the conditions are expected to be with the implementation of the Integrated Plan. The other, the baseline scenario, reflects what the conditions are expected to be without it. The difference between the two provides the basis for identifying the costs and benefits attributable solely to the Integrated Plan. For the purposes of this analysis, the baseline scenario is defined as construction by 2025 of the six LTCP projects summarized in Table 8-5 above. The Integrated Plan scenario consists of implementing the three stormwater projects listed in Table 8-5 by 2025 and completing the six deferred LTCP projects by 2030.

The comparison of the two scenarios considers both the costs and benefits that would accrue to the City through its implementation of the Integrated Plan, and the external costs and benefits that would accrue to others. Readily available data were sufficient to estimate, in monetary terms, the City's costs to implement the Integrated Plan. For other costs and all the benefits, the City determined that the available information is not sufficiently robust and reliable to support a monetized description. In some instances suitable information was available to describe costs and benefits quantitatively.

8.4.4.1 Costs

The City developed planning-level cost estimates for the selected projects. The estimates for the selected stormwater projects are based on the conceptual designs contained in Appendix J. Estimates for the LTCP projects selected for deferral are described in the LTCP.

Table 8-8 lists the City's estimated costs for the six deferred LTCP projects and the three stormwater projects that comprise the Integrated Plan. The costs are expressed in present-value terms. In each case, the present value is a single amount that is economically equivalent to the stream of costs the City would incur over the study period. The present value is calculated through a process known as discounting, using a real (adjusted for inflation) discount rate of 3 percent per year. The City assumes a 3 percent discount rate for its CSO program.

Implementation of the Integrated Plan also may result in external costs, such as traffic delays associated with street sweeping. Insufficient information currently exists to quantify or monetize the external costs. Therefore, external costs were considered qualitatively in the MODA.

Table 8-8. Estimated Costs for the Integrated Plan Projects

Project name	Capital	O&M ^a	Total
LTCP projects to be completed during 2028-30^b			
CSO Outfall 99	\$5.5	\$2.7	\$8.2
CSO Outfall 107	\$21.4	\$2.8	\$24.2
CSO Outfall 111	\$3.7	\$3.6	\$7.3
CSO Outfall 138	\$5.9	\$1.6	\$7.5
CSO Outfall 139	\$1.2	\$0.7	\$1.9
CSO Outfall 140	\$2.7	\$1.7	\$4.4
Stormwater projects/programs to be implemented by 2025			
NDS Partnering	\$24.5	\$2.8	\$27.2
South Park WQ Facility	\$24.3	\$10.5	\$34.8
Street Sweeping Expansion Arterials	\$0.6	\$25.5	\$26.1

a. Present value costs in 2014 dollars (in \$ million over 100 years at 3%).

8.4.4.2 Benefits

The primary benefit of the Integrated Plan projects/program includes not only the significant improvement in water quality, relative to what would occur under the LTCP, but also the time frame in which these benefits would occur. Benefits would be seen sooner because of the advancing of the Integrated Plan water quality improvement projects. The approach to illustrating water quality benefits was to quantify and compare the reduction in the discharge of those pollutants that impact the established human and environmental beneficial uses and the reduction in human and environmental exposure risk. Section 8.4.3 above summarizes the expected water quality benefits of the Integrated Plan relative to the LTCP.

The City has determined that insufficient information exists to monetize the increased value of goods and services that will result from the significant improvements in water quality, but sufficient information exists to quantify some of them in non-monetary terms. The water quality improvements are expected to result in increased value for numerous goods and services associated with an improved aquatic environment, such as better fish habitat, larger fish populations, improved water-related recreation, and reduced water-related illnesses for exposed humans and animals. Other benefits of the Integrated Plan include enhanced protection of sediment cleanup sites from recontamination, improved pedestrian safety and aesthetics associated with green infrastructure (i.e., NDS Partnering), and improved aesthetics due to street sweeping.

8.4.4.3 Comparison of Costs and Benefits

Table 8-9 lists the estimated costs per unit of annual pollutant reduction for the Integrated Plan stormwater projects and the deferred LTCP projects. The table shows that the stormwater projects would provide substantially greater load reductions benefits per dollar of life-cycle cost for all pollutants except ammonia-N.

Table 8-9. Pollutant Load Reduction Costs for Integrated Plan		
Pollutant	Stormwater projects (\$/kg load reduction/yr)	Deferred LTCP projects (\$/kg load reduction/yr)
Ammonia-N	\$304,598	\$80,777
BOD	\$1,322	\$16,041
Bis(2-ethylhexyl)phthalate	\$4,327,907	\$45,074,610
Dichlobenil	\$584,610,939	\$3,919,536,310
Dissolved copper	\$2,390,588	\$50,412,115
Dissolved zinc	\$161,791	\$10,600,399
Fecal coliform	\$38	\$302
H+	\$190,869,894	\$2,679,223,587
Oil and grease	\$2,389	\$90,271
PBDEs	\$162,279,211	\$5,221,649,390
PCBs	\$231,842,571	\$3,221,987,276
Phosphorus	\$33,434	\$230,839
Total copper	\$254,900	\$7,129,600
TSS	\$41	\$3,160
Total zinc	\$55,150	\$2,706,974

Although the Integrated Plan stormwater projects would be very cost-effective relative to the deferred LTCP projects, the City's overall costs would be higher under the Integrated Plan. The Integrated Plan costs would be higher because the stormwater projects would be completed in addition to the deferred and the non-deferred LTCP projects. Nevertheless, the City has concluded that the additional benefits resulting from the Integrated Plan outweigh the additional costs. The City reached this conclusion based on the results of the MODA process described in Section 8.3. This process weighed the costs and benefits using expert opinion and considering all available information, and concluded that the benefits would outweigh the costs. Relying on MODA to complete the comparison of costs and benefits was necessitated because insufficient information exists to support a monetized, quantitative comparison. The City frequently relies on the MODA process to conduct a cost-benefit analysis of investment decisions that considers contributions to positive environmental outcomes, social good for the community, and the City's financial strength.

8.4.5 Compliance Assurance

The Consent Decree allows the City to develop an Integrated Plan as an alternative to the LTCP. An approved Integrated Plan would allow the City to defer implementation of selected LTCP projects and implement stormwater projects that would provide significant benefits to water quality beyond those that would be achieved by implementing the LTCP projects alone. This language indicates that the “significant benefits” of the stormwater projects should be determined relative to the deferred LTCP projects. Therefore, the City compared the candidate LTCP and stormwater projects in terms of pollutant load reductions and other factors relevant to water quality benefits. The City selected three stormwater projects that would meet the “significant benefits” criterion by providing the following benefits:

- substantially larger pollutant load reductions than the six LTCP projects proposed for deferral
- substantially greater long-term environmental benefits than the LTCP projects alone, because the deferred LTCP projects will be operational by 2030 and add to the water quality benefits of the stormwater projects
- greater reductions in pollutant loads to water bodies with impairments and special circumstances compared to the LTCP projects proposed for deferral
- greater reductions in discharges of PCBs and other toxic organic compounds to the Duwamish Waterway, where sediments are listed under CERCLA and MTCA, compared to the LTCP projects proposed for deferral
- reductions in pollutant loads to a number of water bodies, such as Piper’s Creek, Thornton Creek, and Elliott Bay, that would not benefit from the LTCP projects
- reductions in geomorphically significant flows to Piper’s, Thornton, and Longfellow creeks, which will help to protect spawning grounds and improve aquatic habitat in these water bodies

Although the City used the best available data and robust evaluation methods to estimate pollutant load reductions for the LTCP and stormwater projects, the City recognizes that there is uncertainty associated with the estimates. Figures 8-11 through 8-16 below show the upper and lower confidence limits for the proposed stormwater projects. As shown in these figures, the lower confidence limits (LCLs) for the stormwater projects are much higher than the upper confidence limits (UCLs) for the deferred LTCP projects. Moreover, the stormwater load reductions will continue for many years after the deferred LTCP projects have been completed. The figures show that the proposed stormwater projects clearly meet the “significant benefit” criterion of the Consent Decree.

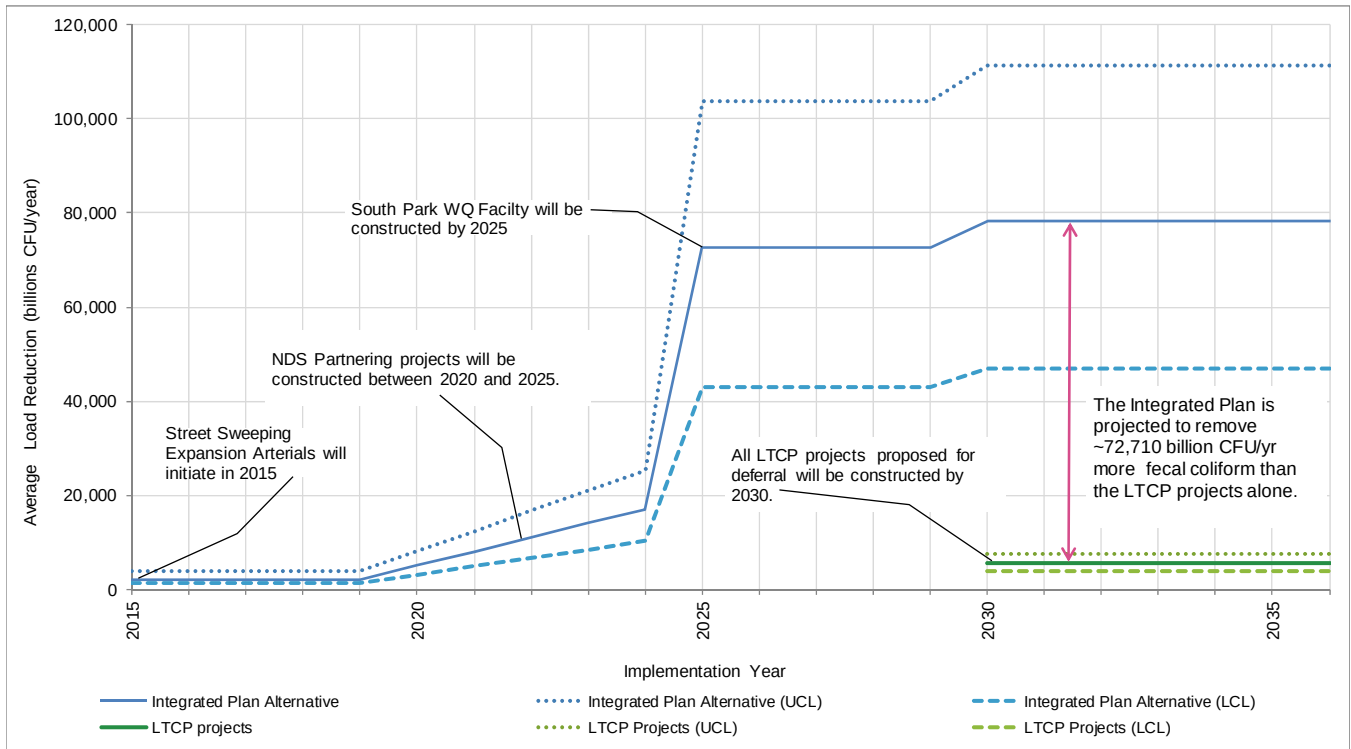


Figure 8-11. Estimated fecal coliform load reduction benefits of the Integrated Plan

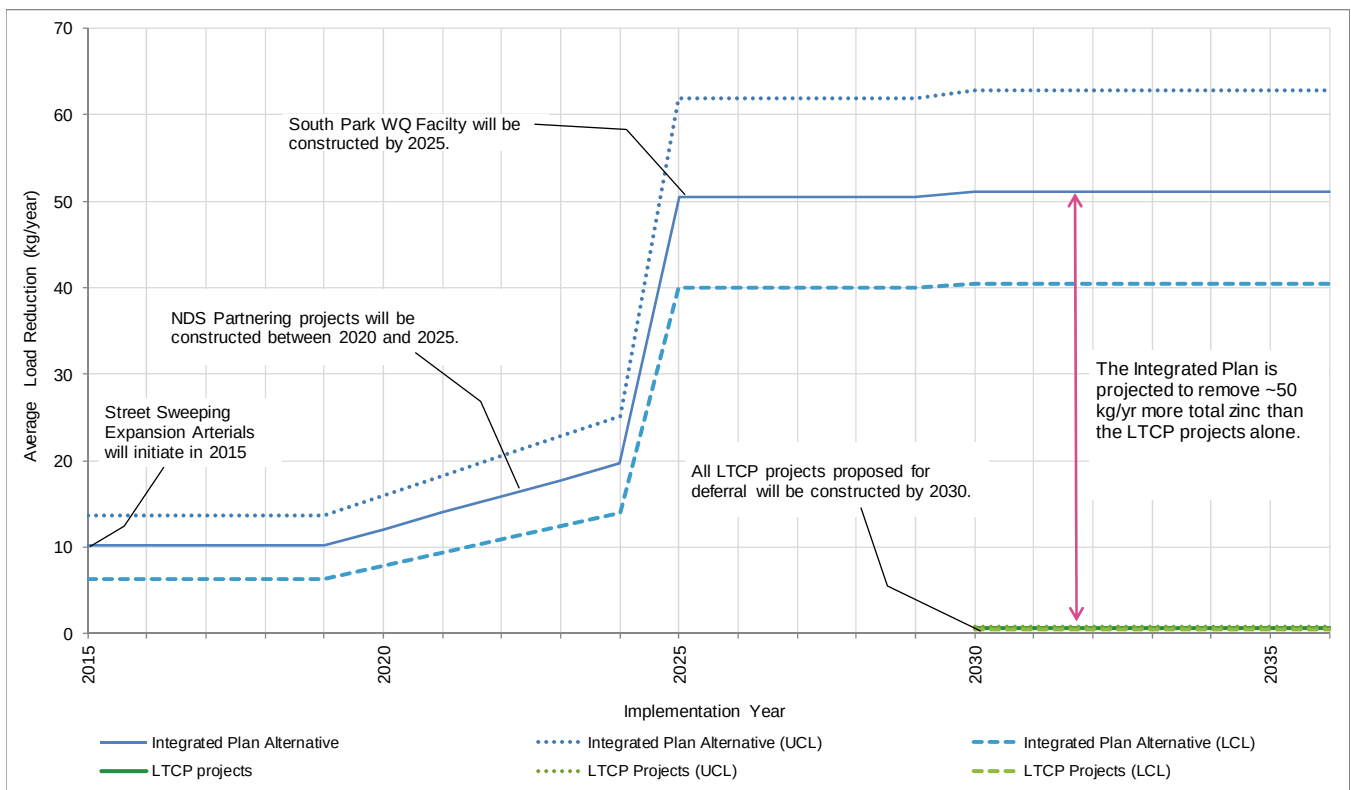


Figure 8-12. Estimated total zinc load reduction benefits of the Integrated Plan

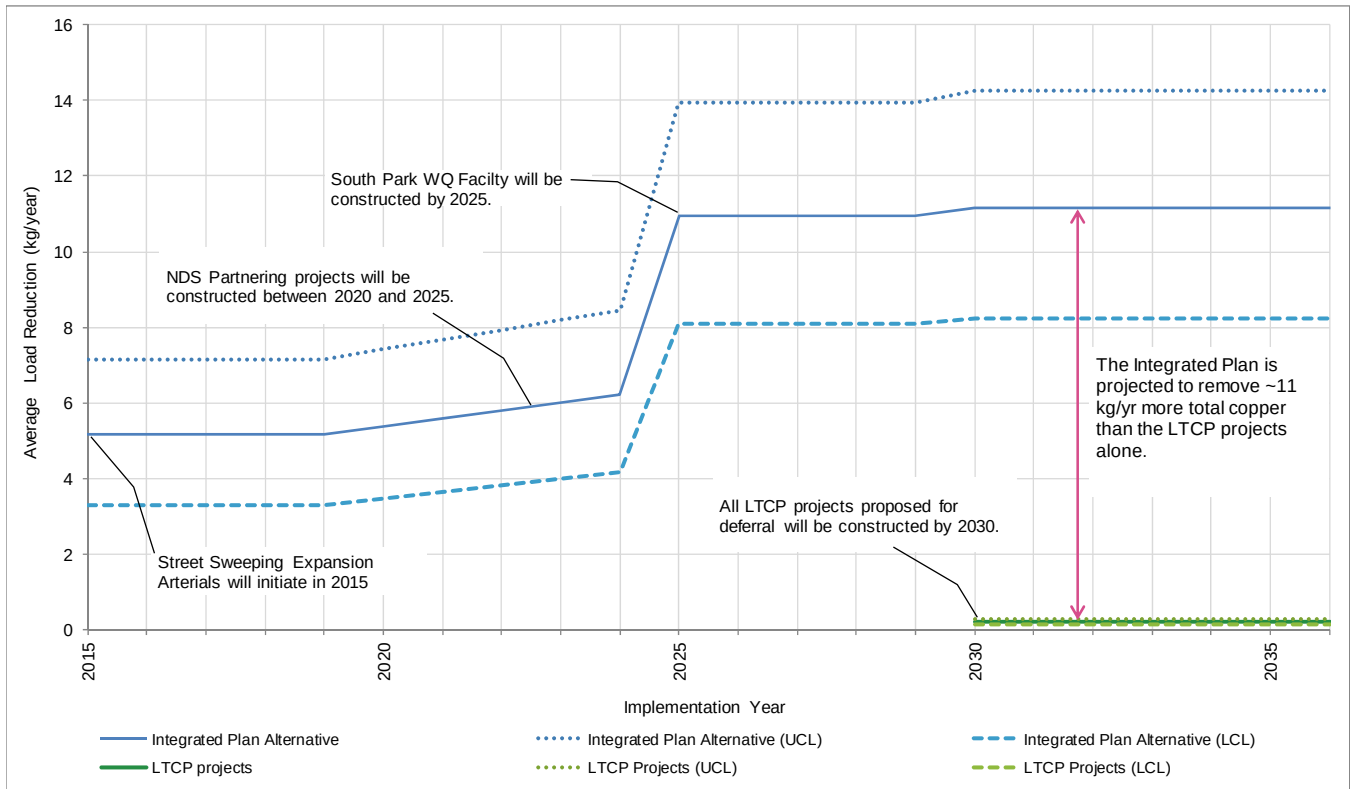


Figure 8-13. Estimated total copper load reduction benefits of the Integrated Plan

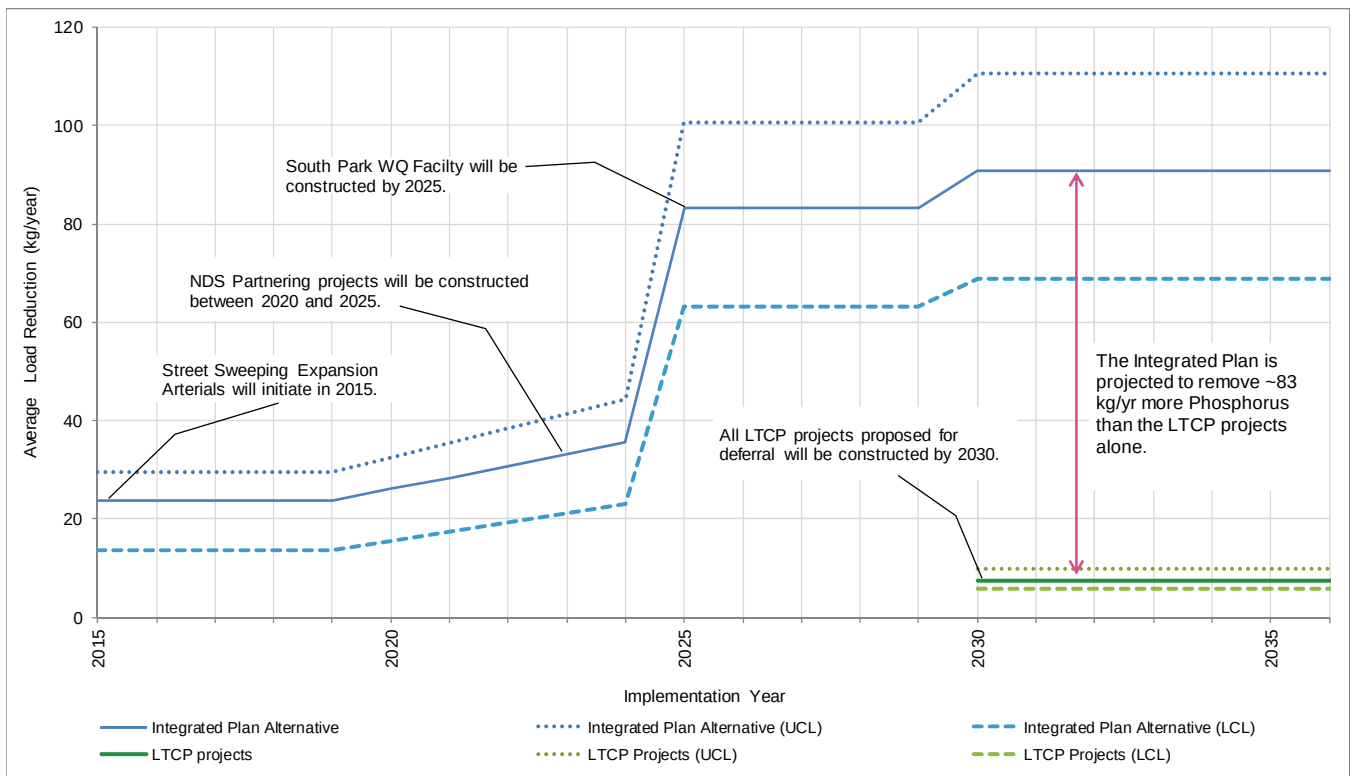


Figure 8-14. Estimated phosphorus load reduction benefits of the Integrated Plan

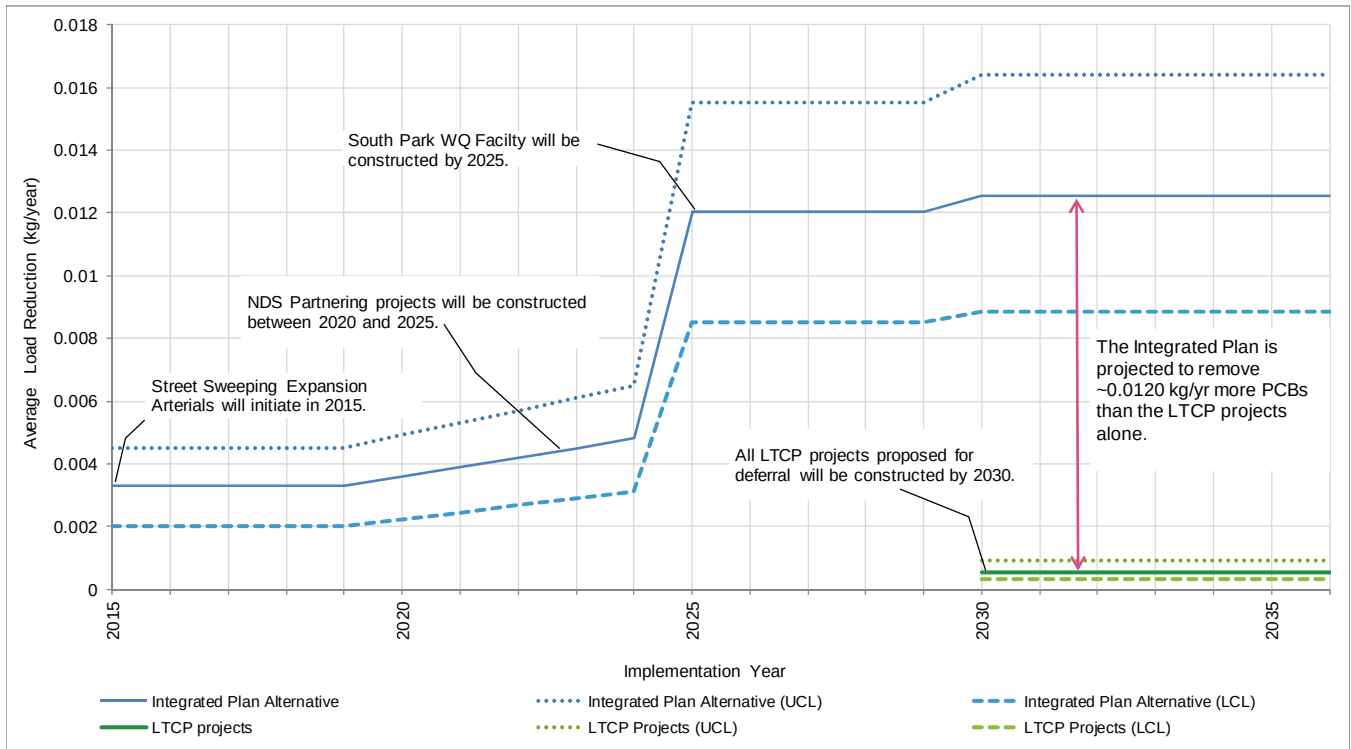


Figure 8-15. Estimated PCB load reduction benefits of the Integrated Plan

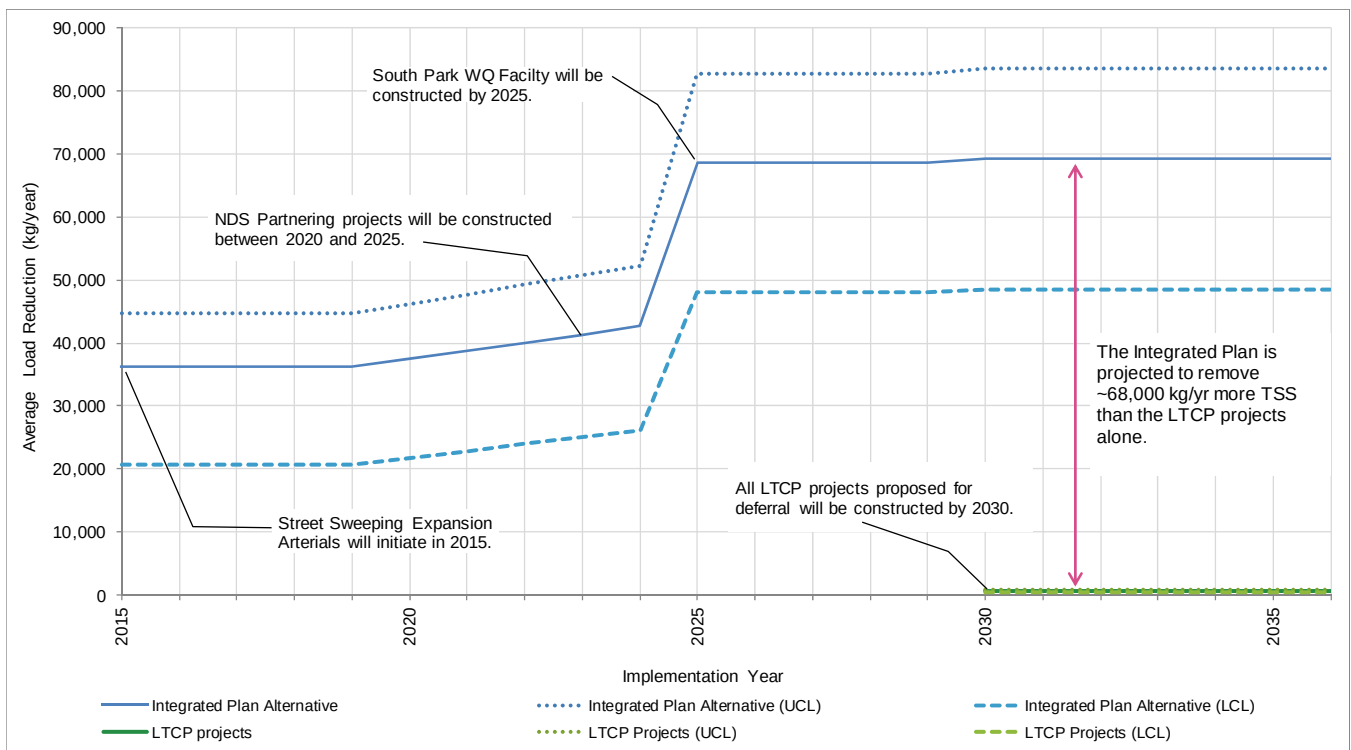


Figure 8-16. Estimated TSS load reduction benefits of the Integrated Plan

The City proposes to set a performance goal for measuring the success of the Integrated Plan stormwater projects. The performance goal is based on the LCLs for the estimated fecal coliform, total zinc, total copper, phosphorus, PCB, and TSS load reductions. TSS was selected because it is commonly used to measure stormwater project performance. The other pollutants were selected based on the exposure assessment performed for the Integrated Plan.

The individual stormwater projects will be monitored as described in Chapter 10 of this plan and summarized below:

- The Street Sweeping Expansion Arterials project monitoring will consist of measuring the curb-miles swept and the dry tons of material removed. The monitoring data will be used to calculate pollutant load removals using the City's existing robust data set collected by the Seattle street sweeping program over the past 2 years.
- The NDS Partnering project monitoring will involve monitoring flow and water quality at representative swales in each of the basins (Thornton, Piper's, and Longfellow creeks). At each representative swale the City will measure inflow and bypass flow (and underdrain flow if present). The City will also collect samples of inflow and outflow (and underdrain flow if present) for RCOC analysis. The flow and water quality measurements will be used to calculate pollutant load reductions for each of the monitored NDS facilities. The City will extrapolate these results to the rest of the NDS Partnering project swales using flow simulations from hydrologic models, which will be developed during facility design and calibrated based on flow data collected at the representative swales.
- The South Park WQ Facility project monitoring will involve measuring the volume of stormwater managed by the project. These data will be used to re-calculate the pollutant load removals.

Following completion of all post-construction monitoring for the three stormwater projects/programs, the City will evaluate the monitoring results in light of the performance goal, as described in Chapter 10. The City will report the results to EPA and Ecology and if necessary develop a Supplemental Compliance Plan as described in Appendix C, Section D, Paragraph 2 of the Consent Decree.

CHAPTER 9

Implementation Schedule

Table 9-1 presents the implementation schedule for the Integrated Plan.

Table 9-1. Implementation Schedule

Project name	Draft engineering report	Final engineering report	Draft plans and specs	Final plans and specs	Construction start	Construction completion/ project completion ^a	Achieve controlled status/ post-construction monitoring completed ^b
LTCP projects to be completed during 2028-30							
CSO Outfall 99	6/30/2017	12/31/2026	6/30/2018	12/31/2027	7/1/2028	9/30/2030	3/31/2031
CSO Outfall 107	6/30/2017	12/31/2024	6/30/2019	12/31/2026	7/1/2027	9/30/2030	3/31/2031
CSO Outfall 111	6/30/2021	12/31/2026	6/30/2022	12/31/2027	7/1/2028	9/30/2030	3/31/2031
CSO Outfall 138	6/30/2016	12/31/2026	6/30/2017	12/31/2027	7/1/2028	9/30/2030	3/31/2031
CSO Outfall 139	6/30/2016	12/31/2026	6/30/2017	12/31/2027	7/1/2028	9/30/2030	3/31/2031
CSO Outfall 140	6/30/2016	12/31/2026	6/30/2017	12/31/2027	7/1/2028	9/30/2030	3/31/2031
Stormwater projects/programs to be implemented by 2025							
NDS Partnering	NA	NA	NA	NA	7/17/2019	12/28/2025	9/30/2029
South Park WQ Facility	NA	NA	NA	NA	12/31/2023	12/31/2025	9/30/2028
Street Sweeping Expansion Arterials	NA	NA	NA	NA	2015 ^c	N/A	9/30/2019

a. "Construction Completion" dates apply to the LTCP projects and that "Project Completion" dates apply to the Stormwater projects/programs.

b. "Achieve Controlled Status" dates apply to the LTCP projects and that "Post-Construction Monitoring Completed" dates apply to the Stormwater projects/programs.

c. The "Construction Start" for Street Sweeping Expansion Arterials is the notice to proceed date for SDOT to initiate the program.

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CHAPTER 10

Post-Construction Monitoring Plan

This chapter discusses the methods SPU will use to perform post-construction monitoring of the three stormwater projects included in the Integrated Plan.

10.1 Introduction

In accordance with the Consent Decree, the City will conduct post-construction monitoring of the Integrated Plan stormwater projects to assess whether their anticipated water quality benefits have been achieved.

As discussed in Chapter 8, the pollutant load modeling performed for this Integrated Plan indicates that the stormwater projects should provide substantially greater load reductions for key pollutants than the deferred CSO projects. The City used the pollutant loads modeling results to establish performance goals for the Integrated Plan stormwater projects. The performance goals are listed in Table 10-1. The goals are based on the LCLs for the estimated load reductions for fecal coliform, PCBs, total phosphorus, total copper, TSS, and total zinc. TSS was selected because it is commonly used as a general indicator of stormwater project performance. Fecal coliform, PCBs, total phosphorus, total copper, and total zinc were selected because they were identified as important parameters by the exposure assessment performed for the Integrated Plan. As noted in Section 8.4.5 above, the stormwater project LCLs for these pollutants are considerably higher than the UCLs for the six LTCP projects to be deferred.

Table 10-1. Integrated Plan Performance Monitoring Goals

Project name	Average volume treated or removed (MG/yr)	Fecal coliform bacteria (billion CFU/yr) ^a	PCBs (g/yr) ^a	Total phosphorus (kg/yr) ^a	Total copper (kg/yr) ^a	TSS (kg/yr) ^a	Total zinc (kg/yr) ^a
NDS Partnering	32 ^a	10,649	1.3	11	1.1	6,478	9.2
South Park WQ Facility	67 ^a	31,000	5.2	38	3.8	20,935	25
Street Sweeping Expansion Arterials	1,477 ^{a,b}	1,380	2.0	14	3.3	20,700	6.3
Total	1,576	43,029	8.5	63	8.1	48,113	40

a. These values represent the 95% lower confidence limits (LCL) from the pollutant load model (PLM) results.

b. Volume of runoff from swept streets.

The City will monitor the influent and effluent concentrations and volumes of the stormwater managed by the NDS Partnering Project and the South Park Water Quality Facility for 2 years after these projects become operational. Similarly, the City will monitor the mass of material collected data during the first 2 years of its expanded arterial street sweeping program. After monitoring has been completed for all three projects, the results will be used to calculate the total pollutant load reductions for the three projects combined and compared to the total load reduction goals listed in Table 10-1 above.

Chapter 9 contains the implementation schedules for the three stormwater projects. Table 10-2 summarizes the proposed post-construction monitoring schedule for each project. Sections 10.2, 10.3, and 10.4, respectively, describe the monitoring methods for the NDS Partnering, South Park Water Quality Facility, and Street Sweeping Expansion Arterials projects. Section 10.5 describes how the post-construction monitoring data will be evaluated against the Integrated Plan performance targets and how the findings will be reported. Appendix J provides additional details for each project, including the estimated long-term average pollutant load reductions for the constituents included in the post-construction monitoring program.

Table 10-2. Proposed Integrated Plan Stormwater Projects Monitoring Summary				
Project name	Construction completed (year) ^a	Post-construction monitoring completed (year)	Water years of monitoring	Facilities to be monitored
NDS Partnering ^b	2025	2029	2 per facility	2/watershed; 6 total
South Park WQ Facility	2025	2028	2	1
Street Sweeping Expansion Arterials	2016 ^c	2019	2	2 ^d

a. SPU will submit monitoring Quality Assurance Project Plans (QAPP) for Ecology review for each project prior to construction completion.

b. NDS Partnering monitoring will begin 1 full year following construction completion in each basin.

c. Start of Street Sweeping Expansion Arterials program.

d. Street sweepings collected across Seattle are deposited at two collection facilities depending on the area where they are collected.

10.2 NDS Partnering

This section provides an overview and monitoring summary of the NDS Partnering project.

10.2.1 Overview

The NDS Partnering project will use bioretention in the form of engineered rain gardens to manage stormwater in the basins that drain to Longfellow, Piper's, and Thornton creeks. The NDS facilities will be small distributed bioretention cells designed to capture and treat stormwater from a street block or set of street blocks. Two types of rain gardens will be constructed: (1) shallow infiltration rain gardens with no underdrains and (2) rain gardens with underdrains (perforated pipes) to collect stormwater that passes through the bioretention media but does not infiltrate in an acceptable time frame. The underdrains will collect the portion of the treated stormwater that does not infiltrate and convey it to a City stormwater conveyance system or UIC structure. The remainder of the treated stormwater (assumed to be less than 80 percent of the inflow volume) will be infiltrated as the soil and other conditions allow. Collectively, the NDS facilities will be designed to allow for 50 percent of the captured volume to be infiltrated into native soils while the remaining 50 percent will be discharged after treatment via an underdrain. Hydrologic models will be used to size the facilities based on basin characteristics.

For the purposes of monitoring, an NDS bioretention "facility" is defined as a contiguous rain garden (which may consist of several individual cells) on one side of a project street block.

10.2.2 Monitoring Summary

The monitoring approach for the NDS Partnering bioretention facilities will involve the four steps described below.

Step 1: Monitor Flow. In each of the three watersheds, the City will monitor two NDS bioretention facilities, one without an underdrain and a second with or without an underdrain, depending on the final design and relative number of each type of facility constructed in each basin. (Note that underdrains may not be installed in all of the basins or only in limited cases). Thus, a total of six NDS facilities will be monitored.

The NDS facilities to be monitored will be designed to have a single inflow location, if feasible. If this is not feasible (i.e., the NDS facility requires multiple inflow points), one representative inlet may be used as a surrogate for all of the influent stormwater. The runoff volume entering each facility will be monitored by level sensors and data loggers upstream or at the inlet(s) to each facility.

Overflow volumes will be measured at the overflow out of a facility (if present) or downstream curb cuts (if acting as an overflow structure). Bypass flows will be measured at the point where any runoff externally that bypasses the NDS facility inlets discharges back into the stormwater conveyance system via a roadway storm drain inlet.

For monitored facilities with underdrains, the underdrain flow will be measured by level sensors and volumetric weirs installed at the point where the underdrains discharge back into the local stormwater conveyance system (or other suitable location). The type and location of the monitoring instrumentation will be dependent on the configuration of the facility and the corresponding conveyance system. The flow measurements will be continuous over the 2 years each facility is monitored.

Step 2: Monitor Water Quality. Flow-proportioned composite and discrete, instantaneous grab samples will be collected on untreated influent (roadway runoff) and treated effluent (underdrain flow). Automatic water quality samplers will be paced by the flow monitoring equipment to collect flow-proportioned sample aliquots throughout the duration of each event monitored. The aliquots will be combined for analysis (flow-weighted composite sample). Influent and effluent grab samples (for bacteria analysis) will be collected once during each event. Six influent/effluent sample pairs will be collected each year for a sample total of 12 sample pairs per each facility monitored over 2 full water years of monitoring.

Table 10-3 lists the storm event criteria for storm event parameters and sampling goals for the NDS Partnering project. Storm events of various sizes and antecedent conditions will be targeted.

Table 10-3. NDS Partnering Storm Event and Sampling Criteria

Criterion	Requirement
Target storm depth	A minimum of 0.15 inch of precipitation over a 24-hour period
Rainfall duration	Target storms must have a duration of at least 1 hour
Antecedent dry period	A period of at least 6 hours preceding the event with less than 0.04 inch of precipitation
Storm capture coverage	75% (for storms longer than 24 hours, 75% of first 24 hours)
End of storm	A continuous 6-hour period with less than 0.04 inch of precipitation

Table 10-4 lists the water quality parameters to be sampled and sample collection methods to be used for the NDS Partnering project.

Table 10-4. Water Quality Parameters and Sample Collection Method	
Parameter	Collection method
PCBs	Composite
Total phosphorus	Composite
Total copper and zinc	Composite
TSS	Composite
Fecal coliform	Grab

Step 3: Model Flow Volumes. The 2 years of continuous monitored flow data will be used to calibrate the hydrologic models (e.g., HSPF or EPA SWMM) that the City developed to design each of the NDS facilities. The calibrated models will be used to estimate the flows managed by the NDS facilities that were not directly monitored for 2 years after construction. Volumes will be aggregated across all the facilities in each basin to generate the total flow volume managed by the NDS facilities within each basin.

Step 4: Calculate Pollutant Load Reductions. Data from Step 2 will be averaged across the two monitored facilities in each basin to generate mean influent and treated effluent concentrations, which will be used to represent concentrations for all of the NDS facilities within each respective basin. These concentrations will be multiplied by the volumes from Step 3 to generate pollutant load reduction estimates for each basin per year. Pollutant load reductions will be summed across basins to generate a total NDS project pollutant load reduction estimate for each of the 2 years monitored. The load reductions will be averaged over the 2 years to generate the average annual pollutant load removed by the project and used to evaluate performance as discussed in Section 10.5 below.

10.3 South Park WQ Facility

This section provides an overview and monitoring summary of the South Park WQ Facility project.

10.3.1 Overview

The South Park WQ facility will be a basic, active treatment system, such as a CESF system. The specific treatment technology will be selected and designed after the Integrated Plan has been approved by EPA and Ecology. The treatment facility will have built-in flow monitors; inline sensors to measure parameters such as turbidity, conductivity, and pH; and water quality sample collection ports. The South Park WQ facility will treat the stormwater but will not reduce flow volume, so inflow volume will equal outflow volume. These factors will simplify water quality monitoring and load reduction calculation.

10.3.2 Monitoring Summary

The monitoring approach for the South Park WQ facility will consist of the four steps described below.

Step 1: Monitor Flow. The total flow volume treated by the facility will be measured by built-in, in-line flow monitors. Flow measurements will be continuous over a 2-year period.

Step 2: Monitor Water Quality. Flow-proportioned composite and discrete, instantaneous grab stormwater samples will be collected on untreated stormwater influent and treated effluent. Automatic water quality samplers will be paced by in-line flow monitoring equipment to collect one flow-proportioned influent and one effluent composite sample per event. Influent and effluent grab samples will be collected once during each event monitored. Paired influent and effluent samples from six stormwater events per water year will be sampled per year for a total 12 pair samples over 2 years of monitoring.

Table 10-5 lists the storm event criteria and sampling goals for the South Park WQ facility. Storm events of various sizes and antecedent conditions will be targeted.

Table 10-5. South Park WQ Facility Storm Event and Sampling Criteria	
Criterion	Requirement
Target storm rainfall amount	A minimum of 0.15 inch of precipitation over a 24-hour period
Rainfall duration	Storms must have a duration of at least 1 hour
Antecedent dry period	A period of at least 6 hours preceding the event with less than 0.04 inch of precipitation in total
Minimum storm capture coverage	75% (for storms longer than 24 hours, 75% of first 24 hours)
End of storm	A continuous 6-hour period with less than 0.04 inch of precipitation in total

Table 10-6 lists the water quality parameters to be sampled and sample collection methods to be used for the South Park facility.

Table 10-6. South Park WQ Facility Water Quality Parameters and Sample Collection Method	
Parameter	Collection method
PCBs	Composite
Total phosphorus	Composite
Total copper and zinc	Composite
TSS	Composite
Fecal coliform	Grab

Step 3: Calculate Pollutant Load Reduction. Water quality concentration data from Step 2 will be averaged across the monitored storms within each water year to generate one mean influent and effluent concentration for the facility for the respective water year. These mean annual concentrations will be multiplied by the annual flow volumes from Step 1 to generate pollutant load reduction estimates for each year monitored.

The project pollutant load reduction calculated above will be averaged over the 2 years of monitoring and used to evaluate performance as discussed in Section 10.5 below.

10.4 Street Sweeping Expansion Arterials

This section provides an overview and monitoring summary of the Street Sweeping Expansion Arterials project.

10.4.1 Overview

The Street Sweeping Expansion Arterials project will augment SPU's current Street Sweeping for Water Quality (SS4WQ) program by increasing the extent of arterials swept from 83 to 85 percent, increasing sweeping frequency from every 2 weeks to weekly for some routes, and extending the sweeping season from 40 to 48 weeks per year. The project goal is to sweep an additional 10,700 curb-miles of arterials per year, which is predicted to remove an additional 400 short dry tons (sdt) of sweepings material per year.

The City will perform post-construction monitoring for the Integrated Plan to quantify the pollutant load removed by the Street Sweeping Expansion Arterials program. The monitoring will compare the pollutant load reductions from the pre-Integrated Plan sweeping program (baseline) to the load reductions from the expanded (baseline plus Expansion Arterials project) sweeping program to estimate the load removed by the Expansion Arterials project only.

Street sweepings (solid material removed from roadways by sweepers) are collected by the sweepers into built-in hoppers on the sweeper equipment. The sweeper operators empty the hoppers into two temporary storage bins. Sweepings collected on arterials located in the northern portion of Seattle are emptied into a bin at the Haller Lake maintenance facility and sweepings collected on arterials in the southern portion of Seattle are emptied into a bin at the Charles Street facility. Bins are emptied periodically, at intervals ranging from 2 weeks to 2 months, and solids material is disposed of at a waste disposal facility.

The SS4WQ program has been tracking wet and dry sweepings load removed since mid-2011 and analyzing pollutant concentrations since December 2011. Analysis of the fine particulate matter (PM) fraction and additional pollutants on both the whole samples and fine PM fraction began in fall 2012. At least 2 full years of pollutant concentration data for the fine PM will be available before the program is expanded in 2016. The pre-Integrated Plan concentration and load data will be used as baseline data. The baseline load removal data will then be compared to load removal data collected after the Expansion Arterials program has been implemented in order to estimate the additional load reduction associated with the Expansion Arterials program. Table 10-7 presents the annual baseline load removed by the current (baseline) street sweeping program for fecal coliform, total zinc, total copper, PCBs, and TSS equivalent.

Table 10-7. Annual Baseline Load Removed by Current Street Sweeping Program					
Fecal coliform bacteria (billion CFU/yr)	PCBs (g/yr)	Total phosphorus (kg/yr)	Total copper (kg/yr)	Total suspended solids equivalent (washoff load) (kg/yr)	Total zinc (kg/yr)
5,700	9	60	14	90,000	28

10.4.2 Monitoring Summary

The monitoring approach for the Street Sweeping Expansion Arterials project will consist of calculating the total annual pollutant load removed by the augmented SS4WQ program after it is expanded in 2016 and subtracting the load removed by the program before it was expanded (listed in Table 10-7) to calculate the additional load removed by the Expansion Arterials project.

Specifically, the monitoring approach will consist of the following steps: (1) measuring the curb-miles swept annually for 2 water years, (2) measuring the wet solids weight of the street sweepings collected annually for 2 water years, (3) collecting 30 solids samples per year for 2 years (for a total of 60 samples) and analyzing for chemical parameters and total solids, (4) calculating the dry weight of sweepings collected using the wet solids weight and total solids concentration, and (5) using data collected in the steps above and the existing Street Sweeping Pollutant reduction model, calculating the pollutant load removed.

Step 1: Measure Curb Miles. Curb miles swept for the Street Sweeping program are calculated by an Automated Vehicle Location (AVL) system. The AVL system reports time and distance each sweeper truck travels and is sweeping using a global positioning system on each sweeper truck and monitors connected to the sweeper brooms. These data are broken down by the system software to determine the distance and time of actions performed (e.g., miles traveled, total miles swept, miles swept in an MS4 basin, miles swept in a non-MS4 or unspecified route, vehicle speed when sweeping, etc.).

Step 2: Measure Wet Solids Weight. Wet weight of sweeping will be measured when material is disposed of at the waste disposal facility using truck scale readings.

Step 3: Collect and Analyze Solids Samples. Street sweeping samples will be collected from the two bins during periods of sweeping operations (i.e., 46 to 48 weeks per year) over a 2-year period, beginning the second year of the expansion (2017). A minimum of 30 (15 from each bin) samples per year, or 60 (30 from each bin) over the 2-year monitoring period, will be collected.

Table 10-8 lists solids parameters to be analyzed on both the whole grain solids and fine PM portion of each sweepings sample and sample collection methods to be used for the Street Sweeping Expansions Arterials project.

Table 10-8. Street Sweeping Solids Parameters and Sample Collection Method	
Parameter	Collection method
PCBs	Composite
Phosphorus	Composite
Total copper and zinc	Composite
Total solids	Composite
Fecal coliform	Composite

Step 4: Calculate Dry Solids Mass. The average monthly dry solids mass of sweepings will be calculated by multiplying the average monthly wet solids mass by the corresponding monthly total solids concentration. The monthly dry solids mass will be segregated by dry and wet season and then summed to produce seasonal totals.

Step 5: Calculate Pollutant Loads Removed. The information collected in the preceding steps will be inputted into the existing Street Sweeping Pollutant reduction model (detailed in Appendix G) to calculate the total pollutant load removed by the augmented SS4WQ program over the 2 years of monitoring.

The annual baseline load for each parameter removed by the pre-Integrated Plan (baseline) Street Sweeping program (listed in Table 10-3) will be subtracted from the average annual load removed by the augmented SS4WQ program (baseline plus Expansion Arterials project) to determine the load removed by the Expansion

Arterials project only for fecal coliform, total zinc, total copper, total phosphorus, PCBs, and TSS. This pollutant load reduced by the Expansion Arterials project will be as discussed in Section 10.5 below.

10.5 Post-Construction Monitoring Reporting

The post-construction monitoring results for the three stormwater projects will be included in the CSO Reduction Program Annual Report, which will document the activities that occurred in the prior calendar year. Due to the lag time between sample collection, laboratory analysis, data delivery, data analysis, and reporting, the Annual Report will present post-construction monitoring results for the stormwater projects for the prior water year (not calendar year), which begins on October 1 and ends on September 30.

Annual pollutant load removed by each stormwater project will be presented in the annual CSO report following the end of the first water year for which data are collected for each stormwater project. However, the post-construction monitoring results will not be compared to the performance monitoring goals until monitoring has been completed for all three stormwater projects because the goals are based on the total load reductions for the three projects combined.

After all of the post-construction monitoring has been completed for the three stormwater projects, the median load reductions will be compared to the total load reduction goals listed in Table 10-1. If all of the post-construction median load reductions meet or exceed the total load reductions for all constituents listed in Table 10-1, the Integrated Plan will have clearly met the performance goals. If the post-construction monitoring results indicate that load reductions for one or more constituents were smaller than the value(s) listed in Table 10-1, the City will evaluate the cumulative load reductions for the three stormwater projects in light of the UCLs for the deferred LTCP projects. The performance goals listed in Table 10-1 are substantially higher than the corresponding UCLs for the deferred LTCP projects. Consequently, stormwater project pollutant load reductions that fall short of the goals listed in Table 10-1 could still meet the significant benefits criterion of the Consent Decree. In the event that this occurs, the City will meet with Ecology and EPA to discuss the post-construction monitoring results and the need for adaptive management actions. If additional action is deemed necessary, the City will develop a Supplemental Compliance Plan as described in Appendix C, Section D, Paragraph 2 of the Consent Decree.

CHAPTER 11

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Protecting Seattle's Waterways

Volume 3 Integrated Plan Appendices

Final | May 29, 2015



Appendix A: Consent Decree Requirements for the Integrated Plan



Protecting Seattle's Waterways

Volume 3 – Integrated Plan

Appendix A: CONSENT DECREE REQUIREMENTS FOR THE INTEGRATED PLAN

Final

May 29, 2015



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List of Abbreviations

Term	Definition
BOD	biochemical oxygen demand
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
City	City of Seattle
CSO	combined sewer overflow
CWA	Clean Water Act
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
LTCP	Long-Term Control Plan
MTCA	Model Toxics Control Act
NPDES	National Pollutant Discharge Elimination System
PCB	polychlorinated biphenyl
TSS	total suspended solids
WWPCA	Washington Water Pollution Control Act

Consent Decree Requirements for the Integrated Plan

The Integrated Plan addresses a number of criteria or requirements described in the negotiated Consent Decree, including:

- Stormwater quality project(s) that result in significant benefits to water quality beyond those that would be achieved by implementation of the Long-Term Control Plan (LTCP) alone.
- Stormwater quality project(s) that will be in addition to all combined sewer overflow (CSO) control measures required in the LTCP, but that may affect the schedule of CSO control measures and CSO project completion by the compliance date of 2025.
- A schedule for implementation of the Integrated Plan projects and the deferred CSO control measures that would be completed after 2025. (All CSO control projects in the approved LTCP will be completed, but some would be deferred beyond 2025 under an approved Integrated Plan.)

The Consent Decree cites specific elements that must be included within the Integrated Plan, as summarized below:

- V.B.20.a: Describe in detail each proposed project, including at a minimum, the following information:
 - V.B.20.a.i: the design criteria and cost estimates for each proposed project contained within the Integrated Plan
 - V.B.20.a.ii: a cost-benefit analysis for implementation of the Integrated Plan
 - V.B.20.a.iii: a pollutant load reduction analysis, including projected load reductions for conventional pollutant parameters (e.g., biochemical oxygen demand [BOD], fecal coliform bacteria, total suspended solids [TSS], oil and grease, and pH), metals, nitrogen ammonia, phosphorus, and pathogens, as well as projected dissolved oxygen (DO) concentrations associated with each proposed project under the Integrated Plan
 - V.B.20.a.iv: a description of the public participation process that the City of Seattle (City) will use in its development and implementation of the proposed project(s) under the Integrated Plan
 - V.B.20.a.v: a description of the projected pollutant reductions to water bodies impaired for pathogens, metals, nitrogen ammonia, and DO through implementation of each proposed project under the Integrated Plan
 - V.B.20.a.vi: a description of projected pollutant reductions, including toxic organic compounds (i.e., select indicators for polychlorinated biphenyls [PCBs], polybrominated diphenyl ethers [PBDEs], semi-volatile organic compounds, and pesticides) as appropriate, to water bodies with specialized circumstances, such as beach closure advisories, protected spawning grounds, and contaminated sediment sites listed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or Model Toxics Control Act (MTCA), through implementation of each proposed project under the Integrated Plan
 - V.B.20.a.vii: a description of projected reductions in pollutant exposure for humans, ecological receptors, and/or threatened or endangered species through implementation of the proposed project(s) under the Integrated Plan
- V.B.20.b: Demonstrate that the Integrated Plan will achieve compliance with the federal Clean Water Act (CWA) and the Washington Water Pollution Control Act (WWPCA), as well as their implementing state and federal requirements for CSO discharges

- V.B.20.c: Propose a schedule for implementation of the Integrated Plan and all remaining CSO control measures that is as expeditious as possible that may include an extension to the final construction completion milestone
- V.B.20.d: Propose a plan and schedule for performing any post-construction monitoring required for the proposed project(s)
- V.B.20.e. Include all documents, models, studies, and information supporting implementation of the Integrated Plan

Table 1 shows where the Consent Decree requirements are addressed in this Integrated Plan.

Table 1. Regulatory Compliance Crosswalk		
Consent decree item	Chapter	Comments
V.B.20	1.1	Chapter 1.1 provides an overview of integrated planning.
	1.5	Chapter 1.5 describes the integrated planning in the Consent Decree.
V.B.20.e	1.4	Describes the supporting documentation for the development of the Integrated Plan.
V.B.20.a.iii, v, vi, vii	2.0	Describes the water bodies in the planning area.
None	3.1	Chapter 3.1 provides a description of the existing combined sewer system.
	3.2	
	3.3	- Chapter 3.2 provides a description of the existing separated system. - Chapter 3.3 provides a description of the existing partial separated system.
V.B.20.a.iv	4.0	Describes the public participation process incorporated into the integrated planning process.
V.B.20.a	5.1	Chapters 5.1 and 5.2 describe the planning approach and methodology used for identifying the candidate LTCP projects proposed for deferral.
	5.2	
	5.3	Chapter 5.3 describes the planning approach and methodology used for identifying the candidate stormwater projects.
V.B.20.a, V.B.20.a.iii, V.B.20.a.v, V.B.20.a.vi, V.B.20.a.vii	6.5	Chapter 6.5 describes the methodology and data used to estimate the pollutant load reductions of the candidate LTCP projects proposed for deferral.
	6.6	Chapter 6.6 describes the methodology and data used to estimate the pollutant load reductions of the candidate stormwater projects.
	6.7	Chapter 6.7 describes the methodology used for evaluating the exposure assessments on the candidate LTCP and stormwater projects.

Table 1. Regulatory Compliance Crosswalk		
Consent decree item	Chapter	Comments
V.B.20.a.iii, v, vi, vii	7.2 7.3 7.4	- Chapter 7.2 describes the project evaluation results for the pollutant load reduction estimations on the candidate LTCP projects proposed for deferral. - Chapter 7.3 describes the project evaluation results for the pollutant load reduction estimations on the candidate stormwater projects. - Chapter 7.4 describes the exposure assessment results for the candidate LTCP and stormwater projects.
V.B.20.a.ii	8.4	Describes the estimated costs and cost-benefit analysis for the selected stormwater project option.
V.B.20.a.iii, v, vi, vii V.B.20.b	8.4	Discusses the significant benefits of the Integrated Plan projects and describes the compliance assurance and documents that the Integrated Plan will achieve compliance with the CWA, WWPCA, municipal sewer system and state and federal requirements for CSO discharges, and EPA CSO Control Policy.
V.B.20.c	9.0	Describes the implementation schedule for the Integrated Plan stormwater projects and the candidate LTCP projects that will be deferred.
V.B.20.d	10.0	Describes the post-construction monitoring that will be conducted for the Integrated Plan stormwater projects.

Appendix B: Surface Water Resources of the Integrated Plan

This appendix contains a description of the surface water resources of the Integrated Plan area, which was originally provided as Appendix A to the following document: *Integrated Plan: Briefing Memorandum for April 29, 2013, Expert Panel Meeting. Briefing Memorandum on Stormwater and CSO Project Evaluation and Exposure Assessment Methods. April 22, 2013. Revised May 23.*



Protecting Seattle's Waterways

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Appendix B: SURFACE WATER RESOURCES OF THE INTEGRATED PLAN

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List of Abbreviations

Term	Definition
cfs	cubic feet per second
Corps	U.S. Army Corps of Engineers
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSO	combined sewer overflow
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ft/s	foot/feet per second
MTCA	Model Toxics Control Act
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl

Summary

This document describes the major water bodies in the Integrated Plan area, and was originally provided as Appendix A to the Receiving Water Body and Drainage Basin Ranking Memorandum (SPU, 2013e). The receiving water bodies located around the city that are discussed within this appendix are shown in Figure 1.

Table 1 lists the State of Washington use designations and Table 2 lists the State of Washington 303(d) Impairments for the water bodies discussed in this appendix.

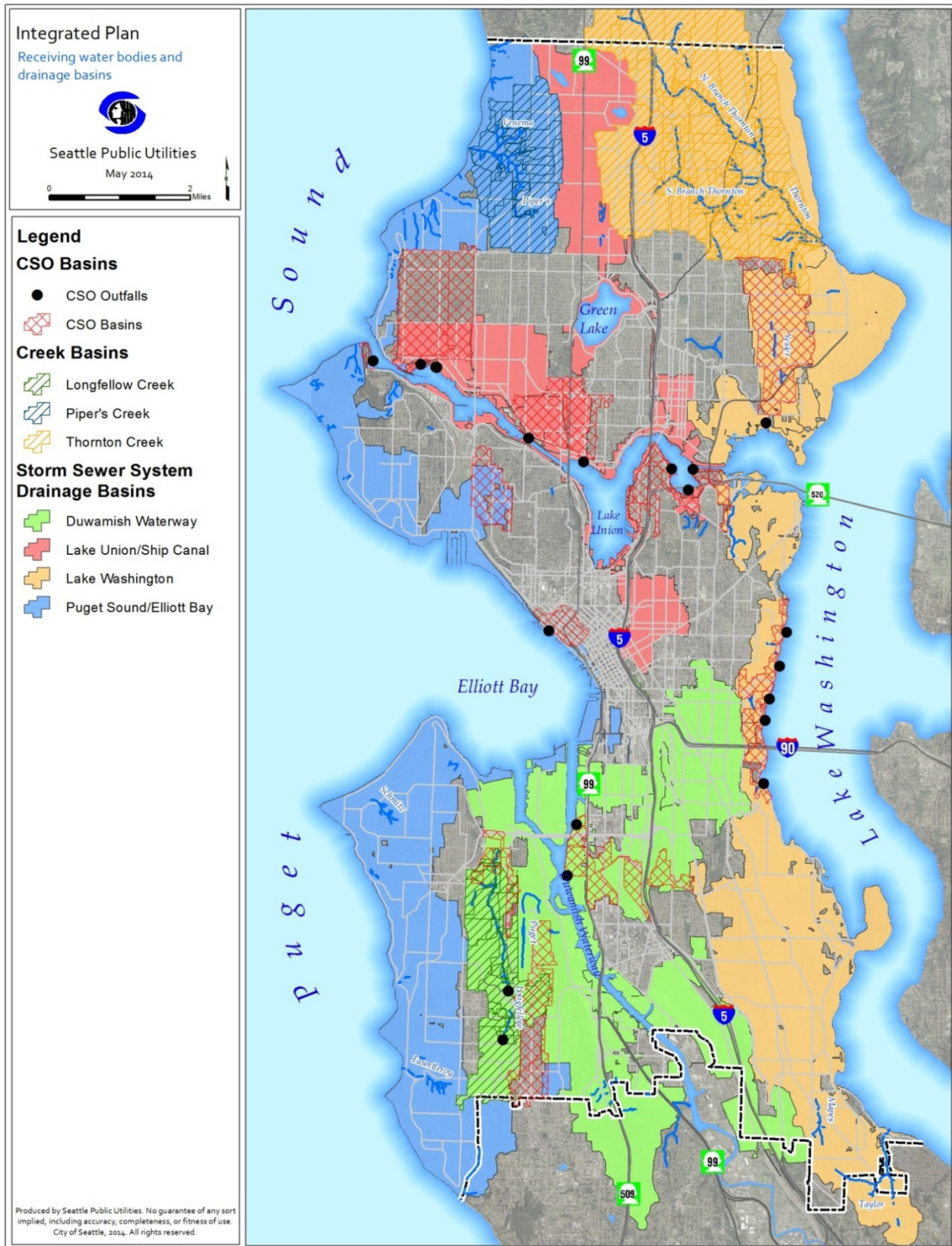


Figure 1. Receiving water bodies and drainage basins

Table 1. State of Washington Use Designations for Receiving Water Bodies in and around Seattle

Uses	Aquatic Life: Freshwater						Aquatic Life: Marine				Recreational: Freshwater		Recreational: Marine		Water Supply				Miscellaneous						
Surface water criteria relevant to use designation ¹	Numeric for temperature, turbidity, dissolved oxygen, total dissolved gases, pH, and toxic substances; also narrative						Numeric for temperature, turbidity, dissolved oxygen, pH, and toxic substances; also narrative				Numeric for fecal bacteria; also narrative						Narrative only				Narrative only				
Use designation	Char Spawning/ Rearing	Core Summer Habitat	Spawning/Rearing	Rearing/Migration Only	Redband Trout	Warm Water Species	Extraordinary	Excellent	Good	Fair	Extra. Primary Contact	Primary Contact	Secondary Contact	Shellfish Harvesting	Primary Contact	Secondary Contact	Domestic Water	Industrial Water	Agricultural Water	Stock Water	Wildlife Habitat	Harvesting	Commerce/Navigation	Boating	Aesthetics
Puget Sound ^a							✓							✓	✓						✓	✓	✓	✓	✓
Elliott Bay ^b								✓						✓	✓						✓	✓	✓	✓	✓
Lake Washington		✓									✓						✓	✓	✓	✓	✓	✓	✓	✓	✓
Ship Canal/Lake Union ^c		✓									✓						✓	✓	✓	✓	✓	✓	✓	✓	✓
Duwamish River ^d				✓									✓					✓	✓	✓	✓	✓	✓	✓	✓
Longfellow Creek			✓									✓					✓	✓	✓	✓	✓	✓	✓	✓	✓
Thornton Creek		✓									✓						✓	✓	✓	✓	✓	✓	✓	✓	✓
Piper's Creek			✓								✓						✓	✓	✓	✓	✓	✓	✓	✓	✓

1. Surface water criteria:

173 201A 200: freshwater numeric for aquatic life uses (temperature, turbidity, dissolved oxygen, total dissolved gas, and pH) and for recreation (fecal bacteria)

173 201A 210: marine numeric for aquatic life uses temperature, turbidity, dissolved oxygen, and pH) and for recreation/shellfish harvest (fecal bacteria)

173 201A 220: lake nutrient criteria (miscellaneous uses: aesthetics)

173 201A 240: toxic substances (aquatic life uses for freshwater and marine acute and chronic criteria)

173 201A 250: radioactive substances (relevant to all uses)

173 201A 260: natural conditions and other water quality criteria and applications (narrative criteria relevant to all designated uses)

Excerpts from WAC 173-201A Surface Water Standards for the State of Washington, Table 602:

a. Puget Sound through Admiralty Inlet and South Puget Sound, south and west to longitude 122°52'30"W (Brisco Point) and longitude 122°51'W (northern tip of Hartstene Island).

b. Elliott Bay east of a line between Pier 91 and Duwamish Head.

c. Lake Washington Ship Canal from Government Locks (river mile 1.0) to Lake Washington (river mile 8.6).

d. Duwamish River from mouth south of a line bearing 254° true from the NW corner of berth 3, terminal 37 to the Black River (river mile 11.0) (Duwamish River continues as the Green River above the Black River).

Table 2. Washington Department of Ecology Water Quality Assessment (303(d) Listings)

Source: http://www.ecy.wa.gov/programs/wq/links/wq_assessments.html

Water body	Impairment: 303(d) Category 5 Listing
Duwamish Waterway	Fecal Coliform (water column)
	Dissolved Oxygen (water column)
	PCB (tissue)
	Dieldrin (tissue)
	HPAH (tissue)
	Numerous Sediment Listings
Lake Washington	Total Phosphorus (water column)
	Fecal Coliform (water column)
	2,3,7,8-TCDD (tissue)
	PCB (tissue)
	4,4'DDD (tissue)
	4,4'DDE (tissue)
	Total Chlordane (tissue)
Puget Sound/Elliott Bay	Fecal Coliform (water column)
	PCB (tissue)
	2,3,7,8-TCDD (tissue)
	Total Dioxins (tissue)
	Total Furans (tissue)
	Benz(a)anthracene (tissue)
	Benzo(a)pyrene (tissue)
	Benzo(b)fluoranthene (tissue)
	Benzo(k)fluoranthene (tissue)
	Chrysene (tissue)
	Indeno(1,2,3-cd)pyrene (tissue)
	Dibenzo(a,h)anthracene (tissue)
Ship Canal/Lake Union	Total Phosphorus (water column)
	Lead (water column)
	Aldrin (water column)
	Fecal Coliform (water column)
Thornton Creek	Dissolved Oxygen (water column)
	Temperature (water column)
	Fecal Coliform (water column)
Longfellow Creek	Fecal Coliform (water column)
	Dissolved Oxygen (water column)
Piper's Creek	No 303(d) Category 5 Listings. Listed 4a for Fecal Coliform

Chapter 1

Lower Duwamish Waterway

The Duwamish River originates at the confluence of the Green and Black rivers near Tukwila and flows northwest for approximately 12 miles, splitting at the southern end of Harbor Island to form the East and West waterways, prior to discharging into Elliott Bay. The downstream portion of the Duwamish Waterway, located in Seattle, serves as a major shipping route for bulk and containerized cargo, and the shoreline along the majority of the lower Duwamish River (i.e., the reach downstream of the Upper Turning Basin, about 5.5 miles in length) has been developed for industrial and commercial operations. A portion of the lower Duwamish River is maintained as a federal navigation channel by the U.S. Army Corps of Engineers (Corps).

The Green River, which is the main freshwater source for the lower Duwamish Waterway, originates in the Cascade Mountains near Stampede Pass and is impounded by the Howard Hanson Dam and the Tacoma Headworks Dam. Between 2000 and 2006, the annual average flow rate measured at the Auburn gauging station was 1,190 cubic feet per second (cfs), and ranged from 851 to 1,549 cfs. Approximately 80 percent of the water in the Duwamish River eventually flows through the West Waterway because of a sill at the south end of the East Waterway. Flow rates are greatest during the winter months because of seasonal precipitation and lowest throughout the late summer dry season. Water circulation within the lower Duwamish River is driven by tidal actions and river flow; the relative influence of each is highly dependent on seasonal river discharge volumes.

Consent Decree Information

Table 1 lists the State of Washington use designations and Table 2 lists the State of Washington 303(d) Impairments for the Duwamish River.

The Duwamish River is listed as secondary contact recreation; there are no monitored swimming beaches on the Duwamish River and therefore there is no information on beach closures.

The Lower Duwamish Waterway is listed as a Superfund Site under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (EPA, 2013) and as a Model Toxics Control Act (MTCA) site (Ecology, 2013b). The CERCLA and MTCA listings are for sediments in the river that contain a wide range of contaminants associated with industrial activity. The contaminants include polychlorinated biphenyls (PCBs), carcinogenic polycyclic aromatic hydrocarbons (cPAHs), arsenic, and chlorinated dioxins and furans.

The Duwamish River is listed as Critical habitat for the following Proposed, Threatened, and Endangered species (City of Seattle, 2012):

- Chinook Salmon (*Oncorhynchus tshawytscha*) are listed as a Threatened species.
- Coastal-Puget Sound Bull Trout (*Salvelinus confluentus*) are listed as a Threatened species.
- Puget Sound Steelhead (*Oncorhynchus mykiss*) are listed as a Threatened species; however, no Critical habitats are designated at this time.

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Chapter 2

Lake Washington

Lake Washington is the second-largest natural lake in the state, with a surface area of 21,500 acres and a watershed of 472 square miles. Overall, almost two-thirds of the land use in the Lake Washington watershed has been converted to residential, commercial, or industrial uses (King County, 2009). Historically, Lake Washington drained to the south through the Black River to the Duwamish River and Puget Sound. In 1912, the Cedar River was diverted into Lake Washington from its original discharge into the Duwamish River. In 1916, construction of the Lake Washington Ship Canal system diverted Lake Washington's outlet from the Black River to Shilshole Bay (Chrzastowski, 1983).

Lake Washington's two major influent streams are the Cedar River at the southern end, and Lake Sammamish via the Sammamish River from the north. In addition, numerous small streams enter Lake Washington.

The Lake Washington basin is a deep, narrow, glacial trough with steeply sloping sides. The Corps maintains daily lake elevations to within 0.01 foot. The summer high-water level is 22 feet mean sea level; the lake is lowered approximately 2 feet during the winter to minimize shoreline erosion and property damage and to allow dock and other facility maintenance (Chrzastowski, 1983; Corps, 2012a, 2012b).

The mean depth of the lake is 108 feet with a maximum depth of 214 feet (King County, 2009). The average water-residence time in Lake Washington is currently about 2.3 years, which is about half of its historical flushing rate of 5 years (Chrzastowski, 1983). This change in replacement rate was caused by construction of the Lake Washington Ship Canal system and diversion of the Cedar River into the lake.

Consent Decree Information

Table 1 lists the State of Washington use designations and Table 2 lists the State of Washington 303(d) Impairments for Lake Washington.

King County (King County, 2013) monitors swimming beaches along the shore of Lake Washington once per week from May through September to determine the fecal coliform level and to inform the public on the risks to swimmers. There are seven monitored beaches in the city of Seattle on Lake Washington and over the period of 1996–2012 there have been 39 beach closures.

At this time there are no CERCLA or MTCA listings for Lake Washington in the waters adjacent to Seattle (EPA, 2013 and Ecology, 2013b).

Lake Washington is listed as Critical habitat for the following Proposed, Threatened, and Endangered species (City of Seattle, 2012):

- Chinook Salmon (*Oncorhynchus tshawytscha*) are listed as a Threatened species.
- Coastal-Puget Sound Bull Trout (*Salvelinus confluentus*) are listed as a Threatened species.
- Puget Sound Steelhead (*Oncorhynchus mykiss*) are listed as a Threatened species; however, no Critical habitats are designated at this time.

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Chapter 3

Puget Sound

Puget Sound is a fjord-like estuary that consists of a series of underwater valleys and ridges (called basins) and submerged hills (called sills). Sills impede the flow of water in and out of the Sound and also induce vertical mixing as water moves over the sill. Puget Sound consists of four major interconnected basins: the Main (Admiralty Inlet and the Central Basin), Whidbey, Southern, and Hood Canal Basins (King County, 2009). All of Seattle's marine combined sewer overflows (CSOs) and stormwater outfalls discharge to the Central Basin. The Central Basin has near-oceanic salinity throughout the year and is supplemented with cold, nutrient-rich, low-oxygenated deep oceanic water upwelled off the Washington coast during the late summer months. The Central Basin contains water depths up to 932 feet. Freshwater flows influence water circulation in the Central Basin as the amount of freshwater input varies seasonally and affects water temperature, salinity, and density, which then determines stratification of the water column. Water column stratification can affect biological populations by trapping nutrients and/or affecting vertical migration through the water column. Freshwater input into rivers is mainly through rainfall; however, snowmelt also contributes a large source in later spring and early summer.

The two main freshwater inputs to the Central Basin are the Green/Duwamish River, which enters Elliott Bay, and the Cedar River (Lake Washington drainage basin), which flows into the Sound primarily through the Lake Washington Ship Canal. Because flows in the Lake Washington drainage basin and the Green River are regulated, snowmelt does not increase the flows in these river systems to the extent that it does in unregulated systems and has little effect on salinity and stratification near the river mouths.

Water circulation in the Central Basin is dominated by tidal currents and generally consists of a two-layered flow, with incoming, saltier oceanic water flowing along the bottom and a fresher, less dense water layer flowing out at the surface. Salty, cold, dense waters enter Puget Sound at depth through Admiralty Inlet. A portion flows south in the Central Basin while the other portion flows northeast through Possession Sound to the Whidbey Basin. Water tends to flow faster on the eastern side of the Central Basin near Alki Point and Point Wells and along the western side near Point Monroe and north of Kingston, where major topographic features affect the currents (Ebbesmeyer and Cannon, 2001). The residence time of water in the Central Basin is about 48 days, depending upon the time of year (King County, 2009). Amplitudes of tidal currents in the Central Basin are about 1.6 feet per second (ft/s). Estuarine circulation is important for transporting water masses and is typically up to about 0.3 ft/s, but can be higher during storms and bottom-water saltwater intrusion from Admiralty Inlet (Ebbesmeyer et al., 2002).

Consent Decree Information

Table 1 lists the State of Washington use designations and Table 2 lists the State of Washington 303(d) Impairments for Puget Sound.

There are around 21 official beach/water access locations within Seattle for Puget Sound. Of these, the State of Washington monitors four within the city of Seattle from Memorial Day to Labor Day each year. There were 13 beach closures for the period of 2004–10 (Ecology, 2013a).

At this time there are no CERCLA or MTCA listings for Puget Sound in the waters adjacent to Seattle (EPA, 2013 and Ecology, 2013b).

Puget Sound is listed as Critical habitat for the following Proposed, Threatened, and Endangered species occurring within Puget Sound adjacent to Seattle (City of Seattle, 2012):

- Chinook Salmon (*Oncorhynchus tshawytscha*) are listed as a Threatened species, with the inshore and offshore habitat (to depths of 98 feet) listed as Critical habitat.
- Coastal-Puget Sound Bull Trout (*Salvelinus confluentus*) are listed as a Threatened species, with the inshore and offshore habitat (to depths of 33 feet) listed as Critical habitat.
- Killer Whale (*Orcinus orca*) are listed as Endangered, with all waters greater than 20 feet deep listed as Critical habitat.
- Puget Sound Steelhead (*Oncorhynchus mykiss*) are listed as a Threatened species; however, no Critical habitats are designated at this time.

Chapter 4

Elliott Bay

Elliott Bay, part of Puget Sound, is a partially enclosed embayment that is surrounded on the north, east, and south sides by urbanized areas. The eastern shoreline borders downtown Seattle and has been heavily modified from historical conditions. Most of the shoreline is armored, generally with rock, riprap, and/or bulkheads. Much of the southern and eastern waterfront land area was created by filling in what was once intertidal habitat by constructing bulkheads. As a result, the shoreline is much steeper than a natural shoreline. Harbor Island, located in the southern portion of the bay, is a man-made island completed in 1909.

Other than a few intertidal areas, depths in Elliott Bay range from about 33 feet to slightly over 490 feet near the western portion of the bay. The eastern and western (from Duwamish Head south of Seacrest Park) shorelines have steep slopes, and the middle of the bay has deep, flat areas.

Consent Decree Information

Table 1 lists the State of Washington use designations and Table 2 lists the State of Washington 303(d) Impairments for Elliott Bay.

Information on Beach closures for Elliott Bay is included in the Puget Sound section above.

At this time there are no CERCLA or MTCA listings for Elliott Bay in the waters adjacent to Seattle (EPA, 2013 and Ecology, 2013b).

Elliott Bay, like Puget Sound, is listed as Critical habitat for the following Proposed, Threatened, and Endangered species occurring within Puget Sound adjacent to Seattle (City of Seattle, 2012):

- Chinook Salmon (*Oncorhynchus tshawytscha*) are listed as a Threatened species, with the inshore and offshore habitat (to depths of 98 feet) listed as Critical habitat.
- Coastal-Puget Sound Bull Trout (*Salvelinus confluentus*) are listed as a Threatened species, with the inshore and offshore habitat (to depths of 33 feet) listed as Critical habitat.
- Killer Whale (*Orcinus orca*) are listed as Endangered, with all waters greater than 20 feet deep listed as Critical habitat.
- Puget Sound Steelhead (*Oncorhynchus mykiss*) are listed as a Threatened species; however, no Critical habitats are designated at this time.

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Chapter 5

Ship Canal/Lake Union

The Lake Washington Ship Canal system is an 8.6-mile-long (13.8-kilometer-long) man-made navigable waterway connecting Shilshole Bay in Puget Sound to Union Bay in Lake Washington in Seattle. This system includes the following interconnected waterways:

- Hiram M. Chittenden Locks (Ballard Locks)
- Salmon Bay
- Salmon Bay Waterway
- Fremont Cut
- Lake Union
- Portage Bay
- Montlake Cut

Lake Union is a freshwater lake with a maximum depth of 50 feet. The lake receives most of its inflow from Lake Washington via the Montlake Cut and Portage Bay. Lake Union discharges to the Puget Sound Central Basin via the Hiram Chittenden Locks. At certain times of the year the lake has a significant amount of salt water near the bottom because of saltwater intrusion entering from the Ballard Locks.

Water circulation patterns in Lake Union are complex and affected by several factors, such as saltwater intrusion, freshwater flows from Lake Washington, wind, and temperature and density stratification. Lake Union exhibits a general pattern of winter flushing and summer stratification. The water in Lake Union is completely replaced about once per week during high freshwater flows in the winter (King County, 2012b), but there is a significant amount of short circuiting of flow, where the inflowing water does not completely flush southern portions of the lake. During the dry summer months, water movement from Lake Washington into Lake Union decreases by over 90 percent compared to peak winter flows (Herrera, 1993).

As the flow from Lake Washington decreases, the water temperature in Lake Union rises and saltwater moves into the lake from the Ballard Locks. This results in a stratified water column with colder, saltier water on the bottom and warmer fresh water at the surface. The saltwater intrusion begins around May and continues through the summer until around November, when rainfall increases freshwater flow into the lake and flushes out salt water.

Consent Decree Information

Table 1 lists the State of Washington use designations and Table 2 lists the State of Washington 303(d) Impairments for Lake Union.

There are no monitored swimming beaches on Lake Union and therefore there is no information on beach closures.

Gas Works Park is located on the north shore of Lake Union and is listed by the Washington Department of Ecology as a MTCA site (Ecology, 2013b). Gas Works is now a City of Seattle park but prior to this use it was the location of a plant that converted coal and oil into manufactured gas. The sediments off the shore of Gas Works Park contain polycyclic aromatic hydrocarbons (PAHs), which are currently undergoing study to determine the best cleanup remedy.

The Lake Washington Ship Canal/Lake Union is listed as Critical habitat for the following Proposed, Threatened, and Endangered species (City of Seattle, 2012):

- Chinook Salmon (*Oncorhynchus tshawytscha*) are listed as a Threatened species.
- Coastal-Puget Sound Bull Trout (*Salvelinus confluentus*) are listed as a Threatened species.
- Puget Sound Steelhead (*Oncorhynchus mykiss*) are listed as a Threatened species; however, no Critical habitats are designated at this time.

Chapter 6

Thornton Creek

The Thornton Creek watershed is the largest drainage basin within Seattle, draining 7,120 acres or 11.1 square miles. The watercourse headwaters are located in northeast Seattle and the city of Shoreline, flowing generally south and east before discharging to Lake Washington. The drainage system is the longest within the city of Seattle, with nearly 20 miles of watercourse channel length contained in two main branches, the main stem, and 20 tributaries (City of Seattle, 2007).

The north branch of Thornton Creek originates at the Ronald bog in the city of Shoreline and flows 5 miles southeast through Seattle's Jackson Park golf course and the Lake City Way commercial area. This branch drains 7 square miles, or 60 percent of the watershed. The south branch, also known as Maple Leaf Creek, drains a watershed of 3.8 square miles, or 33 percent of the watershed. The south branch originally began in wetlands in the Northgate–North Seattle Community College–Interstate-5 area, but the headwaters were extensively filled during development of the area. Consequently, the south branch now begins at a reach that has been recently uncovered and restored in the Northgate shopping center, and flows 2.3 miles before joining the north branch.

The north and south branches converge just upstream of Meadowbrook pond near 35th Avenue NE and NE 107th Street. The main stem of Thornton Creek drains a small portion (7 percent) of the watershed and flows southeast approximately 1.4 miles before emptying into Lake Washington at Matthews Beach. The Thornton Creek watershed is the most extensively developed of Seattle's five major watercourse basins. Most of the development is residential with some areas preserved as park land or open space.

Thornton Creek flows throughout the year, with mean annual flows of 13 and 12 cfs at the mouth for water years 2004 and 2005, respectively (City of Seattle, 2007). The peak flows recorded for water years 2004 and 2005 were 539 cfs and 129 cfs, respectively (based on 15-minute data), and the 7-day low flows were 3.9 and 3.6 cfs, respectively. A high-flow bypass at Meadowbrook Pond can divert up to 350 cfs directly to Lake Washington and dampen storm flow peaks at the mouth of Thornton Creek. Thornton Creek has no City of Seattle CSOs discharging into the creek but does have numerous stormwater outfalls.

Consent Decree Information

Table 1 lists the State of Washington use designations and Table 2 lists the State of Washington 303(d) Impairments for Thornton Creek.

There are no monitored swimming beaches on Thornton Creek and therefore there is no information on beach closures.

At this time there are no CERCLA or MTCA listings for Thornton Creek in Seattle (EPA, 2013 and Ecology, 2013b).

Thornton Creek does not contain any Critical habitat for Threatened or Endangered species.

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Chapter 7

Longfellow Creek

Seattle's second-largest watershed, the Longfellow Creek basin, is located in West Seattle. The Longfellow watershed covers 1,729 acres, or 2.7 square miles, with 4.6 miles of watercourse length (City of Seattle, 2007). The structure of Longfellow Creek is very different from the other major Seattle watercourses; the watercourse is dominated by a single channel with a few short tributaries. The watercourse includes 3.9 miles of main channel, one-third of which (6,350 feet) is piped, and 0.7 mile of tributaries.

Longfellow Creek is relatively flat compared to other major watercourses in Seattle. The watercourse flows through the broad Delridge Valley, which prior to urbanization would have allowed wide meandering of the stream and extensive valley bottom wetlands (City of Seattle, 2005). Longfellow Creek flows from south to north, dropping 250 feet in elevation from its headwaters near the southern city limits to its mouth at the Duwamish River near Harbor Island. The watercourse discharges to the Duwamish River through a 3,250-foot-long culvert.

The Longfellow watershed is heavily developed with residential, industrial, and commercial uses. Urbanization increases the amount of impervious surface area in the watershed, which drains stormwater to watercourses more quickly and causes higher-than-normal peaks in flow. These peaks rise and fall rapidly and produce a characteristic flashiness in the watercourse's hydrograph. The areas that have the highest potential to contribute large storm flows quickly are located in the upper portion of the basin (City of Seattle, 2007). Although the upper portion of the basin has the lowest gradient, it is characterized by high levels of impervious surfaces and some areas with low permeability. Based on limited flow data collected from November 2004 through December 2005, the peak flow on Longfellow Creek was 45 cfs with a 7-day low-flow rate of 0.4 cfs (City of Seattle, 2007). Longfellow creek has numerous stormwater outfalls and two City of Seattle CSO outfalls discharging into the creek.

Consent Decree Information

Table 1 lists the State of Washington use designations and Table 2 lists the State of Washington 303(d) Impairments for Longfellow Creek.

There are no monitored swimming beaches on Longfellow Creek and therefore there is no information on beach closures.

At this time there are no CERCLA or MTCA listings for Longfellow Creek in Seattle (EPA, 2013 and Ecology, 2013b).

Longfellow Creek does not contain any Critical habitat for Threatened or Endangered species.

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Chapter 8

Piper's Creek

The Piper's Creek watershed covers 1,604 acres, or 2.5 square miles, in northwest Seattle. Piper's Creek is the third-largest watershed in the city, and is just under one-quarter the size of the largest watershed, Thornton Creek. The main stem channel is roughly 2 miles in length, with an additional 3 miles in tributaries, including one major tributary (Venema/Mohlendorph) and 13 minor tributaries.

The watershed has three distinct zones: a gently rolling upland plateau, an area of steep-walled ravines, and a low gradient valley. The headwaters of Piper's Creek originate on the upland plateau, and the watercourse enters Carkeek Park as it drops down from the plateau through a steep ravine. Once on the low-gradient valley, the watercourse discharges to Puget Sound. Piper's Creek is perennial with average flows of 3 to 9 cfs.

Historically, the Piper's Creek watershed was a heavily forested drainage but urbanization has developed nearly 90 percent of the watershed into residential (59 percent), transportation, and commercial areas (31 percent), with the remainder in parks (10 percent).

Consent Decree Information

Table 1 lists the State of Washington use designations for Piper's Creek. There are no 303(b) Category 5 listings for Piper's Creek.

There are no monitored swimming beaches on Longfellow Creek and therefore there is no information on beach closures.

At this time there are no CERCLA or MTCA listings for Piper's Creek in Seattle (EPA, 2013 and Ecology 2013b).

Piper's Creek does not contain any Critical habitat for Threatened or Endangered species.

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Chapter 9

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Appendix C: Stormwater Project Identification Process



Protecting Seattle's Waterways

Volume 3 – Integrated Plan

Appendix C: STORMWATER PROJECT IDENTIFICATION PROCESS

Final

May 29, 2015



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List of Abbreviations

Term	Definition
303(d)	list of impaired water bodies
AARV	average annual runoff volumes
AUI	area unsuitable for infiltration
BMP	best management practice
CERCLA	Comprehensive Environmental Response, compensation, and Liability Act
CIP	capital improvement project
City	City of Seattle
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSO	combined sewer overflow
Ecology	Washington State Department of Ecology
GIS	geographic information system
LDW	Lower Duwamish Waterway
LUST	leaking underground storage tank
MODA	Multiple Objective Decision Analysis
MTCA	Model Toxics Control Act
NDS	Natural Drainage Systems
PACT	Planning, Analysis, and Coordination Tool
PCB	polychlorinated biphenyls
PLT	Pollutant Load Estimator Tool
POC	pollutant of concern
ROW	right-of-way
SDOT	Seattle Department of Transportation
T&E	threatened and endangered
TMDL	total maximum daily load
TSS	total suspended solids
UIC	underground injection control
WSDOT	Washington State Department of Transportation
WWHM3	Western Washington Hydrology Model, version 3

Summary

This document provides an overview of the process, methods, and criteria that the City of Seattle (City) used to identify stormwater best management practices (BMPs) projects for evaluation as part of the planning effort known as the Integrated Plan. The process outlined in this document served as a first screen to help the City team identify stormwater BMP projects that could meet the objectives of the Integrated Plan. Additional screening by way of the pollutant load estimates, significant benefits analysis and Multiple Objective Decision Analysis (MODA) were used to further refine the list of candidate stormwater projects for inclusion in the Integrated Plan.

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CHAPTER 1

Stormwater Project Identification Process

This section provides a high-level overview of the stormwater treatment project identification process that was used to identify stormwater projects for consideration in the Integrated Plan. The process was a broad approach for identifying potential projects that would have significant merit for further analysis and potential inclusion in the Integrated Plan. Additional evaluations in the future development of each project in the Integrated Plan may be affected by the following factors:

- Further detailed investigation of individual basins or projects may indicate new alternatives that need to be investigated.
- Currently unknown collaborative projects with other departments or agencies may be identified.
- Community involvement and the environmental review process may influence projects.
- Determination of implementation needs would be an iterative process gained as information is further developed and other non-cost factors are integrated into the recommended alternatives.

1.1 Methodology for Identifying Projects

The Integrated Planning team employed the following steps to develop a list of stormwater treatment projects:

- develop pollutant and average annual runoff volume (AARV) estimates for each storm sewer system basin
- rank receiving water bodies and identify primary pollutant(s) of concern (POCs) for each water body
- rank storm sewer system drainage basins using the pollutant estimates and rank of receiving water body
- create a geographic information system (GIS) basin atlas for high-ranking storm sewer system basins in Seattle
- use the GIS basin atlas information and knowledge of stormwater treatment technologies to identify potential locations for stormwater treatment considering the general and project-specific screening criteria
- develop planning-level stormwater project descriptions and cost estimates for each of the stormwater projects to be considered in the Integrated Plan
- evaluate the stormwater projects against criteria to further refine the list of projects for consideration in the Integrated Plan

1.1.1 Develop Pollutant Load and Flow Estimates for Each Storm Sewer System Basin

The team used information on land use within each storm sewer system basin to develop total suspended solids (TSS) and AARV estimates for each basin area greater than 100 acres in size. The TSS load for each of the basins was estimated using the GIS Pollutant Load Estimator Tool (PLT) developed by the City. The PLT estimates AARV and TSS loads based on the 25th, 50th (median), and 75th percentile concentrations for each storm sewer system basin. Runoff calculations and TSS input were divided into categories based on land use/zoning and surface cover conditions.

AARV was estimated using the Simple Method (Stormwater Center, 2006). The median TSS concentration was used to estimate average annual TSS loads for each basin. The TSS values used in the PLT were based upon data obtained from the report, Sources of Pollutants in Urban Areas (Pitt et al., 2005a). Additional information on the PLT can be found in the City's Standard Operating Procedures Water Quality Evaluation (WQE) 1100 and WQE 1200.

For each stormwater project, the Western Washington Hydrology Model, version 3 (WWHM3) was used to model each storm sewer system basin and to estimate the flow volume, online flow, and offline flow for the storm sewer system basin or the area of the storm sewer system basin that the stormwater project would serve. These flow data were used to size the stormwater facilities that served as the basis for the cost estimates for each project.

The team used the AARV data from WWHM3 and estimates of TSS concentrations (based on land use of the basin upstream of the project) to estimate the TSS load removed per year in kilograms for each of the stormwater projects.

1.1.2 Receiving Water Body Ranking

In Seattle, stormwater storm sewer system outfalls deliver runoff to the Lower Duwamish Waterway (LDW), Lake Washington, Puget Sound, Elliott Bay, Lake Washington Ship Canal/Lake Union, and a number of smaller urban creeks and lakes.

The City ranked these water bodies in order to help focus its efforts to identify potential stormwater projects and programs for the Integrated Plan that would meet the Consent Decree requirements. A complete discussion on this receiving water body ranking process is provided in the City's draft memo: Receiving Water Body and Drainage Basin Ranking Memo (SPU, 2013). The ranking of receiving water bodies incorporated the following Consent Decree elements:

- receiving water body impairments determined by consulting the Washington Department of Ecology (Ecology) list of impaired water bodies 303(d) lists
- presence of threatened or endangered (T&E) species and habitats
- receiving water bodies with swimming beaches where closures have occurred
- receiving water bodies that have Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or Model Toxics Control Act (MTCA) designations

In addition to the Consent Decree elements, the City added consideration of fish consumption advisories in the receiving water body.

Each receiving water body was ranked against the criteria above and given a score of High, Moderate, or Low, as summarized below:

- High (●) rating: High ratings were given to receiving water bodies that contained multiple 303(d) listings in the water column, sediment, and/or fish tissue indicating that they were impaired, were listed as providing a primary migration corridor and critical rearing habitat for ESA-listed (T&E) species, were listed as having swim beach closures, had CERCLA and/or MTCA listings, and had any fish consumption advisories.
- Moderate (●) rating: Moderate ratings were given to receiving water bodies that contained multiple 303(d) listings in the water column, sediment, and/or fish tissue indicating that they may be at risk for impairment, were listed as providing a migration corridor and critical habitat for ESA-listed (T&E) species for some life stages, were listed as having swim beach closures, had CERCLA and/or MTCA listings, or had any fish consumption advisories.

- Low (●) rating: Low ratings were given to receiving water bodies that had a combination of bacteria 303(d) listings and other historical use or suspected contamination problems indicating that the water column, sediment, and/or fish tissue may be at risk for impairment, were listed as not providing critical habitat for ESA-listed (T&E) species, had no listing of beach closures but contained an active swimming beach, had no CERCLA or MTCA listings, or had any fish consumption advisories.
- Not applicable (●): NA ratings were given to receiving water bodies that had no information or no 303(d) listings, no T&E species use, no designated swimming beaches, no CERCLA or MTCA listings, and no fish consumption advisories.

The scores were then added together to provide an overall rank for each receiving water body. Table 1-1 provides a summary of the ranking criteria results for each of the evaluated receiving water bodies discussed within the Integrated Plan.

Table 1-1. Ranking Criteria for Receiving Water Bodies						
Water body	303(d)	T&E species	Swim beach closures	CERCLA/MTCA sites	Fish consumption	Overall rank ^a
Duwamish Waterway	●	●	●	●	●	1
Lake Washington	●	●	●	●	●	2
Puget Sound/Elliott Bay	●	●	●	●	●	3
Ship Canal/Lake Union	●	●	●	●	●	4
Thornton Creek	●	●	●	●	●	5
Longfellow Creek	●	●	●	●	●	6
Piper's Creek	●	●	●	●	●	7

Notes:

● High rank ● Moderate rank ● Low rank ● Not applicable

a. This process is a high-level planning tool to assist the planning and development of stormwater projects for evaluation as part of the Integrated Plan. Note that for programs and projects outside the Integrated Plan, the City may use different ranking systems and rank receiving waters and basins in different ways based on the objective of the program.

1.1.3 Storm Sewer System Basin Ranking

The next step in the storm sewer system basin ranking process was to combine the pollution potential (TSS load) of each storm sewer system basin with the receiving water body ranking in order to develop a list, in order of preference, of storm sewer system basins draining to large water bodies and storm sewer system basins draining to creek watersheds (Figure 1-1). A basin atlas was subsequently developed for the highest-ranked basins.

1.1.4 Basin Atlas Development

GIS data were used to create a Basin Atlas for each of the basins identified by the City's Integrated Planning team as a high-priority basin. These GIS data were displayed in a series of maps to provide basin characteristics to the team charged with identification of potential stormwater projects. Each Basin Atlas included the following information:

- aerial overview
- surface type; i.e., impervious or pervious and the percentage of the basin that discharges to combined sewer overflow (CSO) vs. the stormwater system

- land use and zoning
- existing/proposed water quality treatment
- underground facility opportunities/constraints
- partnership opportunities
- location opportunities for retrofit
- green stormwater infrastructure suitability
- source control and monitoring
- topography

1.1.5 Pollutants of Concern for Receiving Water Bodies

The City established the POCs for each receiving water body for the Integrated Plan based on consideration of the Consent Decree, total maximum daily load (TMDL) listings or impairments, available water quality data, and professional judgment. Pollutants considered included TSS, phosphorus and nitrogen, dissolved metals, hydrocarbons, fecal coliform, temperature, and flow rate and volume for streams. TSS was often selected as the target POC for a receiving water body as it represents pollutants that tend to adsorb and those that are in particulate form that include many of the organics and total metals. The pollutants were rated on a High-Moderate-Low scale with each rating summarized as follows:

- High (●) rating: High ratings were given to the pollutant considered the target POC for a stormwater treatment project for a particular stormwater drainage basin. The target POC for a project was determined based on TMDL listings or impairments, available water quality data, and/or professional judgment. While the target POC was the focus for identifying a stormwater project, much of the time, addressing the target POC also reduces many of the moderate- and low- rated pollutants.
- Moderate (●) rating: Moderate ratings were given to a pollutant for which treatment is recommended (in addition to the target POC for the project). These pollutants are present in the stormwater from the basin and may be impacting the receiving water body; however, they are not the most critical pollutant to address.
- Low (●) rating: Low ratings were given to a pollutant for which treatment should be considered (in addition to the target POC for project), but it was not necessary for the pollutant removal to be planned for, or used, in the selection or sizing of a treatment project.
- Not applicable (●): NA was given to a pollutant that had no known measurable impact on the receiving water body.

Table 1-2 provides a summary of the ranking criteria results from the POC evaluation conducted for each of the evaluated receiving water bodies discussed within the Integrated Plan.

Table 1-2. Pollutants of Concern for Receiving Water Bodies ^a										
Category	Water body	Flow rate	Volume	TSS	Phosphorus and nitrogen	Metals (total)	Metals (dissolved)	Hydrocarbons	Fecals	Temperature
Central Puget Sound	Central/Elliott Bay	●	●	●	●	●	●	●	●	●
	North Central	●	●	●	●	●	●	●	●	●
	South Central	●	●	●	●	●	●	●	●	●
Major Waterway	Duamish Waterway	●	●	●	●	●	●	●	●	●
	Ship Canal/Salmon Bay	●	●	●	●	●	●	●	●	●
Major Lakes	Lake Washington	●	●	●	●	●	●	●	●	●
	Lake Union	●	●	●	●	●	●	●	●	●
Creeks	Thornton Creek	●	●	●	●	●	●	●	●	●
	Longfellow Creek	●	●	●	●	●	●	●	●	●
	Piper's Creek	●	●	●	●	●	●	●	●	●

Notes:

● High rank ● Moderate rank ● Low rank ● Not applicable

a. This process is a high-level planning tool to assist the planning and development of stormwater projects for evaluation as part of the Integrated Plan. Note that for programs and projects outside the Integrated Plan, the City may use different ranking systems and rank receiving waters and basins in different ways based on the objective of the program.

1.1.6 Stormwater Project Identification

Using these GIS data, the City's Integrated Planning team conducted a high-level evaluation of the high-priority basins in order to identify potential locations to install stormwater projects. Once the location(s) were identified, the team used its knowledge of stormwater treatment and receiving water body POCs to identify a stormwater project(s) for the basin.

Each stormwater project was evaluated against the criteria discussed in Chapter 2 of this document in order to determine if the project should receive additional analysis and consideration as part of the Integrated Plan.

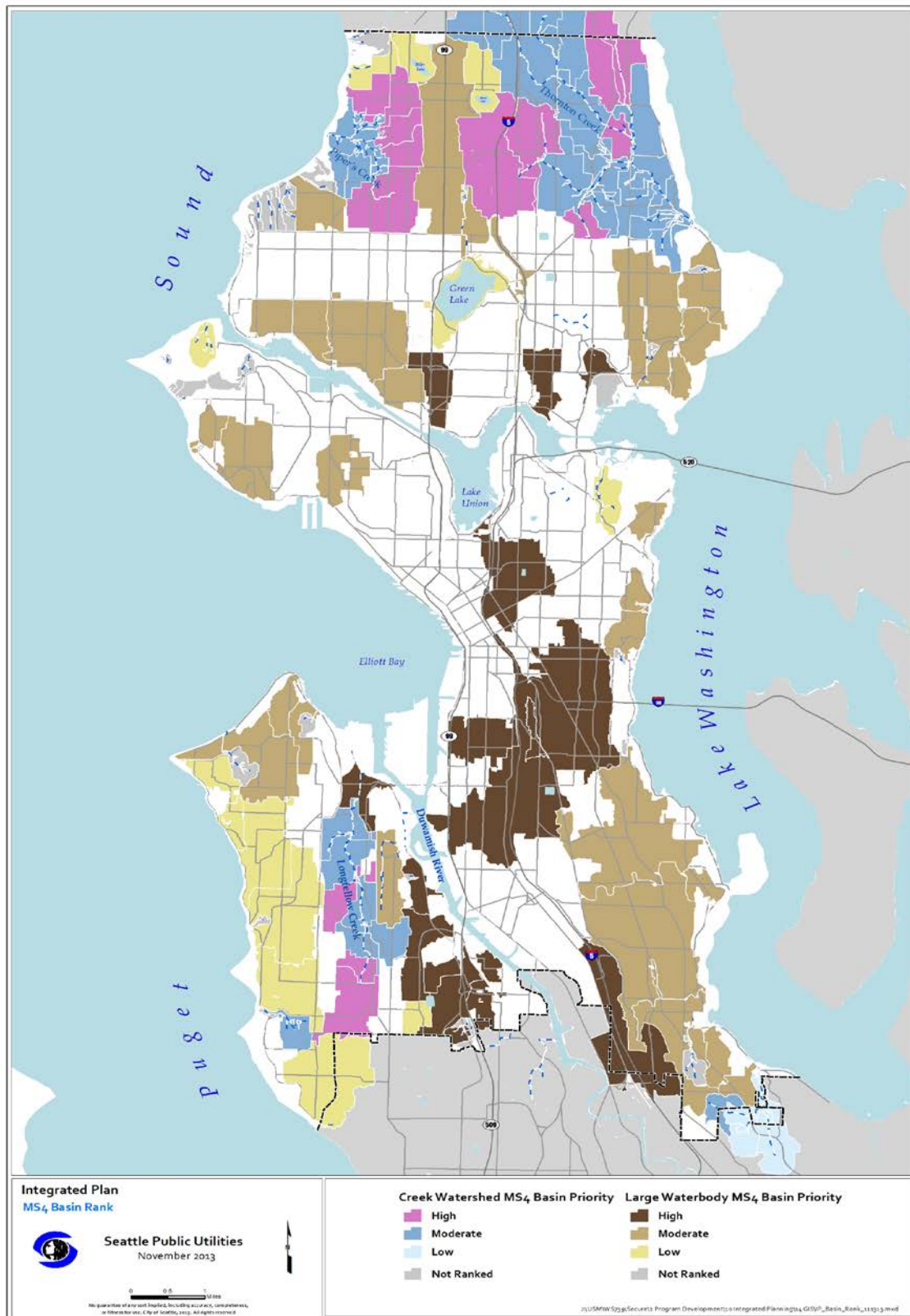


Figure 1-1. Priority ranking of storm sewer system basins in Seattle

CHAPTER 2

Initial Project Screening

The proposed stormwater projects developed using the methods described in Chapter 1 were screened against the following criteria in order to develop a list of stormwater projects that could be designed at the conceptual level along with commensurate cost estimates. Criteria were both general priority assignments (Section 2.1) and area and project-specific (Section 2.2).

2.1 Priority Assignments

Designations of High, Moderate, and Low priority were given to each evaluated stormwater project, as described below.

2.1.1 High-Priority Assignments

A High priority was assigned to the following elements, traits, or details that were deemed desirable:

- must be connected to and discharge into the City of Seattle storm sewer system
- construction in the City's right-of-way (ROW)
- construction on City-owned property
- gravity operated
- multiple benefits
- meeting code requirements/code equivalent
- sited on a vacant and available parcel or City's ROW
- treats runoff from a subbasin with high pollutant loading potential (e.g., industrial use, known pollutant sources, source control efforts likely to be unsuccessful)
- opportunity to leverage water quality project with other ongoing projects to reduce cost
- can be constructed by 2025

2.1.2 Moderate-Priority Assignments

A Moderate priority was assigned to elements, traits, or details that were deemed acceptable:

- sited on Seattle City Light owned property
- sited on property with a willing seller
- pumped operations
- sited on school property
- sited in a parking lot
- sited on City of Seattle Fleets and Administrative Services Department owned property

2.1.3 Low-Priority Assignments

A Low priority was assigned to those elements, traits, or details that were not desirable:

- sited in City of Seattle Parks and Recreation Department property
- sited on Washington Department of Transportation (WSDOT)-owned property
- sited on Port of Seattle property
- sited on church property
- requires adversarial condemnation
- sited in a landfill
- sited with high groundwater
- sited where there is significant flooding
- requires significant mitigation
- impacted by sea level rise
- sited on federal property

2.2 Stormwater Project Criteria

In addition to priority assignments, area- and project-specific criteria were evaluated.

2.2.1 Citywide Criteria

Probably the most common and significant difficulty in developing a stormwater project was the need for the treatment facility to be constructed by 2025. The City does not currently have many projects in the pipeline that could be designed/constructed in such a short time frame. Large regional stormwater treatment facilities typically require land acquisition (often condemnation) that often needs substantial environmental cleanup before work can begin and involves coordination among multiple local agencies, which results in significantly more time to plan, develop, design, and construct. For this reason, large end-of-pipe treatment facilities were generally not considered for this Integrated Plan.

The City determined that standalone pretreatment projects would not be considered due to the following:

- Pretreatment technologies target larger-sized solids and a limited number of pollutants.
- Pretreatment is intended to ensure and extend performance of downstream treatment facilities. No downstream stormwater treatment facilities are associated with the pretreatment projects evaluated for inclusion in the Integrated Plan.

The City determined that in those storm sewer system basins that had existing regional stormwater treatment, a lower priority would be given to the basin so that efforts could be focused on other high-ranking storm sewer system basins that currently have no regional stormwater treatment at all.

2.2.2 Lower Duwamish Waterway Project Criteria

The LDW has been the subject of extensive source control efforts over the past 10 years due to its status as a Superfund site and ongoing efforts to clean up sediments containing elevated levels of arsenic, polychlorinated biphenyls (PCBs), carcinogenic polycyclic aromatic hydrocarbons (cPAHs), and dioxins/furans. The City has inspected businesses and collected numerous sediment samples from the collection/conveyance system in order

to identify and control pollutant sources in the LDW basin. As a result, the City likely knows more about potential sources and its ability to control them in this basin than in any other drainage basin in the city. Because of its Superfund status, this area is also subject to significantly more scrutiny from regulatory agencies, which is leading to more extensive requirements for City programs (e.g., source controls, expanded line cleaning to remove accumulations of contaminated sediment, stronger operations/maintenance efforts), as well as structural retrofits to reduce the potential for sediment in the waterway to recontaminate subsequent to a cleanup.

Stormwater treatment projects in the LDW were selected to capture and treat runoff from the most significant source areas. To better address the water quality concerns described above, the City looked for potential opportunities to implement higher levels of treatment. Examples of targeted projects included:

- subbasins where fugitive dust emissions/atmospheric deposition from local industries and vehicle emissions are affecting stormwater quality and where existing regulations are insufficient to address these issues
- large multi-use basins that contribute a large proportion of the overall stormwater load and where given the drainage infrastructure, it would be difficult to isolate specific industrial/high pollution generating subbasins for treatment (e.g., subbasins within the 2,600-acre Diagonal Avenue S drainage basin) and where there is an opportunity to team with King County on a joint-use facility
- major arterials in industrial/commercial areas
- sites where Ecology has already requested drainage/roadway improvements to reduce stormwater pollution

A number of sites/projects were considered, but were not found to be feasible given one or more of the following constraints:

- The City determined that while it represented a great opportunity for both the City and King County, inclusion of an opportunity to partner with King County on a wet weather treatment plant was not appropriate for consideration in the Integrated Plan for the following reasons:
 - The project was not a City project.
 - The timeline of the construction was beyond the timeline for the Integrated Plan.
 - The cost of the project (~\$380 million) was greater than the dollars available from the potential deferred CSO projects.
- Projects on major arterials/transportation corridors, where the remaining ROW has already been developed for pedestrian paths and other non-motorized use, would leave no space to construct surface treatment systems (e.g., biofiltration and/or bioretention systems) and high-volume traffic would create significant barriers to construct and operate large underground facilities.
- Other areas with a lack of space to construct a stormwater treatment facility would necessitate a lengthy, expensive, and/or politically unpopular condemnation process and/or would lack a suitable site to even consider condemnation.
- A site is suitable to construct a stormwater facility, but the property is located within the WSDOT ROW. WSDOT is unwilling to allow any activity in its ROW that could preclude future transportation use.

2.2.3 Street Sweeping Program Criteria

Unlike construction of major structural treatment facilities, street sweeping is not constrained by site feasibility, is scalable, and can be readily implemented. Specific criteria that were considered for this program include:

- sweeping curbed roadways that drain directly to Seattle's receiving waters
- using high-efficiency sweepers
- having a frequency of every 1 to 2 weeks

- requiring a specified speed for the sweepers to ensure effectiveness
- consideration of parking; currently no parking enforcement on swept streets

2.2.4 Creek Watersheds Project Criteria

Stormwater treatment projects to be considered within creek watersheds were selected based upon the criteria of providing water quantity benefit in addition to achieving the water quality objectives consistent with the other basins evaluated for the Integrated Plan. Stormwater projects included alternatives relying on flow routing, as well as practices addressing flow directly at the source of the runoff.

Solutions that include routing (or capturing existing routed) flows from multiple blocks to a stormwater project location tend to maximize the cost-effectiveness of the solution. Locations with minimal alterations of the upstream and downstream conveyance system were preferred. The following practices were considered for each basin evaluated where feasible:

2.2.4.1 Projects with Flow Routing

Criteria associated with project flow routing are presented below.

2.2.4.1.1 Roadside Bioretention with Flow Routing (Green Infrastructure Project)

Roadside bioretention with flow routing consists of constructing bioretention facilities within the planter area of the ROW to capture and infiltrate runoff in a shallow landscaped depression (a.k.a. natural drainage systems or NDS). Where infiltration hazards did not exist and infiltration potential was considered to be high, these practices would be designed to capture the water quality event for infiltration into native soils. Where site condition constraints existed, underdrains were assumed, either directing flow to an underground injection control (UIC) or an orifice control outlet. Where space or slopes considerations were more challenging, vertical walls and/or use of weirs was assumed.

2.2.4.1.2 Biofilter Wetland Channel with Bioretention Elements (Green Infrastructure Project)

Biofilter wetland channels consist of a sloped vegetated channel that filters runoff as it flows through the vegetation to an outlet. An example of this type of design includes the Swale on Yale project. These practices are enhanced to provide additional flow retention through storage, infiltration, and evapotranspiration by adding underlying bioretention soils. Biofilter wetland channels typically include an upstream flow splitter to bypass high flows around the channel to avoid resuspension of captured pollutants and typically have a smaller footprint than bioretention facilities and therefore provide reduced flow retention. A pretreatment BMP such as a swirl concentrator may also be included upstream of the biofilter wetland channel.

2.2.4.1.3 Extended Detention Basins

Extended detention basins are a more traditional method of stormwater management intended to provide flow control through temporary storage, and to provide some water quality benefit through settling and biological processes. This type of stormwater project is expected to provide minimal volume reduction, as there is little opportunity for infiltration or evapotranspiration.

2.2.4.2 Projects Evaluated without Flow Routing (NDS Partnering)

Social and technical considerations can limit the opportunity for solutions with flow routing. Additionally, addressing polluted runoff at the source allows addressing other utility or agency goals (e.g., local conveyance and sidewalks). Projects such as the NDS Partnering (Piper's, Longfellow, and Thornton Creeks) were planned to maximize overlap with other agency or community goals. Project blocks would be prioritized through a community engagement process.

This type of stormwater project focused on the most cost-effective of the NDS practices for ROW application, bioretention. Each stormwater project block was planned to be designed to provide stormwater conveyance improvements within the block with bioretention cells installed at the lower portion of the block to manage the runoff flow reaching that block. For the analysis of this stormwater project, runoff was assumed to be the project block only; future refinements of this project were anticipated to reflect the increased loading when the upstream drainage area is routed to the project street (for example, a block that currently has a ditch and culvert system).

2.2.4.3 Basin-Scale Feasibility Screening

Stormwater projects identified for consideration in creek watersheds were screened within each individual priority basin by developing map atlases, identifying opportunities and constraints, and conducting a screening workshop.

If a stormwater project was able to be sited only within a low-priority site, as defined above, those projects were not put forward as prioritized projects. This was the case for all the considered extended detention pond options.

NDS-related projects were all identified within high-priority sites, specifically in the City's ROW. Opportunities for NDS-related projects were prioritized based upon their generally accepted technical feasibility. Sites where infiltration is restricted due to generally accepted geotechnical information of the site were excluded. Primary NDS-related project suitability was determined by excluding sites with the characteristics outlined below.

2.2.4.3.1 Areas Unsuitable for Infiltration (AUI)

This includes the following and designates any land parcel as an AUI if at least 5 percent of its area is unsuitable for infiltration, which is determined by evaluating the following components:

- steep slopes (greater than 40 percent) with less than 100 feet of an uphill buffer from the stormwater project site
- potential for landslides within 500 feet down gradient of the project site (landslides are based on known landslide events from City records, including those in the ROWs and private property)
- confirmed and suspected contaminated sites, including:
 - leaking underground storage tank (LUST) sites
 - other known or suspected sites/plumes
- landfills located within 100 feet of the project site
- bedrock near the land surface
- groundwater near the land surface

2.2.4.3.2 ROW Considerations

The minimum available “planting strip” width must be at least 10 feet (for both sides of the street added together). This was determined by calculating “available ROW width,” which was calculated by subtracting the required roadway width and the curb width from the total required ROW width. The formula is as follows:

$$\text{Available ROW} = \text{Required ROW} - (\text{Required Roadway Width} + (\# \text{ of curbs} * 6.5 \text{ feet}))$$

- Required ROW is specified in the Seattle Department of Transportation (SDOT) ROW Improvements Manual. Arterial widths or the minimum street ROW are derived from Figure 3.1.1b (SDOT, on-line ROW Improvements Manual).
- Curb counts is the number of curbs for the street segment with possible values of 0, 1, or 2, and No Data receiving zero curbs. Each curb receives 6 feet for sidewalk and 0.5 foot for curbs.

2.2.4.3.3 Street Slope Considerations

Street slope is the percentage slope of the roadway segment with the optimum range for horizontal treatment systems, being 0 to 4 percent. Sites with 0 to 7 percent slopes were also considered potentially feasible.

2.2.4.3.4 Areas Mitigated by NDS

Areas already partially or fully managed by previous retrofit capital improvement projects (CIPs) were excluded from the evaluation for installing new potential stormwater projects. Although there are potential project opportunities and an ability to further improve water quality and/or water quantity objectives, a focus was placed on areas with limited or no improvements.

For NDS-related projects with flow routing, the Integrated Planning project team also reviewed the City’s Planning, Analysis, Coordination Tool (PACT) database, and using GIS and Google Earth, evaluated available widths, sidewalks, informal drainage systems, areas of high pollutant loads (e.g., arterials), and City priority areas in order to identify opportunities to locate water quality improvement projects to provide additional benefits with minimal infrastructure improvement costs. General considerations for stormwater project refinement included:

- facilities that were not located on arterials, but that however would ideally receive runoff routed from a nearby arterial to maximize pollutant reductions
- streets with informal drainage systems (i.e., no curb) were preferred.

Specific considerations were given for bioretention facilities where an underdrain was included where the infiltration potential was considered low or medium, as follows:

- Potential for UIC wells was determined from the map atlases, based on elevation in the basin relative to nearby surface water or known shallow groundwater.
- Sufficient space was provided in the ROW to accommodate the required sizing factor for water quality.

Specific considerations were given for biofilter wetland channels (with bioretention elements) facilities and included that a project would be considered infeasible where sufficient uninterrupted longitudinal flow (i.e., presence of driveways) was unavailable.

CHAPTER 3

References

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Appendix D: Expert Panel for the Integrated Plan

This appendix contains the information on the Expert Panel and the meeting minutes notes.



Protecting Seattle's Waterways

Volume 3 – Integrated Plan

Appendix D: EXPERT PANEL FOR THE INTEGRATED PLAN

Final

May 29, 2015



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List of Abbreviations

Term	Definition
BMP	best management practice
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
City	City of Seattle
CSO	combined sewer overflow
District	Northeast Ohio Regional Sewer District
EA	environmental assessment
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
IRIS	Integrated Risk Information System
NACWA	National Association of Clean Water Agencies
NPDES	National Pollution Discharge Elimination System
USGS	U.S. Geological Survey

Background

The City of Seattle (City) worked with a five-member Expert Panel during the development of the Integrated Plan. The role of the Expert Panel was to provide input on the data, methods, and assumptions used to develop the Integrated Plan. The Expert Panel acted as a technical sounding board for the City, reviewing and commenting on technical questions and issues relevant to the methodology developed and implemented. The Expert Panel was not involved in the selection of the stormwater projects included in the Integrated Plan. The process included participating in three face-to-face meetings and three group conference calls, as well as reviewing technical materials provided by the City before and after meetings during March through October 2013. The Expert Panel summarized its notes in a letter to Ray Hoffman (see Attachment D-1 to this appendix). The observations made at each Expert Panel meeting and call were documented (see Attachment D-2 to this appendix).

Expert Panel Members

The Integrated Plan Expert Panel consists of five members appointed by Seattle Public Utilities Director Ray Hoffman. Panelists represent a diverse set of perspectives with technical expertise in the following areas:

- receiving water quality: Bob Gearheart, Ph.D., PE
- effects of urbanization on stream water quality and morphology: Derek Booth, Ph.D., PE, PG
- managing large wet weather programs: Kyle Dreyfuss-Wells
- effectiveness of best management practices (BMPs): Bob Pitt, Ph.D.
- human exposure: Jean Zodrow, Ph.D.

Bob Gearheart, Ph.D., PE, Panel Chair

Bob Gearheart is a Professor Emeritus at Humboldt State University in Arcata, California. Dr. Gearheart teaches courses in environmental impact assessment, hazardous waste management, and water quality management. Dr. Gearheart is an international expert on water quality, wetlands, and wastewater treatment. Dr. Gearheart is involved with the development of Arcata's Integrated Wetland and Wastewater Treatment Facility and the Arcata Marsh. The Arcata Marsh serves as a sewage treatment plant, recreation area, wildlife sanctuary, and aquaculture project. He is also involved with a number of public- and private-sector agencies providing support for water supply facilities in developing countries, such as Indonesia, Kenya, Ghana, and Sierra Leone.

Dr. Gearheart's area of expertise is water quality and wastewater treatment. He was included in the Expert Panel to provide input on fate and transport assumptions and water quality of local receiving waters.

Derek Booth, Ph.D., PE, PG

Derek Booth is an Adjunct Professor at the Bren School of Environmental Science and Management, University of California Santa Barbara, in Santa Barbara, California. Dr. Booth is also President of Stillwater Sciences, a 60-person environmental consulting firm in California, Oregon, and Washington. He has studied geomorphology, hydrology, and watershed management for the past 30 years. His publications include more than 40 peer-reviewed articles, 26 U.S. Geological Survey (USGS)-published geologic maps, more than a dozen book chapters, and the National Research Council's 2009 report, *Urban Stormwater Management in the United States*, which he coauthored.

His area of expertise is the impact of urbanization on streams. He was included on the Expert Panel to provide input on the effects of urbanization on stream water quality and morphology.

Kyle Dreyfuss-Wells

Kyle Dreyfuss-Wells is the Manager of Watershed Programs for Northeast Ohio Regional Sewer District (District) in Cleveland, Ohio. Ms. Dreyfuss-Wells leads the District's watershed management efforts across District programs, including implementation of the Regional Stormwater Management Program to provide innovative options to address the flooding, erosion, water quality, and infrastructure needs of the region; the application of stormwater control measures to combined sewer overflow (CSO) control through the District's green infrastructure program; and implementation of stormwater management and stream restoration projects across the District's 62 Member Communities. She is chair of the National Association of Clean Water Agencies' (NACWA) Stormwater Management Committee and Vice Chair of the Urban Water Sustainability Council of the U.S. Water Alliance.

Ms. Dreyfuss-Wells area of expertise is managing large wet weather programs. She was included on the Expert Panel to provide input on municipal wet weather management programs.

Bob Pitt, Ph.D.

Bob Pitt is the Cudworth Professor of Urban Water Systems in the Department of Civil, Construction and Environmental Engineering at the University of Alabama in Tuscaloosa, Alabama. Dr. Pitt has conducted research for the U.S. Environmental Protection Agency (EPA), Environment Canada, Ontario Ministry of the Environment, states, and local governments concerning the beneficial uses, effects, sources, and control of wet weather flows for more than 35 years. He has also been involved in a number of projects that have used this research information to develop management plans, stormwater ordinances, and design manuals. Dr. Pitt has also conducted research for the EPA to develop and test procedures to recognize and reduce inappropriate discharges of wastewaters to separate storm drainages. These procedures are being used by municipalities involved in the Clean Water Act's stormwater permit program as a field screening technique to identify and quantify discharge sources. Dr. Pitt has evaluated the effects of municipal, industrial, and nonpoint water pollution discharges on receiving water quality and beneficial uses, including model development.

Dr. Pitt's area of expertise is stormwater quality and stormwater BMPs. He was included on the Expert Panel to provide input on issues related to the effectiveness of BMPs in removing pollutants.

Jean Zodrow, Ph.D.

Jean Zodrow is a Project Toxicologist at ARCADIS U.S., Inc., in Lakewood, Colorado. Dr. Zodrow has more than 7 years of experience as a toxicologist/ecological risk assessment expert for EPA, where she prepared biological evaluations for National Pollution Discharge Elimination System (NPDES) permit reviews, managed Integrated Risk Information System (IRIS) toxicological reviews, and performed Endangered Species Act (ESA) Section 7 consultations both for oil and gas exploration and mining activities and for wastewater treatment plant discharges. Dr. Zodrow has also contributed to environmental assessments (EAs) and environmental impact statements (EISs) where impacts to water quality were critical concerns and provided oversight of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) ecological risk assessments.

Dr. Zodrow's area of expertise is exposure analysis. She was included on the Expert Panel to provide input on the exposure assessment.

Expert Panel Recommendations

During the project calls and meetings, the Expert Panel provided input on the City's data, methods, and assumptions. The observations made at each Expert Panel meeting and call were documented in meeting summary notes (see Attachment D-2 to this appendix). The Expert Panel summarized these notes in a letter to Ray Hoffman (see Attachment D-1 to this appendix). One of the recommendations regarding utility curves was not applicable to the Integrated Plan. This is explained in Attachment D-3 to this appendix.

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Attachment D-1: Expert Panel Comments and Recommendations Letter

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November 12, 2013

Ray Hoffman, Director
Seattle Public Utilities
700 Fifth Avenue, Suite 4900
PO Box 34018
Seattle, WA 98124

Subject: Expert Panel Comments and Recommendations on the Integrated Plan

Dear Mr. Hoffman:

Thank you for providing us the opportunity to participate in the Expert Panel for Seattle Public Utilities' (SPU) Integrated Plan. We appreciate the opportunity to provide technical input on the methodology that SPU is planning to use for its Integrated Plan. This plan will be submitted to the U.S. Environmental Protection Agency and the Washington State Department of Ecology as part of SPU's Long Term Control Plan (LTCP) for controlling combined sewer overflows (CSOs). The Integrated Plan is an important effort for the City of Seattle (City). It allows the City to evaluate the relative water quality benefits of a variety of alternative stormwater and CSO control projects. Based on this evaluation, the City is planning to request from its regulators the ability to invest in projects that will likely produce significantly better water quality outcomes for the community while meeting or exceeding the overall intent of regulatory requirements.

Role of the Expert Panel and the Integrated Plan Option in the City's Consent Decree

Our role as the Expert Panel was to provide input on the data, methods, and assumptions that SPU is using to develop the Integrated Plan. We acted as a technical sounding board for SPU, reviewing and commenting on technical questions and issues relevant to the methodology. We did not, however, review or comment on SPU's potential decisions about final project selection. Our process included participating in three face-to-face meetings and three group conference calls, as well as reviewing technical materials provided by SPU before and after meetings. The observations that we made at each of the Expert Panel meetings and calls were documented in summaries of those meetings (attached).

As outlined in the City's consent decree, which was lodged on July 3, 2013, the City may propose alternative water quality improvement projects (stormwater projects) in the Integrated Plan that will result in significant benefits to water quality beyond those that would be achieved by implementing the approved CSO control measures only. The City would proceed with these stormwater projects and defer selected CSO control measures that it determined would result in significantly less benefit to water quality than would the stormwater projects. The CSO control measures selected for deferral are referred to as "low-benefit CSO control measures." If the Integrated Plan is approved, the City would defer implementation of these low-benefit CSO control measures until after 2025 and then implement both

the stormwater projects proposed in the Integrated Plan and the higher benefit CSO control measures in the LTCP by 2025. Regardless of the stormwater and CSO control projects the City implements, the City must meet Clean Water Act and Washington Water Pollution Control Act requirements.

We understand that the City has a long history of CSO and stormwater control research and implementation, and that SPU has controlled most of the CSO volumes under its jurisdiction. Seattle has reduced its annual CSO discharge volumes by more than 99 percent, from an estimated 20 to 30 billion gallons in the 1960s to 154 million gallons in 2012. SPU also has a stormwater management program that manages 6,400 million gallons per year of runoff volume. This history of CSO and stormwater control research and implementation in the City provides context for understanding the range of alternatives that SPU is considering for the Integrated Plan.

Work Completed on the Integrated Plan and Discussed with the Expert Panel

Our understanding is that SPU and the Integrated Plan consultant teams have completed the following work to date on the Integrated Plan:

- Identified low-priority CSO control projects that address low-volume, low-frequency CSOs (i.e., nearly controlled) to consider for deferral in the Integrated Plan.
- Identified potential stormwater pollution control projects to consider for inclusion in the Integrated Plan through a process that examined receiving water body rankings, pollutant and flow estimates, and the cost-effectiveness of different treatment alternatives within each basin.
- Selected representative constituents of concern (RCOCs) for the pollutants identified in the consent decree.
- Estimated the pollutant load reductions that would be attained from the CSO projects to be deferred using calibrated hydrologic and hydraulic models of the combined sewer system.
- Estimated the pollutant load reductions that would be attained from the stormwater projects (other than street sweeping) based on information about volume, land use, and best management practice effectiveness.
- Developed estimates of pollutant load reductions from street sweeping projects based on information about pickup rates and sample concentration data from past sweeping efforts, anticipated curb-miles swept, and local studies about washoff pollutant loads and concentrations.
- Conducted a relative assessment of the effects of the stormwater and CSO projects on exposure to ecological receptors and exposure to human health receptors (considering acute exposure to bacteria separately from chronic exposure to toxic pollutants).
- Identified criteria—including criteria for positive environmental outcomes, social good for the community, external drivers, technical feasibility, and life-cycle cost—to use to evaluate projects through multi-objective decision analysis (MODA) to select the final set of stormwater and CSO projects in the Integrated Plan.

Observations and Recommendations

Based on the information provided to us, our major observations about the Integrated Plan methodology, data, and assumptions include the following:

- The results of SPU's analysis show that the stormwater projects SPU is considering for the Integrated Plan, in part or in whole, provide significant net benefits to receiving water quality compared to the CSO projects SPU may propose to defer.
 - The considerable difference in discharge volume reductions of the stormwater projects compared to the CSO projects drives much of these benefits.
 - We believe SPU can create a set or sets of stormwater projects that yield significantly better water quality outcomes than the set of CSO projects to be deferred, even though any individual CSO project to be deferred may provide modestly greater benefit for one or a few of the water quality parameters relative to one or a few of the individual stormwater projects.
- SPU has based its methodology for the exposure assessment on standard procedures for ecological risk assessment, and enhanced those procedures based on project-specific data and assumptions relevant to the task of creating relative exposure assessments. We explored this methodology in some detail in our meetings, and believe it is reasonable but operationally complicated. The complexity derives from the number of assumptions and subjective scaling factors that are necessary to incorporate the available data and conduct a relative assessment of the effects of the proposed projects on exposures to ecological and human receptors.
- We reviewed SPU's methodology for estimating the pollutant load reductions from street sweeping projects specifically, and believe that SPU's approach to the methodology, use of data, and assumptions is reasonable. We also believe that it is important for SPU to characterize the uncertainty in its estimates for street sweeping projects.
- In SPU's analysis of the differential benefits from projects, we believe it is important to consider not only the magnitude of pollutant load reduction benefit or exposure reduction benefit from projects, but also the importance of those changes. For example, depending on how ranges are normalized in the analysis, changes that occur at or near ecological and/or human health thresholds could appear to be equivalent to similar magnitude changes that occur far from those regulatory thresholds, even though the relative "importance" of those changes differs.
- We appreciate that SPU has highlighted areas of uncertainty and data gaps in its analysis thus far. We believe it will be important to appropriately document these data gaps, areas of uncertainty, and confidence intervals in the Integrated Plan and supporting materials.
- Overall, we feel that SPU and the consultant team used an innovative, scientifically sound, and understandable approach to evaluating stormwater and CSO projects in the Integrated Plan according to the consent decree requirements, and that this approach has thus far produced results that are defensible and reasonable.

- We also believe that future integrated planning processes in other jurisdictions need not be as extensive, exhaustive, or complicated as this to make these types of decisions. However, because SPU is leading nationally on integrated planning, we agree that such a robust approach was worthwhile here.

Our recommendations to SPU for the Integrated Plan include the following:

- While it is important to articulate the uncertainty inherent in an analysis such as SPU has done, the focus on uncertainty should not obscure the overall message that the stormwater projects to be proposed in the Integrated Plan are expected to produce significantly greater reductions in pollutant loads and exposures to human and ecological receptors than the CSO projects to be deferred.
- In the final selection of stormwater projects for the Integrated Plan, we understand that SPU is considering the tradeoffs between potentially competing objectives through a systematic multi-objective decision analysis (MODA) process. We believe that this analysis would be stronger if it incorporated the concept of utility curves, which would allow normalization of the units and which would consider non-linear cause-and-effect relationships in the MODA criteria. If SPU does not choose to use utility curves in this analysis, it should document its rationale for this decision.
- Post-construction monitoring of the performance of the CSO and stormwater projects in the Integrated Plan will be important to demonstrate the projects meet consent decree requirements. SPU should also use post-construction compliance monitoring to address uncertainties and data gaps in its analysis and add to the stock of knowledge associated with the stormwater best management practices, including street sweeping. Performance monitoring of areas likely to be affected by the planned CSO and stormwater projects should begin as soon as feasible to provide a useful “before implementation” baseline for subsequently evaluating project effectiveness.

Upon reflection about the transferability of this approach to other jurisdictions that are considering the development of an Integrated Plan, we offer the following observations:

- The analysis that SPU and its consultant team conducted was applied to a specific set of high-value stormwater projects compared to a specific set of low-priority (low-frequency/low-volume) CSO projects. This set of projects was specific to Seattle, but a different suite of CSO and stormwater projects, both in Seattle and in other communities, would not necessarily demonstrate similar anticipated water quality benefits. As a result, communities across the country can learn a great deal from the structure of SPU’s analysis but must realize that the implementation in each community will be specific to their unique history, land use, governance, and other factors.
- While it is important to carefully examine and document the comparative water quality benefits of CSO and stormwater projects through Integrated Planning processes, we do not believe that other communities will necessarily need to conduct the same level of analysis or data utilization to demonstrate differences in anticipated water quality benefits. In particular, the data analysis should not need to be as complicated, exhaustive, or costly to make these types of decisions about the comparative water quality benefits of projects. It may also be appropriate for other communities to

evaluate significant benefits differently, such as by considering co-benefits from stormwater projects and/or the cost-effectiveness of projects.

- The MODA criteria will always be jurisdiction-specific and should not be “exported” elsewhere without careful consideration of their local applicability and need. Excess attention to these ancillary considerations may risk losing sight of the primary purpose of an Integrated Plan, namely to achieve greater improvements in water quality more rapidly and at reduced cost.

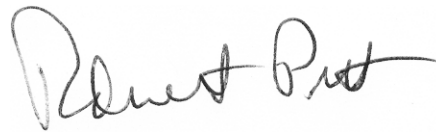
We look forward to hearing how SPU uses the methodology we have reviewed to select projects for the Integrated Plan and to document how the projects meet the consent decree requirements. Please keep us informed as SPU selects stormwater and CSO projects for the Integrated Plan and as the LTCP and Integrated Plan go through review by the regulatory agencies.

We appreciate the opportunity to assist SPU in its development of the technical methodology for its Integrated Plan.

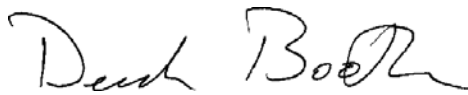
Sincerely,



Robert Gearheart, Ph.D., P.E., Chair
*Professor Emeritus, Humboldt State University,
Arcata, CA*



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Kyle Dreyfuss-Wells
*Manager of Watershed Programs, Northeast
Ohio Regional Sewer District, Cleveland, OH*

CC: Nancy Ahern, Deputy Director, Utility Systems Management, SPU
Andrew Lee, CSO Program Manager, SPU
Kevin Buckley, Integrated Plan Project Manager, SPU

Enclosures

Attachment D-2: Expert Panel Meeting Summaries

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Seattle Public Utilities Integrated Plan Expert Panel

Meeting (Call) #1, March 14, 2013

Call Summary

Call Objectives

- Review and clarify the purpose and responsibilities of Expert Panel members
- Answer questions about SPU's Stormwater and CSO Programs and the Integrated Plan option in SPU's Consent Decree
- Discuss the scope of the Expert Panel's discussions, including questions the Expert Panel will be asked to consider
- Review upcoming meeting plans and identify next steps

Summary

Opening Remarks

- Kevin Buckley of Seattle Public Utilities (SPU) welcomed members of the Expert Panel. He described the importance of the Integrated Plan as an opportunity for Seattle, and noted that the methodology also could be used to evaluate stormwater projects in the future.
- Bob Gearheart, the Expert Panel chair, also welcomed the group and thanked members for their participation.

Schedule for the Expert Panel and Integrated Plan

- The Integrated Plan is being developed along with the combined sewer overflow (CSO) Long Term Control Plan (LTCP), a draft of which is due to EPA and the Washington State Department of Ecology in May 2014 (final in May 2015).
- The Integrated Plan has a similar process to the LTCP and the same final deadlines but the work on the Integrated Plan started much later.
- During the development of the LTCP and Integrated Plan SPU is doing quarterly updates with EPA and the Washington Department of Ecology as well as public outreach and engagement activities.
- The Expert Panel will be meeting at least three more times this summer and fall, as follows.
 - **Expert Panel Meeting #2 (April 29, in Seattle):** This meeting will include a review and discussion of the pollutant estimating methodology and a discussion of how SPU is planning to use the existing data in its analysis.
 - **Expert Panel Meeting #3 (June, in Seattle):** This meeting will feature a discussion of the technical evaluation criteria SPU plans to use in the Multi-Objective Decision Analysis (MODA).
 - **Expert Panel Meeting #4 (September, potentially via web-enabled teleconference):** This meeting will review and discuss how SPU has evaluated selected CSO and stormwater projects using the technical evaluation criteria.

Expert Panel Charter Discussion

- Facilitator Bill Ross reviewed the main components of the Draft Charter for the Expert Panel with the group, including the focus on providing input on the technical methodology and data for estimating the environmental benefits from CSO and stormwater projects. SPU will be using the technical methodology, along with other factors (such as cost benefit), to make decisions about stormwater projects to include in the Integrated Plan and which CSO projects to defer.
- He noted that the objective for this group is not consensus, since the Expert Panel won't be making decisions; however, to the extent that panel members differ in their views, these will be recorded.
- Expert Panel meetings will be open to members of the public.
- The Expert Panel members did not have any questions or concerns about the charter.

Questions about SPU's Stormwater and CSO Programs, and the Integrated Plan

- Trish Rhay of Seattle Public Utilities thanked the Expert Panel members for their participation and the opportunity to help Seattle potentially develop the first Integrated Plan in the nation.
- She said that she hoped the Integrated Plan would help SPU work in all areas of its system—the combined sewer system, the fully separated system, and the partially separated system, each of which represents a third of the geographic area of the city.
- The Expert Panel asked questions of SPU about the background video presented by Trish Rhay and SPU's consent decree. The responses were as follows.
 - o **LTCP and Integrated Plan Approach:** In the LTCP, SPU must control overflows to one overflow event per outfall per year by 2025. With the Integrated Plan, the compliance deadline for getting some CSO outfalls to meet that one overflow per year state standard can be later, and it allows SPU to invest in stormwater projects that will provide greater water quality benefits before 2025. It does not change the level of control (quality or frequency) for CSOs, only the compliance schedule.
 - o **Deferred CSO Projects:** SPU will still implement the highest priority CSO projects, including the "big three" on Lake Washington. There are 5-10 projects that are being considered for deferral in the Integrated Plan.
 - o **Relation of Stormwater and CSO Projects in Integrated Plan:** The consent decree does not specify the relationship of the deferred CSO projects and the stormwater projects in the Integrated Plan (e.g., proximity, receiving water body).
 - o **Expert Panel Not in Consent Decree:** The Expert Panel is not mentioned in the consent decree. It was SPU's idea to have an Expert Panel to provide a check on the methodology for showing the difference in environmental benefit between projects.
 - o **Stormwater Project Parameters:** The stormwater projects will not have to meet specific parameters. SPU is focusing on projects that will show the significant relative difference in pollutant loading reductions between the deferred CSO projects and the stormwater projects, as well as other requirements in the consent decree.

Scope of the Expert Panel's Discussion – Review of Questions for the Panel

- The Expert Panel reviewed and discussed the document, "Questions for the Expert Panel," and the section of SPU's consent decree that focuses on the Integrated Plan, pages 15-19. Highlights of this discussion include:

- o The key pollutants and parameters for which the Expert Panel will be advising SPU on how to evaluate CSO and stormwater projects on are listed on page 16 of the consent decree.
- o For some of these pollutants (e.g., toxic organic compounds), the data are not available, so it will be necessary to identify appropriate surrogates.
- o Several of the Expert Panel members indicated an interest in a presentation on MODA. Some indicated experience using MODA, but not commercial software for it.
- o The regulatory agencies will be briefed about the MODA analysis and the Expert Panel's work as part of the quarterly meetings. They also will be invited to the Expert Panel meetings and likely will follow the Expert Panel's discussions closely.
- o Expert Panel members noted that the transparency of the Expert Panel process to the regulatory agencies and the public will be very important.

Next Steps

- The **next Expert Panel meeting** will be on **Monday, April 29, 2013**, in Seattle.
 - o The materials for the April meeting will include a summary of the available data and how it will be used in the evaluation methodology.
 - o Materials for meetings will be provided to Expert Panel members at least a week in advance to allow for review.
 - o If panel members have questions about materials they'd like to have addressed, please let the facilitation team (Bill Ross or Jennifer Tice of Ross Strategic) know, so we can ensure that the appropriate technical staff are present at the meeting.
- The June and September Expert Panel meetings will be scheduled soon.
- A briefing on MODA will be scheduled for sometime before the June meeting.

Participants

Name	Organization
Expert Panel Members	
Bob Gearheart, Chair	Humboldt State University (Professor Emeritus)
Derek Booth	University of California Santa Barbara
Kyle Dreyfuss-Wells	Northeast Ohio Regional Sewer District
Bob Pitt	University of Alabama
Jean Zodrow	ARCADIS U.S., Inc.
Other Participants	
Kevin Buckley	Integrated Plan Project Manager, Seattle Public Utilities
Trish Rhay	Drainage and Wastewater Division Director, Seattle Public Utilities
Mike Milne	Brown and Caldwell
Eric Strecker	Geosyntec Consultants
Bill Ross	Ross Strategic
Jennifer Tice	Ross Strategic

Seattle Public Utilities Integrated Plan Expert Panel

Meeting #2, April 29, 2013

Meeting Summary

Participants

The second meeting of Seattle Public Utilities (SPU) Integrated Plan Expert Panel was attended by the five Expert Panel members, SPU managers and staff, consultants, and observers. The audience consisted largely of SPU staff and technical consultants. A full list of attendees is at the end of the summary.

Name	Organization
Expert Panel Members	
Bob Gearheart, Chair	Professor Emeritus, Humboldt State University, Arcata, CA
Derek Booth	Adjunct Professor, Bren School of Environmental Science and Management, University of California Santa Barbara, Santa Barbara, CA
Kyle Dreyfuss-Wells	Manager of Watershed Programs, Northeast Ohio Regional Sewer District, Cleveland, OH
Bob Pitt	Cudworth Professor of Urban Water Systems, Department of Civil, Construction, and Environmental Engineering, University of Alabama, Tuscaloosa, AL
Jean Zodrow	Project Toxicologist, ARCADIS U.S., Inc., Lakewood, CO
SPU and Consultant Participants at the Table	
Kevin Buckley	Integrated Plan Project Manager, SPU
Ray Hoffman	Director, SPU
Trish Rhay	Drainage and Wastewater Division Director, SPU
Mike Milne	Integrated Plan Consultant Team Project Manager, Brown and Caldwell
Bill Ross	Expert Panel Facilitator, Ross Strategic

Meeting Objectives

The objectives for the Expert Panel meeting included:

- Review and gather Expert Panel feedback on SPU's proposed methodology for evaluating the potential water quality impacts of stormwater and combined sewer overflow (CSO) projects, including whether it seems appropriate given the consent decree requirements and available data.
- Collect Expert Panel feedback on proposed approaches to using data in the methodology, including proposed metrics and representative constituents of concern for evaluation.
- Identify additional available data or data sources that could help SPU and the technical team to refine and improve the proposed methodology and analysis of stormwater and CSO projects.
- Review upcoming meeting plans and identify next steps.

A summary of the meeting discussions, organized by the agenda topic, is below. Key themes from the meeting are not attributed to individuals, but comments pertaining to individual sessions are attributed.

Summary

Opening Remarks

- SPU Director Ray Hoffman welcomed the Expert Panel and thanked members for their participation. He described the challenges Seattle is facing, including stormwater runoff, CSOs, climate change, urban streams, and a landscape that is 65 percent impermeable surfaces.
- He noted that SPU had just signed its consent decree, and has an opportunity to do an Integrated Plan, which could potentially be a model for other jurisdictions. He said the Expert Panel would be important in helping SPU with the Integrated Plan.

Key Themes from the Expert Panel's Comments

Throughout the meeting, Expert Panel members commented on SPU's proposed methodology for evaluating stormwater and CSO projects, including the use of available data and the multi-objective decision analysis (MODA) process. The following were key themes from these comments and notes about SPU's responses (individual comments and responses are also included later in the summary):

- SPU should provide information on the process and criteria it used to identify projects for consideration for the Integrated Plan, including any "fatal flaw" screening criteria and the locations of projects, as this is an important part of the project evaluation.
 - SPU Response: The Integrated Plan team is preparing a memorandum on the selection criteria that were used to help the team identify projects for consideration as part of the Integrated Plan. In general, the criteria were developed to help the team identify a list of potential projects that would meet the objectives established by the Integrated Plan, focus on receiving water bodies with water quality impairments, fit into the existing built-out environment, and provide reasonable assurance that the list of potential projects can be constructed by 2025.
- It is not clear how SPU plans to consider and evaluate benefits from projects other than pollutant load reductions and other criteria listed in the consent decree. Expert Panel members recommended that co-benefits from projects, including habitat improvements, be considered. Furthermore, some Expert Panel members expressed concern that the proposed methodology for the CSO and stormwater project evaluations could become a matter of "dueling spreadsheets" and might ignore other important factors that do not lend themselves well to quantitative comparisons.
 - SPU Response: Benefits in addition those identified in the Consent Decree will be considered as part of the MODA that SPU will use to help inform the decision process for selection of stormwater projects to propose and the identification of CSO projects to defer in the Integrated Plan. SPU will be discussing these benefits and the technical criteria for the MODA evaluation of stormwater and CSO projects with the panel members at the June 25th meeting.
- Verification monitoring, including pre-project monitoring and monitoring of receiving water quality, is important to show whether projects achieve their goals and to reduce uncertainties.
 - SPU Response: SPU will consider this input as it plans the monitoring that will be proposed as part of the Integrated Plan. Monitoring for the Integrated Plan will include a post-project monitoring plan.

- It is important that the proposed metrics match the projects (both CSO and stormwater) that are being considered, and that the proposed analytic methods match the data being evaluated (e.g., the nomographs relate to the devices).
 - o SPU Response: SPU agrees that the proposed metrics for evaluating CSO and stormwater projects should be appropriate for both types of projects. The purpose of the nomograph approach is to bracket the (hydrologic and hydraulic) performance of best management practices (BMPs). The nomographs are one way to represent the uncertainty in performance expected in modeling. The performance range for the nomographs will be geared to the BMPs being considered.
 - o Care must be given to how these performance ranges are used in generating output that will then be compared with the metrics. The list of proposed metrics will be refined in the coming weeks as the technical team better understands the data going into the model and the stormwater projects being considered versus the CSO projects. For example, a stormwater project is usually designed to capture higher frequency, low-intensity storm events while a CSO project is designed to capture low frequency, but higher intensity storm events, so simply comparing reduced frequency of occurrence between the two types of projects is not a fair comparison. Other metrics may be considered, such as volume reduction or phosphorus reduction, as more appropriate comparisons between projects. SPU and the technical team will update the Expert Panel as this list of metrics is refined.

Overview of Approach to CSO and Stormwater Project Evaluation

- Mike Milne of Brown and Caldwell and Kevin Buckley of SPU gave a presentation that provided an overview of SPU's approach to the evaluation of CSO and stormwater projects in the Integrated Plan. This included:
 - o The consent decree requirements for analyzing pollutant load reductions and describing reductions in exposure
 - o The process SPU used to prioritize receiving water bodies for the purpose of selecting locations for stormwater projects
 - o The overall evaluation process, from the ranking of water bodies and selection of candidate stormwater and CSO projects to the analysis of those projects and alternative combinations using the multi-objective decision analysis (MODA) process
 - o An overview of the work completed to date to compile data and develop evaluation methods
- SPU manages a stormwater system that has 6,400 million gallons of stormwater runoff annually, and a combined sewer system that discharged 154 million gallons of CSOs in 2012.

Expert Panel Comments and Responses

Scope/Criteria for the Project Evaluation:

- Derek Booth and Bob Pitt asked whether the project evaluation was only focused on pollutant loads. Derek Booth expressed concern that the analysis would only cover chemical loads rather than other benefits such as habitat improvements from stormwater projects. Kyle Dreyfuss-Wells added that many of those other benefits are not part of the consent decree.

- o Mike Milne and Rob Annear of the technical team responded that pollutant loads are important, but SPU would also look at exposure, frequency, duration, flow, volume, and other issues.
- Kyle Dreyfuss-Wells noted that co-benefits from stormwater projects need to be considered as part of the analysis.
- Bob Gearheart asked about the relationship of the pollutant load evaluation and Total Maximum Daily Loads (TMDLs).
 - o Technical team members noted that the pollutant load evaluation of projects for the Integrated Plan is separate from looking at the assimilative capacity of water bodies; however, the Integrated Plan analysis (and associated information from the Integrated Plan) could help with TMDL efforts in the future.

Comments on the Basin Ranking and Criteria:

- Bob Pitt asked whether the technical team had considered locations where there had been a lot of work done already.
 - o SPU acknowledged that although most of the “low-hanging fruit” for CSO control had already been addressed, SPU did not consider prior project work in the ranking of basins and initial selection of projects.
- Jean Zodrow asked why certain salmon-bearing streams were rated as not applicable in the basin ranking results.
 - o SPU clarified that the ranking focused on federally listed threatened and endangered species, which wouldn’t capture the problems with pre-spawn mortality of coho salmon since coho salmon aren’t a listed species in Seattle.
- Derek Booth noted that the fishable/swimmable criterion for the basin ranking is dependent on the other criteria, rather than a fully separate criterion.

Comments on Stormwater Projects Being Considered and the Comparison to CSO Projects:

- Kyle Dreyfuss-Wells expressed concern about how CSO and stormwater projects were being compared, and noted that it is important that stormwater projects are not asked to solve all issues associated with a watershed.
- Bob Pitt commented on the Consent Decree standard for showing that the stormwater projects are “significantly better” than the CSO projects that will be deferred.¹ He said most communities only need to show that the projects are equivalent or better. Moreover, SPU will also need to consider uncertainty.
- Kyle Dreyfuss-Wells asked about the relationship of the types of stormwater projects SPU is considering and green stormwater infrastructure.
 - o SPU noted that green infrastructure (natural drainage solutions) is part of the city’s code.
 - o Eric Strecker of Geosyntec and Beth Schmoyer of SPU said that many of the solutions are not “green” in part because they occur in areas where there is contaminated sediment, and the Consent Decree has standards for meeting pollutant load removals such as PCBs.

¹ The consent decree language pertaining to this comment is as follows: “the City may submit...a work plan (“Integrated Plan”) that proposes water quality improvement project(s) (“Proposed Project”) to be implemented by the City, provided that the Proposed Project(s) will result in significant benefits to water quality beyond those that would be achieved by implementation of the approved CSO Controls Measures only.”

Terminology and Definitions:

- Bob Pitt recommended that SPU be specific about its terminology and definitions.
 - Based on this comment, SPU and the Integrated Plan team have begun preparing a glossary to address this need.

Discussion of Representative Constituents of Concern for Evaluation and Proposed Metrics for Technical Comparison of Stormwater and CSO Projects

- Eric Strecker of Geosyntec provided an overview of the proposed representative constituents of concern (RCOCs) for evaluation, the data compiled on the RCOCs, the extent of stormwater characterization data and the gaps in that data, and potential metrics to use in comparing stormwater and CSO projects.
 - The stormwater characterization data is from three sites in Seattle with different land uses.
 - He noted that the technical team was continuing to analyze the data it had received. In some cases, the technical team had not yet determined how much data is above detection levels.
 - The technical team is still evaluating appropriate constituents to measure for certain RCOCs, including oil and grease, pesticides, and PBDEs.
 - The candidate metrics for evaluation presented in this session did not include the metrics for the exposure assessment.
- In response to a question, SPU clarified the relationship of SPU's and King County's stormwater and wastewater systems, noting that both agencies have CSOs within the city of Seattle, SPU has responsibility for the majority of stormwater pollution control (for all but two stormwater basins where SPU and King County have MOAs), and SPU's wastewater collection system feeds into King County's regional wastewater treatment system.
- SPU reported that Ecology has recently changed the NPDES Municipal Stormwater permit requirement for monitoring from end-of-pipe monitoring to a regional, Puget Sound-wide monitoring of receiving waters, including marine nearshore and second order streams. Municipalities across Puget Sound (NPDES Phase I and Phase II) pay in to the regional monitoring. The sites were selected randomly across Puget Sound, and this has meant that there is only one site in Seattle.
- Members of the technical team noted that metrics for evaluation could consider peak events, and benefits such as how stormwater projects could reduce peak load and reduce floods.

Expert Panel Comments and Responses

Monitoring:

- After learning about SPU's monitoring of receiving waters, Bob Pitt commented that it would have been better if SPU had conducted monitoring that could show a connection between water quality in the pipes and in the receiving waters.
 - Jonathan Frodge of SPU noted that the best data showing increased body burden of pollutants associated with stormwater are from the National Mussel Watch Contaminant Monitoring program.
- Bob Pitt recommended that SPU start pre-project monitoring soon, and said that verification monitoring was critical.

Comments on RCOCs:

- Bob Pitt cautioned against using five-day biological oxygen demand (BOD) to evaluate stormwater projects, as the analytical method can give distorted results. This is particularly a problem for measuring dissolved oxygen in sediments. The ultimate BOD (or also looking at the chemical oxygen demand, COD) is more accurate than the five-day measure.
 - o Based on this comment, Geosyntec will further investigate how to characterize BOD when ultimate BOD was not measured but five-day BOD was included in the sampling events. There are a few alternatives to address this issue.

Comments on Candidates for Comparison Metrics:

- Bob Gearheart and Kyle Dreyfuss-Wells asked about the sediment issues that were being considered. Legacy sediments will be mobilized in different runoff events.
 - o Eric Strecker said that the evaluation is considering both minimizing recontamination of remediated legacy sediment sites and reducing new sediment loads. The idea is that retrofitting an area will reduce or prevent mobilization of certain sediments.
- Kyle Dreyfuss-Wells noted that it is important for there to be a connection between the projects and the metrics that will be used to evaluate them. It was not clear that some of the projects would have the types of benefits listed. Many of the CSO projects would not have the benefits.
- Derek Booth commented that the “frequency of untreated discharges” metric did not seem appropriate for stormwater projects, and therefore it was not useful for comparing CSO and stormwater projects. He said the benefits from projects come from attributes other than frequency of discharges, and that it would be disingenuous to consider green stormwater infrastructure as “treatment.”
 - o Eric Strecker said that the technical team would work on that metric. He mentioned that one attribute they were considering was volume reduction.

Discussion of Pollutant Estimation Methodology for Stormwater and CSO Projects

- Rob Annear of Geosyntec gave a presentation on the proposed methodology for estimating pollutant loads from stormwater projects. His presentation covered:
 - o Understanding baseline conditions and developing a pollutant load model to estimate average annual runoff volumes, pollutant loads, and pollutant concentrations
 - o The stormwater structural projects and programmatic measures SPU is considering in the Integrated Plan evaluation
 - o The process proposed for estimating and evaluating the expected performance of stormwater projects, factoring in conceptual design parameters, variability, and uncertainty
- He noted that the technical team proposes using pre-processed nomographs for evaluating hydrology and hydraulics (H&H) performance, where possible, rather than facility-specific models.
- Justin Twenter of Brown and Caldwell presented on the technical team’s proposed methodology for estimating pollutant loads from CSO projects. His presentation covered:
 - o The CSO projects SPU is considering to defer as part of the Integrated Plan
 - o Information on the CSO basins from modeling conducted for the long-term control plan (LTCP)
 - o Four potential approaches for evaluating deferred CSO projects: source area evaluation, land-use evaluation, CSO characterization, and/or a hybrid approach

- The 10 potential CSO projects to defer would reduce out of compliance volume by 10 million gallons per year on average.
 - o SPU is doing an environmental impact statement, which will describe the potential impacts of the projects. In general, they will involve local disturbance during construction. For example, SPU needs to find seven storage tanks to control four million gallons of overflow in a waterfront area of Seattle. Green infrastructure projects also can be disruptive (e.g., to parking).
 - o The 10 CSO projects represent about 20 percent of the projects in the long-term control plan.
- Trish Rhay of SPU noted that without the Integrated Plan, all the CSO projects would have to be built by 2025, for a cost of \$500-\$550 million. With the Integrated Plan, SPU can propose to defer some of those CSO projects, proposing other completion dates, and then implement stormwater projects between now and 2025 that could provide greater water quality benefits. SPU is assuming that these stormwater projects would be done without increasing the cost through 2025.
- SPU staff and the technical team noted that because of the requirements of the consent decree for the Integrated Plan, SPU would need to evaluate the CSO projects being considered for deferral according to additional water quality parameters.
- There is not much public reaction to CSOs in Seattle, which mostly occur in the winter. SPU and King County have a website that shows where CSO outfalls are and when they are overflowing.
- Overflows are evaluated on a 20-year rolling average, so if there are 21 overflows at one site in 20 years the CSO is in violation of the one overflow per outfall per year standard. Seattle's NPDES permit is on a five-year window.

Expert Panel Comments and Responses

Selection of Projects for Consideration:

- Derek Booth commented on the projects that SPU had selected for consideration for the Integrated Plan, and asked for more information about the process SPU used to get to the initial list. He thought the Expert Panel could have provided input on that phase of the evaluation.
 - o Kevin Buckley of SPU explained that SPU's process for identifying stormwater projects included prioritizing the basins and looking at the goals for the water bodies, evaluating technologies and green infrastructure options for meeting the goals, estimating the cost per weight of total suspended solids (TSS) removed for the potential solutions, and reviewing the options with management. He noted that SPU selected a list of stormwater projects for the Integrated Plan evaluation that went far beyond the number needed for the Integrated Plan, in order to ensure that there would be a healthy menu of options to evaluate, while not being an overly exhaustive list that would be too time consuming to optimize.
- Kyle Dreyfuss-Wells and Bob Pitt asked about whether the projects were limited to those that were under SPU's control or whether they could include projects with private landowners. In Kansas City, the efforts with private land were done simultaneously to those on public land.
 - o Kevin Buckley and Tracy Tackett of SPU said that there were some constraints on the projects selected, since SPU needed to have assurance that the projects will be completed for the Consent Decree. One of the stormwater alternatives focuses on retrofitting neighborhood blocks for natural drainage; this focuses on the right-of-way, but it could be expanded to include the RainWise program, which affects private property.

- Bob Pitt asked about the street sweeping projects planned, and noted that the current street sweeping efforts could be evaluated for their effects on receiving water quality.
 - o Shelly Basketfield of SPU described Seattle's street sweeping program, and that the projects being considered for the Integrated Plan would increase both the frequency of sweeping and the coverage. SPU is evaluating whether street sweeping is cost-effective in areas that do not have curbs.
 - o Beth Schmoyer of SPU noted that SPU did a mass balance analysis for the street sweeping pilot in 2007-08, but acknowledged the utility does not have stormwater monitoring data.
- Kyle Dreyfuss-Wells asked why green stormwater infrastructure (GSI) / natural drainage solutions were considered part of the CSO projects, not the stormwater projects.
 - o SPU staff said that the GSI projects are viewed differently depending on where they are in the system. Within the CSO area, GSI projects can reduce the volume of CSO overflows or the size of CSO storage facilities.
- Kyle Dreyfuss-Wells also asked whether the City's stormwater monitoring basins contain any stormwater treatment BMPs that could reduce pollutant concentrations in the samples.
 - o Kevin Buckley of SPU replied that the monitored basins have minimal BMPs.
- Bob Pitt suggested that it would be important to know where the potential deferred CSO projects are, and how that relates to where benefits might be gained through stormwater projects. Derek Booth expressed doubt about whether regulators would see a pound of pollutant reduced in Pipers Creek as equivalent to a pound of pollutant reduced in Lake Washington, even though the Consent Decree is not explicit on this issue.
- Bob Pitt, Bob Gearheart, and Derek Booth commented on the high proportions of groundwater shown in the delineation of flow source areas for CSO basins.
 - o Ed Mirabella of SPU noted that the "groundwater" included inflow and infiltration (I&I), and the numbers were from CSO events.
 - o Bob Pitt said that the numbers imply that SPU needs to do more than just address surface water, including I&I reduction efforts. He also asked whether there was any way to validate the constituents in the groundwater.
 - o Derek Booth recommended comparing the modeled groundwater flows for the CSO basins to the groundwater table.

Comments on Proposed Process for Evaluating Projects:

- Bob Pitt noted that a potential problem with nomographs is that they assume a certain device. It is therefore important to include a step to verify that the device fits within the range of data.
 - o SPU and the technical team agree with the comment. Nomographs can be very general or made more site- and device-specific. The team will make sure that either the nomographs are specific to the performance range for a site or will be verified afterwards if a more general nomograph has been used.
- Bob Pitt said that SPU has an opportunity to reduce uncertainty by incorporating water quality monitoring into projects so that SPU can evaluate whether the projects achieve their expected benefits. He also observed that SPU doesn't have baseline data for the projects.

- Kevin Buckley said that SPU would be doing post-construction monitoring of the stormwater projects, as it does with CSO projects. However, he acknowledged that this monitoring is tied to the projects, not to the receiving water bodies.
 - Bob Pitt suggested considering small-scale intensive demonstration projects that are monitored intensively, such as a drainage area of a watershed that is intensively retrofitted as compared to an area that is not retrofitted. Once you have confidence in the drainage area, then you may understand more about the receiving water body.
- Bob Gearheart asked whether it might be possible to focus projects in one watershed so that success could be more easily demonstrated, rather than dispersing the projects.
- Reacting to the example metric for the project evaluation, Derek Booth expressed concern that the comparison of projects could overlook ancillary benefits from projects by focusing on metrics that can be easily compared in spreadsheets. Jean Zodrow added that it would be important to tie all the benefits together and not just focus on pollutant loads.
 - Rob Annear mentioned that SPU and the technical team welcome suggestions for other ways to compare projects, such as effects on habitat.
- Bob Pitt noted that cost (capital cost, land cost, opportunity cost) is another factor that will need to be built into the decision analysis.
- Kyle Dreyfuss-Wells observed that “gray” infrastructure projects could have much greater impacts during construction compared to “green” infrastructure projects. Bob Pitt added that green infrastructure projects are also disruptive, but the disruption is often smaller and for a shorter time.
 - Ed Mirabella of SPU and Jennifer Price of CH2M HILL noted that community reactions to disruption from green and gray CSO/stormwater projects has varied in Seattle, and some neighborhoods have had more issues with green infrastructure projects than CSO storage tanks.

Receiving Water Exposure Assessment Methodology Discussion

- Rick Pleus of Intertox gave a presentation on the proposed exposure assessment for the Integrated Plan, which would look qualitatively at the hazard (toxicity) and the exposure for both human and ecological receptors.
 - This methodology can be used to compare projects, as well as to compare “before” and “after” conditions associated with projects, for the RCOCs discussed earlier.
 - While the initial approach to the Exposure Assessment methodology has been developed, SPU and the technical team will refine the methodology for the Exposure Assessment after SPU reviews the quality and quantity of the data relevant to the assessment. The key parameter at this point is the concentration of a relevant RCOC.

Expert Panel Comments and Responses

Comments on RCOCs and Data Gaps:

- Jean Zodrow observed that it seemed as though SPU did not have good data for some constituents, such as pesticides, and asked what the technical team would do in the absence of anything other than TSS to measure those constituents. Semi-volatile organic compounds (SVOCs) are another area where there may not be much data.

- Rick Pleus of Intertox clarified that the issue with pesticides was not that SPU did not have data for pesticides, but that the technical team had not identified which pesticide it would evaluate and what data are available to consider. The technical team is currently evaluating the data available. For example, it appears that two weaknesses in data quality and quantity may be PBDEs and oil/grease. He also asked whether choosing certain surrogates, such as copper for metals, would cause the team to miss anything important.
 - Jean Zodrow suggested that PCBs could be a surrogate for PBDE, as those constituents may have similar behavior. For SVOCs, TSS could potentially be used. It is important to pick the right constituents to measure, since they get carried through. Rick Pleus said he understands the possible use of surrogates in the Exposure Assessment but would need to consider the data sets and constituents better to provide an opinion whether either of these is reliable.
- Bob Pitt noted that some constituents, such as copper, could be present in many types of form (complex, ionic, coil, associated with sediment, etc.). The different forms of the constituent will behave differently, and that could affect toxicity and exposures.
 - Bob Pitt asked whether SPU would use water chemistry modeling to evaluate the behavior of different speciation of constituents. Rob Annear of Geosyntec said that the technical team would be relying on receiving water and stormwater sampling data.

Comments on Variations in Exposure:

- In regards to Rick Pleus' question of the Expert Panel on whether acute exposures should be considered, Bob Pitt noted that acute (short exposure) issues are rare for receiving waters; chronic issues, especially associated with sediment, are much more common. Chronic exposure to fecal coliform can lead to regrowth in streams, for example.
- Jean Zodrow said that there are acute issues associated with the first stormwater event. For example, there is the potential for fish to be exposed to dissolved copper, which is what the National Marine Fisheries Service focuses on.
 - Bob Pitt observed that it would be important not to oversimplify the answer, given the complexity of the exposures.
 - Mike Milne of Brown and Caldwell added that the key is not to introduce any bias when comparing projects.
- Kyle Dreyfuss-Wells observed that it would be useful to know what happens to the first flush of stormwater for evaluating effects on exposures. She added that it is important to consider how projects affect exposure in the context of how the overall system is operating.
 - Eric Strecker noted that sediments are often more suspended in CSO areas.
 - Bob Pitt said that volume reduction and maximizing the flows that go to the treatment plant are important strategies.
- Bob Gearheart asked how the technical team would evaluate temporal effects.
 - Rick Pleus of Intertox said that the technical team would review on a case-by-case basis whether it would be useful to get more detail for a given parameter for the Exposure Assessment (e.g., season, duration, etc.).

Bringing It All Together: Reflections on the Proposed Methods and Data Sources

- At this point in the meeting, the Expert Panel was asked for overall impressions and reflections on the proposed methodology and the data that SPU plans to use for the evaluation. Reflections included the following:
 - Bob Gearheart said that the momentum of the project seems to be on the right track.
 - Jean Zodrow said she believed that things were on the right track, except for minor details.
 - Derek Booth commented on the difference between the complexity of understanding the behavior of constituents and their effects on exposure on the one hand and the simplicity of the exposure assessment tools being proposed to evaluate them on the other hand. He did not have suggestions for the exposure assessment methodology, but expressed doubts that it would be adequate.
 - Eric Strecker noted that SPU only needs to compare projects, as opposed to show what the exposure is.
 - Bob Pitt commented that he was astonished by the rapid time frame in which this is being done, and the limited time for evaluation. He noted that it is critical that SPU will be able to verify its efforts, and suggested reserving a fraction of the money for projects for verification.
 - Mike Milne of Brown and Caldwell said that there may be ways to address uncertainties based on how projects are combined into alternatives and selected.
 - Kyle Dreyfuss-Wells said that overall this is a good idea, and that the “perfect can be the enemy of the good.” She expressed concern that stormwater projects are not getting adequate consideration as compared to CSO projects.
 - Bob Pitt added that we should not need a different standard for comparison.

Overview of the Multi-Objective Decision Analysis (MODA) Process

- Emiko Takahashi of SPU presented on SPU’s use of MODA, covering:
 - When and why SPU uses MODA
 - A car example showing different elements of MODA process—the criteria, measurement scale, and weighting of social and environmental criteria, and then comparing those benefits or values to the costs of the options
 - An example of MODA applied to stormwater projects from Bob Pitt’s paper, with the key difference in SPU’s analysis that costs were analyzed separately from other criteria
 - Categories of draft MODA criteria SPU is considering for the Integrated Plan
- She noted that MODA will be used to evaluate CSO and stormwater projects individually, and then to compare CSO and stormwater projects. The MODA doesn’t make the decisions, but helps inform the decisions.
- In June, SPU will present draft technical criteria for the MODA evaluation for the Expert Panel to review and comment on.

Expert Panel Comments and Responses

- Derek Booth asked how SPU would use MODA to choose projects when there is a hard decision—that is, there are no obvious choices (high value/low cost) that emerge.

- Emiko Takahashi said that one way to help with those situations is to reconsider the weights for the criteria.
 - Bob Pitt said that external constraints, such as budget, also influence the decision.
- Bob Gearheart said that the transparency of the weighting is critical. He also asked how the weighting would be done.
 - Emiko Takahashi replied that SPU would have a diverse staff group do the weighting, and then would conduct sensitivity analyses of the results.
- Bob Pitt suggested incorporating dollars per pound into the analysis, rather than evaluating cost separately.
- Derek Booth said that an important weighting is the “fatal flaw weighting”—how SPU decided which projects would be considered for the Integrated Plan. The Expert Panel needs to know what criteria were used to determine whether projects were fatal flaws. People have different opinions of what makes something a fatal flaw.
 - Emiko Takahashi said that one fatal flaw criterion was whether SPU could fund the project.
- Derek Booth and Kyle Dreyfuss-Wells discussed the potential criterion for leveraged funding. Derek Booth noted that leveraged funding could be double counted since cost is considered elsewhere in the MODA; instead of including it as a social/environmental value, the cost with leveraged funding could be plotted as another point on the cost chart. Kyle Dreyfuss-Wells said that this criterion should not be overlooked, but agreed it could be handled that way.
- Several Expert Panel members commented that may have advice relevant to the non-environmental criteria for the MODA and could offer comments, even though they may not be “experts” on those topics.

Observer Comments

- Rachel McCrea of the Washington State Department of Ecology said that some of the comments expressed at the meeting resonated with her, but she had no further comments at this time.
- Jennifer Price of CH2M HILL noted that she was attending the meeting as an observer for the City of Spokane, which is evaluating similar issues, but not within the context of a consent decree. She is interested in identifying a methodology that could be replicated that is not too cost prohibitive or complicated.

Wrap Up and Next Steps

- Trish Rhay of SPU thanked Expert Panel members for their participation, and said that SPU’s challenge is to have solid enough data to tell a reasonable story and have enough time to get the analysis done.
- Bob Gearheart acknowledged his appreciation for the staff work supporting the Integrated Plan thus far, and noted that engineers need to make decisions with less data than this all of the time.
- Bill Ross of Ross Strategic added that SPU will need to make a reasoned judgment comparing stormwater and CSO projects based on available data, without understanding everything that may be occurring in the landscape and water bodies.
- Next steps identified at the meeting included:

- o The **next Expert Panel meeting** will be on **Tuesday, June 25, 2013**, in Seattle. It will focus on the technical criteria for the MODA evaluation.
- o Kevin Buckley of SPU said that he will brief SPU management on this meeting, and will meet with the technical team to discuss how to respond to the Expert Panel's suggestions.
Information on the technical team's proposed responses will be distributed to the panel.

Participants and Observers

Name	Organization
Expert Panel Members	
Bob Gearheart, Chair	Professor Emeritus, Humboldt State University, Arcata, CA
Derek Booth	Adjunct Professor, Bren School of Environmental Science and Management, University of California Santa Barbara, Santa Barbara, CA
Kyle Dreyfuss-Wells	Manager of Watershed Programs, Northeast Ohio Regional Sewer District, Cleveland, OH
Bob Pitt	Cudworth Professor of Urban Water Systems, Department of Civil, Construction, and Environmental Engineering, University of Alabama, Tuscaloosa, AL
Jean Zodrow	Project Toxicologist, ARCADIS U.S., Inc., Lakewood, CO
SPU and Consultant Participants at the Table	
Kevin Buckley	Integrated Plan Project Manager, SPU
Ray Hoffman	Director, SPU
Trish Rhay	Drainage and Wastewater Division Director, SPU
Mike Milne	Integrated Plan Consultant Team Project Manager, Brown and Caldwell
Bill Ross	Expert Panel Facilitator, Ross Strategic
Audience Members	
Nancy Ahern	SPU
Maythia Airhart	SPU
Martin Baker	SPU
Shelly Basketfield	SPU
Andy Chittick	SPU
Rex Davis	SPU
Pam Emerson	SPU
Jonathan Frodge	SPU
Ed Mirabella	SPU
Charles Oppelt	SPU
Beth Schmoyer	SPU
Tracy Tackett	SPU
Emiko Takahashi	SPU
Ingrid Wertz	SPU
Justin Twenter	Brown and Caldwell
Jennifer Price	CH2M HILL
Molly Adolfson	ESA
Rob Annear	Geosyntec Consultants
Eric Strecker	Geosyntec Consultants

Name	Organization
Rick Pleus	Intertox
Jennifer Tice	Ross Strategic
Rachel McCrea	Washington State Department of Ecology

Seattle Public Utilities Integrated Plan Expert Panel

Meeting #3, June 25, 2013

Meeting Summary

Participants

The third meeting of Seattle Public Utilities (SPU) Integrated Plan Expert Panel was attended by the five Expert Panel members, SPU managers and staff, consultants, and observers. The audience consisted largely of SPU staff and technical consultants. A full list of attendees is at the end of the summary.

Name	Organization
Expert Panel Members	
Bob Gearheart, Chair	Professor Emeritus, Humboldt State University, Arcata, CA
Derek Booth	Adjunct Professor, Bren School of Environmental Science and Management, University of California Santa Barbara, Santa Barbara, CA
Kyle Dreyfuss-Wells	Manager of Watershed Programs, Northeast Ohio Regional Sewer District, Cleveland, OH
Bob Pitt	Cudworth Professor of Urban Water Systems, Department of Civil, Construction, and Environmental Engineering, University of Alabama, Tuscaloosa, AL
Jean Zodrow	Project Toxicologist, ARCADIS U.S., Inc., Lakewood, CO
SPU and Consultant Participants at the Table	
Kevin Buckley	Integrated Plan Project Manager, SPU
Andrew Lee	Combined Sewer Overflow Program Manager, SPU
Mike Milne	Integrated Plan Consultant Team Project Manager, Brown and Caldwell
Bill Ross	Expert Panel Facilitator, Ross Strategic

Meeting Objectives

The objectives for the Expert Panel meeting included:

- Review the overall flow of the decision-making framework for the Integrated Plan, including the purpose and role of multi-objective decision analysis (MODA) in that context.
- Review and collect Expert Panel member feedback on changes to the methodology for evaluating combined sewer overflow (CSO) and stormwater projects, including the pollutant load estimation methodology and the exposure assessment methodology.
- Present and obtain Expert Panel feedback on the proposed evaluation criteria and scales for the MODA.
- Review example projects, which have been previously implemented by SPU and which have been evaluated using the proposed MODA criteria, and discuss the process for ranking projects and evaluating benefits and costs.
- Review upcoming meeting plans and identify next steps.

A summary of the meeting discussions, organized by the agenda topic, is below. Key themes from the meeting are not attributed to individuals, but comments pertaining to individual sessions are attributed.

Summary

Opening Remarks

- Bill Ross of Ross Strategic welcomed participants to the meeting, reviewed the agenda, and noted that SPU's decision-making for the Integrated Plan will proceed soon after the Expert Panel's final meeting in September. He said that the Expert Panel's contributions to SPU's decision-making are recorded in the summaries of the Expert Panel meetings.

Key Themes from the Expert Panel's Comments

Throughout the meeting, Expert Panel members commented on SPU's proposed methodology for assessing exposure and evaluating pollutant loads from stormwater and CSO projects, and how SPU plans to use multi-objective decision analysis (MODA) to support its decision-making. The following were key themes from these comments and notes about SPU's responses (individual comments and responses are also included later in the summary):

- By focusing on concentrations, the proposed exposure assessment methodology ignores important considerations. SPU should add mass loadings to its formula for exposure index values (EIVs), so that mass, volume, frequency, timing, and concentration are considered in some way when evaluating exposure reductions from stormwater and CSO projects.
 - o SPU Response: The Integrated Plan team has considered adding these factors to the EIV calculations, but has not finalized the algorithms to account for mass, volume, and timing of discharge. These algorithms will be developed during the next phase of the project. The intention is to have this work completed by the August conference call with the Panel.
- It is important for SPU to consider not only the relative change in exposure or loads, but also the value or utility of that change. Changes that occur near regulatory thresholds or levels associated with human health or ecological effects should be valued differently than changes that do not occur near these levels. Incorporating utility curves is one way that SPU could address this concern.
 - o SPU Response: Following the June 25th Panel meeting, the Integrated Plan team considered the recommendation to use utility curves for evaluation of changes in the loads and concentrations associated with stormwater and CSO projects. The team acknowledged that utility curves could be a useful tool to help determine which stormwater projects provide significant benefit over CSO projects but decided that utility curves would not be used as part of the pollutant reduction methodology or MODA. This decision was based upon the reality that the consent decree does not require Seattle to meet a standard or target, only show a significant benefit of stormwater projects over CSO projects and that total maximum daily loads (TMDLs) have not been established for most of the consent decree constituents in our receiving water bodies; therefore, SPU does not have waste load or load allocations that could serve as benchmarks for the Integrated Plan project load reductions. Furthermore, the information required to make such an assessment cannot be generated given the available time and data for this project.

Because of these factors the team did not want to create a benchmark or target for use with the utility curves as suggested by the Panel.

- SPU should focus its analytic attention for the Integrated Plan first and foremost on meeting the consent decree requirements of showing that the proposed stormwater projects provide significantly better water quality benefits than the CSO projects proposed to be deferred. MODA is a useful second step for adding transparency to SPU's decision-making process; however, it does not warrant as much attention from the Expert Panel.
 - SPU Response: SPU and the Integrated Plan team remain committed to demonstrating the requirements of the consent decree with the Integrated Plan. Based on the Expert Panel's comments, SPU has revised plans for the final meeting of the Expert Panel in September and added a conference call in August to reflect this focus and the interests of the Panel. SPU also will be simplifying its process by conducting MODA only on options (combinations of proposed stormwater projects and CSO projects to be deferred) and not first conducting MODA on individual stormwater and CSO projects. For all of the options, SPU will demonstrate the consent decree requirements that the proposed stormwater projects provide greater water quality benefits than the CSO projects proposed for deferral.
- Since monetization cannot be done uniformly and consistently across the MODA criteria, the Expert Panel thought that this would not be a particularly useful investment of SPU time and resources.
 - SPU Response: After considering the Expert Panel's advice, SPU has decided not to monetize the MODA criteria for evaluating Integrated Plan projects. The Integrated Plan team will, however, quantify the benefits or impacts from projects where possible (e.g., CO₂ reductions).
- Expert Panel members commented on the difficulty of providing input on SPU's methodology in the abstract, particularly for the exposure assessment, and said that it would be helpful to see more of the analyses conducted by the SPU and the Integrated Plan team. For example, some of the potential issues the Panel raised included addressing data with significant amounts of non-detect values, using linear scales to represent non-linear data, considering results that are very similar (e.g., after normalization), and combining exposure scores from different pollutants or receptors.
 - SPU Response: There will be an Expert Panel conference call scheduled in August during which the Integrated Plan team will review its analyses for the exposure assessment and the assessment of water quality impacts of projects. This will allow the team to follow up on the potential issues the Panel identified.
- Expert Panel members had differing views regarding the complexity of SPU's analysis. On the one hand, Panel members noted the importance of avoiding over-simplification of analytic results, such as by summing all exposure index values or by reducing MODA results to a single score by normalizing, scaling, and averaging. They noted it is important for staff and decision-makers to understand the factors contributing to aggregate scores (effects of projects on individual pollutant loads, sensitivity analysis of how different MODA criteria affect the value scores, etc.). On the other hand, Panel members noted that it would also be important for SPU to avoid overcomplicating the analysis to demonstrate the consent decree requirements, particularly since this Integrated Plan could inform similar plans that other utilities develop across the country.

- o SPU Response: Based on concerns about complexity and the importance of demonstrating the consent decree requirements, SPU is creating a more distinct divide between the first phase of its analysis, which focuses on demonstrating that proposed stormwater projects have significantly greater water quality benefits than the CSO projects to be deferred, and later stages of its decision-making, which include MODA and consideration of other decision factors. SPU will only evaluate options in MODA that meet the consent decree water quality requirements. SPU will also keep in mind the importance of providing relevant information to decision-makers based on SPU and team's analysis of exposures, pollutant loads, and other criteria.

Review of Integrated Plan Decision-Making Framework

- Emiko Takahashi and Kevin Buckley of SPU described the overall decision-making framework for the Integrated Plan, which includes four parts:
 - o Evaluation of projects based on consent decree requirements (pollutant loads and exposure assessment) and other evaluation criteria relevant to SPU's decision-making
 - o MODA on *individual* stormwater and CSO projects (Note: Following the meeting, SPU decided to skip this step in its process.)
 - o MODA on Integrated Plan *options*—combinations of stormwater projects to be implemented and CSO projects to be deferred (all options must meet the consent decree requirement that proposed stormwater projects “will result in significant benefits to water quality beyond those that would be achieved by implementation of the approved CSO Controls Measures only”)
 - o Other decision factors (e.g., scheduling and financing)
- Emiko Takahashi added that MODA is used extensively at SPU to transparently consider potentially competing objectives in its decisions. SPU also intends to use MODA to satisfy the cost-benefit analysis requirements of the consent decree.
- Kevin Buckley said Integrated Plan options, all of which will have been analyzed as described above, will be presented to the public in the Environmental Impact Statement (EIS); one option will then be recommended to SPU management and included as the Integrated Plan option for the Long Term Control Plan (LTCP).

Expert Panel Comments and Responses

- Kyle Dreyfuss-Wells asked SPU to comment on SPU potentially using receiving waters with deferred CSO projects as a factor for selecting Integrated Plan options.
 - o Kevin Buckley of SPU said the consent decree does not require SPU to consider the locations of the receiving water bodies for the stormwater projects and CSO projects to be deferred in the Integrated Plan, but SPU could consider this. In response to a question, he said the issue of deferring a CSO project in one location but getting the benefit in another location has not come up in public meetings, because the CSO projects SPU plans to defer are low priority.
 - o Bob Gearheart asked whether this factor was implied by the performance standard for projects to meet water quality standards. Kevin Buckley responded that the consent decree requires comparing the pollutant load reductions and the relative water quality benefits of Integrated Plan projects. (This is a relative comparison of project impacts, rather than an evaluation of water quality standards attainment.)

- Bob Pitt recommended that SPU and the technical team avoid the terminology “deferred CSO,” but rather specify “deferred CSO projects” to avoid confusion.

Exposure Assessment Methodology Discussion

- Rick Pleus of Intertox gave a presentation on the proposed exposure assessment methodology; his presentation covered the following topics:
 - o The consent decree requirements for assessing reductions in pollutant exposure for human and ecological receptors
 - o The use of relative, not absolute, estimates of exposure and hazard for the exposure assessment
 - o The Integrated Plan team’s progress to date in developing the exposure assessment methodology, including conducting site visits and identifying receptors
 - o The equations fundamental to the exposure assessment, including Exposure Index Values (EIVs) and receptor factors
 - o Steps in the exposure assessment to identify the components of the EIV equation (pre- and post-project concentrations, target concentrations, and receptor factors), calculate the EIVs, and sum and normalize the EIVs for human and ecological factors for each project
 - o Remaining work to complete, including considering frequency, volume, and time in the algorithm
- In answer to questions from the Expert Panel, Rick Pleus clarified that the team visited sites that it thought would provide the best information about the different site types, rather than all of the project sites, and that the target values for water quality or human health are typically not mandates (e.g., they might be a reference dose for human health). He also noted that the EIVs for human and ecological receptors would not be combined, but would remain separate.

Expert Panel Comments and Responses

- Derek Booth and Bob Pitt commented on the fact that relying exclusively on comparisons of relative risk might not allow differentiation between cases where a very small risk is reduced and where a large risk is reduced.
 - o Rick Pleus said that the Integrated Plan team will prioritize the biggest drivers of risk, based on 20 years of professional experience.
 - o Based on this information that the team will consider other information, Bob Pitt said that he would have concerns if the team shared the same slides with the public since they are overly extreme about the use of relative risk and could cause the team to have to backtrack.
- Jean Zodrow asked the team about how sensitivity would be considered for threatened and endangered species, and whether it would consider species distribution.
 - o Gretchen Bruce of Intertox said that they would be considering the age, life stage, and the threatened and endangered status of species, but it would not be worth the effort to consider species distribution for this analysis.
- Bob Pitt recommended that the Integrated Plan team adjust the formula for EIVs so that it considers volume and mass discharge, not simply concentration. He noted that target concentrations do not mean much for stormwater projects; the important factors are sediment and volume reduction. Groundwater contamination and the fate of groundwater is another consideration. He said that if

the TMDL requirement for the water body were based on exposure, the TMDL could be used as the target in the EIV. To avoid double counting (since concentration is based on mass over volume), Dr. Pitt recommended that the EIV be revised so that it examined the change in mass over the TMDL target value as well as the post-project concentration.

- Rick Pleus noted that the TMDL is based on the entire reach or stream, and doesn't have the same nuances for assessing exposure. Bob Pitt responded that TMDL values could be assigned to locations. SPU staff also noted that TMDLs have not been established for most of the consent decree constituents in Seattle's receiving water bodies.
 - Jean Zodrow commented that this conversation omitted an important factor in the EIV equation—the receptor factor. If the receptor factor were 1 in a high-quality stream versus 0.5 in a degraded area, this would have a large effect on the final result. Rick Pleus agreed and pointed out the receptor factor in the newest version of the EIV algorithm.
- Derek Booth commented that the EIV formula captures the magnitude of the change, but not the value of the change. He said that may not be particularly useful. To illustrate his point, he provided an example of two projects that would produce the same results, even though one project would meet the target concentration (Case 1: $10-9 = 1$; Case 2: $2-1 = 1$ and meet target concentration).
 - Rick Pleus mentioned that, while he understood the point, it is important to remember that the consent decree emphasizes establishing the “benefit” of one project over another project, but that there is no requirement to meet some standard such as a water quality guideline. Furthermore, the data might not be sufficient to make an accurate prediction of the post-project concentration with any degree of certainty.
- Bob Pitt suggested that the Integrated Plan team consider the utility function in the exposure assessment. The utility function examines the overall utility or value of changes in a parameter. It would, for example, help SPU and the Integrated Plan team to assess how much more one concentration was worth than another (e.g., if the concentrations are well above the goal, changes do not matter as much). The paper Dr. Pitt circulated to SPU and the Panel previously describes the concept of utility function.
 - Gretchen Bruce of Intertox said that the team would be looking at the change in concentrations in the exposure assessment, but not the value of the change. Rick Pleus added that the team is not doing a full exposure assessment.
 - As noted in the summary of themes above, since the meeting, the Integrated Plan team reviewed the recommendation to use utility curves and concluded that the concept would be difficult to apply here since the consent decree does not require Seattle to meet a standard or target (it only requires that SPU show a significant benefit of stormwater projects over deferred CSO projects), and TMDLs have not been established for most of the consent decree constituents in receiving water bodies for Seattle's discharges. Thus benchmarks are not available to apply to the utility curves.
- Reflecting on the site photos, Expert Panel members commented on how public uses would be considered in the exposure assessment. Bob Pitt noted that it would be important to look not just at the site, but also in the vicinity of the site to identify swimming beaches, parks, and other nearby

public use areas. Kyle Dreyfuss-Wells said that the most important factor is whether the overflow is in a public beach or in a hidden or inaccessible area.

- Mike Milne of Brown and Caldwell and Rick Pleus of Intertox concurred with the comments about the importance of considering public uses and indicated that the team will incorporate information on locations of nearby beaches, parks, tribal fishing areas, and public access points. The EIV considers, for example, the distance to locations of public use from a given outfall. Several Expert Panel members commented that it would be useful to see numerical examples to better understand and comment on how the exposure assessment calculations would work.
 - The Integrated Plan team concurred and will generate data to input into the draft EIV algorithms. Given no unforeseen obstacles, these data will be available for the Expert Panel to review at a conference call in August.
- Bob Pitt and Derek Booth observed that treating the data linearly by normalizing the data could present some problems. For example, there may be a lot of low values in the results, and normalizing them could make them artificially high. Another outcome could be that the normalization will produce very similar results that are not very meaningful. Examining how the data are clustering could help as well as considering utility (as described earlier).
 - Integrated Plan team members acknowledged the Panel's potential concerns with normalization. Both the Integrated Plan team and Panel members noted that examining actual output data will allow appropriate assessments of how to normalize data..

Observer Comments and Responses

- Mark Henley of the Washington State Department of Ecology (Ecology) asked how the exposure assessment would consider impaired water bodies and those listed under section 303(d) of the Clean Water Act.
 - Mike Milne of Brown and Caldwell, Kevin Buckley of SPU, and Eric Strecker of Geosyntec identified several places in the Integrated Plan team's analysis where regulatory status has been or would be considered, as follows.
 - SPU considered impaired water bodies when it prioritized water bodies where candidate stormwater projects would be identified.
 - The numerical values in the EIVs (e.g., target concentration) relate to regulatory requirements.
 - When SPU forms "options" of stormwater projects to implement and CSO projects to defer, it will consider the offset in the receiving water body.
 - In SPU's MODA analysis, there is an opportunity to consider regulatory status (impaired water body, recontamination of Superfund site, etc.).
- Mark Henley commented that he did not want the Integrated Plan to undermine the overall value of achieving CSO control and that it should provide a fair and balanced evaluation of CSO project water quality benefits, particularly since SPU's Integrated Plan may serve as a national model for these plans. It should be clear that in the Integrated Plan SPU is looking at low-priority CSO projects that address CSOs that are almost under control, and that SPU does not plan to defer other CSO projects that have more benefits.

- o Bill Ross of Ross Strategic said that the Integrated Plan would be examining the benefit of the deferred CSO projects if implemented (controlling the outfalls to one overflow per year) and the benefit of the stormwater projects if implemented.
- o Andrew Lee of SPU said that this issue was largely one of messaging for the Integrated Plan. SPU will state that it is looking at a certain set of projects for the Integrated Plan; the agency will not be claiming that all stormwater projects are better than all CSO projects.
- Mark Henley observed that the range of values in the receptor factor equation was 1 to 5 for the likelihood of exposure, but 1 to 15 for magnitude of exposure.
 - o Gretchen Bruce of Intertox said that the basis of the 1-15 range is data compiled by EPA on relative exposure levels associated with different scenarios (e.g., skin surface area exposed to water during swimming or wading, incidental water ingestion rates during recreational activities, or fish and shellfish consumption). The team will provide documentation for the approach.

Updates to the Pollutant Load Estimation Methodology for Stormwater Projects

- Rob Annear of Geosyntec presented updates to the methodology for estimating pollutant load reductions from stormwater projects. His presentation included:
 - o The current list of representative constituents of concern (RCOCs), including changes from the potential RCOCs identified at the April Expert Panel meeting
 - o The status of the stormwater project analysis
 - o Examples of the box plots of the pollutant load data the team is examining for commercial, residential, and industrial sites
 - o Recommended project comparison metrics to meet the consent decree requirements (including water quality impacts and exposure assessment) and inform SPU's MODA
 - o Proposed methodology for characterizing baseline conditions and estimating pollutant loadings from stormwater projects

Expert Panel Comments and Responses

Comments on RCOCs and the Available Data:

- Jean Zodrow asked why zinc was added as a constituent of concern.
 - o Beth Schmoyer of SPU said that SPU added zinc because it is a specific benchmark for industrial stormwater permits that facilities often struggle with. SPU plans to look at both copper and zinc.
- For the proposal to assess PBDEs using total suspended solids (TSS), Jean Zodrow mentioned Sandy O'Neill's study of pollutant loads and cycling through biological organisms in Puget Sound, although Ms. Zodrow wasn't sure whether the study specifically considered PBDEs.
 - o Members of the technical team said that they would examine that resource.
- Bob Pitt questioned the decision to use BOD/TSS as an RCOC for pH, if pH were specifically listed in the consent decree. He said that reduced concentrations result in subtle changes in pH. Rob Annear of Geosyntec said that the team can discuss the approach to pH at a future Expert Panel meeting.
- Panel members made several suggestions related to the presentation of the data, as follows.
 - o Bob Pitt suggested adding the numbers of observations to the box plot charts.
 - o He also suggested presenting the data with a truncated probability distribution, or plotting the data based on percent detected.

- Some Panel members noted that the Y axis was different in the slides, but should be consistent in future presentations.
- Eric Strecker of Geosyntec said the team would be increasing the font size for the charts.
- Several Panel members commented on the differences between the data for different site types, and noted that land use categories such as industrial can vary significantly. There are highly site specific reasons why the data may differ, such as roof runoff and urban wildlife in forested areas. In addition, Bob Pitt noted that seasonality is important, due to inputs to the land.
- Bob Pitt and Derek Booth commented that for some pollutants, there may be a significant amount of data that are below or very close to detection levels (practical quantification levels). Furthermore, they noted that scaling data containing a large amount of non-detected values could skew the overall results. (The suggestions above for indicating the number of observations in charts and presenting data with truncated probability distributions could help address issues with non-detects.) For the PCBs, in particular, Bob Pitt said that detection limits will be critical.

Comments on the Stormwater Project Analysis:

- Kyle Dreyfuss-Wells commented on the fact that only two metrics were proposed as inputs to MODA, when there were many other metrics proposed for comparing stormwater and CSO projects. Bob Pitt added that concentrations and loads could be considered separately in MODA.
 - Kevin Buckley of SPU indicated that SPU had not yet fully determined how water quality would be considered in MODA.
- Bob Pitt asked whether SPU would be conducting demonstration projects to supplement the performance data, or will it directly implement full-scale projects.
 - Andrew Lee of SPU said SPU would consider demonstration projects on a case-by-case basis.
- Bob Pitt added that there is more uncertainty on some projects than others, and recommended that SPU conduct mass-balance analysis to determine if anything looks odd. He noted that the performance of street sweeping, in particular, should be verified.
 - Eric Strecker of Geosyntec noted that the consent decree requires post-construction monitoring.
- In response to a question from Bob Gearheart, Rob Annear clarified that the team will apply the model to the catchments, but does not plan to include other subcatchments that feed into them.

Observer Comments and Responses

- Mark Henley of Ecology asked how the technical team would compare the reductions in fecal coliform loads from stormwater projects to those that come from eliminating CSOs. He indicated that the stormwater projects would have to reduce fecal coliform levels significantly to be comparable to the benefit from reducing CSOs.
 - Bob Pitt commented that there are highly site specific reasons why some sites have high fecal coliform levels. Jonathan Frodge of SPU said that some of the numbers may be correlated with homeless encampments in the vicinity of the sites.
- Beth Schmoyer of SPU expressed concern about the technical team's proposal to use bis(2-ethylhexyl)phthalate as the RCOC for semi-volatile organic compounds (SVOCs). She noted that bis(2-ethylhexyl)phthalate is everywhere (including lab contamination) and is not very toxic to humans. Other contaminants are more differentiated. Bob Pitt suggested that including the frequency of detection as a measure would help.

- Beth Schmoyer and Rob Annear discussed the use of use bis(2-ethylhexyl)phthalate as the RCOC for SVOCs following the meeting and determined that given the available data, the use of use bis(2-ethylhexyl)phthalate as the RCOC for SVOCs would be acceptable.

Updates to the Pollutant Load Estimation Methodology for CSO Projects

- Justin Twenter of Brown and Caldwell provided an update on the Integrated Plan team's methodology for evaluating pollutant loads from the 10 candidate CSO projects that could be deferred.
 - The team's proposed approach is to use simulated flow from models, and to pool city-wide sampling data and use average values for each of the residential and commercial sites.
 - The team will also be using sampling data from a King County industrial site.

Expert Panel Comments and Responses

- Kyle Dreyfuss-Wells commented that in the consent decree it seems like fecal coliform is treated as equal to other pollutants, yet she believes that people would not tolerate having significant fecal coliform remaining in either CSO overflows or stormwater discharges. You do not want raw sewage in the water. Not all pollutants are created equal; a project could do a "rock star" job on some contaminants, but not as well on others.
 - Jonathan Frodge of SPU said that the city's CSOs primarily occur in the winter, so fecal coliform levels are not necessarily the biggest concern from an actual exposure point of view.
 - Bob Pitt commented that 10,000 CFU/100 mL is not unusual for stormwater discharges, and that it is difficult to get below 400 CFU/100 mL. He said that regrowth and initial die off of bacteria are complicating factors. Classical modeling only looks at the first phase.
 - Mark Henley of Ecology said that the pollutants are treated equally in terms of having water quality standards that are appropriate for each pollutant and which must be met by any discharges.

Observer Comments and Responses

- Beth Schmoyer of SPU questioned whether the SPU sites were a mixture of industrial and non-industrial land uses, and proposed to discuss this outside of the meeting with the consultant team.
- In answer to a question from Mark Henley of Ecology regarding the fact that some years there might not be any CSO discharges, Justin Twenter said that the team would be looking at an average of 30 years when evaluating whether the CSO is controlled to an average of one overflow per year. Justin Twenter added that the team will examine seasonal loadings as well as the frequency of discharge.

Discussion of the Proposed MODA Criteria, Scales, and Process

- Dan Pitzler of CH2M HILL reviewed the criteria and scales that SPU and the Integrated Plan team have developed for the multi-objective decision analysis (MODA) that SPU will conduct for the Integrated Plan, although noted that the team is still working on water quality criteria, which could consider a variety of subfactors.
 - The criteria reflect the City's goals and are intended to give insight into what SPU feels is important for its decision.
 - All projects evaluated in MODA will meet the consent decree requirements for water quality.

- o Many of the scales are constructed to be on a 1-5 scale, with 5 being the best.
- In response to a question from the Expert Panel, Dan Pitzler clarified that carbon dioxide, which has a direct measure, will be normalized to a 0-1 scale and criteria will be measured on a qualitative 1-5 scale.
- Kevin Buckley of SPU reviewed five example stormwater and CSO projects that either have been or are about to be built. SPU and consultant staff scored these projects using the MODA criteria proposed for Integrated Plan.
- After reviewing the MODA criteria and scales with the Panel, Dan Pitzler described the steps in the MODA process, and showed the results of the analysis for the example projects. He described how SPU would plot the value scores for projects against the costs, conduct a sensitivity analysis of the weights, and then look at a graph of cumulative cost to cumulative value to identify the “knee of the curve.” Finally, Mr. Pitzler said that a team is examining which of the MODA criteria can be monetized, and that SPU plans to conduct MODA both with and without monetized information.
- As part of this discussion, Emiko Takahashi of SPU and Dan Pitzler of CH2M HILL reviewed the steps in the overall Integrated Plan decision-making process, including the use of MODA on options or packages of stormwater and CSO projects, and other decision factors considered after MODA.
 - o Ms. Takahashi noted that other factors SPU may consider in developing the options or later in its decision-making process include matching the locations of stormwater and deferred CSO projects, an emphasis on pedestrian/green grid, whether SPU has the money and ability to implement the projects, and for joint projects with King County, whether King County would be ready to implement the projects within the required schedule.

Expert Panel Comments and Responses

Comments on the MODA Criteria and Scales:

- Kyle Dreyfuss-Wells asked where in the MODA criteria would the tradeoff between capital and operations and maintenance (O&M) costs be considered. She noted that from an organizational standpoint, it is often easier to fund capital projects than projects that have high O&M costs.
 - o Andrew Lee of SPU said that the City looks at total lifecycle costs, and does not differentiate between capital and O&M costs.
- Bob Pitt asked why energy use was not considered, and recommended that SPU document the methods it would be using to quantify impacts. Dan Pitzler of CH2M HILL said that the team thought that energy use would be captured by other factors, including CO₂ emissions.
- There was considerable discussion among Expert Panel members and observers about the environmental criteria for MODA, the importance of water quality, and the relationship of the consent decree requirements and MODA.
 - o There was initially confusion about how the MODA water quality criteria differed from the consent decree requirements. The Integrated Plan team clarified that the water quality criteria in MODA represents incremental water quality benefit beyond consent decree requirements. To meet the requirements of the consent decree, SPU will be showing that the stormwater projects proposed to be implemented will have significantly better water quality benefits than the CSO projects that are proposed for deferral.

- Bob Pitt suggested that the MODA criteria for water quality consider concentration, volume, and mass loading, since the regulations deal with different issues, and MODA would allow each factor to be considered as specifically as desired. He also said that SPU shouldn't combine pollutants.
- Kyle Dreyfuss-Wells suggested that a simpler way to do the water quality analysis in MODA would be to filter out any projects that do not meet water quality requirements.
 - o Bill Ross of Ross Strategic noted that stormwater projects do not have numerical standards that they need to meet, unlike CSO projects, which have the one overflow per year standard.
 - o Beth Schmoyer of SPU said a concern with removing the water quality component from MODA is that there are different ways that projects could be "better" in terms of water quality, such as volume reductions, load reductions, and effects on regulatory requirements.

Comments on the Example Projects:

- Bob Pitt commented that combinations of projects should be considered to meet water quality standards rather than individual control measures. For example, a smaller tank might be needed for CSO control in an area that also has green infrastructure.
 - o Andrew Lee and Emiko Takahashi of SPU said that SPU looked at combinations of options to address the problems, even though they are not represented in the example projects. Bob Pitt said that does not detract from the method, but it should be documented that other projects were considered.
- Bob Pitt also recommended that the example projects be described by their control measure (e.g., wet pond) and then indicate that they were demonstrated with specific locations.
 - o Rob Annear of Geosyntec and Dan Pitzler of CH2M HILL clarified that the projects are site specific and represent specific solutions to specific problems. The projects are being compared because SPU may have a certain amount of money and is deciding which projects to fund.

Comments on the Monetization of MODA Criteria:

- Derek Booth recommended that if SPU cannot uniformly and consistently monetize the MODA criteria, it should stop pursuing it. The criterion of whether to monetize—whether it is feasible—is arbitrary to the decision-making. He noted that once you have two ways to look at something, it is human nature to make them equivalent. The monetization does not consider water quality, among other criteria, and should not be considered side-by-side to the other method of evaluation, especially if the monetization is incomplete across all MODA factors.
 - o Andrew Lee and Emiko Takahashi of SPU noted that they understood the skepticism about the monetization, and that SPU will keep in mind the Panel's comments that its methodology for the Integrated Plan could set a national precedent.
 - o Based on the advice of the Panel, SPU has decided not to monetize the MODA criteria, but will quantify the impacts of projects where possible to support its decision-making process.
- Bob Pitt commented that he could appreciate the value of monetization for explaining decisions to ratepayers, but he was less sure whether it would be of value to regulators. The important information is the quantification of the impacts (e.g., CO₂ emissions); monetization could be problematic when comparing monetary values of dissimilar items (e.g., CO₂ emissions and lost parking spaces).
 - o Kyle Dreyfuss-Wells said that her utility (Northeast Ohio Regional Sewer District in Cleveland) did monetize the benefits of CSO controls, even though it was not required. She said this was

very useful in the utility's consent decree negotiations with regulators. For example, their tunnel project had a larger carbon impact as compared to green projects.

- o Mark Henley of Ecology said the consent decree does not require monetization. He advised being careful with how monetization is done, and that monetization is not accurate unless it is complete. For example, he said that all emissions would need to be considered for street sweeping projects.

Comments on the Application of MODA and the Team's Overall Methodology:

- Derek Booth expressed concern about the Integrated Plan team's methodologies (including MODA) that represent very complicated issues as a single number, commenting that they are "reductionist" approaches that obscure the impact of each individual factor in the decision-making. He recommended that more nuances of the MODA results be carried forward when SPU presents the information to decision-makers (e.g., the bar graph showing scores for the criteria, not simply the total MODA score), and noted that the sensitivity analysis would be very useful.
- Derek Booth indicated that the Integrated Plan team appeared to be spending a disproportionate level of effort in MODA, when the focus ("90-95% of the effort") should be on showing the water quality benefits of stormwater projects as compared to deferred CSO projects, although he acknowledged that this could be due to the structure of this meeting's agenda, which had reflected requests from the Panel. He added that SPU's analysis for the Integrated Plan is precedent setting, so SPU should be careful to not overly complicate things. He recommended that SPU concentrate on the analysis that shows which proposed stormwater projects "knock it out of the park" in terms of showing water quality benefits when compared to the CSO projects proposed for deferral. After that, SPU can consider other utility priorities through MODA to select which projects to implement.
- Bob Gearheart observed that MODA is important because it provides both transparency and a replicable methodology with respect to its decision-making process.

Observer Comments and Responses

- Mark Henley of Ecology said that environmental factors should be weighted highly in MODA given the focus of the consent decree and other regulations. He also observed that only select measures were proposed for evaluating environmental factors in MODA, and that others, such as carbon monoxide, were not included. Finally, he added that street sweeping would have more air emissions over the project lifetime than appears to be captured by the analysis demonstrated at this meeting.
 - o Andrew Lee commented that one would have expected street sweeping to score lower in the MODA results for air quality given the emissions associated with the truck miles traveled.
 - o Kyle Dreyfuss-Wells noted that there is an assumption that the projects to be proposed would meet water quality criteria; otherwise the regulators would not accept them.
- Mark Henley added that the Integrated Plan needs to show water quality benefit of stormwater projects as compared to deferred CSO projects, and that SPU will need to rationalize why CSO projects will be deferred. For example, if a CSO project is deferred and that CSO still has fecal coliform impacts, how will that key parameter be compensated?
 - o Bill Ross of Ross Strategic noted that the consent decree does not specify that SPU compare pollutants on a one-by-one basis or compare impacts by receiving water body.

- o After the meeting, the Integrated Plan team provided the following additional clarification: While CSOs have a spike in fecal coliform when there is a release, some of the stormwater projects may reduce fecal coliform releases during more frequent smaller storm events, leading to reduced frequency and reduced coliform counts over a year.
- Mark Henley said that the Integrated Plan is a voluntary approach, and that the deferred CSO projects will be implemented at some point in the future.
 - o Jonathan Frodge noted that there is no regulatory requirement that the stormwater projects be implemented. Mark Henley clarified that there could be requirements in MS4 permits.

Reflections on the SPU's Direction with the Consent Decree Analysis

- Near the end of the meeting, the Expert Panel was asked to reflect on the direction SPU was headed with its proposed analysis to meet the consent decree requirements. Reflections included:
 - o Derek Booth said he thought the Integrated Plan team was well on its way towards evaluating the consent decree requirements of projects, as long as the team did not get “distracted” by less important analyses. Bob Pitt added that “distracted” was not the right word.
 - o Bob Pitt noted the Panel had talked about providing additional detail and descriptions to explain various analyses. He would like the team to evaluate utility, not simply tradeoffs, in the exposure assessment. He also suggested considering non-linear results, and looking at contaminants individually rather than lumping them together.
 - o Jean Zodrow commented that the EIVs needed more refinement, but that overall, it seemed as though the team was on a path to make the distinction that some projects are significantly better. She added that she was still struggling with having conversations in the abstract, and needed to see what the numbers do.
 - o Bob Gearheart said he felt very comfortable with the direction of the team, even without having all the information. He noted that the meeting’s conversation shifted from tactics to strategy. He believes MODA is useful for helping to evaluate non-technical considerations.
 - o Kyle Dreyfuss-Wells noted that she felt the team was on the right track. She expressed concern, however, about the team overcomplicating the analysis (“building a complex house around a simple solution”), especially considering that this could set a national precedent.

Wrap Up and Next Steps

- Next steps identified at the meeting included:
 - o There will be an **Expert Panel conference call** in August to follow up on this meeting’s discussions related to the exposure assessment and the methodology to meet the consent decree requirements for the Integrated Plan.
 - o The **final Expert Panel meeting** will be on **Monday, September 16, 2013**, in Seattle. There will also be a reception around this meeting to acknowledge the Panel’s work.
 - This meeting will focus mostly on reviewing how SPU will show how proposed stormwater projects are significantly better than potentially deferred CSO projects, but may include some discussion of MODA.

Participants and Observers

Name	Organization
Expert Panel Members	
Bob Gearheart, Chair	Professor Emeritus, Humboldt State University, Arcata, CA
Derek Booth	Adjunct Professor, Bren School of Environmental Science and Management, University of California Santa Barbara, Santa Barbara, CA
Kyle Dreyfuss-Wells	Manager of Watershed Programs, Northeast Ohio Regional Sewer District, Cleveland, OH
Bob Pitt	Cudworth Professor of Urban Water Systems, Department of Civil, Construction, and Environmental Engineering, University of Alabama, Tuscaloosa, AL
Jean Zodrow	Project Toxicologist, ARCADIS U.S., Inc., Lakewood, CO
SPU and Consultant Participants at the Table	
Kevin Buckley	Integrated Plan Project Manager, SPU
Andrew Lee	Combined Sewer Overflow Program Manager, SPU
Mike Milne	Integrated Plan Consultant Team Project Manager, Brown and Caldwell
Bill Ross	Expert Panel Facilitator, Ross Strategic
Audience Members	
Shanti Colwell	SPU
Rex Davis	SPU
Jonathan Frodge	SPU
Ed Mirabella	SPU
Pete Rude	SPU
Beth Schmoyer	SPU
Emiko Takahashi	SPU
Ingrid Wertz	SPU
Justin Twenter	Brown and Caldwell
Dan Pitzler	CH2M HILL
Rob Annear	Geosyntec Consultants
Eric Strecker	Geosyntec Consultants
Gretchen Bruce	Intertox
Rick Pleus	Intertox
Jennifer Tice	Ross Strategic
Mark Henley	Washington State Department of Ecology

Seattle Public Utilities Integrated Plan Expert Panel

Meeting #4 (Webinar), August 28, 2013

Call Summary

Participants

The fourth meeting of Seattle Public Utilities (SPU) Integrated Plan Expert Panel, a web-enabled call on August 28, 2013, was attended by four Expert Panel members, SPU managers and staff, consultants, and observers. A full list of attendees is at the end of the summary.

Name	Organization
Expert Panel Members	
Bob Gearheart, Chair	Professor Emeritus, Humboldt State University, Arcata, CA
Kyle Dreyfuss-Wells	Manager of Watershed Programs, Northeast Ohio Regional Sewer District, Cleveland, OH
Bob Pitt	Cudworth Professor of Urban Water Systems, Department of Civil, Construction, and Environmental Engineering, University of Alabama, Tuscaloosa, AL
Jean Zodrow	Project Toxicologist, ARCADIS U.S., Inc., Lakewood, CO
SPU and Consultant Participants at the Table	
Kevin Buckley	Integrated Plan Project Manager, SPU
Andrew Lee	Combined Sewer Overflow Program Manager, SPU
Mike Milne	Integrated Plan Consultant Team Project Manager, Brown and Caldwell
Bill Ross	Expert Panel Facilitator, Ross Strategic

Meeting Objectives

The objectives for the Expert Panel meeting included:

- Present and obtain Expert Panel feedback on the results of pollutant load analysis for the proposed stormwater projects and combined sewer overflow (CSO) projects to be deferred in the Integrated Plan, including a comparison of loads for selected representative constituents of concern (RCOCs).
- Review the exposure assessment approach as modified since the June Expert Panel meeting, present results of the exposure assessment algorithms as applied to selected projects and RCOCs, and obtain Expert Panel feedback on the approach and the application of the methodology.
- Review upcoming meeting plans and identify next steps.

A summary of the meeting discussions, organized by the agenda topic, is below.

Summary

Discussion of Stormwater and CSO Project Load Analysis

Justin Twenter of Brown and Caldwell reviewed updates to the methodology for estimating loads for CSO projects, and then Rob Annear of Geosyntec reviewed updates to the methodology for estimating loads for stormwater projects and presented results from the preliminary pollutant load analysis for selected RCOCs for both CSO and stormwater projects. Their presentations included:

- The CSO characterization approach, based largely on simulated CSO flow from calibrated models and estimated RCOC concentrations from SPU and King County sampling results
- Estimates of the capture efficiency and volume reduction of the stormwater best management practices (BMPs) being considered for the Integrated Plan
- Methodology for evaluating water quality inputs for structural BMPs
- Updated methodology for evaluating water quality impacts of street sweeping
- Draft results for proposed stormwater projects and CSO projects being considered for deferrals for the following parameters:
 - Volume of water treated or reduced
 - Total suspended solids
 - Fecal coliform bacteria
 - Dissolved copper loads
 - Polychlorinated biphenyl (PCB) loads
 - Ammonia nitrogen loads

Expert Panel Comments and Responses

Comments on the Methodology:

- In response to a question, Eric Strecker of Geosyntec clarified that capture efficiency for stormwater projects referred to the percent treated (managing via infiltration or BMP) rather than the percent of flow held back.
- In response to a question about whether the Monte Carlo analysis was based on extreme values or event by event, Rob Annear noted that the Monte Carlo analysis uses randomly generated values from within the confidence intervals to derive the 50 percent range for the results.

Comments on the Draft Results:

- Bob Pitt and Bob Gearheart commented on the presentation of CSO project and stormwater project results in the same graphs, and that it was difficult to identify the reductions for the CSO projects since they were so small compared to the stormwater projects. Bob Pitt suggested that a log scale could show help to show the comparative results more clearly. Bob Gearheart suggested that results for CSO and stormwater projects could be displayed on different graphs.
- Kyle Dreyfuss-Wells noted that the difference in volume reductions is what is driving the difference in pollutant load reductions between CSO and stormwater projects. She said that needs to be clearly articulated. For example, Rob Annear of Geosyntec had noted that fecal coliform concentrations are higher with CSOs, but the load reductions are higher with the proposed stormwater projects rather than the CSO projects proposed for deferral since the volume being reduced is so much greater.

- In response to a question, SPU clarified that it does not need to show a positive benefit for the proposed stormwater projects compared to the CSO projects proposed for deferral on every one of the water quality pollutants for the stormwater projects to still have a significant overall water quality benefit.

Discussion of Exposure Assessment Analysis

- Rick Pleus of Intertox gave a presentation on the exposure assessment methodology and initial results from the exposure assessment analysis; his presentation covered the following topics:
 - o Objectives of the exposure assessment for the Integrated Plan
 - o Exposure index value (EIV) formula and calculations for human and ecological receptor factors
 - o Results of EIV calculations, both summary results for the stormwater and CSO projects being considered and detailed calculations for two projects
 - o The findings that the human EIVs are dominated by PCBs and fecal coliform, and that ecological EIVs are dominated by oil and grease, phosphorus and zinc (at freshwater stormwater locations), and nitrogen ammonia (at freshwater CSO locations)

Expert Panel Comments and Responses

- Several Panel members, including Jean Zodrow and Kyle Dreyfuss-Wells, commented on the “Initial Results” table in the presentation on slide 40 that displayed summary results for fifteen stormwater and CSO projects being considered for the Integrated Plan, noting in particular that the columns showing the “relative change in load” was not intuitive, especially since many of the projects with high load reductions had no change in volume.
 - o Gretchen Bruce of Intertox explained that the relative change in load could be due to changes in volume, concentration, or both, and that the EIVs (in the final columns in the table) incorporate receptor factors, which are compound specific.
 - o The Integrated Plan team agreed to examine ways to present the data in a more clear, and concise manner.
 - o Kyle Dreyfuss-Wells added that it would be helpful to think about ways to graphically represent the exposure assessment results so that people could intuitively understand whether something was “good” or “bad” (for example, “percent reduction” makes sense).
- Jean Zodrow suggested that it would be helpful to see how the projects are broken out by RCOC. It could give a clearer picture of how the contaminants affect the EIVs, especially for ecological receptors. In particular, it could be helpful to differentiating those that have acute effects, such as fecal coliform, and those that have chronic effects.
- Bob Gearheart noted that although there are a number of factors that are subjective and/or judgment-based in the methodology, SPU and the Integrated Plan team will need to explain and market the methodology to others. Given that, it will be important to represent the methodology more clearly and to provide reference material to help establish credibility. Jean Zodrow added that the methodology was still somewhat a black box, and that it would be helpful to see actual data for where the values came from, as well as the supplementary information such as assumptions and rationales for decisions.

- Gretchen Bruce said that the team used EPA criteria for the analysis, and derived assumptions based on established references.
- Rick Pleus added that the team will be providing full data sets to SPU for documentation with the Integrated Plan with the goal of being transparent.
- Bill Ross of Ross Strategic and Rick Pleus of Intertox said that the team would work to provide more documentation for the Panel of the steps of the exposure assessment analysis and additional data to track how the calculations are made.
- Some panel members commented that the bar charts in the exposure assessment slides were hard to read. For example, on slide 43 it was not clear what the different grays were in the chart, and panel members did not know that the pollutants were displayed in the bars in the same order as in the key on the charts until it was mentioned on the call.
- Bob Gearheart said he was surprised by the high oil and grease values. Gretchen Bruce responded that the team was using State of Washington values for oil and grease, but would be looking further into what was driving the results.

Wrap Up and Next Steps

- Kevin Buckley of SPU said that the next steps for the SPU and Integrated Plan team will be to examine whether the proposed stormwater projects provide significant water quality benefits relative to the CSO projects proposed for deferral, based on load reductions and exposures, and then look at other “soft” criteria through the multi-objective decision analysis (MODA) process in selecting projects for the Integrated Plan.
- Bob Gearheart said he would be interested in working with the other Expert Panel members to prepare a letter or small report that would summarize the goal of the Expert Panel process, the methods used by the Integrated Plan team, how the Panel felt about the methods, and any recommendations for SPU. It would be an opportunity to summarize the Panel’s work that could be advanced with the process.
 - The Panel members present at the meeting—Bob Pitt, Kyle Dreyfuss-Wells, and Jean Zodrow—indicated support for the idea.
 - Bob Gearheart said he would develop an outline for the letter.
- The final Expert Panel meeting will be on **Monday, September 16, 2013**, in Seattle. There will also be a reception after this meeting to acknowledge the Panel’s work.
 - This meeting will include updates on the exposure assessment and load results, a discussion of SPU’s approach for evaluating how proposed stormwater projects are significantly better than CSO projects proposed for deferral in terms of the consent decree criteria, and final reflections and recommendations from the Expert Panel.

Participants and Observers

Name	Organization
Expert Panel Members	
Bob Gearheart, Chair	Professor Emeritus, Humboldt State University, Arcata, CA
Kyle Dreyfuss-Wells	Manager of Watershed Programs, Northeast Ohio Regional Sewer District, Cleveland, OH
Bob Pitt	Cudworth Professor of Urban Water Systems, Department of Civil, Construction, and Environmental Engineering, University of Alabama, Tuscaloosa, AL
Jean Zodrow	Project Toxicologist, ARCADIS U.S., Inc., Lakewood, CO
SPU and Consultant Participants at the Table	
Kevin Buckley	Integrated Plan Project Manager, SPU
Andrew Lee	Combined Sewer Overflow Program Manager, SPU
Mike Milne	Integrated Plan Consultant Team Project Manager, Brown and Caldwell
Bill Ross	Expert Panel Facilitator, Ross Strategic
Audience Members	
Timothy Croll	SPU
Rex Davis	SPU
Jonathan Frodge	SPU
Beth Schmoyer	SPU
Tracy Tackett	SPU
Emiko Takahashi	SPU
Justin Twenter	Brown and Caldwell
Rob Annear	Geosyntec Consultants
Aaron Poresky	Geosyntec Consultants
Eric Strecker	Geosyntec Consultants
Gretchen Bruce	Intertox
Rick Pleus	Intertox
Jennifer Tice	Ross Strategic
Dino Marshalonis	U.S. Environmental Protection Agency
Alison Evans	Washington State Department of Ecology
Rachel McCrea	Washington State Department of Ecology

Seattle Public Utilities Integrated Plan Expert Panel

Meeting #5, September 16, 2013

Meeting Summary

Participants

The fifth meeting of Seattle Public Utilities (SPU) Integrated Plan Expert Panel was attended by the five Expert Panel members, SPU managers and staff, consultants, and observers. The audience consisted largely of SPU staff and technical consultants. A full list of attendees is at the end of the summary.

Name	Organization
Expert Panel Members	
Bob Gearheart, Chair	Professor Emeritus, Humboldt State University, Arcata, CA
Derek Booth	Adjunct Professor, Bren School of Environmental Science and Management, University of California Santa Barbara, Santa Barbara, CA
Kyle Dreyfuss-Wells	Manager of Watershed Programs, Northeast Ohio Regional Sewer District, Cleveland, OH
Bob Pitt	Cudworth Professor of Urban Water Systems, Department of Civil, Construction, and Environmental Engineering, University of Alabama, Tuscaloosa, AL
Jean Zodrow	Project Toxicologist, ARCADIS U.S., Inc., Lakewood, CO
SPU and Consultant Participants at the Table	
Nancy Ahern	Deputy Director, Utility Systems Management, SPU
Kevin Buckley	Integrated Plan Project Manager, SPU
Andrew Lee	Combined Sewer Overflow Program Manager, SPU
Mike Milne	Integrated Plan Consultant Team Project Manager, Brown and Caldwell
Bill Ross	Expert Panel Facilitator, Ross Strategic

Meeting Objectives

The objectives for the Expert Panel meeting included:

- Review the consent decree requirements for the Integrated Plan and Seattle Public Utilities' approach to development of an Integrated Plan.
- Present results of the exposure assessment algorithms as applied to selected projects and selected representative constituents of concern (RCOCs), and obtain Expert Panel feedback on the approach and the application of the methodology.
- Present and obtain Expert Panel feedback on the pollutant load analysis for the proposed stormwater projects and potential combined sewer overflow (CSO) projects to be deferred in the Integrated Plan, including a comparison of loads for selected RCOCs.
- Discuss the team's approach to demonstration of "Significant Benefit" and hear Expert Panel members' overall reflections and recommendations on the Integrated Plan process.

A summary of the meeting discussions, organized by agenda topic, is below. Reflections from the Expert Panel and others on the Expert Panel process are included near the end of the summary.

Review of Consent Decree Requirements and Approach for Integrated Plan

- To begin the meeting, Kevin Buckley of SPU reviewed the requirements for the Integrated Plan in the City's consent decree, which was lodged on July 3, 2013. The Integrated Plan provides an opportunity for SPU to "propose water quality improvement project(s) that will result in significant benefits to water quality beyond those that would be achieved by implementing the approved CSO control measures only." The consent decree requirements include:
 - o Pollutant load reduction analysis for conventional water quality parameters for each proposed project
 - o Projected pollutant reductions to water bodies with impairments (impairments have focused on pathogens, metals, dissolved oxygen, and nitrogen ammonia)
 - o Projected pollutant reductions, including toxic organic compounds, to water bodies with specialized circumstances such as beach closure advisories, protected spawning grounds, and contaminated sediment cleanup sites
 - o Projected reductions in pollutant exposure for humans, ecological receptors, and/or threatened or endangered species
 - o Cost-benefit analysis of projects
- In addition to the consent decree requirements, SPU is using multi-objective decision analysis (MODA) to add to the significant benefit evaluation and help select projects that meet "triple bottom line" criteria.
- SPU has also selected low frequency, low volume CSO projects to analyze for potential deferral.

There were no comments or questions during this session.

Discussion of Exposure Assessment Analysis

- Rick Pleus and Gretchen Bruce of Intertox gave a presentation that walked through the details of the exposure assessment methodology and presented initial results of the analysis for human and ecological receptors. Their presentation covered the following topics:
 - o The team is now calculating three separate exposure index value (EIV) metrics:
 - Human: toxics (using chronic toxicity criteria)
 - Human: fecal coliform (using acute toxicity criteria)
 - Ecological: toxics and nutrients (using chronic criteria)
 - o Steps involved in the EIV calculation, which is based on concentration, water quality criteria, change in load, and the receptor factor (a measure of exposure potential)
 - o Steps needed to calculate human and ecological receptor factors
 - o An example of exposure assessment calculations for the South Park Water Quality Facility
 - o Draft results of human and ecological EIVs for toxics and fecal coliform for all potential stormwater projects and CSO projects under consideration for the Integrated Plan
- Intertox's presentation included the formulas for the exposure assessment, sources and assumptions for the analysis, and draft summary results for the three types of EIVs.

- In response to questions, Rick Pleus and Gretchen Bruce provided the following clarifications:
 - o The water quality criteria provide a way of evaluating relative hazards of different pollutants, through the calculation of pre-project concentration divided by the water quality criteria. Their approach is not a formal risk assessment, but a relative analysis of exposure across common assumptions and data sets for the stormwater and CSO projects.
 - o The water quality criteria used in the analysis are either federal government or state government criteria. If there are multiple criteria available (e.g., cancerous or noncancerous reference doses), the team used the criteria with the most conservative outcome.
 - o The ingestion values for exposure are based on EPA guidelines, local studies, and at times professional judgment. The team focused on data that were the closest available to the outfall. For example, if data were obtained from a local risk assessment that reported that fish consumption rates were higher (or lower) than in the EPA assumptions, the team used the local values.
 - o The human receptor factor calculations are based on an average “adult” and “child.”
 - o In answer to a question from Bob Gearheart about whether the exposure assessment considers race, Gretchen Bruce of Intertox said that the team used mean values in its analysis, but drew from local exposure assessments that considered the local population, which would include a diverse racial population.
 - o In answer to a question from Jean Zodrow about whether the human receptor factor was based on an annual average, Gretchen Bruce responded that the team calculated EIVs separately for the “high” release (cool) and “low” release (warm) seasons, in order to account for differences in exposure potential during those seasons, and then calculated an annual average EIV by weighting the average for the number of months in each season. The final EIV results for the CSO and stormwater projects are based on annual conditions.

Expert Panel Comments and Responses

- Derek Booth commented that if the water quality criteria are based on certain thresholds, there may be a more significant effect on exposure or a “step function” that occurs around that threshold as compared to the effect of similar magnitude changes in concentration that are not near the criteria level. He noted that the EIV calculations do not differentiate between changes that occur near the criteria and those that occur at other concentration levels.
 - o Gretchen Bruce of Intertox responded that the concentrations are end-of-pipe concentrations, not real exposure values (no one is really exposed to this concentration of RCOs), and that the team is using the criteria to evaluate relative exposures.
- Jean Zodrow observed that the hardness of the water could change the pre-project concentration values. She suggested looking at the average hardness and seeing how that affects the ratio of pre-project concentration to water quality criteria. Rick Pleus of Intertox said the team could do that.
- Several Expert Panel members, including Kyle Dreyfuss-Wells, Derek Booth, and Bob Pitt, commented on the fact that the denominator in the EIV equation depended on values for all projects, not just the project being analyzed. Panel members noted that SPU should consider whether to change the denominator if it changes the set of projects that it actually puts forward in the Integrated Plan.

- o Derek Booth said that an alternative would be to look at pre-project and post-project loads. Mike Milne of Brown and Caldwell said that the SPU team initially saw weird results, such as large projects not looking as good as expected, when the team did not consider changes in load relative to the reductions for all projects.
 - o Dividing by the same value for all projects provides a way to show relative values, which Bob Pitt indicated was a good approach. Derek Booth added that although the approach may make sense, it may not be intuitive.
 - o Panel members raised the issue of whether SPU would be updating the value for the change in load for all projects after SPU selected its projects for the Integrated Plan, or whether the denominator would be based on the original 14 projects that were considered. Gretchen Bruce of Intertox commented that since all of the values are divided by the same total load estimate, the EIV estimates would change in a proportional manner and this update would have no effect on the final results.
- Bob Pitt said that the distance of the receptor from the outfall does not have a linear effect on exposures, although that is how the receptor values are calculated. There will be a big impact of pollutant loads on receptors that are located really close to the outfalls, but differences in distance to the receptor will not matter as much for locations that are farther away. He suggested that SPU consider using a Gaussian distribution.
 - o Eric Strecker of Geosyntec noted that sediment contamination studies show a non-linear distribution of contaminants.
 - o The SPU Integrated Plan team will consider other ways of evaluating the distance component of the receptor factor equation whether these alternative approaches and how much impact they will have on the resulting EIV.
- Several Expert Panel members commented on how the EIV calculations depicted uncertainty, and that in several cases the information was presented as being more precise than it actually was, based on the significant figures in the analysis.
 - o For example, Kyle Dreyfuss-Wells noted that the South Park project example had 0.3 hours per month of wading, but that number actually reflects survey results extrapolated to the water body being examined.
 - o Eric Strecker of Geosyntec said that the team could pay more attention to the significant figures in the results.
 - o Bob Pitt said that the most important thing would be to truncate the final result based on the significant figures.
 - o A few panel members commented that it was surprising that one project accounted for 22 percent of the total reduction in zinc across all the projects, and they suggested that SPU double-check the numbers. Beth Schmoyer of SPU noted that this was a large project in an industrial basin, but said the team would take another look at the results.
- Bob Gearheart commented that the receptor factors for humans should indicate the number of people that the estimates apply to, not just the time for potential exposure over a given period. Gretchen Bruce of Intertox responded that this is incorporated implicitly into the overall “likelihood of exposure” estimate.

- Derek Booth asked the team how much variability there was in the data for the relative change in load for the RCOCs, as that part of the EIV calculation relates to project effectiveness and will be a large driver in the end results. He also noted that the column that has the most variability in the equation will drive the results.
 - Rick Pleus agreed, and noted that the choice of RCOCs also drives the outcome. Derek Booth and Jean Zodrow commented that there was a history of why SPU selected the RCOCs, and that this was based in part upon data availability.
- Bob Pitt said he found it difficult to evaluate the differences between projects when the results were not normalized by volumes (the differences could be due to the size of the project and/or the effectiveness of the treatment controls).
 - He noted that for the table that showed projects with the volumes on slide 50 of the presentation, the projects seemed to generally be ranked according to the volume reduction.
 - One exception to the trend that the better ranked projects reduced the most volume were the Longfellow Creek projects, which may imply that SPU should evaluate whether more can be done to address the water quality problems in that area.
- Derek Booth asked why the figure 91 percent volume reduction was so common across the stormwater projects.
 - The SPU team responded that 91 percent is an estimate of the flow reduction from bioretention projects; it is not location specific. Members of the team added that this estimate would likely be revised to 80 percent.
- Expert Panel members also provided several comments on how the information was presented, as follows.
 - Kyle Dreyfuss-Wells said that it would be important to document the additional clarifications and explanatory statements provided during the meeting as part of the Integrated Plan.
 - Bob Pitt noted that the slides would be clearer if they used consistent units across slides for concentrations (micrograms/liter or milligrams/liter).
 - Derek Booth and Bob Pitt commented on how the team described the duration of exposure, and noted that since hours per day is what is in the calculation, the team could describe exposures as a range of least to most likely, without converting them to a 1-to-5 scale. Gretchen Bruce of Intertox agreed.
 - Bob Pitt suggested that the arrows on slide 43 indicating the amount of time for different activities (e.g., 0.3 hours/month of wading) could be represented as bars to show the ranges instead of precise point values. It was also noted that February was omitted from this slide in the seasons (it should be February-September, not March-September).
- Kyle Dreyfuss-Wells observed that the EIV calculations are very complex, with a lot of assumptions, and they can raise a number of questions. It is important to be comfortable about the analysis, but also, when communicating the results of the analysis, it is important for there to be a clear message. The data should “pop.” If the results are confusing or unclear, there is a risk that the Integrated Plan could be poorly understood when the actual results are quite clear. The “sale” of the Integrated Plan and the analysis behind it needs to be considered. She suggested a FAQ document could be helpful.
 - Bob Pitt added that it is important to have defensible analysis (for example, looking at distance to receptors as a non-linear function).

- o Jean Zodrow noted that people will have preconceived notions, such as copper is bad for salmon in the Northwest, so it will be important to frame the results in terms of people's reference point to get the message across. Transparency is important, so communicating what the exposure assessment analysis provides will be important.
- o Bob Gearheart suggested doing a sensitivity analysis to see what changes the results and what does not.

Observer Comments and Responses

- Rob Grandinetti of the U.S. Environmental Protection Agency (EPA) asked why SPU selected the specific RCOCs it did, such as copper and zinc.
 - o Kevin Buckley of SPU said that SPU chose to use copper and zinc as RCOCs for the consent decree requirement to evaluate reductions in metals. Copper is a concern for species, and Eric Strecker added that it has been cited by NOAA Fisheries in biological opinions. Zinc has been present in industrial discharges in the city.
 - o SPU's process and rationale for selecting RCOCs for the pollutants identified in the consent decree was more fully described in the background materials and presentations provided to the Expert Panel in April and June.
- Rachel McCrea of the Washington Department of Ecology asked how the Integrated Plan team derived the 3 hours per month estimate for fishing for the example exposure assessment calculations for the South Park project in the Duwamish River basin.
 - o Gretchen Bruce said the estimate was based on a King County survey and was not specific to the Duwamish River.
 - o Rachel McCrea said that there is specific information about the Duwamish River and immigrant use of it, but she is reserving judgment and not disputing the numbers.
- Rob Grandinetti of the U.S. EPA said that he was not clear how the EIV calculations allow for comparison across pollutants.
 - o Andrew Lee of SPU and Rick Pleus of Intertox responded that the water quality criteria allow for the comparison of the relative hazard from different pollutants. Andrew Lee of SPU added that PCBs will make up a larger proportion of the EIV because they have high concentrations.
- Jonathan Frodge of SPU asked the Integrated Plan team why they only considered migratory species of fish (salmon) in the exposure assessment, and not non-migratory fish such as pile perch. He said state data show non-migratory species are a bigger issue for consumption than migratory species.
 - o Rick Pleus of Intertox clarified that the human EIV calculations include migratory and non-migratory fish species (an average across all fish consumed).
 - o It is the ecological EIV that uses salmon species as ecological receptors. SPU focused initially on threatened and endangered species as a means of meeting the consent decree requirements, and then decided to consider other species of salmon as other ecological receptors.
- Jonathan Frodge of SPU suggested that the Integrated Plan should emphasize that its goal is to select stormwater projects that will provide significant receiving water quality improvements compared to the deferred CSO projects, rather than to fully restore the receiving bodies.

Highlights of Stormwater and CSO Project Pollutant Load Analysis

- Justin Twenter of Brown and Caldwell and Rob Annear of Geosyntec provided updates on the pollutant load reduction analysis for CSO and stormwater projects being considered for the Integrated Plan, and reviewed the draft results for several key parameters.
 - Since the August Expert Panel webinar, the SPU Integrated Plan team simulated load reductions for CSO projects in the Long Term Control Plan (LTCP) that are not being considered for deferral to provide additional context for the analysis of projects for the Integrated Plan.
 - The presentation covered draft results of the pollutant load analysis for stormwater and CSO projects being considered for the Integrated Plan (and additional LTCP projects for some pollutants), focusing on volume treated/removed, total suspended solids, fecal coliform, dissolved copper, PCBs, and ammonia-Nitrogen. Results were shown in log and non-log scales.
 - The Integrated Plan team is working on several adjustments and updates to approach to evaluating stormwater project loads, including:
 - Revisiting the land use effluent mean concentrations for a few RCOCs
 - Refining the team's understanding of data collected for fecal coliform load reduction from street sweeping projects to ensure that estimates are sufficiently conservative regarding removal efficiency
 - Refining the approach for representing the performance of bioretention facilities

Expert Panel Comments and Responses

- Derek Booth commented on the fact that the street sweeping projects showed very high load reductions for many RCOCs, yet there were no error bars shown for those results, whereas other projects showed error bars indicating the uncertainty range.
 - Rob Annear of Geosyntec said that the load reduction estimates for street sweeping projects would be broken down by season (like other projects) and the team would be adding error bars.
 - He added that the street sweeping results are preliminary and most likely will come down. As noted above, the team is reevaluating the fecal coliform data collected for street sweeping projects, in particular, to make sure that load reduction estimates are sufficiently conservative.
 - Bob Pitt added that he would like to see the load reduction results for street sweeping projects, along with the supporting documentation, because the numbers were so high.
- Derek Booth also suggested that since there was not much variation in the results by season, perhaps SPU does not need to show both.
 - Rob Annear of Geosyntec said that the team did not know that there would not be significant seasonal variation until the data analysis was completed.
- Bob Gearheart asked whether there were any “pre-conditions” for projects, in particular whether street sweeping would eliminate load reduction benefits from other projects.
 - A member of the Integrated Plan team said that there would be some overlap across projects, but not much.
- Kyle Dreyfuss-Wells asked how the team was considering other flows that enter the system, such as sanitary sewer overflows and infiltration and inflow (I&I) from leaky pipes and other sources.
 - Rob Annear said that the team is using data collected by SPU that would reflect any I&I that occurred. There is some uncertainty in that SPU does not have groundwater sampling data.

- The Integrated Plan team asked for the Expert Panel’s perspectives on different approaches for estimating pollutant load reductions from natural drainage systems, based on assumptions about whether water leaving biofiltration facilities enters the receiving waters, goes into an underdrain, or is “treated” as it goes through the ground (100 percent removal of pollutants). Tracy Tackett of SPU indicated that SPU plans to use a conservative estimate that half the biofiltration projects will have underdrains and half will discharge to the receiving waters. For the half with underdrains, data from past studies will be used to estimate the pollutant removal. For the half without underdrains, the assumption will be that there is 100 percent pollutant removal for the volume treated (80 percent).
 - Bob Gearheart indicated that it made sense to consider groundwater quality in considering the effects of projects on the receiving waters.
 - Bob Pitt said that the filters provide good removal, and that if underdrains are not included, the remaining water could go to the groundwater. The main problem with flows getting to the receiving waters after being filtered is when the underdrain is daylighted. This is primarily an issue for organic toxics, not metals. He added that local experience with biofiltration is critical.
 - Bob Pitt said that he thought SPU’s proposed assumptions for where flows from biofiltration projects would end up seemed reasonable (literature values for removal efficiency of projects discharging to underdrains / 100 percent pollutant removal for projects discharging to groundwater).
 - In response to a question, SPU confirmed that it would also be changing the amount of volume treated by biofiltration projects from 91 to 80 percent, as mentioned earlier.

Observer Comments and Responses

- Mark Henley of the Washington Department of Ecology commented that his understanding was that the load reduction values were based on actual data for CSO projects, but based on published values for the stormwater projects.
 - Rob Annear of Geosyntec and Kevin Buckley of SPU responded that the stormwater project values are based on data collected locally, although the data are not specific to the project sites. The CSO project load reduction values are also modeled.
 - The Integrated Plan team examined the land uses relevant to the stormwater project sites, the range of pollutant loads coming from those land uses, and the estimated project performance based on the effectiveness of similar stormwater best management practices.
 - The load estimates from land use are based on the City’s NPDES stormwater characterization data, which was collected for three sites. The team then compared those data to data from sites in Tacoma, Washington, and Western Oregon, as well as national data, using box plots and showing 95 percent confidence intervals.
 - Eric Strecker of Geosyntec added that for many projects there is less concentration data available for CSO projects than for stormwater projects.
- Rob Grandinetti of EPA asked how the street sweeping projects being considered for the Integrated Plan differ from what SPU is required to do under its MS4 municipal stormwater requirements.
 - Kevin Buckley of SPU responded that street sweeping is not required by the MS4 permit but that SPU is doing some street sweeping (every other week in certain areas of the city) as part of the structural controls in its stormwater management plan. The street sweeping projects and other

stormwater projects being considered for the Integrated Plan are in addition to the stormwater pollution controls in the City's MS4 permit.

- o Rachel McCrea, the City's MS4 permit manager at Ecology, confirmed that street sweeping is not a requirement in the MS4 permit.
- o SPU is considering two street sweeping projects for the Integrated Plan: Phase 1, which will expand the miles of sweeping; and Phase 2, which will extend sweeping into residential areas.
- o Rob Grandinetti also asked whether the street sweeping data were monitoring and/or modeling results. Kevin Buckley of SPU said that street sweeping performance data are collected monthly as a composite sample, and then examined for the wet and dry seasons.
- Mark Henley of Ecology said he was surprised that the LTCP CSO projects (for some of the larger CSOs in SPU's system, CSOs #147 and #152) included in the comparison with potential Integrated Plan projects did not show much difference in load reductions from the stormwater projects. He said he would expect that the results for fecal coliform reductions for those CSO projects should be even higher than shown since they are addressing large volume CSOs.
 - o Eric Strecker said that the stormwater projects discharge more often than the CSO projects, and that CSOs are composed largely of stormwater, so those factors minimize the differences.
 - o Andrew Lee of SPU commented that since the load reductions of CSO projects 147 and 152 are comparable to the proposed stormwater, SPU is not proposing to defer those CSO projects. In addition, those CSO projects would show a better "bang for the buck" with respect to fecal coliform load reductions.
 - o Eric Strecker of Geosyntec said that the team could add a description to help explain the results.

Discussion of Approach to Demonstration of Significant Benefit

- Kevin Buckley of SPU and Mike Milne of Brown and Caldwell gave a brief presentation on how SPU is thinking about approaching the demonstration of significantly greater water quality benefits from the stormwater projects proposed in the Integrated Plan to those CSO projects proposed for deferral. Their presentation covered the following:
 - o SPU will evaluate "packages" of stormwater and CSO projects according to the consent decree criteria, including:
 - Pollutant loads
 - Exposure
 - Water body characteristics (considering impaired water body status, frequency of overflows, volume treated, etc.)
 - o As part of its analysis, SPU is considering how the pollutant load reductions for individual stormwater projects compare to the load reduction benefits of all the CSO projects SPU is considering for deferral.
 - o To help show significant benefits, SPU is planning to present a bar graph of the total load reductions of all stormwater projects proposed in the Integrated Plan compared to the benefits from all CSO projects to be deferred. (The graphs in the presentation depicted results for all 14 stormwater projects under consideration, but similar graphs would be produced after SPU selects a subset of stormwater projects for the Integrated Plan. The bar graph results were shown with and without the street sweeping results, since those numbers were in flux.)

- o In addition, SPU will examine the EIVs for stormwater projects as compared to the CSO projects; however, unlike the graphs for the pollutant loads, the EIV graphs uses the “most beneficial” CSO project as the baseline for comparison rather than using a baseline derived from summing the EIVs for all CSO projects being considered for deferral.
- o Overall, most individual candidate stormwater projects show significant benefits above all potentially deferred CSO projects, according to loads, EIVs, and frequency. Multiple combinations of stormwater projects would provide even more significant benefits as compared to all the potentially deferred CSO projects.
- o SPU will consider cost-effectiveness and other objectives (e.g., through the MODA process) to choose the final set of stormwater projects that will have load reductions and EIVs that far exceed the deferred CSO projects.

Expert Panel Comments and Responses

- Kyle Dreyfuss-Wells commented on the differential benefit shown between stormwater and CSO projects in the graphs. She asked whether any project that fell below the dotted black line representing the loads for all CSO projects (or the best CSO project, for EIVs) would be excluded from the Integrated Plan.
 - o Mike Milne of Brown and Caldwell indicated that SPU would be choosing packages of projects that significantly exceed the load or exposure reduction benefit from the CSO projects, rather than excluding individual projects solely based on that comparison.
- Derek Booth indicated that there will be a lot of scrutiny on the results, and people could question them because they are so much in favor of stormwater projects—questioning why the projects had not already been done or questioning the validity of the results.
 - o Mike Milne of Brown and Caldwell responded that SPU has a lot of “low-hanging fruit” with stormwater projects, while the City has already done most of the work to control CSOs; current CSO volumes are a fraction of what they were 20-30 years ago. The candidate CSO projects for potential deferral would address relatively small CSOs that are nearly under control. SPU has deliberately “stacked the deck” by identifying candidate stormwater projects that are expected to provide substantial water quality benefits compared to the small CSO projects that are candidate for deferral. That is one benefit of being able to do an Integrated Plan.
 - o Nancy Ahern of SPU commented that regulatory drivers for CSO and stormwater control differ, and that one of the benefits of the Integrated Plan is that it lets the City prioritize implementation of stormwater projects that will have significant water quality benefits in the near term.
 - o Derek Booth noted that comparing the stormwater projects to all the CSO projects is potentially doing the City a disservice in that the stormwater projects that do not show as good of benefits still outperform most of the CSO projects to be deferred. He thought it would be better to show why those stormwater projects were selected.
 - o He also suggested that more precise project names, such as the amount of linear feet of natural drainage systems (NDS or green infrastructure), could be helpful rather than using general labels such as “NDS partnering.” Bob Pitt added that many of the projects could probably be scaled.

- Bob Gearheart recommended that SPU consider the cost per pound of pollutant removal in comparing projects.
 - o Kevin Buckley said that the combined costs for the deferred CSO projects is around \$50-75 million, while the potential stormwater projects from which the City will choose is \$150 million, so SPU will not propose all of them.
 - o Kyle Dreyfuss-Wells said that it is not a fair comparison if SPU is comparing \$150 million in stormwater projects to \$75 million in CSO projects. The focus of the significant benefit analysis for the consent decree is on load reductions and other aspects of water quality. She added that it is important to note that the significant benefit analysis does not look at other co-benefits of stormwater projects for the community.

Observer Comments and Responses

- Mark Henley of Ecology noted that SPU intentionally chose CSO projects to defer that were low volume, and close to being controlled. Due to this, he is concerned about the potential for this plan to be taken out of context and used to undermine CSO control nationally.
 - o Andrew Lee of SPU said that SPU would tell the story of how it selected CSOs that were nearly under control (had overflow frequencies close to the state standard of one event per outfall per year), and note that Seattle is different from other locations in that it manages smaller basins and has controlled most of the historical CSO volume already (e.g., reducing volumes from 20 billion million gallons initially to 200 million gallons now annually).
 - o Kyle Dreyfuss-Wells agreed with that point, noting that Cleveland would never consider not addressing CSOs in its community that occur 40 to 80 times per year.
 - o Rob Grandinetti added that there are significant flow disparities among cities; if five percent of New York City's discharges were controlled by green infrastructure, then that could represent more than the total volume in Seattle's municipal system.
 - o One panel member suggested that an alternate graph could be to show the load reductions / volume treated for all CSO projects being deferred as well as for all the CSO projects in the LTCP.
- Rob Grandinetti of EPA asked how the SPU team derived the estimate of 150 stormwater discharges per year.
 - o Kevin Buckley of SPU responded that 150 discharges per year was an educated guess, but that a better estimate would be calculated.
 - o Beth Schmoyer of SPU suggested that the team could evaluate rain gage data to produce a better estimate.

Next Steps for the Integrated Plan Team and Summary Observations

- Kevin Buckley of SPU reviewed the next steps in SPU's overall process for the Integrated Plan, which include:
 - o Reviewing/refining aspects of the Integrated Plan methodology and data as they pertain to street sweeping and natural drainage systems
 - o Finalizing the pollutant load reduction estimates and the exposure assessment
 - o Completing the significant benefit evaluation of potential projects for the Integrated Plan
 - o Conducting a cost-benefit analysis of the potential Integrated Plan projects

- o Developing packages of stormwater and CSO projects and analyzing them in the MODA process
- o Submitting drafts of the Integrated Plan along with the Long Term Control Plan, Environmental Impact Statement, and a summary/overview to EPA and the Washington Department of Ecology by May 2014
- He noted that this meeting was the formal end of the Expert Panel process, but asked the Panel and observers if there were other areas where it would be useful for the Expert Panel to provide input on the methodology/approach.

Expert Panel Comments and Responses

- Bob Gearheart said he would like the Expert Panel to draft a letter to SPU with observations and recommendations from the Panel. He has worked with Jennifer Tice of Ross Strategic to prepare a draft outline of the letter, which was shared with the Expert Panel at the meeting.
- The group discussed the desired audience for the letter. Derek Booth suggested that it should be focused on SPU, but will be read by SPU management, the collective technical staff working on the Integrated Plan, the regulatory agencies, and others. Nancy Ahern of SPU added that the main audience should be SPU management, but that it will also be useful for the City Council, as it will help provide a lay perspective on the methodology.
 - o Kyle Dreyfuss-Wells said that the City Council will focus on the summary and the list of panel members.
- Observations of the Expert Panel on SPU's Integrated Plan approach and ideas that the group discussed for the letter included the following:
 - o Kyle Dreyfuss-Wells said that overall she feels very positive about SPU's Integrated Plan approach, but she has some concern about it being over complicated. It is important that SPU not lose the forest for the trees, since overall this is a "good news" story.
 - o Jean Zodrow noted that SPU has used good science, with reasonable approaches and some innovations. The team has presented this information well. The exposure assessment was a "black box" earlier in the process, but the Expert Panel has looked at the science and finds it to be reasonable.
 - o Bob Pitt said he found the Integrated Plan methodology to be an intriguing approach. There are some data gaps, and he expressed some concern that SPU had not covered how to explain remaining uncertainties that thoroughly. With large differentials in the results between stormwater and CSO projects, as long as the uncertainty bands are smaller than the overall differential, the results will hold.
 - o Derek Booth echoed Bob Pitt's comments in saying that the overwhelming difference in the volumes treated between the stormwater and CSO projects forgives many of the uncertainties and questions about the data. He added that it is appropriate to do a good job on the individual elements of analysis, but that should not undermine the common-sense outcomes the project is heading towards. Overall, it should be clear that it makes sense to do the proposed stormwater projects in the Integrated Plan and defer the CSO projects.
 - o Bob Gearheart observed that one of the things that he is taking away from this process is the way that the team has used site-specific information to make decisions about performance management.

- Comments that the group had about the relevance of this process to other communities included:
 - Bob Pitt noted that other communities are driven more by economics in their decision-making. They may need to show additional benefits from stormwater/green projects in order to show that they make sense from a cost-benefit standpoint.
 - Kyle Dreyfuss-Wells said that she thinks that overall the level of scrutiny on integrated planning is necessary at this point.
- Comments that the group had about the Expert Panel process included:
 - Jean Zodrow said that SPU was great at responding to comments.
 - Kyle Dreyfuss-Wells commented that she benefited from the process, and thought that utilities should share more about their efforts.
 - Bob Pitt said that the process was very condensed, but involved a good mix of participants.
 - Derek Booth observed that big and small issues raised by Expert Panel members seemed to receive equal weight/treatment. He suggested that the Expert Panel might have had an opportunity to form more refined/focused opinions and coalesce as a group if the panel members had had an opportunity to meet as a group on their own early on in the process
 - Kyle Dreyfuss-Wells added that if each panel member had been given 15 minutes to share his or her background at the first meeting/call, it might have allowed people to better tap each other's expertise.

Observer Comments and Responses

- Mark Henley of Ecology said that he would like the Expert Panel to provide more input on the street sweeping project alternatives and, in particular, on the assumptions about the effectiveness of street sweeping at reducing fecal coliform loads and how that compares to observed/sampled data.
 - SPU agreed and will be holding a call with the Expert Panel on the approach for the street sweeping alternatives in late October.
- Rob Grandinetti of EPA asked the group how the estimated pollutant load reductions would be evaluated and quantified after the projects are implemented, and whether SPU would be committing to those load reductions (e.g., 80 percent removal). Mark Henley of Ecology added that the consent decree specifies what the City must do if it does not meet its commitments.
 - Kevin Buckley of SPU said that this issue of tracking pollutant load reductions during implementation would be addressed as part of the City's post-construction compliance monitoring plan, which is a required part of the City's consent decree submittal.
 - Rob Annear noted that the estimates the team has developed have uncertainty bands associated with them, and that provides an indication about the confidence in individual results.
- Alison Evans of Ecology asked whether the Expert Panel had seen all the data they were interested in reviewing to feel comfortable with SPU's approach to the Integrated Plan. She added that Ecology would like to see a summary of the data that SPU used, the calculations performed, and the results.
 - Kevin Buckley of SPU and Rob Annear of Geosyntec said that the Integrated Plan team had presented a summary of the data used in the Integrated Plan analysis and where it came from, the methodology, the assumptions, and the results to the Expert Panel.
 - At the April Expert Panel meeting, the team presented the summary of the data sources and the assumptions.

- o Bill Ross of Ross Strategic clarified that the Expert Panel had not done a quality control review on the data entry.
- o Kyle Dreyfuss-Wells commented that what the Expert Panel asked for in terms of more details about the methodology and the numbers that SPU is using, particularly on the exposure assessment methodology, is what the SPU Integrated Plan team presented to the Panel at this meeting. She said that with the exception of additional information on the street sweeping project alternatives analysis, the Panel has been able to review the information it requested.
- o Derek Booth noted that the Expert Panel was never asked to serve in an approval or judgment role; rather, SPU has asked the Expert Panel for opinions on topics related to its Integrated Plan methodology. SPU is not required to do anything with the Expert Panel's comments. He feels like the Panel has been of use to the utility in the Integrated Plan development process, and does not feel a need to explore into the data in more detail.
- o Bob Pitt said that the April presentations did show that summary of the data and sources, and noted that for some of the results that looked "funny" (street sweeping/fecal coliform), it could be useful to look at those data further.

Wrap Up and Next Steps

- In wrapping up, Kevin Buckley of SPU said he and the Integrated Plan team have gotten the type of input they sought from an expert panel. The team meets after each Expert Panel meeting to review the suggestions and discuss how to proceed. He appreciates that he can call individual panel members to discuss specific issues. The Expert Panel reviewed more than just the methodology in the last couple of meetings, by looking at the results of the analysis of projects being considered for the Integrated Plan, but he said he was glad SPU sought the Expert Panel's input on these issues.
- Mike Milne of Brown and Caldwell added that he thought the Expert Panel's input had added a lot to the Integrated Plan. Eric Strecker of Geosyntec and Rick Pleus of Intertox said the ability to ask questions of the Expert Panel was valuable, and the panel's input was extremely helpful.
- Nancy Ahern of SPU said that the utility has gotten a huge amount out of the Expert Panel's discussions.
 - o SPU continues to be very excited about opportunity to do the Integrated Plan. The Integrated Plan is groundbreaking work that will allow SPU to make the case for implementing stormwater projects in the near-term and delaying regulatorily required, low-priority CSO projects.
 - o The conclusions that might be simple in Seattle's context may be harder to derive in other contexts. She said she thought the Expert Panel has done a great service for other communities working on integrated planning processes.
 - o Nancy Ahern thanked the Expert Panel, the SPU and consultant team working on the Integrated Plan, and the regulators observing the process.
- Bill Ross of Ross Strategic suggested that the Expert Panel would like to be kept informed about the Integrated Plan as SPU selects projects and as regulatory agencies review the Integrated Plan.
 - o Bob Gearheart agreed and said that perhaps SPU could send a newsletter to update the Panel. He would like to see how the process turns out.
 - o Nancy Ahern said that SPU would keep the Expert Panel informed about the outcomes of the Integrated Plan.

- Next steps identified at the meeting included:
 - SPU plans to convene the Expert Panel for a **conference call on October 23** to discuss the methodology and data for evaluating street sweeping alternatives for the Integrated Plan.
 - Ross Strategic will work with Bob Gearheart and other Expert Panel members to draft a letter summarizing the Expert Panel’s observations about SPU’s approach to the Integrated Plan.

Participants and Observers

Name	Organization
Expert Panel Members	
Bob Gearheart, Chair	Professor Emeritus, Humboldt State University, Arcata, CA
Derek Booth	Adjunct Professor, Bren School of Environmental Science and Management, University of California Santa Barbara, Santa Barbara, CA
Kyle Dreyfuss-Wells	Manager of Watershed Programs, Northeast Ohio Regional Sewer District, Cleveland, OH
Bob Pitt	Cudworth Professor of Urban Water Systems, Department of Civil, Construction, and Environmental Engineering, University of Alabama, Tuscaloosa, AL
Jean Zodrow	Project Toxicologist, ARCADIS U.S., Inc., Lakewood, CO
SPU and Consultant Participants at the Table	
Nancy Ahern	Deputy Director, Utility Systems Management, SPU
Kevin Buckley	Integrated Plan Project Manager, SPU
Andrew Lee	Combined Sewer Overflow Program Manager, SPU
Mike Milne	Integrated Plan Consultant Team Project Manager, Brown and Caldwell
Bill Ross	Expert Panel Facilitator, Ross Strategic
Audience Members	
Jonathan Frodge	SPU
Ed Mirabella	SPU
Charles Oppelt	SPU
Beth Schmoyer	SPU
Tracy Tackett	SPU
Ingrid Wertz	SPU
Justin Twenter	Brown and Caldwell
Kurt Playstead	CH2M HILL
Theresa Wagner	City of Seattle, Attorney’s Office
Rob Annear	Geosyntec Consultants
Eric Strecker	Geosyntec Consultants
Gretchen Bruce	Intertox
Rick Pleus	Intertox
Jennifer Tice	Ross Strategic
Rob Grandinetti	U.S. Environmental Protection Agency
Alison Evans	Washington State Department of Ecology
Mark Henley	Washington State Department of Ecology
Rachel McCrea	Washington State Department of Ecology

Seattle Public Utilities Integrated Plan Expert Panel

Meeting #6 (Webinar), October 23, 2013

Call Summary

Participants

The sixth meeting of Seattle Public Utilities (SPU) Integrated Plan Expert Panel, a web-enabled call on October 23, 2013, was attended by five Expert Panel members, SPU managers and staff, consultants, and observers. A full list of attendees is at the end of the summary.

Name	Organization
Expert Panel Members	
Bob Gearheart, Chair	Professor Emeritus, Humboldt State University, Arcata, CA
Derek Booth	Adjunct Professor, Bren School of Environmental Science and Management, University of California Santa Barbara, Santa Barbara, CA
Kyle Dreyfuss-Wells	Manager of Watershed Programs, Northeast Ohio Regional Sewer District, Cleveland, OH
Bob Pitt	Cudworth Professor of Urban Water Systems, Department of Civil, Construction, and Environmental Engineering, University of Alabama, Tuscaloosa, AL
Jean Zodrow	Project Toxicologist, ARCADIS U.S., Inc., Lakewood, CO
SPU and Consultant Participants at the Table	
Kevin Buckley	Integrated Plan Project Manager, SPU
Andrew Lee	Combined Sewer Overflow Program Manager, SPU
Mike Milne	Integrated Plan Consultant Team Project Manager, Brown and Caldwell
Bill Ross	Expert Panel Facilitator, Ross Strategic

Meeting Objectives

The objectives for the Expert Panel meeting included:

- Provide an overview of SPU's street sweeping program and the potential street sweeping projects being considered as part of the Integrated Plan.
- Present and obtain Expert Panel feedback on SPU's methodology and use of data for estimating the pollutant load reductions from street sweeping projects being considered for the Integrated Plan.
- Provide an opportunity for final Expert Panel observations and recommendations on the Integrated Plan approach.

A summary of the meeting discussions, organized by the agenda topic, is below.

Summary

Introduction

At the beginning of the meeting, Kevin Buckley of SPU noted that this webinar was intended as a follow-up discussion following the September 16th Expert Panel meeting when several Expert Panel members and observers had had questions about the methodology and preliminary pollutant load reduction results for street sweeping projects.

- On October 17, two SPU staff in the street sweeping program, Louise Kulzer and Shelly Basketfield, had a conference call with Expert Panel member Bob Pitt so that they could hear his comments firsthand, as they had not attended the September 16th meeting. Notes from that call were distributed as part of the meeting materials for this webinar.
- Bob Pitt said that he had appreciated the opportunity to provide his comments to SPU.

Discussion of Methodology for Estimating Pollutant Load Reductions from Street Sweeping Projects Being Considered for the Integrated Plan

- Shelly Basketfield of SPU gave a presentation on SPU's street sweeping program, the two projects SPU is considering for the Integrated Plan, and how SPU is estimating the pollutant load reductions that could be anticipated from those projects. Her presentation covered:
 - o The City's current street sweeping for water quality program and what it has achieved
 - o The two projects being considered for the Integrated Plan ("phase 1" and "phase 2" street sweeping)
 - o Assumptions SPU used to estimate the alternatives' water quality benefits (the assumptions related to street dirt washoff particle distribution, representative sample concentrations, representative pickup rates for Seattle, and representative pickup rates for alternatives)
 - o The process to develop water quality benefit estimates based on street sweeper pickup rates and estimated washoff pollutant load and concentration reductions
- She noted that SPU had revised its methodology since the September Expert Panel meeting to produce more conservative estimates. The key changes to the methodology included using only wet season fecal coliform data (instead of wet and dry season data) and using particle washoff rates derived from a study in Bellevue, WA conducted by Bob Pitt, which reduced SPU's previous estimates of the percentage of particles picked up by the sweeper that would have been washed off.
- After Shelly Basketfield's presentation, Rob Annear of Geosyntec gave an overview of the pollutant load reduction estimates for the street sweeping projects in the context of other stormwater projects being considered for the Integrated Plan and potential CSO control projects to defer.
- Key changes the Integrated Plan team made to the results since the September meeting included:
 - o Refining the effluent mean concentrations (EMCs) for different land uses
 - o Narrowing the scope of the natural drainage system (NDS) partnering
 - o Incorporating the assumptions discussed in September related to underdrains for NDS (50 percent of NDS will have underdrains, and for those NDS projects with underdrains, the assumption is that all pollutant removal occurs within the bioswale, so load reduction estimates are based on the estimated RCOC concentrations in the underdrains), and

- o Refining the estimates of street sweeping load reductions.
- These changes reduced the load reduction estimates for stormwater projects, but in general they still remained larger than those for most CSO projects being proposed for deferral. The exception to this trend was ammonia-nitrogen (ammonia-N), for which some of the CSO projects proposed for deferral showed greater load reductions than did many of the proposed stormwater projects.
 - o This is consistent with the team's previous results, which indicated that the candidate CSO projects would provide greater ammonia-N load reductions than most stormwater projects. The new assumptions for the NDS Partnering and Piper's Creek Bioretention project resulted in lower ammonia-N load reductions for those projects.
- Draft results shown in the presentation included:
 - o Volume treated/removed
 - o Total suspended solid loads
 - o Fecal coliform loads
 - o Dissolved copper loads
 - o PCB loads
 - o Ammonia-nitrogen loads

Slides from Shelly Basketfield and Rob Annear's presentations were distributed with the materials for the webinar and contain more information about the above topics.

Expert Panel Comments and Responses

- Bob Gearheart asked whether there would be an increase in biological oxygen demand (BOD) and chemical oxygen demand (COD) over time as the material in the pile decomposed.
 - o Rob Annear of Geosyntec said that there would be some decay that occurs in the 14-day window before samples are collected from the pile.
 - o Bob Pitt said that BOD is not a stable component (it varies over time and that can complicate laboratory results), and that COD is a more consistent measure, although there is a lag time for evaluating COD. Because of the lag time provided in the pile, Bob Pitt said he thought that SPU would probably be okay with its analyses for BOD/COD.
- In answer to a question from Eric Strecker of Geosyntec about using COD to predict BOD using standard stormwater ratios, Bob Pitt said the delay time for evaluating COD is several days, not a few hours. He added that the ultimate BOD value will be closer to the COD. To fully evaluate these relationships, a BOD rate study of 10-15 lab analyses would need to be done.
 - o Rob Annear said that one of the representative constituents of concern (RCOCs) is BOD, so if SPU is unable to use the ratio of COD to BOD-5, it will need to look at BOD.
 - o Following the webinar, Bob Pitt forwarded a chapter of a monitoring book to the Expert Panel and the Integrated Plan team that contained more information about studies of BOD in urban runoff. Research conducted by Dr. Pitt in 1979 showed that BOD from urban runoff after a 10-20 day incubation period can be 5-10 times greater than the BOD levels after 1-5 days.
- In answer to a question from Jean Zodrow, Rob Annear clarified that for dissolved copper, it is not necessarily the case that the street sweeping projects would have "no reduction" in dissolved

copper loads, but rather that SPU does not know what the load reduction would be so the SPU team assumed zero reductions to be conservative.

- Bob Gearheart commented that some of the projects could have synergistic or cumulative effects, and it was not clear whether the results accounted for any potential double-counting.
- Near the end of the discussion, Bill Ross of Ross Strategic asked each Expert Panel member to comment on his/her overall reactions to the street sweeping methodology and the draft pollutant load reduction results. Their responses were as follows.
 - Kyle Dreyfuss-Wells and Derek Booth both said that the methodology seemed reasonable, although they noted that this was not their area of expertise.
 - Bob Pitt said that the overall methodology for evaluating street sweeping project pollutant load reductions seemed fine, and that SPU was using reasonable assumptions and correct calculations. He encouraged SPU to conduct monitoring of street sweeping and any other stormwater projects that are implemented under the Integrated Plan.
 - Derek Booth added to Bob Pitt's comments that given the cost of this effort, monitoring would be worthwhile.
 - Jean Zodrow asked about the uncertainty in the estimates for street sweeping, and whether the adjustments had generally been overestimates or underestimates.
 - Aaron Poresky of Geosyntec said the Integrated Plan team looked at the variability in the monitoring data in the bins, characterized the uncertainty in that data, and used a Monte Carlo analysis to apply that uncertainty to the ranges of load reduction estimates for street sweeping projects. He added that SPU does not yet have a clear picture about the central tendency of the results.
 - Jean Zodrow said that that approach made logical sense to her.
 - Bob Gearheart noted the uncertainty/confidence ranges will be important for street sweeping, since there are less data for that type of project. In addition, there is an opportunity to monitor, sample, and add to the stock of knowledge regarding the efficacy of street sweeping programs, which would be of great benefit for other jurisdictions contemplating street sweeping.

Observer Comments and Responses

- Mark Henley of the Washington State Department of Ecology asked whether there would be bacterial regrowth in the wet season pile, and whether this would overestimate fecal coliform bacteria removal.
 - Shelly Basketfield of SPU said that when the overall runoff concentrations and SPU's assumptions are considered, she thinks that the results will still be conservative. However, the City plans to continue to look at the fecal coliform levels and do more sampling.
 - Overall, fecal coliform concentrations are low because SPU is only using wet season data.
- Mark Henley of Ecology asked how the volume treated was calculated for street sweeping projects, since the sweepers are not running all of the time it is raining.
 - The SPU team replied that it calculated the amount of land associated with the area being swept (streets and connected sidewalks) to estimate annual runoff volume of streets being swept.
- Mark Henley of Ecology said that the consent decree requires post-construction monitoring for options in the Integrated Plan, so he encouraged SPU not to overestimate load reductions since he

said they would need to be verified, and if load reductions were not as estimated, SPU may be required to construct additional stormwater projects to make up the difference.

Wrap Up and Next Steps

- Bob Gearheart said that the Expert Panel had worked with the support of Jennifer Tice of Ross Strategic to develop a letter summarizing the Expert Panel's observations and recommendations for SPU related to the Integrated Plan. He said that the Expert Panel would add anything relevant related to this call, and that they expected to finish the letter in a couple of weeks.
- Kevin Buckley of SPU thanked the Expert Panel for their participation in the process and their input on the Integrated Plan methodology. He said that although this was the final meeting of the Expert Panel, SPU plans to keep the Expert Panel informed about developments with the Integrated Plan.

Participants and Observers

Name	Organization
Expert Panel Members	
Bob Gearheart, Chair	Professor Emeritus, Humboldt State University, Arcata, CA
Derek Booth	Adjunct Professor, Bren School of Environmental Science and Management, University of California Santa Barbara, Santa Barbara, CA
Kyle Dreyfuss-Wells	Manager of Watershed Programs, Northeast Ohio Regional Sewer District, Cleveland, OH
Bob Pitt	Cudworth Professor of Urban Water Systems, Department of Civil, Construction, and Environmental Engineering, University of Alabama, Tuscaloosa, AL
Jean Zodrow	Project Toxicologist, ARCADIS U.S., Inc., Lakewood, CO
SPU and Consultant Participants at the Table	
Kevin Buckley	Integrated Plan Project Manager, SPU
Andrew Lee	Combined Sewer Overflow Program Manager, SPU
Mike Milne	Integrated Plan Consultant Team Project Manager, Brown and Caldwell
Bill Ross	Expert Panel Facilitator, Ross Strategic
Audience Members	
Shelly Basketfield	SPU
Margaret Bay	SPU
Rex Davis	SPU
Louise Kulzer	SPU
Rob Annear	Geosyntec Consultants
Aaron Poresky	Geosyntec Consultants
Eric Strecker	Geosyntec Consultants
Jennifer Tice	Ross Strategic
Alison Evans	Washington State Department of Ecology
Mark Henley	Washington State Department of Ecology
Rachel McCrea	Washington State Department of Ecology
Dino Marshalonis (phone only)	U.S. Environmental Protection Agency

Attachment D-3: Response to Expert Panel Comment Regarding Utility Curves

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Response to Expert Panel Comment Regarding Utility Curves

PREPARED FOR: Mike Milne, Brown and Caldwell

COPY TO: Kevin Buckley, SPU
Emiko Takahashi, SPU
Kurt Playstead/SEA

PREPARED BY: Pitzler, Dan/SEA

DATE: November 14, 2013

PROJECT NUMBER:

A recent letter to the SPU Director titled Expert Panel Comments and Recommendations on the Integrated Plan, dated November 12, 2013 included the following comment related to the multi-objective decision analysis (MODA) methodology used in the Integrated Plan:

In the final selection of stormwater projects for the Integrated Plan, we understand that SPU is considering the tradeoffs between potentially competing objectives through a systematic multi-objective decision analysis (MODA) process. We believe that this analysis would be stronger if it incorporated the concept of utility curves, which would allow normalization of the units and which would consider non-linear cause-and-effect relationships in the MODA criteria. If SPU does not choose to use utility curves in this analysis, it should document its rationale for this decision.

The normalization of units in the MODA evaluation did use the concept of utility curves, but it assumed that changes in value were linear within the range of the scale endpoints for each decision criterion. In this particular MODA, all measurement scales (excepting water quality) were constructed scales (i.e., qualitative) where words were used to define the midpoint and endpoints of 1-5 scales. Constructed scales were used because data were not available to develop more quantitative scales. It is our opinion that the changes in value resulting when moving along the constructed scales used in this analysis are generally linear in nature. Perhaps, an in-depth exploration of value scales would have uncovered some modest non-linear cause and effect relationships in some scales, but it was determined that the potential benefits of added scaling precision would be out-weighed by the time and complexity required to develop the scales with the multi-disciplinary team of staff and consultants that did the scoring.

For water quality, the MODA model used weighted changes in loads for three indicator parameters (fecal coliform, PCBs, and dissolved copper) to establish relative water quality scores for each project. In this case, the team believed that not enough was known about how these water quality parameters affected water quality in the different water bodies relevant to the projects to explore non-linear relationships in the scales.

Appendix E: Pollutant Reduction Estimation Method— Candidate LTCP Projects



Protecting Seattle's Waterways

Volume 3 – Integrated Plan

Appendix E: POLLUTANT REDUCTION ESTIMATION METHOD—CANDIDATE LTCP PROJECTS

Final

May 29, 2015



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List of Abbreviations

Term	Definition
ac	acre(s)
BECV	best estimate control volume
BOD	biochemical oxygen demand
CFU	colony forming unit(s)
City	City of Seattle
COC	Constituent of Concern
CSO	combined sewer overflow
Cu	copper
DO	dissolved oxygen
L	liter(s)
LCL	lower confidence limit
LTCP	Long-Term Control Plan
mg	milligram(s)
MG	million gallon(s)
PBDE	polybrominated diphenyl ether
PCB	polychlorinated biphenyl
RCOC	Representative Constituent of Concern
TSS	total suspended solids
UCL	upper confidence limit
Zn	zinc

Summary

This appendix describes the process used for the determination of load reductions of various pollutants, as identified in the Consent Decree (United States, 2013), to Seattle's waterways from the implementation of the Long-Term Control Plan (LTCP) projects considered candidates for deferral under this Integrated Plan (referred to herein as "candidate LTCP projects"). The results of this analysis facilitate comparison of these candidate LTCP projects with candidate stormwater projects. LTCP project load reductions are a function of both the modeled combined sewer overflow (CSO) discharge volume reduction from the implementation of a given project and the concentration of each Representative Constituent of Concern (RCOC) assumed to be present in a particular CSO's effluent. The CSO Outfall 107 project is the major contributor to the overall load reductions from all of the candidate LTCP projects, with the rest of the projects contributing less than 23 percent of the total load reductions for all RCOCs. Refer to Attachment E-2 of this appendix for a summary of projected load reductions from the implementation of each LTCP project by RCOC. Refer to Attachments E-1 and E-2 of this appendix for a summary of each LTCP project's contribution (as a percentage of total) to load reductions from all candidate LTCP projects.

Introduction

This appendix accompanies the City of Seattle (City)'s Integrated Plan. It describes the process used for the determination of load reductions of various pollutants identified in the Consent Decree (United States, 2013) to Seattle's waterways from the implementation of the candidate LTCP projects. The results of this analysis facilitate comparison of these candidate LTCP projects with candidate stormwater projects.

Objectives

The objective of this analysis was to determine the load reductions for Constituents of Concern (COC) that would be achieved if the candidate LTCP projects were implemented. This analysis formed the basis for comparison of candidate LTCP projects with candidate stormwater projects proposed for implementation under the Integrated Plan. Candidate stormwater projects were required to complete a similar load-reduction analysis under the terms of the Consent Decree. Candidate LTCP and stormwater projects were objectively compared to demonstrate that candidate stormwater projects offered "significant benefits" relative to candidate LTCP projects (one of the terms for stormwater project implementation under the Consent Decree).

By estimating the quantities of various undesirable and/or harmful substances that would be kept out of Seattle's waterways through the implementation of certain projects, this analysis provides a relatively simple and straightforward metric for comparing candidate LTCP projects, both to one another and to candidate stormwater projects.

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CHAPTER 1

Methodology

Estimation of the pollutant discharge reduction from the implementation of a particular LTCP project required characterization of the following two parameters:

- the volume reduction of CSO discharge in a given time period (i.e., seasonally or annually)
- the concentration of a given pollutant assumed to be present in CSOs

This chapter describes the methodology used in the estimation of these parameters, as well as the calculation methodology behind how they were used to estimate load reductions for particular pollutants at specific CSOs.

1.1 Determination of Pollutant Concentrations

This section provides a summary of the background RCOCs and pollutant concentrations.

1.1.1 Background: Representative Constituents of Concern

Section V.B. paragraph 20 of the Consent Decree lists a number of specific constituents that the Integrated Plan must address. These include fecal coliform bacteria, total suspended solids (TSS), biochemical oxygen demand (BOD), ammonia, phosphorus, oil and grease, and pH. The Consent Decree also lists several general categories of constituents (e.g., metals, pesticides, and semi-volatile organic compounds).

Due to the very tight schedule for developing the Integrated Plan, it was not possible to collect new water quality data. Therefore, the City compiled and reviewed existing CSO water data in light of the Consent Decree requirements to develop a list of "Representative Constituents of Concern" (RCOCs). In some cases, the City identified surrogates to represent a category of constituents (e.g., dissolved copper [Cu] and dissolved zinc [Zn] for metals; polychlorinated biphenyls [PCBs] and polybrominated diphenyl ethers [PBDEs] for toxic organic compounds).

The Consent Decree listed numerous specific constituents as well as categories of constituents. For some of these constituents, little or no data were available for an adequate evaluation. Also, it was not feasible to model each COC given the available data and schedule. Therefore, the Integrated Plan team selected RCOCs with guidance from the Expert Panel. RCOCs were selected based on Consent Decree requirements, data availability, and professional judgment. Table 1-1 lists the COCs listed in the Consent Decree and the recommended RCOCs to be used in the pollutant load reduction evaluations.

Table 1-1. COCs Identified in the Consent Decree and Recommended RCOCs Used for Project Evaluations

COCs identified in the Consent Decree	Recommended RCOCs
Biochemical oxygen demand (BOD)	BOD
Semi-volatile organic compounds	Bis(2-ethylhexyl)phthalate
Pesticides	Dichlobenil
Pathogens (fecal coliform bacteria)	Fecal coliform bacteria
pH	H+
Nitrogen ammonia	Ammonia-N
Oil and grease	Oil and grease
Polybrominated diphenyl ethers (PBDEs)	PBDEs ^a
Projected dissolved oxygen (DO)	Projected DO
Polychlorinated biphenyls (PCBs)	PCBs ^a
Phosphorus	Phosphorus ^a
Total suspended solids (TSS)	TSS
Metals	Dissolved copper
	Dissolved zinc
	Total copper
	Total zinc

a. Total phosphorus, total PCBs, and total PBDEs were used as RCOCs.

1.1.2 RCOC Concentrations

Local CSO water quality data were used to develop concentrations for each RCOC. The City sampled CSO water quality at 15 locations between 2007 and 2010. Sites were sampled from one to four times. In addition, King County sampled CSO water quality at seven locations in the Duwamish area between 2007 and 2009. These sites were sampled from three to five times.

Using these water quality concentrations was advantageous because they were actual data from the City and King County CSO systems. In addition, the samples were analyzed for most of the COCs listed in the Consent Decree.

A challenge in using these water quality concentrations was the fact that only one of the six CSOs with candidate LTCP projects were included in the locations sampled for water quality by the City and King County. This challenge was addressed by showing comparability between locations with and without candidate LTCP projects—specifically, showing that tributary basin land uses and RCOC concentrations between the locations with and without projects were similar.

The City sampling locations included one CSO with a project proposed for deferral in the Integrated Plan (CSO Outfall 99). Showing similarity between tributary area land uses (of sampled and unsampled CSOs with candidate LTCP projects) is assumed to support use of sampled CSO water quality concentrations for the unsampled CSOs. The comparison of tributary area land uses showed that the sampled CSO was predominantly residential/commercial, which was similar to three of the remaining CSOs with candidate LTCP projects. This is shown on Figure 1-1 below. This result suggests that the sampled water quality concentrations from the one CSO (CSO Outfall 99) could be applied to the three CSOs with similar tributary land use (CSO Outfalls 138, 139, and

140). Note: the remaining two unsampled CSOs consisted of mostly industrial land use (CSO Outfalls 107 and 111).

In addition to the comparison described above, the tributary land uses for the remaining 13 CSOs sampled by the City (but not proposed for deferral by the City) were summarized. This showed that the predominant tributary land use for all 13 CSOs was residential/commercial. This is also shown in Figure 1-1 below. Therefore, pooling all the water quality data sampled by the City, and using this to describe the CSOs, with mostly residential/commercial land use, with candidate LTCP projects (CSO Outfalls 99, 138, 139, and 140), was considered a reasonable approach.

The idea of pooling all the City sampling data and using them for the four Integrated Plan LTCP projects with residential/commercial land use was further evaluated by reviewing the water quality data collected by the City. Figures 1-2 through 1-4 summarize data of TSS, fecal coliform, and copper. Table 2-1 presents this information in tabular form. The median TSS value for the Integrated Plan CSO sampled by the City are significantly higher than the median value of the pooled data, which may suggest that using only data from this CSO for the remaining Integrated Plan CSOs would over-predict TSS. Therefore, the TSS summary could be interpreted to support use of the pooled data for characterizing Integrated Plan CSO water quality. The fecal coliform and copper medians for the Integrated Plan CSO are similar to the medians for the pooled data, which supports the use of the pooled data for describing the water quality of the residential/commercial CSOs with candidate LTCP projects.

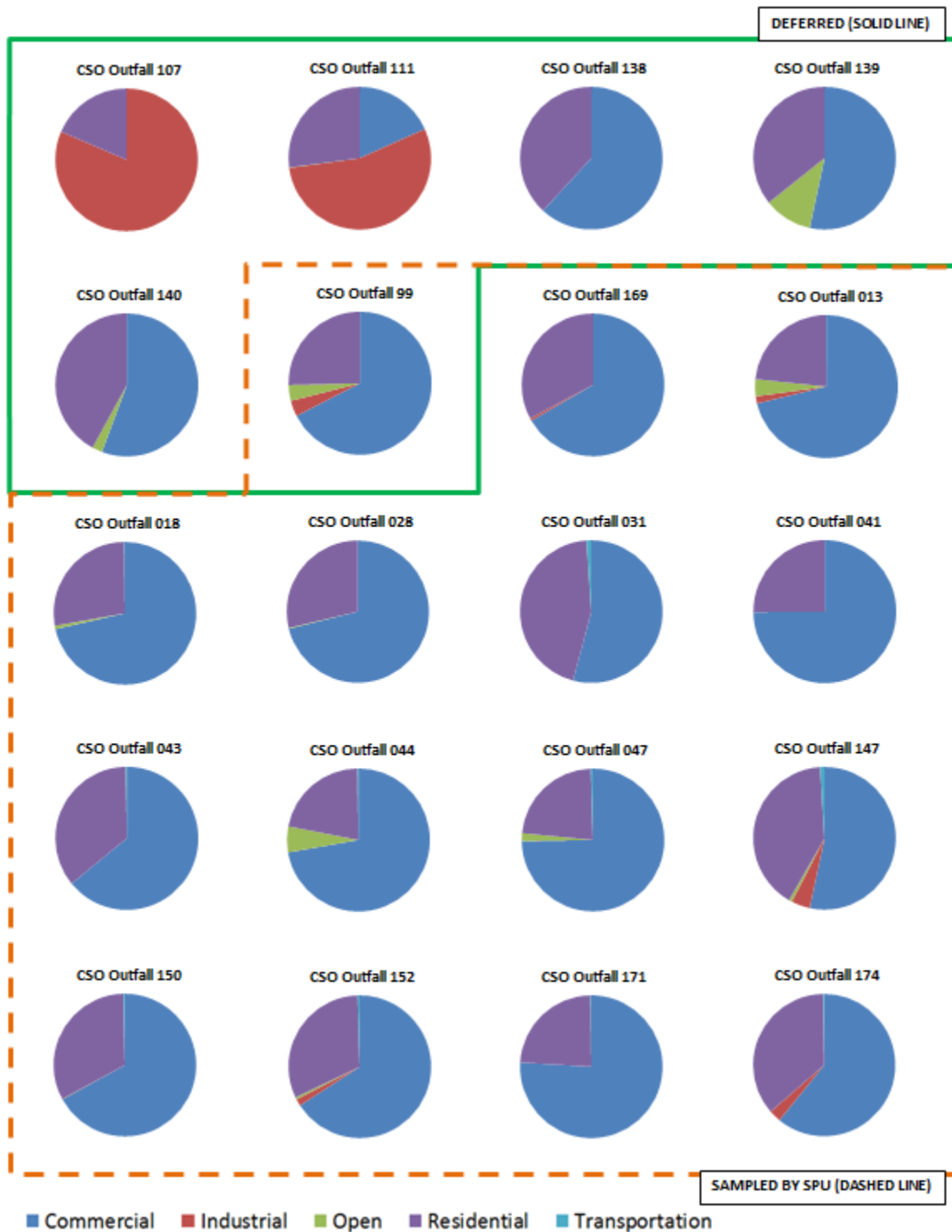


Figure 1-1. Tributary area land use for CSOs with candidate LTCP projects and CSOs sampled by the City

Table 1-2. Tributary Area Land Use for CSOs with Candidate LTCP Projects and CSOs Sampled by the City

CSO	Sampled by the City or proposed for deferral	Basin area (ac)	Percent of basin				
			Commercial	Industrial	Open	Residential	Transportation
013	Sampled	562	6.4%	0.1%	3.9%	66.4%	23.3%
018	Sampled	914	10.3%	0.0%	0.8%	61.2%	27.7%
028	Sampled	20	0.0%	0.0%	0.2%	71.1%	28.7%
031	Sampled	7	0.0%	0.0%	0.0%	54.7%	45.3%
041	Sampled	5	0.0%	0.0%	0.0%	74.9%	25.1%
043	Sampled	74	2.2%	0.0%	0.0%	62.1%	35.8%
044	Sampled	172	1.0%	0.0%	5.9%	71.3%	21.8%
047	Sampled	823	7.5%	0.3%	1.8%	67.5%	23.0%
147	Sampled	288	14.2%	1.3%	0.7%	42.9%	40.9%
150	Sampled	353	8.7%	0.1%	0.1%	58.4%	32.7%
152	Sampled	717	6.5%	1.1%	0.5%	60.2%	31.7%
171	Sampled	180	12.5%	0.0%	0.0%	63.6%	23.9%
169	Sampled	184	21.0%	0.1%	1.5%	54.8%	22.6%
174	Sampled	323	7.5%	1.3%	0.0%	55.0%	36.2%
99	Proposed for deferral and sampled	156	25.8%	1.7%	3.6%	43.5%	25.4%
107	Proposed for deferral	51	74.0%	7.5%	0.0%	0.0%	18.5%
111	Proposed for deferral	416	42.8%	15.8%	0.1%	13.3%	27.9%
138	Proposed for deferral	45	4.4%	0.0%	0.0%	57.4%	38.2%
139	Proposed for deferral	54	13.9%	0.0%	11.0%	39.4%	35.7%
140	Proposed for deferral	16	0.0%	0.0%	2.3%	55.7%	42.0%

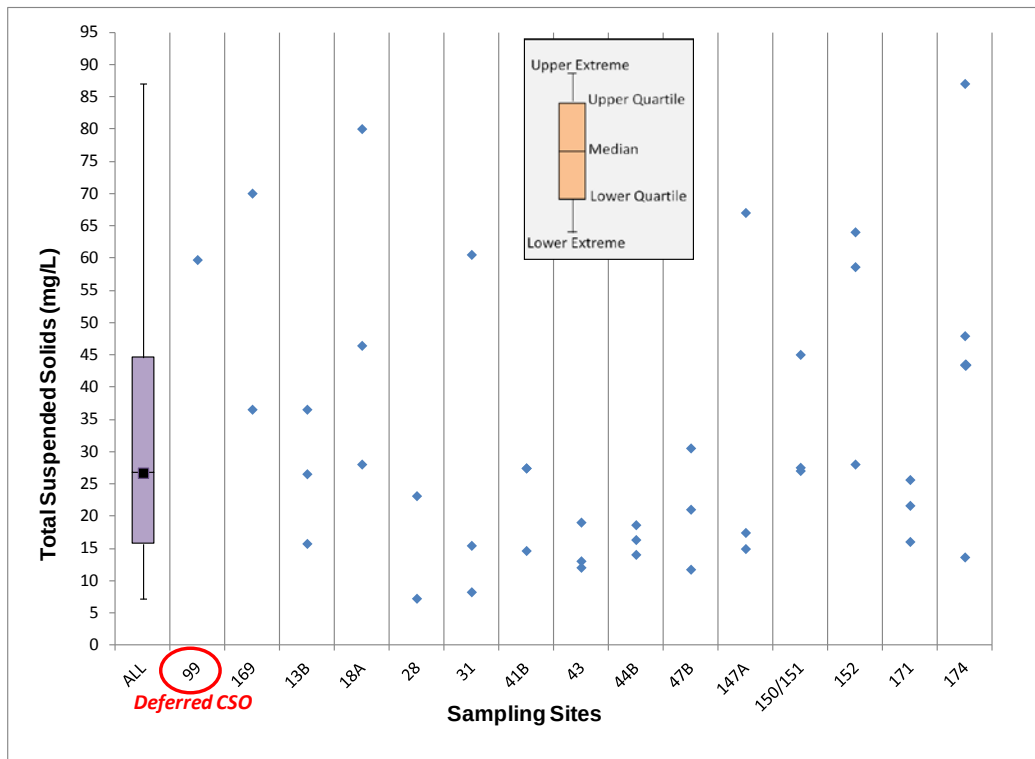


Figure 1-2. Total suspended solids, City sampling data

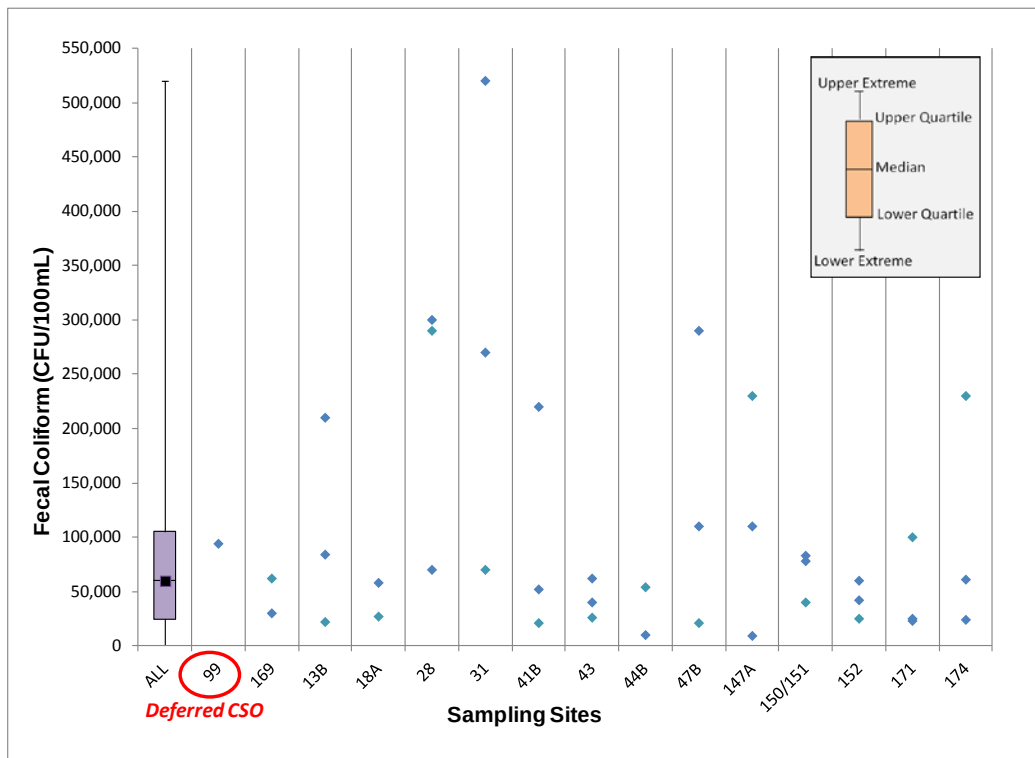


Figure 1-3. Fecal coliform, City sampling data

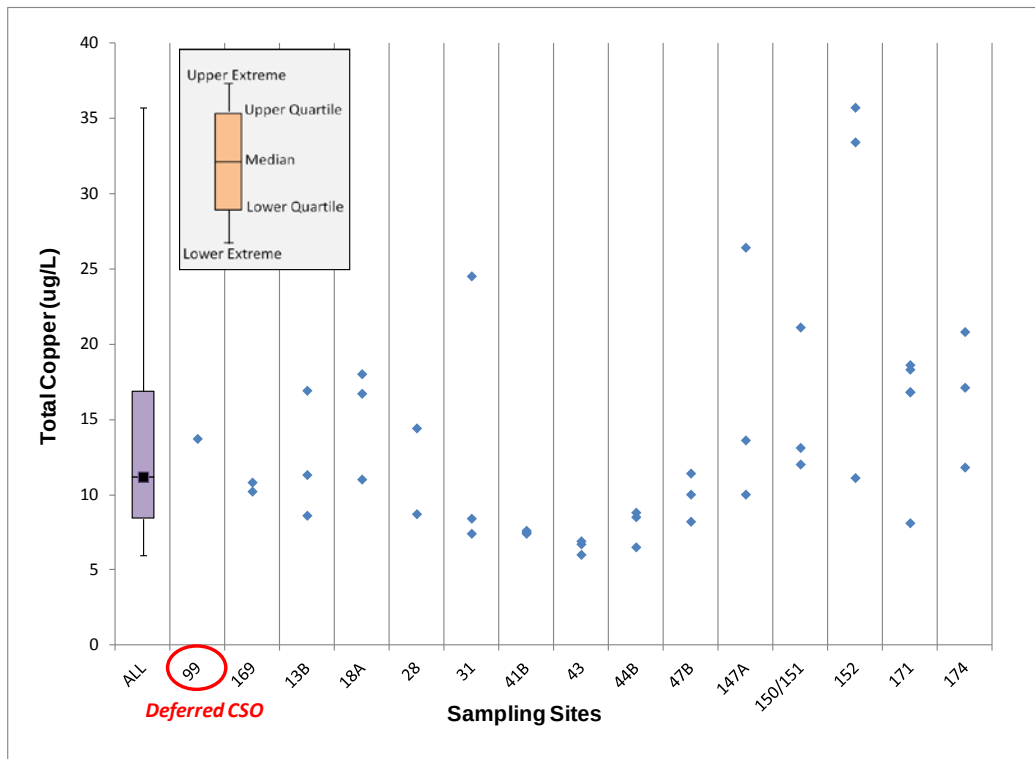


Figure 1-4. Total copper, City sampling data

Data for PCBs, PBDEs, and pesticides were not available from the City sampling data. Therefore, data from King County describing PCBs and PBDEs in CSO discharges (King County, 2011 and 2013) were used to fill the data gap. The Duwamish, Lander, Kingdome, and West Michigan sampling locations identified in the 2011 report were assumed to represent residential/commercial land use. Therefore, the PCB values for these locations, as reported in Table 4-3 of the report, were summarized for use in this analysis. The PBDE value used in this analysis is the median value reported by King County (2013) for all CSOs.

The two CSOs with candidate LTCP projects that were identified as having industrial land use (CSO Outfalls 107 and 111) are located in the Duwamish River basin. These CSO basins have similar land use as two CSOs, Brandon and Michigan, located nearby in the Duwamish River basin, which were sampled by King County (2011). Unlike the City data collection, the Michigan location was sampled in the combined sewer pipe (and not the overflow), during CSO or “near” CSO events. Three of the five events sampled at Michigan corresponded with recorded CSO events. The City pooled the King County water quality data from the two locations to estimate concentrations for the two CSOs with candidate LTCP projects.

The King County sample data included all RCOCs with the exception of the following parameters: BOD, fecal coliform bacteria, oil and grease, and H+. Residential/commercial (City sample data) values were used for industrial values to fill this data gap. PBDE concentrations were developed in the same way as described above.

Dichlobenil was used as a surrogate for the pesticide parameter because there were no CSO sampling data for pesticides. Dichlobenil was sampled in stormwater, as part of the state and federal requirements for CSO discharge required monitoring. The stormwater sampling provided concentrations of dichlobenil for residential, commercial, and industrial land uses. Therefore, median dichlobenil concentrations of each land use type were used to estimate a weighted concentration based on the land use of each CSO basin. This weighted

concentration was factored by percentage of flow attributable to groundwater and stormwater within each CSO basin, based on the assumption that the pesticide is found only in stormwater and groundwater.

The RCOC concentrations used in this LTCP analysis were the mean of the data set, as calculated by the bootstrap method. The upper confidence limit (UCL) and lower confidence limit (LCL) were also estimated. This bootstrap method—used for deriving the mean, UCL, and LCL of the CSO water quality data set—was also applied to the data set used for the stormwater project evaluation, as discussed in the Integrated Plan and the stormwater project evaluation appendix.

For the results of this pollutant concentration analysis, see Section 2.1.

1.2 Determination of Volume Reductions

The methods used for estimating the reduction in CSO discharge volumes from the candidate LTCP projects entailed the use of the City's calibrated CSO flow models.

The City developed hydrologic and hydraulic models (EPA-SWMM 5 Build 5.0.022) for the currently uncontrolled CSO basins to support development of the LTCP. The models were developed to assess the performance of the existing system, predict wet weather flows, and estimate the frequency and volume of CSO events. The models were calibrated to flow monitoring data collected within each CSO basin. A full discussion of the modeling conducted for each of these CSO basins is provided within the LTCP reports, Volumes 2–10 (Brown and Caldwell, 2012).

These calibrated models were a good source of flow volume information for this LTCP pollutant reduction evaluation because they provide simulated, long-term time series of CSO events (detailing volume and duration). In addition, the models were used to develop estimates of control volumes (i.e., required storage) to limit the CSO to one or fewer overflows per year.

The basic steps involved in estimating volume reduction for each LTCP project were as follows:

1. Summarize the model results to determine the CSO events for the last 20 years of the simulation record. The past 20 years of the simulation record are used to correspond to the regulatory requirement of one allowable CSO per year, on average, for a 20-year period. Model results for a precipitation scaling factor near 1.00 are used. See below for more discussion regarding the scaling factor.
 - a. Note: CSO Outfall 107 model results were summarized for the past 10 years of record because there was additional uncertainty regarding the past 20 years of record. The LTCP describes this in more detail.
2. Retrieve the best estimate control volume (BECV) developed for the candidate LTCP project. The BECV is the storage volume needed to bring an uncontrolled CSO basin into control (i.e., one overflow per year, on average), as determined by the modeling analysis.
3. Subtract the BECV from each pre-project CSO event volume to estimate post-project CSO volume for each event.

4. Summarize the average LTCP project reduction volume for a given time period (i.e., seasonally or annually). Two seasons were used for the seasonal summary: Season 1 represented the period between October and January and Season 2 represented the period between February and September. In general, a higher frequency and CSO volume is observed for events occurring in Season 1 while a lower frequency and CSO volume is observed for events in Season 2.

Uncertainty was represented in the calibrated model simulations by using precipitation scaling factors. The models were simulated 11 times with different scaled precipitation time series to produce results representing the range of uncertainty. The BECV was estimated as the mean of the control volumes from the 11 simulations. The precipitation scaling factor associated with the BECV, for the CSOs included in this analysis, ranged from 1.07 to 1.15.

Model results associated with a scaling factor of 1.00 were used for this LTCP pollutant reduction analysis. This scaling factor was used, in part, because the stormwater projects included in this analysis did not use scaled rainfall to account for uncertainty related to, among others, using historical rainfall to predict future conditions or the effects of climate change. Climate change effects, which would presumably occur in the future (after the proposed deferral has ended) were accounted for in the models by adding 0.06 to the scaling factor. Removing climate change from the scaling factors provided above would reduce many scaling factors to near 1.00.

For the results of this volume reduction analysis, see Section 2.2.

1.3 Load Reduction Calculations

Load reductions were calculated as a function of RCOC concentration and modeled CSO discharge volume reduction for every RCOC except fecal coliform using the following formula:

$$L_R = C \times V_R \times \left(\frac{10^6 \text{ gal}}{\text{MG}} \right) \times \left(\frac{3.78541 \text{ L}}{\text{gal}} \right) \times \left(\frac{\text{kg}}{10^6 \text{ mg}} \right)$$

Where:

L_R = Average load reduction for a given RCOC (except fecal coliform) over a given time period $\left(\frac{\text{kg}}{\text{time}} \right)$

C = Concentration of a given RCOC in effluent from a given CSO outfall $\left(\frac{\text{mg}}{\text{L}} \right)$

V_R = Modeled average CSO discharge volume reduction for a given time period $\left(\frac{\text{MG}}{\text{time}} \right)$

Note that V_R is defined as the modeled average CSO discharge volume per time (i.e., seasonally or annually) prior to the installation of a control measure (e.g., a large storage pipe) minus the modeled average CSO discharge volume per time after the installation an control measure. Also note that because concentrations for each RCOC other than fecal coliform were given in a variety of units, it was necessary to convert those units to $\frac{\text{mg}}{\text{L}}$ prior to applying the above formula.

When calculating fecal coliform load reductions, the following formula was used:

$$L_{RFC} = C \times V_R \times \left(\frac{10^6 \text{ gal}}{\text{MG}} \right) \times \left(\frac{3.78541 \text{ L}}{\text{gal}} \right) \times \left(\frac{1000 \text{ mL}}{\text{L}} \right)$$

Where:

L_{RFC} = Average load reduction for fecal coliform over a given time period $\left(\frac{\text{CFU}}{\text{time}} \right)$

C = Concentration of a given RCOC in effluent from a given CSO outfall $\left(\frac{\text{CFU}}{\text{mL}} \right)$

V_R = Modeled CSO discharge volume reduction for a given time period $\left(\frac{\text{MG}}{\text{time}} \right)$

Note that because concentrations for fecal coliform were given in standard units of colony-forming units (CFU) per 100 mL $\left(\frac{\text{CFU}}{100 \text{ mL}} \right)$, it was necessary to convert those units to $\frac{\text{CFU}}{\text{mL}}$ prior to applying the above formula.

For tables showing the assumed concentrations in CSO effluent of the various RCOCs and modeled volume reductions, consult Tables 2-1, 2-2, and 2-3. Note that CSO Outfalls 107, 111B, 111C, and 111H are classified as industrial and the rest of the LTCP projects are classified as residential/commercial, these data can be used with the above equations to recreate the load reduction results shown in Attachment E-2 (also note that for dichlobenil, Table 2-2 should be used instead of Table 2-1).

CHAPTER 2

Results

The pollutant (RCOC) concentration analysis and the volume reduction analysis form the “building blocks” of the load reduction analysis. Results of all three of these analyses are summarized in this chapter.

2.1 Pollutant Concentration Results

Table 2-1 shows the results of the pollutant concentration analysis.

Table 2-1. Mean, UCL, and LCL of RCOCs Applied to the Stormwater Volumes for Estimating Pollutant Reductions							
Constituents of concern	Units	Residential/commercial			Industrial		
		Bootstrap mean	Bootstrap 95% lower confidence limit (LCL)	Bootstrap 95% upper confidence limit (UCL)	Boot-strap mean	Bootstrap 95% lower confidence limit (LCL)	Bootstrap 95% upper confidence limit (UCL)
Ammonia-N	mg/L	1.24	1.00	1.62	4.62	2.80	7.07
BOD	mg/L	19.5	15.3	24.7	19.5	15.3	24.7
Bis(2-ethylhexyl) phthalate	mg/L	0.0023	0.0018	0.0030	0.0083	0.0025	0.019
Dichlobenil	mg/L	Residential: 0.00012	N/A	N/A	0.000070	N/A	N/A
		Commercial: 0.000098					
Dissolved copper	mg/L	0.0051	0.0046	0.0057	0.0065	0.0041	0.011
Dissolved zinc	mg/L	0.019	0.018	0.021	0.032	0.022	0.046
Fecal coliform bacteria	CFU/100 mL	103,885	72,200	140,048	103,885	72,200	140,048
H+	mg/L	0.00012	0.000088	0.00017	0.00012	0.000088	0.00017
Oil and grease	mg/L	3.47	2.79	4.44	3.47	2.79	4.44
PBDEs	mg/L	0.000060	N/A	N/A	0.000060	N/A	N/A
PCBs	mg/L	0.000052	0.000040	0.000067	0.00011	0.000063	0.00020
Phosphorus	mg/L	0.60	0.44	0.75	1.57	1.23	2.12
Total copper	mg/L	0.013	0.011	0.016	0.053	0.034	0.068
TSS	mg/L	31.9	26.5	38.8	118.1	78.3	179.3
Total zinc	mg/L	0.042	0.038	0.048	0.14	0.10	0.19

Dichlobenil concentrations by LTCP project are shown in Table 2-2.

Table 2-2. Dichlobenil Concentration by LTCP Project	
Outfall	Dichlobenil concentration (mg/L)
CSO Outfall 24	1.18E-04
CSO Outfall 25	1.17E-04
CSO Outfall 99	1.11E-04
CSO Outfall 107	7.00E-05
CSO Outfall 111B	7.00E-05
CSO Outfall 111C	7.00E-05
CSO Outfall 111H	1.15E-04
CSO Outfall 138	1.18E-04
CSO Outfall 139	1.18E-04
CSO Outfall 140	1.18E-04

2.2 Volume Reduction Results

Table 2-3 shows the results of the volume reduction analysis. The same information is also illustrated in Attachment E-3.

Table 2-3. Modeled Volume Reductions				
Outfall	Season	Pre-project volume (MG/time period)	Post-project volume (MG/time period)	Volume reduction (MG/time period)
CSO Outfall 99	Annual	0.821	0.656	0.166
	Season 1 (Oct–Jan)	0.643	0.511	0.133
	Season 2 (Feb–Sep)	0.178	0.145	0.033
CSO Outfall 107	Annual	1.491	0.386	1.105
	Season 1 (Oct–Jan)	1.214	0.368	0.846
	Season 2 (Feb–Sep)	0.278	0.019	0.259
CSO Outfall 111	Annual	1.954	1.945	0.009
	Season 1 (Oct–Jan)	1.400	1.395	0.006
	Season 2 (Feb–Sep)	0.554	0.551	0.003

Table 2-3. Modeled Volume Reductions				
Outfall	Season	Pre-project volume (MG/time period)	Post-project volume (MG/time period)	Volume reduction (MG/time period)
CSO Outfall 138	Annual	0.281	0.190	0.091
	Season 1 (Oct–Jan)	0.236	0.171	0.065
	Season 2 (Feb–Sep)	0.045	0.019	0.027
CSO Outfall 139	Annual	0.034	0.028	0.006
	Season 1 (Oct–Jan)	0.027	0.023	0.004
	Season 2 (Feb–Sep)	0.007	0.006	0.002
CSO Outfall 140	Annual	0.245	0.194	0.051
	Season 1 (Oct–Jan)	0.194	0.161	0.033
	Season 2 (Feb–Sep)	0.052	0.033	0.018

2.3 Load Reduction Calculation Results

Results of volume-reduction and load-reduction calculations are shown in tabular form in Attachment E-2 and are illustrated visually in Attachments E-3 (volume reductions), E-4 (load reductions, regular scale), and E-5 (load reductions, log scale). The total volume reduction from all candidate LTCP projects is approximately 1.4 million gallons (MG)/year. The CSO Outfall 107 project exhibits the greatest volume and average load reductions. This project constitutes 77 percent of the total annual volume reduction and 77 percent of the annual average total load reduction for all RCOCs, with the other CSOs making relatively minor contributions to total volume and load reductions. Relative contributions of each LTCP project to total load reductions from all candidate LTCP projects (by RCOC) are shown in Attachments E-1 (chart) and E-2 (table).

As stated previously, the two variables necessary for calculating load reductions for a given RCOC at a given LTCP project are volume reduced per time for the CSO and the concentration of a given RCOC assumed to be present in the LTCP project's effluent. Of these two variables, the volume reduced per time exhibits much greater variability between CSOs—often varying over several orders of magnitude—than assumed concentration (see Attachment E-3 for a visual comparison of the volume reductions between different candidate LTCP projects). Hence, the “driving force” behind variability in load reductions for a given RCOC between LTCP projects is volume reduction.

This idea is illustrated in Attachment E-1, which shows, as a percentage, the relative contributions of each candidate LTCP project to the total load reduction from all candidate LTCP projects (by RCOC). Note that the percentage contributions of each LTCP project to total load reductions for each RCOC closely parallel the percentage contributions of each LTCP project to total volume reduced, in general. The notable exception is CSO Outfall 107, which for certain RCOCs makes a significantly greater contribution to overall load reductions than might be expected from its contribution to volume reduction. For instance, CSO Outfall 107 is responsible for 77

percent of the overall volume reduction, yet contributes 92 percent to TSS reduction, 93 percent to total copper reduction, and 92 percent to bis(2-ethylhexyl)phthalate reduction. This is because this LTCP project is located in an industrial area, whereas most of the other LTCP projects are located in residential/commercial areas, and concentrations of suspended solids (i.e., TSS), metals (i.e. total copper), and semi-volatile organic compounds (i.e., bis(2-ethylhexyl)phthalate) would be expected to be higher in CSO discharge from industrial areas. See Table 2-1 for concentrations of RCOCs assumed to be present in effluent from the CSOs.

When applied to the CSO Outfall 111 project, however, the above comparison between concentrations of RCOCs in CSO effluent in commercial/residential areas and those in industrial areas also illustrates the primary importance of volume reduction in the load reduction calculations. Like CSO Outfall 107, CSO Outfall 111 has higher effluent concentrations of suspended solids, metals, and semi-volatile organic compounds than the LTCP projects in residential/commercial areas, yet because the volume reduction is relatively small (0.6 percent of the total volume reduction), they contribute only a very small amount to the overall load reduction for these constituents.

In summary, estimated load reductions are generally driven primarily by modeled volume reductions. CSO Outfall 107 has the greatest volume reduction and the greatest load reduction for all RCOCs. The remaining LTCP projects proposed for deferral collectively make a relatively small (<23 percent) contribution to overall load and volume reductions.

CHAPTER 3

Limitations

3.1 Pollutant Concentration Analysis

As discussed in Section 1.1.2, LTCP project CSO-sampling data were limited in number of samples and overall time period of sampling. However, the limited data used were specific to City and King County CSOs and covered the geographic extent of the candidate LTCP projects.

3.2 Volume Reduction Analysis

There is uncertainty associated with the model results used for this analysis. This uncertainty is explained, in detail, in the City LTCP hydraulic modeling reports (Brown and Caldwell, 2012).

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CHAPTER 4

References

Brown and Caldwell. (2012). Seattle Public Utilities Long-Term Control Plan Hydraulic Reports. Volumes 1–13.

King County, 2011. Final. Duwamish River Basin Combined Sewer Overflow Data Report for Samples Collected from September 2007 to January 2010. Department of Natural Resources and Parks. Water and Land Resources Division.

King County, 2013. Draft. PCB/PBDE Loading Estimates for the Greater Lake Washington Watershed.

Seattle Public Utilities, 2013. Integrated Plan: Briefing Memorandum for April 29, 2013, Expert Panel Meeting. Briefing Memorandum on Stormwater and CSO Project Evaluation and Exposure Assessment Methods. April 22, 2013. Revised May 23.

United States of America and The State of Washington vs. The City of Seattle. 2013. Consent Decree. Civil Action No. 2:13-cv-678. July.

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Attachment E-1: Annual Volume and Load Reduction Summary Chart



Attachment E-2: Annual Volume and Load Reduction Summary Tables

Attachment E-2: Annual Volume and Load Reduction Summary Tables

Annual Volume and Load Reductions (Values)																
Project	Ammonia-N (kg)	Biochemical oxygen demand (kg)	Bis(2-ethylhexyl) phthalate (kg)	Dichlobenil (kg)	Dissolved copper (kg)	Dissolved zinc (kg)	Fecal coliform bacteria (billion CFU)	H+ (kg)	Oil and grease (kg)	PBDEs (kg)	PCBs (kg)	Phosphorus (kg)	Total copper (kg)	Total suspended solids (TSS) (kg)	Total zinc (kg)	Volume reduced (MG)
CSO Outfall 99	0.78	12	0.0015	0.00007	0.0032	0.012	651	0.000073	2.2	0.000038	0.000032	0.37	0.0084	20	0.026	0.17
CSO Outfall 107	19	82	0.035	0.00029	0.027	0.14	4,346	0.00049	15	0.00025	0.00046	6.6	0.22	494	0.57	1.1
CSO Outfall 111	0.15	0.64	0.00027	0.000003	0.00021	0.0011	34	0.0000038	0.11	0.0000020	0.0000036	0.05	0.0017	4	0.0044	0.0086
CSO Outfall 138	0.43	6.8	0.00081	0.000041	0.0018	0.0067	360	0.000040	1.2	0.000021	0.000018	0.21	0.0046	11	0.015	0.091
CSO Outfall 139	0.027	0.42	0.000050	0.000003	0.00011	0.00042	22	0.0000025	0.075	0.0000013	0.0000011	0.013	0.00029	0.69	0.00090	0.0057
CSO Outfall 140	0.24	3.8	0.00045	0.000023	0.0010	0.0038	201	0.000023	0.67	0.000012	0.000010	0.12	0.0026	6	0.0081	0.051
TOTAL	21	106	0.038	0.00043	0.034	0.16	5,614	0.00063	19	0.00032	0.00053	7.3	0.24	536	0.63	1.4

Annual Volume and Load Reductions (Percent of Total from All Candidate LTCP Projects)																	
Project	Ammonia-N (kg)	Biochemical oxygen demand (kg)	Bis(2-ethylhexyl) phthalate (kg)	Dichlobenil (kg)	Dissolved copper (kg)	Dissolved zinc (kg)	Fecal coliform bacteria (billion CFU)	H+ (kg)	Oil and grease (kg)	PBDEs (kg)	PCBs (kg)	Phosphorus (kg)	Total copper (kg)	Total suspended solids (TSS) (kg)	Total zinc (kg)	Average (all RCOCs)	Volume reduced
CSO Outfall 99	3.72%	11.60%	3.89%	16.16%	9.49%	7.61%	11.60%	11.60%	11.60%	11.60%	6.16%	5.11%	3.54%	3.74%	4.20%	8.11%	11.60%
CSO Outfall 107	92.23%	77.41%	91.90%	67.79%	81.37%	84.91%	77.41%	77.41%	77.41%	77.41%	87.64%	89.62%	92.57%	92.20%	91.32%	83.91%	77.41%
CSO Outfall 111	0.72%	0.60%	0.71%	0.71%	0.63%	0.66%	0.60%	0.60%	0.60%	0.60%	0.68%	0.70%	0.72%	0.72%	0.71%	0.66%	0.60%
CSO Outfall 138	2.05%	6.41%	2.15%	9.46%	5.24%	4.20%	6.41%	6.41%	6.41%	6.41%	3.40%	2.82%	1.95%	2.06%	2.32%	4.51%	6.41%
CSO Outfall 139	0.13%	0.40%	0.13%	0.59%	0.33%	0.26%	0.40%	0.40%	0.40%	0.40%	0.21%	0.18%	0.12%	0.13%	0.14%	0.28%	0.40%
CSO Outfall 140	1.15%	3.59%	1.20%	5.30%	2.94%	2.35%	3.59%	3.59%	3.59%	3.59%	1.91%	1.58%	1.09%	1.16%	1.30%	2.53%	3.59%

Attachment E-3: Volume Reductions by Candidate LTCP Project

This attachment contains the following figures:

- Figure E-3a. Average volume of water treated or reduced by the candidate LTCP projects
- Figure E-3b. Average volume of water treated or reduced by the candidate LTCP projects (Log Scale)

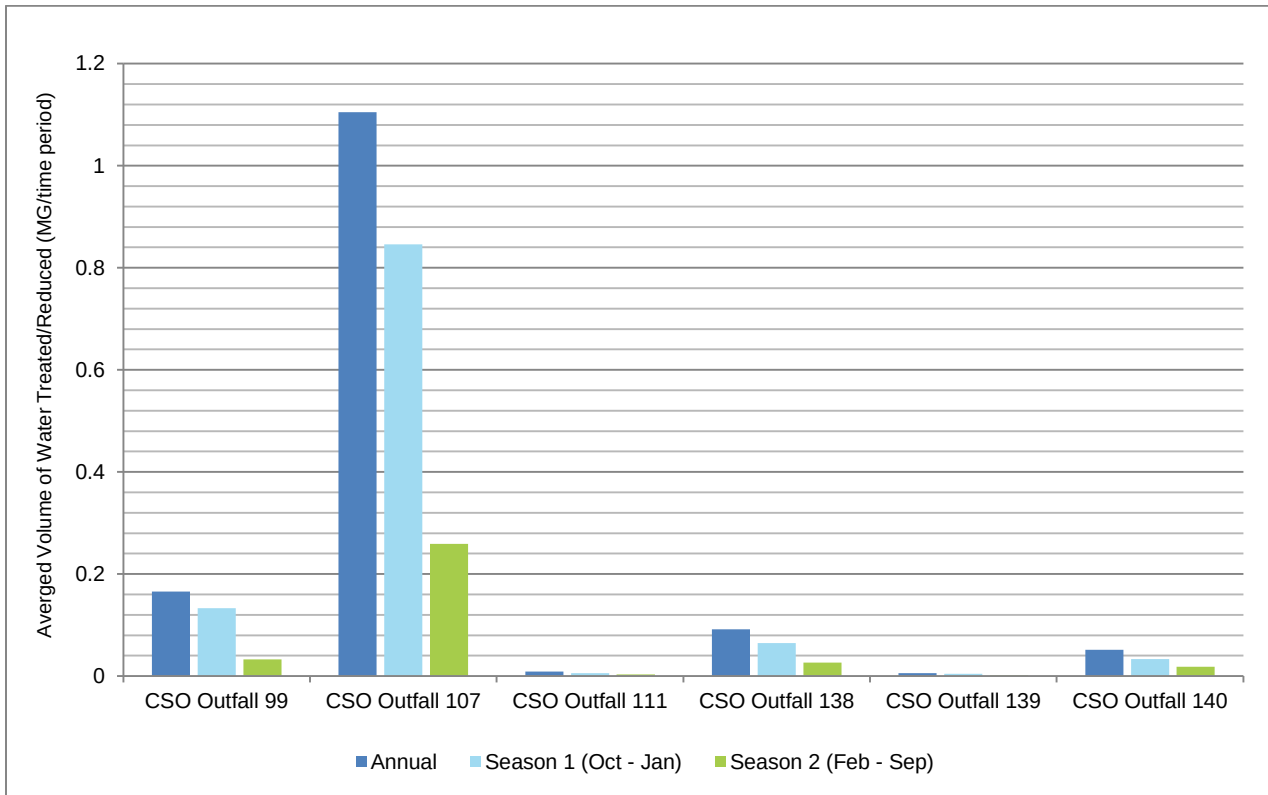


Figure E-3a. Average volume of water treated or reduced by the candidate LTCP projects

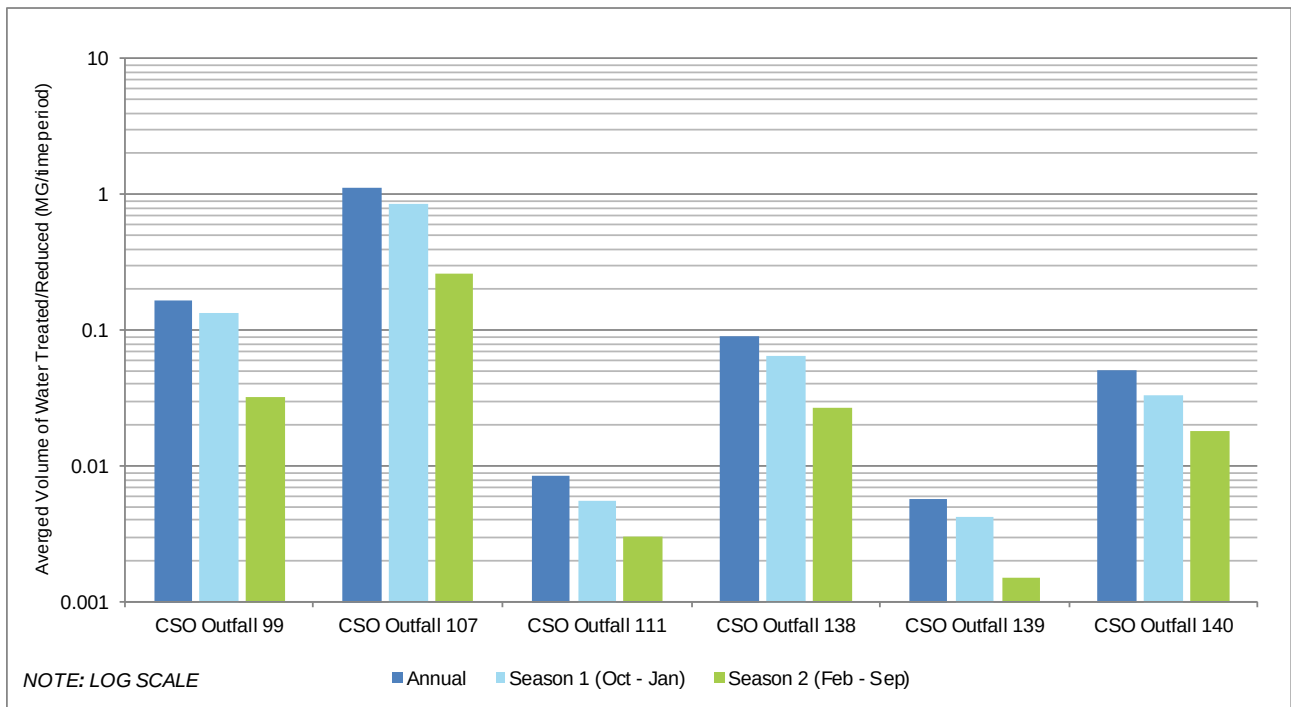


Figure E-3b. Average volume of water treated or reduced by the candidate LTCP projects (Log Scale)

Attachment E-4: Load Reductions by Candidate LTCP Project (Regular Scale)

This attachment contains the following figures:

- Figure E-4a. Average ammonia-N load reduction from the candidate LTCP projects (regular scale)
- Figure E-4b. Average BOD load reduction from the candidate LTCP projects (regular scale)
- Figure E-4c. Average Bis(2-Ethylhexyl)Phthalate load reduction from the candidate LTCP projects (regular scale)
- Figure E-4d. Average dichlobenil load reduction from the candidate LTCP projects (regular scale)
- Figure E-4e. Average dissolved copper load reduction from the candidate LTCP projects (regular scale)
- Figure E-4f. Average dissolved zinc load reduction from the candidate LTCP projects (regular scale)
- Figure E-4g. Average fecal coliform bacteria load reduction from the candidate LTCP projects (regular scale)
- Figure E-4h. Average H⁺ load reduction from the candidate LTCP projects (regular scale)
- Figure E-4i. Average oil and grease load reduction from the candidate LTCP projects (regular scale)
- Figure E-4j. Average PBDEs load reduction from the candidate LTCP projects (regular scale)
- Figure E-4k. Average PCBs load reduction from the candidate LTCP projects (regular scale)
- Figure E-4l. Average phosphorus load reduction from the candidate LTCP projects (regular scale)
- Figure E-4m. Average total copper load reduction from the candidate LTCP projects (regular scale)
- Figure E-4n. Average TSS load reduction from the candidate LTCP projects (regular scale)
- Figure E-4o. Average total zinc load reduction from the candidate LTCP projects (regular scale)

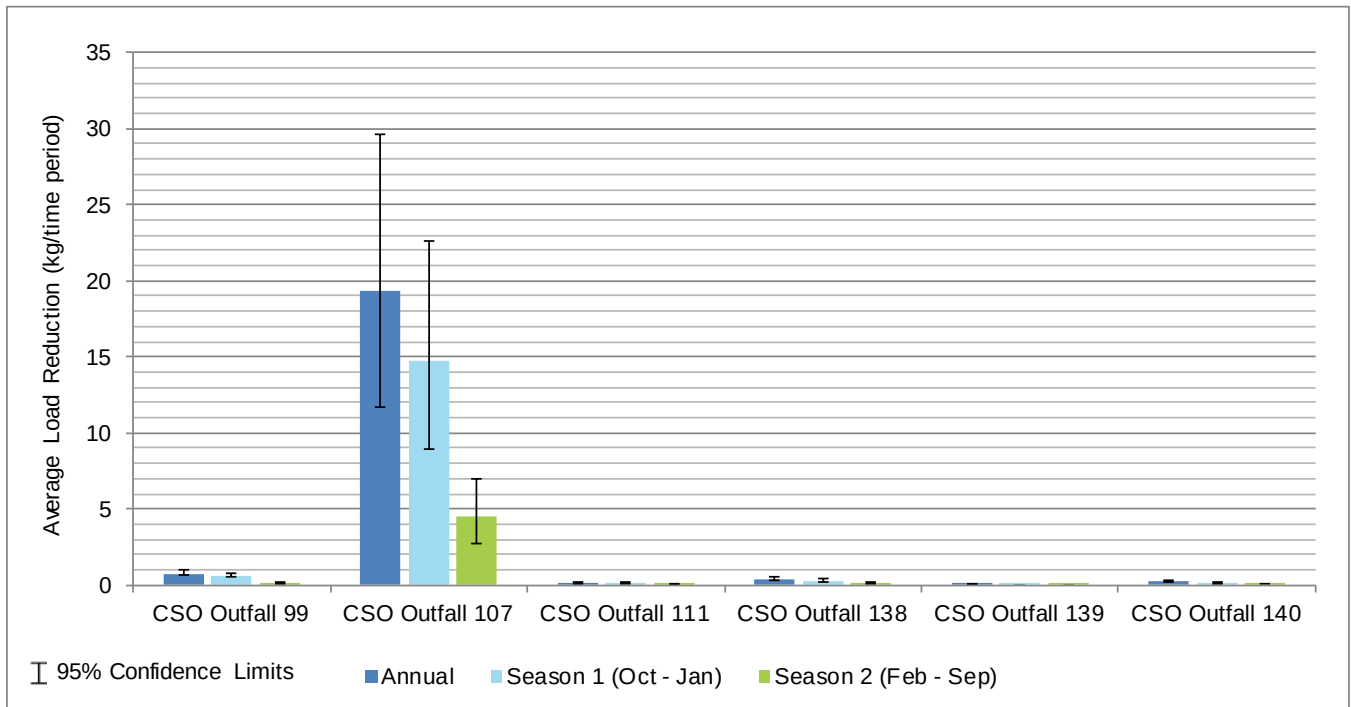


Figure E-4a. Average ammonia-N load reduction from the candidate LTCP projects (regular scale)

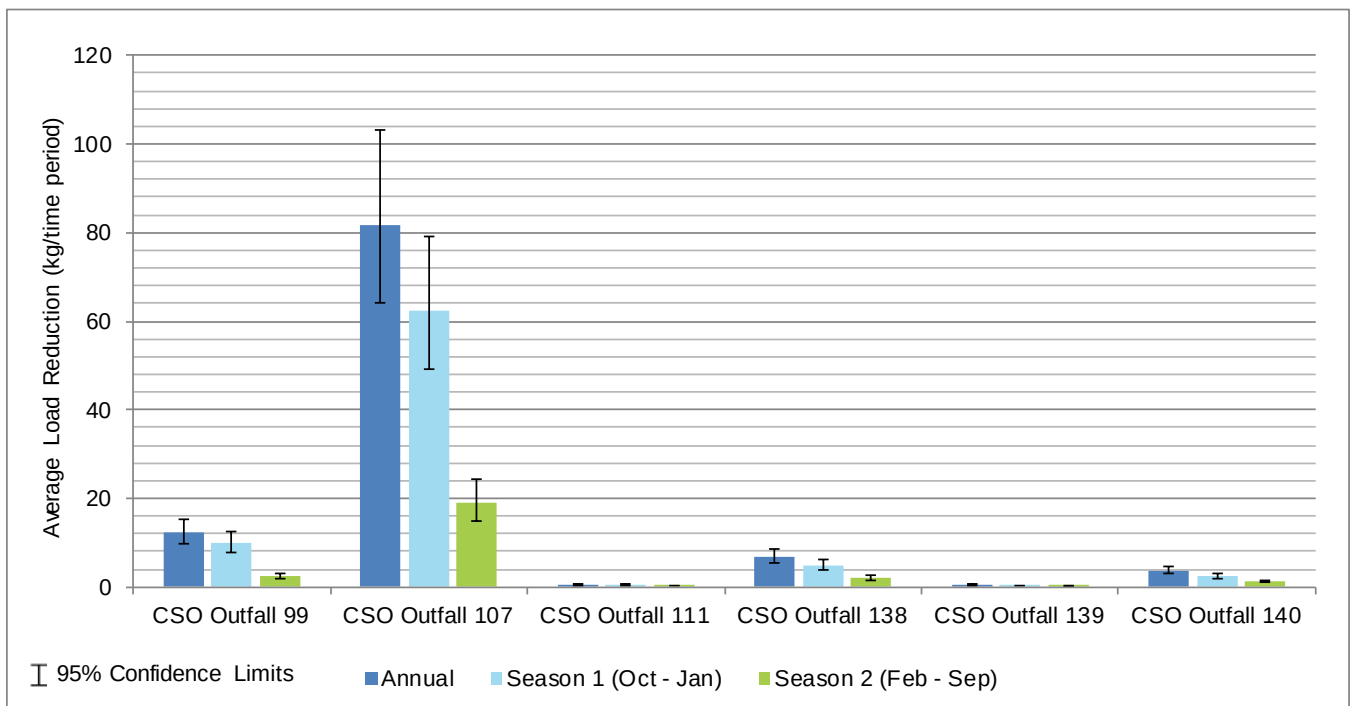


Figure E-4b. Average BOD load reduction from the candidate LTCP projects (regular scale)

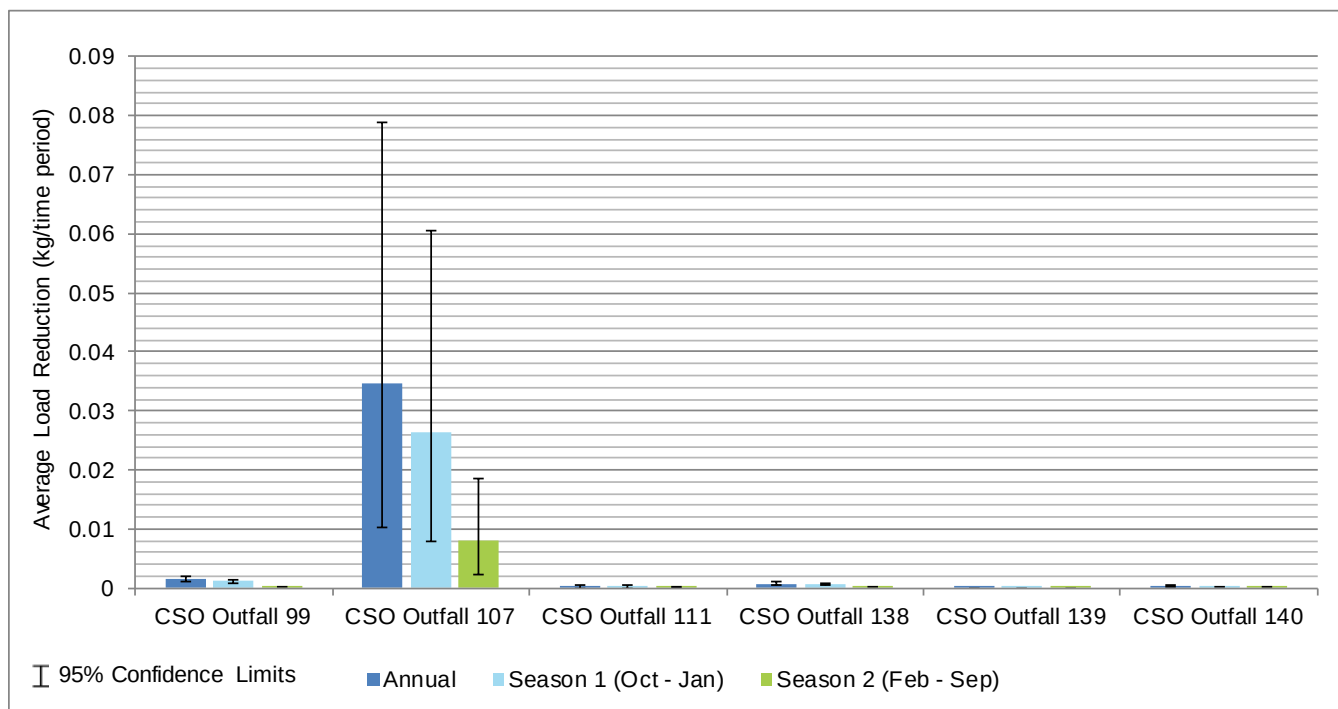


Figure E-4c. Average bis(2-Ethylhexyl)Phthalate load reduction from the candidate LTCP projects (regular scale)

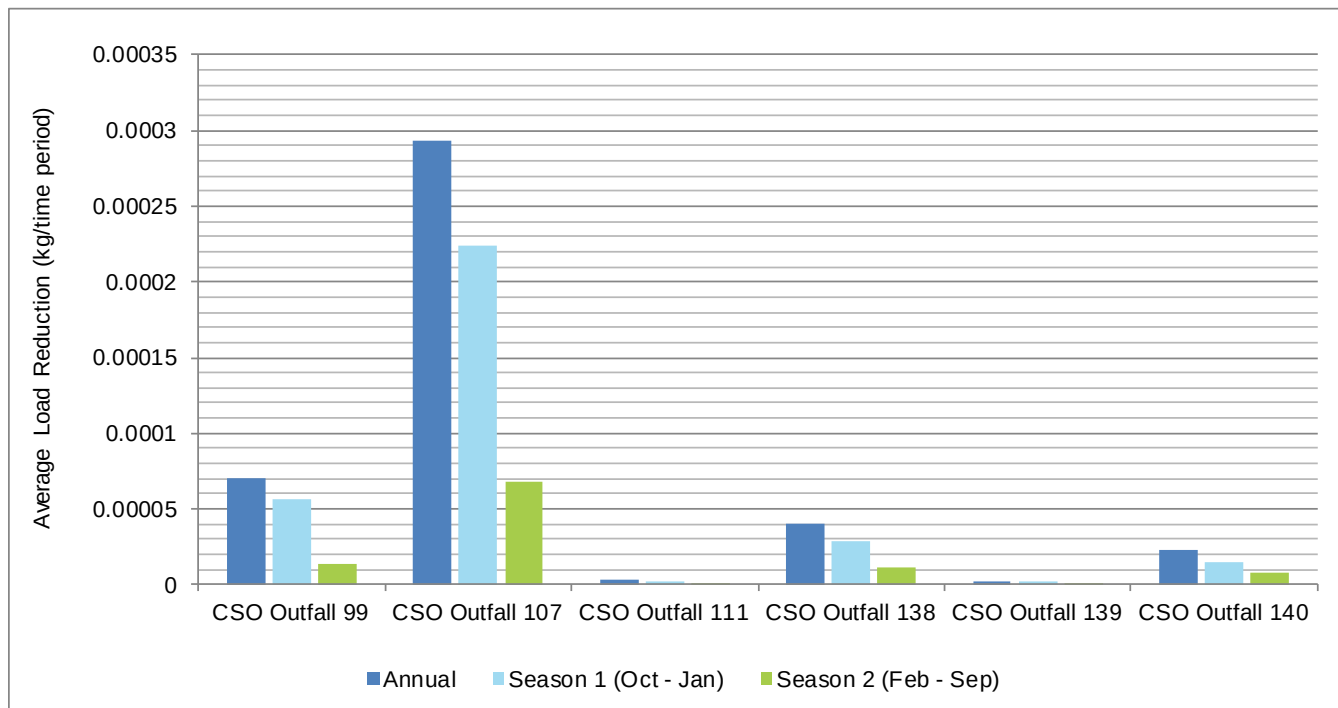


Figure E-4d. Average dichlobenil load reduction from the candidate LTCP projects (regular scale)

Note that for dichlobenil, there was insufficient data to calculate the UCLs and LCLs

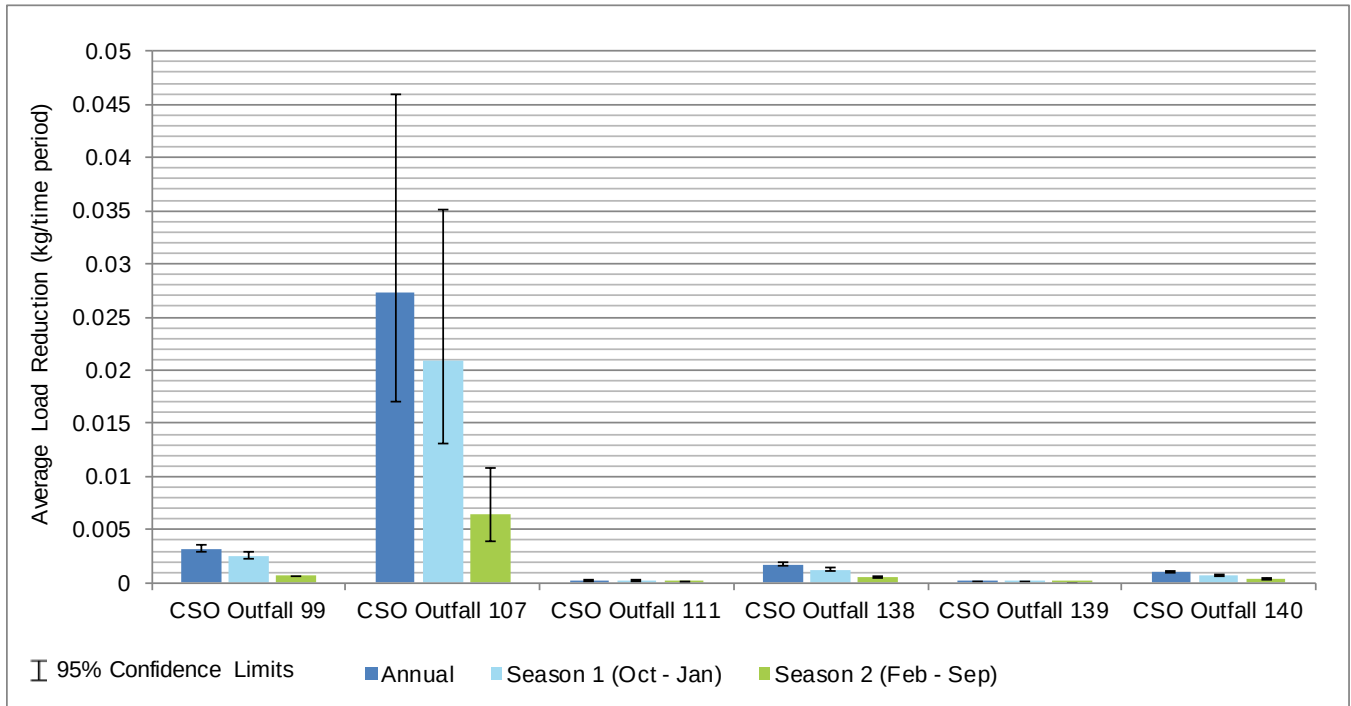


Figure E-4e. Average dissolved copper load reduction from the candidate LTCP projects (regular scale)

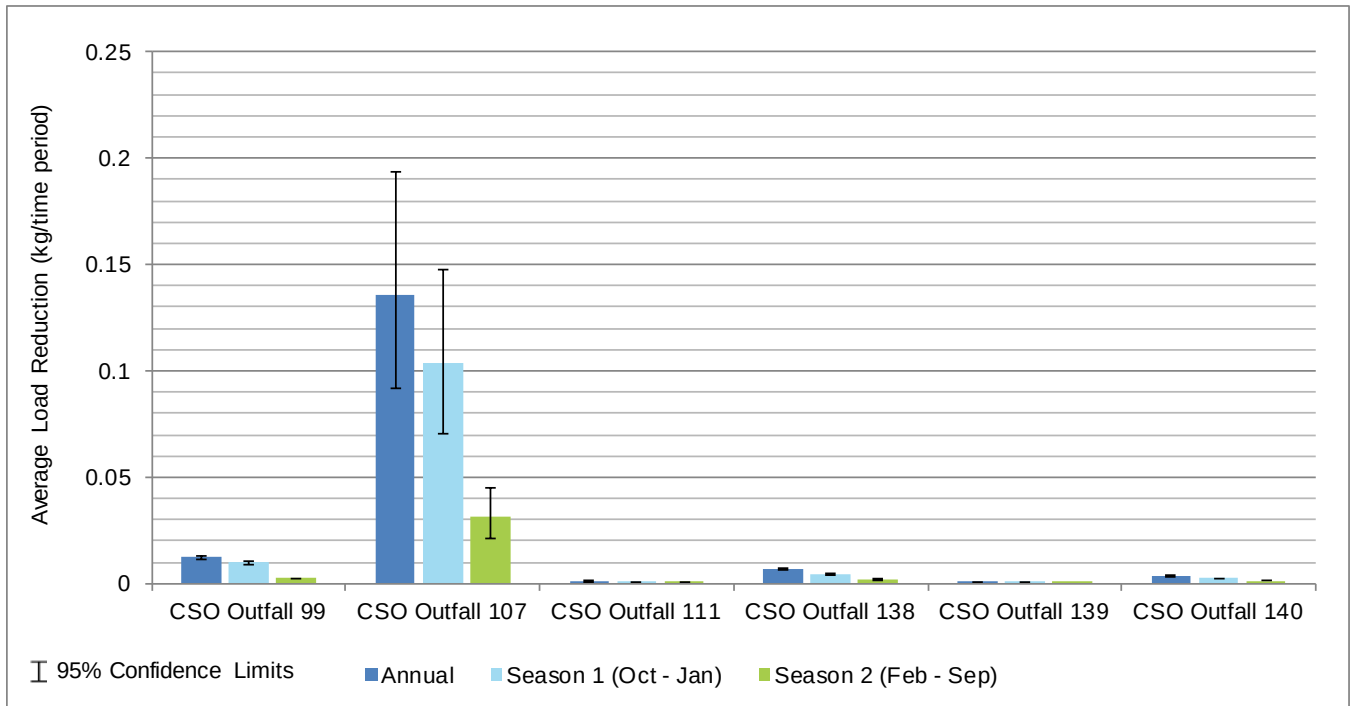


Figure E-4f. Average dissolved zinc load reduction from the candidate LTCP projects (regular scale)

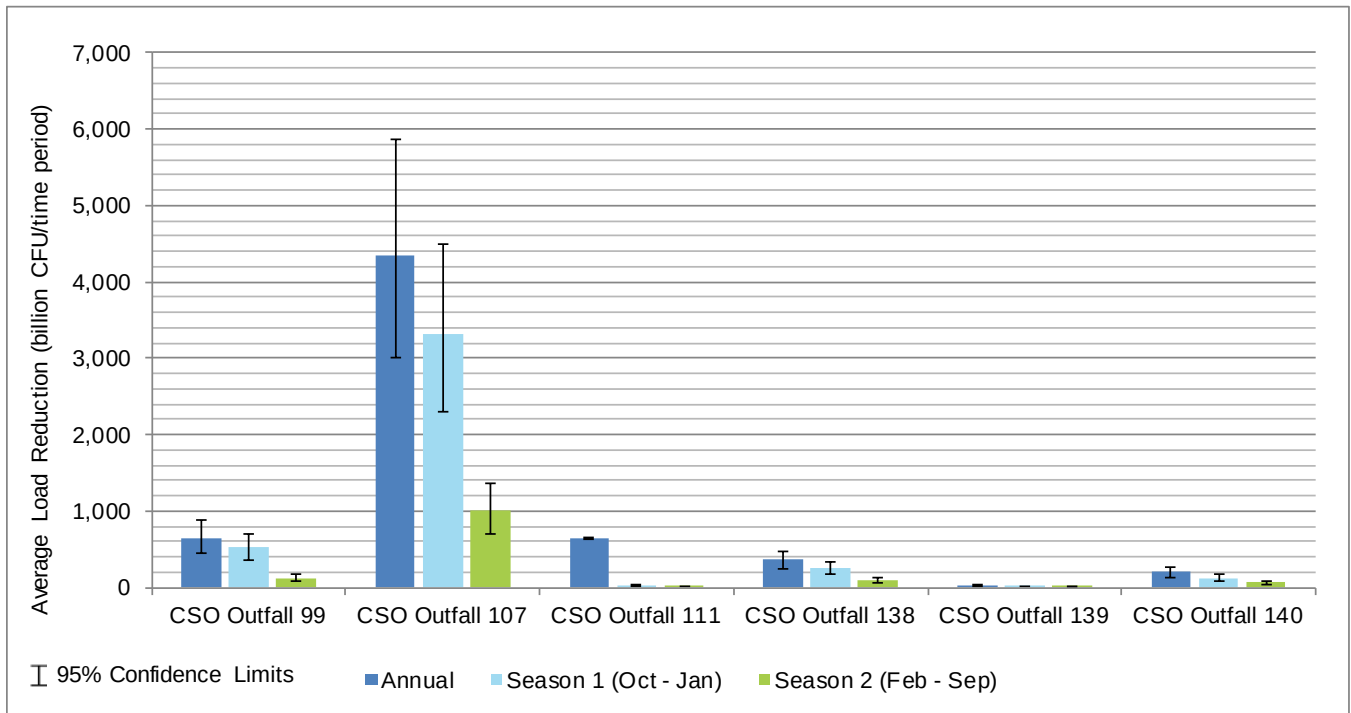


Figure E-4g. Average fecal coliform load reduction from the candidate LTCP projects (regular scale)

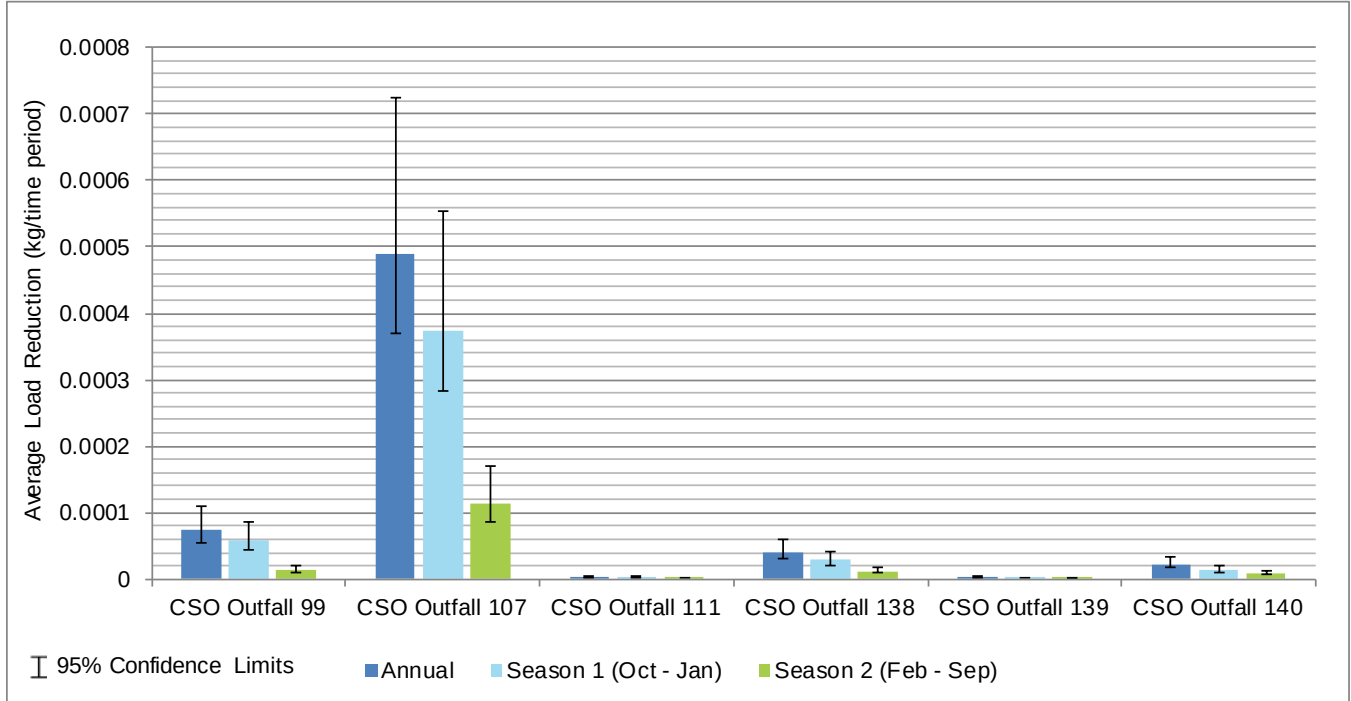


Figure E-4h. Average H+ load reduction from the candidate LTCP projects (regular scale)

Attachment E-4: Load Reductions by Candidate LTCP Project (Regular Scale)

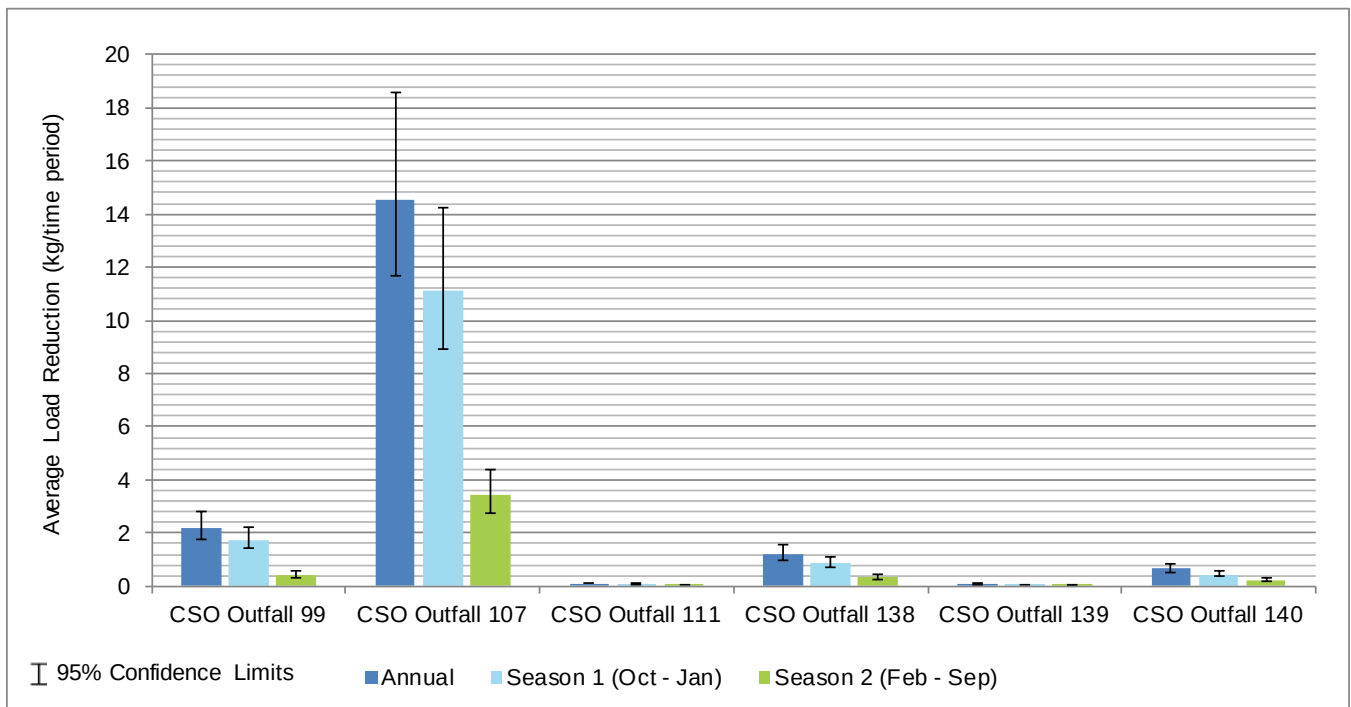


Figure E-4i. Average oil and grease load reduction from the candidate LTCP projects (regular scale)

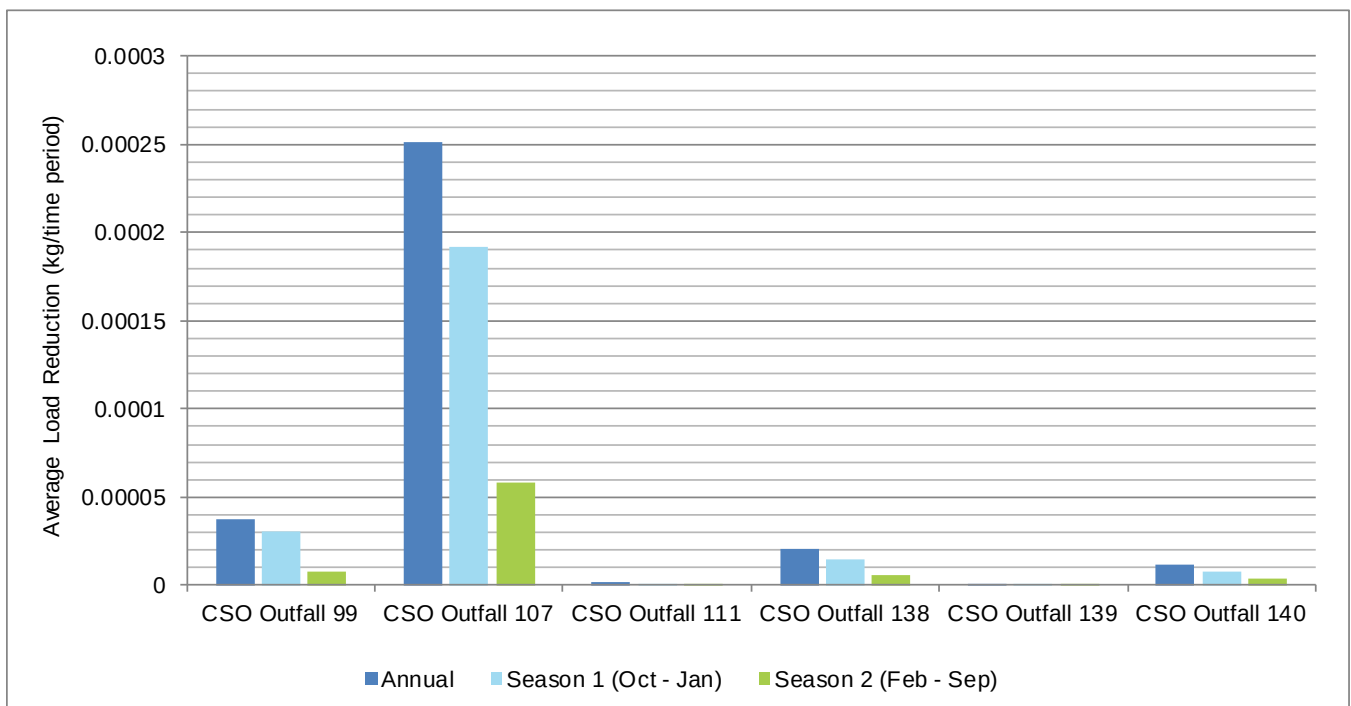


Figure E-4j. Average PBDEs load reduction from the candidate LTCP projects (regular scale)

Note that for PBDEs, there was insufficient data to calculate the UCLs and LCLs

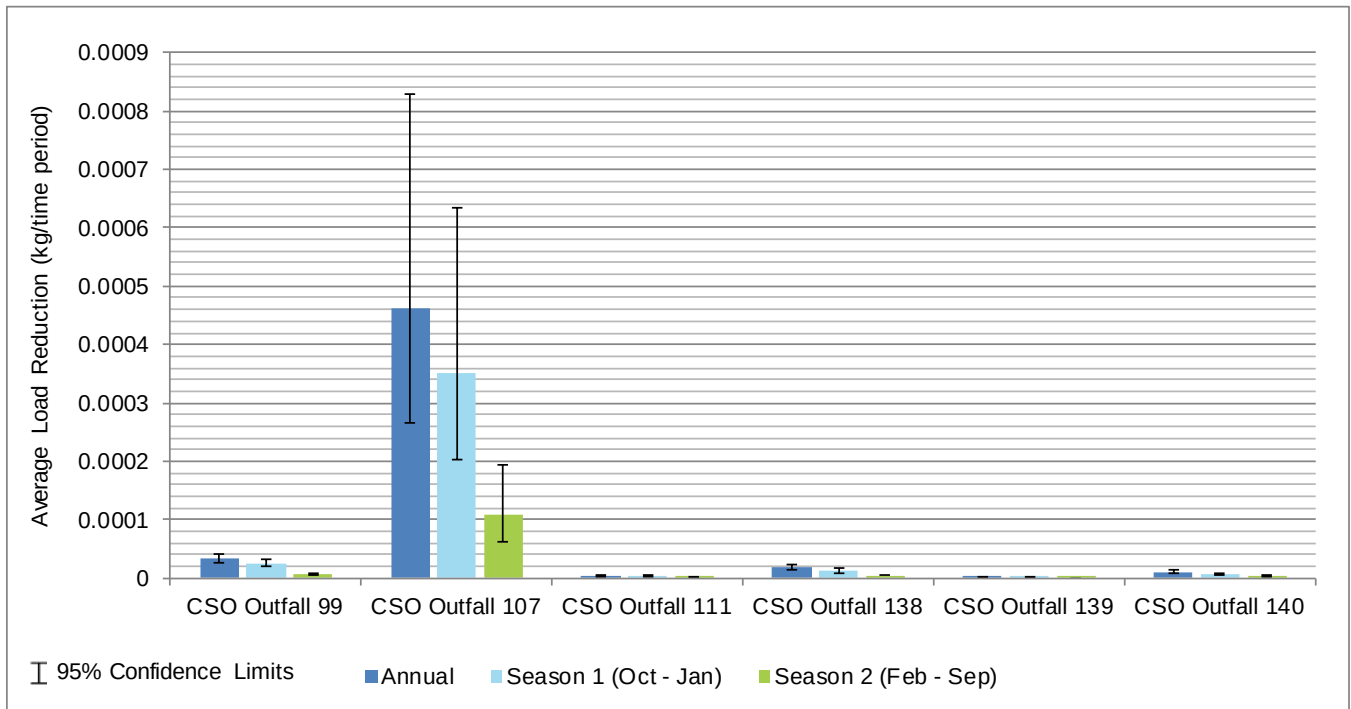


Figure E-4k. Average PCBs load reduction from the candidate LTCP projects (regular scale)

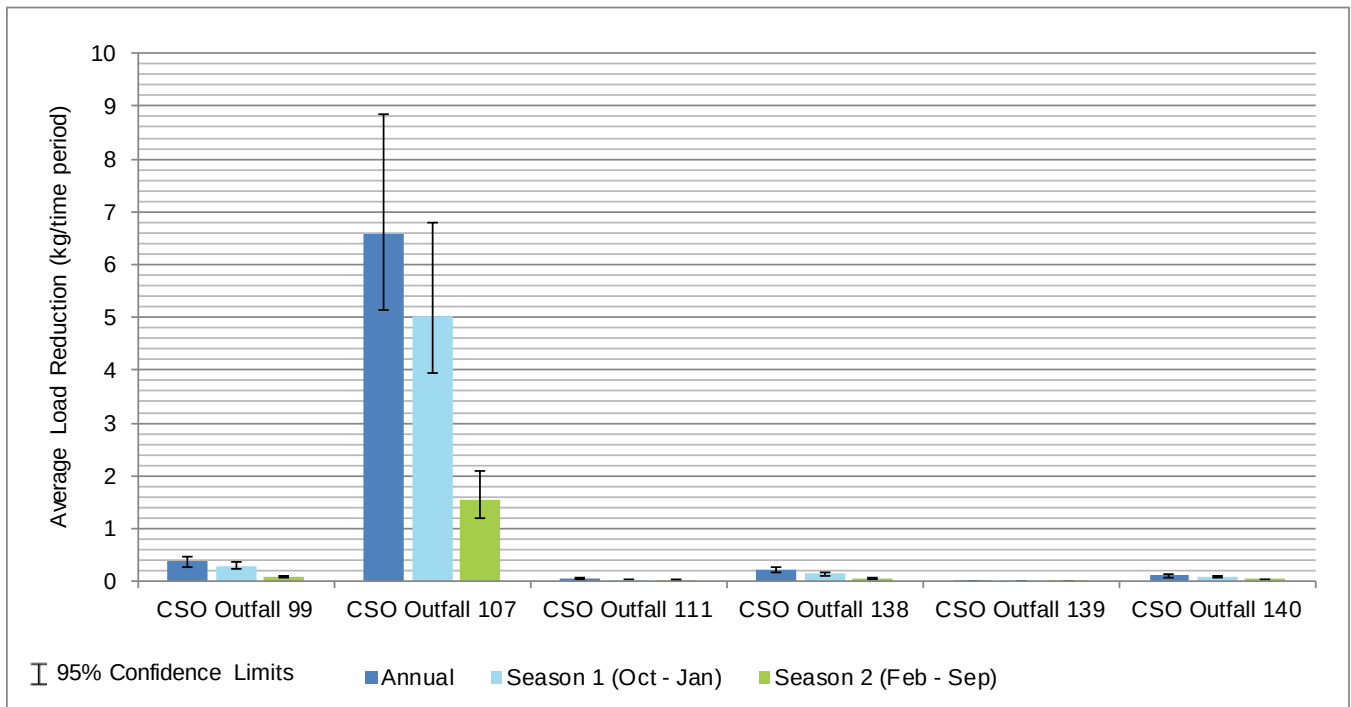


Figure E-4l. Average phosphorus load reduction from the candidate LTCP projects (regular scale)

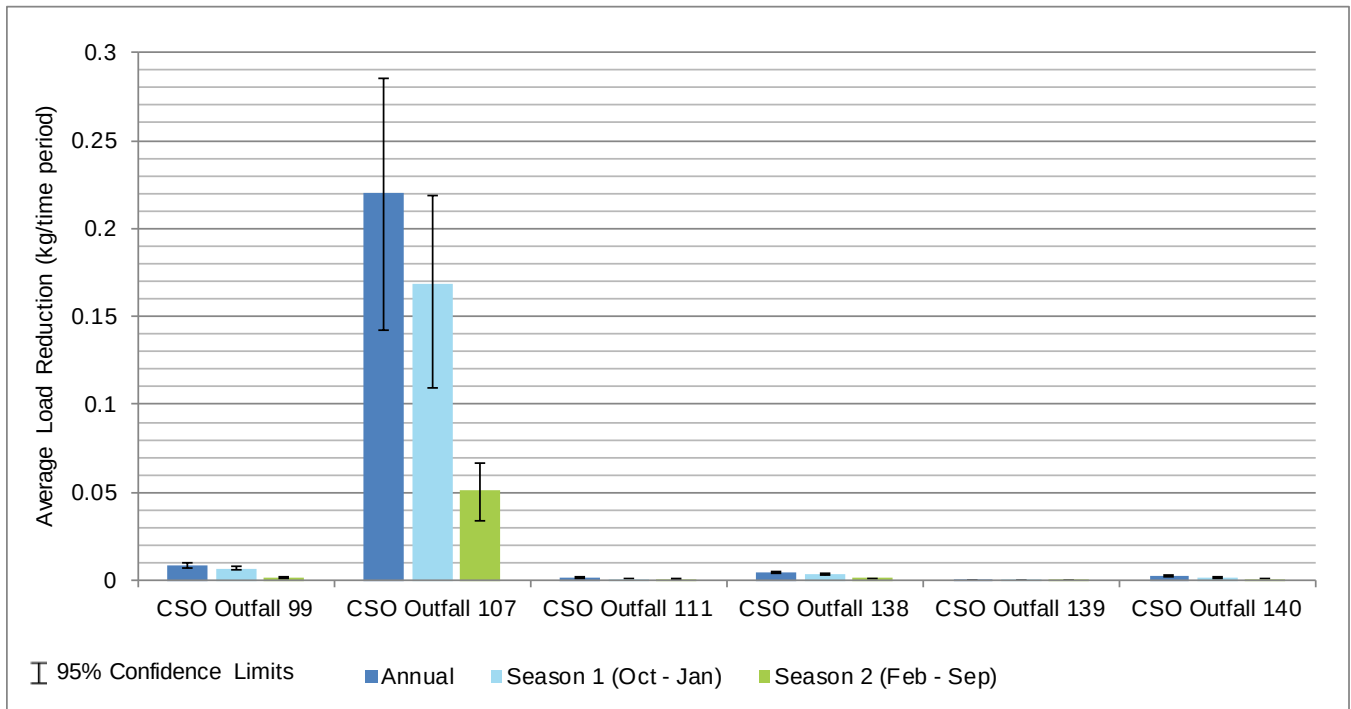


Figure E-4m. Average total copper load reduction from the candidate LTCP projects (regular scale)

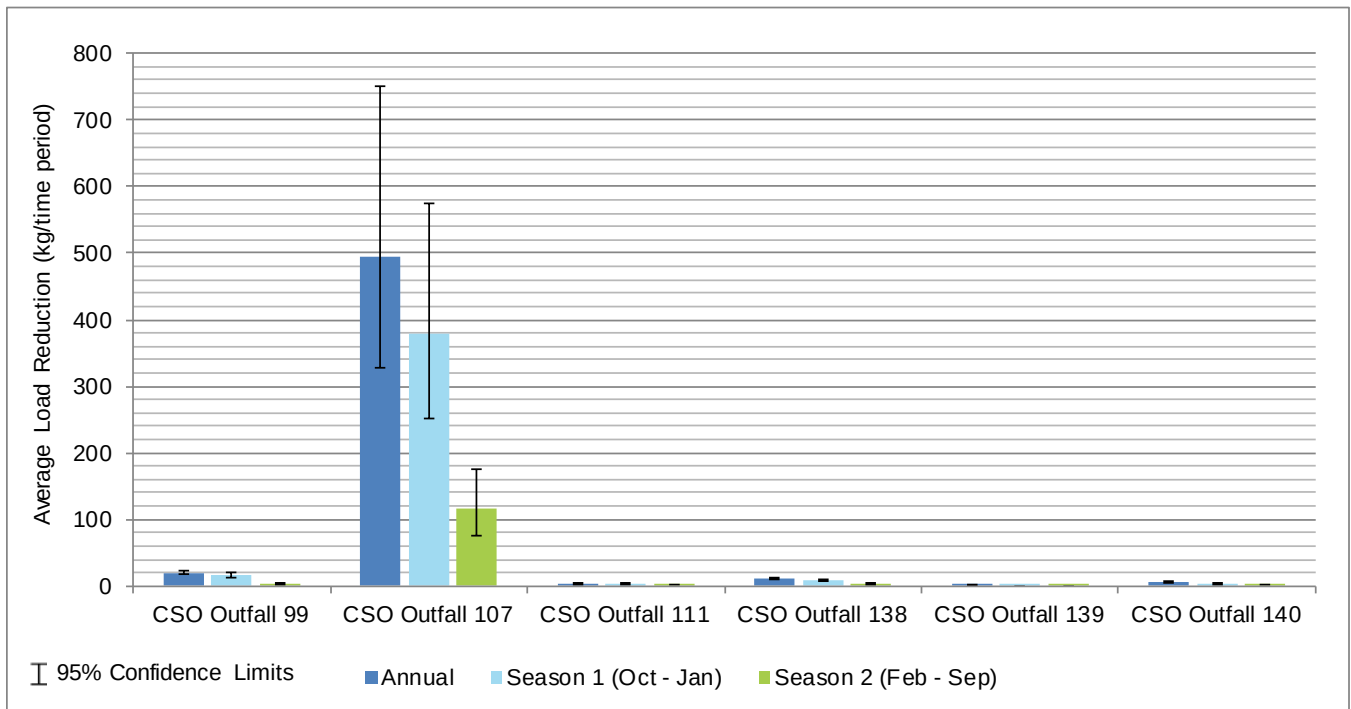


Figure E-4n. Average TSS load reduction from the candidate LTCP projects (regular scale)

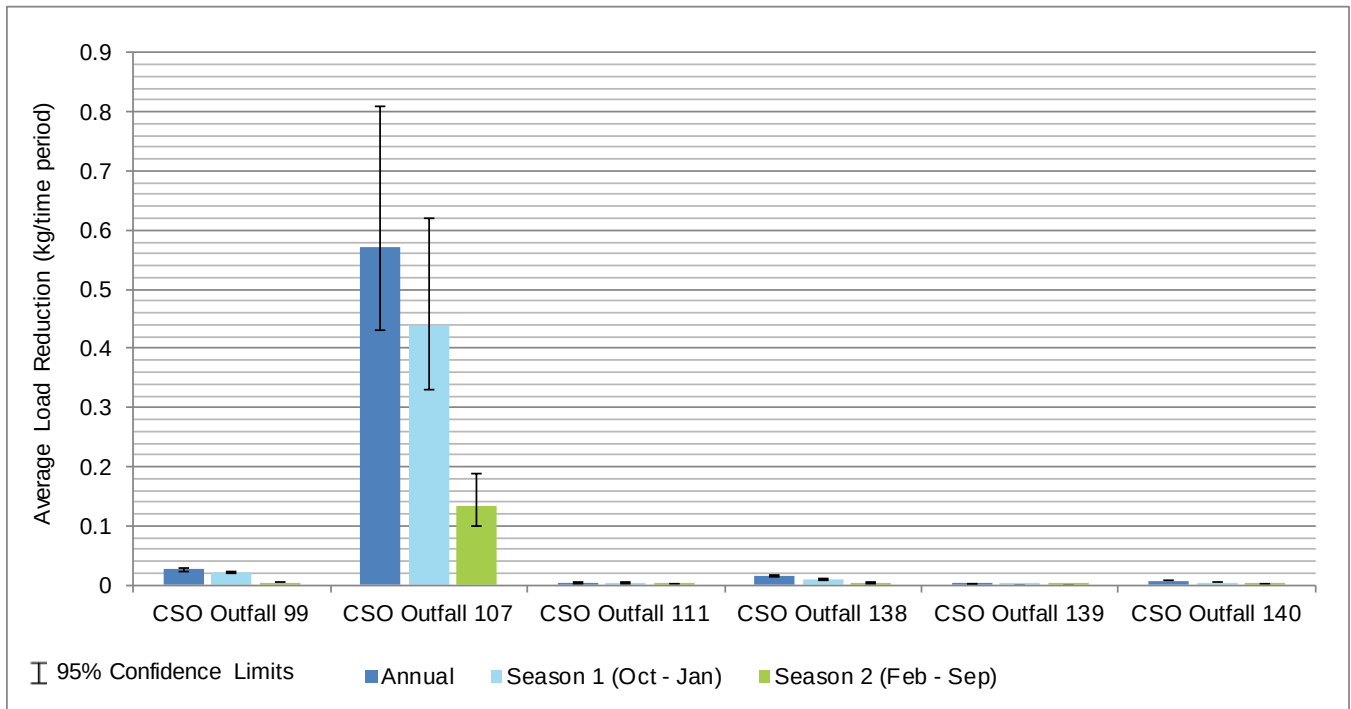


Figure E-4o. Average total zinc load reduction from the candidate LTCP projects (regular scale)

Attachment E-5: Load Reductions by Candidate LTCP Project (Log Scale)

This attachment contains the following figures:

- Figure E-5a. Average ammonia-N load reduction from the candidate LTCP projects (log scale)
- Figure E-5b. Average BOD load reduction from the candidate LTCP projects (log scale)
- Figure E-5c. Average Bis(2-Ethylhexyl)Phthalate load reduction from the candidate LTCP projects (log scale)
- Figure E-5d. Average dichlobenil load reduction from the candidate LTCP projects (log scale)
- Figure E-5e. Average dissolved copper load reduction from the candidate LTCP projects (log scale)
- Figure E-5f. Average dissolved zinc load reduction from the candidate LTCP projects (log scale)
- Figure E-5g. Average fecal coliform bacteria load reduction from the candidate LTCP projects (log scale)
- Figure E-5h. Average H⁺ load reduction from the candidate LTCP projects (log scale)
- Figure E-5i. Average oil and grease load reduction from the candidate LTCP projects (log scale)
- Figure E-5j. Average PBDEs load reduction from the candidate LTCP projects (log scale)
- Figure E-5k. Average PCBs load reduction from the candidate LTCP projects (log scale)
- Figure E-5l. Average phosphorus load reduction from the candidate LTCP projects (log scale)
- Figure E-5m. Average total copper load reduction from the candidate LTCP projects (log scale)
- Figure E-5n. Average TSS load reduction from the candidate LTCP projects (log scale)
- Figure E-5o. Average total zinc load reduction from the candidate LTCP projects (log scale)

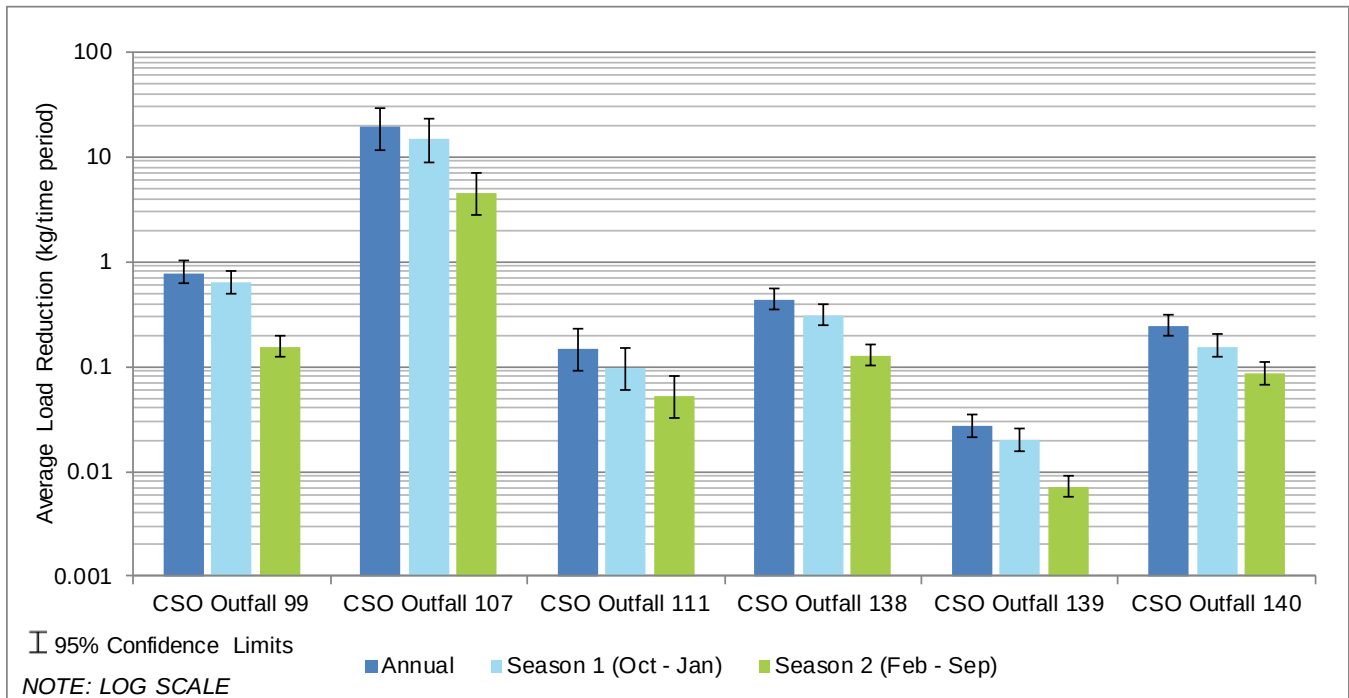


Figure E-5a. Average ammonia-N load reduction from the candidate LTCP projects (log scale)

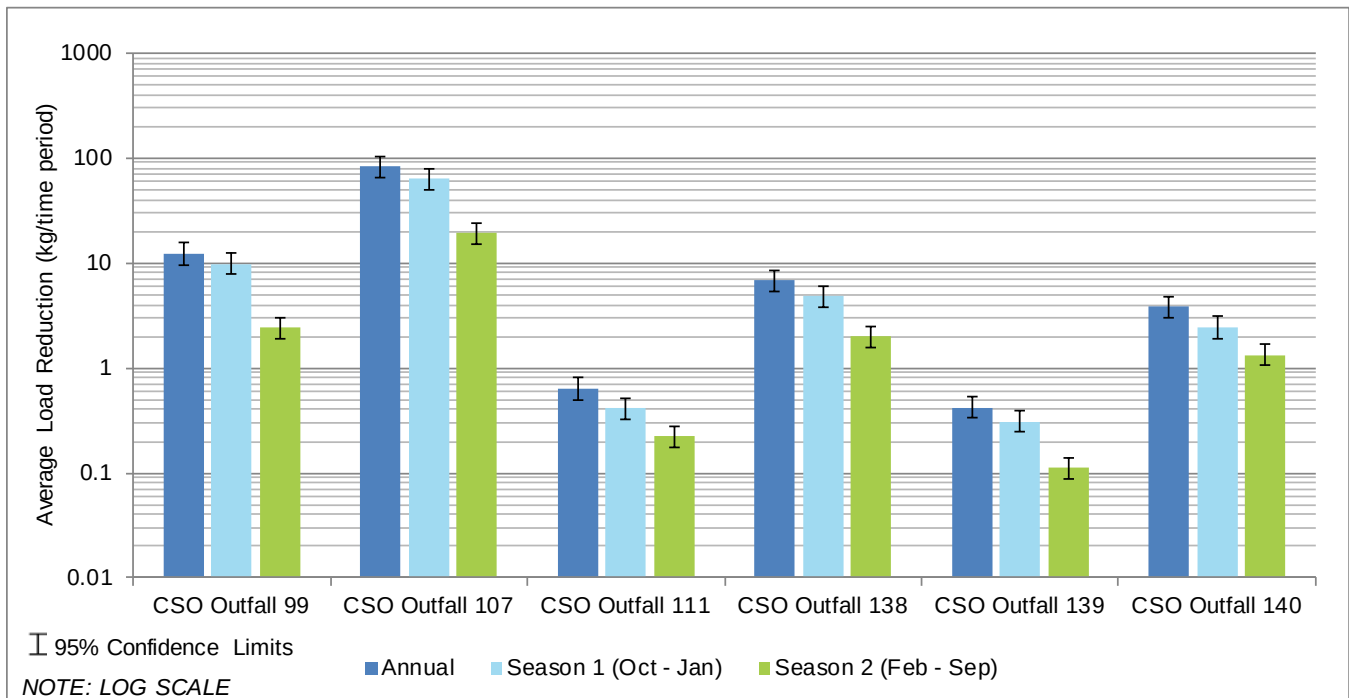


Figure E-5b. Average BOD load reduction from the candidate LTCP projects (log scale)

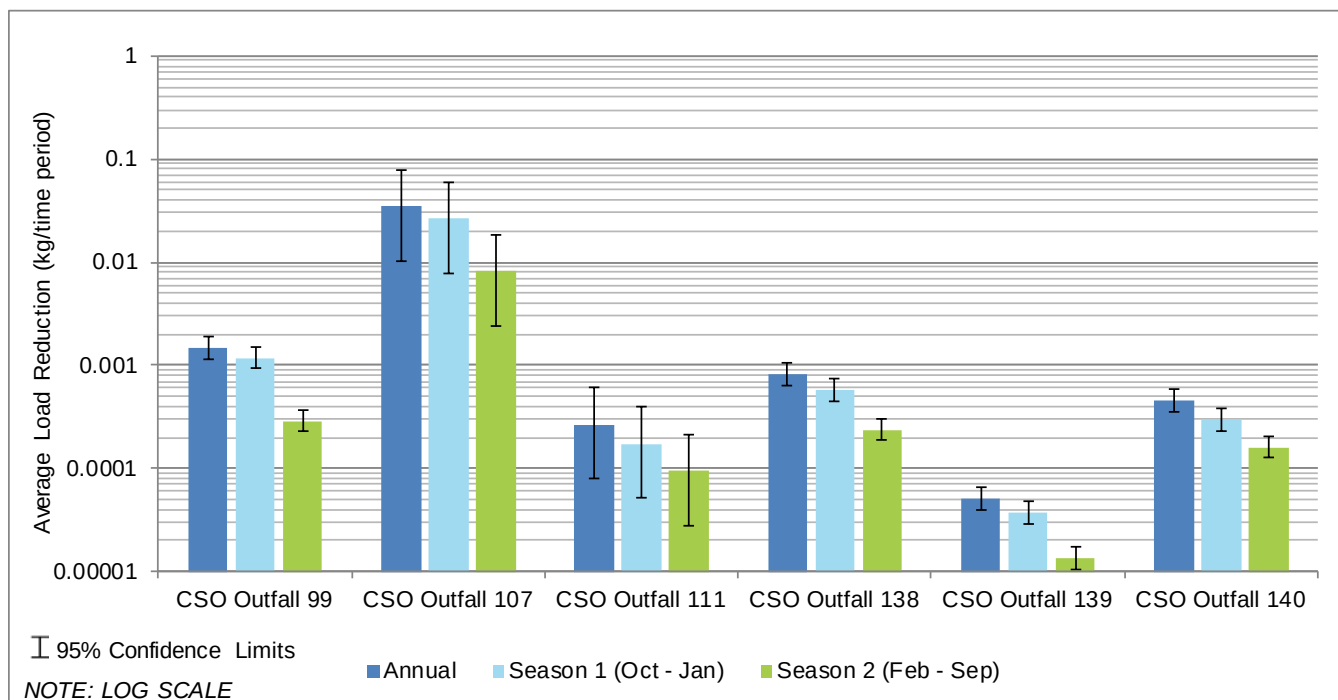


Figure E-5c. Average Bis(2-Ethylhexyl)Phthalate load reduction from the candidate LTCP projects (log scale)

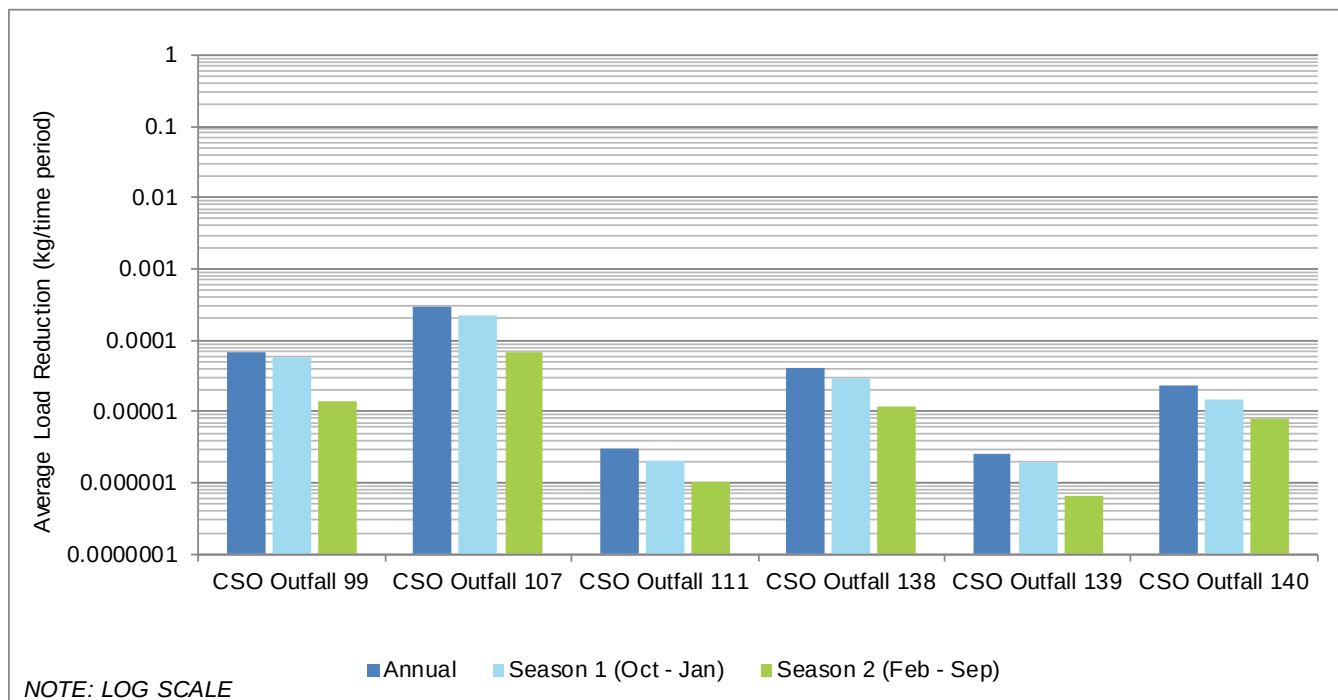


Figure E-5d. Average dichlobenil load reduction from the candidate LTCP projects (log scale)

Note that for dichlobenil, there was insufficient data to calculate the UCLs and LCLs

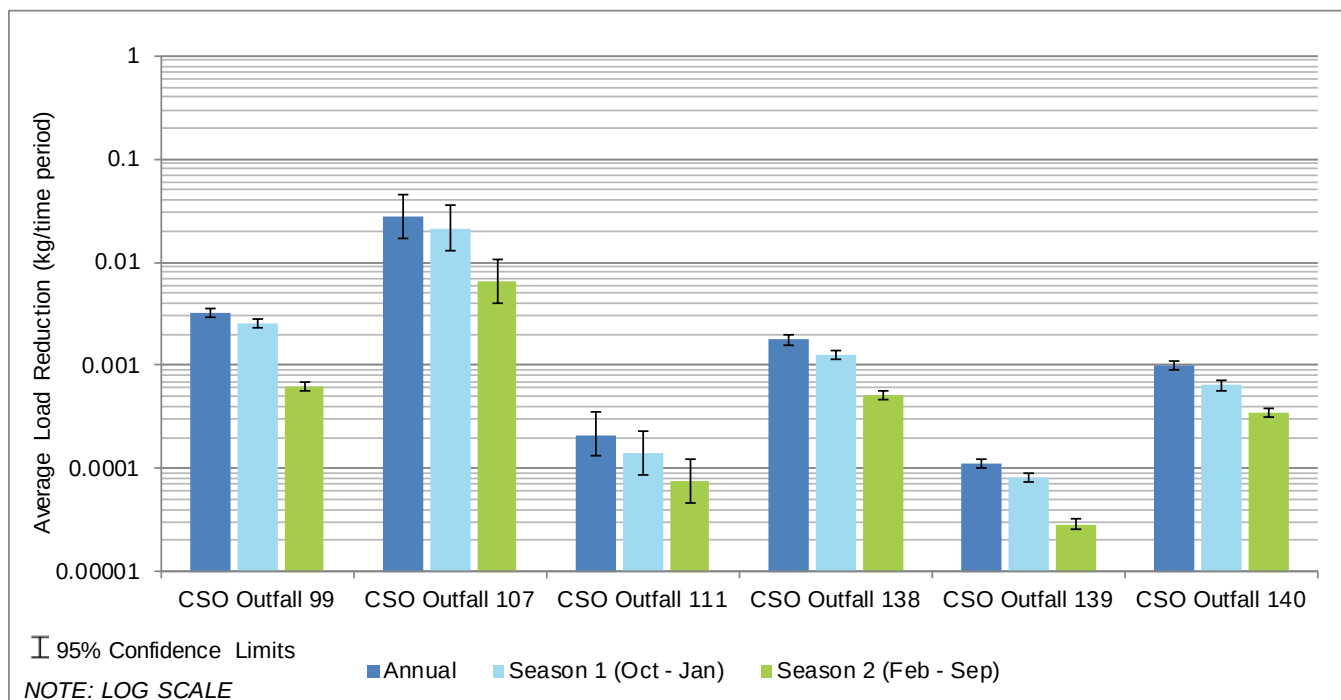


Figure E-5e. Average dissolved copper load reduction from the candidate LTCP projects (log scale)

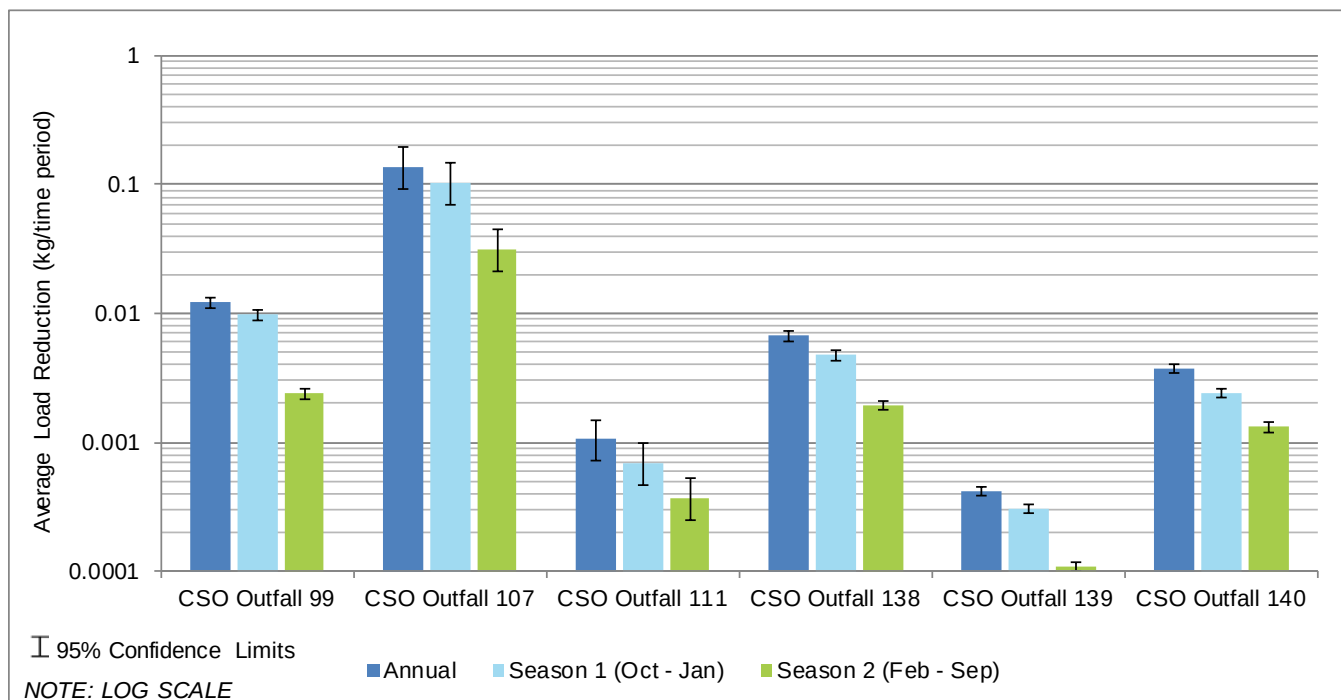


Figure E-5f. Average dissolved zinc load reduction from the candidate LTCP projects (log scale)

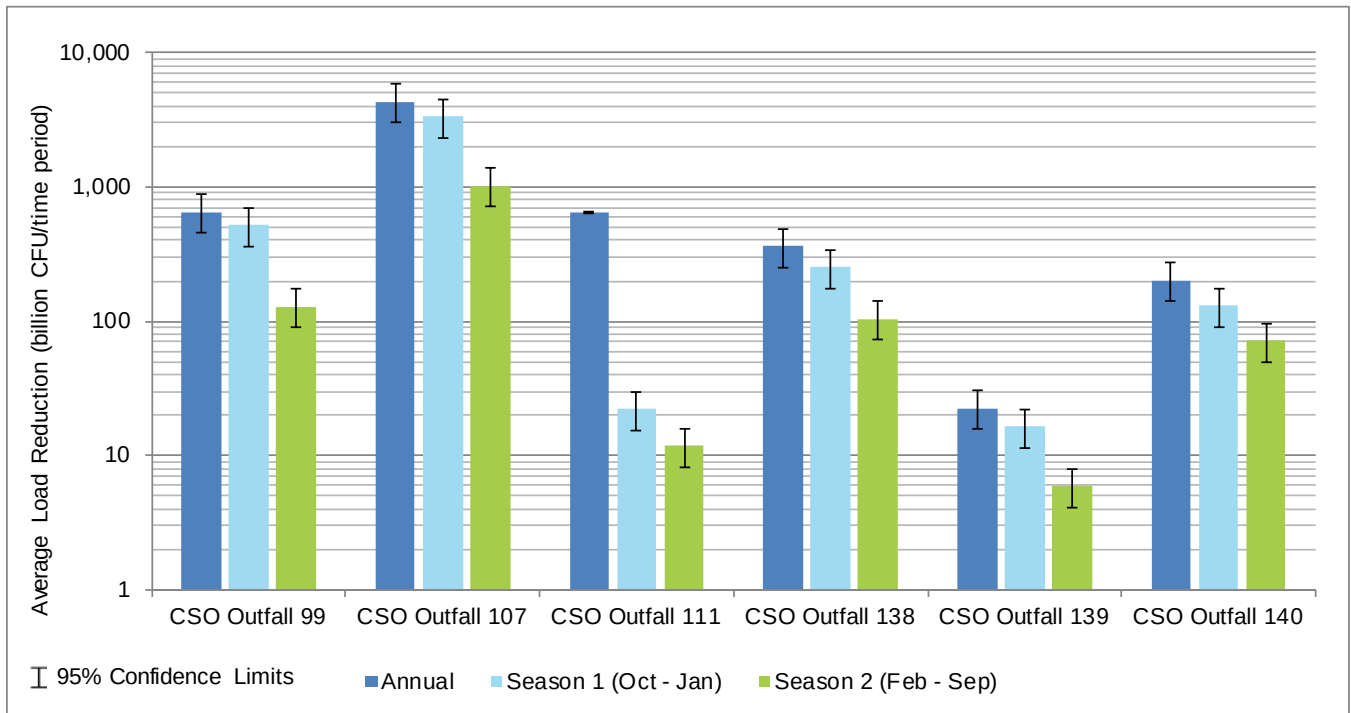


Figure E-5g. Average fecal coliform load reduction from the candidate LTCP projects (log scale)

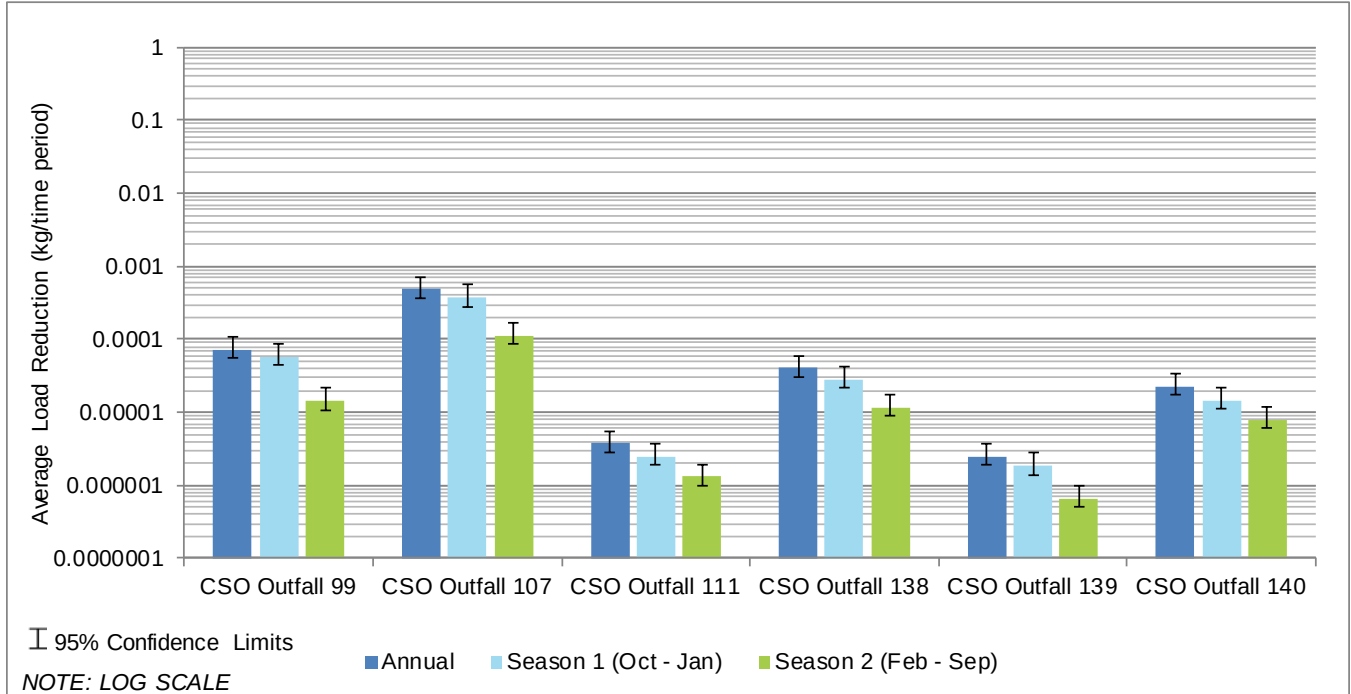


Figure E-5h. Average H+ load reduction from the candidate LTCP projects (log scale)

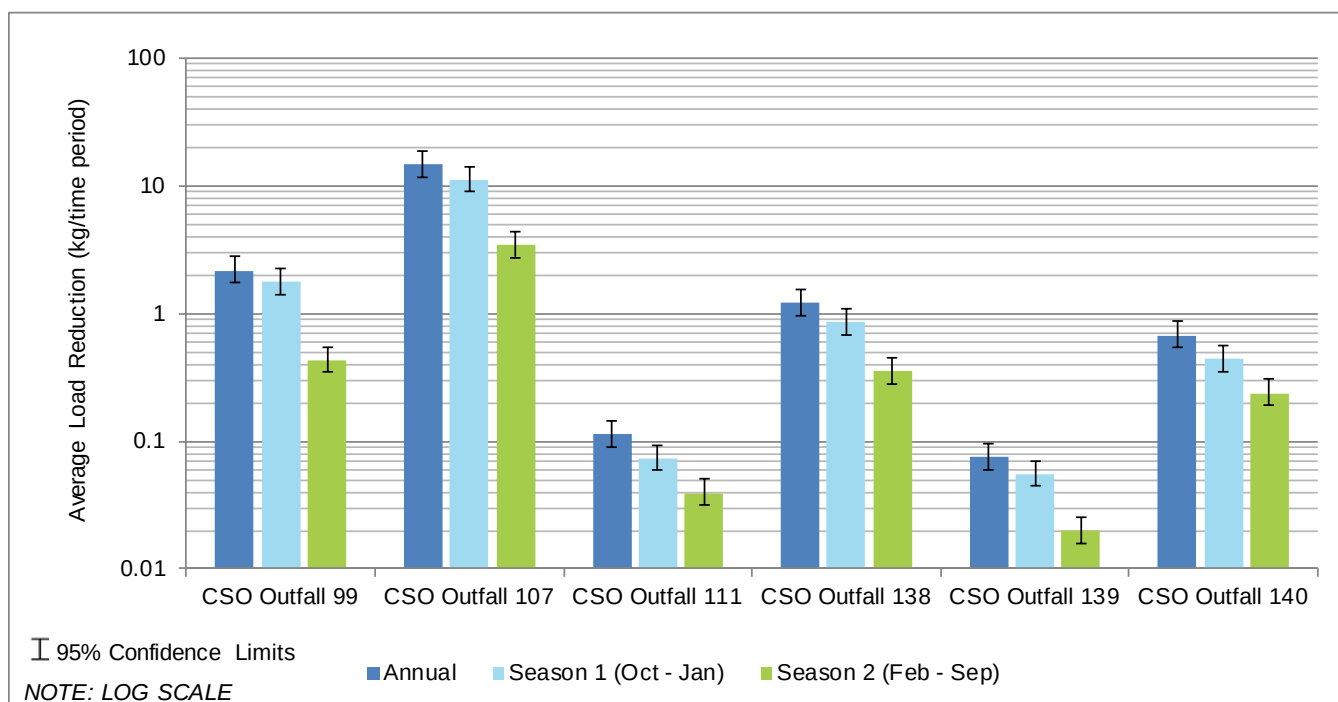


Figure E-5i. Average oil and grease load reduction from the candidate LTCP projects (log scale)

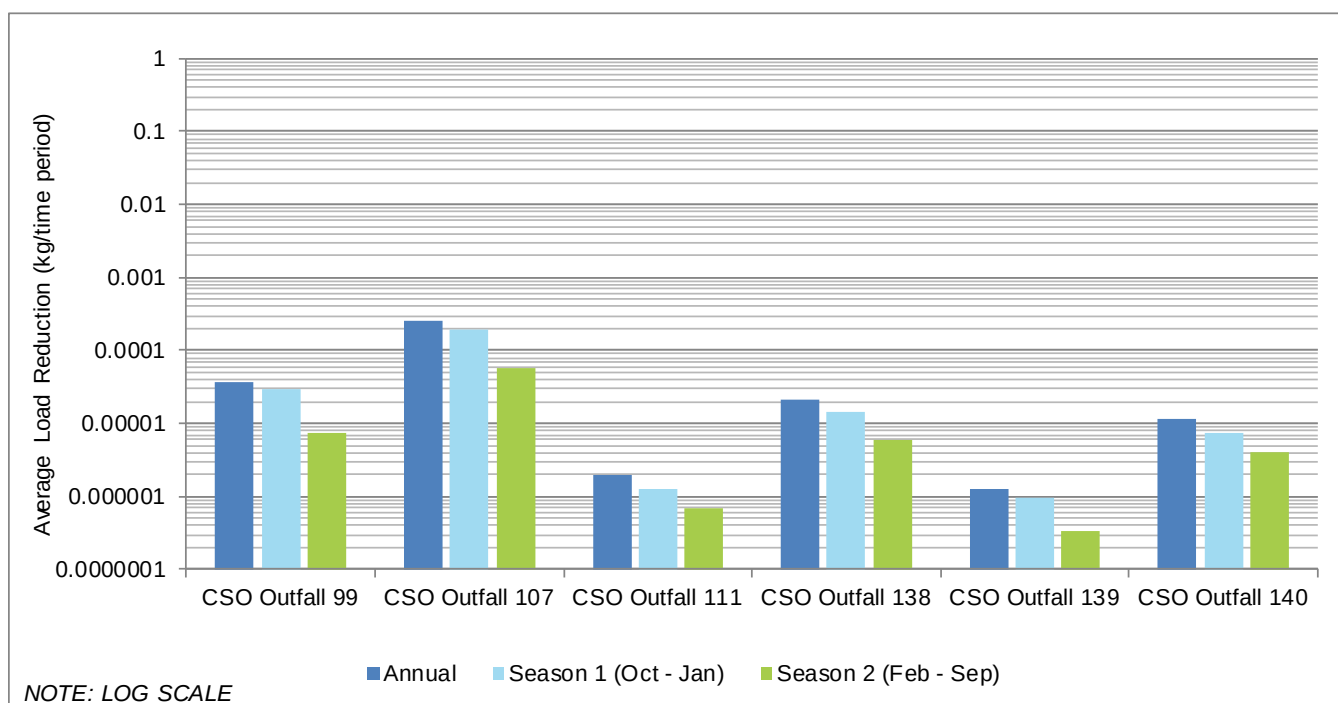


Figure E-5j. Average PBDEs load reduction from the candidate LTCP projects (log scale)

Note that for PBDEs, there was insufficient data to calculate the UCLs and LCLs

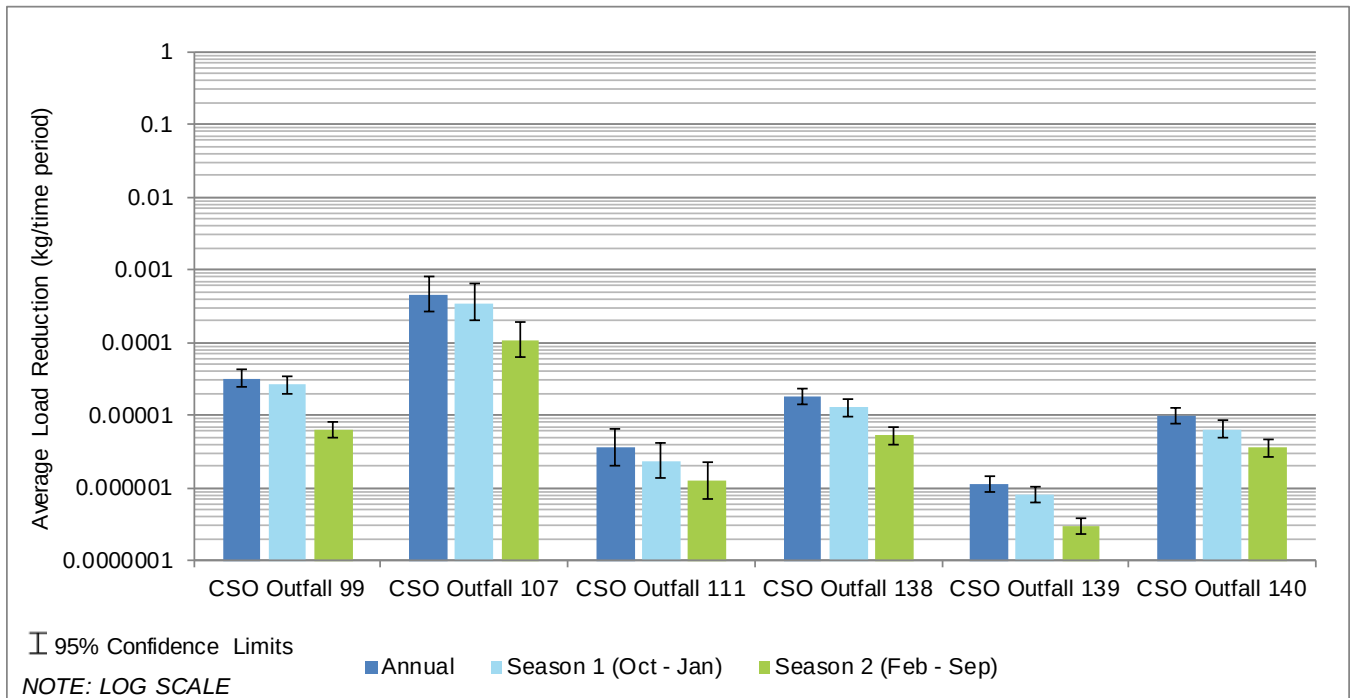


Figure E-5k. Average PCBs load reduction from the candidate LTCP projects (log scale)

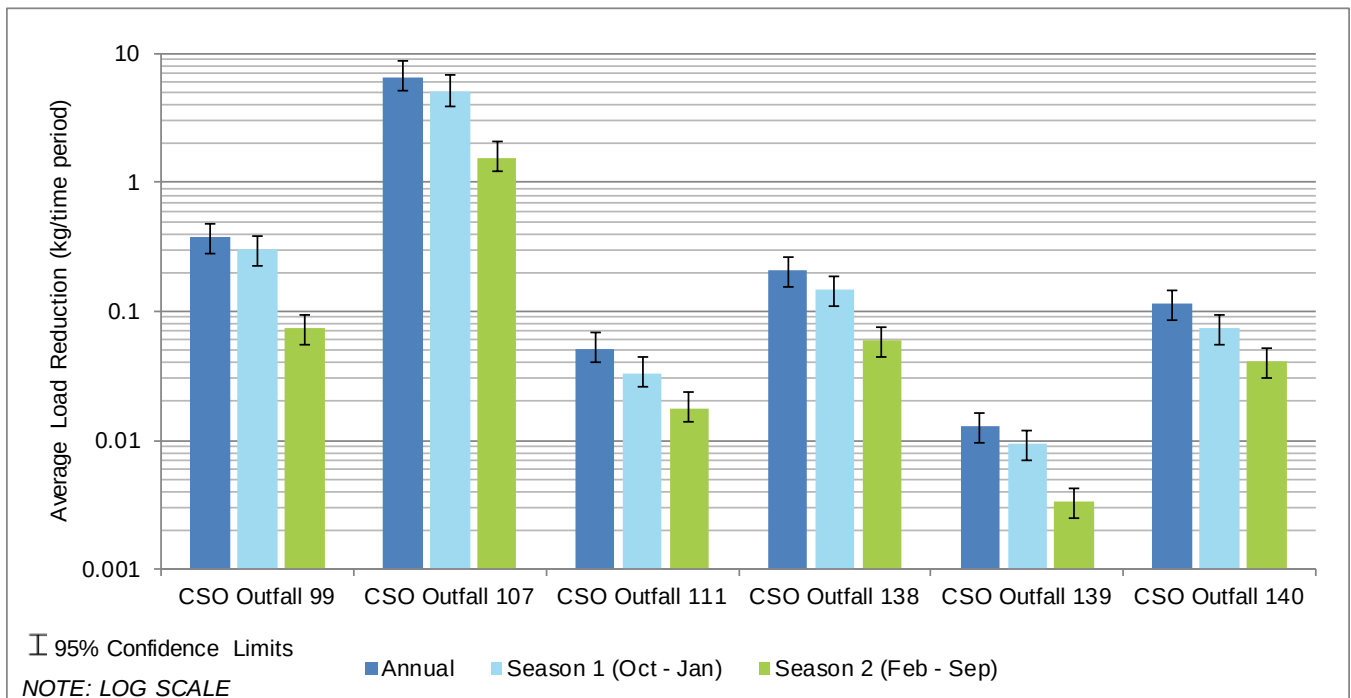


Figure E-5l. Average phosphorus load reduction from the candidate LTCP projects (log scale)

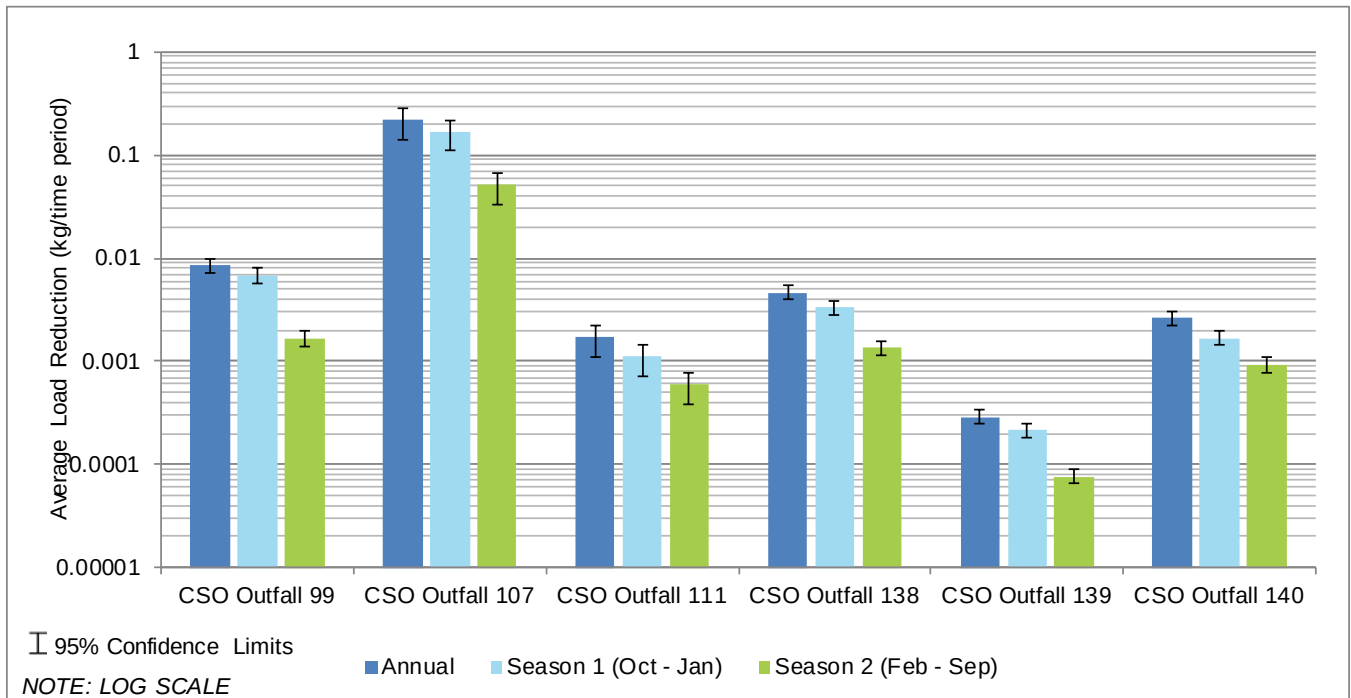


Figure E-5m. Average total copper load reduction from the candidate LTCP projects (log scale)

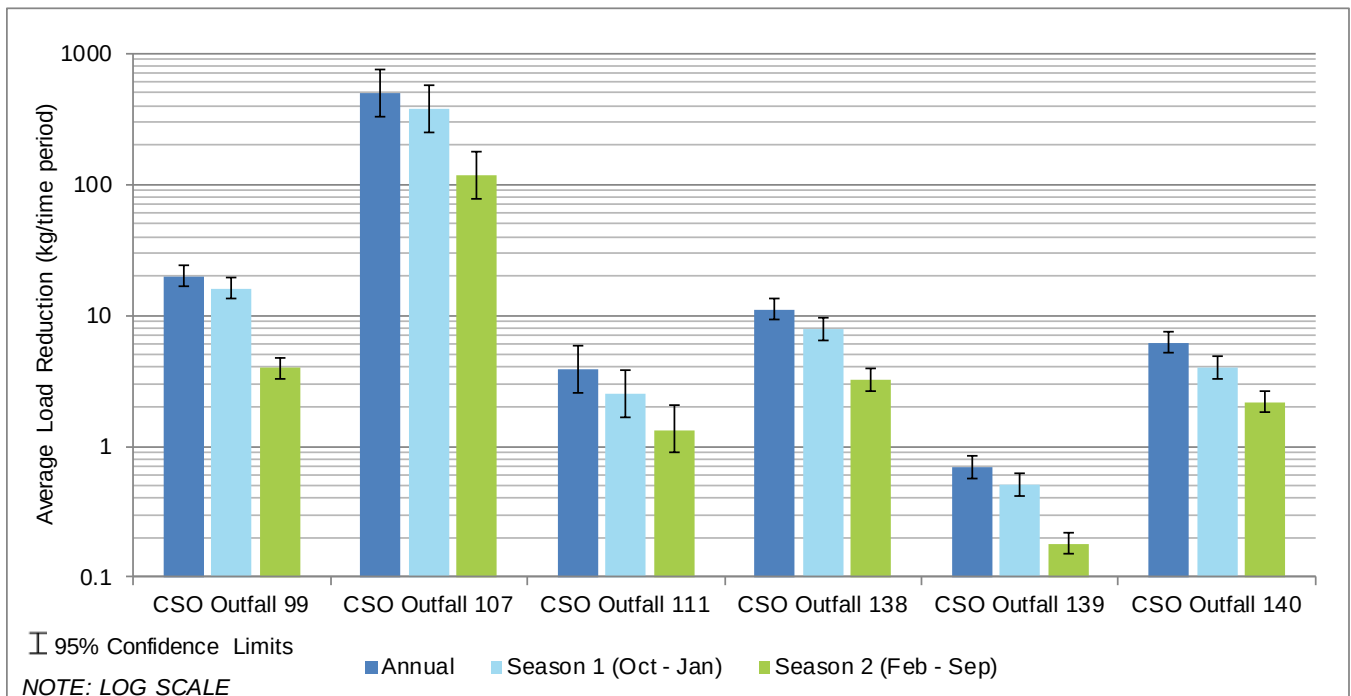


Figure E-5n. Average TSS load reduction from the candidate LTCP projects (log scale)

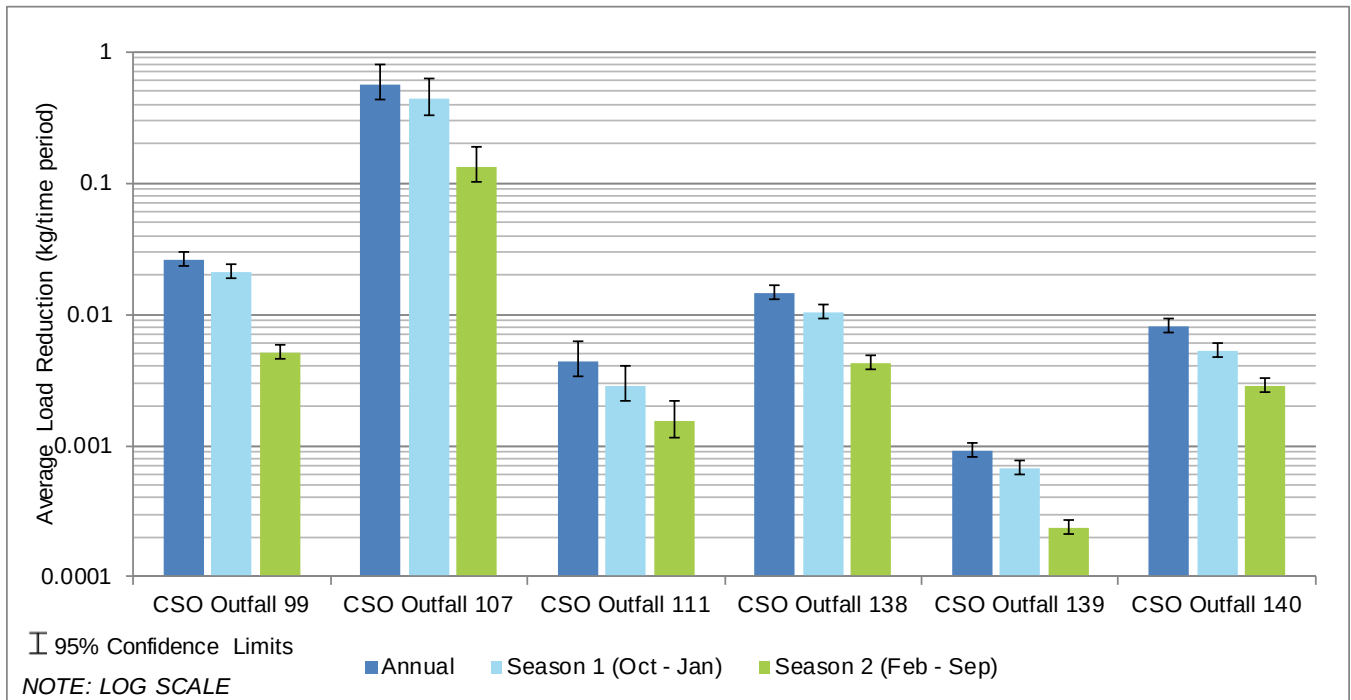


Figure E-5o. Average total zinc load reduction from the candidate LTCP projects (log scale)

Attachment E-6a: Supplementary LTCP Data—Overall Summary

Supplementary LTCP Data—Overall Summary									
LTCP project	Analysis type	Precipitation scaling factor	Analysis period range	Analysis period (years)	Pre-project		BECV (MG)	Post-project	
					# of overflow events	Total overflow (MG)		# of overflow events	Total overflow (MG)
CSO Outfall 99	Model	1.0079	Jan 1992–Dec 2011	20	27	1.64E+01	1.71E-01	14	1.31E+01
CSO Outfall 107	Model	1.0	Jan 2003–Dec 2012	10	57	1.49E+01	5.00E-01	9	3.86E+00
CSO Outfall 111B	Model	1.0	Jan 1992–Dec 2011	20	21	2.90E+00	3.21E-03	15	2.84E+00
CSO Outfall 111C	Model	1.0	Jan 1992–Dec 2011	20	21	2.90E+00	3.21E-03	15	2.84E+00
CSO Outfall 111H	Model	1.0	Jan 1992–Dec 2011	20	17	2.95E+00	2.00E-03	11	2.92E+00
CSO Outfall 138	Model	1.0	Jan 1992–Dec 2011	20	13	3.32E+01	6.97E-03	13	3.31E+01
CSO Outfall 139	Model	1.0	Jan 1992–Dec 2011	20	29	5.63E+00	1.06E-01	11	3.80E+00
CSO Outfall 140	Model	1.0	Jan 1992–Dec 2011	20	22	6.80E-01	7.00E-03	13	5.66E-01

Note: Some LTCP projects have less than one overflow per year in the 20-year analysis period, which suggests compliance with current regulations. However, this is a result of using model results for precipitation scaling factor = 1.00.

Attachment E-6b: Supplementary LTCP Data—Monthly and Seasonal Summary

Monthly and Seasonal Summary for CSO Outfall 99			
Month	Pre-project volume (MG/time period)	Post-project volume (MG/time period)	Volume reduction (MG/time period)
1	1.07E-02	0.00E+00	1.07E-02
2	9.04E-02	7.96E-02	1.08E-02
3	6.08E-02	4.76E-02	1.32E-02
4	2.67E-02	1.81E-02	8.55E-03
5	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00
7	0.00E+00	0.00E+00	0.00E+00
8	0.00E+00	0.00E+00	0.00E+00
9	0.00E+00	0.00E+00	0.00E+00
10	0.00E+00	0.00E+00	0.00E+00
11	1.86E-01	1.29E-01	5.79E-02
12	4.46E-01	3.82E-01	6.44E-02
Season			
Oct–Jan	6.43E-01	5.11E-01	1.33E-01
Feb–Sep	1.78E-01	1.45E-01	3.26E-02
Annual	8.21E-01	6.56E-01	1.66E-01

Monthly and Seasonal Summary for CSO Outfall 107			
Month	Pre-project volume (MG/time period)	Post-project volume (MG/time period)	Volume reduction (MG/time period)
1	1.85E-01	3.68E-02	1.49E-01
2	8.10E-03	0.00E+00	8.10E-03
3	9.94E-02	1.17E-02	8.77E-02
4	2.70E-02	0.00E+00	2.70E-02
5	6.48E-02	0.00E+00	6.48E-02
6	0.00E+00	0.00E+00	0.00E+00
7	0.00E+00	0.00E+00	0.00E+00
8	2.14E-02	0.00E+00	2.14E-02
9	5.70E-02	6.99E-03	5.00E-02
10	1.74E-01	7.26E-03	1.67E-01
11	4.42E-01	9.09E-02	3.52E-01
12	4.11E-01	2.33E-01	1.79E-01
Season			
Oct–Jan	1.21E+00	3.68E-01	8.46E-01
Feb–Sep	2.78E-01	1.87E-02	2.59E-01
Annual	1.49E+00	3.86E-01	1.11E+00

Monthly and Seasonal Summary for CSO Outfall 111B			
Month	Pre-project volume (MG/time period)	Post-project volume (MG/time period)	Volume reduction (MG/time period)
1	6.80E-03	6.48E-03	3.21E-04
2	1.46E-02	1.44E-02	1.60E-04
3	4.40E-03	4.04E-03	3.60E-04
4	5.00E-05	0.00E+00	5.00E-05
5	4.00E-04	2.40E-04	1.60E-04
6	3.50E-04	1.90E-04	1.60E-04
7	0.00E+00	0.00E+00	0.00E+00
8	1.50E-03	1.24E-03	2.60E-04
9	0.00E+00	0.00E+00	0.00E+00
10	1.13E-02	1.09E-02	3.71E-04
11	1.58E-02	1.56E-02	1.60E-04
12	8.98E-02	8.90E-02	8.02E-04
Season			
Oct–Jan	1.24E-01	1.22E-01	1.65E-03
Feb–Sep	2.13E-02	2.01E-02	1.15E-03
Annual	1.45E-01	1.42E-01	2.81E-03

Monthly and Seasonal Summary for CSO Outfall 111C			
Month	Pre-project volume (MG/time period)	Post-project volume (MG/time period)	Volume reduction (MG/time period)
1	3.10E-03	3.00E-03	1.00E-04
2	1.44E-02	1.43E-02	1.00E-04
3	1.50E-04	0.00E+00	1.50E-04
4	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00
6	4.00E-04	3.00E-04	1.00E-04
7	0.00E+00	0.00E+00	0.00E+00
8	1.70E-03	1.60E-03	1.00E-04
9	0.00E+00	0.00E+00	0.00E+00
10	1.10E-02	1.07E-02	3.00E-04
11	1.23E-02	1.22E-02	1.00E-04
12	1.04E-01	1.04E-01	3.00E-04
Season			
Oct–Jan	1.31E-01	1.30E-01	8.00E-04
Feb–Sep	1.67E-02	1.62E-02	4.50E-04
Annual	1.47E-01	1.46E-01	1.25E-03

Monthly and Seasonal Summary for CSO Outfall 111H			
Month	Pre-project volume (MG/time period)	Post-project volume (MG/time period)	Volume reduction (MG/time period)
1	2.22E-02	2.18E-02	3.49E-04
2	1.80E-01	1.80E-01	3.49E-04
3	3.17E-02	3.13E-02	3.49E-04
4	1.67E-01	1.66E-01	3.49E-04
5	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00
7	0.00E+00	0.00E+00	0.00E+00
8	1.38E-01	1.37E-01	3.49E-04
9	0.00E+00	0.00E+00	0.00E+00
10	0.00E+00	0.00E+00	0.00E+00
11	2.64E-01	2.63E-01	1.05E-03
12	8.60E-01	8.58E-01	1.74E-03
Season			
Oct–Jan	1.15E+00	1.14E+00	3.14E-03
Feb–Sep	5.16E-01	5.14E-01	1.39E-03
Annual	1.66E+00	1.66E+00	4.53E-03

Monthly and Seasonal Summary for CSO Outfall 138			
Month	Pre-project volume (MG/time period)	Post-project volume (MG/time period)	Volume reduction (MG/time period)
1	9.50E-03	0.00E+00	9.50E-03
2	9.50E-03	4.20E-03	5.30E-03
3	1.20E-02	6.55E-03	5.40E-03
4	2.90E-03	0.00E+00	2.90E-03
5	8.10E-03	4.50E-04	7.65E-03
6	1.00E-04	0.00E+00	1.00E-04
7	0.00E+00	0.00E+00	0.00E+00
8	1.26E-02	7.30E-03	5.30E-03
9	0.00E+00	0.00E+00	0.00E+00
10	1.98E-02	1.45E-02	5.30E-03
11	4.82E-02	2.39E-02	2.43E-02
12	1.59E-01	1.33E-01	2.57E-02
Season			
Oct–Jan	2.36E-01	1.71E-01	6.48E-02
Feb–Sep	4.52E-02	1.85E-02	2.67E-02
Annual	2.81E-01	1.90E-01	9.15E-02

Monthly and Seasonal Summary for CSO Outfall 139			
Month	Pre-project volume (MG/time period)	Post-project volume (MG/time period)	Volume reduction (MG/time period)
1	3.50E-04	0.00E+00	3.50E-04
2	5.00E-05	0.00E+00	5.00E-05
3	5.00E-05	0.00E+00	5.00E-05
4	1.50E-04	0.00E+00	1.50E-04
5	3.30E-03	2.40E-03	9.00E-04
6	0.00E+00	0.00E+00	0.00E+00
7	0.00E+00	0.00E+00	0.00E+00
8	3.55E-03	3.20E-03	3.50E-04
9	0.00E+00	0.00E+00	0.00E+00
10	3.00E-03	1.60E-03	1.40E-03
11	4.01E-03	2.96E-03	1.05E-03
12	1.96E-02	1.82E-02	1.40E-03
Season			
Oct–Jan	2.69E-02	2.27E-02	4.20E-03
Feb–Sep	7.10E-03	5.60E-03	1.50E-03
Annual	3.40E-02	2.83E-02	5.70E-03

Monthly and Seasonal Summary for CSO Outfall 140			
Month	Pre-project volume (MG/time period)	Post-project volume (MG/time period)	Volume reduction (MG/time period)
1	1.35E-03	0.00E+00	1.35E-03
2	1.10E-03	0.00E+00	1.10E-03
3	1.85E-03	0.00E+00	1.85E-03
4	1.80E-03	0.00E+00	1.80E-03
5	2.56E-02	1.87E-02	6.97E-03
6	2.00E-03	0.00E+00	2.00E-03
7	0.00E+00	0.00E+00	0.00E+00
8	1.77E-02	1.48E-02	2.93E-03
9	1.45E-03	0.00E+00	1.45E-03
10	2.26E-02	1.54E-02	7.25E-03
11	3.10E-02	1.96E-02	1.13E-02
12	1.39E-01	1.26E-01	1.32E-02
Season			
Oct–Jan	1.94E-01	1.61E-01	3.31E-02
Feb–Sep	5.15E-02	3.34E-02	1.81E-02
Annual	2.45E-01	1.94E-01	5.12E-02

Appendix F: Pollutant Reduction Estimation Method— Candidate Stormwater Projects



Protecting Seattle's Waterways

Volume 3 – Integrated Plan

Appendix F: POLLUTANT REDUCTION ESTIMATION METHOD—CANDIDATE STORMWATER PROJECTS

Final

May 29, 2015



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List of Abbreviations

Term	Definition	Term	Definition
ACWA	(Oregon) Association of Clean Water Agencies	RCOC	Representative Constituent of Concern
BC	Brown and Caldwell	RG	rain gauge
BEHP	Bis(2-ethylhexyl)phthalate	ROS	Regression on Order Statistics
BMP	best management practice	SMMWW	Stormwater Management Manual for Western Washington, version 2012
BOD	biochemical oxygen demand	SS4WQ	Street Sweeping for Water Quality
CBODU	Ultimate Chemical and Biological Oxygen Demand	TAPE	Technology Assessment Protocol – Ecology
CESF	chitosan-enhanced sand filter	TP	total phosphorus
CFU	colony forming unit(s)	TSS	total suspended solids
CI	confidence interval	UCL	upper confidence limit
City	City of Seattle	WWHM	Western Washington Continuous 2012 Simulation Hydrology Model, version 2012
CSO	combined sewer overflow	yr	year(s)
CSS	combined sewer system	Zn	zinc
Cu	copper		
DO	dissolved oxygen		
Ecology	Washington State Department of Ecology		
EMC	event mean concentration		
EPA	U.S. Environmental Protection Agency		
GIS	geographic information system		
gpd	gallon(s) per day		
GSI	green stormwater infrastructure		
GULD	General Use Level Designation		
[H+]	hydrogen ion		
LCL	lower confidence limit		
LTCP	Long-Term Control Plan		
MG	million gallon(s)		
mg/L	milligram(s) per liter		
mL	milliliter(s)		
MPN	most probable number		
MS4	municipal separate storm sewer system		
NBF	North Boeing Field		
NBOD	Nitrogenous Biochemical Oxygen Demand		
NDS	Natural Drainage System		
NSQD	National Stormwater Quality Database		
PBDE	polybrominated diphenyl ether		
PCB	polychlorinated biphenyl		
PLM	pollutant load model		

Summary

This appendix documents the pollutant load model (PLM) analysis for stormwater projects conducted as part of the City of Seattle (City) Integrated Plan. Geosyntec conducted this analysis to help the City develop the Integrated Plan, which is an alternative in the City's Long-Term Control Plan (LTCP) for combined sewer overflows (CSOs).

Geosyntec estimated the pollutant load reductions of the 14 candidate stormwater projects identified by the City (Table 1-1). The load reduction analysis focused on the constituents of concern identified in the Consent Decree. Where the Consent Decree identified categories of pollutants (e.g., metals, pathogens, semi-volatile organic compounds, and pesticides), Representative Constituents of Concern (RCOCs) were identified in consultation with the City and the Expert Panel.

Model Overview

The general approach for assessing pollutant load reductions relies on the use of existing information and a relatively simple spreadsheet model. Although the PLM was not calibrated to site-specific conditions, local information provided by the City where possible (e.g., local stormwater runoff study data and local precipitation data) was used in the model. Information from literature and the International Stormwater Best Management Practices (BMP) Database (www.bmpdatabase.org) was also used for parameterizing the PLM.

The Pre-Project component of the model is based on observed and literature-developed rainfall/runoff relationships and estimated pollutant concentrations in stormwater runoff. The volume of stormwater runoff is estimated using a simple volumetric runoff coefficient, an empirical expression that relates runoff volume to the rainfall depth and the basin characteristics such as imperviousness and soil infiltration characteristics. The pollutant concentration in stormwater runoff is represented by an expected average pollutant concentration, developed based on analysis of event mean concentrations (EMC). The EMCs used in this analysis were obtained from available monitoring data and are dependent on the land use type.

The Post-Project component of the model utilizes the Pre-Project concentrations and runoff volumes and applies project performance estimates for stormwater treatment projects. The modeled performance of projects depends on three factors: (1) the fraction of average long-term stormwater runoff volume receiving treatment (referred to hereafter as "capture efficiency"), (2) the pollutant removal achieved in the project by virtue of surface runoff reduction via infiltration and/or evapotranspiration (generically referred to as "volume reduction"), and (3) the pollutant removal achieved in the treatment project by virtue of improved water quality of treated runoff. The flow chart in Figure S-1 provides an overview of the Post-Project modeling component.

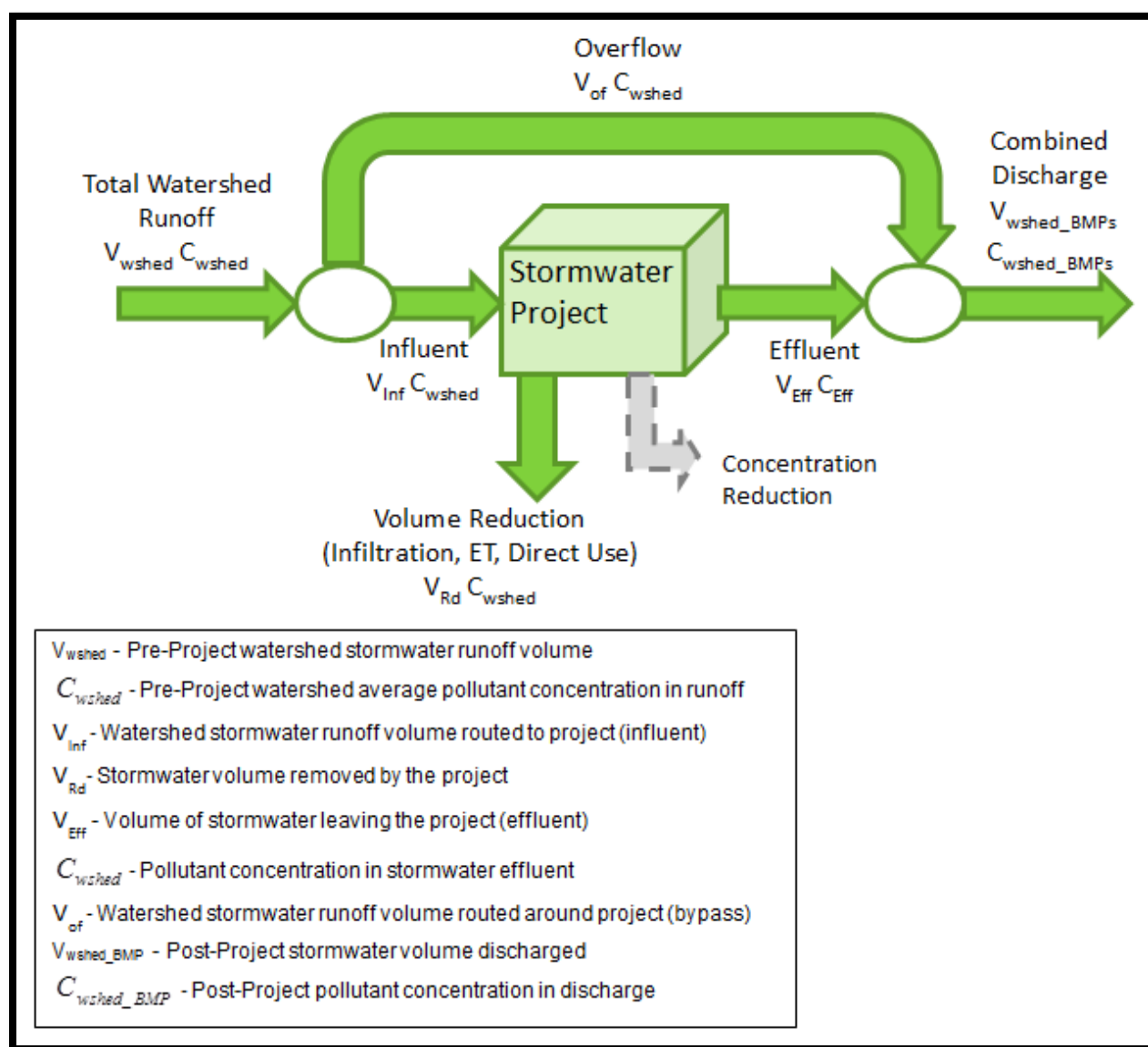


Figure S-1. Conceptual diagram of PLM Post-Project component

Uncertainty in Input Parameters

There is an inherent level of uncertainty in the stormwater sampling data, watershed characteristics, geographic information system (GIS) data, stormwater project performance data, and other data sets that were used to help understand the water quality benefits of stormwater projects. Therefore, understanding and quantifying these sources of uncertainty and incorporating them into the PLM creates a more robust analysis. A statistical modeling approach (Monte Carlo Analysis) was employed to allow the uncertainty in input parameters to be reflected in model inputs and to provide an indication of the average characteristics and variability of the stormwater concentrations and loadings in model results. For each Monte Carlo iteration, the PLM randomly selects a value between the lower and upper bounds for each key parameter to develop a unique estimate of average long-term conditions. The calculation is repeated for a large number of iterations, resulting in a large distribution of different estimates of potential long-term runoff volume, pollutant concentrations, and pollutant loadings results from each of the project tributary areas.

Geosyntec first developed a lower and upper bound for each of the parameters that is sensitive in the analysis and can be meaningfully quantified. When possible, the model expressed these input parameters in terms of a 95 percent confidence interval (CI) on the long-term average (i.e., bounded by the lower confidence limit [LCL] and the upper confidence limit [UCL]). CIs were developed for the land use runoff concentrations, project effluent concentrations, and street sediment concentrations using the bootstrap approach in combination with Regression on Order Statistics (ROS). Additionally, when the underlying data sets did not allow for the explicit estimation of CIs, the LCL and UCL for each key model input parameter were estimated using other methods, such as modeling calculations, data analysis, literature, or best professional judgment as described in Chapter 3.

The PLM is intended to estimate long-term average annual conditions for a given location and project. The PLM does not seek to describe the temporal variability that is inherent in stormwater pollutant loading. Additionally, the PLM is not intended to predict conditions for a given storm event or monitoring period.

Street Sweeping Model Overview

The City has implemented the Street Sweeping for Water Quality (SS4WQ) program, and as part of this, street solids are monitored to determine pollutant removal. Because the City has the SS4WQ program and the monitoring data, a separate PLM was developed to characterize long-term average pollutant loading reductions and concentration reductions for the City Integrated Plan street sweeping stormwater programs. This model uses a rate of pollutant removed by sweeping per curb-mile (pick-up rate) calculated from data measured during the City's current street sweeping program. The pick-up rate is then applied to the area that will receive enhancements to the street sweeping program to generate the total pollutant mass removed. Adjustments were applied to the total pollutant mass removed to convert this mass into a portion that would have been expected to be washed off the street during rain events and discharged at stormwater outfalls. A detailed discussion of the street sweeping analysis is included in Appendix G of the City's Integrated Plan report. The methodology and data provided by the City was then used to characterize the uncertainty inherent in the street sweeping data, as described below, and run with the Monte Carlo iterations.

Model Input Parameters

The PLM input parameters for the Pre-Project pollutant loadings include precipitation, stormwater project drainage area, runoff coefficients, and land use runoff concentrations. The PLM input parameters for the Post-Project pollutant loadings include project performance parameters, including capture efficiency, volume reduction, and effluent quality and/or other expressions of treatment efficiency. The PLM was modified to allow estimation of uncertainty in model predictions and seasonal variations.

Precipitation Characteristics

The annual and seasonal average precipitation in the Seattle area, as well as uncertainty in long-term average precipitation, were characterized based on an analysis of the City's network of 12 active rain gauges (RGs), which span a period of 35 years from 1978 to 2012. RG20 was selected as the central representative gauge. Spatial variability was used to estimate the range of long-term averages that may exist across the city. Table 3-1 presents the average precipitation and CIs used in the PLM for the three modeling time periods. These three modeling periods (annual, Season 1 [October–January], and Season 2 [February–September]) were selected based on an evaluation of the magnitude and frequency of CSO events.

Stormwater Projects Drainage Areas

The City identified and mapped the potential extent of the drainage area for each of the 14 candidate stormwater projects (Table 1-1 and Figure 3-1). The PLM calculated the “effective” drainage area, runoff coefficient, and land use pollutant runoff concentrations based on the conveyance class (e.g., informal vs. formal), surface type (e.g., roofs vs. lawns), and land use within each stormwater project drainage area. Other parameters also influence runoff and pollutant loads (e.g., soils, source area type, slope); however, these parameters were not as well supported by available data. The variability introduced by these parameters was considered to be encompassed within the overall uncertainty applied to the other parameters. Additionally, the stormwater project drainage area for several projects includes greater area than it may be possible to completely address by projects, and therefore the degree of implementation was also considered as a model parameter.

Effective Drainage Area Adjustments

A portion of the storm flow from a drainage basin may be “lost” during conveyance and not discharge from the municipal separate storm sewer system (MS4) outfall, due to two separate components of the conveyance system: (1) the type of conveyance system the area is connected to (i.e., excluding the areas in which flow is routed into the sanitary sewer system), and (2) the losses within the conveyance system (e.g., infiltration). To account for these losses, a connection factor was used to adjust the effective area of the drainage basin. The connection factor was estimated using the following equation:

$$\text{Connection factor} = \text{area connect to MS4 (\%)} * [1 - \text{conveyance losses (\%)}]$$

The City developed estimates based on citywide conditions. Significant catchment-specific and watershed-specific variations in system types and system losses are considered likely. Therefore, it was assumed that the estimated connection factors have a plus or minus 25 percent upper and lower bound of uncertainty. Table 3-3 lists the connection factor and the range of uncertainty for each land surface type in the partially separated and fully separated areas. Because it is assumed that zero percent of the combined sewer system (CSS) areas are connected to the MS4, the connection factor for all the land surface types in those areas is zero.

Degree of Project Implementation

All of the stormwater projects, excluding the green stormwater infrastructure (GSI) bioretention alternatives, are planned to be fully implemented for the watersheds identified. The GSI bioretention projects underwent a desktop GIS evaluation to establish a broad range of potentially feasible areas for implementation. However, due to site-specific conditions (e.g., actual infiltration rates) and social considerations (e.g., neighborhood concerns), many locations may not be suitable for implementation following site investigations. To account for these potential constraints, the estimated degree of implementation of these projects and therefore the Integrated Plan stormwater project drainage area was adjusted (Table 3-4).

Runoff Coefficients

The Western Washington Continuous Simulation Hydrology Model (WWHM, 2012) was applied to estimate runoff coefficients for each land surface type based on various soil types and surface slopes (Table 3-5). The range of long-term runoff coefficients estimated from this analysis was interpreted to develop Seattle-specific LCLs and UCLs for each land surface type (e.g., roofs, lawns, parking, streets, etc.). Note that while land surface types were used to estimate runoff coefficients in the PLM, data were not available to characterize pollutant runoff concentrations at the scale of discrete land surface types/source areas. Instead, land use-based information was used to estimate pollutant runoff concentrations.

Land Use Runoff Concentrations

The process of developing land use runoff concentrations included compiling stormwater runoff data from multiple sources (including local, regional, and national data sets), developing criteria for applying these data sets (e.g., attempt to represent Pacific Northwest runoff quality), and developing an approach for interpreting the data.

Using the runoff data, criteria, and approach described in Section 3.4, the upper and lower bound for each land use concentration was selected from summary statistics presented in Attachment F-1 of this appendix. The CIs and selected ranges for each EMC are graphically depicted in Attachment F-2 of this appendix. Final land use runoff concentration values are summarized in Table 3-7.

Project Performance

Project performance was modeled as a function of three elements: (1) the capture efficiency, discussed in Section 3.5.1; (2) the volume reduction, discussed in Section 3.5.2; and (3) the pollutant removal, discussed in Section 3.5.3.

Project Capture Efficiency

The City selected the preliminary design criteria for most of the stormwater projects to achieve a capture efficiency of 91 percent of the runoff volume. However, due to size and cost limitations or the availability of land for construction, several of the stormwater projects have preliminary designs with lower capture efficiencies (Table 3-8). No uncertainty is associated with the capture efficiency of the stormwater projects, because the projects will be further designed and built to satisfy the assumed capture efficiency criteria, with appropriate margins of safety, as needed.

Project Volume Reduction

The majority of the stormwater projects are treatment projects that do not infiltrate runoff; however, the bioretention and biofiltration projects are designed to reduce surface flow via infiltration. Preliminary planning of the GSI bioretention projects assumes that site-specific conditions will allow 50 percent of the captured volume to be infiltrated into native soils while the remaining 50 percent will be discharged after treatment to the receiving waters via underdrains. For the South Myrtle St. Shoulder Stabilization project, a range of volume reductions was developed that accounts for uncertainty arising from a lack of site-specific design conditions (e.g., infiltration rate) and variability in biofiltration performance (Table 3-9).

Project Pollutant Removal

The pollutant removals for the stormwater projects (excluding street sweeping) were estimated based on available data, using (1) an effluent quality-based approach, derived from the International Stormwater BMP Database (Table 3-10); (2) correlating pollutant removal to total suspended solids (TSS) reduction based on pollutant characteristics; or (3) other methods based on available data and best professional judgment. When using the effluent quality-based approach (which was preferred), project performance data from the International Stormwater BMP Database were also analyzed to evaluate whether there is a statistically significant difference between influent and effluent concentrations. Where there was not a statistically significant difference between influent and effluent concentrations, no concentration reduction was assumed.

For the NDS Partnering project where some of the treated stormwater infiltrates into native soils and some may be treated but discharged through an underdrain, the PLM calculates the pollutant removal by considering both pathways: the mass of pollutants removed from the infiltrated water and the mass of pollutants removed based on the treatment and then discharged where there is an underdrain present.

Street Sweeping

The City has been monitoring street sediment mass and quality in conjunction with its SS4WQ program. The data collected through this program, including street sediment removed, curb-miles swept, and concentrations of RCOC in street sediment, directed the development of the model estimating the potential load reductions resulting from enhancements to the street sweeping program.

The discussion of each of the necessary model inputs along with the resulting values can be found in Appendix G of the City Integrated Plan document: Pollutant Reduction Estimation Method—Candidate Stormwater Street Sweeping Programs. Additionally, quantifiable uncertainty was estimated for the seasonal precipitation, sample variability, and sweeper productivity (Section 3.6).

Model Methodology

Calculate the Pre-Project stormwater runoff volume:

1. Calculate the implemented effective drainage area for each land use type within the candidate stormwater project drainage basin based on the degree of project implementation, land use (e.g., residential, commercial, industrial), surface type (e.g., street, building, sidewalk, landscaped area), and drainage system connection factors (see Section 3.2).
2. Estimate the runoff coefficient for each land use type within the candidate stormwater project drainage basin based on land use, surface type, and surface type runoff coefficients (see Section 3.3).
3. Select the rainfall depth for the time period to be evaluated (annual, wet and dry seasons; see Section 3.1) to calculate the stormwater runoff volume from each land use type within the candidate stormwater project drainage area and then sum the volumes to calculate the Pre-Project runoff volume.

Calculate the Pre-Project pollutant loads and concentrations:

4. Select a pollutant concentration in stormwater runoff for each land use type and each RCOC (see Section 3.4) and multiply by the runoff volume to calculate the Pre-Project load from each discrete land use type in the project drainage basin and then sum the loads for each RCOC to calculate the Pre-Project RCOC loads.
5. Divide each Pre-Project RCOC load by the Pre-Project volume to calculate the Pre-Project average concentration for each RCOC.

Calculate the Post-Project stormwater runoff volume, pollutant loads, and concentrations:

6. Calculate the Post-Project runoff volume by summing the bypass volume (Pre-Project volume multiplied by 1 minus the capture efficiency [see Section 3.5.1]) and the project effluent volume (Pre-Project volume multiplied by capture efficiency and 1 minus the project volume reduction [see Section 3.5.2]).

7. Calculate the Post-Project load by summing the bypass load (bypass volume multiplied by the Pre-Project concentration) and the project effluent load (project effluent volume multiplied by the project effluent concentration [see Section 3.5.3]). This calculation assumes complete removal of all RCOCs in the fraction of the captured stormwater that infiltrates the native soils beneath the facility (e.g. NDS Partnering facilities with no underdrains).
8. Divide each Post-Project RCOC load by the Post-Project volume to calculate the Post-Project average concentration for each RCOC.

Calculate the stormwater runoff volume, pollutant load, and concentration reductions:

9. Calculate the Post-Project average volume reduction, concentration reduction, and load reduction for each RCOC based on the difference between Pre-Project and Post-Project results.

Calculate the distribution of results:

10. Repeat steps 1–9 a total of 1,000 times for each RCOC and time period, recording the Pre-Project, Post-Project, and reduction model results for each iteration.

Model Methodology Assumptions

The following key assumptions are made for the Monte Carlo water quality modeling methodology:

1. The stormwater projects were modeled to only remove pollutants and not act as a source.
2. The stormwater projects were modeled so that the dissolved fraction of RCOCs were always less than or equal to their respective total RCOC.

Street Sweeping Model

The PLM was modified to be able to quantify the uncertainty and estimate the seasonal RCOC concentrations and loads for the street sweeping data provided by the City.

Model Results

The PLM results are summarized in a series of box-and-whisker charts (Attachment F-3). Each chart displays the long-term average concentration or load reduction for an RCOC during the annual time period. Each candidate Integrated Plan stormwater project is included on the x-axis with the estimated reduction on the y-axis, the median reduction is indicated by the horizontal line within the box, the top and bottom of the box represents the 25th and 75th percentile average long-term reductions, respectively, and the top and bottom whiskers represent the 95th and 5th percentile average long-term reductions, respectively.

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CHAPTER 1

Introduction

This appendix documents the pollutant load model (PLM) analysis for stormwater projects conducted as part of developing the City of Seattle (City) Integrated Plan. The Integrated Plan is an alternative in the City's Long-Term Control Plan (LTCP) for combined sewer overflows (CSOs). Geosyntec conducted the pollutant load analysis in partnership with the City and Brown and Caldwell to help develop the Integrated Plan.

Geosyntec developed a PLM to estimate the pollutant load reductions of the candidate stormwater projects identified by the City. The City identified 14 potential candidate stormwater projects based on Step 2¹ of the Integrated Planning process, as listed in Table 1-1. The *Stormwater Treatment Project Screening Technical Memorandum* (SPU, 2013) includes a planning-level description of each project and describes the best management practice (BMP) selection process, which consisted of the following steps:

- **Step 2.1:** Identify characteristics of the priority ranked basins
- **Step 2.2:** Identify receiving water body and its primary pollutant(s) of concern
- **Step 2.3:** Estimate pollutant loading and flow for each basin
- **Step 2.4:** Conduct stormwater project feasibility screening
- **Step 2.5:** Estimate costs

Table 1-1. Potential Integrated Plan Stormwater Projects

Name	Total tributary drainage area (acres)	Project type	Treatment type	Receiving water body
Blue Dog Pond/Pretreatment	242	Swirl concentrator	Basic (particle separation)	Duwamish Waterway
Longfellow Cascades	68	Bioretention with routing to infiltration	Flow control/basic (vegetated media filtration/sorption)	Longfellow Creek
Minor Ave./Cascades Filterras	56	Media filter	Basic (media filtration/sorption)	Lake Union
Minor Ave./I-5 StormFilter Vault	140	Cartridge media filter	Basic (media filtration)	Lake Union
NDS Partnering	Piper's Creek: 684 Thornton Creek: 2,703 Longfellow Creek: 557	Bioretention with routing to infiltration	Flow control/basic (vegetated media filtration/sorption)	Piper's Creek Thornton Creek Longfellow Creek

¹ See City's Integrated Plan report, Figure 1-2 for the steps taken in the Integrated Planning approach.

Table 1-1. Potential Integrated Plan Stormwater Projects

Name	Total tributary drainage area (acres)	Project type	Treatment type	Receiving water body
Piper's Cascades	159	Bioretention with routing to infiltration	Flow control/basic (vegetated media filtration/sorption)	Piper's Creek
South Myrtle St. Shoulder Stabilization	3.2	Biofiltration swale	Basic (vegetated filtration)	Duwamish Waterway
South Myrtle St. StormFilter Vault	8.5	Cartridge media filter	Basic (vegetated media filtration/sorption)	Duwamish Waterway
South Park WQ Facility	254	Active treatment (CESF)	Chitosan-enhanced sand filtration system	Duwamish Waterway
Street Sweeping Expansion Arterials	1,736	Street sweeping	Regenerative air street sweeper	Varies/multiple
Street Sweeping Expansion Residential	1,120	Street sweeping	Regenerative air street sweeper	Varies/multiple
SW Hinds SD StormFilter Vault	29	Cartridge media filter	Basic (media filtration/sorption)	Duwamish Waterway
U Village Filterrras	5.4	Media filter	Basic (media filtration/sorption)	Lake Washington
Webster Pond/Pretreatment	366	Swirl concentrator	Basic (particle separation)	Longfellow Creek

1.1 Objectives

The objective of this PLM analysis was to assess pollutant load reductions for those stormwater projects and programs identified in Step 2 of the Integrated Planning process.

This assessment was performed using the constituents of concern identified in the Consent Decree the City recently entered into with the U.S. Environmental Protection Agency (EPA), Washington State Department of Ecology (Ecology), and United States Department of Justice (e.g., metals, pathogens, semi-volatile organic compounds, and pesticides). Representative Constituents of Concern (RCOCs) carried forward in the loading analyses were identified in consultation with the City and the Expert Panel. The RCOCs were selected with consideration for known environmental concerns and data availability. For example, copper and zinc were selected as representative of metals because copper and zinc are the most common and well-known toxicants characterized by multiple stormwater runoff studies. Table 1-2 identifies the complete list of RCOCs.

Table 1-2. Representative Constituents of Concern

Constituents identified in Consent Decree	Selected RCOC
Biochemical oxygen demand (BOD)	BOD ^a
Semi-volatile organic compounds	Bis(2-ethylhexyl)phthalate
Pesticides	Dichlobenil
Pathogens	Fecal coliform bacteria
pH	[H ⁺] ^b
Nitrogen ammonia	Ammonia-N ^c
Oil and grease	Oil and grease ^d
Polybrominated diphenyl ethers (PBDE)	Total PBDEs
Fecal coliform bacteria	Fecal coliform bacteria
Projected dissolved oxygen (DO)	Projected DO ^e
Polychlorinated biphenyls (PCB)	Total PCBs
Phosphorus	Total phosphorus (TP)
Total suspended solids (TSS)	TSS
Metals	Dissolved copper Dissolved zinc Total copper Total zinc

a. BOD = 5-day biochemical oxygen demand (BOD₅).

b. H⁺ = hydrogen ion concentration.

c. Ammonia-N = nitrogen-ammonia

d. Oil and grease analyzed using a combination of EPA 1664A and earlier comparable methods (EPA 1664, EPA 413.1, etc.).

e. Projected DO = change in DO deficit.

1.2 Methodology

The general approach for assessing pollutant load reductions relies on the use of existing information and a relatively simple spreadsheet model. Although the PLM was not calibrated to site-specific conditions, local information provided by the City was used where possible (e.g., local stormwater quality data and local precipitation data). Information from literature reviews and the International Stormwater BMP Database was also used for parameterizing the PLM.

The project (City and consultant team) team consulted with the Expert Panel via three full-day face-to-face panel meetings and two conference calls to reach consensus on model inputs and methodology. The Expert Panel reviewed the stormwater project evaluation methodology and provided feedback on data used, assumptions, and

the proposed methods for developing the baseline PLM and the performance of the potential candidate stormwater projects. Their feedback was valuable for selecting an appropriate list of RCOCs to meet the Consent Decree requirements, assessing the most appropriate land use and project performance data, and the statistical method selected for demonstrating project performance and uncertainty. The Expert Panel also provided feedback and insight into specific considerations such as addressing PCBs in the Duwamish Waterway and how to refine the performance of street sweeping.

Appendix D of the City's Integrated Plan report contains a summary of the Expert Panel meetings and their findings.

CHAPTER 2

Model Overview

2.1 Pollutant Load Model Overview

The PLM was developed to characterize long-term average² pollutant concentrations and loadings (total mass of pollutants) for each RCOC from each candidate stormwater project drainage area prior to project implementation (Pre-Project) and after project implementation (Post-Project) on an annual and seasonal basis. It was also used to develop estimates of the variability in performance. This empirical, volume-based PLM is generally applicable in the planning and evaluation stages of a project³.

The Pre-Project component of the model is based on simple rainfall/runoff relationships and estimated pollutant concentrations in stormwater runoff. The volume of stormwater runoff is estimated using a simple runoff coefficient method, an empirical expression that relates runoff volume to the rainfall depth and the basin characteristics such as the amount of impervious land cover. The pollutant concentration in stormwater runoff is represented by an expected average pollutant concentration, which was developed based on analysis of the event mean concentrations (EMC). EMCs were obtained from available monitoring data and are dependent on the land use type (e.g., commercial, industrial, and residential).

The Post-Project component of the model utilized the Pre-Project concentrations and runoff volumes and applied project performance parameters to estimate Post-Project conditions. The performance of projects was modeled as a function of three factors: (1) the fraction of average long-term stormwater runoff volume receiving treatment (referred to hereafter as “capture efficiency”), (2) the long-term average pollutant removal achieved in the project by virtue of surface runoff reduction via infiltration and/or evapotranspiration (generically referred to as “volume reduction”), and (3) the long-term average pollutant removal achieved in the treatment project by virtue of improved water quality of treated runoff. The flow chart in Figure 2-1 provides an overview of the Post-Project modeling component.

² The long-term average condition is a more reliable indication of total long-term loading (considering the influence of both normal and extreme events), while the long-term median condition is a more reliable indicator of conditions that occur most frequently.

³ The model does not incorporate the hydraulics or detailed hydrology of the site, which would be appropriate for subsequent design stages and requires additional data and more sophisticated modeling.

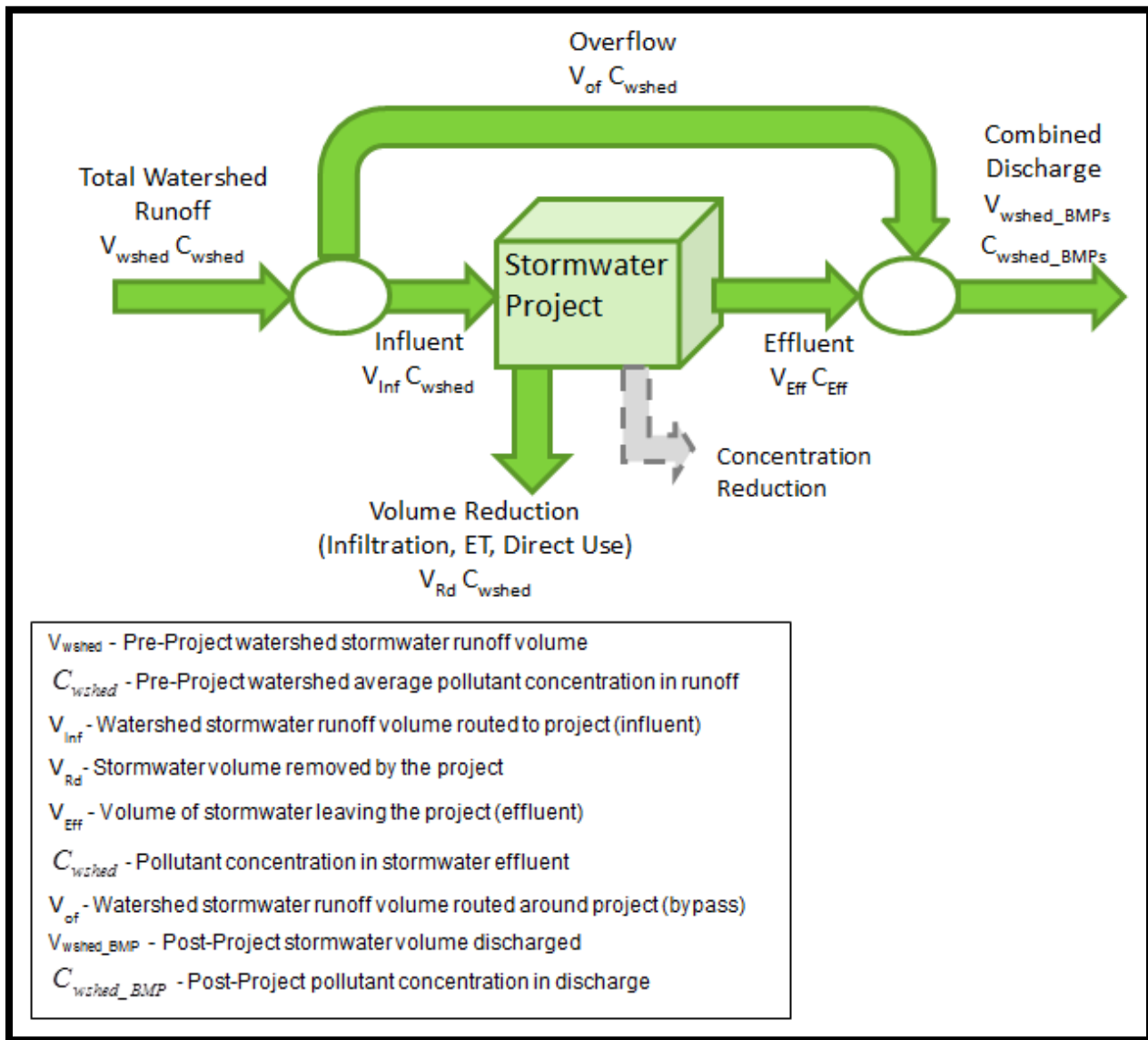


Figure 2-1. Conceptual diagram of PLM Post-Project model component

Runoff volumes, stormwater quality characteristics, and project performance are highly variable. Therefore, a statistical modeling approach (Monte Carlo Analysis) was employed to allow the uncertainty in input parameters to be reflected in model inputs and to provide an indication of the average characteristics and variability of the stormwater concentrations and loadings in the model results. For each Monte Carlo iteration, the PLM randomly selects a value from between the lower and upper bounds for each key parameter to develop a unique estimate of average long-term conditions. The calculation is repeated for a large number of iterations, resulting in a large distribution of different estimates of potential long-term runoff volume, pollutant concentrations, and pollutant loading results from each of the stormwater project drainage areas.

Using the model methodology described in further detail in Chapter 4, the PLM estimates a distribution of the long-term average annual runoff loadings for each RCOC and time period for the following eight outputs (each expressed as an average long-term estimate):

1. Pre-Project Runoff: The runoff volume from the stormwater project drainage basins prior to stormwater project implementation
2. Post-Project Runoff: The runoff volume from the stormwater project drainage basins after the implementation of the stormwater project
3. Pre-Project Concentration: The concentrations of the RCOCs in runoff from the stormwater project drainage basins prior to the stormwater project implementation
4. Post-Project Concentration: The concentrations of the RCOCs in runoff from the stormwater project drainage basins after the implementation of the stormwater project
5. Concentration Reduction: The concentration reductions of the RCOCs in the runoff from stormwater project drainage basins as a result of the implementation of the stormwater project
6. Pre-Project Load: The loadings of the RCOCs from the stormwater project drainage basins prior to the stormwater project implementation
7. Post-Project Load: The loadings of the RCOCs from the stormwater project drainage basins after the implementation of the stormwater project
8. Load Reduction: The load reductions of the RCOCs in runoff from the stormwater project drainage basins after the implementation of the stormwater project

An additional PLM was developed to characterize long-term average pollutant loading reductions and concentration reductions for the City Integrated Plan proposed enhanced street sweeping stormwater projects. This model uses a rate of pollutant removed by sweeping per curb-mile (pick-up rate) calculated from data measured during the City's current street sweeping program. The pick-up rate is then applied to the area that will receive enhanced street sweeping (more frequent and more miles) to the current street sweeping program to generate the total pollutant mass removed. Adjustments were applied to the total pollutant mass removed to convert this mass into a portion that would have been expected to be washed off the street during rain events and discharged at stormwater outfalls. A detailed discussion of the street sweeping analysis is included in Appendix G of the City's Integrated Plan report. The street sweeping methodology was used with the data provided by the City to characterize the uncertainty inherent in the street sweeping data and run using the Monte Carlo iterations.

2.2 Uncertainty in Input Parameters

There is an inherent level of uncertainty in the stormwater quality data, watershed characteristics, basin boundary delineations, stormwater project performance data, and other information that was used to help understand the water quality benefits of the proposed stormwater projects. Therefore, it is important to understand the sources of uncertainty so that they can be quantified and incorporated into the PLM to create a more robust analysis. Below are described the sources of uncertainty and a brief discussion of the main approaches for characterizing the uncertainty of the model input parameters. Additionally, Chapter 3 discusses in greater detail the uncertainty analysis and results for each individual model input parameter.

2.2.1 Sources of Uncertainty

The sources of uncertainty relating to the PLM input parameters arise from, but are not limited to, the following:

- representativeness of data from studies conducted in other areas that were used in the analysis (e.g., runoff concentrations)
- general uncertainty in any stormwater data due to measurements, field protocols, data quality, and data accuracy
- stormwater volume estimating methods that rely on empirical relationships between annual rainfall and runoff
- spatial uncertainty in watershed/site conditions (e.g., imperviousness, soils, runoff parameters), as they relate to the certainty that can be had regarding hydrologic conditions at a given location

It is important to note that the PLM does not seek to describe the temporal variability that is inherent in stormwater pollutant loading. The PLM is intended to estimate long-term average conditions for a given location and project. At this scale, temporal variability (e.g., storm-to-storm, year-to-year) is not relevant. Additionally, the PLM is not intended to predict conditions for a given storm event or monitoring period.

2.2.2 Characterizing Uncertainty

A lower and upper bound was developed for each of the most important and sensitive model input parameters that can be meaningfully quantified. When possible, the model expressed these input parameters in terms of a 95 percent confidence interval (CI) on the long-term average (i.e., bounded by the lower confidence limit [LCL] and the upper confidence limit [UCL]). CIs were developed for the land use runoff concentrations, project effluent concentrations, and street sediment concentrations using the bootstrap approach (Singh et al., 1997) in combination with Regression on Order Statistics (ROS). Additionally, when underlying data sets did not allow for the explicit estimation of CIs, the LCL and UCL for each key model input parameter were estimated using other methods such as modeling calculations, data analysis, literature, or best professional judgment as described in Chapter 3. Table 2-1 summarizes the model input parameters with the uncertainty quantified and the method of quantification employed.

2.2.2.1 Method for Dealing with Multiple Detection Limits

To account for the multiple detection limits in the censored data sets, an ROS method was employed. ROS is a category of robust methods for estimating descriptive statistics of censored data sets that utilize the normal scores for the order statistics (Shumway et al., 2002). The plotting position method by Hirsch and Stenderinger (1987) (summarized by Helsel and Cohn, 1988) was used. In this method, plotting positions are based on conditional probabilities and ranks, where the ranks of the censored (below detection) and uncensored (above detection) data related to each detection limit are ranked independently. The method is summarized in the equations below.

After plotting positions for the censored and uncensored values have been calculated, the uncensored values are plotted against the z-statistic corresponding to the plotting position and the best-fit line of the known data points is derived. Using this line and the plotting positions for the uncensored data, the values for the uncensored data are extrapolated.

$$pe_j = pe_{j+1} + \frac{A_j}{(A_j + B_j)} \times (1 - pe_{j+1}) \quad (1)$$

Where:

- A_j = the number of uncensored observations above the j detection limit and below the $j+1$ detection limit
- B_j = the number of censored and uncensored observations less than or equal to the j detection limit
- pe_j = the probability of exceeding the j threshold for $j = m, m-1, \dots, 2, 1$ where m is the number of thresholds; by convention $pe_{m+1} = 0$

Equation 2 was used for plotting the uncensored data and equation 3 was used for plotting the censored data; the plotting positions of the data were calculated using the Weibull plotting position formula (Weibull, 1951).

$$p(i) = (1 - pe_j) + \frac{(pe_j - pe_{j+1}) \times r}{(A_j + 1)} \quad (2)$$

Where:

- $p(i)$ = the plotting position of the uncensored i data point
- r = the rank of the i^{th} observation of the A_j observations above the j detection limit

$$pc(i) = \frac{(1 - pe_j) \times r}{(n_j + 1)} \quad (3)$$

Where:

- $pc(i)$ = the plotting position of the censored i data point
- R = the rank of the i^{th} observation of the n_j censored values below the j detection limit

2.2.2.2 Method for Calculating Descriptive Statistics

After replacement values were estimated for censored data (or for data sets without non-detects), descriptive statistics were computed using the bootstrap method (Singh et al., 1997). The bootstrap method samples from the data set with replacement⁴ several thousand times and calculates the desired descriptive statistics from the sampled data. The steps of the bootstrap estimation method are described below.

1. Take a sample of size n with replacement (the sampled data point remains in the data set for subsequent sampling) from the existing data set (Singh et al. (1997) recommends that n be the same size as the original

⁴ The data point selected for the bootstrap analysis remains in the data set and is allowed to be selected more than one time, rather than a single time, which is known as "sampling without replacement."

data set, this recommendation was followed for the analysis) and compute the descriptive statistic, θ_i (e.g., mean), from the sampled data.

2. Repeat Step 1 independently N times (10,000 for this analysis) each time calculating a new estimate for θ_i .
3. Calculate the bootstrap estimate, θ_B , by averaging the θ_i 's for $i=1$ to N.

Fundamentally, the bootstrap procedure is based on the Central Limit Theorem, which suggests that even when the underlying population distribution is non-normal, averaging produces a distribution more closely approximated with normal distribution than the sampled distribution (Devore, 1995).

Table 2-1. Uncertainty and Methods in Input Parameters

Parameter	Lower and upper bounds of uncertainty ^a	Characterization source
Average Annual and Seasonal Precipitation	Plus or minus 10% of the arithmetic mean	Best professional judgment based on analysis of spatial variability of rainfall across the city
Effective Drainage Area	Plus or minus 25% of the mean	Best professional judgment
Runoff Coefficient	Varied	Analyzed using WWHM with different inputs for soil type and slope conditions
Land Use Runoff Concentrations	95% confident interval on the long-term average	Statistical analysis of various land use runoff concentration data sets
Project Volume Reduction ^b	Biofiltration swale: 18%–32%	Statistical analysis of International Stormwater BMP Database
Project Effluent Concentrations or Concentration Reductions	95% confident interval on the long-term average	Statistical analysis of International Stormwater BMP Database; supplemental information, where available; best professional judgment where necessary to fill data gaps
Street Sediment Concentrations	95% confident interval on the long-term average	Statistical analysis of raw street sediment concentrations
Street Sweeper Productivity	Plus or minus 25% of the mean	Best professional judgment

a. Many parameters had extenuating circumstances in which different lower and/or upper bounds were used. A detailed explanation of the uncertainty in every parameter input is included in Chapter 3.

b. The bioretention projects had volume reductions as well; however, there was no quantifiable uncertainty for the volume reduction of these projects.

CHAPTER 3

Model Input Parameters

The PLM simulates pollutant loadings into (Pre-Project) and out of (Post-Project) each candidate stormwater project. PLM input parameters for the Pre-Project pollutant loadings include precipitation, stormwater project drainage area, runoff coefficients, and land use runoff concentrations. The PLM input parameters for the Post-Project pollutant loadings include project performance parameters, including capture efficiency, volume reduction, and effluent quality and/or other expressions of treatment efficiency. A discussion of these model input parameters is provided below. Additionally, there is a separate discussion of the model input parameters for street sweeping.

Many parameters that can affect pollutant loads and concentrations vary spatially and may not be adequately represented by stormwater monitoring data collected at discrete locations. Examples include specific high or low source concentrations, topography, soil types, and precipitation characteristics, among others, all of which can influence the buildup and mobilization of pollutants. The following model input parameters represent the best data currently available for representation of existing and developed site conditions in the water quality model (PLM).

3.1 Precipitation Characteristics

Annual and seasonal average precipitation in the Seattle area, as well as uncertainty in long-term annual average precipitation, was characterized according to the water year based on the City's network of 12 active rain gauges (RGs), which span a period of 35 years from 1978 to 2012. Based on this network, a single rain gauge (RG20), was selected for purposes of parameterizing the PLM. RG20 is believed to be representative of the City's network of rain gauges for the reasons listed below:

- RG20's mean annual precipitation value (33.8 inches) approximates the mean annual precipitation value across all stations (33.6 inches).
- RG20's 95 percent CI about the mean overlapped the 95 percent CIs for all other stations with the exception of RG11, which had the lowest annual precipitation value (29.5 inches).
- RG20 is centrally located in the city of Seattle.

Table 3-1 presents the average precipitation and CIs used in the PLM for the three modeling time periods. These three modeling periods were selected based on an evaluation of the magnitude and frequency of CSO events.

Table 3-1. Cumulative Precipitation Estimates Used in the PLM

(Based on Water Year, Rain Gauge RG20, and n=34)

Period	Average (inches)	Confidence interval ^a (inches)
Annual	33.8	30.4–37.2
October–January (Season 1)	18.3	16.5–20.1
February–September (Season 2)	15.5	14.0–17.1

a. Confidence interval is defined as plus or minus 10% of the average based on best professional judgment of an analysis of general spatial variability of precipitation data across the city.

3.2 Stormwater Projects Drainage Areas

The City identified and mapped the drainage area for each of the 14 candidate stormwater projects (Table 1-1 and Figure 3-1). The PLM then calculated the “effective” drainage area, runoff coefficient, and land use pollutant runoff concentrations based on the conveyance class (e.g., informal vs. formal), surface type (e.g., roofs vs. lawns), and land use within each candidate stormwater project drainage area. Other parameters are also understood to influence runoff and pollutant loads (e.g., soils, source area type, and slope); however, these parameters were not as well supported by available data. The variability introduced by these parameters is considered to be encompassed within the overall uncertainty applied to the other parameters. Additionally, the candidate stormwater project drainage areas for several of the projects include larger drainage areas than possible to completely be addressed by the projects; therefore, the degree of implementation was also considered as a model parameter.

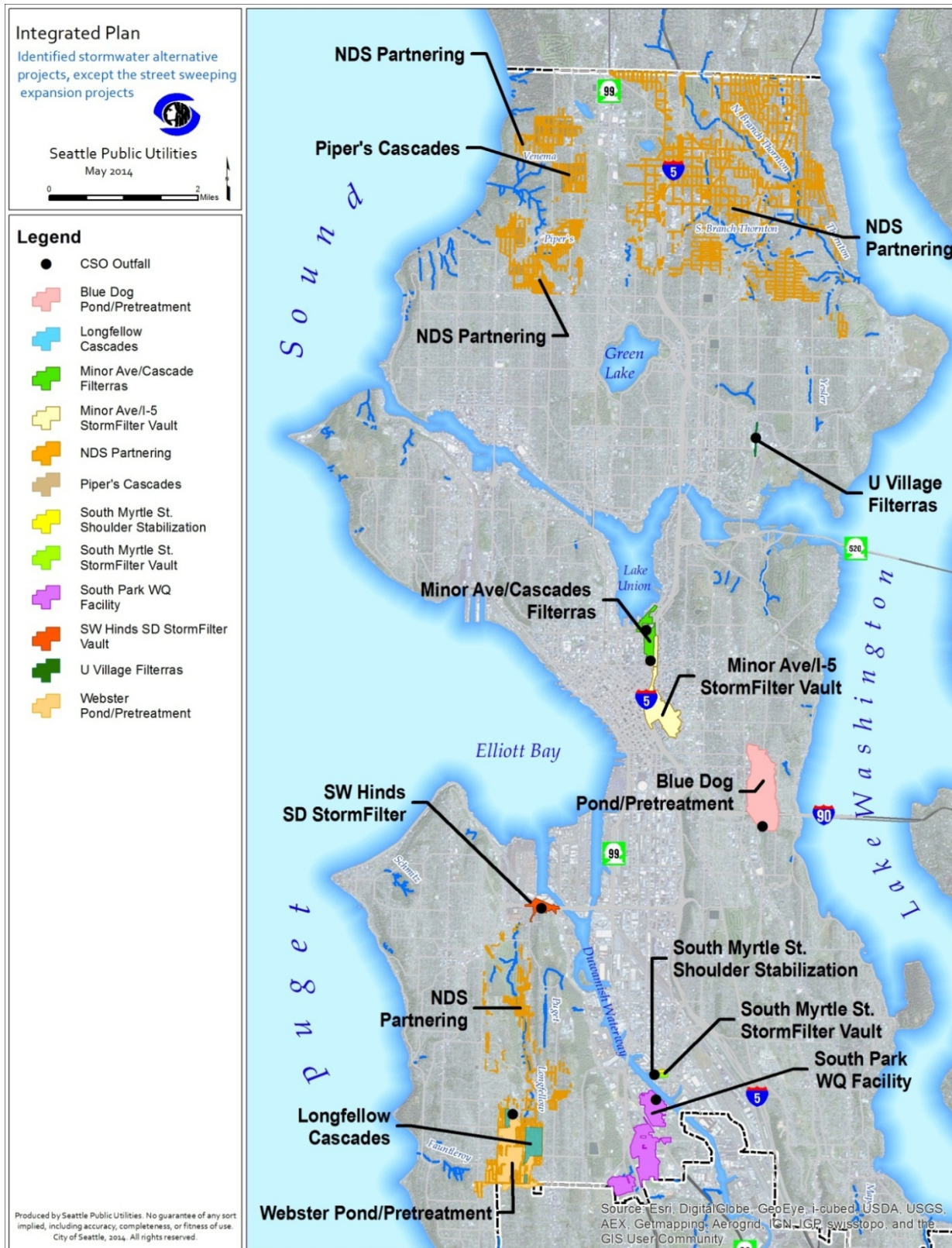


Figure 3-1. Identified stormwater alternative projects, except the street sweeping expansion projects
(tributary watershed and discharge point are shown for each)

3.2.1 Conveyance Class, Surface Type, and Land Use

The drainage areas for the candidate stormwater projects (excluding street sweeping) were characterized by conveyance class, surface type, and land use in a geographic information system (GIS) by intersecting the respective City GIS layers (Table 3-2). Conveyance classes, surface types, and land uses are described below.

Table 3-2. GIS Layers Used for Characterizing Conveyance Class, Surface Type, and Land Use	
GIS layer	File name
Project drainage area	IPAlternativeBndry.lpk
Conveyance class	Combined_updated feature class from IPtoBNC.gdb
Surface type	SurfaceType feature class from IP_PLE.gdb
Land uses	LNDUSEZONING feature class from IP_PLE.gdb

Source: City of Seattle

Conveyance Class. The stormwater conveyance systems found within the candidate stormwater project drainage areas determines whether stormwater is directed into a municipal separate storm sewer system (MS4) or the combined sewer system (CSS) (Figure 3-2). The conveyance class GIS layer is classified into the following three classes:

- Combined sewer systems: Areas where stormwater and sanitary sewage are collected and conveyed to the wastewater treatment plant in a single pipe. Most of the older sections of Seattle are served by combined sewers.
- Municipal separate storm sewer systems: Areas where stormwater and sewage are collected and conveyed in totally separate systems (e.g., MS4s and sanitary sewers). Stormwater is discharged directly to the nearest receiving water body and sewage is conveyed to the wastewater treatment plant.
- Partially separated systems: Areas where combined sewer and MS4 systems overlap. These systems typically exist in areas where the City has separated stormwater from the combined system to reduce CSOs. In these areas, runoff from the streets is generally collected and conveyed in a separate storm drain system, but runoff from the adjacent parcels may or may not continue to be connected to the CSS. The degree of separation on private parcels depends on the ease with which these areas could be connected to the storm drain system during construction.

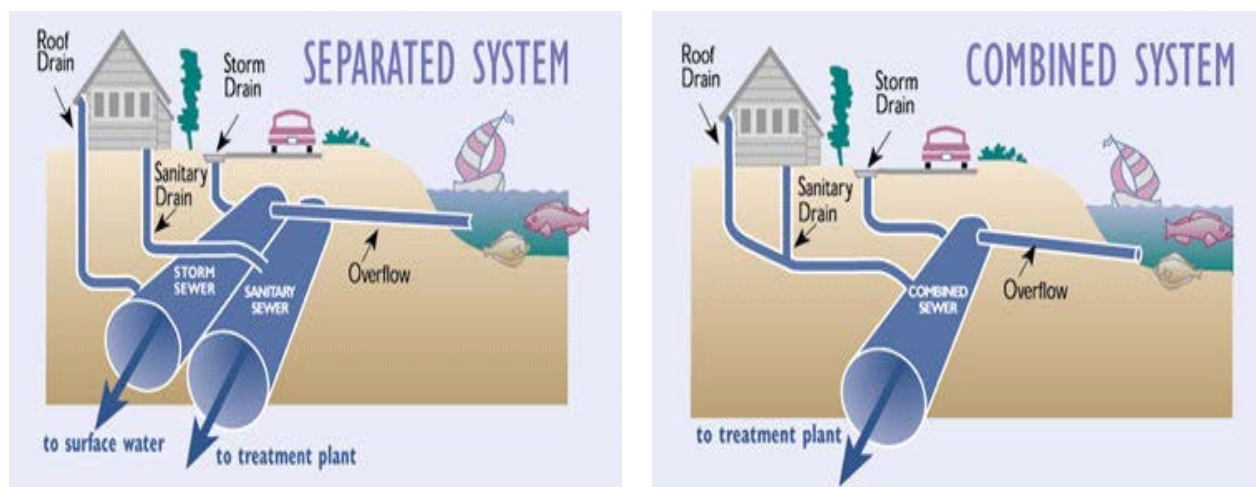


Figure 3-2. Schematic of separated and combined sewer systems

The conveyance class layer was used to estimate the portion of the candidate stormwater project's drainage area that would produce runoff to an MS4 outfall (see description of effective area in Section 3.2.2).

Surface Type. The City created the surface type GIS layer utilizing three data sources, starting with the most precise layer and filling in missing areas with the less precise layers to produce a comprehensive representation of the various ground covers found within the Integrated Plan stormwater project drainage areas (see description in the Pollutant Loading Estimation Technical Memorandum by the City on April 18, 2013 [SPU, 2013(b)]). The surface type GIS layer is classified into the following eight classes:

- Building
- Driveway/Parking Lot
- Other Impervious
- Pervious Landscape
- Sidewalk
- Street
- Trees/Scrub
- Water

The surface type GIS layer was used primarily to estimate the volume of runoff generated from the Integrated Plan stormwater project drainage area based on empirical rainfall-runoff relationships developed for areas characterized by different levels of imperviousness (see Section 3.3 and Section 4.1). However, surface type also came into play in the estimates of effective drainage area as the connection factors developed for areas served by partially and fully separated systems varied depending on surface type (e.g., streets are more likely to be connected to the MS4 than roofs in partially separated systems), discussed in Section 3.2.2.

Land Uses. Land use in the candidate project drainage areas was divided into the following six categories using King County parcel GIS information:

- Commercial
- Industrial
- Open Space
- Residential
- Vacant/Unknown
- Water

The land use GIS layer was used in the PLM to characterize pollutant runoff concentrations expected from those land uses based upon observed data in Seattle as well as regional and national land use runoff quality data sets, discussed in Section 3.4.

3.2.2 Effective Drainage Area Adjustments

A significant portion of the flow that leaves a drainage basin may not discharge out of an MS4 outfall, due to two separate components of the conveyance system: (1) the type of conveyance system the area is connected to, and (2) the losses within the conveyance system. To account for these losses, a connection factor was used to adjust the effective area of the drainage basin. The connection factor was estimated using the following equation:

$$\text{Connection factor} = \text{area connect to MS4 (\%)} * [1 - \text{conveyance losses (\%)}]$$

3.2.2.1 Conveyance Class Adjustment

The drainage basin areas were reduced to represent only the percent of the area connected to the MS4 (i.e., excluding the areas in which flow is routed into the sanitary sewer system). It is assumed that in areas of MS4 and CSS all runoff flows to the respective system, while in the partially connected systems only a portion of the area flows to the MS4. For these partially separated areas, the degree of separation from the combined system and connection to the MS4 is based on the City's knowledge of how these separation projects were designed and constructed. As explained above, for most separation projects, runoff from the streets was separated from the CSS and routed to the separated storm drain system (i.e., MS4). However, runoff from areas adjacent to the right-of-way was not as easily separated. Therefore, runoff from the adjacent parcels often continues to flow to the CSS. Table 3-3 lists the estimated area connected to the MS4 in the partially separated areas for each surface type. Additionally, it is assumed that 100 percent of the MS4 areas and zero percent of the CSS areas are connected to the MS4.

3.2.2.2 Conveyance System Losses Adjustment

Flow can be lost from certain drainage systems due to factors such as soil infiltration in the informal drainage areas served by ditches and culverts and pipe exfiltration through leaking joints and cracks in the formal piped drainage system. These losses are represented in the PLM as a percent of the area contributing flow (i.e., flow from X percent of the area is lost within the conveyance system). The informal conveyance systems experience higher losses due to the nature of the system (e.g., greater infiltration in the bottom of unlined open channels). Partially separated areas are assumed to have a formal conveyance, because it was previously part of the combined system. The fully separated areas are assumed to have an informal conveyance north of 85th Street. In the rest of the city, fully separated systems are piped. Conveyance losses in these areas are zero. The City's

experience at the surface type level within formal and informal conveyance areas informs the estimated percent of the typical flow that is lost. Table 3-3 lists the estimated losses occurring within the formal and informal conveyance systems for each surface type. Note that because the open land use areas calibrated conditions may already account for some of these losses, the overall assumed losses may be somewhat conservative (i.e., baseline loadings may be underestimated). When estimating pollutant load reductions, it is considered conservative to make assumptions that underestimate baseline runoff volumes and pollutant loads.

3.2.2.3 Connection Factor Uncertainty

The City developed estimates based on citywide conditions. Significant catchment-specific and watershed-specific variations in system types and system losses are considered likely. Therefore, it was assumed that the estimated connection factors have a plus or minus 25 percent lower and upper bound of uncertainty. For connection factors that are estimated to be 100 percent, the uncertainty ranges from 80 to 100 percent. Table 3-3 lists the connection factor and the range of uncertainty for each surface type in the partially separated and fully separated areas. Because it is assumed that none of the CSS areas are connected to the MS4, all of the surface types in those areas were assigned a connection factor of zero.

Table 3-3. Surface Type Connection Factors ^a						
Surface type	Partially separated areas			Fully separated areas (MS4)		
	Area connected to MS4 (%)	Loss in formal conveyance (%)	Connection factor (%) [low–high]	Area connected to MS4 (%)	Loss in informal conveyance (%)	Connection factor (%) [low–high]
Street	100	0	100 [80–100]	100	0	100 [80–100]
Driveway/ Parking Lot	75	0	75 [50–100]	100	50	50 [25–75]
Building (Roof)	60	0	60 [35–80]	100	65	35 [10–60]
Sidewalk	100	10	90 [80–100]	100	20	80 [60–100]
Other Impervious	100	0	75 [50–100]	100	50	50 [25–75]
Water	100	0	100 [80–100]	100	0	100 [80–100]
Landscape Area	100	0	100 [80–100]	100	0	100 [80–100]
Tree/scrub	100	0	100 [80–100]	100	0	100 [80–100]

a. Very small GIS slivers of land use areas are found with no surface type and/or no conveyance type defined. To be conservative these areas are assigned a connection factor of 0%. When estimating pollutant load reductions, it is considered conservative to make assumptions that underestimate baseline runoff volumes and pollutant loads.

3.2.3 Degree of Project Implementation

All of the candidate stormwater projects, excluding the green stormwater infrastructure (GSI) bioretention alternatives, are planned to be fully implemented. The GSI bioretention projects underwent a desktop GIS evaluation to establish a broad area potentially feasible for implementation. However, due to site-specific conditions (e.g., actual infiltration rates) and social considerations (e.g., neighborhood concerns), many locations may not be suitable for implementation following site investigations. To account for these potential constraints, the estimated degree of implementation of these projects, and therefore the stormwater project drainage area, was adjusted (Table 3-4).

Table 3-4. Degree of Implementation for Stormwater Projects	
Alternative name	Project implementation
Longfellow Cascades	60%
NDS Partnering	4% ^a
Piper's Cascades	60%
All other stormwater projects	100%

a. The design implementation level provided by the City. Although significantly higher percentages are feasible, this implementation level is reasonable within the confines of the potential budget allocation.

3.3 Runoff Coefficients

The Western Washington Continuous Simulation Hydrology Model (WWHM, 2012) was used to estimate Seattle-specific runoff coefficients for each surface type. The WWHM (2012) utilizes long-term 15-minute precipitation data, measured evaporation data, and other region-specific data sets in a continuous-simulation hydrology model to calculate annual precipitation volumes and runoff and other loss volumes.

To simulate the runoff from the various Seattle surface types, the WWHM program was set to the precipitation file “VLPRECIP 15 min.”⁵ This gauge, located in north Seattle, provides representative rainfall for the stormwater projects. RG20, used in the overall analysis of annual rainfall amounts, has only hourly data and therefore could not be used for this more detailed analysis. Additionally, the use of WWHM was intended only to develop a unitless fraction of stormwater runoff, and not to provide an absolute estimate of runoff volumes; therefore, minor differences in rainfall depths between these gauges were not important.

⁵ The precipitation gauge RG20, used to establish the precipitation values for the PLM, is not calibrated in the WWHM program. Therefore, the VLPRECIP gauge was chosen as a similar precipitation file.

The eight surface types classified in the City GIS layer were combined into four groups for analysis and modeled with a closely matching WWHM category:

- Building (WWHM category roof)
- Driveway/Parking Lot, Other Impervious, Sidewalk, Street, and Water (WWHM categories Driveways, Sidewalks, Parking)
- Pervious Landscape (WWHM category Lawn)
- Trees/Scrub (WWHM category Forest)

Each of the four WWHM categories was modeled as 1-acre drainage areas. To characterize the lower and upper bounds of uncertainty relating to site-specific conditions, the following soil and slope attributes were used:

- soil type A/B and flat slope (LCL)
- soil type C and steep slope (UCL)

WWHM uses these input definitions to estimate the volume of annual precipitation, surface runoff, and interflow (pervious areas only). The surface runoff and interflow (when applicable) were divided by the annual precipitation to calculate the runoff coefficients for the four groups of surface types. The LCL and UCL for each surface type group are listed in Table 3-5.

Table 3-5. WWHM Surface Type Runoff Coefficients		
Surface type	LCL	UCL
Pervious Landscape	0.0	0.40
Pervious Trees/Scrub	0.0	0.18
Impervious Land Cover ^a	0.82	0.87

a. The WWHM Roof category produced the same runoff volumes as the Driveways, Sidewalk, and Parking category; therefore, they are reported simply as impervious.

3.4 Land Use Runoff Concentrations

Land use runoff concentrations representative of each RCOC were developed to estimate Pre-Project loadings. The process of developing land use runoff concentrations included compiling stormwater runoff data from multiple sources (Table 3-6), developing criteria for selecting appropriate data sets, and developing an approach for interpreting the data. This process and the final land use runoff concentrations used in the PLM are described below.

3.4.1 EMC Data Compilation

Stormwater runoff data from multiple data sources were evaluated to estimate the land use runoff concentrations upper and lower bounds using identified EMC values for each RCOC (Table 3-6). Prior to the analysis, the

stormwater data were compiled into a single database. Attributes in the compiled database include data source, land use, date, parameter, units, data qualifier (e.g., non-detected values), and value (both censored/non-detect and uncensored).

Stormwater data were excluded from the compiled database if the assigned land uses were inconsistent with the modeled land use categories (e.g., residential, commercial, industrial, open space, and vacant). Exceptions were made for PCB and PBDE, in which cases land use was not a consideration of the PLM for the following reasons:

- PBDE data were limited to King County and Spokane, Washington. Land use information was not available from these data sources.
- PCB data were limited to King County, Washington; Portland, Oregon; the City of Seattle, Washington; and data from Ecology. Land use information was not available from King County or Ecology.
- The amount of PBDE and PCB data were limited. Pooling the data into a single land use category made for a more robust data set (a special exception is described below).

Total PBDEs and PCBs concentrations were calculated by summing the detected congeners and Aroclor sample results. Where all congeners and Aroclors are non-detect, an uncensored value equal to the minimum detection limit was assigned. This approach helps to avoid overestimates of PCB and PBDE loads that could occur by summing half of the detection limit for each of the respective congeners/Aroclors. It also helps to avoid a case where a sample with all non-detects could be considered to be higher than a sample with one detection. However, by taking the full detection limit of the lowest congener/Aroclor, this approach also recognizes that the sum of many congeners/Aroclors that are each below detection could still sum to more than half of the lowest detection limit of any one congener. The [H⁺] (hydrogen concentration for calculating pH) was calculated using pH sample results using the following equation: $10^{(-1 \cdot \text{pH})} \cdot (1.0079) \cdot (1,000)$.

Prior to calculating descriptive statistics, the raw data were uncensored using the robust ROS method described in Section 2.2.2. If there were three or fewer detect values or if a sample set exceeded 80 percent non-detect, a simple substitution of half the reporting limit was used.

Table 3-6. EMC Data Sources

Agency	Data set description	Available RCOCs	Reference
City of Seattle	Stormwater samples collected between February 2009 and July 2012 from three locations	[H ⁺], ammonia-N, bis(2-ethylhexyl)phthalate, BOD ₅ , D-Cu, T-Cu, dichlobenil, fecal coliform, PCB, TP, TSS, D-Zn, T-Zn	City's stormwater characterization monitoring conducted for NPDES permit (SPU, 2013c)
City of Tacoma	Samples collected between November 2001 and June 2012 from six stations in the Thea Foss and Wheeler-Osgood Waterways	[H ⁺], BOD ₅ , D-Cu, T-Cu, dichlobenil, fecal coliform, TP, TSS, D-Zn, T-Zn	The Thea Foss and Wheeler-Osgood Waterways Annual Source Control and Water Year Stormwater Monitoring Report (Tacoma, 2013)
King Co.	Stormwater samples collected from seven locations in the Lake Washington watershed between November 2011 and April 2012	PCB, PBDE	2013 study for PCB/PBDE Loading Estimates for the Greater Lake Washington Watershed (King County, 2013)

Table 3-6. EMC Data Sources

Agency	Data set description	Available RCOCs	Reference
ACWA	Samples collected between May 1991 and May 1996 from 23 stations throughout Oregon	[H+], ammonia-N, BOD ₅ , D-Cu, T-Cu, fecal coliform, oil and grease, TP, TSS, D-Zn, T-Zn	Oregon Association of Clean Water Agencies (ACWA): ACWA stormwater database (ACWA, 2013)
NSQD	Samples collected between March 1980 and November 2008 from 347 stations across the country	[H+], ammonia-N, BOD ₅ , D-Cu, T-Cu, fecal coliform, oil and grease, TP, TSS, D-Zn, T-Zn	National Stormwater Quality Database: Version 3 (NSQD, 2013)
City of Spokane	Stormwater samples collected between May and June 2007 from 10 stations in the Spokane River basin	PBDE, dioxins/furans	2009 Washington Department of Ecology study: PBDE and Dioxin/Furans in Spokane Stormwater (Ecology, 2009)
City of Portland	Stormwater samples collected between May 1993 and April 2008 from 241 stations around the city	[H+], bis(2-ethylhexyl)phthalate, D-Cu, T-Cu, oil and grease, PCB, TP, TSS, D-Zn, T-Zn	Portland stormwater sample database (Portland, 2013)
Ecology	Stormwater samples collected between January 2011 and May 2011 from nine stations	PCB	Washington Department of Ecology's Lower Duwamish database (Ecology, 2013)

3.4.2 Land Use Runoff Concentration Upper/Lower Bounds Selection

This section provides a summary of the goals and approach used for developing land use runoff concentration upper and lower bounds for input into the PLM.

3.4.2.1 Goals

The compiled stormwater runoff data were evaluated to define a reasonable range of land use runoff concentrations LCL and UCL for input into the PLM. To that end, the data set was assessed to:

- include data that account for various development conditions, age, and types, with potential for pollutant sources and magnitudes to vary from site to site
- define statistics that are valid for pollutant load modeling (i.e., means) rather than frequency analysis (i.e., medians)
- reasonably represent the anticipated quality of stormwater runoff in the Integrated Plan project drainage areas recognizing the uncertainty associated with using data from other similar areas, particularly when the available data are associated with a limited number of or only one sampling station
- attempt to preserve expected relative trends in pollutant concentrations between land uses, where supported by data
- attempt to reduce potential for unreasonably high upper ends of runoff concentration ranges, which could result in a high bias estimate of pollutant load reduction

3.4.2.2 Approach

The approach in the land use runoff concentration selection process consisted of (1) defining the mean, LCL, and UCL for each RCOC by data source and land use, and (2) selecting a lower and upper bound for each RCOC by land use from the summary statistics. As the default approach, the bounding range of land use concentration was defined to the lowest LCL and highest UCL on long-term average from all the data sets. Various additional restrictions and considerations are discussed below.

Filter Data Sets with Known Potential for High Bias. Data from Portland industrial and residential data sets were identified as having a potential for a high bias. The Portland industrial data are primarily from heavy industrial sites, which may over-predict loads from the industrial areas located in stormwater project drainage areas, which could be characterized more as light industrial rather than heavy industrial. The Portland residential data are also prone to broader CIs because of the small sample size. Finally, one residential site in the ACWA database (Portland-R-1) was anomalous and had been identified as an outlier in the original analyses of these data by Woodward-Clyde (1997); therefore, this site was removed.

Consider City Industrial Monitoring Station Data on a Case-by-Case Basis. The City industrial monitoring site would likely result in a low bias in industrial load estimates based on the actual distribution of land use. Land use in this area is only 37 percent industrial with the rest comprising 32 percent residential, 13 percent commercial, and 18 percent open space uses. The City industrial monitoring site data were used only where needed to provide a “second opinion” to increase the upper end of the bounded range.

Give Preference to Pacific Northwest Data Sets Where Reasonable. Data from the Pacific Northwest data sets (e.g., Seattle, Tacoma, ACWA) are likely more representative of stormwater runoff in the Seattle area than from a national data set (e.g., NSQD). Therefore, by default, the long-term average range was developed by the lowest LCL and highest UCL from the Seattle, Tacoma, and ACWA data sets. Where Pacific Northwest data are higher than NSQD, the upper bound was adjusted to the NSQD UCL. The result of this approach is that the highest study is not used where estimates are available from all four sources (Seattle, Tacoma, ACWA, NSQD).

Where the Mean of the Second-highest Study is Higher than UCL95 of Other Studies, Set the Upper Range to the Mean of the Second-highest Study. The intent of this guideline is to truncate the actual range to reduce the potential for high bias in loading estimates.

Apply Concentrations from a Comparable Land Use if Data Are Absent for a Particular Land Use. Data sets were not available for the vacant land use category. Additionally, dichlobenil data were not available from the open space land use category. In these instances, the land use runoff concentrations were set equal to the residential land use category based on an evaluation of surface types. The surface type evaluation showed that “Pervious Landscape” and “Trees/Scrub” predominantly characterize open space (88 percent), vacant (65 percent), and residential (54 percent) land uses in the stormwater project drainage areas. This is in contrast to commercial and industrial land uses (61 percent and 75 percent, respectively), which are predominantly characterized by the surface types “Driveway/Parking Lot,” “Street,” and “Building.” Any potential bias introduced by equating vacant and open space with residential land use will have minimal impacts on the final results as open space and vacant land use categories represent a small fraction (5 percent and 4 percent, respectively) of the stormwater drainage areas.

Apply Special Considerations for Defining PCB Concentration for Projects in the Duwamish Watershed.

Stormwater PCB runoff concentrations are likely higher in the Duwamish watershed than elsewhere in the Seattle area as this watershed contains several known sources of PCBs. Therefore, the PCB data from Ecology's Lower Duwamish database (Ecology, 2011) were used exclusively for defining PCB concentrations in the Duwamish watershed. For the remaining drainage areas, the standard approach described in this section was used to estimate concentrations.

3.4.2.3 Final Selections

Using the goals and approach described above, an upper and lower bound was selected for each land use concentration from summary statistics presented in Attachment F-1. The CIs and selected ranges for each RCOC/land use combination are graphically depicted in Attachment F-2. Final land use runoff concentration characteristic values are summarized below in Table 3-7.

Table 3-7. Land Use Runoff Concentrations: Selected Upper and Lower Bounds

(Assumed 95% Confidence Levels on Long-Term Averages)

RCOC	Units	Residential		Commercial		Industrial		Open space		Vacant	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
BOD ₅	mg/L	2.88	11.53	3.39	17.56	2.30	16.82	1.39	3.51	2.88	11.53
Fecal coliform	CFU/100 mL	1,184	30,106	4,068	32,323	2,965	66,589	658	24,406	1,184	30,106
TSS	mg/L	44.51	93.12	58.33	106.28	58.24	176.89	6.86	105.70	44.51	93.12
Oil and grease	mg/L	2.27	5.89	2.87	9.50	2.84	10.07	0.49	2.79	2.27	5.89
[H ⁺]	mg/L	8.97E-05	3.32E-04	6.32E-05	4.62E-04	7.75E-05	1.33E-03	2.65E-05	1.65E-04	8.97E-05	3.32E-04
Total copper	µg/L	9.0	19	21	44	14	39	1.0	16	9.0	19
Dissolved copper	µg/L	3.0	7.0	7.0	16	3.0	10	1.0	5.0	3.0	7.0
Total zinc	µg/L	47	129	124	204	133	258	9.0	45	47	129
Dissolved zinc	µg/L	13	40	44	124	133	258	2.0	25	13	40
Ammonia-N	µg/L	83	151	127	311	184	297	123	229	83	151
TP	µg/L	97	343	93	330	114	383	28	202	97	343
Total PCBs	ng/L	4.226	28.982	4.226	28.982	4.226 ^a	28.982 ^a	4.226	28.982	4.226	28.982
Total PBDEs	ng/L	1.958	52.218	1.958	52.218	1.958	52.218	1.958	52.218	1.958	52.218
Bis(2-ethylhexyl)phthalate	µg/L	1.154	3.152	3.201	6.644	2.445	3.491	0.632	3.435	1.154	3.152
Dichlobenil	µg/L	0.0532	0.1123	0.0250	0.0581	0.0236	0.0390	0.0000	0.0000	0.0532	0.1123

a. The total PCB concentrations for the industrial areas draining to the Duwamish used higher LCL and UCL (25.63 and 97.56) as described above.

3.5 Project Performance

The candidate stormwater projects identified by the City encompass seven types of projects:

1. Active treatment (chitosan-enhanced sand filter [CESF])
2. Biofiltration swale
3. Bioretention with infiltration
4. Cartridge media filter
5. Media filter
6. Street sweeping
7. Swirl concentrator

The project performance of each project and RCOC were modeled for the purpose of estimating Post-Project loadings. The project performance was modeled as a function of three factors: (1) the capture efficiency, discussed in Section 3.5.1; (2) the volume reduction, discussed in Section 3.5.2; and (3) the pollutant removal, discussed in Section 3.5.3.

3.5.1 Project Capture Efficiency

The percent of the annual runoff volume a stormwater project will be capable of treating/managing is referred to as capture efficiency. Projects are typically designed in such a way that the flow exceeding the capture efficiency volume or flow rate will be routed around the project and will receive no treatment or in some cases where on-line and overflow occurs, minimal treatment (assumed to be zero in this modeling effort).

The City selected the preliminary design criteria for most of the candidate stormwater projects to achieve a capture efficiency of 91 percent⁶. However, due to size and cost limitations or the availability of land for construction, several of the candidate stormwater projects have preliminary designs with lower capture efficiencies (Table 3-8). No uncertainty is associated with the capture efficiency of the stormwater projects, because the projects will be further designed and built to satisfy the assumed capture efficiency criteria, with appropriate margins of safety, as needed. For example, the NDS Partnering Project is expected to have 80% of the stormwater entering the facilities captured and 20% is expected to be bypassed.

Table 3-8. Project Capture Efficiency	
Alternative name	Capture efficiency
Longfellow Cascades	80%
NDS Partnering	80%
Piper's Cascades	80%
South Park WQ Facility	83%
Webster Pond/Pretreatment: Swirl Concentrator	86%

⁶ The Stormwater Management Manual for Western Washington (SMMWW) lists the target capture efficiency for most new and re-development BMP as 91 percent of the total runoff estimated using an approved continuous model. The City's stormwater projects are retrofit projects and therefore are not subject to new and re-development based capture efficiency targets. However, the City will strive to maximize the efficiency of individual projects, considering size and cost considerations.

Table 3-8. Project Capture Efficiency

Alternative name	Capture efficiency
All other stormwater projects, except sweeping programs	91% ^a

a. This design criteria level was provided by the City.

3.5.2 Project Volume Reduction

In addition to treating the stormwater through physical and biological processes, some stormwater projects (e.g., biofiltration and bioretention systems) may infiltrate and/or evapotranspire the flow when site conditions are favorable (e.g., high infiltration rates, low groundwater table). In these facilities the volume of water that is infiltrated is considered removed and the associated pollutant load is reduced to zero. The volume reduction refers to the percent of the captured flow the project is estimated to lose via infiltration and/or evapotranspiration. For the other types of projects considered (e.g., media filtration, swirl concentrators, and active treatment), it is assumed that there will be no reduction in stormwater volume.

Preliminary planning of the GSI bioretention projects assumes the site-specific conditions will allow 50 percent of the captured volume to be infiltrated into native soils while the remaining 50 percent will be discharged after treatment to the receiving waters via an underdrain. Bioretention projects with underdrains have pollutant load reductions based on the pollutant removal performance discussed in Section 3.5.3. No uncertainty is associated with the volume reduction of the GSI bioretention projects, because the projects will be sited, designed, and built at later phases to ensure that they achieve at least 50 percent volume reduction, with appropriate margins of safety, as needed.

For the South Myrtle St. Shoulder Stabilization project, a range of volume reductions was developed to account for uncertainty arising from a lack of site-specific design conditions (e.g., infiltration rate) and variability in biofiltration performance. An analysis of 13 studies of biofiltration swales in the International Stormwater BMP Database with paired inflow and outflow volumes resulted in volume reductions ranging from 35 to 65 percent (Geosyntec Consultants and Wright Water Engineers, Inc., 2011). This reported range is intended to be useful at a planning level, recognizing that it represents performance that could be expected over a range of conditions and design standards. However, to add an additional level of conservativeness, half the range of reported volume reductions was used in the PLM. The estimated LCL and UCL for the project volume reductions for all projects are included in Table 3-9.

Table 3-9. Stormwater Project Volume Reduction

Candidate stormwater project	Volume reduction
Longfellow Cascades	50% ^a
NDS Partnering	50% ^a
Piper's Cascades	50% ^a
South Myrtle St. Shoulder Stabilization	LCL: 18% UCL: 32%
All other projects, except sweeping programs	0%

a. The City set the minimum design criteria; therefore, this volume reduction is considered conservative and no uncertainty is necessary.

3.5.3 Project Pollutant Removal

The pollutant removals for the stormwater projects (excluding street sweeping) were estimated based on available data, using: (1) an effluent quality-based approach, derived from the International Stormwater BMP Database, (2) correlating pollutant removal to TSS reduction based on pollutant characteristics, or (3) other methods based on available data and best professional judgment. Each of these approaches is described below.

3.5.3.1 International Stormwater BMP Database

Project effluent quality, like land use EMCs, is highly variable. To account for this variability, effluent quality data from the International Stormwater BMP Database were analyzed and the 95 percent CIs about the mean effluent concentrations (representing the LCLs and UCLs) were calculated. Similar to the estimation of land use EMCs, the final project effluent values used were determined using a combination of ROS and the bootstrap method. A log-normal distribution was assumed for the project effluent concentrations analysis. Table 3-10 includes the LCL and UCL for each RCOC and candidate stormwater project combinations in the International Stormwater BMP Database meeting all of the criteria for analysis.

The International Stormwater BMP Database is a comprehensive source of project performance information. It consists of carefully examined data from a peer-reviewed collection of studies that have monitored the effectiveness of a variety of projects in treating water quality pollutants for a variety of land use types. Research on characterizing project performance suggests that effluent quality rather than percent removal is more reliable in modeling stormwater treatment (Strecker et al., 2001).

The stochastic modeling approach of the PLM helps account for the uncertainty of not knowing the relationship between influent and effluent concentrations because the confidence limits of the average project effluent concentrations are based on a variety of project studies with a wide range of influent concentrations, representing a variety of drainage area land use characteristics. The Monte Carlo model accounts for pollutant reductions only if the predicted influent is greater than the achievable effluent quality estimated for the modeled project (i.e., effluent equals influent [or land use-based] concentrations up until the influent concentration exceeds the effluent concentration). Therefore, influent (or land use runoff-based) concentrations are considered by the model because they are directly used to determine whether treatment occurs.

The steps below were followed to ensure that the appropriate data from the International Stormwater BMP Database were selected in estimating the LCL and UCL of the effluent concentrations for each RCOC and candidate stormwater project combination:

1. Matching candidate stormwater projects to similar categories of stormwater projects in the International Stormwater BMP Database
2. Retrieving appropriate effluent concentrations to characterize each RCOC and candidate stormwater project combination
3. Calculating whether the influent and effluent concentrations are statistically significantly different

Select Analogous International Stormwater BMP Database Categories. Each project category in the International Stormwater BMP Database was carefully reviewed to select an equivalent or comparable project to each of the candidate stormwater projects. The International Stormwater BMP Database subcategory of Cartridge Media Filter was selected to represent candidate stormwater projects using media filters and cartridge media filters. No single stormwater project in the International Stormwater BMP Database was analogous to the Active

Treatment process planned for the South Park WQ Facility project. Project performance for this project was analyzed separately and the assumptions used are included in Section 3.5.3.3.

Criteria for Effluent Concentrations to Be Included in the Analysis. Only RCOC and candidate stormwater project combinations in the International Stormwater BMP Database with at least three separate studies, each of which had at least three effluent concentrations, were included for further analysis. The International Stormwater BMP Database did not have sufficient studies meeting these criteria for:

- Any candidate stormwater project treating bis(2-ethylhexyl)phthalate, dichlobenil, total PCBs, or total PBDEs. The project reduction performance for these combinations was determined using local monitoring studies and TSS correlation as described in Section 3.5.3.2.
- The effluent concentrations of BOD and fecal coliform from media filter projects. To be conservative, the analysis of the International Stormwater BMP Database for these RCOCs was performed based on sand filter projects.
- The effluent concentration of oil and grease from swirl concentrator projects. Oil and grease effluent concentrations were determined from the oil and grease subcategory of manufactured devices.
- The effluent concentration of BOD from bioretention projects. BOD concentrations were analyzed using sand filter project results.
- The effluent concentrations of fecal coliform from bioretention projects. To be conservative, the LCL was analyzed as the *E. coli* effluent concentrations from bioretention, with a 1.59 multiplier to convert to fecal coliform. The 1.59 multiplier is based on the EPA REC-1 Criterion of 200 most probable number (MPN) per 100 milliliters (mL) for fecal coliform versus 126 MPN/100 mL for *E. coli*. This is believed to provide a conservatively high estimate of fecal coliform, as studies have found that ratios are typically lower than 1.59 (Rasmussen, 2003). The UCL was analyzed using the fecal coliform effluent concentrations from sand filter projects.

Check if Influent/Effluent Concentrations Are Statistically Significantly Different. The Mann-Whitney rank-sum test, which is based on the alternative hypothesis that the influent and effluent medians differ, compared each RCOC and candidate stormwater project combination that fulfilled the analysis criteria. This non-parametric test applies to two independent data sets. A p-value less than 0.05 indicates that the influent and effluent median concentrations are statistically significantly different at the 95 percent confidence level. The RCOC and candidate stormwater project combinations that were not statistically significantly different are identified in Table 3-10. Additionally, the following combinations had concerns that led to the use of an alternative analysis of the International Stormwater BMP Database:

- Bioretention studies for dissolved copper contain 66 pairs of influent and effluent concentrations from three studies, but do not show significant removal. However, sand filter studies contain 134 pairs of influent and effluent concentrations from 10 studies and do show a significant removal. It is anticipated that the candidate bioretention projects will be as good as or better than sand filter projects with appropriate media selection. Therefore, the dissolved copper effluent concentrations from sand filter projects were substituted in place of bioretention projects.
- Statistical significance of oil and grease in the Bioretention category is limited by a high number of non-detect samples in both the influent and effluent. Therefore, the oil and grease effluent concentrations from sand filter projects were substituted in place of bioretention projects. It is anticipated that candidate bioretention projects will be as good as or better than sand filter projects with appropriate media selection.

Table 3-10. International Stormwater BMP Database 95 Percent Confidence Intervals about the Mean Effluent Concentrations for Modeling

RCOC	Units	Media filter		Swirl concentrator		Bioretention		Biofiltration swale	
		LCL	UCL	LCL	UCL	LCL	UCL	LCL	UCL
BOD	mg/L	3.83	5.86	NSD	NSD	3.83	5.86	3.68	5.58
Fecal coliform	CFU/100 mL	4,783	9,131	NSD	NSD	937	9,131	NSD	NSD
TSS	mg/L	20.37	27.07	69.08	102.30	17.35	33.06	23.08	30.37
Oil and grease	mg/L	4.71	7.88	2.03	3.54	2.51	3.29	3.50	7.27
[H+]	mg/L	1.02E-04	2.03E-04	NSD	NSD	2.06E-04	8.05E-04	1.76E-04	5.22E-04
Total copper	mg/L	0.010	0.022	0.013	0.018	0.011	0.020	0.0089	0.011
Dissolved copper	mg/L	0.0048	0.010	NSD	NSD	0.0047	0.0065	0.0079	0.011
Total zinc	mg/L	0.058	0.084	0.076	0.123	0.023	0.038	0.031	0.038
Dissolved zinc	mg/L	0.028	0.041	NSD	NSD	0.022	0.034	0.026	0.039
Ammonia-N	mg/L	NSD	NSD	0.482	0.971	0.297	0.588	NSD	NSD
TP	mg/L	0.099	0.166	0.241	0.399	NSD ^a	NSD ^a	0.25	0.31

NSD: Analysis demonstrated that project pollutant effluent concentration was not statistically significantly different from the influent concentration.

a. Soil amendments will be considered and evaluated to ensure that phosphorus is not increased as a result of the bioretention projects.

Washington Department of Ecology, Technology Assessment Protocol – Ecology (TAPE) Certification.

Swirl concentrators, Filterra® tree box units and StormFilter® cartridge filtration units have been approved by Ecology for general use. To be accepted, these devices have undergone extensive lab and field testing under the state's TAPE protocols. All of these systems, except swirl concentrators, are approved for basic stormwater treatment. Swirl concentrators are approved for use only as pretreatment devices. The TSS reductions reported in the International Stormwater BMP Database and the TAPE certification goals are shown in Table 3-11. The pretreatment designation for swirl concentrators establishes TSS removal goals significantly higher than the reductions reported from the International Stormwater BMP Database. Utilizing the regionally specific TAPE monitoring results, while still being conservative, a reduction in TSS was applied to the swirl concentrators in place of the International Stormwater BMP Database effluent concentrations.

Table 3-11. Comparison of TSS Effluent Concentrations (or Percent Reductions) Reported in the International Stormwater BMP Database versus TAPE Certification Goals (Ecology, 2013b) and Assumptions Used in the PLM

Integrated Plan project	Ecology TAPE (2013)		International Stormwater BMP Database		Assumptions used in PLM	
	LCL	UCL	LCL	UCL	LCL	UCL
Swirl concentrators ^a	50%	80%	0%	44%	30%	50%
Media filter (Filterra® tree box units) ^b	20 mg/L		20 mg/L	27 mg/L	20 mg/L	27 mg/L
Media filter (StormFilter® vault) ^b	20 mg/L		20 mg/L	27 mg/L	20 mg/L	27 mg/L

a. Ecology TAPE Pretreatment LCL and UCL are intended to achieve 50% removal of fine (50-micron mean size) (LCL) and 80% removal of coarse (125-micron mean size) TSS.

b. Ecology TAPE Basic treatment is intended to achieve an effluent goal of 20 mg/L based on influent TSS concentrations less than 100 mg/L, which would likely occur in stormwater runoff from the proposed Integrated Plan project sites.

Bioretention. The expected performance of bioretention projects was reinforced by comparing values from the International Stormwater BMP Database with those reported in Roseen and Stone (2013). Roseen and Stone (2013) present summary statistics on effluent concentrations from constructed bioretention systems based on a literature review of multiple sources including the International Stormwater BMP Database, the City of Seattle bioretention projects (NW 110th Cascade), and many other sources (of projects). Roseen and Stone (2013) reported CIs about the study median concentrations (Table 3-12). These CIs could not be used directly in the PLM, which is based on CIs about the population mean (Table 3-10). It is important to note that the effluent LCL and UCL concentrations listed in Table 3-10 are means based on all data within a category, while the Roseen and Stone (2013) and International Stormwater BMP Database effluent LCL and UCL concentrations listed in Table 3-12 are medians (of summaries of individual studies). However, a comparison of equivalent statistics (including effluent concentration medians and the CIs about the medians) from the International Stormwater BMP Database and Roseen and Stone (2013) suggest that the two data sources have comparable effluent concentrations (Table 3-12). Therefore, the limitations of using the smaller data set from the International Stormwater BMP Database were considered to be offset by the ability to extract statistics from the International Stormwater BMP Database that were more suitable for pollutant load modeling purposes (i.e., averages rather than medians).

Table 3-12. Comparison of Bioretention Median Effluent Concentrations Reported in the International Stormwater BMP Database versus Roseen and Stone (2013)

Parameter	Units	Roseen and Stone (2013)				International Stormwater BMP Database			
		# of data points (studies)	Median	LCL	UCL	# of data points (samples)	Median	LCL	UCL
Fecal coliform	CFU/100 mL	7	290	1 ^a	5,000 ^a	N/A	N/A	N/A	N/A
TSS	mg/L	31	8	6	14	193	8.3	5.6	9.0
Oil and grease	mg/L	8	0.28	0.163	2.5	N/A	N/A	N/A	N/A
Total Cu	mg/L	19	0.006	0.005	0.016	56	0.0077	0.0049	0.0099
Dissolved Cu ^b	mg/L	6	0.011	0.0029 ^a	0.020 ^a	186	0.0044	0.0036	0.0051
Total Zn	mg/L	23	0.018	0.013	0.035	99	0.018	0.0077	0.025
Dissolved Zn ^b	mg/L	5	0.025	0.019 ^a	0.026 ^a	185	0.012	0.0083	0.017
Ammonia-N	mg/L	19	0.04	0.03	0.055	184	0.067	0.052	0.08
TP	mg/L	41	0.1	0.06	0.14	249	0.089 ^c	0.073 ^c	0.1 ^c

N/A: The International Stormwater Database did not have sufficient studies for this RCOC/candidate stormwater project combination as discussed earlier in this section. The mean values were approximated based on representative RCOC/ stormwater project combinations; therefore, median concentrations are not available at this time.

- Sample size less than 8. Minimum and maximum values reported in lieu of LCL and UCL, respectively.*
- The median, LCL, and UCL for dissolved copper and zinc were calculated (for comparison only) based on sample results for the Media Filter category in the International Stormwater BMP Database. The Media Filter category is largely dominated by the Sand Filter category, which was the category used to approximate the LCL and UCL of the mean concentrations for these RCOCs in the Bioretention category, as discussed previously.*
- The Mann-Whitney rank-sum test (discussed above) revealed that effluent concentrations of TP are not significantly different from influent concentrations; removal of TP by bioretention was not simulated.*

3.5.3.2 TSS Correlated Pollutant Reductions

The International Stormwater BMP Database did not have sufficient data to accurately characterize the effluent concentrations of bis(2-ethylhexyl)phthalate, dichlobenil, total PCBs, or total PBDEs. Therefore, a secondary approach was used to estimate the removal based on TSS removals by taking into account the physiochemical properties of these RCOCs. Each RCOC was examined to estimate the percent dissolved in the stormwater (dissolved fraction) and the percent associated with the suspended solids (particulate fraction). Because bis(2-ethylhexyl)phthalate, total PCBs, and total PBDEs are highly hydrophobic chemicals (i.e., repelled by water and tend to bond to solids), the dissolved fraction is assumed to be negligible and therefore these RCOCs are

assumed to be associated only with the particulate fraction. The dissolved /particulate fractionation for dichlobenil is highly uncertain. Therefore, to be conservative, it was assumed that dichlobenil would not be effectively removed by any of the proposed treatment devices; e.g., zero removal (but may still be removed via volume reduction).

An attempt was made to correlate the removal of the particulate fraction for bis(2-ethylhexyl)phthalate, total PCBs, and total PBDEs based on the stormwater project removal of each suspended solid particle size and the RCOC particle size relationship (i.e., the mass of the RCOC associated with each particle size removed by the project). However, an investigation of data and literature revealed no evidence upon which to assume particle size relationship in stormwater for these RCOCs. Therefore, the removal of these RCOCs was set equal to the removal of TSS. Table 3-13 shows potential TSS removal for the various projects with a representative influent concentration.

Table 3-13. Stormwater Project TSS Removal Efficiency (Concentration Reduction) for Representative Influent Concentration Scenarios

Project type	LCL	UCL
Media filter ^a	49%	78%
Swirl concentrator	30%	50%
Bioretention ^{a,b}	36%	81%
Biofiltration swale ^{a,b}	41%	75%
Active treatment (South Park WQ Facility project)	88%	98%

a. This removal efficiency is for example only. These removal efficiencies are dependent on the influent stormwater concentration and the effluent concentration reported in the International Stormwater BMP Database. Because the influent concentration varies with land use, the removal efficiencies will fluctuate based on various project land use influent scenarios; however, the relative magnitudes between projects is expected to be similar. The LCL and UCL reported here are the minimum LCL and maximum UCL of TSS reduction based on 1,000 Monte Carlo iterations of a representative land use scenario.

b. Excluding TSS load reduction resulting from the volume reduction.

Several regional monitoring data sets were available to compare TSS removals with bis(2-ethylhexyl)phthalate and total PCBs (Table 3-14). The South Park electrocoagulation pilot test (SPU, 2012a) and data reported in the literature that were compiled for the South Park business case (SPU, 2012b) demonstrated similar removal rates between TSS and PCBs. However, the TSS removal rates were approximately two to four times higher than the measured removal rates for bis(2-ethylhexyl)phthalate from the City's South Park electrocoagulation pilot test and StormFilter® field tests conducted by the City of Tacoma and Seattle (City of Tacoma and Taylor Associates, 2008). Therefore, to be conservative, the candidate stormwater project TSS removal rates were reduced by two (UCL) to four (LCL) times before being applied to bis(2-ethylhexyl)phthalate concentrations.

Table 3-14. Monitoring Data TSS, Bis(2-ethylhexyl)phthalate, and Total PCBs Removal

Monitoring data set	TSS	Bis(2-ethylhexyl)phthalate	Total PCBs
South Park electrocoagulation pilot test ^a	47%–94%	9%–44%	78%–86%
South Park business case ^b	79%–97%	N/A	87%
StormFilter® ^c	27%–91%	13%–36%	N/A

- a. SPU (2012a). Performance testing conducted during seven storm events on stormwater from the South Park drainage basin that was passed through a 6-cell treatment unit.
- b. SPU (2012b). Results from multiple field and bench tests on urban and industrial stormwater, as well as municipal wastewater conducted by various vendors, were compiled to evaluate the performance of a variety of active treatment systems, including electrocoagulation, chitosan-enhanced sand filtration, ballasted sedimentation, and chemically enhanced primary treatment.
- c. City of Tacoma and Taylor Associates (2008). Field tests were conducted between 2003 and 2005 on an 11-cartridge StormFilter® vault installed at the Washington State Department of Transportation's BMP testing facility in Seattle. Testing was conducted during 17 storm events on runoff from I-5 and adjacent areas.

3.5.3.3 Active Treatment System

The pollutant removal for the South Park WQ Facility active treatment system was estimated using a combination of the following approaches: (1) removal estimates from the full-scale monitoring at North Boeing Field (NBF) CESF (North Boeing Field, 2013)⁷, (2) effluent concentrations for a comparable stormwater project category in the International Stormwater BMP Database that includes similar unit processes, or (3) correlating pollutant removal to TSS reduction based on pollutant characteristics. Table 3-15 discusses the assumed range of effluent quality or removal efficiency and the source of the assumption.

Table 3-15. Active Treatment Assumptions

RCOC	Effluent concentration / percent removal estimates ^a		Assumption source
	LCL	UCL	
BOD ₅ (mg/L)	3.83	5.86	No data from full-scale monitoring, use effluent based on Sand Filter category from International Stormwater BMP Database.
Fecal coliform (CFU/100 mL)	4,783	9,131	Data not available from NBF CESF; assumed that disinfection will <u>not</u> be provided. Assumed effluent quality based on International Stormwater BMP Database analysis based on Sand Filter category.

⁷ Six paired influent/effluent sampling results from December 2011 to July 2013 at the long-term stormwater treatment systems installed at the North Boeing Field facility in Seattle. Treatment was installed to reduce PCB loads prior to cleanup of contaminated sediment at the Slip 4 Early Action Area in the Lower Duwamish Waterway.

Table 3-15. Active Treatment Assumptions

RCOC	Effluent concentration / percent removal estimates ^a		Assumption source
	LCL	UCL	
TSS (mg/L)	1.7	6.8	Full-scale CESF at NBF showed excellent removal for all influent up to 107 mg/L. <u>Lower bound:</u> median effluent observed in the first year of the full-scale NBF CESF monitoring <u>Upper bound:</u> 2x the highest observation
Total Cu	85%	61%	10th and 90th percentile from CESF at NBF ^b
Dissolved Cu	57%	15%	10th and 90th percentile from CESF at NBF ^b
Total Zn	88%	52%	10th and 90th percentile from CESF at NBF ^b
Dissolved Zn	61%	12%	10th and 90th percentile from CESF at NBF ^b
Oil and grease (mg/L)	2.51	3.29	Based on International Stormwater BMP Database Sand Filter category
[H+] (moles/L)/pH	0%	0%	No significant change
Ammonia-N	0%	0%	No significant change
TP (mg/L)	Assumed 75% of TP is particulate bound and removed at same rate as TSS		Based on analysis of typical ratio of orthophosphate to TP concentrations measured in stormwater characterization samples collected by the City for its NPDES permit.
Total PCBs	80%	50%	Based on findings from CDM (2010) for chemically enhanced primary treatment ^c . Should be as good or better for CESF based on better removal of finer particle sizes.
Total PBDEs	80%	50%	Assume same as total PCBs based on similar K _{OW}
Bis(2-ethylhexyl)phthalate	Percent removal is 2 times less than TSS removal	Percent removal is 4 times less than TSS removal	Based on analysis of South Park electrocoagulation pilot test and the StormFilter tests (Table 3-14).
Dichlobenil	0%	0%	No removal
Projected DO	Dependent on BOD and ammonia		Based on the Streeter-Phelps equation

a. Ranges indicate 95% confidence interval except where noted.

b. Chose to use percent removal methodology because the average influent concentrations to this study appear to be lower-than-average influent concentrations expected to occur at the South Park WQ Facility. Therefore, effluent quality could over-predict removal.

c. Results from pilot test conducted by King County at West Point wastewater treatment facility. Multiple scenarios were tested using different system loading rates and chemical coagulants. Listed values are for results from tests conducted using system loading rates similar to those expected to be used in full-scale operation.

3.5.3.4 Dissolved Oxygen

In order to characterize the impact of pollutant load reductions on receiving water dissolved oxygen (DO) concentrations a simplified approach for calculating DO based on the Streeter-Phelps equation was used to estimate the change in projected DO concentration associated with each candidate stormwater project. The Streeter-Phelps equation calculates the average daily DO deficit (i.e., difference between DO at saturation and actual DO) as follows:

$$[D]_t = D_0 e^{-k_a t} + \left(\frac{k_d L_0}{k_a - k_d} \right) (e^{-k_d t} - e^{-k_a t}) + \left(\frac{k_n N_0}{k_a - k_n} \right) (e^{-k_n t} - e^{-k_a t})$$

where: D_t = average daily DO deficit at time t downstream of a point source, mg/L

D_0 = initial DO deficit, mg/L

L_0 = initial carbonaceous BOD, mg/L

N_0 = initial nitrogenous BOD, mg/L

k_a = re-aeration rate constant (day^{-1})

k_d = CBODU deoxygenation rate constant (day^{-1})

k_n = NBOD deoxygenation rate constant (day^{-1})

t = time, days

The Streeter-Phelps equation does not implicitly account for flow. As CSO improvements are quantified by reductions in flow and not by decreases in pollutant concentrations, improvements in BOD concentrations are first normalized to account for changes in loading⁸. Using a common normalizing volume, equal to the maximum flow from all the stormwater and CSO projects (e.g., 140.457 million gallons per year [MG/yr]), allowed for a comparison between stormwater and CSO projects. Ultimate Chemical and Biological Oxygen Demand (CBODU) and Nitrogenous Biochemical Oxygen Demand (NBOD) concentrations were normalized by multiplying by the specific project volume and dividing by the normalizing volume.

Using the Street-Phelps equation, the Pre- and Post-Project maximum DO deficit was calculated based on the normalized NBOD and CBODU concentrations. These deficit values were used to calculate the reduction in normalized DO deficit between the Pre-Project condition and the Post-Project condition in milligrams per liter (mg/L).

The assumptions described below were applied to all projects equally (i.e., site-specific rates and conversion factors were not calculated for individual projects).

1. For each project, three DO projections were calculated (annual, October–January [Season 1], February–September [Season 2]).

⁸ Most of the proposed CSO control projects use storage to reduce the frequency and volume of CSO events.

2. $BOD_5 = CBOD_5$. *Rationale:* The CBOD is exerted immediately, whereas the majority of NBOD reactions occur at a slower rate (Thomann and Mueller, 1987).
3. 5-day: ultimate conversion factor = 0.45. *Rationale:* The conversion factor represents the approximate average of primary and secondary treatment (Chapra, 1997).
4. $NBOD = 4.57 \times [\text{ammonia concentration}]$. *Rationale:* The approximation is based on stoichiometry (Thomann and Mueller, 1987 and Chapra, 1997).
5. CBODU decay rate @ $20^\circ = 0.2$, corrected for temperature $\theta = 1.047$ (EPA, 1980). *Rationale:* The decay rate represents the approximate average of primary and secondary treatment (Thomann and Mueller, 1987).
6. NBOD nitrification = $0.3 @ 20^\circ$, corrected for temperature $\theta = 1.08$ (EPA, 1980). *Rationale:* Best professional judgment.
7. Re-aeration @ $20^\circ = 3$, corrected for temperature $\theta = 1.024$ (EPA, 1980). *Rationale:* Best professional judgment.
8. Temperature = modeled value (if available) or estimated from existing data. *Rationale:* Best professional judgment.
9. Time = travel time through proposed project (if available from model) or estimated length of storm event. *Rationale:* Best professional judgment.

3.6 Street Sweeping

Since 2011, the City has been conducting monitoring to track the performance of its street sweeping program for water quality. The data collected through this program, including street sediment removed, curb-miles swept, and concentrations of RCOCs in street sweepings, directed the development of the model used for estimating the potential load reductions resulting from enhancements to street sweeping. Additional inputs necessary for the model include:

- precipitation volume
- runoff coefficient
- route details of street sweeping enhancements (e.g., schedule, street area, distance, percent draining to MS4)
- percent of sweeping schedule that the sweeper will be available (i.e., utilization)
- rate of street sediment accumulation
- percent of street sediment mobilized to an MS4 outfall during storm events
- factor of safety applied to load reductions (i.e., decrease residential load reductions by 50 percent and arterial load reductions by 25 percent, refer to Appendix G)

The discussion of each of these model inputs along the resulting values can be found in Appendix G of the City's Integrated Plan report. Additionally, the following sections include a discussion of how uncertainty in input data sets was developed relating to the seasonal precipitation, sample variability, and sweeper productivity.

3.6.1 Seasonal Precipitation

A description of the development of the annual precipitation used in the street sweeping model is included in Appendix G of the City's Integrated Plan report. To maintain consistency with the PLM, the seasonal precipitation used in the street sweeping model maintains the same proportions to the annual rainfall as the proportions calculated for the PLM discussed in Section 3.1. Additionally, the LCLs and UCLs for the street sweeping model precipitation were determined in the same fashion as in the PLM (i.e., plus or minus 10 percent of the average) (Table 3-16).

Table 3-16. Cumulative Precipitation Estimates Used in the Street Sweeping Model

Time period	Average (inches)	Confidence interval ^a (inches)
Annual ^b	37.2	33.5–40.9
October–January (Season 1)	20.1	18.1–22.1
February–September (Season 2)	17.1	15.3–18.8

a. Confidence interval is defined as plus or minus 10% of the average (consistent with the assumption in Section 3.1).

b. The annual average precipitation for the street sweeping model (see Appendix G of the City's Integrated Plan report) was based on a different rain gauge from the analysis for the other stormwater projects analyzed in this appendix (see Section 3.1); therefore, precipitation amounts differ.

3.6.2 Sample Variability

As with stormwater EMCs, the variability of RCOC concentrations in street sweepings is significant⁹. To account for this variability, City street sweepings RCOC concentration data were analyzed and descriptive statistics were generated using the bootstrap method, similar to what was used to generate land use runoff concentrations and program effluent concentrations (see Section 2.2.2). The descriptive statistics generated, including the mean and 95th percentile CIs on the mean (LCL and UCL), were converted into relative percent differences (i.e., mean minus LCL divided by mean), which were then used to quantify the uncertainty of the pick-up rates¹⁰ (Table 3-17).

City street sweepings have not been analyzed for total PBDEs. Therefore, the LCL and UCL for total PBDEs was developed based on the relative percent difference of the mean stormwater concentration LCL and UCL (see Section 3.4 and Attachment F-1). The relative percent difference for the mean stormwater concentration LCL and UCL is assumed to be similar to the relative percent difference for the mean street sweepings concentration LCL and UCL.

⁹ For example, the total copper sample concentrations in the analysis of sweeper sweepings <250 µm ranged from 87 to 321 mg/kg.

¹⁰ Pickup rates represent the mass of pollutant removed per mile swept and were calculated directly within the City eSweep software program using the RCOC street sediment concentration (Appendix G).

Table 3-17. Street Sweepings Concentration Relative Percent Difference from Mean: Upper and Lower Confidence Intervals on Mean

RCOC	LCL ^a	UCL ^b
BOD ₅	19%	18%
Fecal coliform	67%	143%
TSS	6%	5%
Oil and grease	9%	10%
[H+]	N/A	N/A
Total copper	9%	15%
Dissolved copper	N/A	N/A
Total zinc	9%	10%
Dissolved zinc	N/A	N/A
Ammonia-N	N/A	N/A
TP	14%	12%
Total PCBs	21%	26%
Total PBDEs ^c	38%	113%
Bis(2-ethylhexyl)phthalate	9%	8%
Dichlobenil	N/A	N/A

N/A: Analysis was not performed for the street sweeping load reductions for these RCOCs at this time due to insufficient data or uncertainty in the washoff characteristics. See Appendix G for additional details.

- a. Mean street sweepings concentration minus LCL divided by mean.
- b. Street sweepings UCL concentration minus mean divided by mean.
- c. The LCL and UCL for total PBDEs are actually land use concentration relative percent differences. However, it is assumed applicable.

3.6.3 Sweeper Productivity

The actual curb-miles swept in an MS4 drainage area on an annual basis are susceptible to a wide range of factors, including but not limited to sweeper and operator availability, weather conditions, and parking compliance. Several of these variables have already had safety factors applied. However, to account for additional uncertainty, the LCL and UCL of the annual MS4 curb-miles are plus and minus 25 percent, respectively, of the mean value.

CHAPTER 4

Model Methodology

Each iteration of the PLM uses input parameters randomly selected from between the LCL and UCL values (discussed in detail in Chapter 3) to calculate a unique estimate of the potential long-term average stormwater runoff volume, pollutant concentration, and pollutant loading for the Pre- and Post-Project condition for each RCOC and each of the stormwater projects. A large number of iterations are run to develop an extensive distribution of different estimates of the potential long-term average Pre-Project and Post-Project results, which can be used to characterize the median estimated value and the uncertainty (LCL and UCL) associated with each project. The general steps of the PLM are as follows, with each step described in more detail in Sections 4.1 through 4.5:

Calculate the Pre-Project stormwater runoff volume:

1. Calculate the implemented effective drainage area for each land use type within the candidate stormwater project drainage basin based on the degree of project implementation, land use (e.g., residential, commercial, industrial), surface type (e.g., street, building, sidewalk, landscaped area), and drainage system connection factors (see Section 3.2).
2. Estimate the runoff coefficient for each land use type within the candidate stormwater project drainage basin based on land use, surface type, and surface type runoff coefficients (see Section 3.3).
3. Select the rainfall depth for the time period to be evaluated (annual, wet and dry seasons; see Section 3.1) to calculate the stormwater runoff volume from each land use type within the candidate stormwater project drainage area and then sum the volumes to calculate the Pre-Project runoff volume.

Calculate the Pre-Project pollutant loads and concentrations:

4. Select a pollutant concentration in stormwater runoff for each land use type and each RCOC (see Section 3.4) and multiply by the runoff volume to calculate the Pre-Project load from each discrete land use type in the project drainage basin and then sum the loads for each RCOC to calculate the Pre-Project RCOC loads.
5. Divide each Pre-Project RCOC load by the Pre-Project volume to calculate the Pre-Project average concentration for each RCOC.

Calculate the Post-Project stormwater runoff volume, pollutant loads, and concentrations:

6. Calculate the Post-Project runoff volume by summing the bypass volume (Pre-Project volume multiplied by 1 minus the capture efficiency [see Section 3.5.1]) and the project effluent volume (Pre-Project volume multiplied by capture efficiency and 1 minus the project volume reduction [see Section 3.5.2]).
7. Calculate the Post-Project load by summing the bypass load (bypass volume multiplied by the Pre-Project concentration) and the project effluent load (project effluent volume multiplied by the project effluent concentration [see Section 3.5.3]).
8. Divide each Post-Project RCOC load by the Post-Project volume to calculate the Post-Project average concentration for each RCOC.

Calculate the stormwater runoff volume, pollutant load, and concentration reductions:

9. Calculate the Post-Project average volume reduction, concentration reduction, and load reduction for each RCOC based on the difference between Pre-Project and Post-Project results.

Calculate the distribution of results:

10. Repeat steps 1–9 a total of 1,000 times for each RCOC and time period, recording the Pre-Project, Post-Project, and reduction model results for each iteration.

4.1 Pre-Project Stormwater Runoff Volume (Steps 1–3)

Step 1: Calculate the implemented effective drainage area for each land use type (EA_{lu}) within the candidate stormwater project drainage area using the following equation:

$$EA_{lu} = I \sum_{st} (A_{lu\ st} CF_{st\ cl}) \quad (1)$$

where:

- I = the degree of implementation for the candidate stormwater project, a function of potential feasibility
- $\sum_{st}$ = the sum of the effective drainage area (i.e., drainage area multiplied by the connection factor) for each surface type ($_{st}$) within a land use type
- $A_{lu\ st}$ = the land use and surface type specific drainage area (e.g., acres of roads within residential land use), calculated by merging the GIS surface type and land use layers
- $CF_{st\ cl}$ = the surface type and conveyance class ($_{cl}$) specific connection factor, randomly selected from within the defined LCL and UCL

Step 2: Estimate the runoff coefficient for each land use type ($R_{v\ lu}$) within the candidate stormwater project drainage area using the following equation:

$$R_{v\ lu} = A_{lu\ i} R_i + A_{lu\ pl} R_{pl} + A_{lu\ pt} R_{pt} \quad (2)$$

where:

- $A_{lu\ i}$ = the land use specific impervious drainage area (i.e., acres of roads, sidewalks, roofs, etc. within each land use type), calculated by merging the City GIS surface type and land use layers and selecting the impervious areas
- R_i = the impervious runoff coefficient, randomly selected from within the defined LCL and UCL
- $A_{lu\ pl}$ = the land use specific pervious landscape drainage area, calculated by merging the City GIS surface type and land use layers and selecting the pervious landscape areas

- R_{pl} = the pervious landscape runoff coefficient, randomly selected from within the defined LCL and UCL
- $A_{lu\ pt}$ = the land use specific pervious trees drainage area, calculated by merging the City GIS surface type and land use layers and selecting the pervious trees areas
- R_{pt} = the pervious trees runoff coefficient, randomly selected from within the defined LCL and UCL

Step 3A: Estimate the stormwater runoff volume from each land use type (V_{lu}) within the candidate stormwater project drainage area (e.g., million gallons of stormwater runoff from residential land use) using the following equation:

$$V_{lu} = P_{tp} A_{lu} R_{v\ lu} \quad (3)$$

where:

- P_{tp} = the rainfall depth for the time period (tp), randomly selected from within the defined LCL and UCL. It is assumed that rain falls uniformly over all land uses in the Integrated Plan stormwater project drainage area.
- EA_{lu} = the land use specific implemented effective drainage area, calculated using equation (1)
- $R_{v\ lu}$ = the land use specific runoff coefficient, calculated at the surface type level using equation (2)

Step 3B: Calculate the Pre-Project stormwater runoff volume (V_{wshed}) for the Integrated Plan stormwater project drainage area, as the sum (Σ_{lu}) of runoff volume from each land use type:

$$V_{wshed} = \Sigma_{lu} V_{lu} = \Sigma_{lu} (P_{tp} A_{lu} R_{v\ lu}) \quad (4)$$

4.2 Pre-Project Pollutant Loads and Concentrations (Steps 4 and 5)

Step 4: Calculate the Pre-Project pollutant load (L_{wshed}) from the candidate stormwater project drainage area by:

$$L_{wshed} = \Sigma V_{lu} C_{lu} \quad (5)$$

where:

- C_{lu} = the runoff concentration from each individual land use area (e.g., mg/L of copper from residential land use), randomly selected from within the defined LCL and UCL

Step 5: Calculate the Pre-Project average pollutant concentration in runoff (C_{wshed}) from the Integrated Plan stormwater project drainage area, by dividing the Pre-Project load (Step 4, Eq. 5) by the Pre-Project runoff volume (Step 3B, Eq. 4):

$$C_{wshed} = L_{wshed} / V_{wshed} \quad (6)$$

4.3 Post-Project Stormwater Runoff Volume, Pollutant Loads, and Concentrations (Steps 6–8)

Step 6: Calculate the Post-Project runoff volume (V_{wshed_BMPs}) from the candidate stormwater project drainage area by:

$$V_{wshed_BMPs} = [Cap_{\%} \times V_{wshed} \times (1 - VR\%)] + [(1 - Cap_{\%}) \times V_{wshed}] \quad (7)$$

where:

$Cap_{\%}$ = the capture efficiency of the project

$VR\%$ = the percent reduction in effluent volume achieved by the project, randomly selected from within the defined LCL and UCL

V_{wshed} and C_{wshed} were calculated per Steps 3B (Eq. 4) and 5 (Eq. 6), respectively

Step 7: Calculate the Post-Project pollutant load (L_{wshed_BMPs}) from the candidate stormwater project drainage area by:

$$L_{wshed_BMPs} = [Cap_{\%} \times V_{wshed} \times C_{eff} \times (1 - VR\%)] + [(1 - Cap_{\%}) \times V_{wshed} \times C_{wshed}] \quad (8)$$

where:

$Cap_{\%}$ = the capture efficiency of the project

$VR\%$ = the percent reduction in effluent volume achieved by the project, randomly selected from within the defined LCL and UCL

C_{eff} = the effluent concentration from the project, randomly selected from within the defined LCL and UCL

V_{wshed} and C_{wshed} were calculated per Steps 3B (Eq. 4) and 5 (Eq. 6), respectively

Step 8: Calculate the Post-Project average pollutant concentration in stormwater runoff (C_{wshed_BMPs}) from the candidate stormwater project drainage area by dividing the Post-Project load (Step 7, Eq. 8) by the Post-Project runoff volume (Step 6, Eq. 7):

$$C_{wshed_BMPs} = L_{wshed_BMPs} / V_{wshed_BMPs} \quad (9)$$

4.4 Stormwater Runoff Volume, Pollutant Load, and Concentration Reductions (Step 9)

Step 9A: Calculate the stormwater runoff volume reduction (VR_{wshed}) for the candidate stormwater project drainage area by subtracting the Post-Project volume (Step 6, Eq. 7) from the Pre-Project volume (Step 4, Eq. 5):

$$VR_{wshed} = V_{wshed} - V_{wshed_BMPs} \quad (10)$$

Step 9B: Calculate the pollutant load reduction (LR_{wshed}) for the candidate stormwater project drainage area by subtracting the Post-Project load (Step 7, Eq. 8) from the Pre-Project load (Step 4, Eq. 5):

$$LR_{wshed} = L_{wshed} - L_{wshed_BMPs} \quad (11)$$

Step 9C: Calculate the pollutant concentration reduction (CR_{wshed}) for the candidate stormwater project drainage area by subtracting the Post-Project concentration (Step 8, Eq. 9) from the Pre-Project concentration (Step 5, Eq. 6):

$$CR_{wshed} = C_{wshed} - C_{wshed_BMPs} \quad (12)$$

4.5 Distribution of Results (Step 10)

Steps 1–9 were repeated a total of 1,000 times for the annual time period, recording the Pre-Project, Post-Project, and reduction runoff volume; pollutant concentration; and load from each iteration. The process is repeated again for both Season 1 and Season 2. The resultant distributions can be used to present a frequency distribution for pollutant concentrations and loads using statistics calculated from the 1,000 Monte Carlo iterations (Attachment F-3). Each of the 1,000 iterations represents a different estimate of long-term average conditions, within the range of possibility based on the established CIs on input parameters. Interpretation of the frequency distribution allowed CIs on results to be developed.

4.6 Model Methodology Assumptions

The following key assumptions are made for the Monte Carlo water quality modeling methodology:

1. The stormwater projects were modeled to only remove pollutants and not act as a source.
2. The stormwater projects were modeled so that the dissolved fraction of RCOCs were always less than or equal to their respective total RCOC.

The implications of each of these assumptions to the water quality projections are discussed below.

Project Performance: the Stormwater Projects Are Not a Source of Pollutants. In instances when the randomly determined project effluent concentration exceeds the modeled influent concentration, no pollutant removal occurs and the effluent concentration is modified to equal the influent concentration. This prevents projects from acting as a source of pollutants in the water quality modeling (PLM). The commitment to regular and effective maintenance of the stormwater projects provides support for this assumption.

Project Performance: the Stormwater Dissolved Fraction Must Be Less Than Total. In instances when the randomly determined project effluent concentration for a dissolved RCOC exceeds the randomly determined project effluent concentration for a total RCOC, the effluent concentration of the dissolved RCOC is modified to equal the effluent concentration of the total RCOC. This prevents illogical loading and concentration scenarios, resulting from natural statistical variability associated with overlapping confidence limits.

4.7 Street Sweeping Model

As discussed previously, the City developed a separate PLM to characterize long-term average pollutant loading reductions and concentration reductions for the candidate street sweeping stormwater projects. This model uses a rate of pollutant removed by sweeping per curb-mile (pick-up rate) calculated from data measured during the City's current street sweeping program. The pick-up rate is then applied to the area that will receive enhancements to the street sweeping program to generate the total pollutant mass removed. The methodology and data provided by the City were then used to characterize the uncertainty inherent in the street sweeping data, as described below, and run with the Monte Carlo iterations.

The model methodology was originally developed without the capabilities of quantifying the uncertainty inherent in the street sweeping model inputs or estimating the RCOC concentrations and loads for the seasonal time periods. The original model was modified to be able to quantify the uncertainty and estimate the seasonal RCOC concentrations and loads using the following steps (see Appendix G of the City's Integrated Plan report for a detailed description of the original model):

1. Report the mean long-term annual average concentration and load reduction directly from the original model¹¹.
2. Calculate the LCL_{pr} and UCL_{pr} using equations 1 and 2 for the wet and dry season pick-up rates (PR_w and PR_d) from the original model. Then randomly select new wet and dry season pick-up rates from the LCL_{pr} and UCL_{pr} :

$$LCL_{pr} = PR - (PR * LCL_{\% \text{ diff}}) \quad (1)$$

$$UCL_{pr} = PR + (PR * UCL_{\% \text{ diff}}) \quad (2)$$

where:

$LCL_{\% \text{ diff}}$ and $UCL_{\% \text{ diff}}$ = the relative percent difference for street sediment concentrations developed in Section 3.6.2.

3. Randomly select an equivalent swept distance in the MS4 from the defined LCL and UCL developed in Section 3.6.3.
4. Calculate the average annual pollutant load reduction for each RCOC by multiplying the selected equivalent distance in the MS4 by the selected pick-up rates (same calculation as in the original model).
5. Calculate the average annual runoff volume by multiplying a randomly selected precipitation depth from the defined LCL and UCL in Table 3-16 by the original street and sidewalk area and runoff coefficient (same calculation as the original model).
6. Calculate the average annual concentration reduction by dividing the average annual load reduction by the average annual runoff volume (same calculation as the original model).
7. Estimate the RCOC load reduction (L_s) for each Integrated Plan season based on the cleaning season (e.g., wet, dry, leaf) pick-up rates and the percent of the cleaning season in the Integrated Plan season (Table 4-1) using the following equation:

$$L_s = PR_w * IPs_w + PR_d * IPs_d + PR_l * IPs_l \quad (3)$$

where:

IPs_w = percent of the wet cleaning season in the Integrated Plan season

IPs_d = percent of the dry cleaning season in the Integrated Plan season

IPs_l = percent of the leaf cleaning season in the Integrated Plan season

8. Calculate the average seasonal runoff volume by multiplying a randomly selected rainfall depth from the defined LCL and UCL in Table 3-16 by the original street and sidewalk area and runoff coefficient (same calculation as the original model).

¹¹ Skewedness in the underlying distribution of some of the RCOC input parameters and the use of the fixed mean from the original model, created LCL and UCL results that were skewed low for several of the RCOC.

Table 4-1. Street Cleaning Seasons in Integrated Plan Seasons

Street cleaning season	Percent in Integrated Plan Season 1 (Oct–Jan)	Percent in Integrated Plan Season 2 (Feb–Sept)
Wet (Jan–April)	25%	75%
Dry (May–Sept)	0%	100%
Leaf (Oct–Dec)	100%	0%

9. Calculate the seasonal concentration reduction by dividing the seasonal load reduction by the average seasonal runoff volume (same calculation as the original model).
10. Repeat steps 1–9 a total of 1,000 times for each RCOC and time period, recording the estimated pollutant concentration and load reduction for each iteration. The resultant distributions can be used to present a frequency distribution for pollutant concentrations and loads using statistics calculated from the 1,000 Monte Carlo iterations (Attachment F-3).

4.8 Model Reliability

Overall, the model is considered to be reliable for long-term planning and providing an approximate estimate of anticipated concentration and load reductions. Nonetheless, uncertainties exist that cannot be quantified and may influence the reliability of modeling results. Uncertainties in estimated performance are mitigated in part through the commitment to an adaptive operation approach, monitoring and maintenance, and the incorporation of flexibility in the design.

CHAPTER 5

Model Results

Box-and-whisker charts of the PLM results (pollutant load or concentration reductions) are included as Attachment F-3. Each chart displays the long-term average annual concentration or load reduction for each RCOC. The candidate stormwater projects are included on the x-axis with the estimated long-term average annual reduction on the y-axis, the median of long-term average annual reduction (selected from the distribution of the 1,000 Monte Carlo iterations) is indicated by a horizontal line within the box, the top and bottom of the box represents the 25th and 75th percentile reductions, respectively, and whiskers represent the minimum and maximum reductions. Due to limited data availability, the concentration and load reductions from some candidate stormwater project and RCOC combinations were not calculated at this time (discussed in Section 3.5.3) and therefore are not included on the charts.

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CHAPTER 6

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Attachment F-1: Stormwater Concentration Data Table

The number of studies, the mean runoff concentration, and the LCL and UCL (the 95th CI on the mean calculated as described in Section 2.2.2) are included below each RCOC, land use, and data source combination. A discussion of each data source is included in Section 3.4.

Table F-1-1. Stormwater Runoff Concentration Summary Statistics by Data Source and Land Use							
Parameter	Units	Land use	Source	n	Mean	LCL	UCL
[H+]	mg/L	Commercial	ACWA	60	1.68E-04	6.32E-05^L	4.09E-04
[H+]	mg/L	Commercial	NSQD	266	2.66E-04	1.19E-04	6.11E-04
[H+]	mg/L	Commercial	Seattle	32	1.15E-04	9.20E-05	1.43E-04
[H+]	mg/L	Commercial	Tacoma	224	3.23E-04	2.49E-04	4.62E-04^U
[H+]	mg/L	Industrial	ACWA	36	4.91E-04	7.75E-05^L	1.33E-03^U
[H+]	mg/L	Industrial	NSQD	371	1.23E-03	1.14E-04	4.24E-03
[H+]	mg/L	Industrial	Portland	40	1.25E-03	3.02E-04	3.64E-03
[H+]	mg/L	Industrial	Seattle	34	5.93E-05	4.96E-05	7.15E-05
[H+]	mg/L	Industrial	Tacoma	274	1.92E-04	1.66E-04	2.25E-04
[H+]	mg/L	Open Space	NSQD	19	6.46E-05	2.65E-05^L	1.26E-04
[H+]	mg/L	Open Space	Portland	6	1.17E-04	8.31E-05	1.65E-04^U
[H+]	mg/L	Residential	ACWA	35	1.30E-04	8.97E-05^L	1.79E-04
[H+]	mg/L	Residential	NSQD	579	2.06E-03	1.01E-03	3.28E-03
[H+]	mg/L	Residential	Portland	1	2.42E-04	--	--
[H+]	mg/L	Residential	Seattle	35	2.35E-04	1.84E-04	3.03E-04
[H+]	mg/L	Residential	Tacoma	113	2.68E-04	2.12E-04	3.32E-04^U
Ammonia-N	mg/l	Commercial	NSQD	417	0.659	0.579	0.747
Ammonia-N	mg/l	Commercial	Seattle	24	0.192	0.127^L	0.311^U
Ammonia-N	mg/l	Industrial	NSQD	376	0.572	0.506	0.664
Ammonia-N	mg/l	Industrial	Seattle	24	0.233	0.184^L	0.297^U

Table F-1-1. Stormwater Runoff Concentration Summary Statistics by Data Source and Land Use

Parameter	Units	Land use	Source	n	Mean	LCL	UCL
Ammonia-N	mg/l	Open Space	NSQD	35	0.229	0.123^L	0.388
Ammonia-N	mg/l	Residential	NSQD	774	0.431	0.395	0.471
Ammonia-N	mg/l	Residential	Seattle	24	0.113	0.083^L	0.151^U
Bis(2-ethylhexyl) phthalate	ug/l	Commercial	Seattle	34	3.857	3.201^L	4.433
Bis(2-ethylhexyl) phthalate	ug/l	Commercial	Tacoma	224	5.344	4.494	6.644^U
Bis(2-ethylhexyl) phthalate	ug/l	Industrial	Portland	45	1.904	1.400	2.459
Bis(2-ethylhexyl) phthalate	ug/l	Industrial	Seattle	33	2.186	1.659	2.970
Bis(2-ethylhexyl) phthalate	ug/l	Industrial	Tacoma	273	2.927	2.445^L	3.491^U
Bis(2-ethylhexyl) phthalate	ug/l	Open Space	Portland	9	1.803	0.632^L	3.435^U
Bis(2-ethylhexyl) phthalate	ug/l	Residential	Portland	6	3.778	2.233	5.216
Bis(2-ethylhexyl) phthalate	ug/l	Residential	Seattle	35	1.884	1.154^L	2.752
Bis(2-ethylhexyl) phthalate	ug/l	Residential	Tacoma	113	2.648	2.191	3.152^U
BOD ₅	mg/L	Commercial	ACWA	77	11.00	8.39	14.85
BOD ₅	mg/L	Commercial	NSQD	790	16.00	14.79	17.56^U
BOD ₅	mg/L	Commercial	Seattle	33	14.95	11.62	19.04
BOD ₅	mg/L	Commercial	Tacoma	15	4.16	3.39^L	5.01
BOD ₅	mg/L	Industrial	ACWA	58	23.00	15.68	31.06
BOD ₅	mg/L	Industrial	NSQD	628	14.78	13.12	16.82^U
BOD ₅	mg/L	Industrial	Seattle	33	6.91	5.45	8.86
BOD ₅	mg/L	Industrial	Tacoma	13	2.88	2.30^L	3.78
BOD ₅	mg/L	Open Space	ACWA	10	2.27	1.39^L	3.51^U
BOD ₅	mg/L	Open Space	NSQD	62	5.76	4.66	7.01
BOD ₅	mg/L	Residential	ACWA	58	8.83	6.72	11.53^U
BOD ₅	mg/L	Residential	NSQD	1507	13.15	12.09	14.61

Table F-1-1. Stormwater Runoff Concentration Summary Statistics by Data Source and Land Use

Parameter	Units	Land use	Source	n	Mean	LCL	UCL
BOD ₅	mg/L	Residential	Seattle	35	4.92	3.92	6.17
BOD ₅	mg/L	Residential	Tacoma	16	3.58	2.88^L	4.33
Copper, dissolved	mg/L	Commercial	ACWA	60	0.009	0.007^L	0.014
Copper, dissolved	mg/L	Commercial	NSQD	48	0.008	0.006	0.010
Copper, dissolved	mg/L	Commercial	Seattle	34	0.017	0.014	0.020
Copper, dissolved	mg/L	Commercial	Tacoma	43	0.013	0.011	0.016^U
Copper, dissolved	mg/L	Industrial	ACWA	50	0.008	0.006	0.010^U
Copper, dissolved	mg/L	Industrial	NSQD	42	0.009	0.007	0.011
Copper, dissolved	mg/L	Industrial	Portland	55	0.018	0.012	0.025
Copper, dissolved	mg/L	Industrial	Seattle	33	0.006	0.005	0.007
Copper, dissolved	mg/L	Industrial	Tacoma	34	0.005	0.003^L	0.006
Copper, dissolved	mg/L	Open Space	ACWA	9	0.004	0.003	0.005^U
Copper, dissolved	mg/L	Open Space	NSQD	7	0.003	0.002	0.004
Copper, dissolved	mg/L	Open Space	Portland	4	0.002	0.001^L	0.002
Copper, dissolved	mg/L	Residential	ACWA	34	0.005	0.004	0.007
Copper, dissolved	mg/L	Residential	NSQD	101	0.009	0.006	0.015
Copper, dissolved	mg/L	Residential	Portland	4	0.006	0.004	0.007
Copper, dissolved	mg/L	Residential	Seattle	35	0.006	0.004	0.007^U
Copper, dissolved	mg/L	Residential	Tacoma	36	0.003	0.003^L	0.004
Copper, total	mg/L	Commercial	ACWA	80	0.027	0.021^L	0.036
Copper, total	mg/L	Commercial	NSQD	798	0.026	0.024	0.029
Copper, total	mg/L	Commercial	Seattle	34	0.049	0.043	0.054
Copper, total	mg/L	Commercial	Tacoma	43	0.036	0.030	0.044^U
Copper, total	mg/L	Industrial	ACWA	60	0.031	0.024	0.039^U

Table F-1-1. Stormwater Runoff Concentration Summary Statistics by Data Source and Land Use

Parameter	Units	Land use	Source	n	Mean	LCL	UCL
Copper, total	mg/L	Industrial	NSQD	637	0.032	0.027	0.038
Copper, total	mg/L	Industrial	Portland	96	0.069	0.054	0.087
Copper, total	mg/L	Industrial	Seattle	33	0.023	0.019	0.028
Copper, total	mg/L	Industrial	Tacoma	34	0.016	0.014^L	0.019
Copper, total	mg/L	Open Space	ACWA	10	0.004	0.003	0.005
Copper, total	mg/L	Open Space	NSQD	51	0.013	0.008	0.024
Copper, total	mg/L	Open Space	Portland	9	0.006	0.001^L	0.016^U
Copper, total	mg/L	Residential	ACWA	61	0.012	0.010	0.016
Copper, total	mg/L	Residential	NSQD	1772	0.023	0.021	0.025
Copper, total	mg/L	Residential	Portland	6	0.021	0.008	0.058
Copper, total	mg/L	Residential	Seattle	35	0.016	0.014	0.019^U
Copper, total	mg/L	Residential	Tacoma	36	0.011	0.009^L	0.013
Dichlobenil	ug/l	Commercial	Seattle	34	0.0369	0.0250^L	0.0581^U
Dichlobenil	ug/l	Commercial	Tacoma	54	0.1143	0.0762	0.1608
Dichlobenil	ug/l	Industrial	Seattle	33	0.0711	0.0386	0.1184
Dichlobenil	ug/l	Industrial	Tacoma	49	0.0301	0.0236^L	0.0390^U
Dichlobenil	ug/l	Residential	Seattle	35	0.0999	0.0532^L	0.1920
Dichlobenil	ug/l	Residential	Tacoma	36	0.0777	0.0536	0.1123^U
Fecal coliform	CFU/100mL	Commercial	ACWA	66	27846	5118	63325
Fecal coliform	CFU/100mL	Commercial	NSQD	312	23795	17681	32323^U
Fecal coliform	CFU/100mL	Commercial	Seattle	33	6240	4068^L	9882
Fecal coliform	CFU/100mL	Commercial	Tacoma	20	8089	4203	12984
Fecal coliform	CFU/100mL	Industrial	ACWA	54	79349	3640	281402
Fecal coliform	CFU/100mL	Industrial	NSQD	417	36541	19027	66589^U

Table F-1-1. Stormwater Runoff Concentration Summary Statistics by Data Source and Land Use

Parameter	Units	Land use	Source	n	Mean	LCL	UCL
Fecal coliform	CFU/100mL	Industrial	Seattle	33	4139	1048	12387
Fecal coliform	CFU/100mL	Industrial	Tacoma	19	6484	2965^L	11955
Fecal coliform	CFU/100mL	Open Space	ACWA	9	8588	658^L	24406^U
Fecal coliform	CFU/100mL	Open Space	NSQD	33	23366	12200	37693
Fecal coliform	CFU/100mL	Residential	ACWA	53	15562	6163	28761
Fecal coliform	CFU/100mL	Residential	NSQD	590	45835	28839	72938
Fecal coliform	CFU/100mL	Residential	Seattle	35	2953	1184^L	5808
Fecal coliform	CFU/100mL	Residential	Tacoma	21	14306	4856	30106^U
Oil and grease	mg/L	Commercial	ACWA	58	3.60	2.87^L	4.54
Oil and grease	mg/L	Commercial	NSQD	415	9.50	6.83	12.75
Oil and grease	mg/L	Industrial	ACWA	63	4.92	2.84^L	10.07^U
Oil and grease	mg/L	Industrial	NSQD	423	7.31	5.33	10.54
Oil and grease	mg/L	Industrial	Portland	5	2.50	2.50	2.50
Oil and grease	mg/L	Open Space	ACWA	10	0.59	0.49^L	0.72
Oil and grease	mg/L	Open Space	NSQD	30	1.65	0.86	2.79^U
Oil and grease	mg/L	Residential	ACWA	57	3.25	2.27^L	4.82
Oil and grease	mg/L	Residential	NSQD	652	5.89	4.22	8.22
PBDE	ng/L	Grouped	King Co	27	24.478	10.363	52.218^U
PBDE	ng/L	Grouped	Spokane	38	3.167	1.958^L	5.103
PCB	ng/L	Duwamish	Ecology	26	52.909	25.628^L	97.563^U
PCB	ng/L	Grouped	King Co	27	6.238	4.226^L	9.551
PCB	ng/L	Grouped	Portland	8	28.546	1.054	69.630
PCB	ng/L	Grouped	Seattle	28	18.798	12.186	28.982^U
PCB	ng/L	Industrial ^a	Portland	70	386.939	126.720	872.617

Table F-1-1. Stormwater Runoff Concentration Summary Statistics by Data Source and Land Use							
Parameter	Units	Land use	Source	n	Mean	LCL	UCL
TP	mg/L	Commercial	ACWA	80	0.433	0.311	0.583
TP	mg/L	Commercial	NSQD	992	0.292	0.270	0.315
TP	mg/L	Commercial	Seattle	33	0.290	0.257	0.330^U
TP	mg/L	Commercial	Tacoma	24	0.125	0.093^L	0.164
TP	mg/L	Industrial	ACWA	58	0.494	0.405	0.621
TP	mg/L	Industrial	NSQD	715	0.383^U	0.339	0.427
TP	mg/L	Industrial	Portland	1	0.067	--	--
TP	mg/L	Industrial	Seattle	33	0.264	0.217	0.343
TP	mg/L	Industrial	Tacoma	21	0.140	0.114^L	0.172
TP	mg/L	Open Space	ACWA	9	0.164	0.131	0.202^U
TP	mg/L	Open Space	NSQD	127	0.264	0.125	0.615
TP	mg/L	Open Space	Portland	2	0.028^L	--	--
TP	mg/L	Residential	ACWA	61	0.343^U	0.251	0.481
TP	mg/L	Residential	NSQD	2456	0.383	0.362	0.413
TP	mg/L	Residential	Seattle	35	0.227	0.188	0.276
TP	mg/L	Residential	Tacoma	30	0.118	0.097^L	0.141
TSS	mg/L	Commercial	ACWA	80	85.97	67.21	106.28^U
TSS	mg/L	Commercial	NSQD	904	110.23	97.80	124.76
TSS	mg/L	Commercial	Seattle	34	71.60	60.01	86.27
TSS	mg/L	Commercial	Tacoma	215	66.25	58.33^L	73.91
TSS	mg/L	Industrial	ACWA	58	121.55	87.67	176.89^U
TSS	mg/L	Industrial	NSQD	703	159.00	141.31	179.34
TSS	mg/L	Industrial	Portland	259	75.99	58.24^L	103.80
TSS	mg/L	Industrial	Seattle	33	87.60	60.43	126.47

Table F-1-1. Stormwater Runoff Concentration Summary Statistics by Data Source and Land Use

Parameter	Units	Land use	Source	n	Mean	LCL	UCL
TSS	mg/L	Industrial	Tacoma	269	83.03	76.20	91.21
TSS	mg/L	Open Space	ACWA	10	52.27	21.80	105.70^U
TSS	mg/L	Open Space	NSQD	120	88.74	58.86	122.27
TSS	mg/L	Open Space	Portland	7	23.74	6.86^L	49.98
TSS	mg/L	Residential	ACWA	60	61.51	44.51^L	93.12^U
TSS	mg/L	Residential	NSQD	2339	119.65	110.37	129.53
TSS	mg/L	Residential	Portland	8	67.90	25.63	135.13
TSS	mg/L	Residential	Seattle	35	66.64	50.49	87.77
TSS	mg/L	Residential	Tacoma	111	65.15	57.11	75.23
Zinc, dissolved	mg/L	Commercial	ACWA	60	0.078	0.056	0.124^U
Zinc, dissolved	mg/L	Commercial	NSQD	49	0.107	0.077	0.157
Zinc, dissolved	mg/L	Commercial	Seattle	34	0.053	0.044^L	0.064
Zinc, dissolved	mg/L	Commercial	Tacoma	223	0.057	0.051	0.063
Zinc, dissolved ^b	mg/L	Industrial	ACWA	50	0.267	0.107	0.678
Zinc, dissolved ^b	mg/L	Industrial	NSQD	42	0.297	0.107	0.808
Zinc, dissolved ^b	mg/L	Industrial	Portland	55	0.215	0.111	0.375
Zinc, dissolved ^b	mg/L	Industrial	Seattle	33	0.047	0.040	0.055
Zinc, dissolved ^b	mg/L	Industrial	Tacoma	274	0.060	0.053^L	0.070
Zinc, dissolved	mg/L	Open Space	ACWA	9	0.014	0.006	0.025^U
Zinc, dissolved	mg/L	Open Space	NSQD	7	0.027	0.003	0.071
Zinc, dissolved	mg/L	Open Space	Portland	4	0.006	0.002^L	0.010
Zinc, dissolved	mg/L	Residential	ACWA	34	0.046	0.035	0.057
Zinc, dissolved	mg/L	Residential	NSQD	98	0.033	0.027	0.040^U
Zinc, dissolved	mg/L	Residential	Portland	4	0.035	0.020	0.057

Table F-1-1. Stormwater Runoff Concentration Summary Statistics by Data Source and Land Use

Parameter	Units	Land use	Source	n	Mean	LCL	UCL
Zinc, dissolved	mg/L	Residential	Seattle	35	0.015	0.013^L	0.017
Zinc, dissolved	mg/L	Residential	Tacoma	113	0.029	0.026	0.034
Zinc, total	mg/L	Commercial	ACWA	80	0.163	0.133	0.204^U
Zinc, total	mg/L	Commercial	NSQD	885	0.190	0.174	0.209
Zinc, total	mg/L	Commercial	Seattle	34	0.155	0.139	0.171
Zinc, total	mg/L	Commercial	Tacoma	224	0.134	0.124^L	0.147
Zinc, total	mg/L	Industrial	ACWA	60	0.372	0.205	0.708
Zinc, total	mg/L	Industrial	NSQD	703	0.223	0.202	0.258^U
Zinc, total	mg/L	Industrial	Portland	96	0.536	0.384	0.695
Zinc, total	mg/L	Industrial	Seattle	33	0.155	0.133^L	0.186
Zinc, total	mg/L	Industrial	Tacoma	274	0.152	0.139	0.166
Zinc, total	mg/L	Open Space	ACWA	10	0.023	0.009^L	0.045^U
Zinc, total	mg/L	Open Space	NSQD	56	0.053	0.036	0.077
Zinc, total	mg/L	Open Space	Portland	7	0.007	0.004	0.011
Zinc, total	mg/L	Residential	ACWA	61	0.098	0.077	0.129^U
Zinc, total	mg/L	Residential	NSQD	2042	0.115	0.102	0.135
Zinc, total	mg/L	Residential	Portland	6	0.143	0.038	0.329
Zinc, total	mg/L	Residential	Seattle	35	0.053	0.047^L	0.061
Zinc, total	mg/L	Residential	Tacoma	113	0.077	0.069	0.088

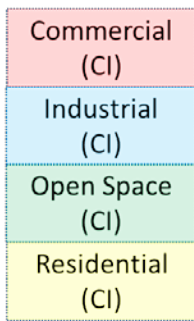
Notes: The upper and lower runoff concentration bounds selected as inputs to the PLM are denoted by values in bold italics. The lower and upper bounds are also denoted with an L and U superscript, respectively.

- The Portland industrial PCB data are not representative of Seattle and was not considered in defining the upper and lower bounds for PCB.
- The industrial dissolved zinc values exceed some of the industrial total zinc values. Therefore, the UCL EMC bound for industrial dissolved zinc was set equal to the industrial total zinc UCL EMC bound.

Attachment F-2: Stormwater Concentration Data Figures

The 95th percent CIs on the mean runoff concentration for each RCOC, land use, data source combination, developed using the approach described in Section 2.2.2, are graphically depicted below. The color-shaded regions represent the land use specific confidence bounds (CI) that were selected as inputs into the PLM as described in Section 3.4. Additionally, some of the studies had suspected bias and required special consideration. The following key illustrates the different land use shading of the select CI on the charts:

Key



Studies with suspected bias
(SPU industrial – low bias)
(Portland industrial – high bias)

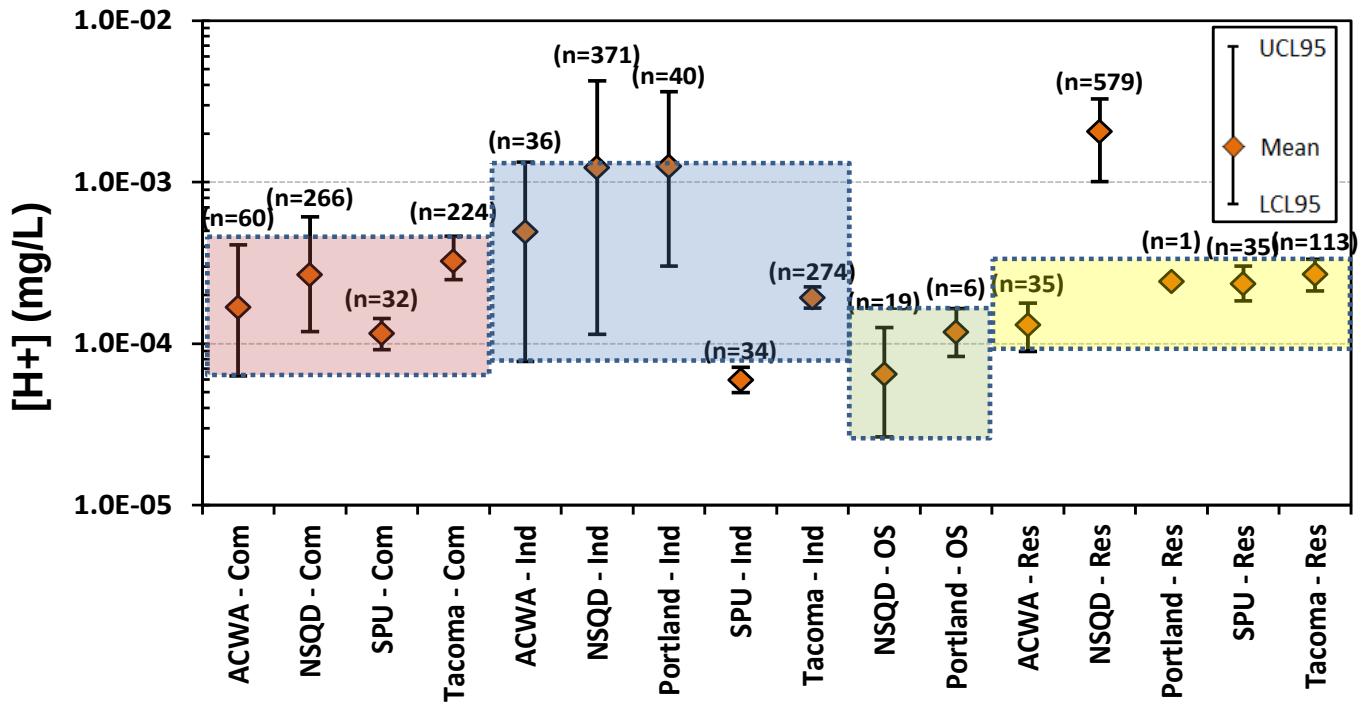


Figure F-2a. Confidence intervals for year-round hydrogen ion concentration stormwater data by source and land use

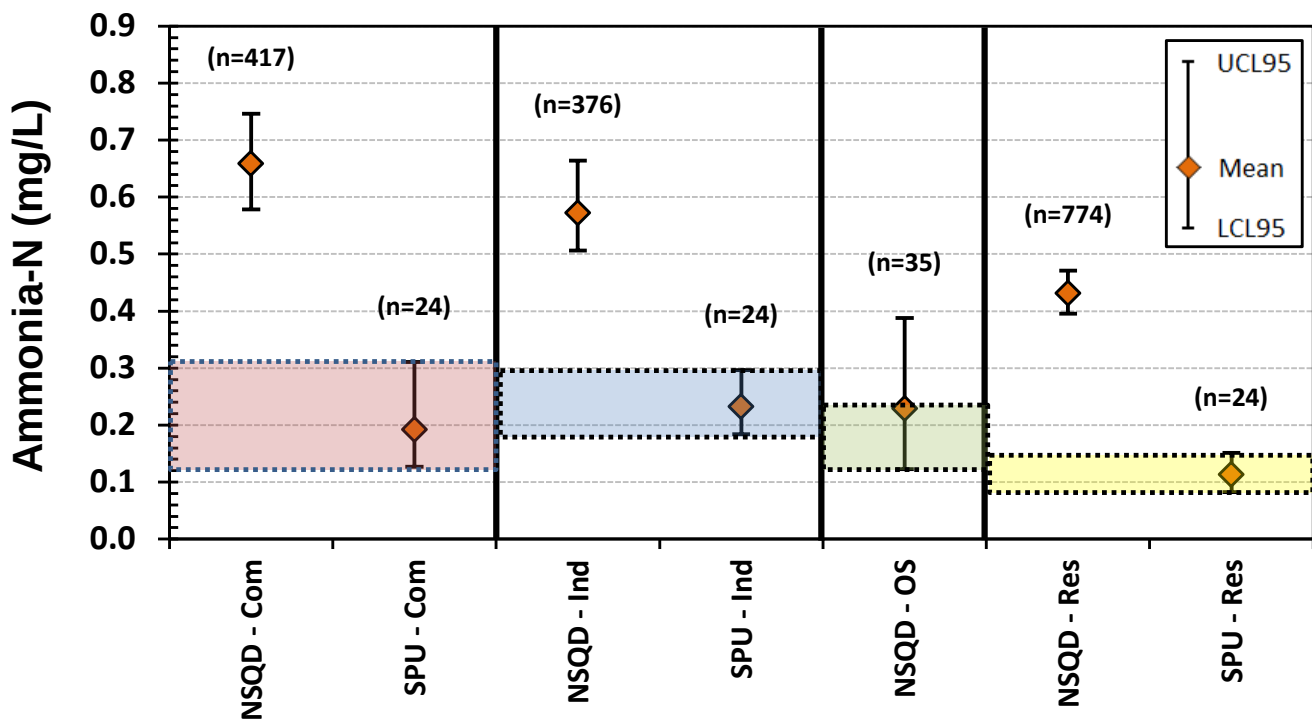


Figure F-2b. Confidence intervals for year-round ammonia-N stormwater data by source and land use

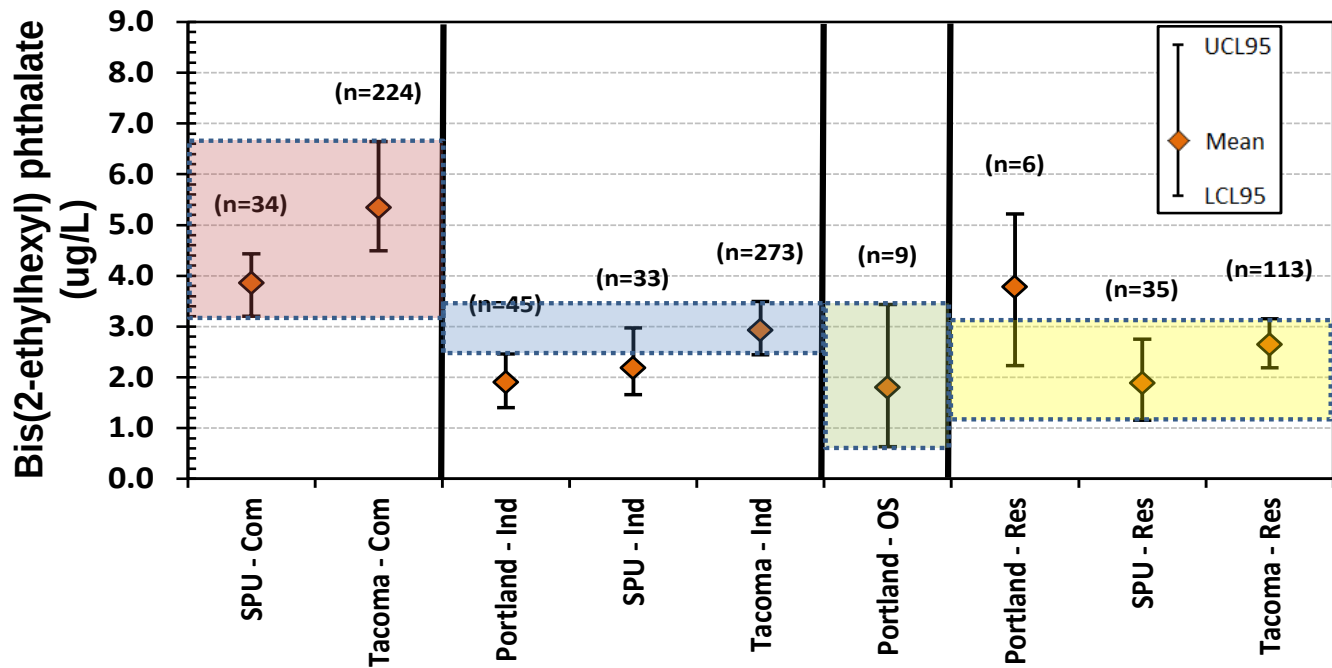


Figure F-2c. Confidence intervals for year-round bis(2-ethylhexyl)phthalate stormwater data by source and land use

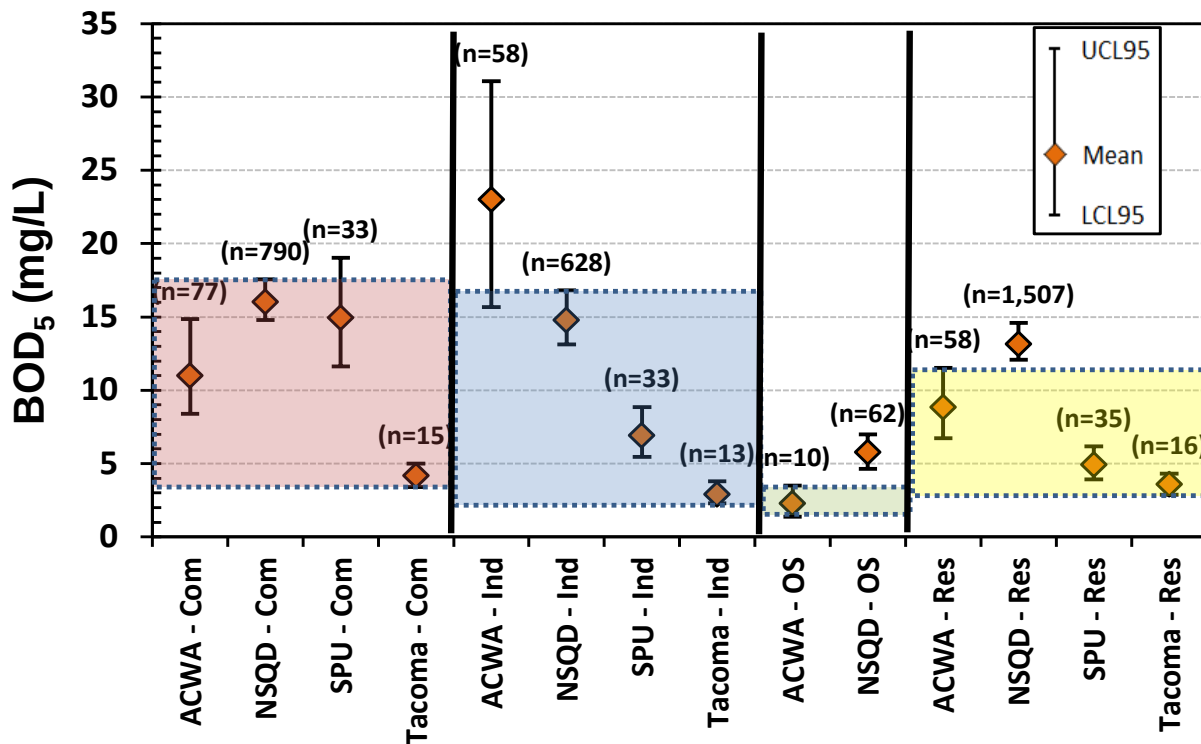


Figure F-2d. Confidence intervals for year-round 5-day BOD₅ data by source and land use

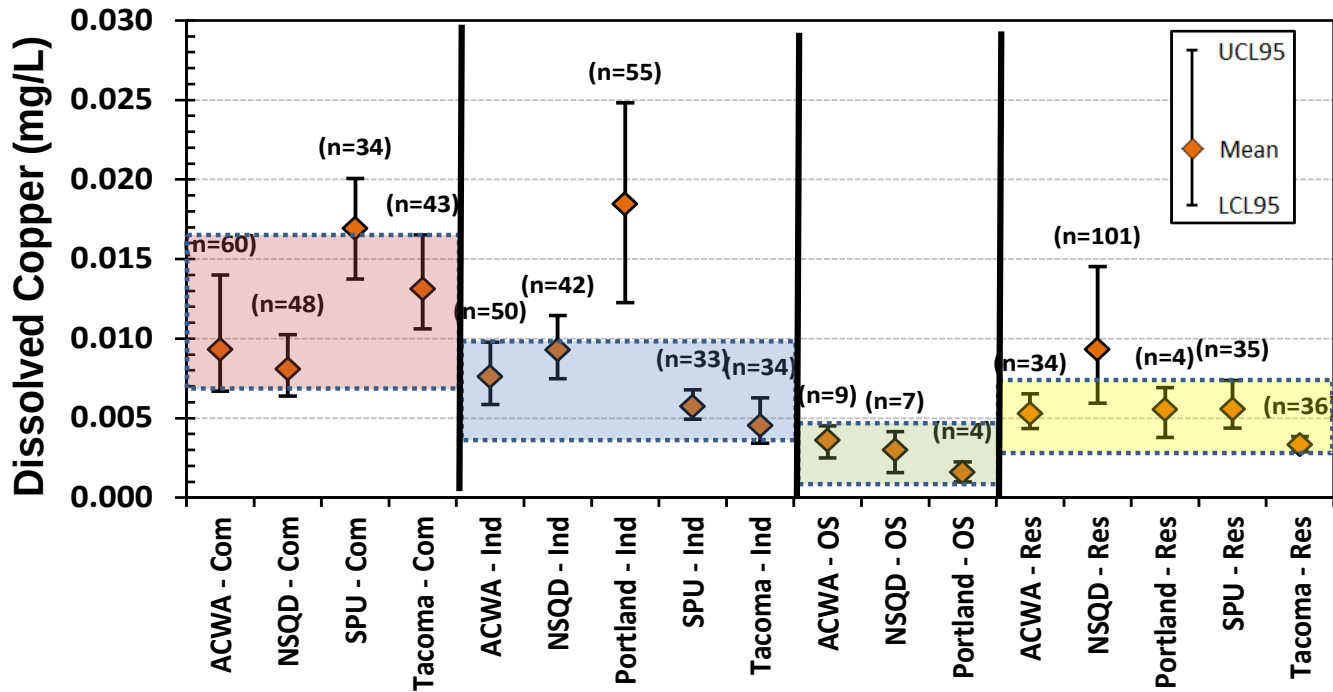


Figure F-2e. Confidence intervals for year-round dissolved copper stormwater data by source and land use

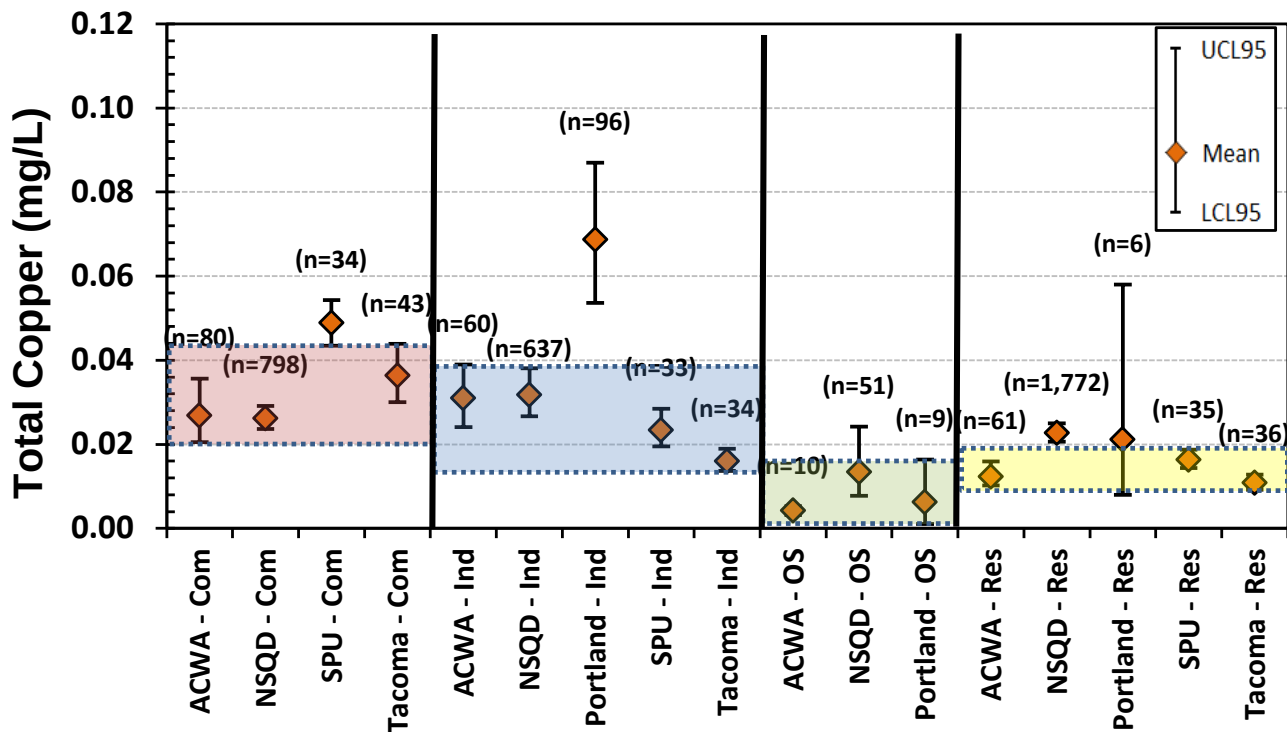


Figure F-2f. Confidence intervals for year-round total copper stormwater data by source and land use

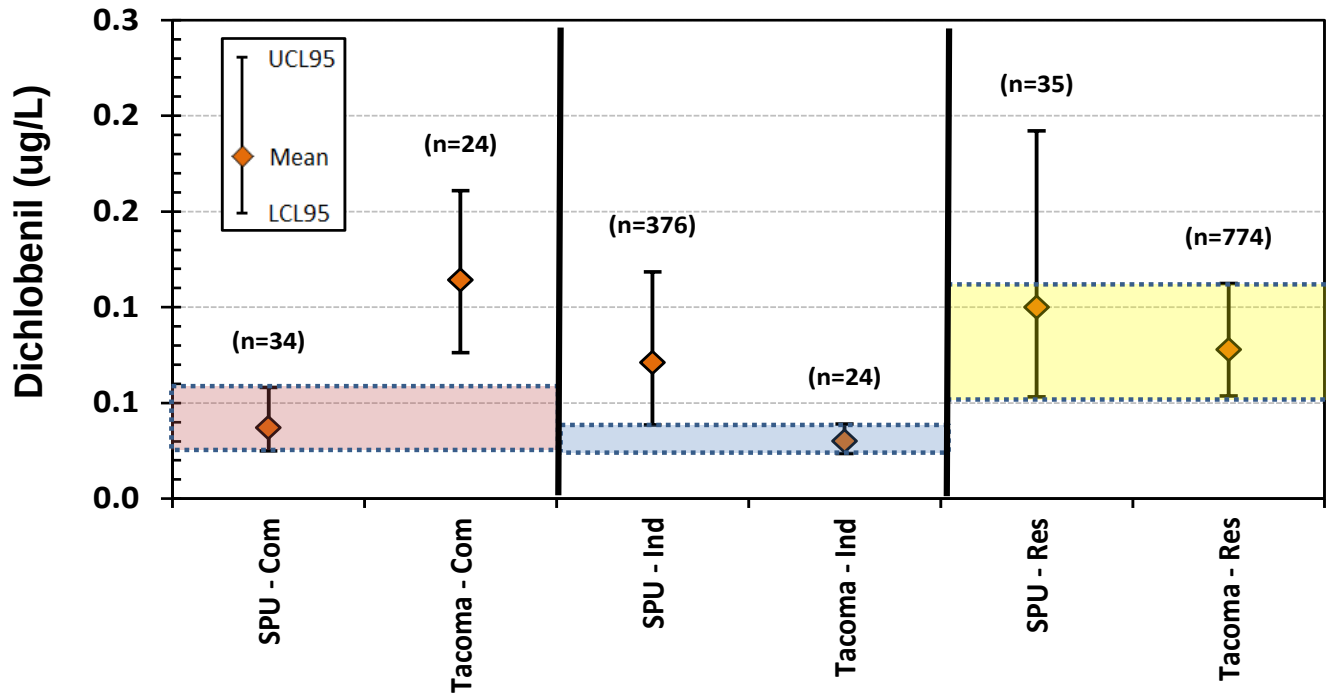


Figure F-2g. Confidence intervals for year-round 5-day dichlobenil stormwater data by source and land use

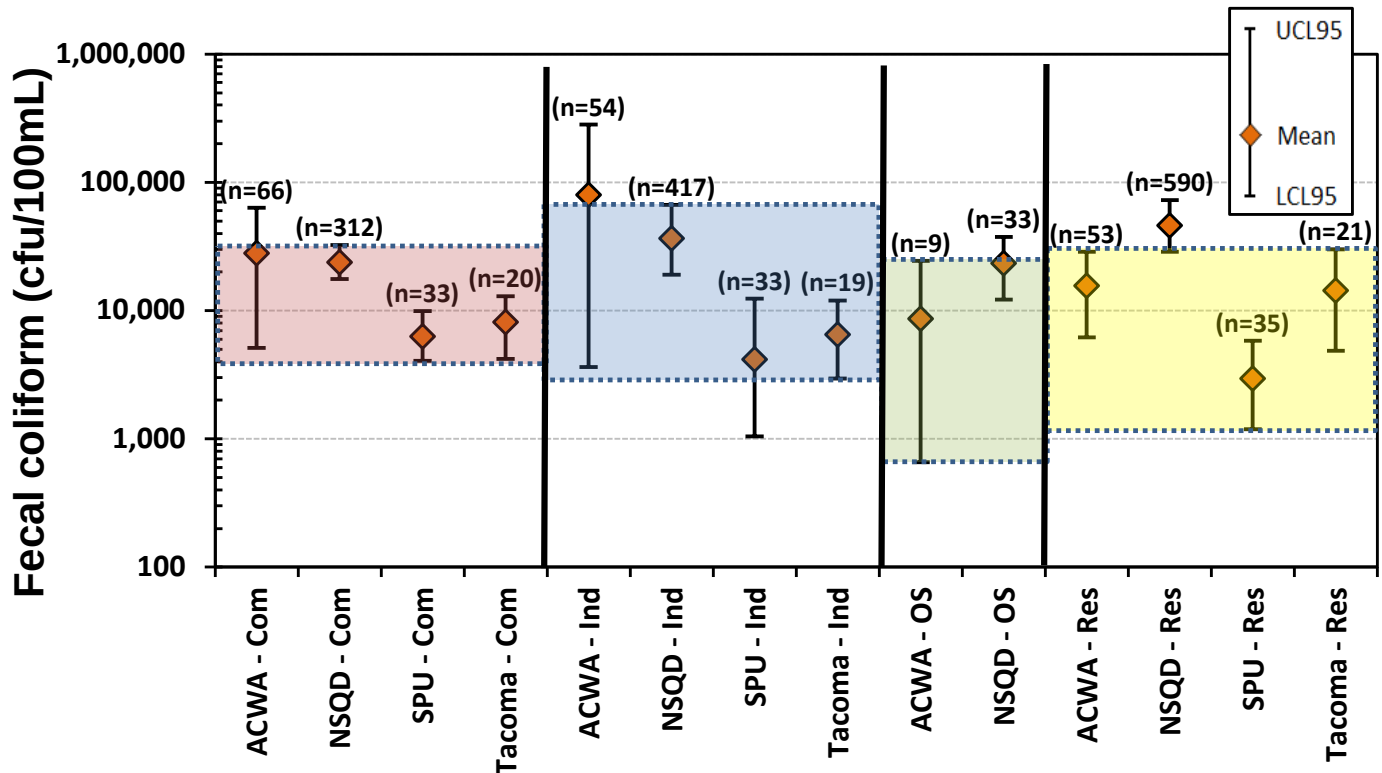


Figure F-2h. Confidence intervals for year-round fecal coliform data by source and land use

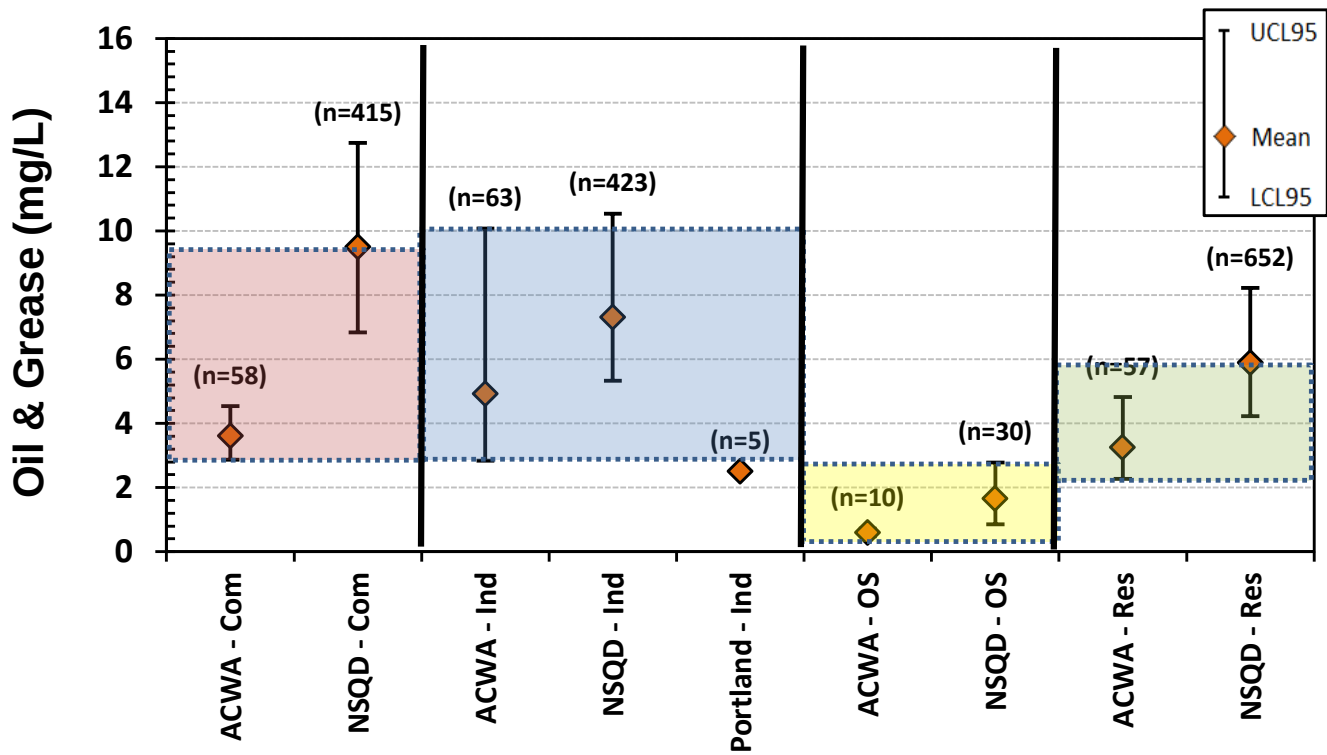


Figure F-2i. Confidence intervals for year-round oil and grease data by source and land use

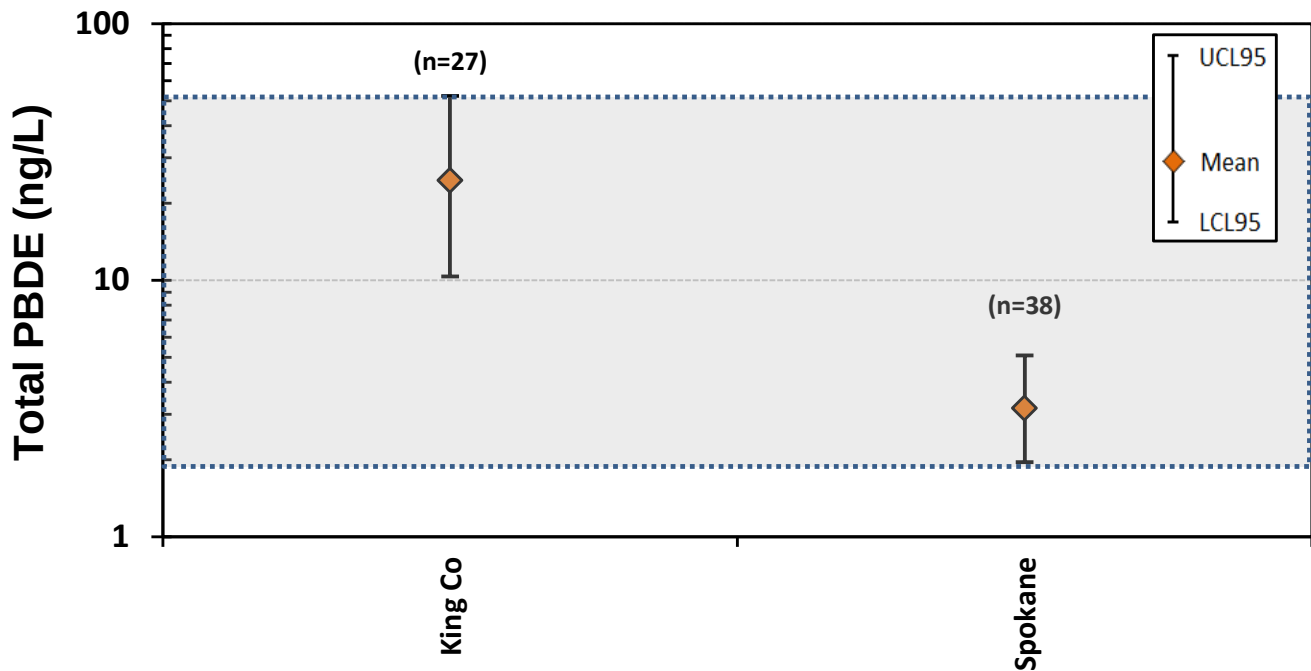


Figure F-2j. Confidence intervals for year-round total polybrominated diphenyl ethers stormwater data by source and land use

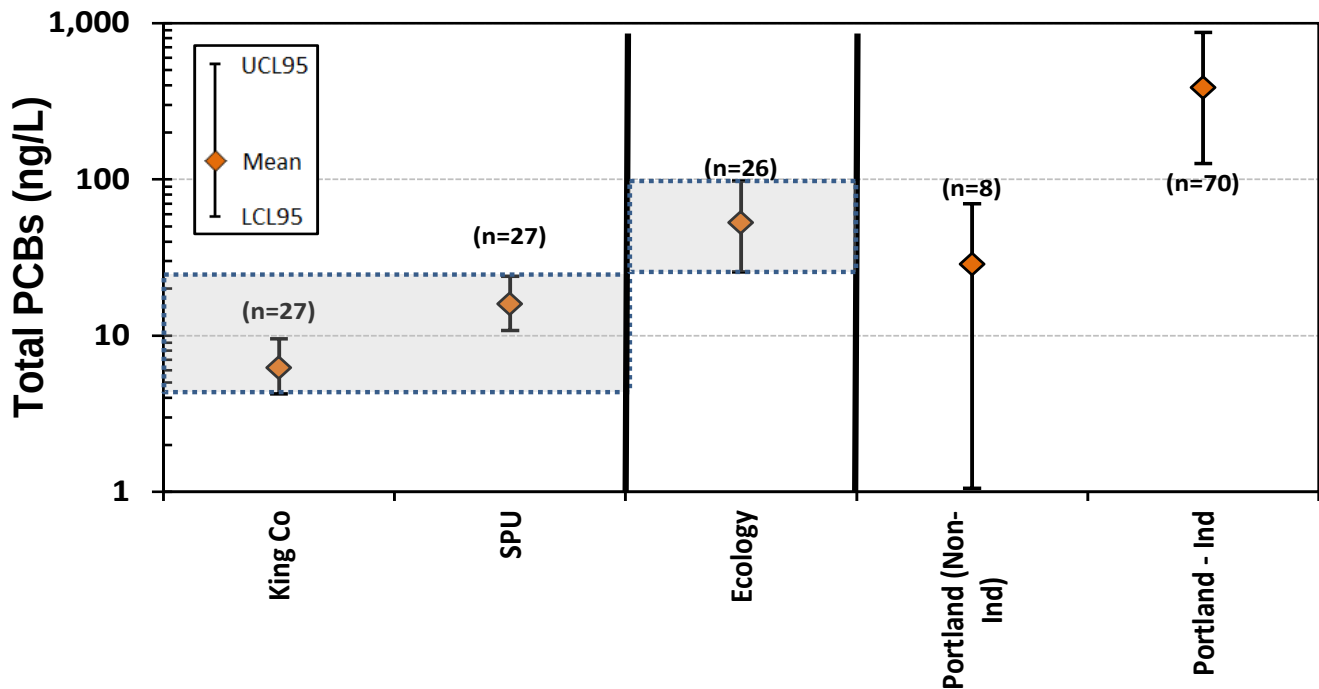


Figure F-2k. Confidence intervals for year-round total polychlorinated biphenyls stormwater data by source and land use

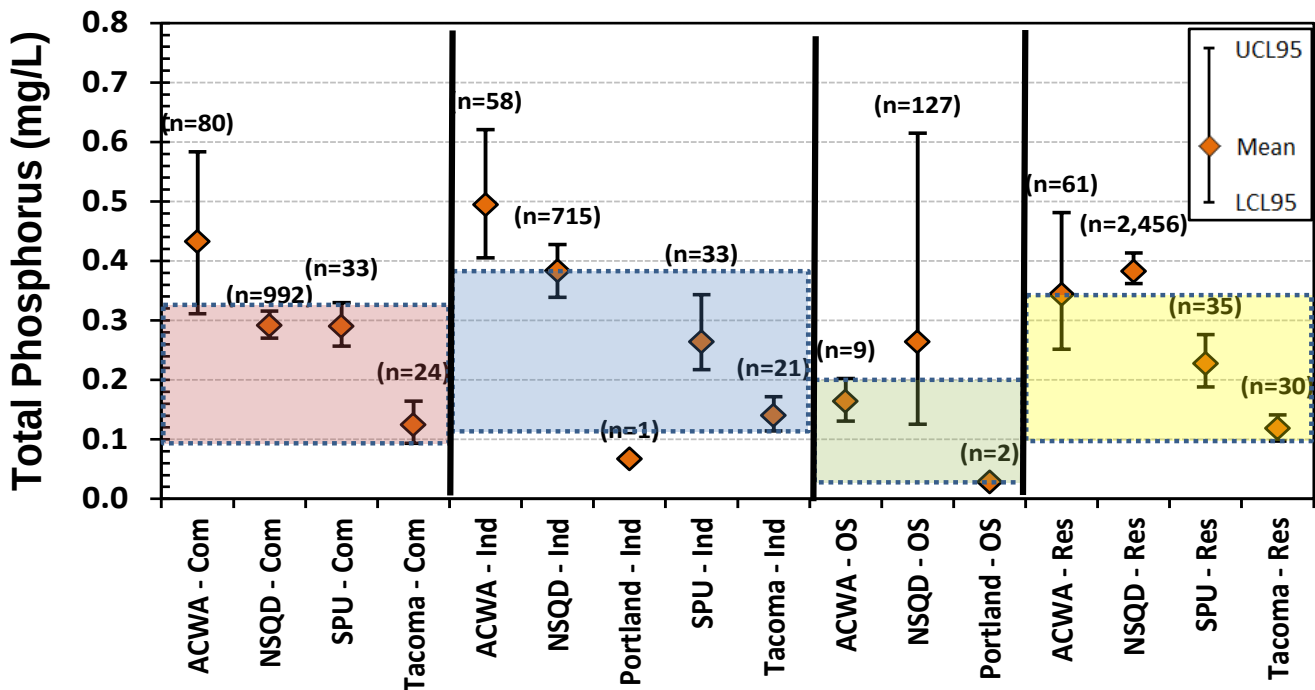


Figure F-2l. Confidence intervals for year-round total phosphorus stormwater data by source and land use

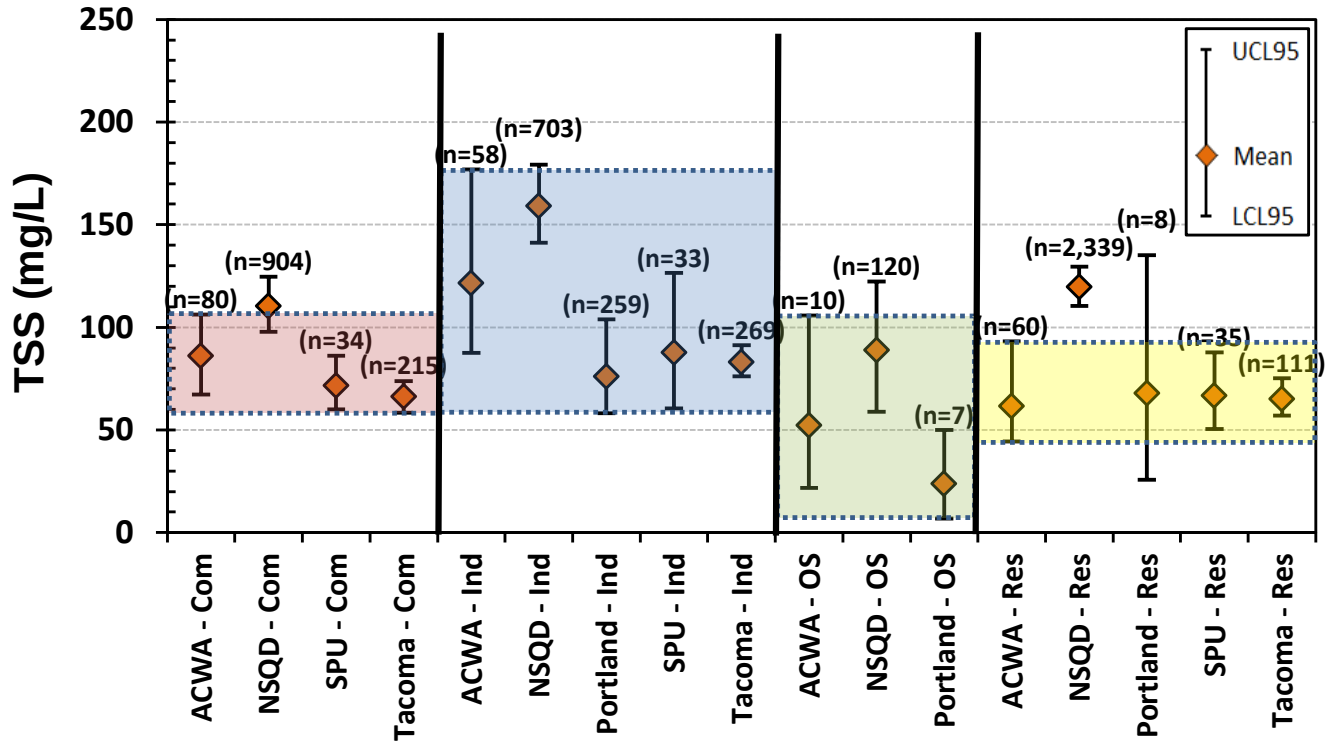


Figure F-2m. Confidence intervals for year-round total suspended solids data by source and land use

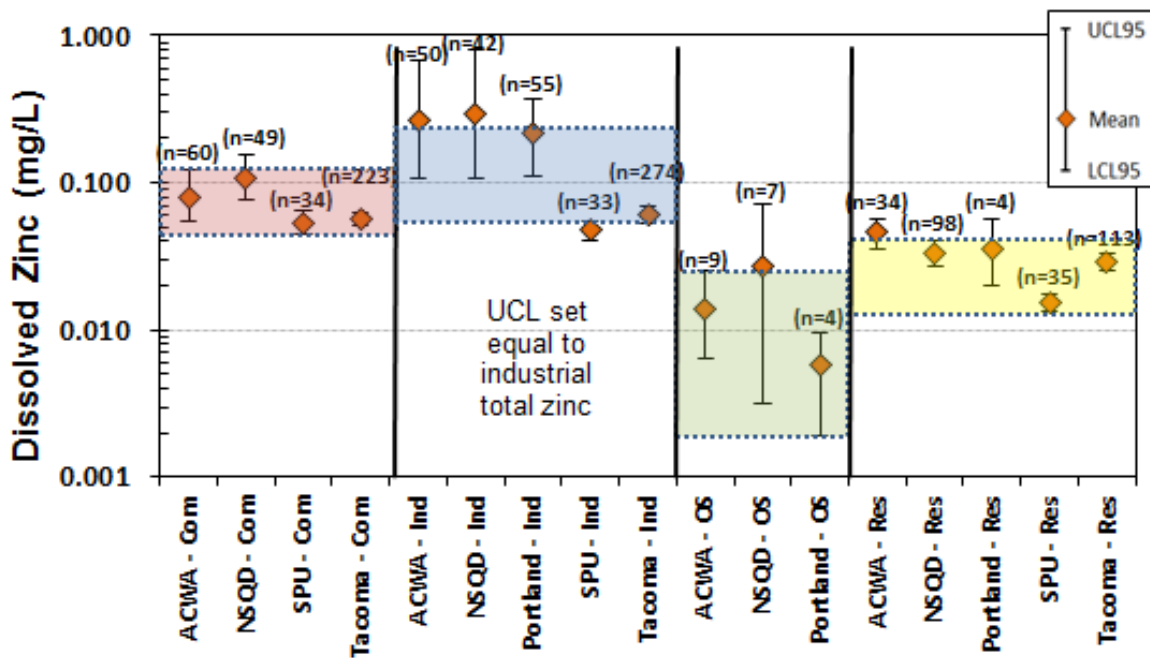


Figure F-2n. Confidence intervals for year-round dissolved zinc stormwater data by source and land use

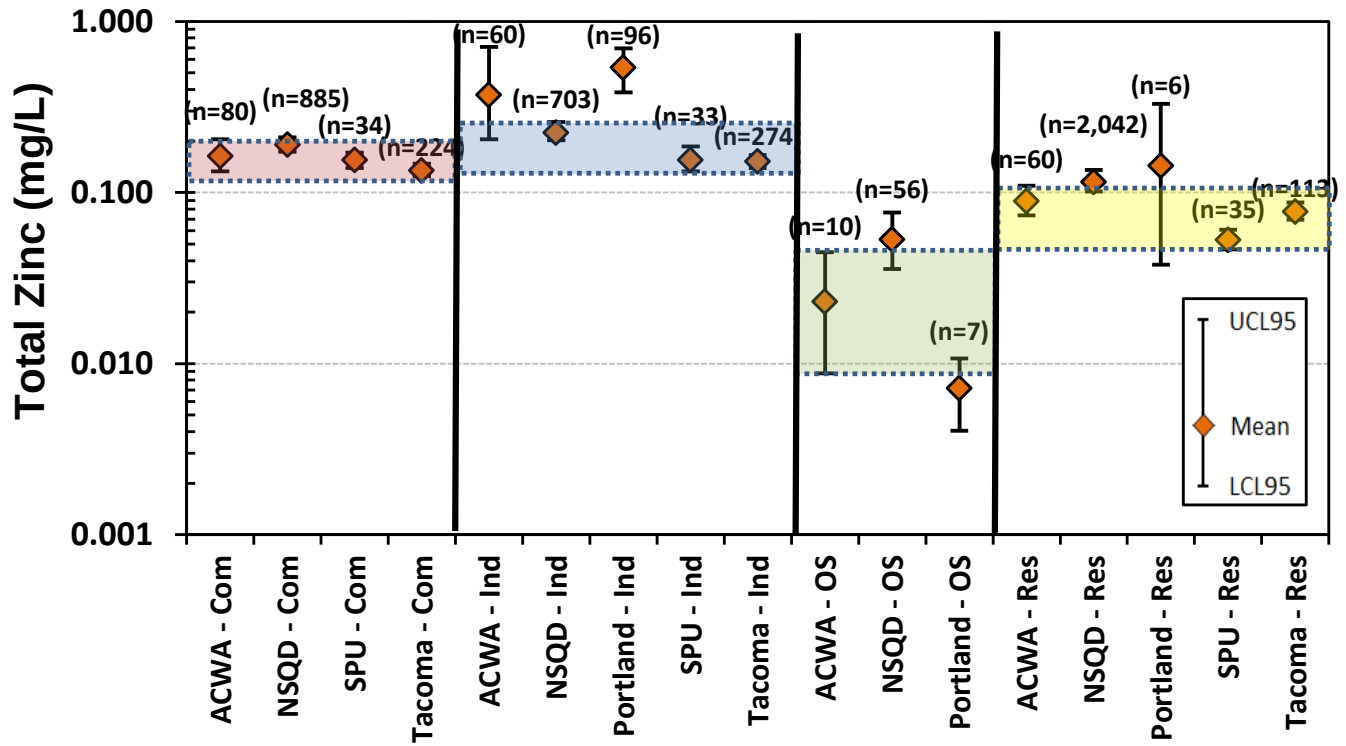


Figure F-2o. Confidence intervals for year-round total zinc stormwater data by source and land use

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Attachment F-3: Integrated Plan Stormwater Project Box and Whisker Results Charts

The box-and-whisker charts graphically present the PLM results. Each chart displays the long-term average annual concentration or load reduction for an RCOC. The candidate stormwater projects are included on the x-axis with the estimated long-term average annual reduction on the y-axis. The median of the long-term average annual reduction (selected from the distribution of the 1,000 Monte Carlo iterations) is indicated by a horizontal line within the box. The top and bottom of the box represent the 75th and 25th percentile reductions, respectively. The top and bottom whiskers represent the 95th and 5th percentile reductions, respectively (see key included within each figure). These percentiles represent the range of long-term average reductions that can be expected from a given project.

Due to limited data availability, the concentration and load reductions for some stormwater project and RCOC combinations were not calculated (discussed in Section 3.5.3). For example, due to limited data availability, concentration reductions for dichlobenil, dissolved copper, dissolved zinc, ammonia-N, [H+], and normalized DO deficit could not be calculated for the street sweeping programs and therefore are not presented. And, due to limited data availability, loads reductions for dichlobenil, dissolved copper, dissolved zinc, ammonia-N, and [H+] were not able to be calculated for the street sweeping projects at this time and therefore are not presented.

For street sweeping projects, the mean of the long-term average annual reductions are reported (not the median), as calculated by the original model.

The long-term average annual concentration reduction for dichlobenil was zero for every Integrated Plan stormwater project (except street sweeping) as described in Section 3.5.3.

The UCL of the land use runoff concentrations for ammonia-N (as described in Section 3.4) were lower than the LCL of the project effluent concentrations (as described in Section 3.5.3) for all of the Integrated Plan stormwater projects (except street sweeping). Therefore, the long-term average annual concentration reduction for ammonia-N was zero for every Integrated Plan stormwater project (except street sweeping).

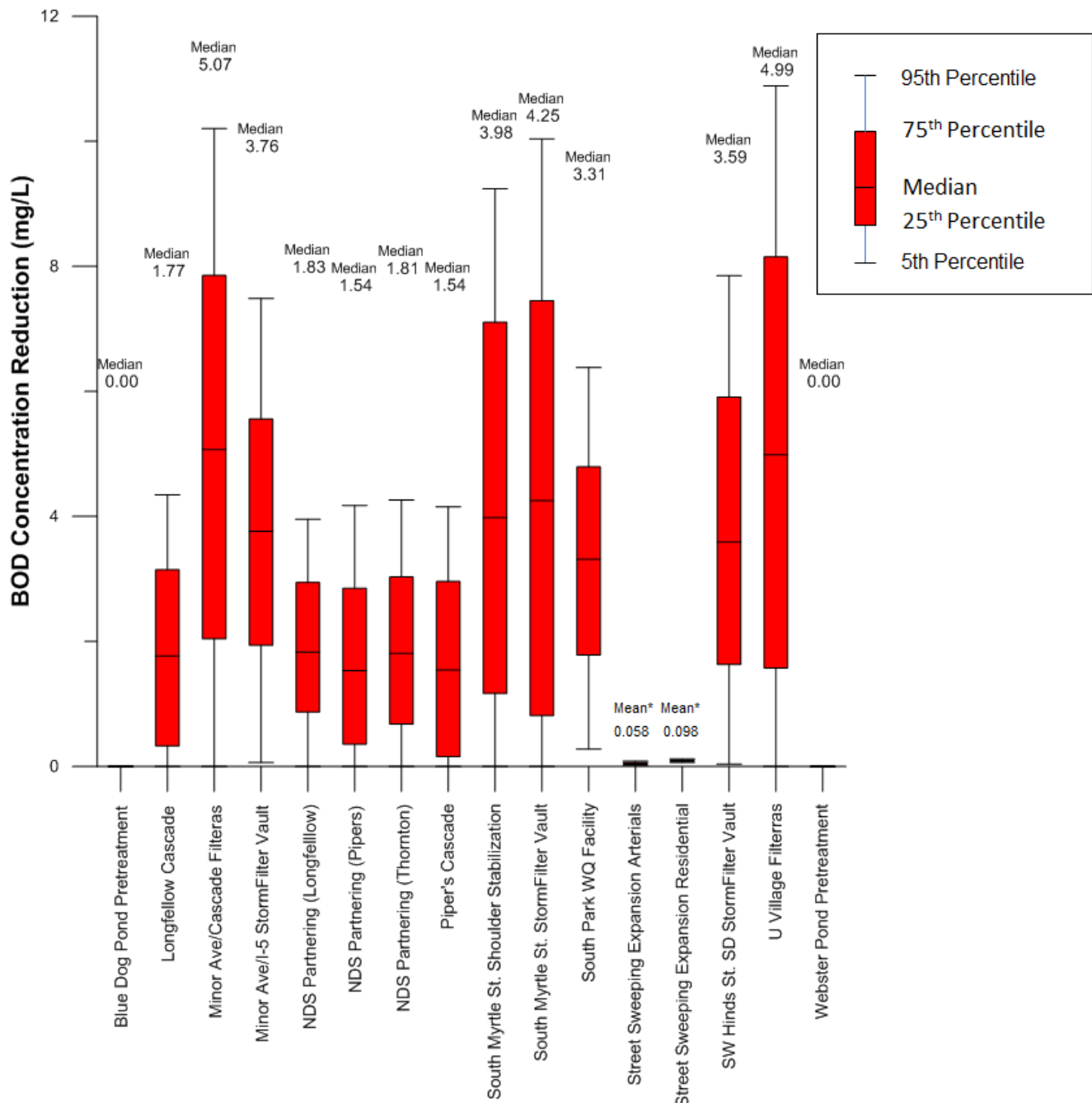


Figure F-3a. Long-term average annual concentration reduction for BOD₅

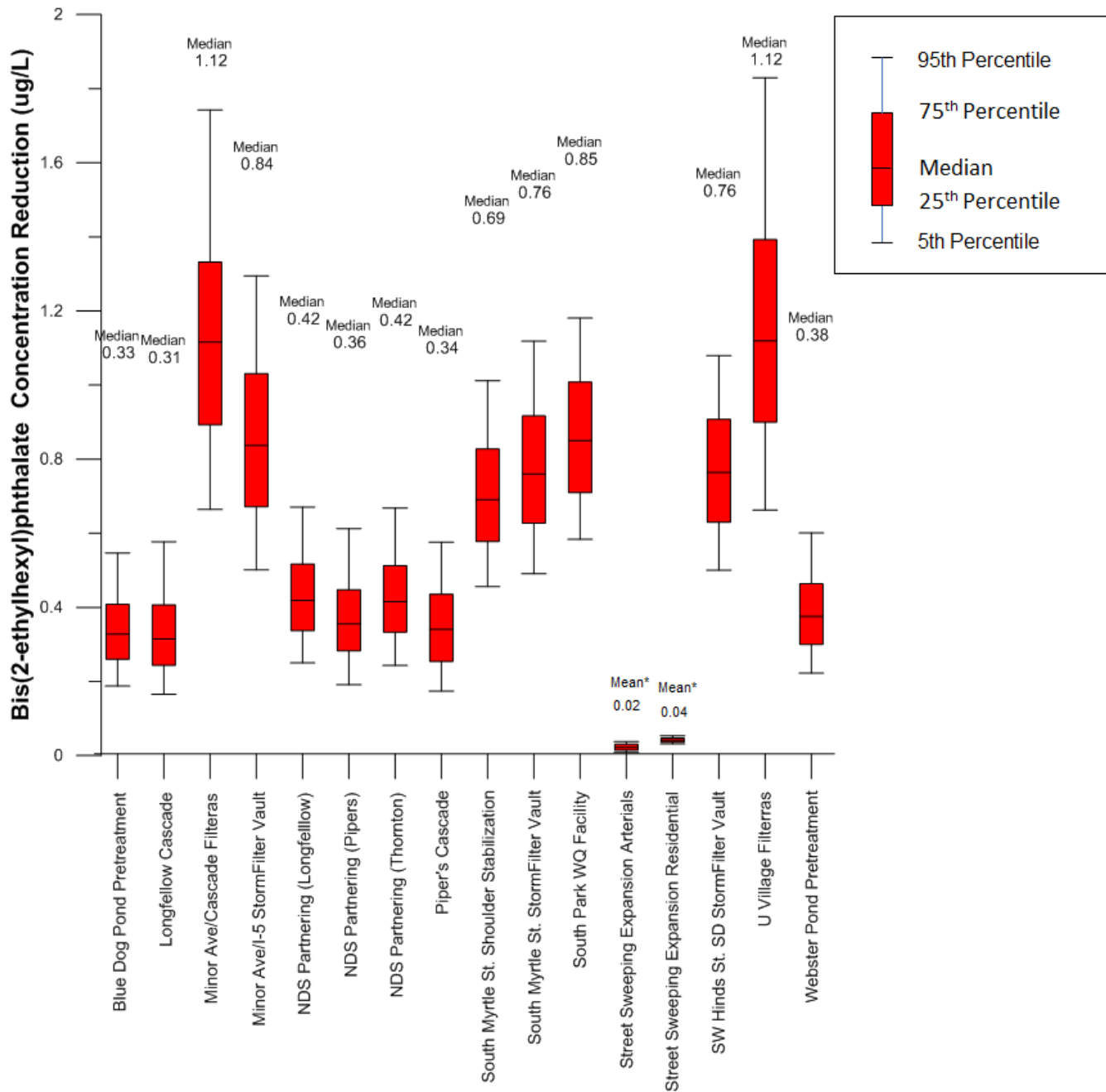


Figure F-3b. Long-term average annual concentration reduction for bis(2-ethylhexyl)phthalate

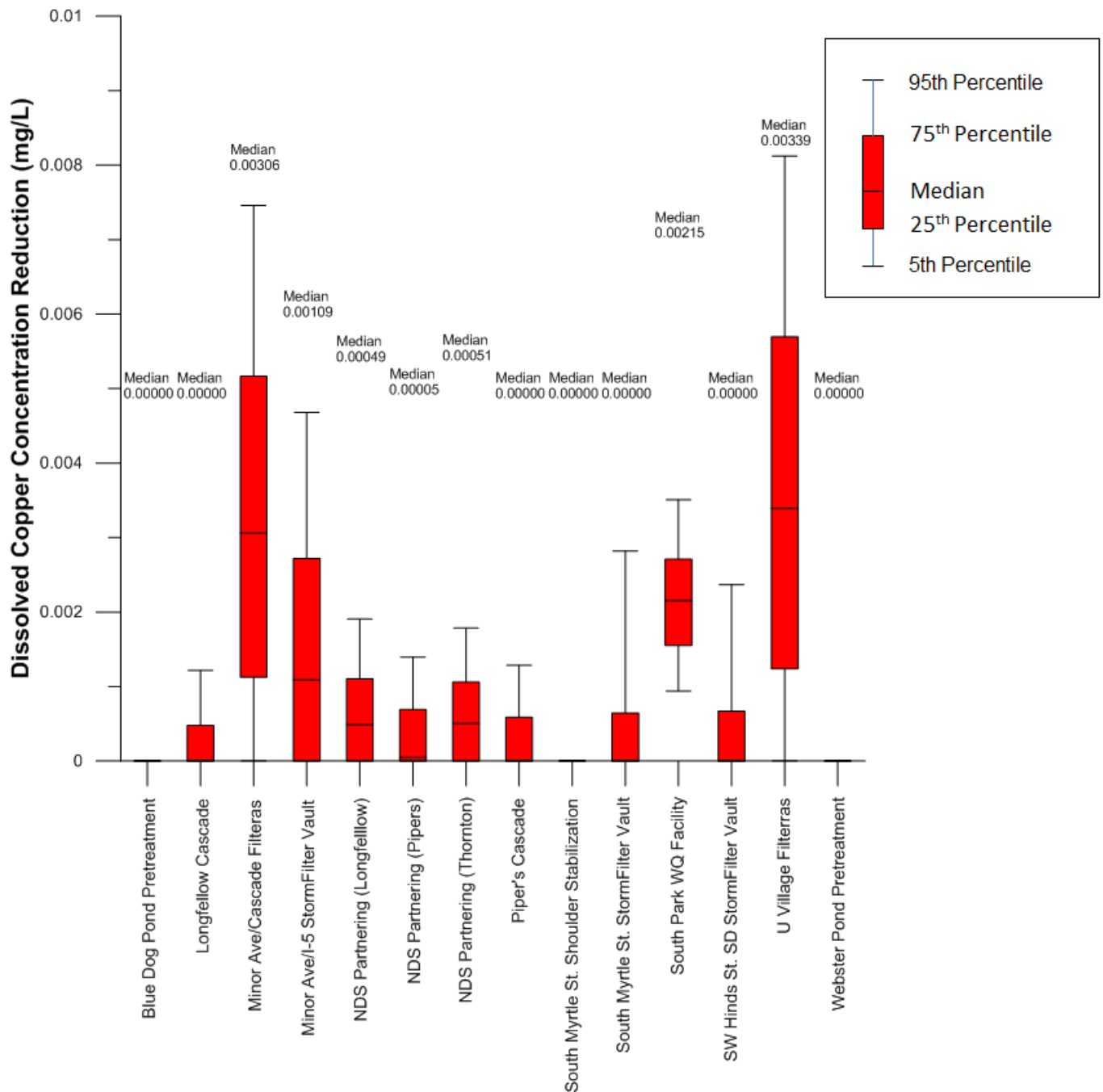


Figure F-3c. Long-term average annual concentration reduction for dissolved copper

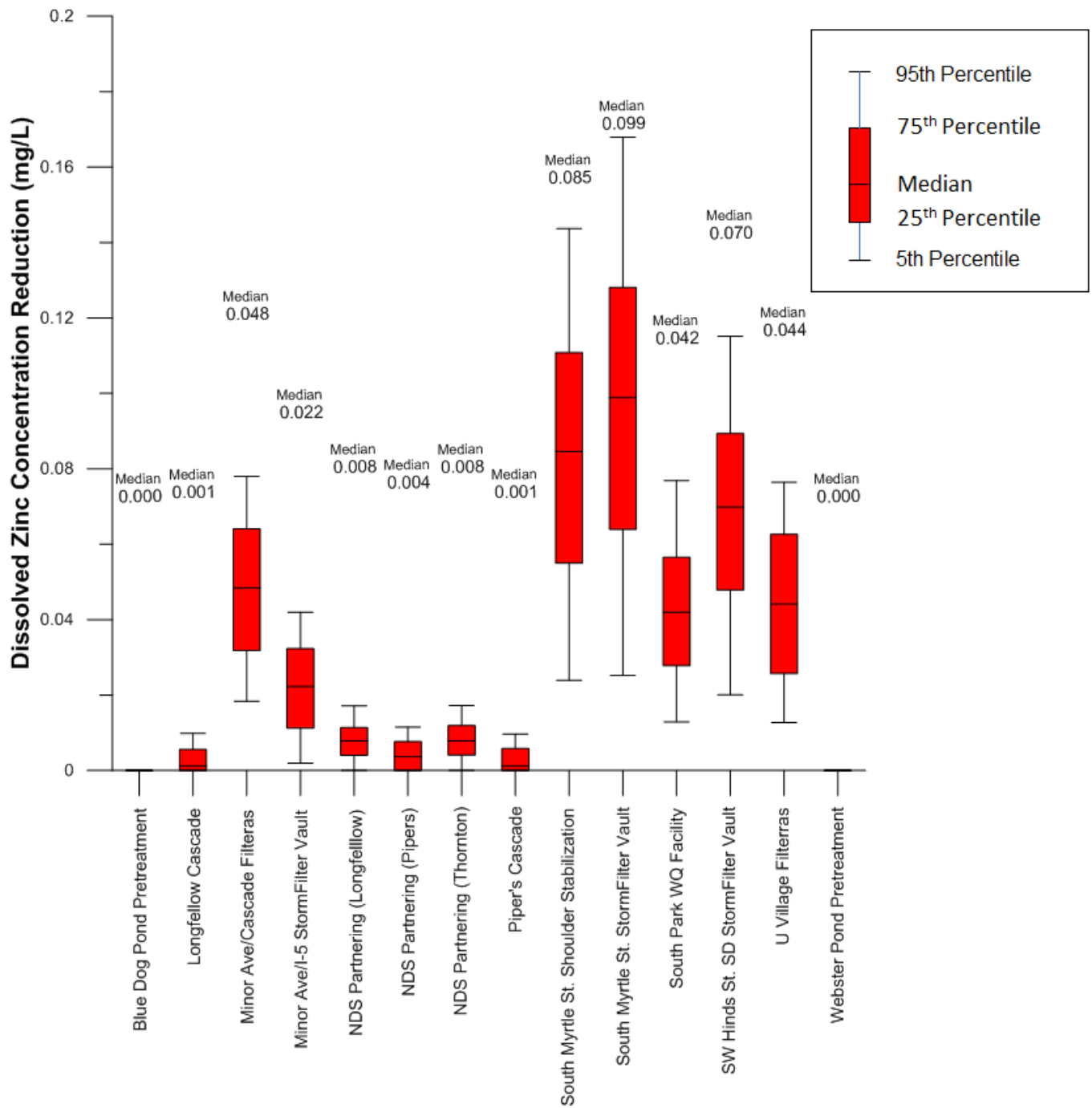


Figure F-3d. Long-term average annual concentration reduction for dissolved zinc

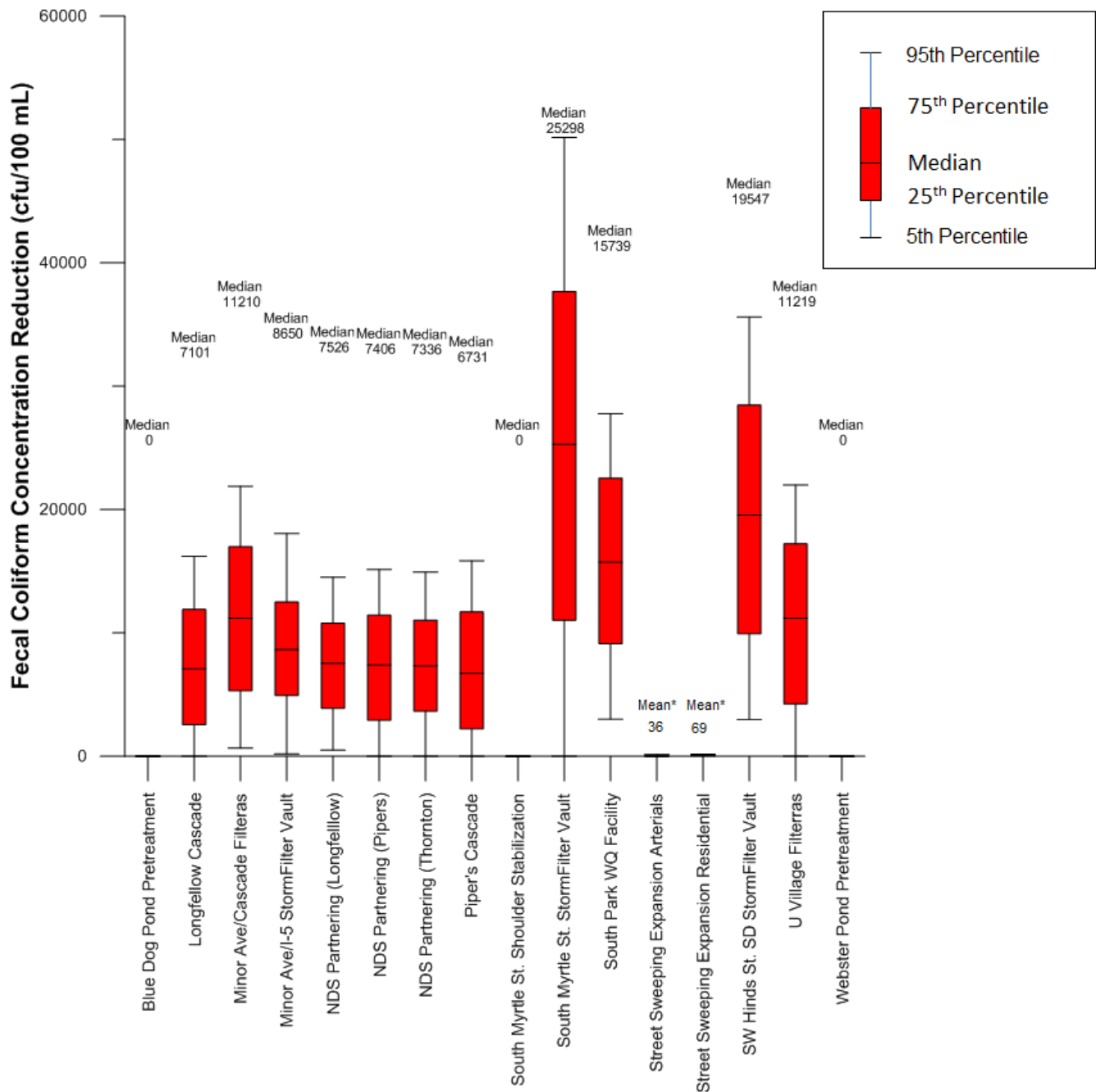


Figure F-3e. Long-term average annual concentration reduction for fecal coliform

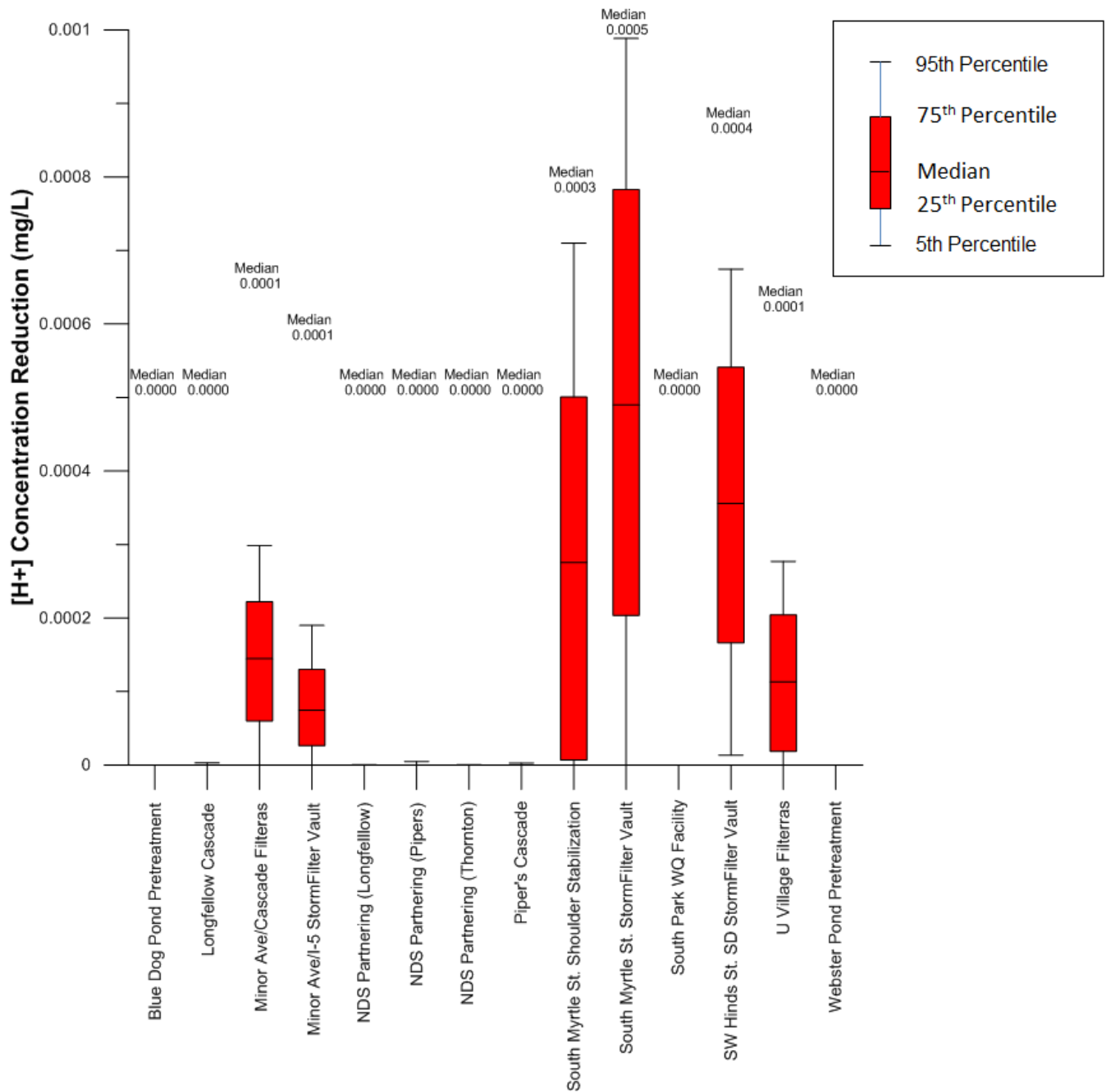


Figure F-3f. Long-term average annual concentration load reduction for [H+]

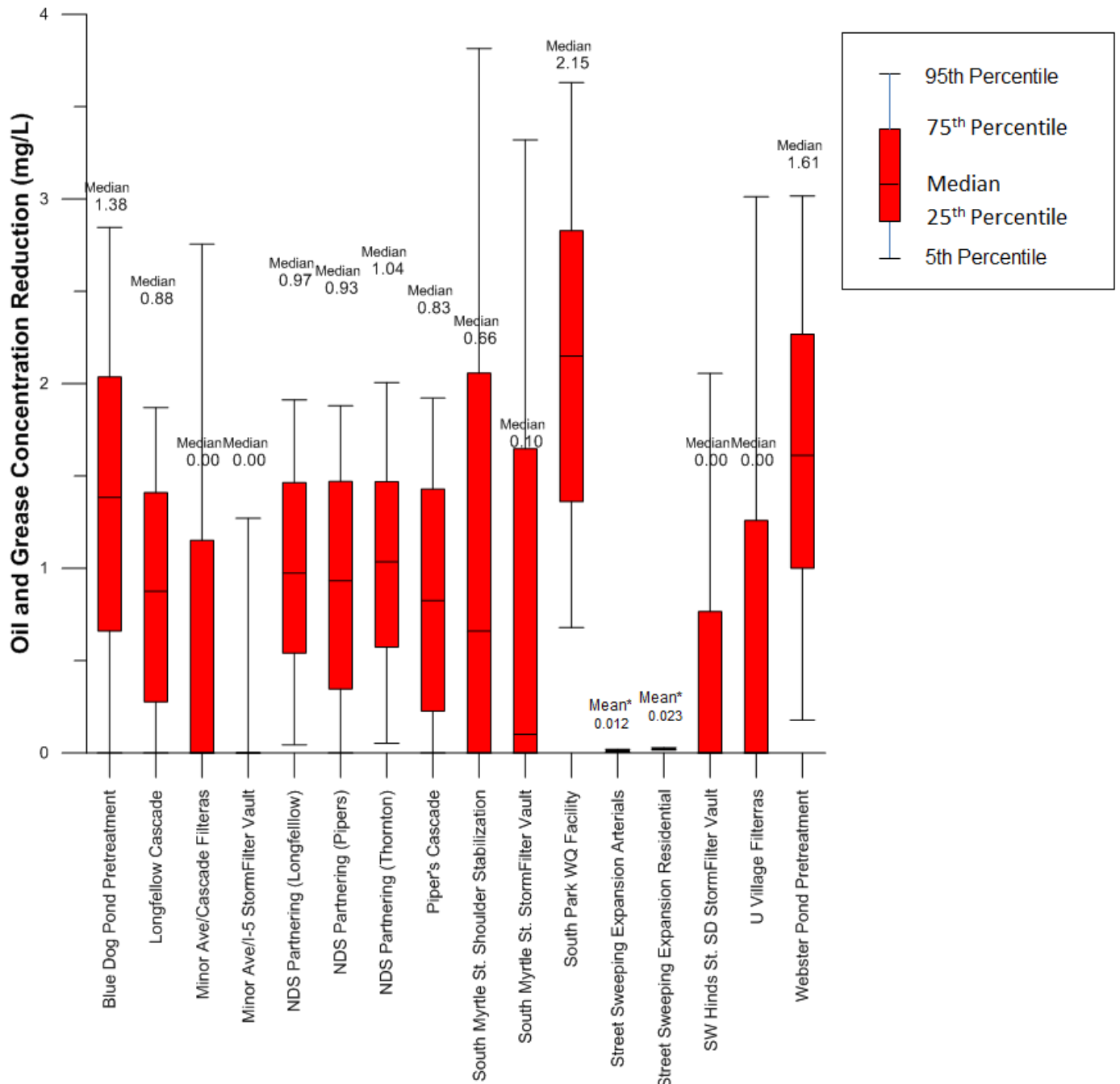


Figure F-3g. Long-term average annual concentration reduction for oil and grease

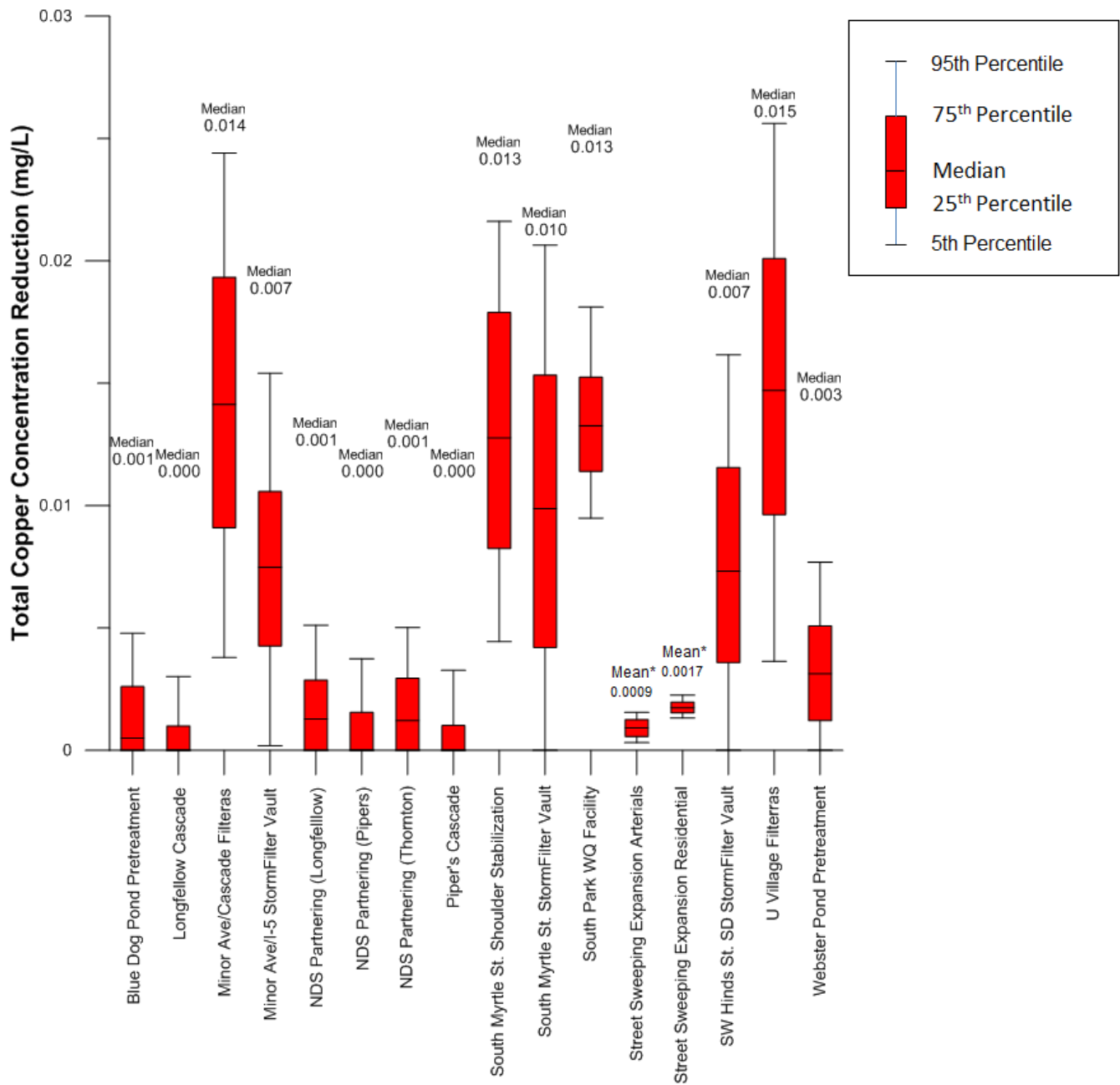


Figure F-3h. Long-term average annual concentration reduction for total copper

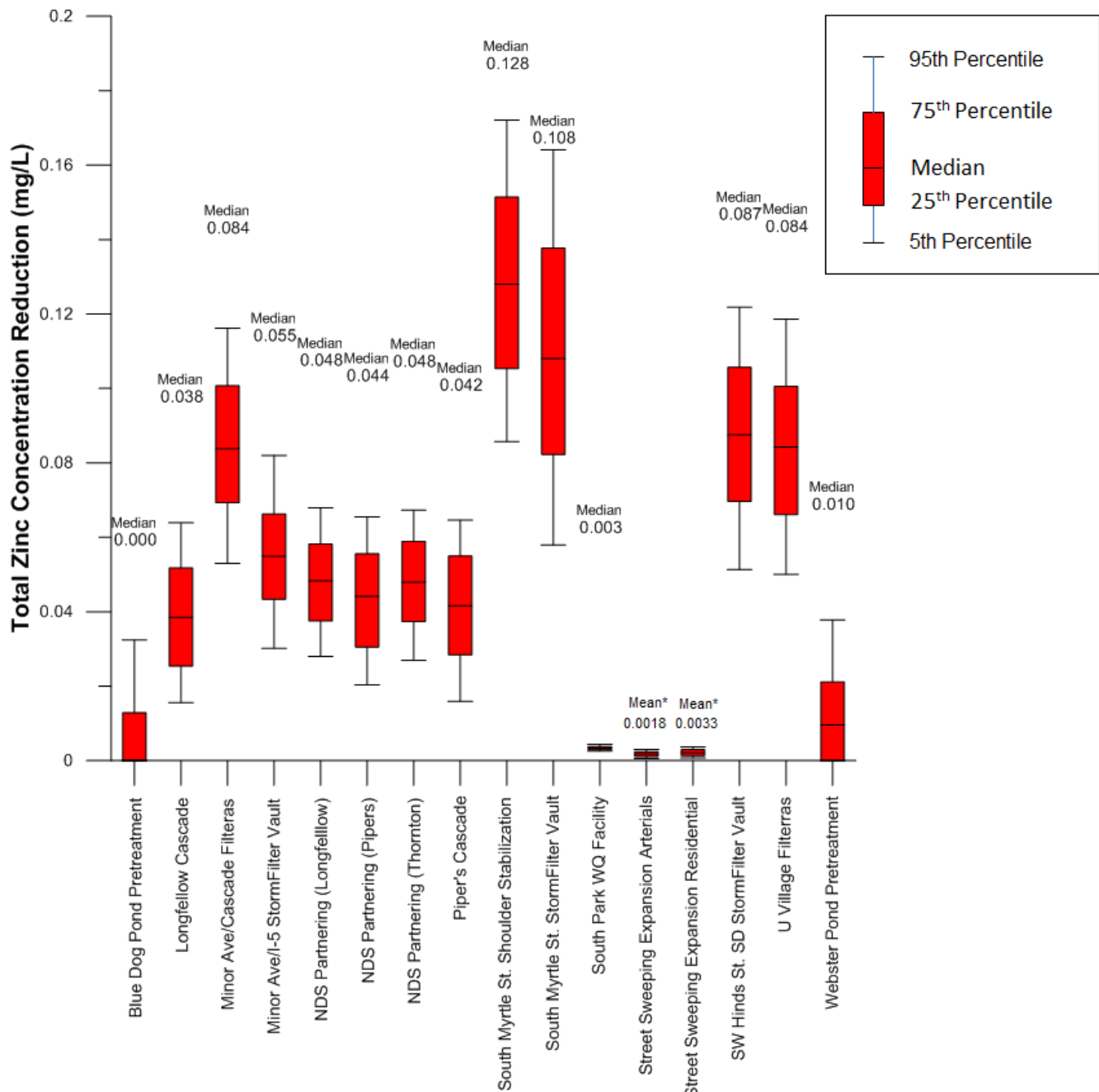


Figure F-3i. Long-term average annual concentration reduction for total zinc

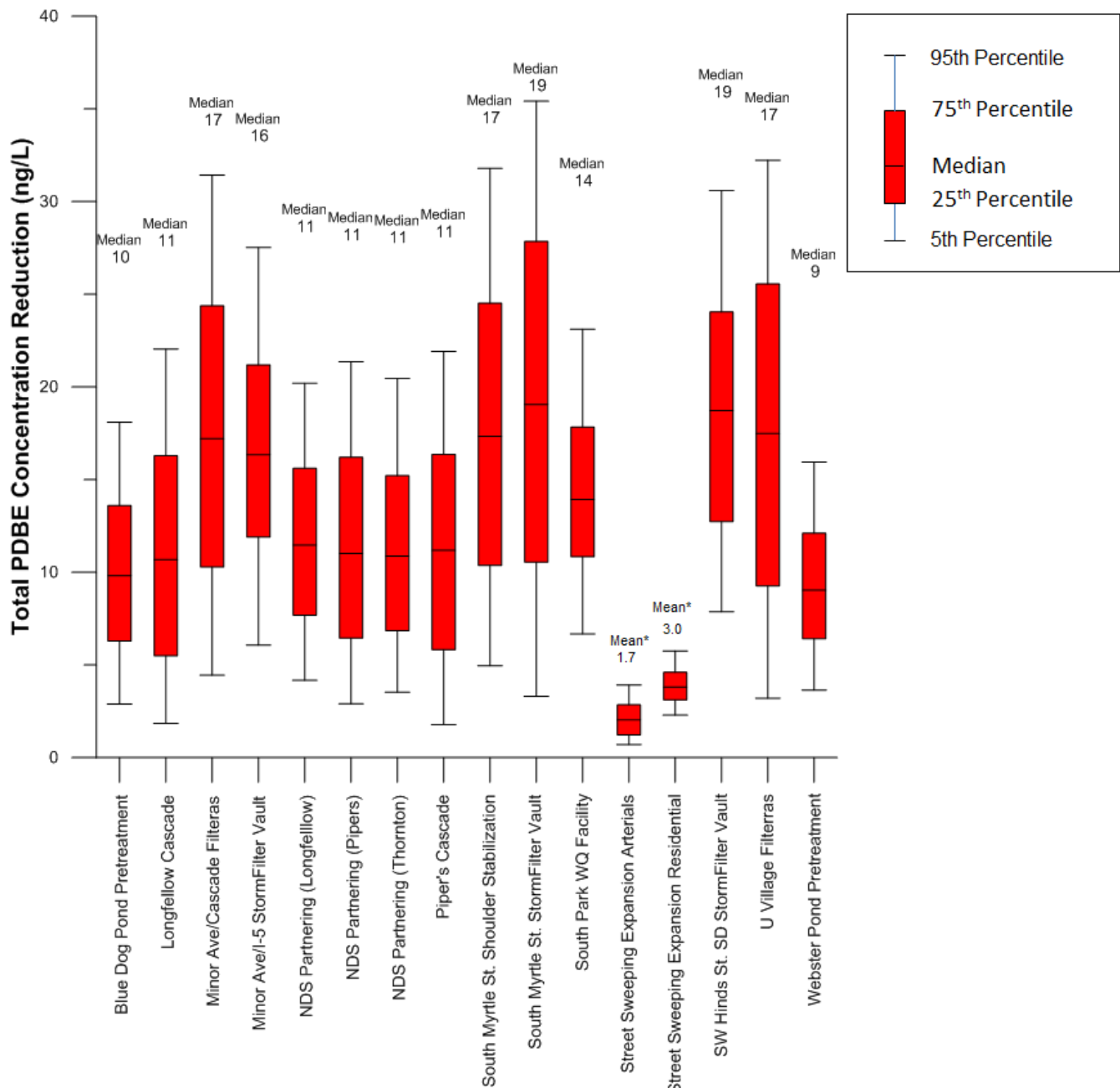


Figure F-3j. Long-term average annual concentration reduction for total PBDEs

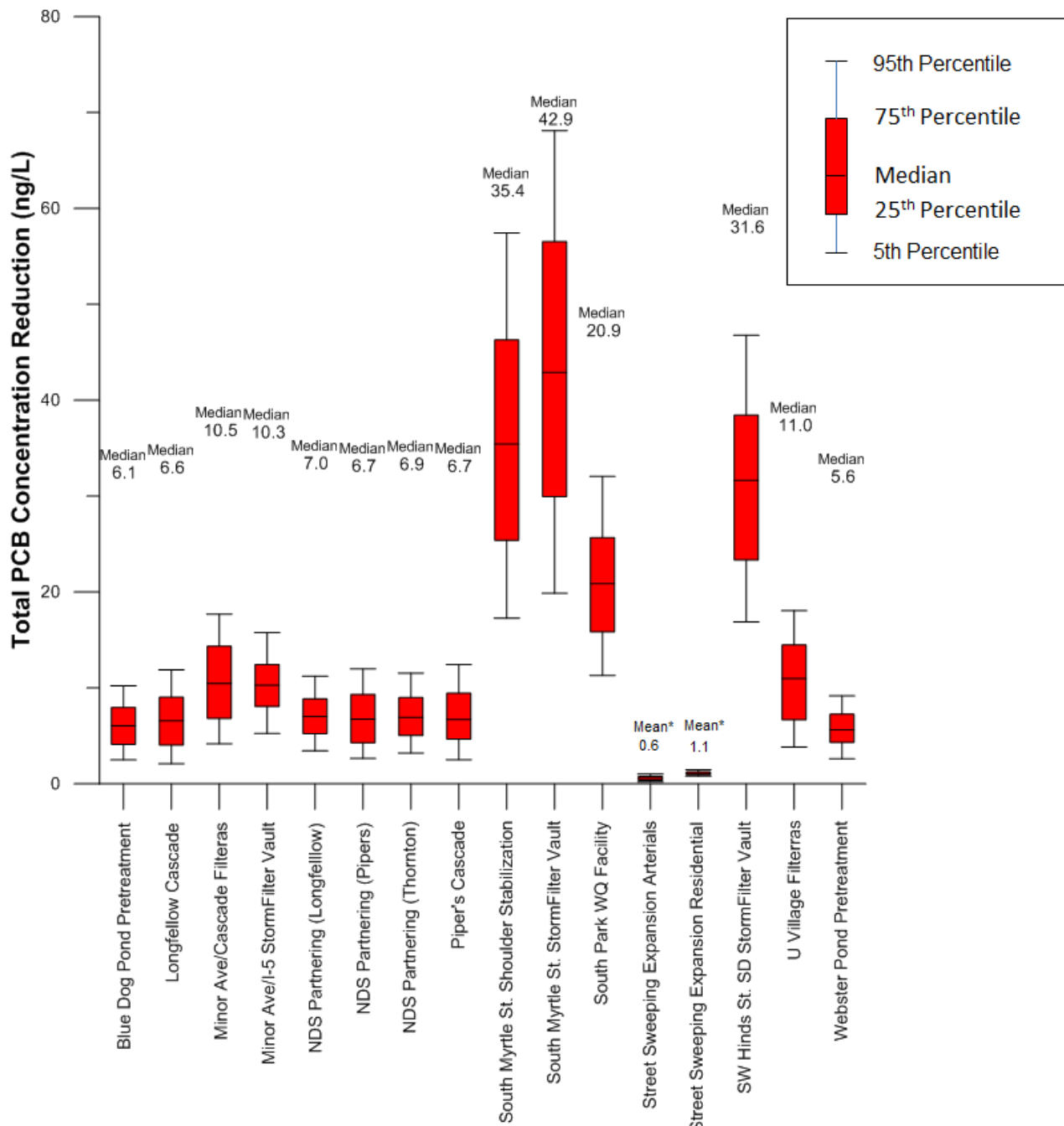


Figure F-3k. Long-term average annual concentration reduction for total PCBs

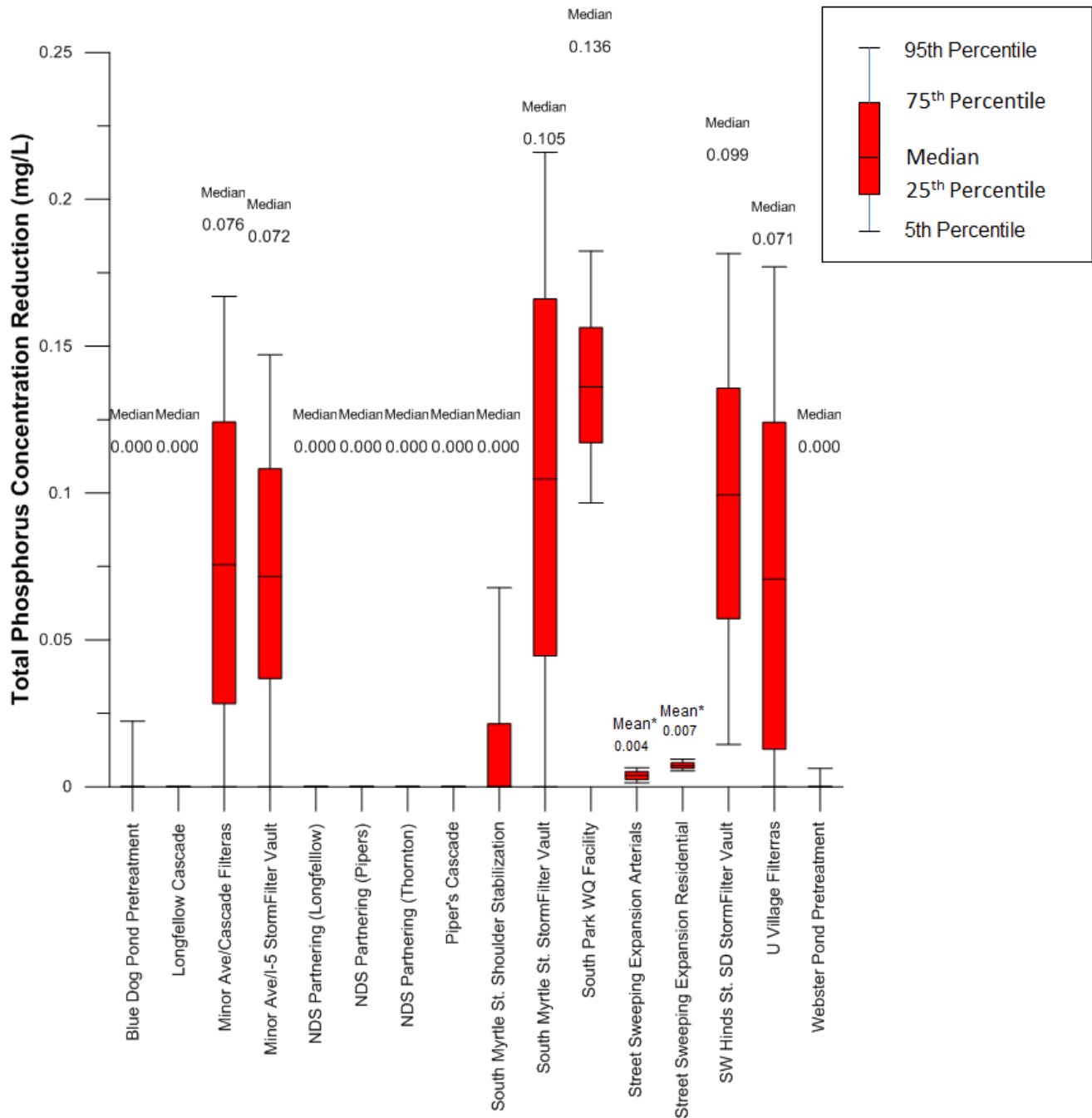


Figure F-3I. Long-term average annual concentration reduction for total phosphorus

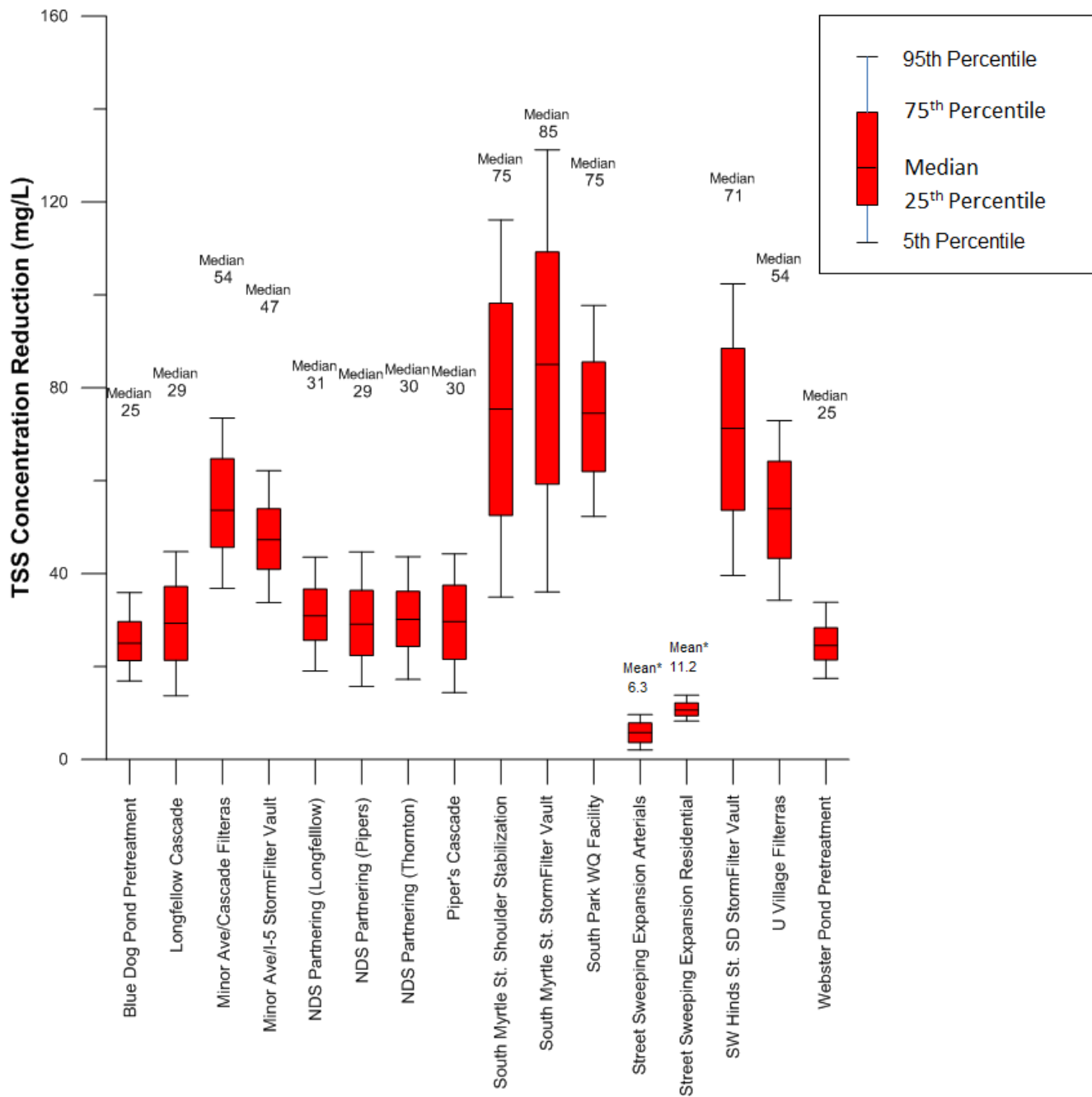


Figure F-3m. Long-term average annual concentration reduction for total phosphorus

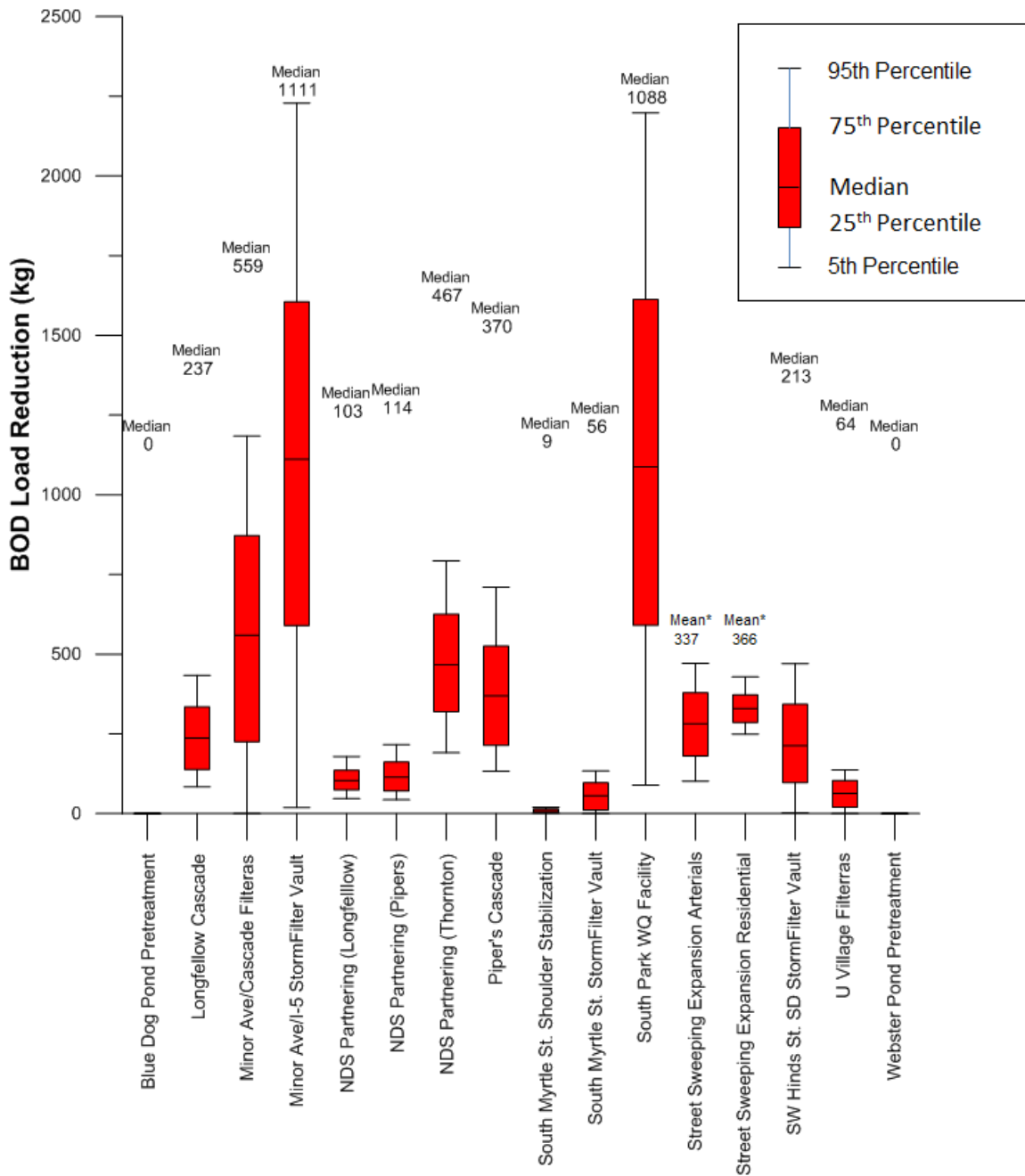


Figure F-3n. Long-term average annual load reduction for BOD₅

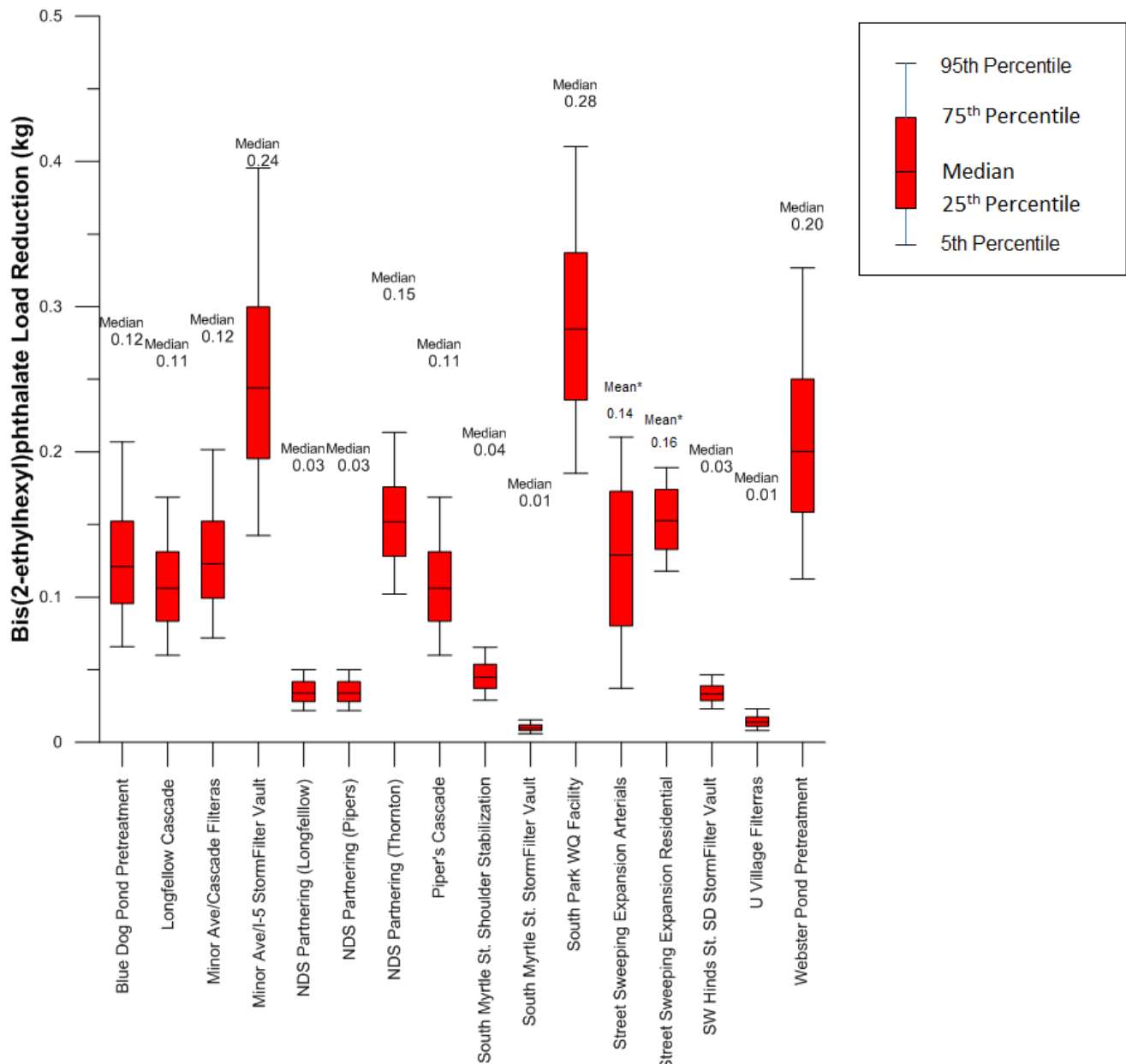


Figure F-30. Long-term average annual load reduction for bis(2-ethylhexyl)phthalate

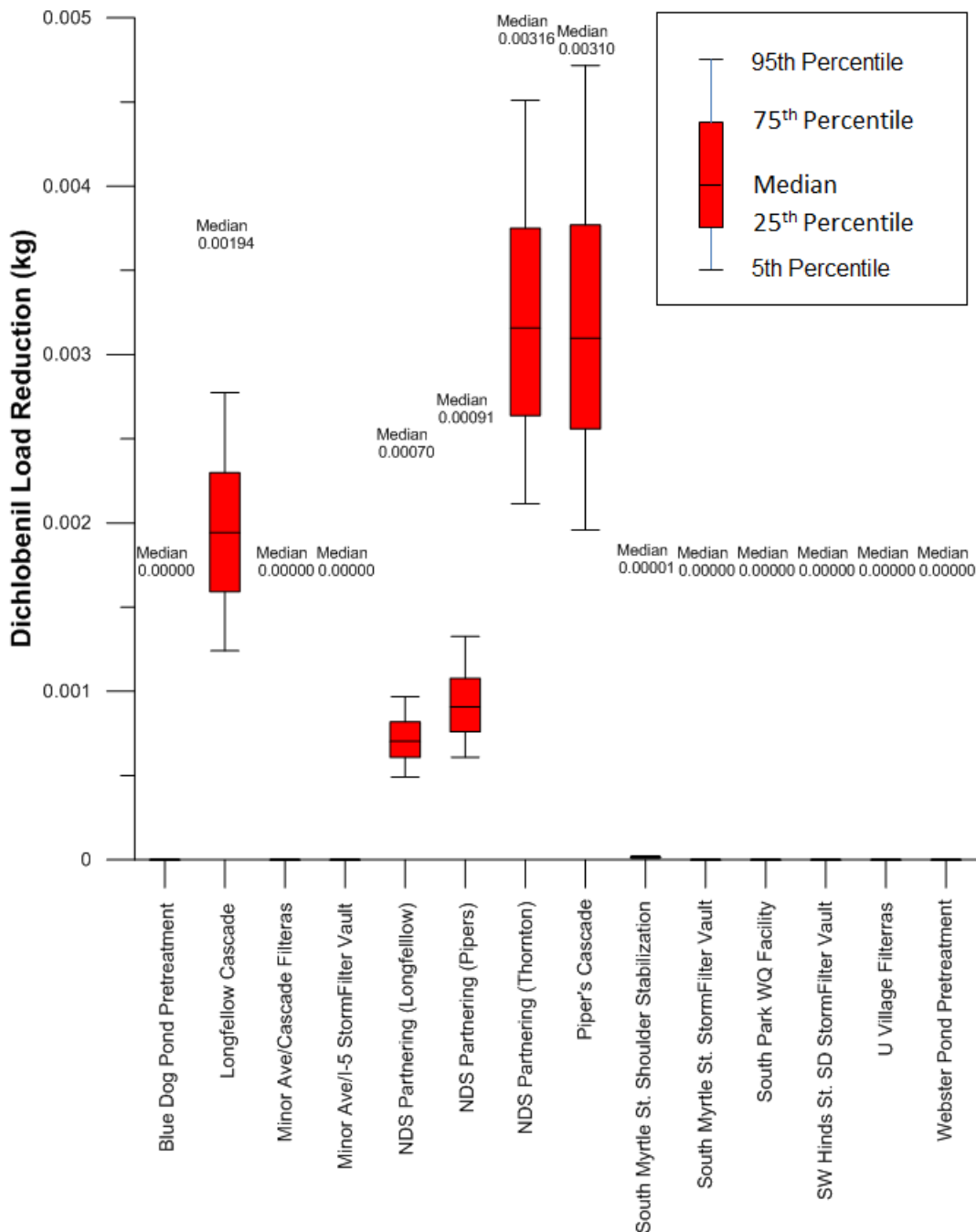


Figure F-3p. Long-term average annual load reduction for dichlobenil

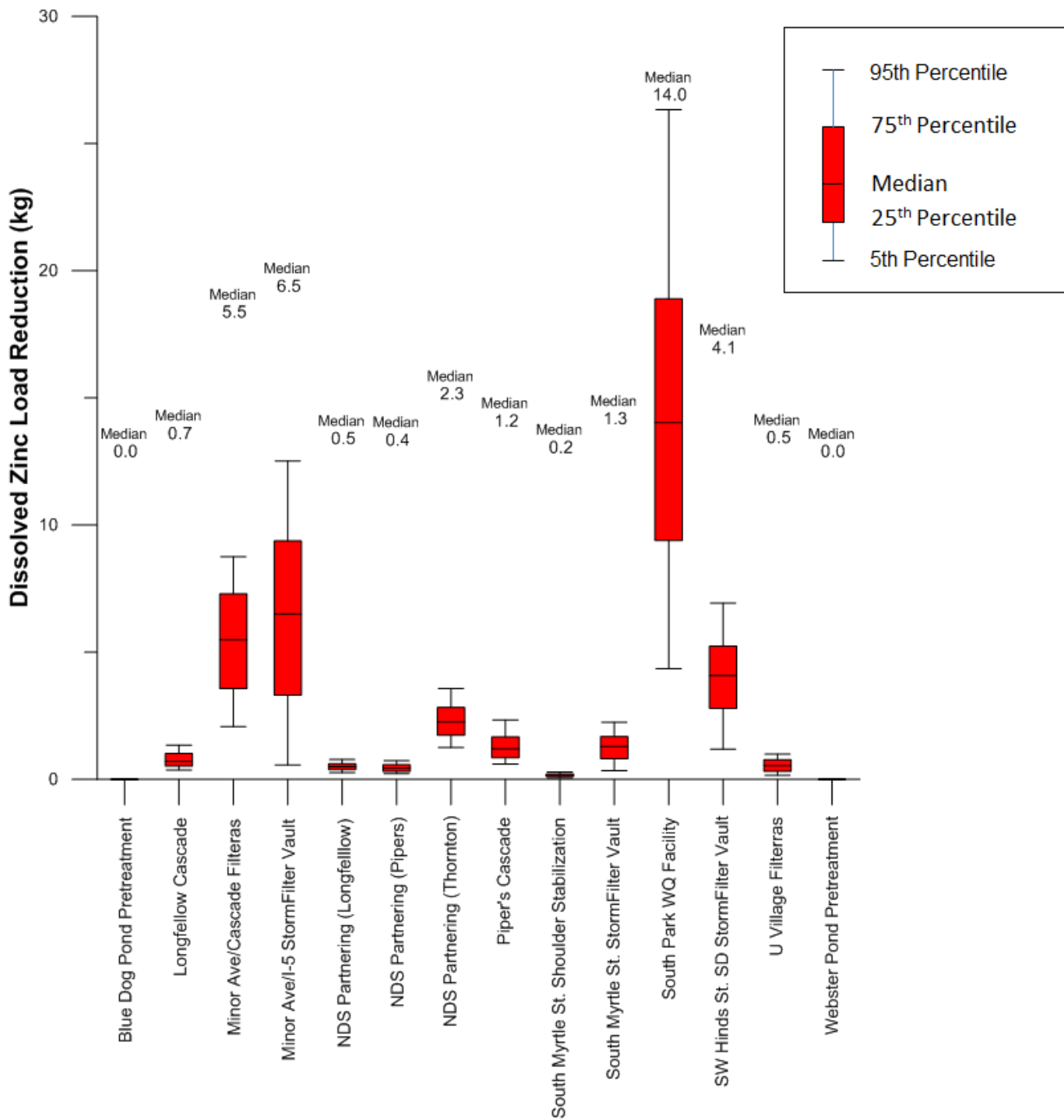


Figure F-3q. Long-term average annual load reduction for dissolved zinc

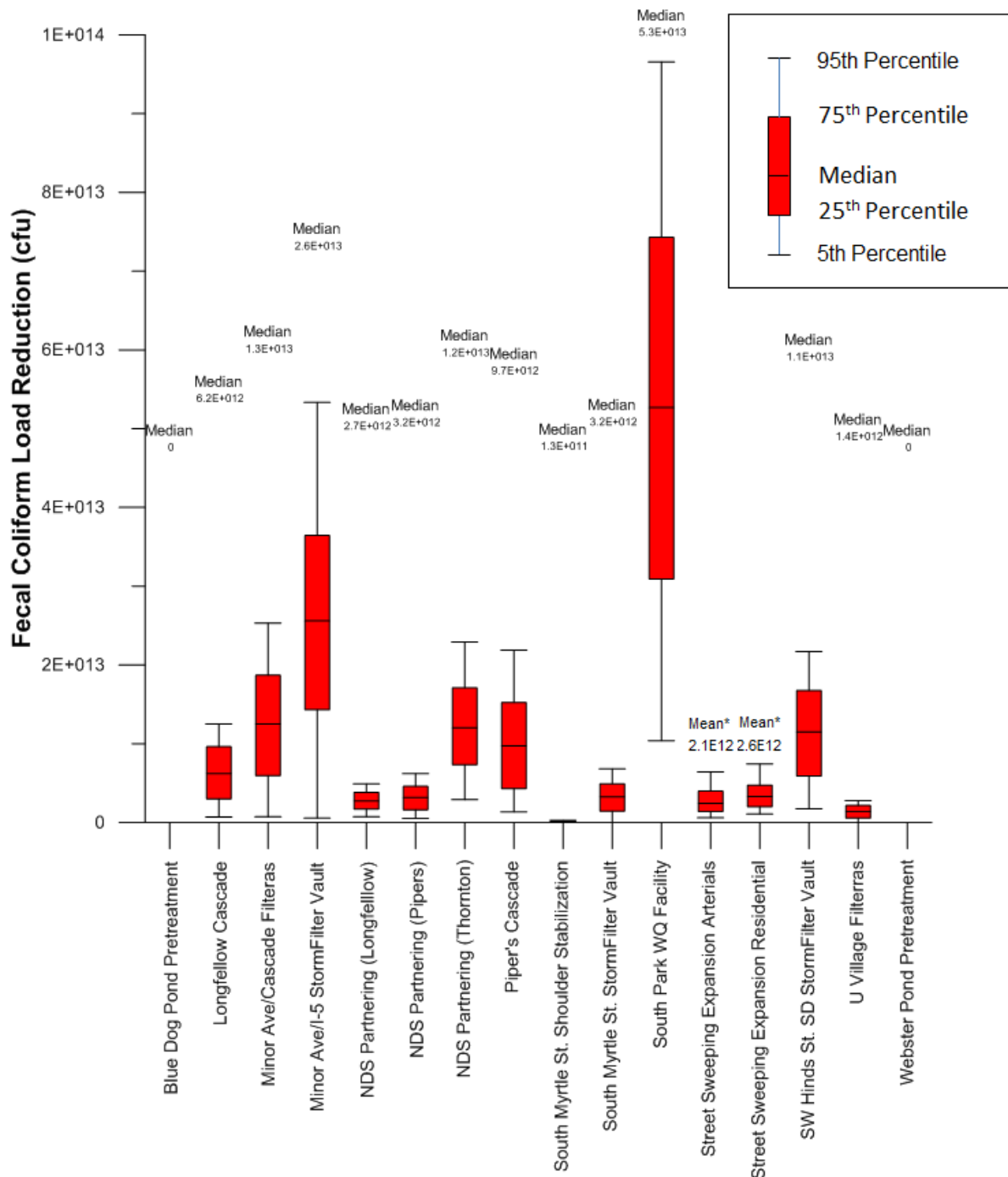


Figure F-3r. Long-term average annual load reduction for fecal coliform bacteria

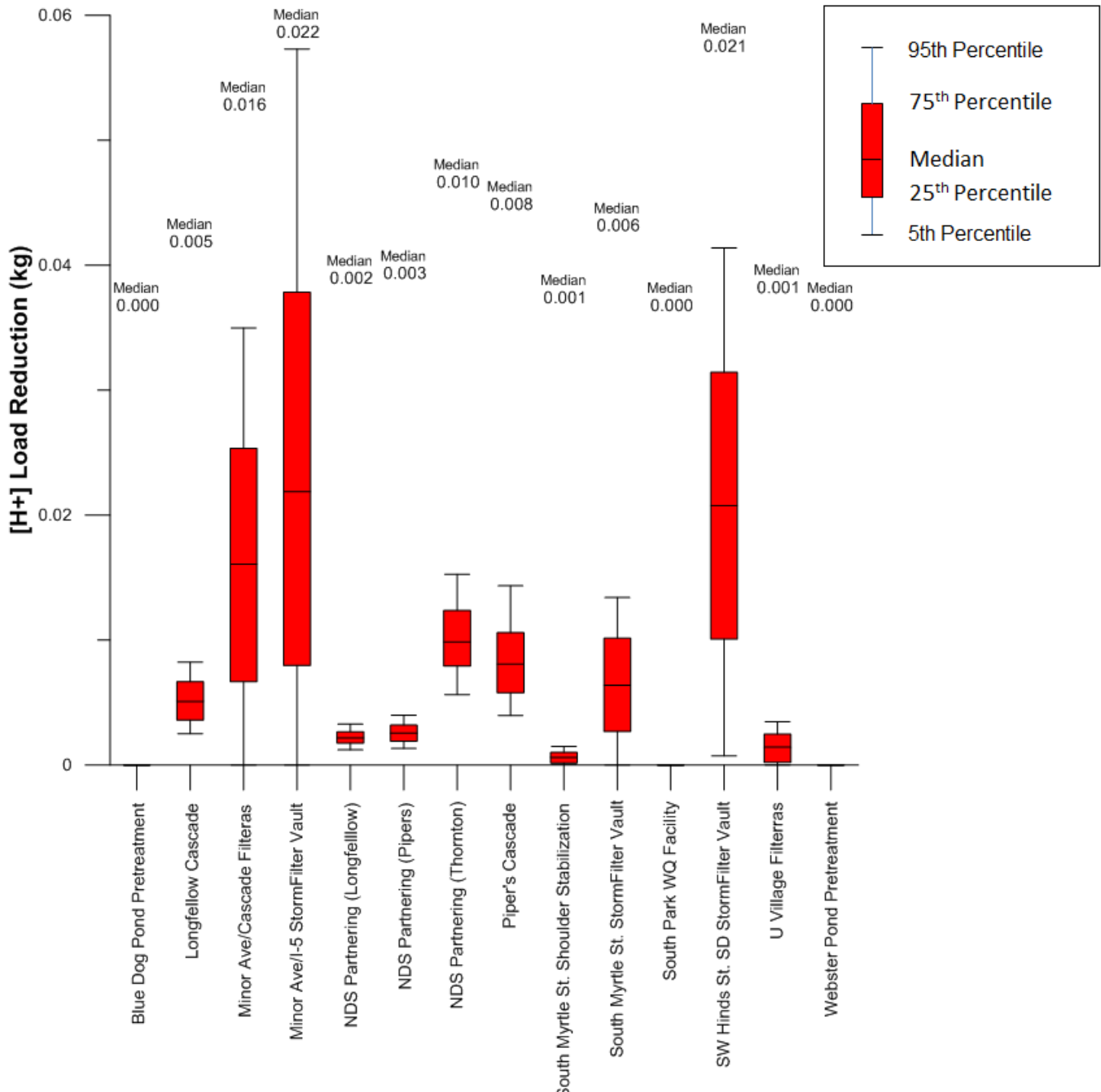


Figure F-3s. Long-term average annual load reduction for [H+]

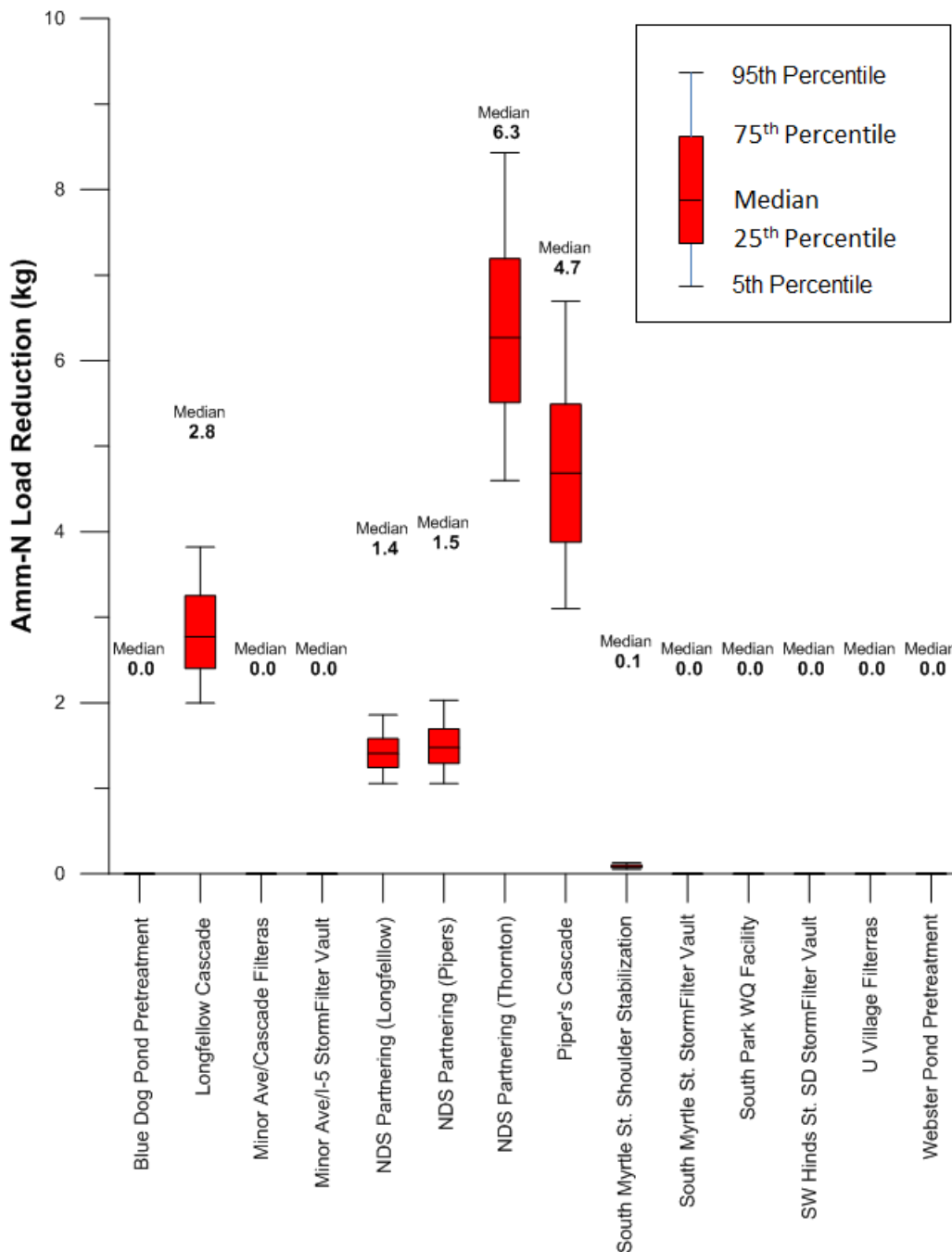


Figure F-3t. Long-term average annual load reduction for ammonia-N

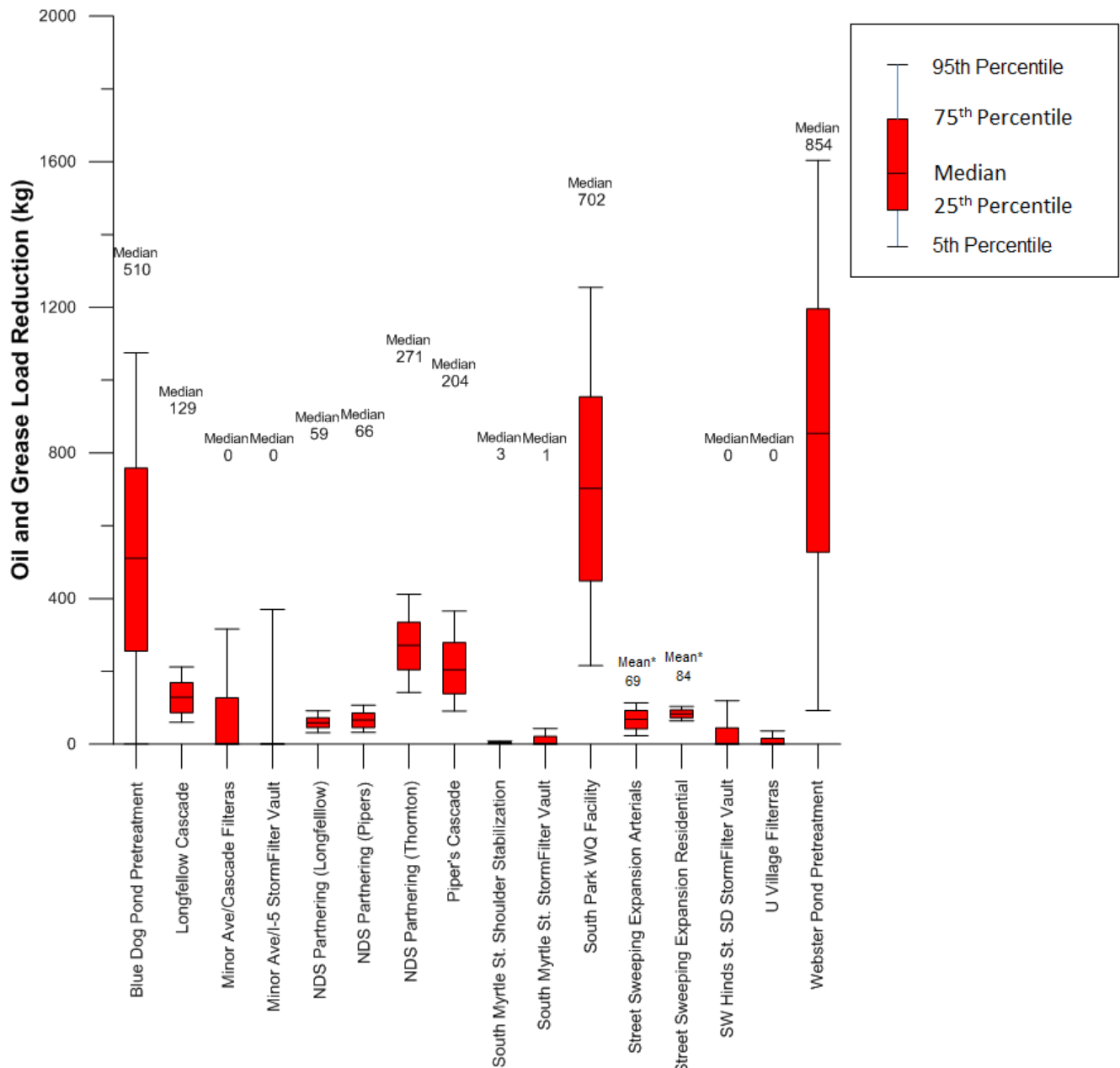


Figure F-3u. Long-term average annual load reduction for oil and grease

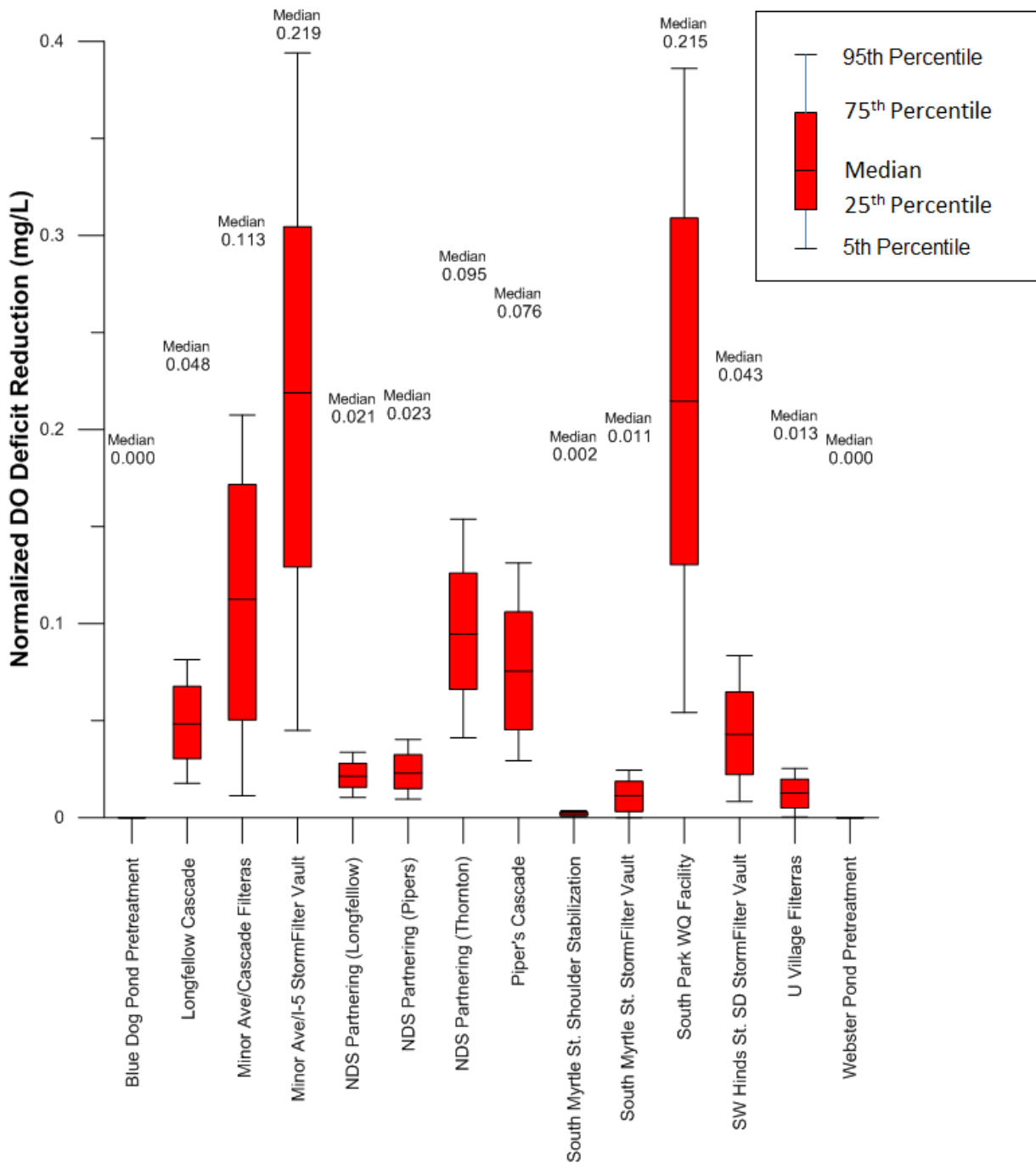


Figure F-3v. Long-term average annual load reduction for normalized DO

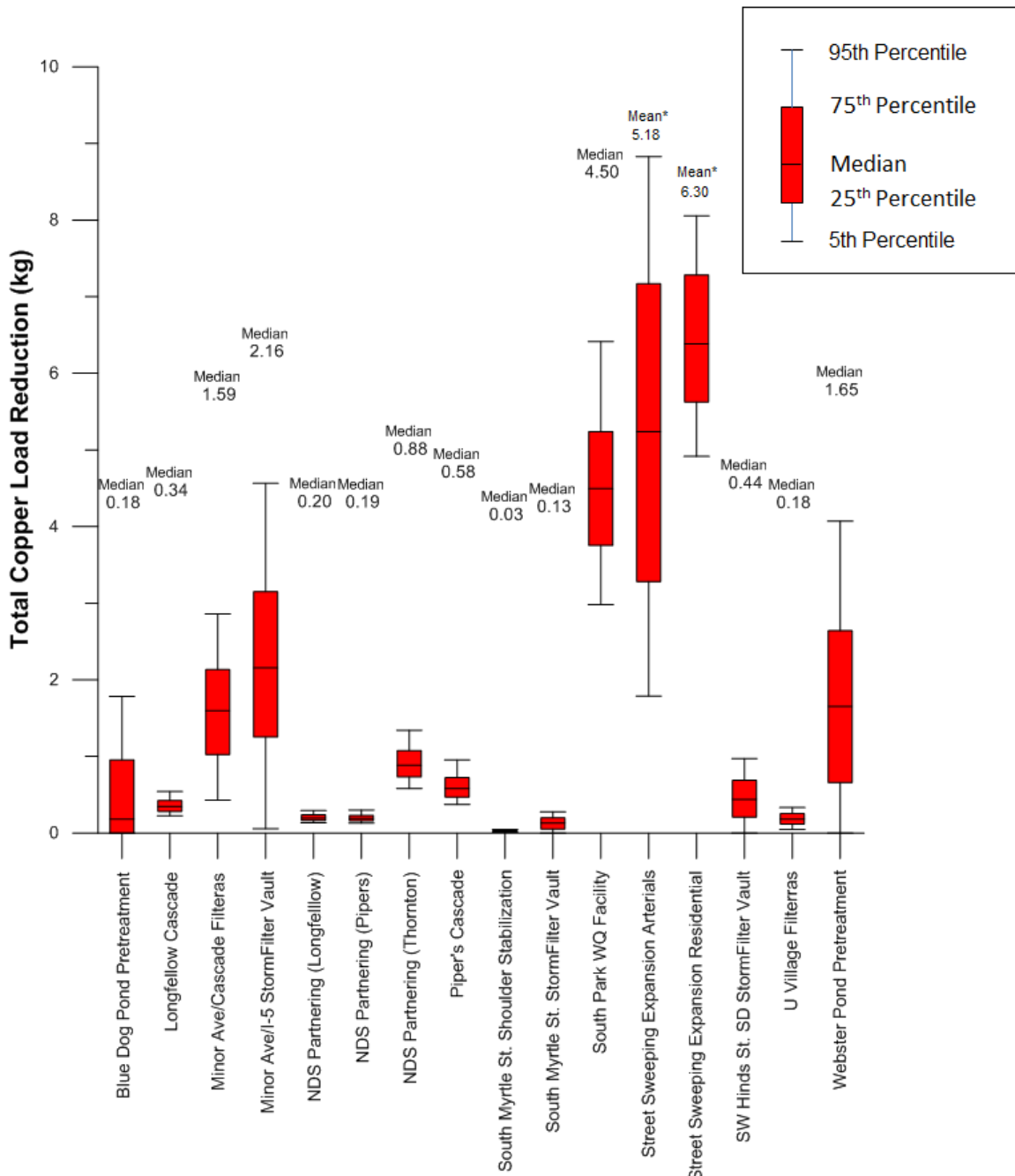


Figure F-3w. Long-term average annual load reduction for total copper

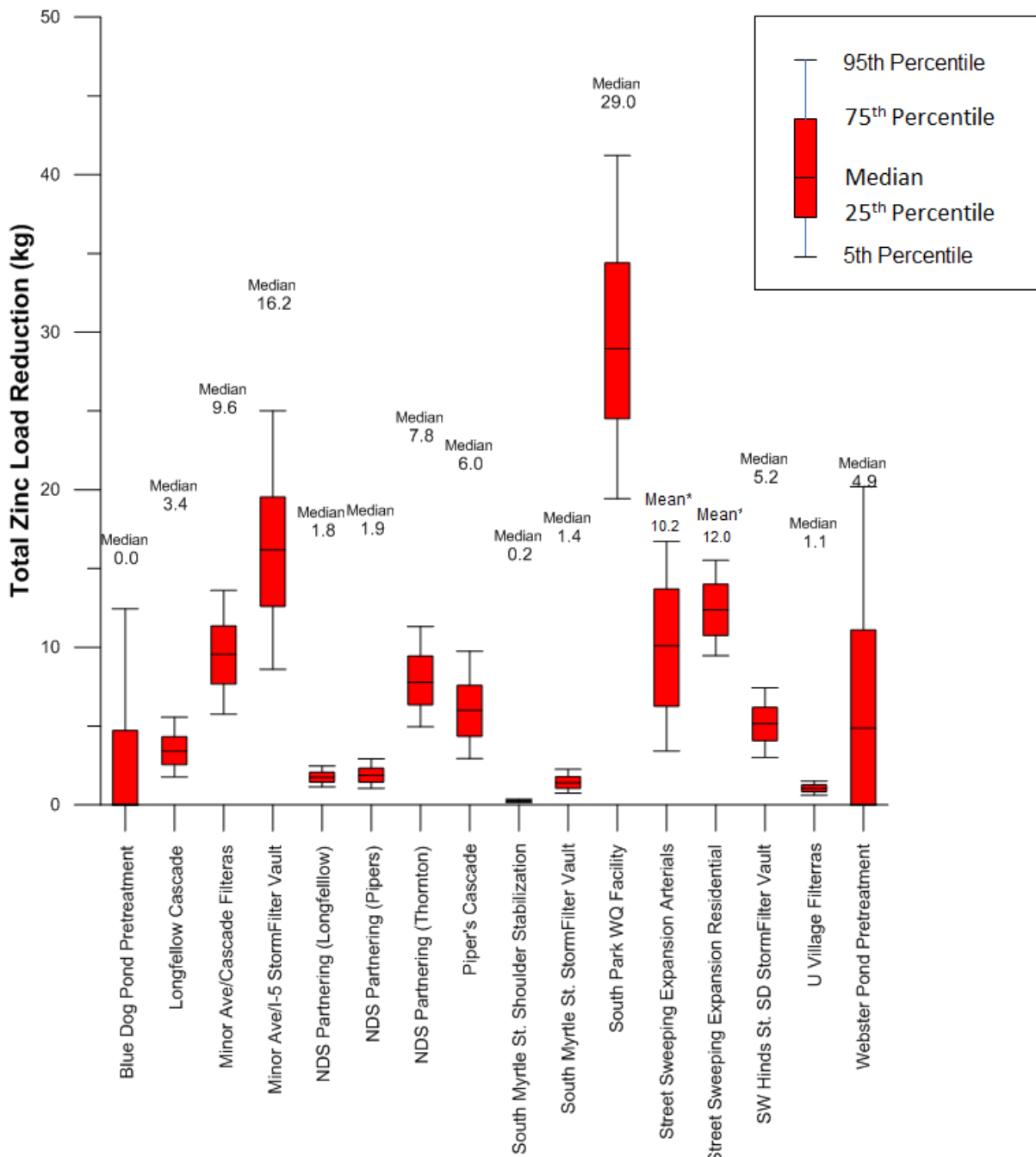


Figure F-3x. Long-term average annual load reduction for total zinc

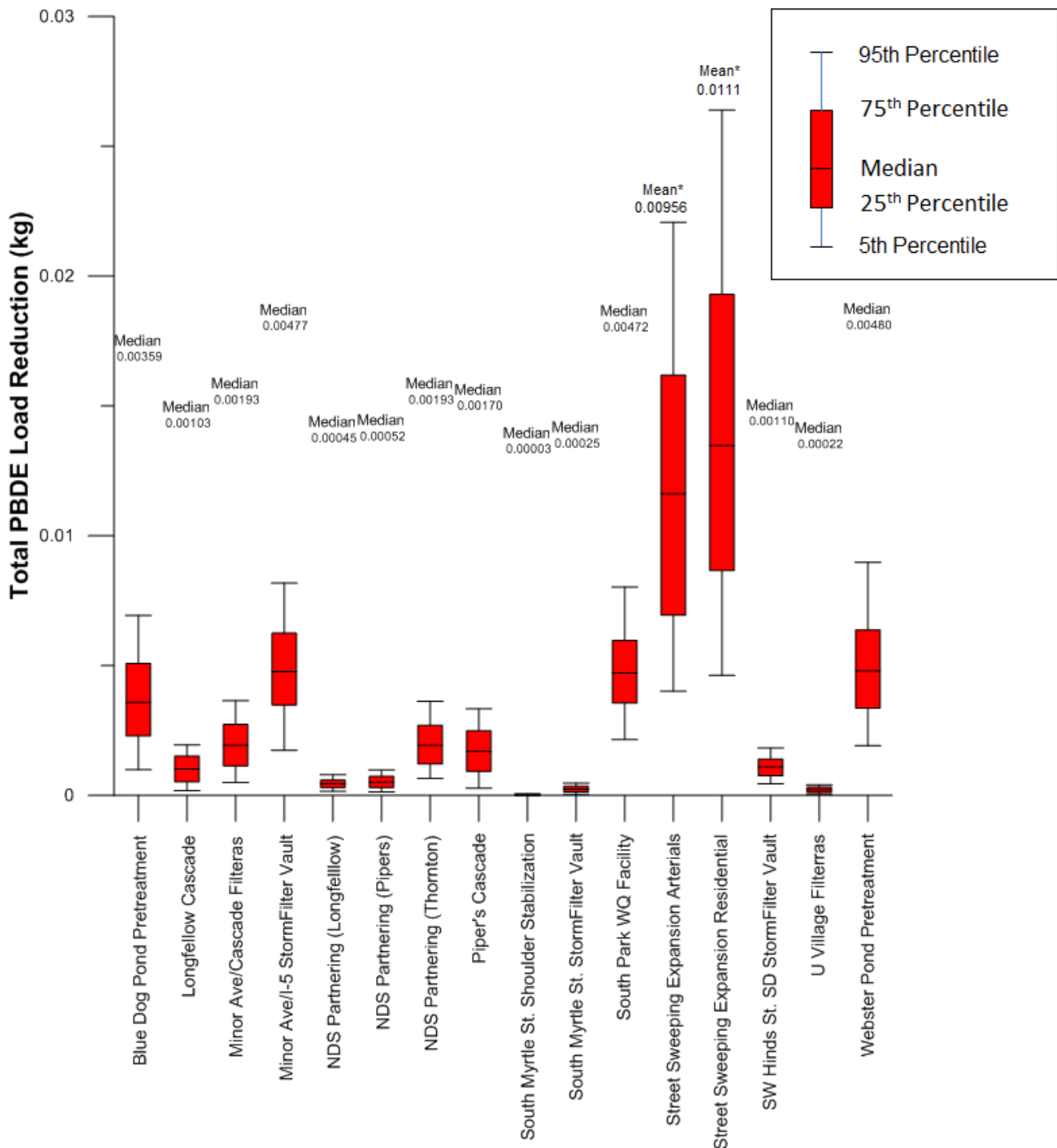


Figure F-3y. Long-term average annual load reduction for total PBDEs

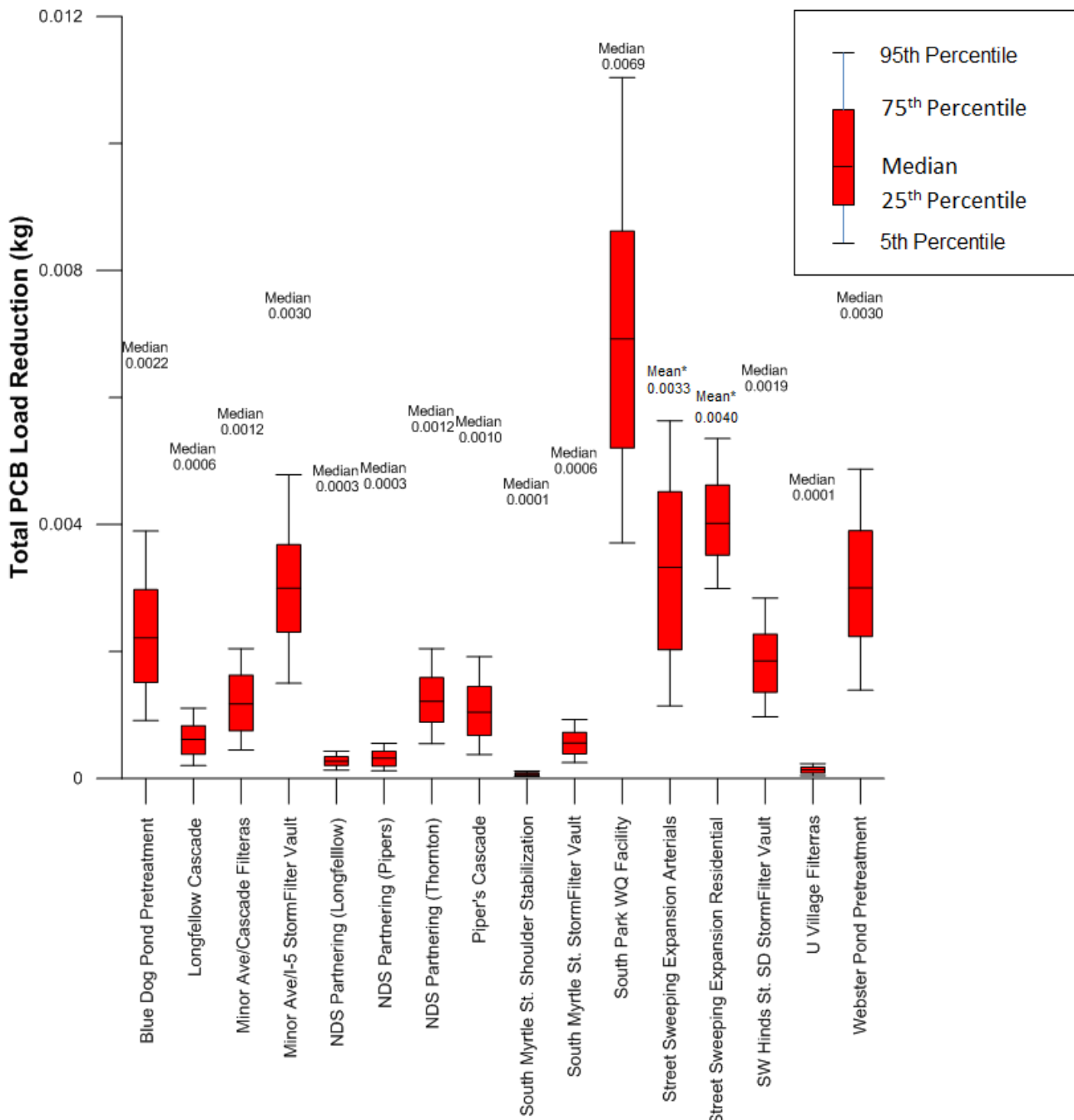


Figure F-3z. Long-term average annual load reduction for total PCBs

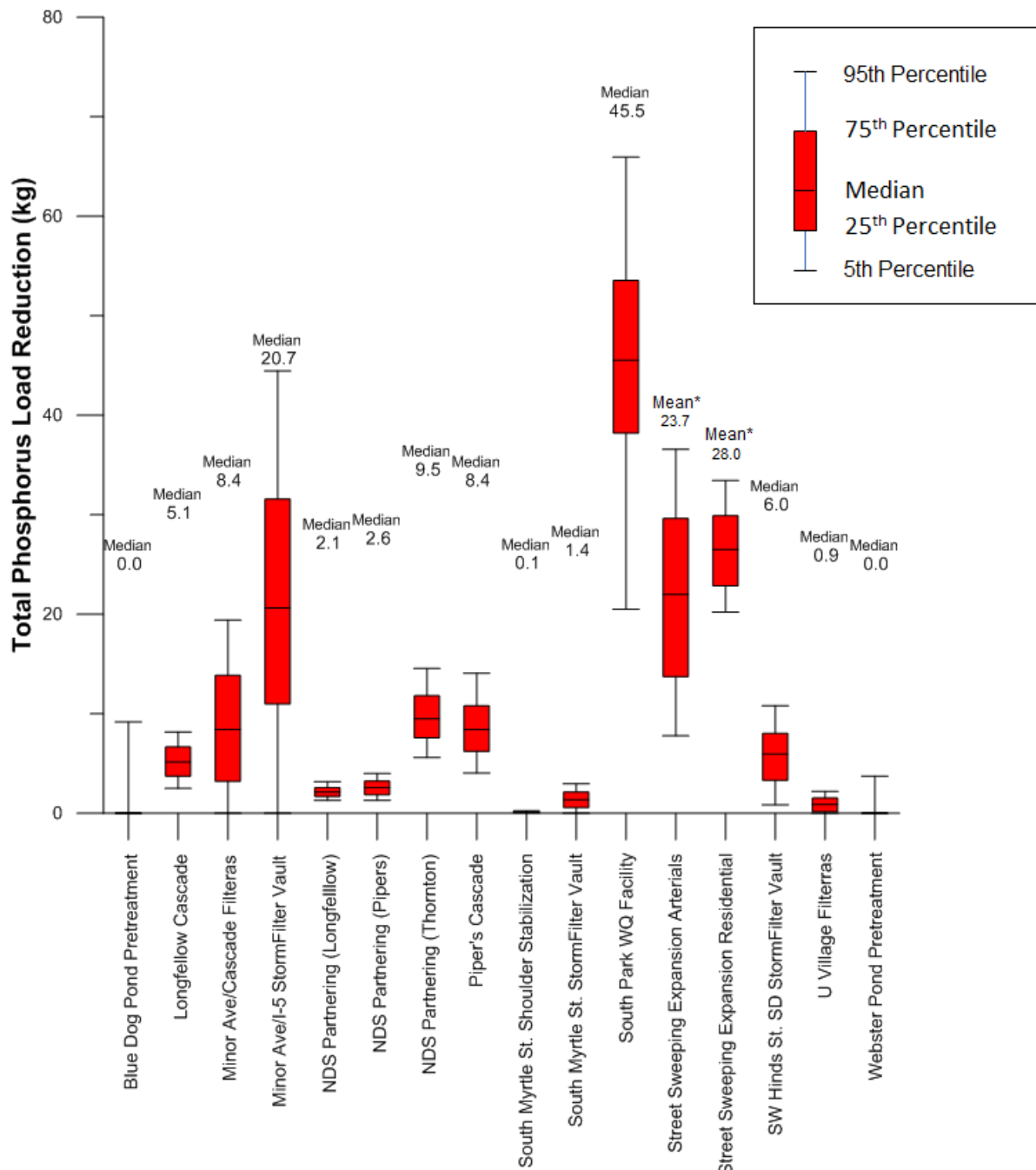


Figure F-3aa. Long-term average annual load reduction for total phosphorus

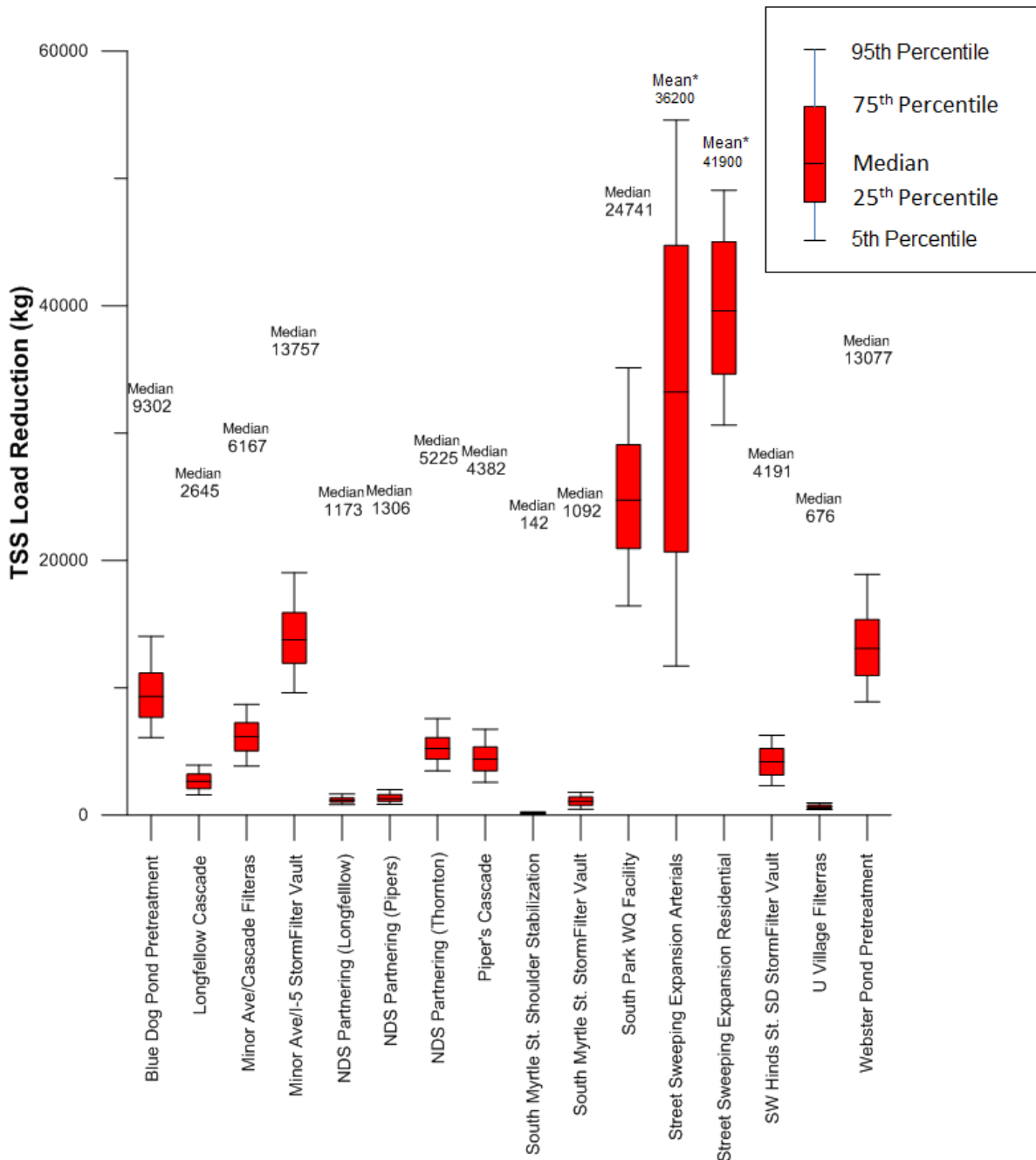


Figure F-3bb. Long-term average annual load reduction for TSS

Appendix G: Pollutant Reduction Estimation Method— Candidate Stormwater Street Sweeping Programs



Protecting Seattle's Waterways

Volume 3 – Integrated Plan

Appendix G: POLLUTANT REDUCTION ESTIMATION METHOD—CANDIDATE STORMWATER STREET SWEEPING PROGRAMS

Final

May 29, 2015



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Attachment G-1: Summary of Descriptive Statistics

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List of Abbreviations

Term	Definition	Term	Definition
°F	degree(s) Fahrenheit	NPDES	National Pollutant Discharge Elimination System
µg	microgram	NSQD	National Stormwater Quality Database
µm	micrometer	NURP	Nationwide Urban Runoff Program
AVL	Automatic Vehicle Location	PCB	polychlorinated biphenyl
BMP	best management practice	PES	primary environmental sample
BOD	biochemical oxygen demand	PM	particulate matter
BTEX	benzene, toluene, ethylbenzene, xylene	Program	Street Sweeping for Water Quality Program
BWOF	Bellevue washoff factor	PSD	particle size distribution
CFU	colony forming unit(s)	PV	Present Value
COD	chemical oxygen demand	PV\$	life-cycle cost
CSO	combined sewer overflow	RCOC	Representative Constituent of Concern
curb-mile	the total miles swept along the curb during a certain time period, typically on an annual basis	SAFL	St. Anthony Falls Laboratory
DSL	dry solids load	SPLP	Synthetic Precipitation Leaching Procedure
EPA	U.S. Environmental Protection Agency	SVOC	semi-volatile organic compound
Fine PM	fine particulate matter (less than 250 µm diameter particles)	swt	short wet tons
g	gram(s)	SDOT	Seattle Department of Transportation
IQR	interquartile range	TS	total solids
kg	kilogram	TSS	total suspended solids
KPI	Key Performance Indicator	TKN	total Kjeldahl nitrogen
lane mile	The length of a defined street sweeping route. Typically there are two lane miles for each mile of street length but may be more if the street has a divider.	WOF%	washoff fraction
lb	pound(s)	WOFL	washoff fraction load
LIMS	Laboratory Information Management System	WQ	water quality
MAG	Maricopa Association of Governments	WSL	wet solids load
mg	milligram(s)	WWHM	Western Washington Hydrology Model
MG	million gallons	yr	year(s)
mL	milliliter(s)		
mm	millimeter(s)		

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CHAPTER 1

Introduction/Overview

This appendix describes the methodology used to estimate washoff particulate-bound pollutant load and concentration reductions for the Integrated Plan candidate stormwater Street Sweeping Expansion Arterials and Street Sweeping Expansion Residential programs. These programs expand on the Street Sweeping for Water Quality Program (Program), a partnership between Seattle Public Utilities and Seattle Department of Transportation (SDOT), which began in February 2011. The objectives of the candidate stormwater street sweeping programs is to cost-effectively reduce the pollutant load running off Seattle's streets and discharging to receiving waters where feasible.

1.1 Candidate Stormwater Street Sweeping Programs

Two candidate stormwater street sweeping programs are included in the Integrated Plan analysis:

- **Street Sweeping Expansion Arterials** augments the current program scope. The target is to sweep 85 percent of curbed arterials during the night by increasing the current sweeping frequency and extending the sweeping season in order to increase the washoff pollutant load removed; i.e., the load picked up by the sweeper that would have washed into the storm drain, from approximately 90,000 to approximately 120,000 kilograms per year (kg/yr). Potentially 25 routes will be swept: 4 on a biweekly basis and 21 on a weekly basis, increasing the annual sweeping from the current amount of 10,000 up to 20,700 curb-miles. A formal parking compliance program is not anticipated.
- **Street Sweeping Expansion Residential** expands into new areas. The target is to sweep 65 percent of curbed local residential streets during the day and reduce the washoff pollutant load by approximately 40,000 kg/yr. Potentially 24 routes would be swept biweekly covering 11,500 curb-miles annually. A phased curbside access program will be implemented, beginning with public outreach and, if needed, including parking enforcement (parking enforcement costs are included in the cost estimate).

At full implementation, the current and candidate Street Sweeping Expansion Arterials and Street Sweeping Expansion Residential programs are anticipated to reduce the citywide annual pollutant load discharging to the municipal separate storm sewer system by approximately 5 percent.

1.2 Objective

The objective of this analysis is to characterize the candidate stormwater street sweeping programs pollutant load reductions to: (1) meet the Consent Decree Integrated Plan requirements for pollutant load reduction estimates and (2) for comparison with other Integrated Plan candidate projects from the perspective of the measurable conditions at the outfall. The basis of comparison is a washoff load, the load that would have been washed off the street to the storm drain had it not been picked up by the sweeper.

The characterization includes the following estimates:

- annual pollutant washoff load reduction from selected streets
- average annual washoff concentration reduction from selected streets for relative comparison with candidate projects and literature values

1.3 Selected Approach

The selected approach builds on the methodology implemented in 2007 to support SPU asset management principles, which determine when and where to make investments. The following triple-bottom-line metrics are typically used to compare and contrast candidate water quality projects and programs:

- Environmental benefits are represented by the average annual pollutant load removed (total suspended solids [TSS] per year).
- Economic considerations are represented by the project cost-effectiveness (life-cycle cost [PV\$] per kg of TSS removed per year [PV]).
- The social costs and benefits are typically represented qualitatively.

In 2010, an equivalent environmental TSS benefit metric was developed for street sweeping, a source-control best management practice (BMP), to allow comparison with water quality treatment BMPs. SPU assumed that the fine particulate matter (Fine PM), material less than 250-micrometer (μm) diameter, removed by the sweeper represents the particles that would be suspended in stormwater¹. The Fine PM is approximately 20 percent of the total load removed by sweeping. A similar approach was adopted by the Chesapeake Bay Program Expert Panel in March 2011 (Schueler, 2011).

In October 2013, based on input from the Integrated Plan Expert Panel, a more conservative approach was adopted for this analysis. The selected approach uses a washoff load, the particulate-bound pollutant load that would have been washed off the street to the storm drain had it not been picked up by the sweeper, as a basis for comparing street sweeping water quality benefits with structural stormwater treatment BMPs.

1.4 Key Assumptions

The washoff load, which is approximately 12 percent of the total load removed by sweeping, is estimated by applying the same percent washoff by size fraction and season observed by Pitt (1985) for street dirt washoff rates measured before and after rains in Bellevue, Washington.

Pollutant load and concentration reductions are reported for the washoff particulate-bound fraction only.

- The washoff particulate-bound pollutant load reductions do not consider the seasonal volatile components removed by the sweeper; for example, fall leaf drop and grass clippings. Others (Kalinsky, 2012; Strynchuck, 2000) found that those components have the potential to increase oxygen demand and contribute to nutrient loading.
- The washoff particulate-bound pollutant load reductions do not consider the potential for metals leaching. Synthetic Precipitation Leaching Procedure (SPLP) tests on the sweepings indicate that this is a possibility (see Attachment G-2, Figures G-2g and G-2h).

¹ Structural treatment BMPs typically have a range of removal performance and automatic samplers have been reported to be less reliable at capturing particulate matter (PM) greater than 250 μm (Clark et al., 2007).

The washoff particulate-bound pollutant load reduction is estimated based on measured pick-up rates, the particulate-bound pollutant load removed per curb-mile swept.

1.5 Method Overview

The data used to develop the load reduction estimates were collected by SPU to support performance monitoring for the Program. Currently, 24 routes covering 675 lane miles, of which 490 lane miles (73 percent) drain directly to the storm sewer system, are scheduled for sweeping. This includes 16 night routes and 4 day routes that are swept on a biweekly basis and 4 night routes on a weekly basis. There is no formal parking compliance program at this time.

In 2011, pick-up rates, pollutant load reduction per curb-mile swept, were established as Program Key Performance Indicators (KPIs) and for planning metrics. Table 1-1 provides measured average annual pick-up rates by year through 2013.

Table 1-1. Program Average Annual Pick-Up Rates by Year through August 2013 (lb/curb-mile swept)			
Pick-up rates	2011	2012	2013
Wet solids load (lb/curb-mile)	230	270	252
Dry solids load (lb/curb-mile)	150	170	160
Fine PM load (lb/curb-mile)	30	38	34
Washoff PM load (lb/curb-mile)	19	22	19

The wet and dry solids loads include the total load removed, regardless of the size fraction. The Fine PM load only includes the material less than 250 μ m.

For the purposes of the Integrated Plan, the use of pick-up rates as a planning metric is expanded to include the Representative Constituents of Concern (RCOC).

- The candidate Street Sweeping Expansion Arterials and Street Sweeping Expansion Residential programs estimated that washoff load reductions for each RCOC are the product of the planned curb-miles for the program for a sweeping frequency times the pick-up rate for the program and sweeping frequency for each RCOC.
- The washoff concentration reduction is the quotient of the estimated load reduction for each RCOC divided by the average annual runoff volume.

Figure 1-1 provides an overview of the process for developing the load and concentration reductions.

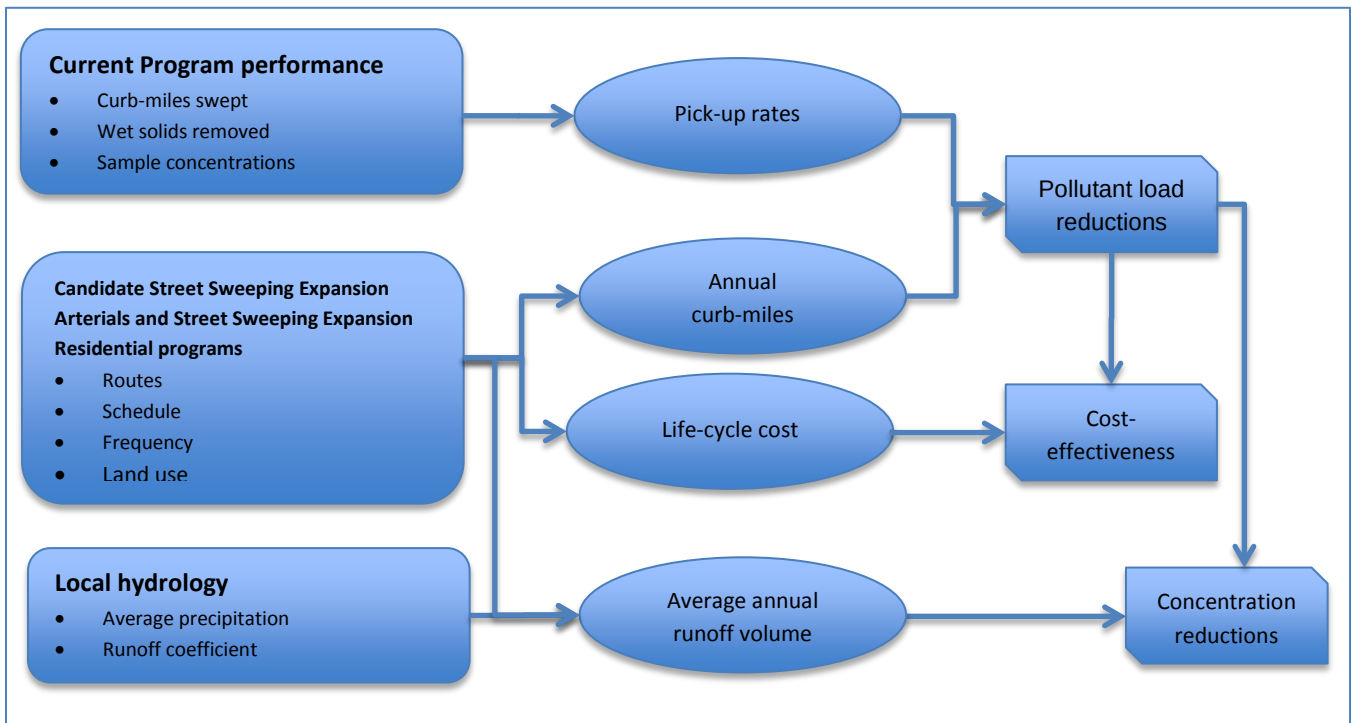


Figure 1-1. Overall process for developing candidate stormwater street sweeping programs performance metrics

1.6 Issues for Further Consideration

During the process of developing pollutant load and concentration reduction estimates for the candidate stormwater street sweeping programs, several areas were identified that may be considered for additional analysis in the future. These include:

- development of a representative dry season fecal coliform pick-up rate
- establishment of the representativeness of particles less than 250 µm in diameter to estimate the concentration of washoff particles
- expansion of the parameter list to include ammonia-N and other organic compounds of interest
- development of a more representative biological oxygen demand (BOD) metric
- development of a relationship to estimate dissolved metals pollutant load and concentration reductions
- development of a method to estimate seasonal volatile solids loadings (e.g., fall leaf drop)
- confirmation that the washoff assumptions are appropriate for the candidate Street Sweeping Expansion Arterials program

1.7 Limitations

The reader should consider the following limitations of the analysis:

- The cost estimate for the candidate Street Sweeping Expansion Arterials program assumes that funding for the portion of the routes draining to the combined sewer system will be provided. This will require an approximate doubling of the SDOT current budget to support the Program.
- The analytical sample results have undergone the process of data review, verification, and validation. The process of quality assessment to ensure that the data meet the quality to support the intended use is ongoing.
- The aggregate nature of the load estimates limits the ability to predict load reductions under different sweeping frequency, land use, road type, and parking compliance conditions.
- The results represent the sweeping practices, sweeping conditions, and rainfall patterns over the course of the period of record.
- The data set is not robust enough to adequately characterize highly variable parameters, such as fecal coliform. Street solids pollutant concentrations are strongly influenced by the particle size and density (ITRC, 2012). In addition, contaminants may bond loosely or tightly to street solids depending on the geochemical makeup of the soil, organic matter content, ambient conditions, and physical and chemical properties of a particular pollutant. Collecting representative samples is challenging.

1.8 Document Organization

This document is organized into three main topics:

- Chapter 2: Data compilation, which describes the data sources, input values, and assumptions used to develop the candidate stormwater street sweeping programs' washoff particulate-bound load and concentration reduction estimates.
- Chapter 3: Methodology, which describes the process to develop the candidate stormwater street sweeping programs' particulate-bound load and concentration reduction estimates.
- Chapter 4: Results, which describes the candidate stormwater street sweeping programs' estimated washoff particulate-bound load and concentration reduction estimates.

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CHAPTER 2

Data Compilation

This chapter describes the data sources, input values, and assumptions used to develop the candidate stormwater street sweeping programs' washoff particulate-bound load and concentration reduction estimates.

2.1 Inputs to Measured Particulate-Bound Pollutant Pick-Up Rate

The two primary inputs needed to estimate measured washoff particulate-bound pollutant pick-up rates include:

- measured program performance metrics: curb-miles swept, and wet load removed
- representative sample concentrations

2.1.1 Program Performance Metrics

Key assumptions supporting development of the pick-up rates include:

- Street sweeping program metrics represent Seattle conditions:
 - street dirt accumulation as a function of land use and street texture
 - washoff as a function of street loads, street texture, and rainfall intensity
 - productivity as a function of sweeper type, street texture, and parking controls and season
- The water quality (WQ) bin wet load recorded by the waste disposal facility truck scale represents the wet load removed from the routes swept and deposited at each location since the last haul date.

From program commencement in February, 2011 through 2013, 37,700 curb-miles, of which 27,030 (72 percent) drain directly to the storm sewer system, have been swept. The current route land use distribution is 29, 15, and 56 percent commercial, industrial, and residential, respectively. Ninety-six percent of the routes are arterials; the remaining 4 percent are local streets; i.e., streets with low traffic volume. Schwarze regenerative air sweepers swept the routes: model A8000 through early 2013 when the fleet was upgraded to model A9000 (Figure 2-1).

The Program performance tracking is based on two data sources:

- **Curb-miles swept:** Approximately 37,700 curb-miles have been swept since the program inception (combined sewer system and storm sewer system). Mileage was manually tracked by sweeper operators from equipment odometer readings until February 2013, at which point an Automatic Vehicle Location (AVL) system went on line. The AVL system reports time and distance sweeping and traveling. The sweeping time and distance is broken down by sweeping of the specified route, sweeping of the portion of the specified route that drains to the storm sewer system, and sweeping of a non-specified route.
- **Wet solids load removed:** Approximately 4,770 short wet tons (swt) of sweepings have been removed since the inception of the Program (combined sewer system and storm sewer system). Sweeper operators empty their hoppers at one of two WQ temporary storage bins: Haller Lake in the north and Charles Street in the south. Bins are emptied periodically, biweekly to bimonthly, and the wet weight removed is recorded from the waste disposal facility truck scale readings.

Table 2-1 summarizes the available performance data and includes the total curb-miles swept and wet solids load removed, of which approximately 72 percent of the mileage is within the storm sewer system.

Table 2-1. Summary of Annual Program Performance and Basis for Estimating Integrated Plan Programs

	2011			2012			2013		
	Annual	Wet season	Dry season	Annual	Wet season	Dry season	Annual	Wet season	Dry season
Annual curb-miles swept	9,848	4,337	5,512	14,710	6,523	8,187	13,116	5,888	7,229
Wet solids load removed (swt)	1,137	545	592	1,978	1,234	744	1,652	716	555



Figure 2-1. Schwarze model A9000 regenerative air sweeper

2.1.2 Program Sample Concentrations

This section includes:

- a brief description of the sample collection process and analysis
- a summary of sample results

2.1.2.1 Sample Collection and Analysis

Key assumptions supporting analysis of the WQ bin sample concentrations include:

- WQ bin samples represent the pollutant concentrations of the load removed by the sweepers sweeping assigned routes and covering recorded curb-miles since the last sample date at that WQ bin, which typically ranges from 1 to 14 days.
- Sample concentrations from the particles less than 250 μm represent the pollutant concentrations in the washoff particles. This may be over-representing some pollutant concentrations that tend to increase with decreasing particle size.

Program street sweeping solids concentration sampling at the temporary storage bin locations began August 19, 2011. On August 24, 2012, a protocol to split the whole sample and analyze both the whole sample and the particles less than 250 µm was implemented (Figure 2-2).

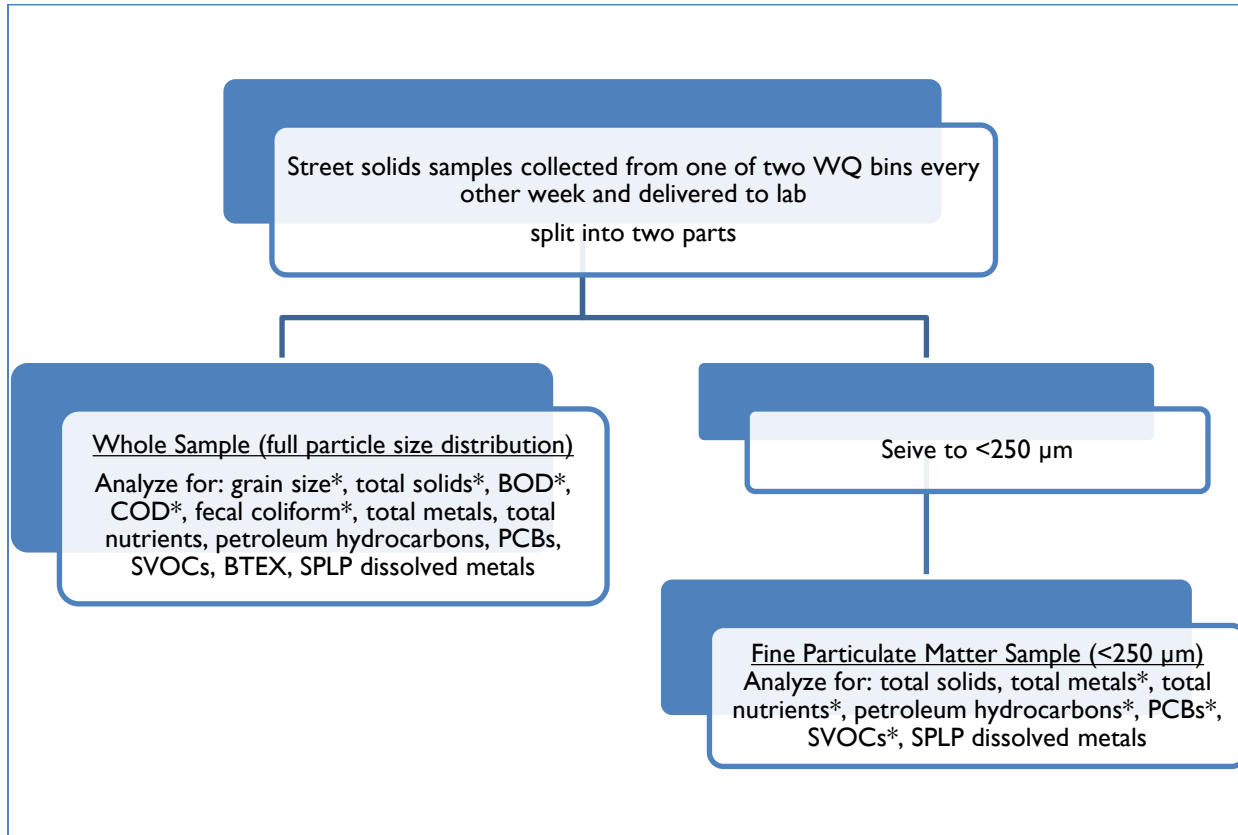


Figure 2-2. Sample processing and analysis summary

Sample results from analytes or analyte groups noted with a * are used in the pollutant reduction analysis.

Samples are collected approximately every other week during program operations from each bin (see Figure 2-3). A decontaminated stainless-steel shovel is used to excavate three to six sub-sampling locations (depending on estimated volume of new material in the bin), each approximately 2 to 2.5 feet deep from the vertical surface of the pile. A sub-sample (approximately one shovelful) is collected from the bottom of each excavation and placed in a large decontaminated stainless-steel bowl.

All sub-samples are homogenized with a decontaminated stainless-steel spoon and synthetic, metal, and/or plastic material is removed. The homogenized material is then placed into sample containers and taken to Analytical Resources, Inc., a local commercial analytical laboratory, to be processed. The laboratory performs analyses on the whole grain size fraction of each sample—with a parallel process of sieving a portion of the material to obtain and analyze the Fine PM (<250 µm grain size fraction). Analytical results are received from the lab, reviewed and verified, loaded to SPU's EQuIS database, a proprietary Laboratory Information Management System (LIMS) application, and then validated by SPU staff.



Figure 2-3. WQ bin sampling at Haller Lake on 10/8/2013

From upper left to lower left; preparing sample locations, homogenizing sub-samples, and final sample jars ready for the laboratory.

Figure 2-4 below shows the Charles Street and Haller Lake WQ bins.



(a) Charles Street WQ bin on 9/24/2013.
Sampling equipment on right side of bin.



(b) Haller Lake WQ bin on 7/31/2013.

Figure 2-4. Temporary WQ sampling bin locations

2.1.2.2 Sample Results

Table 2-2 below summarizes the analyzed RCOCs and the number of samples collected during the period of record. Sample concentration descriptive statistics and box plots are provided in Attachments G-1 and G-2 of this appendix, respectively.

Table 2-2. Summary of Sampling Program Objectives, Parameters, and Sample Sizes			
Street sweeping environmental performance indicator	Analytical parameter	Sampling period of record	No. of samples collected
Dry street solids load removed	Solids, total; moisture %	8/5/2011 through 11/18/2013	88
Fine particulate matter and washoff fraction (load reduction)	Grain size	8/19/2011 through 11/18/2013	88
Pollutant load removed within fine particulate fraction (<250 μm) ^a	Biological oxygen demand (BOD ₅) ^b	7/23/2012 to 11/4/2013	37
	Bis(2-ethylhexyl)phthalate	8/10/2012 to 11/4/2013	34
	Copper, total	8/10/2012 to 11/4/2013	36
	Fecal coliform ^b	8/19/2012 through 11/4/2013	33
	Motor oil	8/19/2012 through 11/4/2013	33
	Nitrogen, total Kjeldahl	8/10/2012 to 11/4/2013	36
	PCBs	8/10/2012 to 11/4/2013	35
	Phosphorus, total	8/10/2012 to 11/4/2013	36
	Zinc, total	8/10/2012 to 11/4/2013	36

a. Fine PM, material less than 250 μm diameter, represents the particles that would be suspended in stormwater. Structural treatment BMPs typically have a range of removal performance and automatic samplers have been reported to be less reliable at capturing PM greater than 250 μm (Clark et al., 2007).

b. Analysis of BOD₅ and fecal coliform is not practical for the Fine PM fraction; concentrations for the whole sample are assumed to be representative of the material less than 250 μm .

Key assumptions supporting analysis of the WQ bin sample concentrations include:

- General:
 - All pollutant sample concentrations are reported on a dry weight basis.
 - Sample results reported as less than the method reporting limit are assumed to be zero for fecal coliform and aroclors, the only RCOC parameters with non-detects. Fine PM is estimated by subtracting the percent mass retained on a 250 μm screen from 100 percent, thus reducing the influence from non-detect sample results for material finer than 250 μm .
- BOD₅ and COD:
 - WQ bin sample analysis of BOD₅ and chemical oxygen demand (COD) within the Fine PM fraction is not practical given the nature of the sampling approach; concentrations for the whole sample for these parameters are assumed to be representative of the material less than 250 μm . Pitt (2004) reported that the concentration of COD increased with increasing particle sizes, likely a function of increasing amounts of organic material in the larger particle sizes.
 - Samples were analyzed for COD to supplement BOD₅ concentration results. It is assumed that the BOD₅ concentrations under-represent the oxygen demanding load because the analytical test was designed to measure the BOD₅ concentration in wastewater. The ratio of the median COD to BOD₅ concentrations reported in the National Stormwater Quality Database (NSQD, version 1.1), is 6.2 for a sample size of 3,105 and 2,750 for BOD₅ and COD, respectively. The ratio of the street sweeping WQ bin sample concentration medians for COD to BOD₅ is 37 to 1.
- Ammonia:
 - Samples were analyzed for total Kjeldahl nitrogen (TKN) to represent ammonia. The results were not used because a reasonable correlation is not available and it is likely that conversion of TKN is ongoing in the pile between sampling events. Walch et al. (2005) found a range of ammonia to TKN ratios between 0.08 and 0.32, indicating that ammonia concentrations in the pile may potentially range from 150 to 600 milligrams per kilogram (mg/kg).
- Dissolved metals:
 - Samples were analyzed using the SPLP (EP SW-846 Method 1312) to indicate potential dissolved metals concentrations. The results were not used for the Integrated Plan because a meaningful correlation between results and runoff concentrations is not known at this time. This test was designed to simulate material left in situ (in or on top of the ground surface, exposed to rainfall, with an assumption that the rainfall is slightly acidic) and then to determine the mobility of analytes present in liquids, soils, and wastes from the leachate the material would produce. The test is applicable for determining the potential of a contaminated material (left in situ) to impact groundwater or surface water when exposed to normal weathering.
- Fecal coliform:
 - WQ bin sample analysis of fecal coliform within the Fine PM fraction is not practical given the nature of the sampling approach; concentrations for the whole sample for these parameters are assumed to be representative of the material less than 250 μm . Borst et al. (2003) found no correlation between fecal coliform concentrations and mean particle size from one summer storm event. Southern California Coastal Water Research Project (2011) found bacteria preferentially associated with less than 6 μm filter fraction during small storm events (<0.3 inch rain).
- The wet season fecal coliform concentration is assumed to be adequately represented by the samples collected during dry weather sampling. This approach was selected after considering several factors and comparing the results to other stormwater and combined sewer overflow (CSO) projects.
 - The ratio of average dry season (5.6 million colony forming units per gram [CFU/g]) to average wet season (0.63 million CFU/g) fecal coliform concentrations is 8.9, which is greater than the Seattle National Pollutant Discharge Elimination System (NPDES) Stormwater Characterization data ratio of 2.6, average dry season fecal coliform bacteria concentration to average wet season concentration but less than the range reported for the Nationwide Urban Runoff Program (NURP) data (20 dry to 1 wet) (EPA, 2006) (see Figure G-2d).

- Using the wet season concentration to characterize the dry season appears reasonable when compared to fecal coliform bacteria concentrations reported in the literature and estimated concentration reductions for the current program (Table 2-3).

Table 2-3. Comparison of Potential Fecal Coliform Removal Efficiencies for Different Runoff Concentrations and Pick-up Rate Assumptions

Source/ description	Average fecal coliform concentration (CFU/100 mL)	Land use/source
Seattle NPDES Stormwater Characterization	2,791	Residential
	5,046	Commercial
	3,980	Industrial
EPA (2006)	430	Street runoff
Burnhart et al. (1991)	9,627	arterial street M_ArterialST
	5,269	arterial street S_ArterialST
Current Program estimate reduction	1,238	Arterials (reduction estimate based on dry and wet season concentrations)
	108	Arterials (reduction estimated based on wet season concentration representing annual concentration)

Seattle NPDES Stormwater Characterization includes both wet and dry season samples. The Burnhart et al. (1991) samples are during the warmer months.

- The street sweeping fecal coliform bacteria concentrations are highly variable (coefficient of variation 1.53 and 3.0 for Charles Street and Haller Lake WQ bins, respectively).
- Conditions within the WQ temporary storage bins may be conducive to bacteria growth due to adequate moisture, nutrients, and carbon source as well as optimum temperatures, especially in the dry season. At the time of sampling, the sweepings may be from 1 to 14 days old. Pile temperatures ranged from 75 degrees Fahrenheit (°F) to 125°F with averages of 87°F and 96°F at the Haller Lake WQ bin on September 24, 2013, and October 8, 2013, respectively. Pile temperatures ranged from 70°F to 110°F at the Charles Street WQ bin on October 8, 2013, with an average of 87°F (See Figure 2-5). Analytical method SM 9222D stipulates an incubation temperature of 112.1°F for 24 hours.
- Conditions on the street may also be conducive for fecal coliform bacteria growth. Burnhart et al. (1991) found that it was possible for bacteria to increase on the street surface until the next rain, when they would be washed off. The San Bernardino County Flood Control District (2011) will evaluate street sweeping to determine if ongoing programs can be enhanced to further reduce the presence of bacterial indicators on street surfaces. The San Bernardino County Flood Control District assumes that sweeping will eliminate the release of bacteria from biofilms in street gutters for a period of 1 day based on work by Skinner et al. (2010), who found that improved street sweeping practices resulted in an order of magnitude reduction in fecal coliform concentration (14,000 CFU/100 mL to 870 CFU/100 mL) in a 300-foot section of gutter before and after sweeping.



Figure 2-5. Evidence of high temperatures within the Charles Street pile on September 30, 2011

2.1.3 Seasonal Street Dirt Washoff Rates

Seasonal street dirt washoff rates are assumed to represent the particles picked up by the sweeper that would have washed to the storm drain had they not been picked up. Key assumptions supporting development of the seasonal washoff rates include:

- The dry season extends from May through September and the wet season from October through April.
- The washoff load is a function of particle size and is estimated using the observed washoff street dirt load reductions by particle size during tests in Bellevue, Washington (Pitt, 1985) (see Table 2-4).

Table 2-4. Observed Washoff of Street Dirt during Test in Bellevue, Washington (Pitt, 1985)				
Size category	Range in size (mm)		Washoff of original load (%)	
	From	To	Dry season	Wet season
Gravel	>2	N/A	0	0
Very coarse sand	1	2	7	6
Coarse sand	0.5	1	8	12
Medium sand	0.25	0.5	15	19
Fine sand	0.125	0.25	20	30
Very fine sand	0.063	0.125	28	49
Silt	<0.063	N/A	39	50

The washoff of original load (%) is referred to as the Bellevue washoff factor (BWOF).

The Bellevue data are based on observations of the difference in approximately 50 pairs of street dirt loading measurements close to the beginnings and ends of rains.

Application of the BWOFF to Program data reduces the estimated WQ benefit from 24 and 20 percent of the total load, Fine PM for dry and wet season, respectively, to 11 and 14 percent of the total load, washoff PM for dry and wet season, respectively (see Figure G-2d).

The washoff fraction (WOF%) for each sample, the percentage of particles picked up by the sweeper that would have washed off the street, is estimated by summing the product of the BWOFF, for each size category and season and multiplying by the percentage of particles in that size category for all size fractions for the sample.

$$[WOF\%]_{sample} = \sum_{size\ category=1}^7 [SizeCategory\%]_{sample,s} \times BWOFF_{size\ category,s}$$

2.2 Inputs to Estimate Projected Particulate-Bound Pollutant Load and Concentration Estimates

This section describes the input values and assumptions used to estimate particulate-bound pollutant load and concentration estimates from the measured washoff particulate-bound pollutant pick-up rate and includes:

- efficiency and implementation factor adjustments to the measured pick-up rate to develop a projected pick-up rate
- candidate stormwater street sweeping programs' sweeping plan
- candidate stormwater street sweeping programs' average annual runoff volume

2.2.1 Adjustments to Measured Pick-up Rate

Measured particulate-bound pollutant pick-up rates are adjusted to develop projected pick-up rates using efficiency and performance reduction factors.

2.2.1.1 Efficiency Factors

Efficiency factors account for reduced pick-up rates for more frequent sweeping (Street Sweeping Expansion Arterials), or sweeping during different land use and operating conditions (Street Sweeping Expansion Residential):

- **Street Sweeping Expansion Arterials efficiency factor:** A 64 percent efficiency factor is applied to the estimated pick-up rate for arterial weekly sweeping frequency compared to arterial biweekly sweeping frequency based on an assumed street dirt buildup rate of 11 days (e.g., 7 days/11 days is 64 percent). Reported street dirt buildup rates range from 6 to 10 days. San Diego (2013) found that the removal rate (mass per curb-mile swept) was similar for two sweeping frequencies: twice per week and weekly, inferring a buildup rate greater than 7 days. Sorensen (2013) found similar results; sweeping every 3 days provided comparable pick-up rates, inferring a buildup rate greater than 6 days. Maricopa Association of Governments (MAG, 2007), assumed a 9-day buildup rate. SAFL (2013) found a buildup rate of 10 days, and that total solids removed increases with tree canopy at any sweeping frequency. Bannerman (2007) reported annual TSS reduction with a vacuum-assisted sweeper sweeping a commercial strip with light parking density once every week at 16 percent, reducing to 7 percent with sweeping once every 4 weeks. Interpolating to a biweekly sweeping frequency results in approximately a 64 percent reduction from biweekly to weekly sweeping frequency.
- **Street Sweeping Expansion Residential efficiency factor:** A 75 percent efficiency factor applied to the estimated pick-up rate for daytime sweeping of residential streets from nighttime sweeping of arterials accounts for expected reduced pollutant loading rates on low traffic volume residential streets, uncertainty around the effectiveness of curb access controls, and restricted operating conditions (tighter corners, overhanging trees, narrow streets, delivery vehicles, etc.). A relative efficiency factor across all RCOCs does not consider that the pollutant loading by land use is likely to be different. The Seattle Street Sweeping Pilot Study (SPU et al., 2009)

found a median pick-up rate of 21 kg Fine PM per curb-mile for two residential basins with daytime sweeping and parking compliance, higher than the measured pick-up rate of 17 kg Fine PM per curb-mile for arterials. Bannerman (2007) found similar average street dirt accumulation rates for residential and commercial streets but predicts a reduction of approximately 50 percent from light to medium parking density with weekly sweeping for both medium residential and commercial strip land uses with a vacuum-assisted sweeper.

2.2.1.2 Reduction Factors to Account for Potential Future Expansion Implementation Issues

Reduction factors account for uncertainty around implementing an expanded program into the future.

- **Street Sweeping Expansion Arterials implementation reduction factor:** A 25 percent reduction in the estimated pick-up rate is applied to account for reduced flexibility when operating at full capacity. Making up missed routes will become increasingly more difficult once all available routes are scheduled.
- **Street Sweeping Expansion Residential implementation reduction factor:** A 50 percent reduction factor in the estimated pick-up rate is applied to account for potential schedule delays around implementing curb access controls (e.g., signs, parking enforcement, etc.).

2.2.2 Sweeping Plan Scope

The load reduction estimate is the product of the projected pick-up rate and planned curb-miles per year. Table 2-5 below provides the frequency and planned curb-miles for each candidate stormwater street sweeping program.

Table 2-5. Candidate Stormwater Street Sweeping Program (Curb-Miles)						
Program	Street type	Routes	Period	Total curb-miles	Biweekly curb-miles	Weekly curb-miles
Street Sweeping Expansion Arterials: augment arterials at night	Arterials	25	Annual	10,600	1,800	8,800
			Wet season	6,500	950	5,550
			Dry season	4,100	840	3,260
Street Sweeping Expansion Residential: expand to local streets during the day	Local streets	24	Annual	11,500	11,500	
			Wet season	6,100	6,100	
			Dry season	5,400	5,400	

2.2.3 Sweeping Plan Runoff Volume

The concentration reduction estimate is the quotient of the projected load reduction by the average annual runoff volume. The average annual runoff volume, V_a , is estimated using the Simple Method (Schueler, 1987). The Simple Method calculates annual runoff as a product of annual runoff volume, and a runoff coefficient (R_v). Runoff volume is calculated as:

$$V_{a,Program} = A_{Program} \times P \times P_j \times R_v$$

where:

$V_{a,Program}$ = Annual runoff volume for the candidate stormwater street sweeping program (Arterials or Residential)

$A_{Program}$ = Runoff surface area for the candidate stormwater street sweeping program (Arterials or Residential)

P = Annual rainfall (37.9 inches)²

P_j = Fraction of annual rainfall events that produce runoff (0.9)

R_v = Runoff coefficient, which is equal to $0.05+0.9I_a$. (I_a , impervious fraction, = 1 for road surfaces and sidewalks)

Although structural BMPs are sized to treat up to 91 percent of the average annual runoff volume, for the purposes of this analysis, 100 percent of the average annual runoff volume is used for the Street Sweeping Expansion Arterials and Street Sweeping Expansion Residential programs, a conservative approach resulting in lower pollutant concentration reductions.

It is assumed that 100 percent of sidewalks are connected in the Street Sweeping Expansion Arterials program and 50 percent connectivity for the Street Sweeping Expansion Residential program, which is predominantly neighborhoods with planting strips. Runoff from parking lots and driveways is not included in either of the candidate stormwater street sweeping program assumptions.

Table 2-6 summarizes the key assumptions used to develop the estimated average annual runoff volume that will be affected by each candidate stormwater street sweeping program.

Table 2-6. Estimated Average Annual Runoff Volume from Streets Considered in Each Candidate Stormwater Street Sweeping Program		
Parameter	Street sweeping expansion arterials	Street sweeping expansion residential
Street width (average, feet)	41.7	28.3
Street area (acres)	1,422	988
Connected sidewalk area (acres)	314	132
Average annual runoff volume (acre-feet)	4,687	3,025
Average annual runoff volume (MG)	1,527	990

Assumed 100% of Street Sweeping Expansion Arterials program sidewalks are connected and 50% connectivity for the Street Sweeping Expansion Residential program.

² The City of Seattle Stormwater code (City of Seattle, 2009) specifies use of an "extended precipitation time series" with a 158-year record length for use in designing water quality facilities. An average runoff value of 37.9 inches was extracted from the Western Washington Continuous Simulation Hydrology Model (WWHM2012). See <http://www.ecy.wa.gov/programs/wq/stormwater/wwhmtraining/index.html> for model description.

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CHAPTER 3

Methodology

This chapter describes the process for developing the candidate stormwater street sweeping programs' particulate-bound pollutant load and concentration reduction estimates and includes four areas:

- developing measured seasonal washoff particulate-bound pollutant load pick-up rates
- developing projected seasonal washoff particulate-bound pollutant load pick-up rates
- developing projected annual washoff particulate-bound pollutant load reductions
- developing projected annual washoff particulate-bound concentration reductions

3.1 Process to Develop Measured Particulate-Bound Pollutant Pick-up Rates

This section describes the process for developing the measured seasonal pick-up rates, which are estimated based on an average monthly swept distance-weighted basis.

Part 1: Develop monthly average sample concentrations and wet loads. A monthly time scale was selected as a common basis for comparison.

Where:

- D = the swept distance (curb-miles for the period of interest)
- $[P]$ = pollutant concentration (mass pollutant per mass of Fine PM)
- $[WSL]$ = the wet solids load (full particle size gradation) (mass)
- m = the month
- e = the sample or hauling event
- n = the number sample or hauling events in the month
- l = the location
- p = the pollutant parameter

Step 1.1 Estimate an average monthly swept distance-weighted sample concentration, $[P]_{l,m,p}$, for each location, l , month, m , and parameter, p . Sum the product of the sample concentration, $[P]_{e,l,p}$ for the sample event, e , at location, l , and parameter, p and multiply by the distance swept, $D_{e,l,m}$, since the last sampling event, e , at location, l , month, m , for all sample events in the month, n . Then divide by the distance swept in the month. Average monthly swept distance-weighted total solids and the washoff fraction are also estimated using this approach.

$$[P]_{l,m,p} = \frac{\sum_{e=1}^n [P]_{e,l,p} \times D_{e,l,m}}{D_{l,m}}$$

Step 1.2 Estimate an average monthly swept distance-weighted wet solids load at each location, $[WSL]_{l,m}$. Sum the product of the wet solids load, $[WSL]_{e,l}$, for the haul event, e , at location, l , then multiply by the distance swept, $D_{e,l,m}$, since the last haul event, e , at location, l , for month, m , for all haul events in the month, n . Then divide by the distance swept in the month.

$$[WSL]_{l,m} = \frac{\sum_{e=1}^n [WSL]_{e,l} \times D_{e,l,m}}{D_{l,m}}$$

Part 2: Develop monthly pick-up rates. The average monthly swept distance-weighted concentrations and wet solids loads are then used to estimate average monthly swept distance-weighted pick-up rates. The four-step process is outlined below.

Where:

- $[DSL]$ = the dry solids load (full particle size gradation) (mass)
- $[WOF]$ = the washoff fraction load (particles that would be washed off the street, see Section 2.1.3) (mass)
- PL = the pollutant load contained in the washoff fraction (mass)
- PkR = the pick-up rate (load per curb-mile swept)
- $[TS]$ = total solids concentration

Step 2.1: Estimate the average monthly swept distance-weighted dry solids load, $[DSL]_{l,m}$, for each location, l , by multiplying the average monthly swept distance-weighted wet solids load, $[WSL]$, by the average monthly swept distance-weighted total solids concentration, $[TS\%]_{l,m}$, for each location.

$$DSL_{l,m} = WSL_{l,m} \times [TS\%]_{l,m}$$

Step 2.2: Estimate the average monthly swept distance-weighted washoff load for the month, $WOL_{m,l}$, for each location, l , by multiplying the average monthly swept distance-weighted dry solids load, $DSL_{m,l}$, by the average monthly swept distance-weighted washoff fraction concentration, $[\% WOF]_{l,m}$, for each location.

$$WOL_{l,m} = DSL_{l,m} \times [\% WOF]_{l,m}$$

Step 2.3: Estimate the average monthly swept distance-weighted dry pollutant load for the month, $PL_{m,l,p}$, for each location and pollutant by multiplying the average monthly swept distance-weighted washoff load, $WOL_{m,l}$, by the average monthly swept distance-weighted sample concentration, $[P]_{l,m,p}$, for each location and parameter.

$$PL_{l,m,p} = WOL_{l,m} \times [P]_{l,m,p}$$

Step 2.4: Estimate the measured monthly swept distance-weighted pick-up rates for the month, $PkR_{m,l,p}$, for each location and pollutant by dividing the average monthly swept distance-weighted dry pollutant load, $PL_{m,l,p}$, for each location and parameter by the average monthly swept distance, $D_{l,m}$, for each location.

$$PkR_{l,m,p} = \frac{PL_{l,m,p}}{D_{l,m}}$$

Part 3: Develop seasonal measured pick-up rates. The monthly average swept distance-weighted loads and distances are then used to estimate the seasonal pick-up rates.

Step 3.1: Estimate the measured seasonal pick-up rates, $PkR_{s,p,Phase,f}$ for frequency f , each season (wet or dry) and pollutant by dividing the sum of the average monthly swept distance-weighted dry pollutant load, $PL_{m,l,p}$, for each location and parameter and month in the season by the average monthly swept distance, $D_{l,m}$, for each location and month in the season.

$$PkR_{s,p,Phase,f} = \frac{\sum_{s=1}^{w \text{ or } d} PL_{l,m,p}}{\sum_{s=1}^{w \text{ or } d} D_{l,m}}$$

3.2 Process to Develop Projected Particulate-Bound Pollutant Pick-up Rates

Once the measured average seasonal washoff particulate-bound pollutant pick-up rates are estimated, the projected seasonal pick-up rates, $PkR_{s,p,Program,f}$, are estimated by applying the efficiency and reduction factors established in Section 2.2:

$$PkR_{s,p,Program,f} = PkR_{s,p} \times Efficiency\ factor_{Program,f} \times Reduction\ factor_{Program}$$

3.3 Process to Develop Particulate-Bound Pollutant Load Reduction Estimates

The annual washoff particulate-bound pollutant load reduction is the sum of the seasonal washoff pollutant load reductions, which are estimated by multiplying the seasonal pick-up rate for the candidate stormwater street sweeping program and sweeping frequency for each RCOC by the candidate stormwater street sweeping program's planned miles for the season and frequency.

$$\Delta WOL_{a,p,Program} = \sum_{s=1}^2 PkR_{s,p,Program,frequency} \times Planned\ curb\ miles_{s,Program,frequency}$$

Where:

$\Delta WOL_{a,p,Program}$ = annual washoff particulate-bound pollutant load reduction for pollutant, p , and candidate stormwater street sweeping program (Arterials or Residential) (mass)
 s = season, either wet or dry
 a = annual

3.4 Process to Develop Particulate-Bound Pollutant Concentration Reduction Estimates

The average annual washoff pollutant concentration reduction, $[\Delta P]_{a,p}$, is the quotient of the annual washoff pollutant load reduction divided by the average annual runoff volume.

$$[\Delta P]_{a,p,Program} = \frac{\Delta WOL_{a,p,Program}}{V_{a,Program}}$$

Where:

$[\Delta P]_{a,p,Program}$ = annual washoff pollutant concentration reduction for pollutant, p , and candidate stormwater street sweeping program (Arterials or Residential) (mass/volume)

$V_{a,Program}$ = Annual runoff volume for the candidate stormwater street sweeping program (Arterials or Residential, see Section 2.2.3)

CHAPTER 4

Results

This chapter describes the results for the candidate stormwater street sweeping programs' particulate-bound pollutant load and concentration reduction estimates and includes:

- measured and projected washoff particulate-bound pollutant pick-up rates
- estimated washoff pollutant load reduction for each candidate stormwater street sweeping program
- estimated washoff pollutant load reduction distribution by receiving water
- estimated washoff pollutant concentration reduction

Table 4-1 provides estimated wet and dry season pick-up rates for each of the RCOs by sweeping frequency and program, Street Sweeping Expansion Arterials or Street Sweeping Expansion Residential.

Table 4-1. Estimated Wet and Dry Season Washoff PM-Bound Pollutant Pick-up Rates for RCOs for Each Candidate Stormwater Street Sweeping Program

Parameter	Units (dry basis)	Measured August 2011 through November 2013		Street Sweeping Expansion Arterials: biweekly frequency		Street Sweeping Expansion Arterials: weekly frequency		Street Sweeping Expansion Residential: biweekly frequency	
		Wet season	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season
Washoff PM (TSS equivalent)	kg/curb-mile	12	7.6	8.7	5.7	5.5	3.6	4.3	2.9
BOD ₅	kg/curb-mile	0.12	0.048	0.088	0.036	0.056	0.023	0.044	0.018
Bis(2-ethylhexyl)pht halate	gram (g)/curb-mile	0.045	0.029	0.034	0.022	0.021	0.014	0.017	0.011
COD	kg/curb-mile	3.6	1.3	2.7	1.0	1.7	0.6	1.35	0.48
Copper, total	g/curb-mile	1.5	1.4	1.1	1.1	0.72	0.68	0.57	0.53
Fecal coliform	million CFU/curb-mile	590	590	440	440	280	280	221	4088
Motor oil range	g/curb-mile	20	18	15	14	9.7	8.8	7.6	6.9
TKN	g/curb-mile	22	17	17	13	11	8.0	8.4	6.3
PCBs, total	g/curb-mile	0.00095	0.00091	0.00071	0.00068	0.00045	0.00043	0.00035	0.00034
Phosphorus, total	g/curb-mile	7.4	5.4	5.6	4.0	3.5	2.6	2.8	2.0
Zinc, total	g/curb-mile	3.0	2.8	2.2	2.1	1.4	1.3	1.11	1.1

See key assumptions above.

Fecal coliform pick-up rate for dry season assumed to be the wet season rate.

Dry season is from May through September. Wet season is from October through April.

Table 4-2 summarizes the estimated average annual load reduction for each RCOC and each candidate stormwater street sweeping program.

Table 4-2. Estimated Average Annual Washoff Particulate-Bound Load Reduction for Each Candidate Stormwater Street Sweeping Program			
RCOC	Units	Street Sweeping Expansion Arterials	Street Sweeping Expansion Residential
Washoff load (TSS equivalent)	kg/year	36,200	42,000
Ammonia-N	NA	No data	No data
Biological oxygen demand (BOD)	kg/year	337	370
Bis(2-ethylhexyl)phthalate	kg/year	0.14	0.16
Chemical oxygen demand (COD)	kg/year	10,000	11,000
Copper, dissolved	NA	Not considered	Not considered
Copper, total	kg/year	5.2	6.3
Dichlobenil	NA	No data	No data
Fecal coliform	trillion CFU/year	2.1	1.8
Oil and grease	kg/year	69	84
TKN	kg/year	72	85
PBDE	NA	No Data	No Data
PCBs ^a	kg/year	0.0033	0.0040
Phosphorus ^a	kg/year	24	28
Zinc, dissolved	NA	Not considered	Not considered
Zinc, total	kg/year	10	12

All washoff pollutant estimate reductions represent the load reduction for particles less than 600 micrometers that would be washed off the street. Fecal coliform dry season pick-up rate is assumed to equal the wet season pick-up rate. Street Sweeping Expansion Arterials and Street Sweeping Expansion Residential program performance estimates reduced to account for uncertainty (see Section 2.2.1.2)

a. For phosphorus and PCBs, the total values were assessed.

Table 4-3 presents the estimated load reduction distributed by receiving water for potential planned routes.

Table 4-3. Estimated Distribution of Average Annual Load Reduction		
Receiving water	Street Sweeping Expansion Arterials	Street Sweeping Expansion Residential
Direct discharge	3%	4%
Duwamish Waterway	30%	14%
Lake Union	13%	13%
Lake Washington	18%	28%
Longfellow Creek	3%	2%
Piper's Creek	1%	2%
Puget Sound Central/Elliott Bay	6%	8%
Puget Sound North	1%	1%
Puget Sound South	9%	12%
Ship Canal/Salmon Bay	7%	12%
Thornton Creek	9%	4%
Total	100%	100%

At full implementation of the Street Sweeping Expansion Arterials and Street Sweeping Expansion Residential programs, the Program is anticipated to reduce the citywide annual pollutant load discharging to the storm sewer system by 5 percent (Table 4-4).³

Table 4-4. Estimated Reduction in Total Runoff Pollutant Load by Candidate Stormwater Street Sweeping Program					
Receiving water	Estimated runoff load (TSS kg/year)	Approximate street sweeping load reduction as a percent of estimated citywide load			
		Current	Street Sweeping Expansion Arterials	Street Sweeping Expansion Residential	Total
Duwamish Waterway	930,900	3%	1%	1%	5%
Lake Union/Ship Canal	504,800	3%	1%	2%	7%
Lake Washington	969,600	3%	1%	2%	5%
Puget Sound	653,700	2%	1%	1%	5%
Total	3,059,000	3%	1%	1%	5%

Estimated runoff load discharging to the storm sewer system is based on land use, source, and coverage.

³ Under current land use and cover assumptions, the street surface area is approximately 12% but contributes approximately 37% of the citywide load. See Seattle Public Utilities (2013) for details.

Table 4-5 summarizes the estimated average annual washoff concentration reduction for each RCOC and candidate stormwater street sweeping program.

Table 4-5. Estimated Average Annual Washoff Particulate-Bound Concentration Reduction for the Current (2013) Program and Each Candidate Stormwater Street Sweeping Program				
RCOC	Units	Current	Street Sweeping Expansion Arterials	Street Sweeping Expansion Residential
Washoff fraction (TSS equivalent)	mg/L	17	6	11
Ammonia-N	NA	No data	No data	No data
BOD ₅	µg/L	144	58	98
Bis(2-ethylhexyl)phthalate	µg/L	0.066	0.024	0.043
COD	mg/L	4.2	1.8	2.9
Copper, dissolved	NA	Not considered	Not considered	Not considered
Copper, total	µg/L	2.7	0.90	1.7
Dichlobenil	NA	No data	No data	No data
Fecal coliform	CFU/100 mL	108	36	49
Oil and grease	µg/L	35	12	23
TKN	µg/L	35	12	23
PBDEs	NA	No data	No data	No data
PCBs	µg/L	0.0017	0.00056	0.0011
Phosphorus, total	µg/L	11	4.1	7.5
Zinc, dissolved	NA	Not considered	Not considered	Not considered
Zinc, total	µg/L	5.2	1.8	3.3

All pollutant estimate reductions represent the load reduction for particles less than 250 µm diameter that would be suspended in the stormwater column. Fecal coliform dry season pick-up rate is assumed to equal the wet season pick-up rate.

Table 4-6 provides an indication of possible removal efficiencies for each candidate stormwater street sweeping program.

Table 4-6. Estimated Potential Washoff Removal Efficiency for Candidate Stormwater Street Sweeping Programs for Selected Parameters					
RCOC	Units	City of Seattle street runoff concentration	Possible current washoff removal efficiency	Candidate Street Sweeping Expansion Arterials program washoff removal efficiency	Candidate Street Sweeping Expansion Residential program washoff removal efficiency
Washoff PM (TSS equivalent)	mg/L	92	18%	7%	12%
Copper, total	µg/L	20	14%	5%	9%
Phosphorus, total	µg/L	173	7%	2%	4%
Zinc, total	µg/L	100	5%	2%	3%

Street Sweeping Expansion Arterials and Street Sweeping Expansion Residential program washoff concentration reductions represent particles that would be washed off the street (see Section 2.1.3).

Fecal coliform dry season pick-up rate is assumed to equal the wet season pick-up rate.

City of Seattle street runoff concentrations are from the NPDES Best Management Practice Study – Catch Basin StormFilters, installed on California Avenue and represent average concentration values.

Combining the possible current and Street Sweeping Expansion Arterials program removal efficiency is indicative of weekly sweeping frequency.

Figure 4-1 presents the schedule of costs and benefits for the Street Sweeping Expansion Arterials and Street Sweeping Expansion Residential programs. Street Sweeping Expansion Arterials is scheduled for implementation in 2016 and Street Sweeping Expansion Residential is scheduled for implementation from 2019 through 2024.

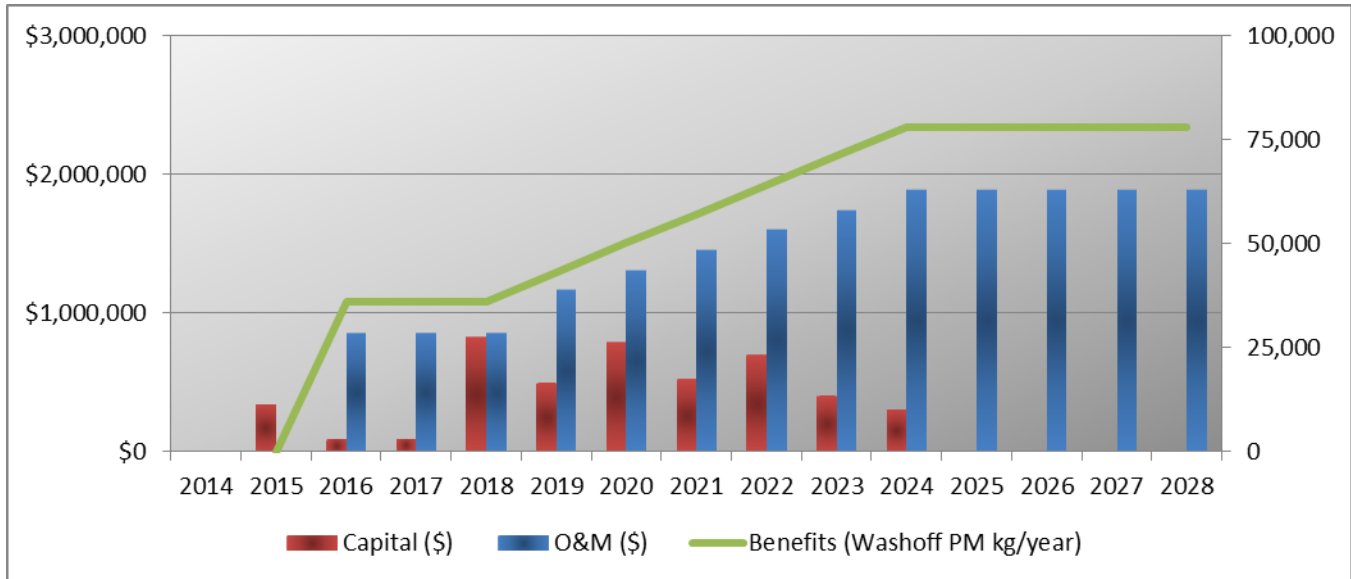


Figure 4-1. Schedule of benefits and costs combined for Street Sweeping Expansion Arterials and Street Sweeping Expansion Residential

Replacement sweeper costs are accrued through the hourly charge rate.

CHAPTER 5

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Attachment G-1: Summary of Descriptive Statistics

Table G-1a. Summary Statistics for BOD ₅ , COD, Fecal Coliform, and Total Solids Sample Concentrations						
	Biological oxygen demand (mg/kg)	Chemical oxygen demand (mg/kg)	Fecal coliform (CFU/g)	Fine particulate matter (%)	Washoff fraction (%)	Solids, total (%)
Sample fraction	PES	PES	PES	PES	PES	PES
Non-detects count	0	0	4	NA	NA	0
Sample count	37	37	35	88	88	69
Mean	6,431	369,981	3,412,613	22	12.6	68
Standard deviation	3,667	486,370	10,286,940	6	2.96	15
Minimum	2,430	79,300	0	10.9	7.68	29.1
Quartile 1	4,040	139,000	1,610	16.8	10.6	64.84
Median	5,220	193,000	382,000	21.45	12.5	72.4
Quartile 3	7,740	250,000	2,145,000	26.525	14.0	77.8
Maximum	17,800	2,220,000	60,300,000	35	22.8	93
Interquartile range (IQR)	3,700	111,000	2,143,390	9.725	3.48	12.96
Outlier count: high	2	8	6	N/A	2	N/A
Outlier count: low	N/A	N/A	N/A	N/A	N/A	7

PES is primary environmental sample, the whole sample including all size fractions.

Outlier count: high is the count of sample results greater than the 75th percentile plus 1.5 times the IQR.

Outlier count: low is the count of sample results less than the 25th percentile minus 1.5 times the IQR.

Table G-1b. Summary Statistics for Organic Sample Concentrations

	Bis(2-ethylhexyl)phthalate (µg/kg)		Oil and grease (mg/kg)		PCBs (µg/kg)	
	PES	<250 µm	PES	<250 µm	PES	<250 µm
Sample fraction	PES	<250 µm	PES	<250 µm	PES	<250 µm
Non-detects count	0	0	0	0	7	1
Sample count	57	34	59	33	39	35
Mean	2,178	4,009	2,374	2,398	61	98
Standard deviation	1,478	1,174	1,413	710	84	71
Minimum	540	1,400	870	950	0	0
Quartile 1	1,330	3,300	1,700	2,000	11.5	41.5
Median	2,000	4,050	2,200	2,300	46	89
Quartile 3	2,500	4,800	2,770	2,700	78	134.5
Maximum	9,300	6,800	8,000	3,900	470	330
IQR	1,170	1,500	1,070	700	66.5	93
Outlier count: high	2	N/A	5	3	2	1
Outlier count: low	N/A	N/A	N/A	N/A	N/A	N/A

PES is primary environmental sample, the whole sample including all size fractions.

Outlier count: high is the count of sample results greater than the 75th percentile plus 1.5 times the IQR.

Outlier count: low is the count of sample results less than the 25th percentile minus 1.5 times the IQR.

Table G-1c. Summary Statistics for Nutrient Sample Concentrations

	TKN (mg/kg)		Phosphorus (mg/kg)	
Sample fraction	9	<250 µm	PES	<250 µm
Non-detects count	0	0	0	0
Sample count	59	36	59	36
Mean	2,241	2,053	526	673
Standard deviation	1,234	687	237	236
Minimum	388	1,220	56.6	67.8
Quartile 1	1,390	1,517.5	419	579.25
Median	2,180	1,950	516	690
Quartile 3	2,995	2,377.5	612	790.75
Maximum	6,620	4,390	1,810	1,350
Interquartile range (IQR)	1,605	860	193	211.5
Outlier count: high	1	1	1	1
Outlier count: low	N/A	N/A	2	3

PES is primary environmental sample, the whole sample including all size fractions.

Outlier count: high is the count of sample results greater than the 75th percentile plus 1.5 times the IQR.

Outlier count: low is the count of sample results less than the 25th percentile minus 1.5 times the IQR.

Table G-1d. Summary Statistics for Copper and Zinc Sample Concentrations

	Copper, total (mg/kg)		Copper, dissolved (µg/L)		Zinc, total (mg/kg)		Zinc, dissolved (µg/L)	
Sample fraction	9	<250 µm	PES	<250 µm	PES	<250 µm	PES	<250 µm
Non-detects count	0	0	0	0	0	0	0	0
Sample count	58	36	31	33	59	36	31	33
Mean	81	184	10	23	209	353	37	33
Standard deviation	41	62	4	13	78	110	24	25
Minimum	28.5	86.8	5.2	9.7	90	169	11	8
Quartile 1	55.175	135.5	7.1	12.8	154	270.75	25.2	20
Median	71.1	177	10.3	19.4	190	325	32	27
Quartile 3	91.7	228.75	13	27.3	240.5	430	44.5	39
Maximum	263	321	5.9	14.5	500	590	130	140
IQR	36.525	93.25	5.9	15.45	86.5	159.25	19.3	19
Outlier count: high	4	N/A	N/A	2	3	N/A	2	2
Outlier count: low	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

PES is primary environmental sample, the whole sample including all size fractions.

Dissolved copper and zinc concentrations represent extracts from the Synthetic Precipitation Leaching Procedure (SPLP), not runoff concentrations.

Outlier count: high is the count of sample results greater than the 75th percentile plus 1.5 times the IQR.

Outlier count: low is the count of sample results less than the 25th percentile minus 1.5 times the IQR.

Attachment G-2: Sample Concentration Box Plots

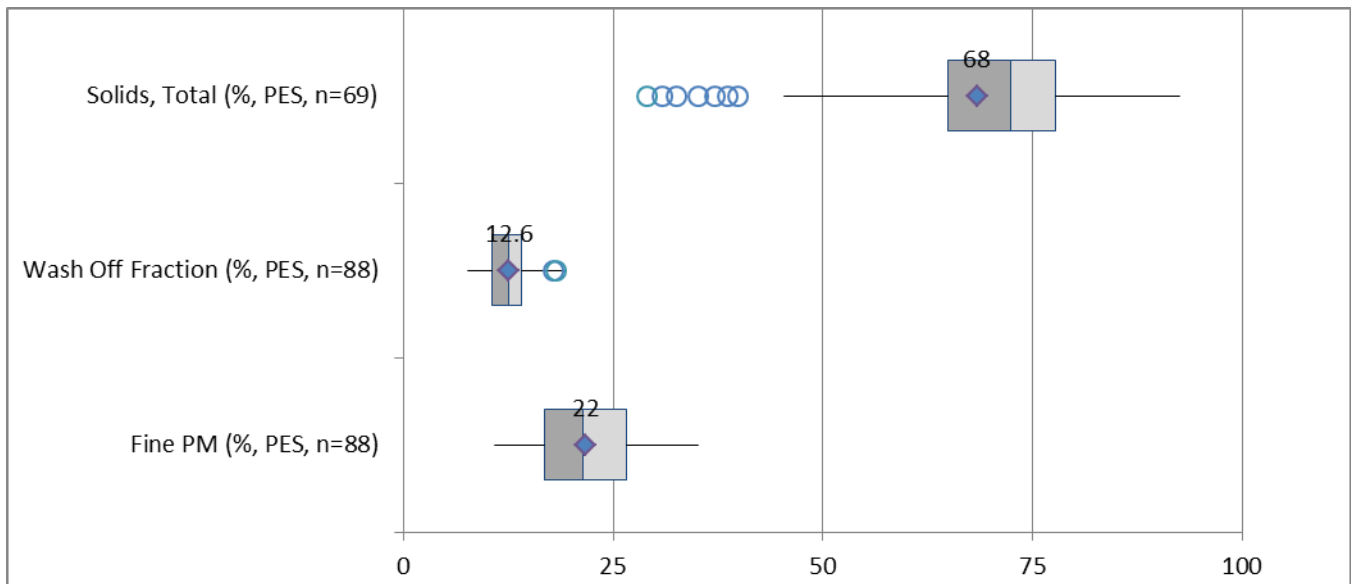


Figure G-2a. Box plot showing percent total solids, washoff fraction, and fine PM (% less than 250 µm) sample concentration distributions

The average values are shown as a diamond, median as a line, and outliers as a circle. The average values are noted on the chart. PES is primary environmental sample (i.e., the whole sample).

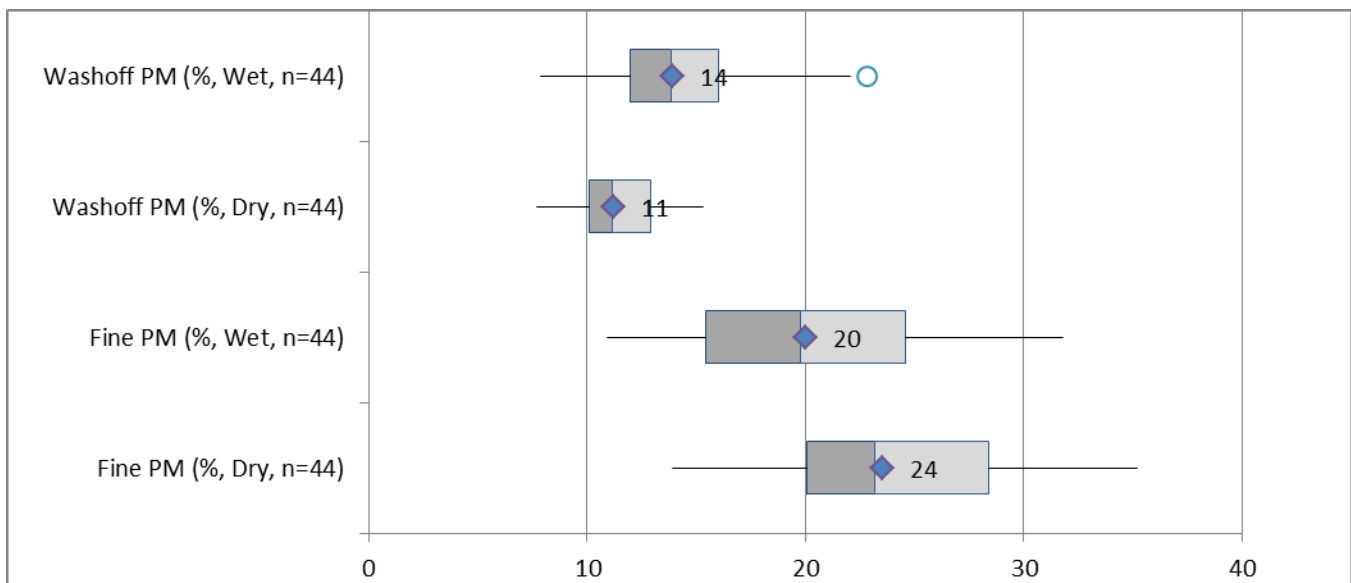


Figure G-2b. Box plot showing washoff fraction and fine PM (% less than 250 µm) sample concentration distributions by season

The average values are shown as a diamond, median as a line, and outliers as a circle. The average values are noted on the chart. PES is primary environmental sample (i.e., the whole sample).

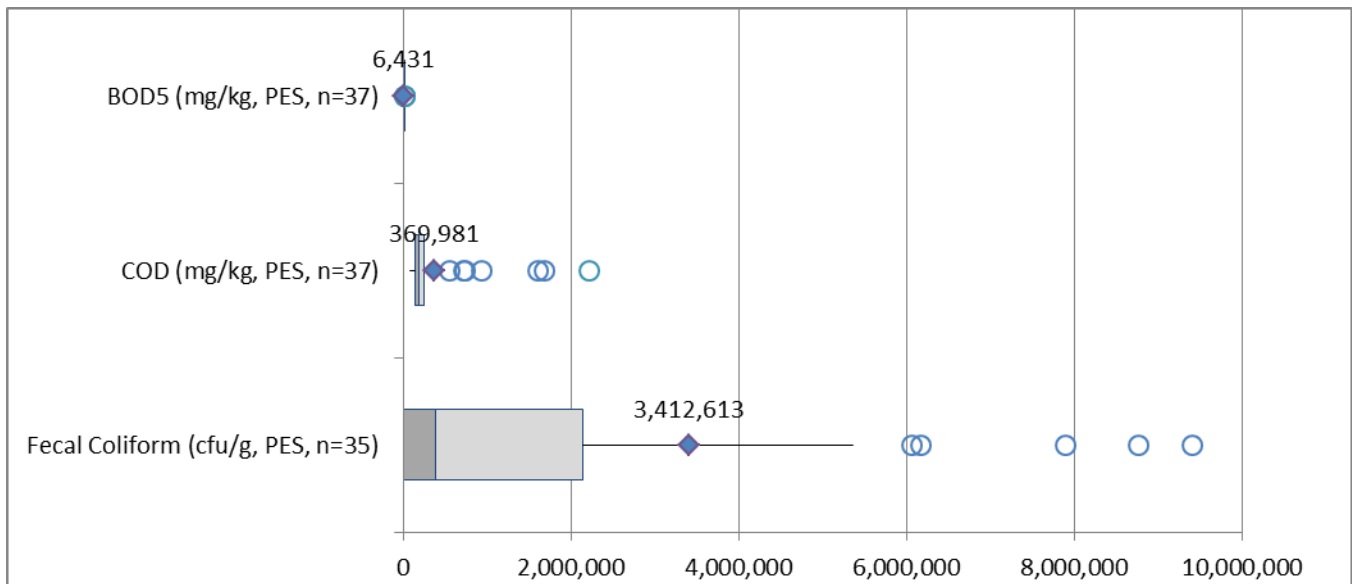


Figure G-2c. Box plot showing BOD₅, COD, and fecal coliform sample concentration distributions

The average values are shown as a diamond, median as a line, and outliers as a circle. The average values are noted on the chart. PES is primary environmental sample (i.e., the whole sample).

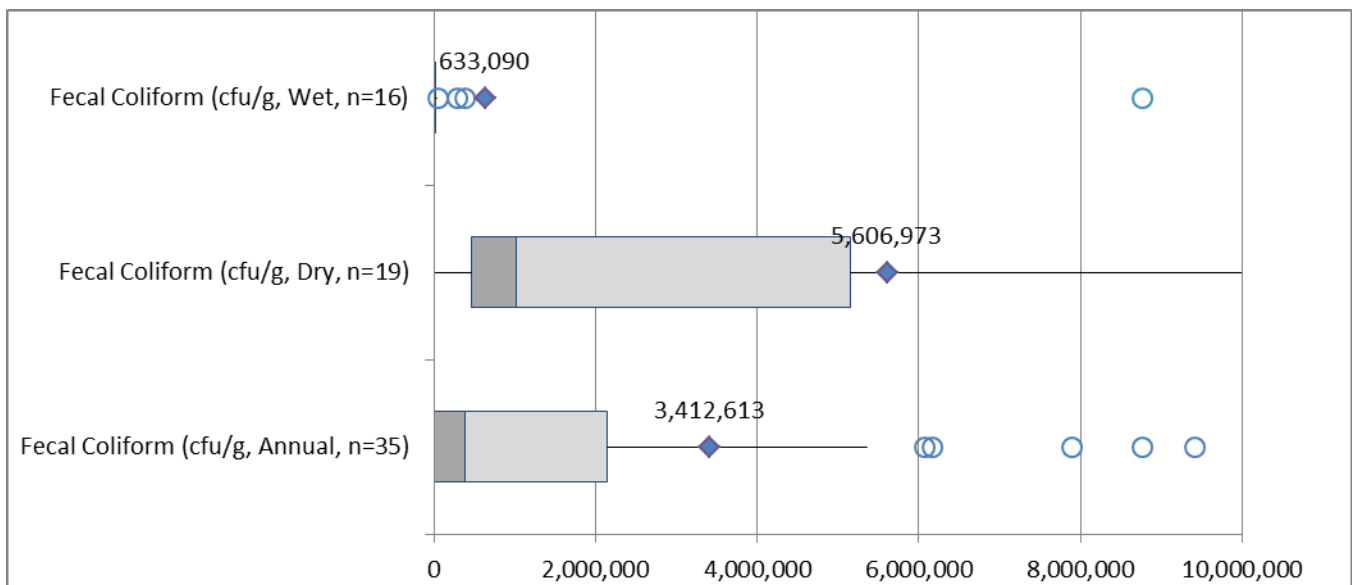


Figure G-2d. Box plot showing fecal coliform sample concentration distributions by season

The average values are shown as a diamond, median as a line, and outliers as a circle. The average values are noted on the chart. PES is primary environmental sample (i.e., the whole sample).

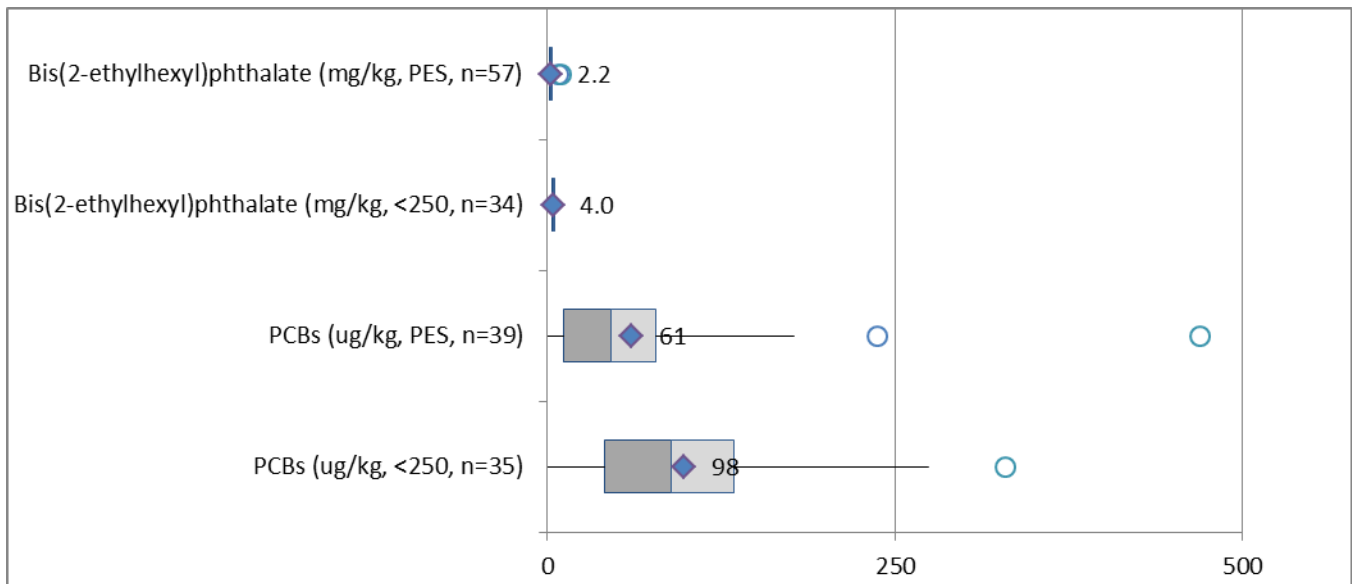


Figure G-2e. Box plot showing organics sample concentration distributions

The average values are shown as a diamond, median as a line, and outliers as a circle. The average values are noted on the chart. PES is primary environmental sample (i.e., the whole sample).

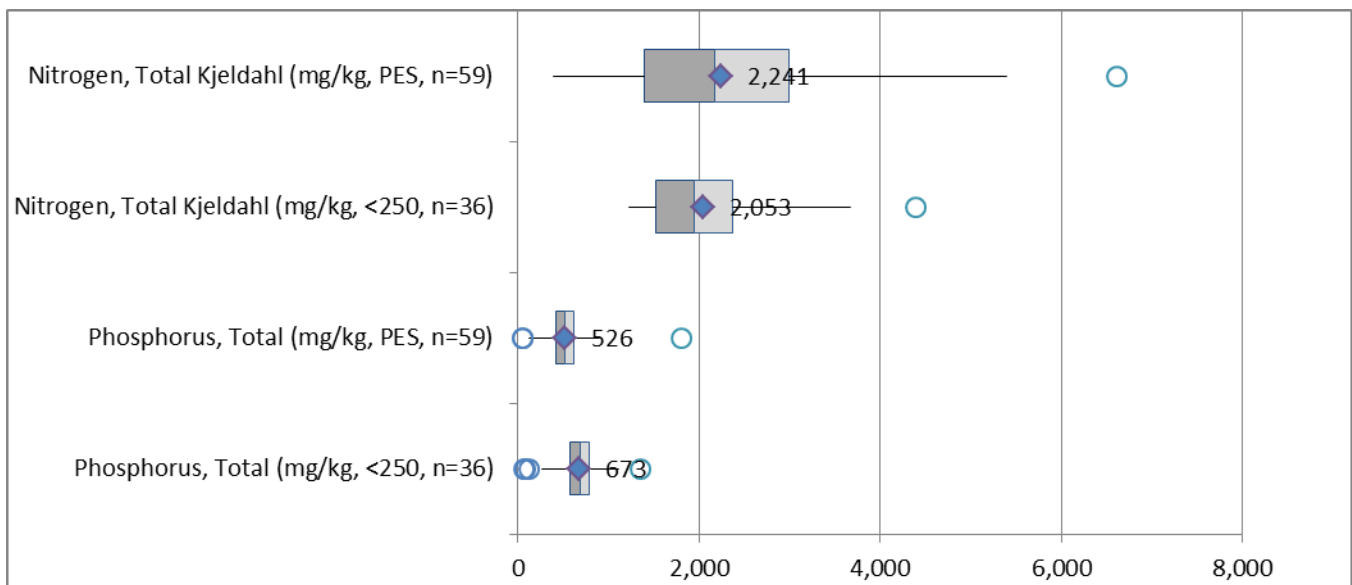


Figure G-2f. Box plot showing nutrient sample concentration distributions

The average values are shown as a diamond, median as a line, and outliers as a circle. The average values are noted on the chart. PES is primary environmental sample (i.e., the whole sample).

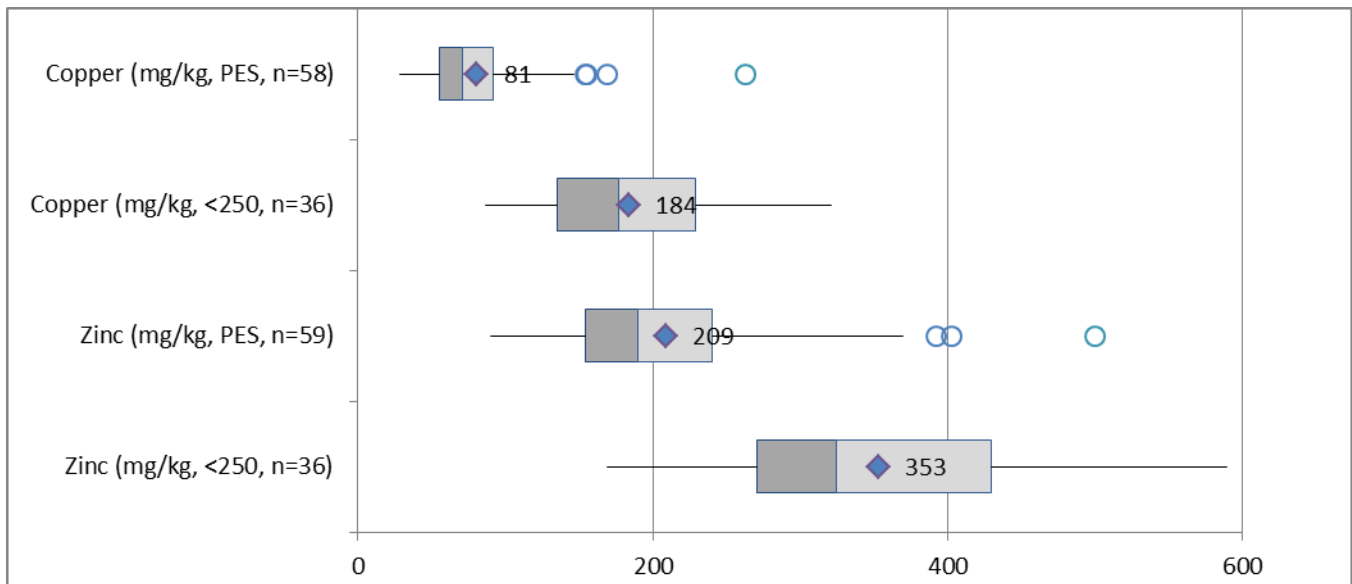


Figure G-2g. Box plot showing total copper and zinc sample concentration distributions

The average values are shown as a diamond, median as a line, and outliers as a circle. The average values are noted on the chart. PES is primary environmental sample (i.e., the whole sample).

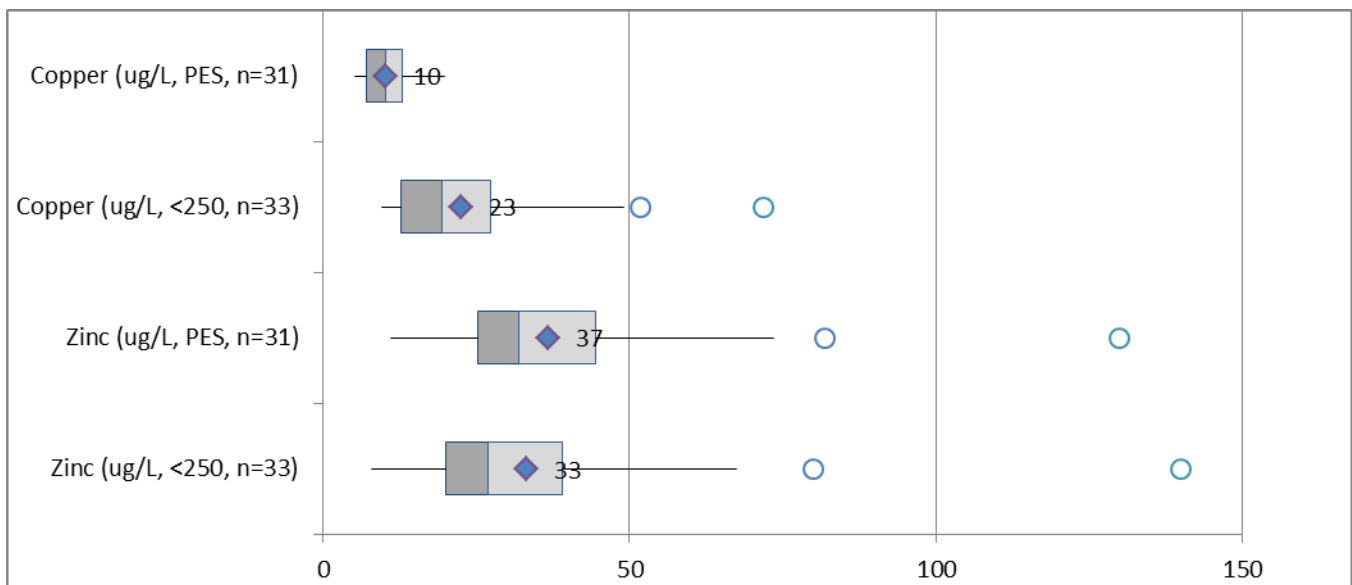


Figure G-2h. Box plot showing dissolved copper and zinc sample concentration distributions

The average values are shown as a diamond, median as a line, and outliers as a circle. The average values are noted on the chart. PES is primary environmental sample (i.e., the whole sample).

Appendix H: Exposure Assessment Methodology and Results



Protecting Seattle's Waterways

Volume 3 – Integrated Plan

Appendix H: EXPOSURE ASSESSMENT METHODOLOGY AND RESULTS

Final

May 29, 2015



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List of Abbreviations

Term	Definition	Term	Definition
°C	degree(s) Celsius	RD	relative dose
°F	degree(s) Fahrenheit	RF	receptor factor
AWQC	ambient water quality criterion	RfD	reference dose
BAF	bioaccumulation factor	SF	slope factor
BOD	biochemical oxygen demand	TL	trophic factor
CaCO ₃	calcium carbonate	TSS	total suspended solids
CFU	colony forming unit(s)	WQC	water quality criterion
cm	centimeter(s)	yr	year(s)
cm ²	centimeter(s) squared		
CSO	combined sewer overflow		
CWA	Clean Water Act		
d	day(s)		
Ecology	Washington State Department of Ecology		
EA	Exposure Assessment		
EIM	Environmental Information Management		
EIV	exposure index value		
EPA	U.S. Environmental Protection Agency		
hr	hour(s)		
kg	kilogram(s)		
km	kilometer(s)		
L	liter(s)		
LA	likelihood of activity		
LP	likelihood of presence		
LTCP	Long-Term Control Plan		
MCLG	maximum contaminant level goal		
mg	milligram(s)		
mL	milliliter(s)		
NH ₃	ammonia		
NPDES	National Pollutant Discharge Elimination System		
NTU	nephelometric turbidity unit(s)		
PAH	polycyclic aromatic hydrocarbon		
PBDE	polybrominated diphenyl ether		
PC	permeability constant		
PCB	polychlorinated biphenyl		
RAGS	Risk Assessment Guidance for Superfund		
RCOC	Representative Constituent of Concern		

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Chapter 1

Introduction

This appendix documents the Exposure Assessment (EA) methodology and results. In particular, this appendix describes the parameters used in the calculation of exposure index values (EIVs) and summarizes the results for the candidate stormwater and Long-Term Control Plan (LTCP) projects proposed for deferral.

Intertox assessed relative hazard reductions and the estimated impact on receiving waters resulting from changes in discharges of Representative Constituents of Concern (RCOCs) associated with each candidate stormwater project or LTCP project proposed for deferral. (EIVs were not calculated for the stormwater street sweeping program as EIVs are based on outfall locations, and runoff from the swept streets would enter many outfalls throughout the city.) The EIV tool is a mathematical model that provides a science-based metric by which the City of Seattle's proposed project outcomes can be compared. The EIV framework is built upon standard principles of risk assessment methodology applied by authoritative bodies worldwide, including the United States' National Academies of Science (EPA, 1996), U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology).

Intertox developed the EIV tool to help address key language in the Consent Decree requirements that:

... the proposed stormwater control project(s) to be implemented by the City, provided that the proposed stormwater project(s) will result in significant benefits to water quality beyond those that would be achieved by implementation of the approved CSO Control Measures only (pg. 15 of Consent Decree).

And that the Integrated Plan must include:

...a description of projected reductions in pollutant exposure for humans, ecological receptors, and/or threatened or endangered species through implementation of the proposed stormwater project(s) under the Integrated Plan (Consent Decree Section 20).

The EIV estimates the potential relative (not absolute) impact of each project, using metrics that are consistently and transparently assigned to reflect the estimated potential hazard of each RCOC, the projected relative decrease in discharge loads, and the estimated relative decrease in exposure potential to human and ecological receptor populations. Because estimates of actual concentrations at points of exposure (e.g., in receiving water) to human or ecological receptors that result from decreases in effluent load are not available, the output of the EA reflects an approximate estimate of changes in *relative* exposure, not actual exposure or risk, induced by changes in effluent releases. These estimates are intended to support comparison of the relative benefit of the candidate LTCP or stormwater projects.

Separate EIVs are calculated for human and ecological receptors for each RCOC associated with each project. EIVs are then summed separately for human and ecological receptors for each project. As formulated, a higher EIV indicates that implementing a particular project would have relatively greater impact on reducing hazards in comparison to other projects with lower EIVs.

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Chapter 2

Key Components of the Exposure Assessment

Three separate EIV metrics—two human metrics and one ecological metric—were calculated for each candidate project as follows:

- human: toxics (calculated using chronic toxicity criteria)
- human: fecal coliform (calculated using acute toxicity criteria)
- ecological: toxics and nutrients (calculated using chronic criteria)

The equation used to calculate the EIVs is presented below. EIVs were calculated for the RCOCs listed in the Integrated Plan (see Table 6-1 of the plan). Several RCOCs were not included in EIV calculations because of a lack of human or ecological water quality criteria (WQC) for these compounds. Section 2.2 identifies the RCOCs that were excluded.

2.1 The Exposure Index Value Calculation

For each LTCP and stormwater scenario, the relative significance of changes in exposure to human and ecological receptors was assessed by calculating an EIV, as follows:

$$EIV_{Human\ or\ Eco-RCOC} = \frac{C_{Pre}}{WQC_{Human\ or\ Eco}} \times Relative\ change\ in\ load \times RF_{Human\ or\ Eco}$$

where:

C_{pre} = Concentration in effluent discharged Pre-project (mg/L, or CFU/100 mL for fecal coliform)

WQC = Human or ecological water quality criterion (mg/L, or CFU/100 mL for fecal coliform)

$Relative\ change\ in\ load$ = (Pre-project load – Post-project load for a specific RCOC)/ Total change in load across all projects (LTCP and stormwater) for this RCOC

RF = Receptor factor (unitless)

Overall, the three main terms in the equation can be interpreted as follows:

- C_{pre}/WQC : Reflects the relative human-health risk or ecological hazard associated with discharges prior to implementation of a project (because concentrations are “end-of-pipe” values and not concentrations in receiving water, this term does not reflect “true” hazards, but rather is an index of “relative” hazards). A higher value for this term suggests that implementing the associated project, per unit relative change in load, would have relatively greater impact on reducing hazards.

- *Relative change in load*: This term reflects the relative impact of the project on decreasing the amount (mass) of a given RCOC discharged to the receiving water, compared to other projects (without regard to the potential toxicity or hazard of a unit mass of that RCOC). A higher value for this term suggests that implementing the associated project would have relatively greater impact on reducing the mass of a RCOC discharged.
- *RF*: Reflects the relative potential magnitude of exposure to a given RCOC. A higher value for this term suggests that implementing the associated project, per unit relative change in load, would have relatively greater impact on reducing overall exposures.

2.2 RCOCs Not Included in EIV Calculations

The following RCOCs were not included in EIV calculations:

- **Biochemical oxygen demand (BOD)**: BOD is a measure of the amount of oxygen consumed by microorganisms in decomposing organic matter in stream water, and directly affects the amount of dissolved oxygen in rivers and streams (EPA, 2012a). The greater the BOD, the more rapidly oxygen is depleted in a stream, indicating less oxygen available to higher forms of aquatic life. Neither the State of Washington nor EPA has published ambient water quality criteria (AWQCs) for either human or ecological effects for BOD. As such, BOD was not included in the EIV calculations.
- **H⁺**: EPA has published national AWQC for ecological effects associated with pH, indicating a recommended range between 6.5 and 9 for fresh water and 6.5 and 8.5 for marine water (EPA, 2013). Per the EPA Red Book (EPA, 1996):

For open ocean waters where the depth is substantially greater than the euphotic zone, the pH should not be changed more than 0.2 units from the naturally occurring variation or any case outside the range of 6.5 to 8.5. For shallow, highly productive coastal and estuarine areas where naturally occurring pH variations approach the lethal limits of some species, changes in pH should be avoided but in any case should not exceed the limits established for fresh water, i.e., 6.5–9.0.

The estimated Pre-project concentration of H⁺ in discharges from the combined sewer overflows (CSOs) and stormwater outfalls ranges from about 2.1×10^{-7} micrograms per liter (µg/L) to 7.1×10^{-7} µg/L, or a pH of about 6.1 to 6.7; however, these estimates do not reflect the pH of receiving waters, and predictions of project impact are based on the change in load of the H⁺ ion, in kilograms (kg) per season, which cannot be extrapolated to pH estimates. As such, H⁺ was not included in the EIV calculations.

- **Oil and grease**: While data have demonstrated toxicity of oils to aquatic organisms, the potential toxicity of oil and grease is highly dependent on the specific chemical components of the mixture. For example, the type and concentration of polycyclic aromatic hydrocarbons (PAHs) in the mixture can significantly impact the toxicity (EPA, 1986; EPA, 1996). Because compound-specific data on concentrations and loads for specific components of the oil and grease mixtures released from the CSOs or stormwater outfalls are not available, oil and grease was not included in the EIV calculations.
- **Total suspended solids**: Total suspended solids (TSS) are measured by the weight of the suspended solid material (e.g., silt and clay) per liter of water. No WQCs for TSS were identified. Ecological water quality standards exist for turbidity (which is related to TSS) based on an acceptable increase over background, and hydrodynamic models exist to predict TSS from turbidity; however, these models are complex and water-body-specific. For example, to protect char spawning and rearing, Ecology proposes aquatic life turbidity criteria for fresh water not to exceed 5 nephelometric turbidity units (NTU) over background when the background is 50 NTU or less, or a 10 percent increase in turbidity when the background turbidity is more than 50 NTU (Ecology, 2011a). However, because the influences of TSS discharges on turbidity levels in receiving water could not be estimated in the current assessment, TSS was not included in the EIV calculations.

In conclusion, although these RCOCs were not included in this evaluation, there is not a significant impact on the results and related conclusions reached within this EA.

Chapter 3

Steps in Conducting the Exposure Assessment

To conduct the EA, the following steps were completed:

1. Determine the Pre-project discharge concentration for each candidate stormwater or LTCP project, for each RCOC
2. Identify WQC for each RCOC for human and ecological receptors
3. Determine the change in load for each RCOC assuming implementation of a project at a given discharge location, relative to the predicted total change in load for that RCOC over all projects
4. Develop receptor factors (RFs) for human and ecological receptors that take into account distance from discharge to a potential exposure point, likelihood of exposure via a given pathway at that point, and relative magnitude of the potential reduction in an exposure via a given pathway
5. Calculate human and ecological EIVs for each RCOC for each candidate stormwater and LTCP project scenario
6. Sum EIVs for humans and ecological receptors for each candidate stormwater and LTCP project scenario

The results of the EA were provided to the Integrated Plan team to support the comparison of water quality benefits associated with each project. Since EIVs were not calculated for the street sweeping program, a more qualitative approach was used, to evaluate the potential reductions in exposure from this program, in support of the water quality benefits comparison (see Section 8.2.3 in the Integrated Plan).

Each of these steps in the EA methodology is explained in the sections below.

3.1 Determine the Pre-Project Discharge Concentration for Each RCOC for Each Candidate Stormwater and LTCP Project

For each candidate stormwater or LTCP project, the Pre-project discharge concentrations for RCOCs at the “end-of-pipe” location were provided to Intertox by Integrated Plan team members. (Chapter 6 and Appendices E and F of the Integrated Plan include information on the estimate of the Pre-project discharge locations.)

3.2 Identify Water Quality Criteria

For each of the RCOCs, WQCs were identified that are assumed to be protective of potential health risks for humans and ecological receptors that come in contact with the water. An index of the potential impact of Pre-project discharge concentrations was estimated by dividing the Pre-project RCOC concentration at the discharge point by the WQC.

WQCs for human health effect endpoints are listed in Table 3-1. WQCs for ecological endpoints are listed in Table 3-2. The bases for the criteria are described below.

Table 3-1. Water Quality Criteria for Human Receptors

RCOC	Criterion (mg/L)	Basis	Health impact basis	Source
Bis(2-ethylhexyl) phthalate	0.0012	Assuming ingestion of water and fish consumption	Chronic, cancer (liver cancer in rodents, EPA SF)	EPA AWQC (EPA, 2013)
Copper	1.3	EPA drinking water MCLG	Chronic, non-cancer (gastrointestinal effects in humans, EPA RfD)	EPA AWQC (EPA, 2013)
Dichlobenil	0.44	Assuming ingestion of water and fish consumption	Chronic, non-cancer (decreased body weight in dogs, EPA RfD)	Derived used EPA AWQC equation (EPA, 2000)
Fecal coliform	50 CFU/100 mL 100 CFU/100 mL 200 CFU/100 mL	Extraordinary primary contact (Ship Canal, Portage Bay, Piper's Creek, Thornton Creek) Primary contact (Longfellow Creek) Secondary contact (Duwamish Waterway)	Acute infection	Ecology, 2011a
PBDEs	0.000088	Assuming ingestion of water and fish consumption	Chronic, non-cancer effects (neurobehavioral effects in rats, EPA RfD)	Derived used EPA AWQC equation (EPA, 2000)
PCBs	0.000000064	Assuming ingestion of water and fish consumption	Chronic, cancer (liver cancer in rats, EPA SF)	EPA AWQC (EPA, 2013)
Zinc	7.4	Assuming ingestion of water and fish consumption	Chronic, non-cancer (enzyme activity in humans, EPA RfD)	EPA AWQC (EPA, 2013)

AWQC = ambient water quality criteria.

CFU = colony forming unit(s).

MCLG = maximum contaminant level goal.

PBDE = polybrominated diphenyl ether.

PCB = polychlorinated biphenyl.

RfD = reference dose.

SF = slope factor.

Table 3-2. Water Quality Criteria for Ecological Receptors

RCOC	Chronic criterion, freshwater (mg/L)	Chronic criterion, marine (mg/L)	Basis	Source
Ammonia-N	Location-specific; see discussion below	8.21 (Oct–Jan) 5.52 (Feb–Sep)	Calculated as un-ionized ammonia and converted to total ammonia, as N, assuming salmonids present; see discussion below	Ecology, 2011a
Bis(2-ethylhexyl) phthalate	0.003	0.003	No criteria, based on data suggesting chronic toxicity to aquatic life as low as 3 µg/L	EPA, 1980
Dichlobenil	0.33	0.33	Chronic criteria for fisheries	Ecology, 2013a
Dissolved copper	0.0041 (mesotrophic) 0.011 (streams)	0.0031	For freshwater, based on water-body-specific hardness assumptions using EPA equation; for marine, equal to EPA value; see discussion below	EPA, 2007
Dissolved zinc	0.054 (mesotrophic) 0.14 (streams)	0.081	Based on water-body-specific hardness assumptions using EPA equation; for marine, equal to EPA value; see discussion below	EPA, 2007
PCBs	0.000014	0.00003	Total PCBs	Ecology, 2011b
Phosphorus	0.00875 (lakes) 0.010 (streams)	No value	Total phosphorus, Ecoregion II	EPA, 2002a

PCB = polychlorinated biphenyl.

Because estimated changes in discharge loads are based on annual averages, the water concentrations were divided by WQCs established for chronic exposure, with the exception of the human WQC for fecal coliform, which is based on acute exposures.

3.2.1 Basis for Human Water Quality Criteria

For humans, WQCs for all RCOCs except fecal coliform were based on EPA AWQCs. The AWQCs consider potential cancer risk and non-cancer health effects, bioaccumulation potential in fish, and human exposure through consumption of water and fish.

For some RCOCs, published AWQC values are available (EPA, 2013). Regarding these, EPA states, “Pursuant to Section 304(a)(1) of the Clean Water Act (CWA), EPA is required to publish, and from time to time thereafter revise, criteria for water quality accurately reflecting the latest scientific knowledge on the kind and extent of all identifiable effects on human health which may be expected from the presence of pollutants in any body of water” (EPA, 2000).

For other RCOCs, AWQCs were derived using EPA’s *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health* (EPA, 2000), based on EPA toxicity criteria for non-cancer effects (reference doses, RfDs) or cancer effects (cancer slope factors, SFs). Per EPA:

The 2000 Human Health Methodology is ... intended to provide States and authorized Tribes flexibility in establishing water quality standards by providing scientifically valid options for developing their own water

quality criteria that consider local conditions. States and authorized Tribes are strongly encouraged to use this methodology to derive their own AWQC. However, the 2000 Human Health Methodology also defines the default factors EPA intends to use in evaluating and determining consistency of State water quality standards with the requirements of the CWA. The Agency intends to use these default factors to calculate national water quality criteria under 1-2 Section 304(a) of the Act.

For non-cancer effects, the AWQC equation is:

$$AWQC = RfD \times RSC \times \left(\frac{BW}{DI + \sum_{i=2}^4 (FI_i \times BAF_i)} \right)$$

For cancer effects, the AWQC equation is:

$$AWQC = RSD \times \left(\frac{BW}{DI + \sum_{i=2}^4 (FI_i \times BAF_i)} \right)$$

where:

AWQC = ambient water quality criterion (mg/L)

RfD = reference dose for non-cancer effects (mg/kg-d)

RSC = risk-specific dose for non-carcinogens

RSD = risk-specific dose for carcinogens based on a linear low-dose extrapolation (mg/kg-d) (equivalent to a target incremental cancer risk of one in 1 million or 10^{-6} /cancer slope factor (mg/kg-d)⁻¹)

BW = human body weight (default = 70 kg for adults)

DI = drinking water intake (default = 2 L/day for adults)

FI_i = fish intake at trophic level (TL) 1 (i = 2, 3, and 4) (default for total intake at TL1= 0.0175 kg/day for general adult population and sport anglers).

BAF_i = bioaccumulation factor at trophic level, lipid normalized (L/kg)

EPA has published human AWQCs for four of the RCOCs, as follows:

- copper: 1.3 mg/L (EPA, 1994; EPA, 2013), based on a drinking water action level (maximum contaminant level goal, or MCLG) of 1.3 mg/L
- zinc: 7.4 mg/L (EPA, 2013), based on an *RfD* of 0.3 mg/kg-d, a relative source contribution of 1, a *BAF* of 47, and a fish intake of 0.0175 kg/d (EPA, 2002b)
- bis(2-ethylhexyl)phthalate: 0.0012 mg/L (EPA, 2013), based on a cancer slope factor (SF) of 0.014 (mg/kg-d)⁻¹, a relative source contribution of 1, a *BAF* of 130, and a fish intake of 0.0175 kg/d (EPA, 2002b)
- PCBs: 0.000000064 mg/L (EPA, 2013), based on a cancer slope factor of 2 (mg/kg-d)⁻¹ (for total PCBs/congeners/isomers), a *BAF* of 31,200, and a fish intake of 0.0175 kg/d (EPA, 2002b)

For the other two RCOCs, AWQCs were derived using the EPA equations (EPA, 2000) to yield the following values:

- PBDEs: 0.000088 mg/L based on a non-cancer *RfD* of 0.0001 mg/kg-d for tetra-BDE (EPA, 2012b), a relative source contribution of 1, a *BAF* of 4,450 (NLM, 2013a), and a fish intake of 0.0175 kg/d
- dichlobenil: 0.44 mg/L based on a non-cancer *RfD* of 0.015 mg/kg-d (EPA, 1998), a relative source contribution of 1, a *BAF* of 22 (NLM, 2013b), and a fish intake of 0.0175 kg/d

Fecal coliform was evaluated separately from the other RCOCs because the primary health effects of concern are associated with acute exposure. For fecal coliform, the acute WQCs were identified based on the assumed nature of contact¹ as follows (Ecology, 2011b):

- Extraordinary Primary Contact recreation: not to exceed a geometric mean of 50 CFU/100 mL
- Primary Contact recreation: not to exceed a geometric mean of 100 CFU/100 mL
- Secondary Contact recreation: not to exceed a geometric mean of 200 CFU/100 mL

These criteria are based on results of studies of humans exposed to fecal coliform in lakes, including in Lake Michigan and the Ohio River (Ecology, 2002). The Lake Michigan study reported that there were no excess illnesses of any type in swimmers at beaches that had median coliform densities of 91 and 180 per 100 mL over a swimming season, when compared to the number of illnesses in the total study population. A significantly greater illness rate was reported in individuals who swam on the three days when the geometric mean coliform density was 2,300/100 mL when compared to swimmers who swam on the three days when the geometric mean coliform density was 43/100 mL. In addition, data from the Ohio River study indicated that swimmers who swam in water with a median coliform density of 2,300 coliforms per 100 mL had an excess of gastrointestinal illness when compared to an expected rate calculated from the total study population.

3.2.2 Basis for Ecological Water Quality Criteria

Ecological WQCs for RCOCs were identified based on values published by Ecology or EPA. Where different values were available for fresh water and marine waters, freshwater criteria were applied to projects on Longfellow Creek, Piper's Creek, Thornton Creek, Portage Bay, and the Ship Canal, and marine criteria were applied to projects on brackish or saltwater bodies of interest (Duwamish Waterway and Elliott Bay).

The basis for the ecological WQCs was as follows:

- Dissolved copper: 0.0041 mg/L for freshwater mesotrophic (i.e., Portage Bay and Ship Canal) and 0.011 mg/L for freshwater rivers and streams calculated according to the following equation:

$$\text{Concentration-freshwater (mg/L)} = (e^{0.8545 [\ln(H)] - 1.702} * 0.96)/1000$$

where H = water hardness (mg/L as CaCO₃) (EPA, 2007).

- For Portage Bay and the Ship Canal, a hardness value of 40 mg/L was assumed, based on the average of a single sample collected from Lake Union and three samples collected from Lake Washington (Ecology, 2013b). For Longfellow, Thornton, and Piper's creeks, a hardness value of 120 mg/L was assumed, based on the average of eight samples collected from Longfellow and Piper's creeks (Ecology, 2013b).
- The marine concentration of 0.0031 mg/L was based on the value for saltwater presented in EPA (2007).

¹ Washington State Department of Ecology designates Recreational Use in the Duwamish River from the mouth to RM 11.0 as being "Secondary Contact," Lake Washington and Ship Canal as "Extraordinary Primary Contact," and all others as "Primary Contact" (Ecology, 2011a).

- Dissolved zinc: 0.054 mg/L for freshwater mesotrophic (i.e., Portage Bay and Ship Canal) and 0.14 mg/L for freshwater rivers and streams, calculated according to the following equation:

$$\text{Concentration-freshwater (mg/L)} = e^{(0.8473 [\ln(H)] + 0.884)} * 0.986$$

- where: H = water hardness (mg/L as CaCO₃) (EPA, 2007). The hardness assumptions applied are the same as those used to calculate the copper criteria.
- The marine concentration of 0.081 mg/L was based on the value for saltwater presented in EPA (2007).
- Ammonia-N: For freshwater locations where salmonid habitat is an existing or designated use (assumed to be all locations except the Duwamish Waterway, which is assumed to be brackish), location-specific concentrations were calculated for un-ionized ammonia (NH₃) according to the following equation (Ecology, 2011a):

$$\text{Un-ionized ammonia } \left(\frac{\text{mg}}{\text{L}} \right) = \frac{0.80}{FT \times FPH \times \text{Ratio}}$$

where:

FT = based on temperature, equal to 1.4 [if 15 ≤ T ≤ 30] or 10^{0.03(20-T)} [if 0 ≤ T ≤ 15]

FPH = based on pH, equal to 1 [if 8 ≤ pH ≤ 9] or (1 + 10^{7.4-pH}) ÷ 1.25 [if 6.5 ≤ pH ≤ 8.0]

Ratio = based on pH, equal to 13.5 [if 7.7 ≤ pH ≤ 9] or (20.25 × 10^{7.7-pH}) ÷ (1 + 10^{7.4-pH}) [if 6.5 ≤ pH ≤ 7.7]

Because the equation, and estimated concentrations, are affected substantially by pH and temperature values, the calculated concentrations are based on an estimated mean pH and temperature for each water body and season (October–January or February–September), based on data from the Ecology Environmental Information Management (EIM) database (Ecology, 2013b). For marine/brackish locations (e.g., the Duwamish Waterway), an un-ionized ammonia concentration of 0.035 mg/L was used based on the value for marine locations presented by Ecology (2011a). Un-ionized ammonia concentrations were converted to season-specific total ammonia concentrations using the calculations in the Washington State Department of Ecology Spreadsheets for Water Quality-Based Permit Calculations (Ecology, 2010).

Location-specific Ammonia-N concentrations are summarized in Table 3-3, below.

Water body	Season	Assumed, mean pH and temperature	Un-ionized ammonia concentration (mg/L)	Total ammonia concentration (mg/L)
Duwamish Waterway	October–January	7.33, 9.1°C	0.035	8.21
Duwamish Waterway	February–September	7.38, 12.9°C	0.035	5.52
Ship Canal	October–January	7.47, 12.1°C	0.017	2.16
Ship Canal	February–September	7.63, 15.3°C	0.030	2.10
Portage Bay	October–January	7.47, 12.1°C	0.017	2.16
Portage Bay	February–September	7.63, 15.3°C	0.030	2.10
Union Bay/Lake Washington	October–January	7.55, 11.6°C	0.020	2.17
Union Bay/Lake Washington	February–September	7.86, 14.5°C	0.038	1.66
Longfellow Creek	October–January	7.47, 8.7°C	0.013	2.23

Table 3-3. Location-Specific Ammonia-N Concentrations

Water body	Season	Assumed, mean pH and temperature	Un-ionized ammonia concentration (mg/L)	Total ammonia concentration (mg/L)
Longfellow Creek	February–September	7.78, 12.6°C	0.031	1.91
Piper's Creek	October–January	7.72, 9.1°C	0.024	2.16
Piper's Creek	February–September	7.83, 10.7°C	0.028	1.79
Thornton Creek	October–January	7.42, 13.8°C	0.017	2.13
Thornton Creek	February–September	7.74, 9.4°C	0.024	2.09

- phosphorus: 0.00875 mg/L for freshwater mesotrophic (i.e., lakes) and 0.010 mg/L for freshwater streams (EPA, 2002a)
- PCBs: 0.000014 mg/L for fresh water and 0.00003 mg/L for marine (Ecology, 2011b)
- bis(2-ethylhexyl)phthalate: 0.003 mg/L based on data suggesting chronic toxicity to aquatic life at concentrations as low as 3 µg/L (EPA, 1980)
- dichlobenil: 0.33 mg/L (chronic criteria for fisheries; Ecology, 2013a)

3.3 Determine the Relative Change in Load for Each RCOC for Each Project

For each RCOC for each project, the relative change in load was estimated as follows:

$$\text{Relative change in load} = \frac{\text{Load}_{\text{post-project}} - \text{Load}_{\text{pre-project}}}{\sum \text{Change in load for all projects}}$$

This term characterizes the project-specific change in load for a given RCOC relative to the total change in load for that RCOC across all other projects (LTCP and stormwater combined). As such, in the EIV equation, it provides a measure of the decrease in discharge mass that would be implemented by a given project.

3.4 Develop Receptor Factors

For human and ecological receptors, the relative magnitude of potential exposure was evaluated using a receptor factor (*RF*). Separate equations and assumptions were used to calculate *RF*s for humans and ecological receptors, as described below.

3.4.1 Receptor Factors for Humans

For each candidate LTCP or stormwater project and RCOC, an RF for human receptors was calculated as a function of three measures: the likelihood of exposure to a receptor at a point via a given exposure pathway, the distance from the discharge point to a human receptor point, and the relative magnitude of reduction in exposure to the receptor via that pathway.

The following scheme was used to calculate RF s for human receptors:

$$RF_H = \frac{LA \times RD}{D}$$

where:

RF_H = Receptor factor for humans (unitless)

LA = Relative likelihood of swimming, wading, recreational boating, fishing, or shellfishing at a given exposure point [scale 1 (low/unlikely) to 5 (high/likely), or 0 if not at all]

RD = Relative dose of RCOC via swimming, wading, recreational boating, fishing, or shellfishing

D = Approximate distance from discharge point to receptor location, in kilometers (maximum 2 km)

The resulting RF_H was adjusted to a normalized RF (RF_HN) based on the maximum RF_H identified for any receptor or scenario, such that the range of normalized RF_HN values ranged from 0 to 1.

Values for each of the component factors of the RF_H were assigned as follows.

3.4.2 Identify Locations of and Pathways of Exposure to Human Receptors

The potential for exposure to discharges from a given CSO or stormwater outfall was assessed by characterizing the relative proximity of human receptors to these discharge points. Potential locations of human receptors were determined for each of the receiving water bodies of interest (Longfellow Creek, Piper's Creek, Thornton Creek, Portage Bay, Lake Washington Ship Canal/Lake Union, Duwamish Waterway, and Elliott Bay) as described below.

3.4.2.1 Recreational Users

Human use surveys of Puget Sound, Lake Washington, and Lake Union shorelines have identified how these areas are utilized recreationally by the public (King County, 2002; 2003). Data from these surveys were used in the EA to characterize the relative likelihood and magnitude of human exposure to RCOCs released from outfalls during CSO or stormwater events.

Examples of activities by site location in the Puget Sound survey are summarized in Tables 3-4 and 3-5; numbers of people engaged in recreational activities by specific locations on Lake Union and Lake Washington are not available, but data on activities for the entire lake system are described. Recreational users at Carkeek Park (the location of Piper's Creek and its outfall into Puget Sound) were observed participating in each activity while users at the two lake locations were interviewed about their activities at Lake Union and Lake Washington (King County, 2002; 2003).

Table 3-4. Percent of People Engaged in Sand/Sediment Activities by Location

Site	Total # surveyed	Sitting on beach	Walking/ running/ hiking	Picnicking/ BBQ	Digging in sand away from water
Carkeek Park	861	28%	40%	6%	7%
Lake Union	125	20%	24%	2%	6%
Lake Washington	2,470	22%	27%	5%	5%

Source: King County (2002, 2003).

Table 3-5. Percent of People Engaged in Water Activities by Location

Site	Total # surveyed	Wading	Swimming	Digging in sand near water	Scuba diving	Surfing	Boating ^a	Jet skiing
Carkeek Park	861	5%	0%	13%	0%	1%	0%	0%
Lake Union	125	1%	1%	1%	0%	0%	18%	0%
Lake Washington	2,470	3%	8%	3%	0%	0%	8%	1%

a. Includes motorboats, sailboats, kayaks, canoes, and rafts.

Source: King County (2002, 2003).

Patterns of human use activities on the Duwamish Waterway and Elliott Bay have also been reviewed, and include swimming and wading, scuba diving, boating, surfing, parasailing, and jet skiing (King County, 1999). However, the number of people engaged in these activities was not assessed.

In all of the water bodies, human use patterns vary depending on seasons and weather conditions. For example, swimming and wading in the Duwamish Waterway and Elliott Bay are expected to be confined to the summer months, if at all, given that average water temperatures are approximately 48 degrees Fahrenheit (°F), with winter water temperatures dropping as low as 39°F and summer water temperatures rising as high as 60°F (King County, 1999). Site visits to Lake Washington and Lake Union were more common during spring and summer than in fall and winter (King County, 2003). In addition, people generally visited these sites more often when the weather was clear or cloudy than when it was raining (King County, 2003). Similar patterns were observed at Carkeek Park (King County, 2002).

3.4.2.2 Anglers/Shellfishers

Human use surveys and fish consumption reports indicate that anglers engage in line fishing (shore/pier and boat) in the Duwamish Waterway, Lake Washington, Lake Union, and Elliott Bay (King County, 1999; 2002; 2003). Interview respondents indicated that they were more likely to fish in Lake Washington than in Lake Union, with an equal number of participants fishing from the shore/pier and boats (King County, 2003). In addition to line fishing, gillnetting was identified as the preferred method of salmon collection by tribal members in the Duwamish Waterway (King County, 1999).

The species of fish collected vary by location (i.e., marine vs. freshwater). Surveys indicate that the majority of fish collected in the Puget Sound and Duwamish Waterway are salmon (King County, 1999; 2002). Sea perch

were also commonly collected in Puget Sound. In Lake Washington, the majority of fish collected were perch, followed by salmon and trout (King County, 2003).

Recreational sport fishing is subject to rules set forth by the Washington Department of Fish and Wildlife (Washington State, 2013a). Salmon fishing is seasonally restricted in all areas. The most recent rules for Marine Area 10 (Seattle/Bremerton) allow year-round fishing for trout, mackerel, herring (and related fish), and perch. Seasonal restrictions apply for lingcod and halibut, while fishing for rockfish, Pacific cod, pollack, and hake are closed. Fishing for trout and other game fish (excluding salmon) is open year-round in Lake Washington and Lake Union. Piper's and Longfellow creeks are closed to fishing, while Thornton Creek is open June through August to anglers under 15 years old only. Tribal fishing is subject to different rules than recreational fishing.

Washington State Department of Health fish advisories for Puget Sound recommend no more than one meal per week of Chinook salmon and no more than two meals per month of Blackmouth Chinook, English sole, and other flatfish (Washington State, 2013c). Advisories for the Duwamish Waterway recommend that people do not eat any resident fish, shellfish, or crab (Washington State, 2013a). Lake Washington advisories suggest limiting cutthroat trout and yellow perch to one meal per month (Ecology, 2013a).

Gathering shellfish and other organisms is common in Puget Sound. Clam and oyster beaches in the region of interest include Carkeek Park and Discovery Park. However, these beaches are currently closed as the Washington State Department of Health cautions that shellfish collected from these areas are not fit for human consumption at any time (Washington State, 2013b). Crab fishing is allowed in all of Marine Area 10 during crab fishing season, typically from July to September (Washington State, 2013b).

Several studies have been conducted regarding consumption of fish and shellfish collected from the areas of interest. A human use survey of the Duwamish Waterway and Elliott Bay indicates that less than 50 percent of people ate the seafood they collected from these areas (King County, 1999). Some people release what they catch, others feed their catch to animals, and some use it as bait. Similar results were obtained from surveying people at Golden Gardens (King County, 2002). Approximately 66 percent of anglers surveyed at Lake Washington and Lake Union indicated that they would consume self-caught fish (King County, 2003). All of these reports indicated that anglers often share their catch with family members, including children. Ecology issued a report regarding fish consumption rates, including data for high fish-consuming populations (i.e., tribal, Asian, and Pacific Islander). These data indicate that local tribal populations (Squaxin, Suquamish, and Tulalip) consume 67–96 percent locally caught fish and 62–98 percent locally harvested shellfish (Washington State, 2013c).

3.4.3 Determine Relative Likelihood of Activity for Each Pathway

For each receptor type, the relative likelihood of activity (LA) was estimated for each activity (swimming, wading, recreational boating, fishing, or shellfishing) with values ranging from 5 (most/very likely) to 1 (not at all likely). Estimates were season-specific and were based on human use surveys of Puget Sound, Lake Washington, and Lake Union (King County, 2002; 2003) and recreational sport fishing information from the Washington Department of Fish and Wildlife (Washington State, 2013a), as discussed above, as well as information on the relative proximity of recreational use sites (e.g., boat docks, fishing piers; Seattle Parks and Recreation, 2013a, 2013b) and professional judgment.

These factors were then translated to an assumed estimate of exposure hours per season for each activity, based on descriptive statistics compiled from the King County Human Use Survey (King County, 2003). In brief, “exposure hours per season” for each activity were calculated as follows:

Exposure hours per season

$$= \text{Mean exposure duration for activity (Table 3-6)} \left(\frac{\text{min}}{\text{event}} \right) \times \frac{1 \text{ hr}}{60 \text{ min}} \times$$

$$\text{Assumed exposure frequency for LA values (Table 3-7)} \left(\frac{\text{d}}{\text{yr}} \right) \times \frac{1 \text{ yr}}{12 \text{ mths}} \times \frac{\text{months}}{\text{season}}$$

The “warm” or low release season was assumed to be comprised of eight months (February to September) and the “cold” or high release season was assumed to be comprised of four months (October to January).

Table 3-6. Assumed Exposure Duration for Specific Activities		
Activity	Exposure duration, “warm” months ^a (minutes per event)	Exposure duration, “cold” months ^b (minutes per event)
Fishing	210 ^c	210 ^c
Wading	57 ^d	19 ^g
Kayaking/other recreational boating	168 ^e	168 ^e
Swimming	95 ^f	32 ^g
Shellfishing	210 ^c	210 ^c

a. “Warm” months are assumed to reflect the “low” season for discharges (February–September).

b. “Cold” months are assumed to reflect the “high” season for discharges (October–January). Modeling results from CSO discharges showed that most CSO discharges occur during the “high” season. More specifically, modeling of the candidate LTCP project locations indicates that about 65% of the CSOs occurred during the high season, and the associated overflow volume was about 85% of the total simulated CSO volume from the candidate LTCP project locations.

c. Based on mean value, all locations (Lake Union, Lake Washington, Lake Sammamish) for “fishing” (Table 26 in King County, 2003).

d. Based on mean value, all locations (Lake Union, Lake Washington, Lake Sammamish) for “wading (legs only)” (Table 11 in King County, 2003).

e. Based on mean value, all locations (Lake Union, Lake Washington, Lake Sammamish) for “boating (all types)” (Table 11 in King County, 2003).

f. Based on mean value, all locations (Lake Union, Lake Washington, Lake Sammamish) for “swimming (full body)” (Table 11 in King County, 2003).

g. Event duration for water contact activities (swimming and wading) during cold months was assumed to be one-third that during warm months (professional judgment).

Table 3-7. Assumed Exposure Frequency Corresponding to LA Values

Likelihood of activity value	Exposure frequency, all sites (events/year) ^a
1	2
2	4
3	10
4	16
5	32

a. Extrapolated from "Event frequency (days/year)" statistics for all recreational activities for Lake Union, Lake Washington, and Lake Sammamish, roughly corresponding to the 5th percentile, 25th percentile, 50th percentile, 75th percentile, and 95th percentile of the presented distributions (Table 15 in King County, 2003).

3.4.4 Determine Relative Dose for Each Pathway

For each receptor and activity, the relative dose (*RD*) resulting from exposure to an RCOC, assuming it is present in surface water at the receptor location, was estimated. *RD* was approximated for three exposure pathways via the five human exposure activities, as summarized in Table 3-8.

Table 3-8. Assumed Exposure Pathways for Human Exposure Activities

Exposure pathway	Exposure activity				
	Swimming	Wading	Recreational boating	Fishing	Shellfishing
Incidental ingestion of surface water	✓	✓	✓		✓
Dermal contact with surface water	✓	✓	✓	✓	✓
Ingestion of fish or shellfish				✓	✓

For each pathway, the relative "unit" dose of a specific RCOC was estimated based on data on intake and absorption rates for these pathways, assuming the following:

- a "Unit" concentration in water (e.g., 1 mg/L)
- EPA default contact rates (e.g., incidental water ingestion rates, skin surface area, fish consumption rates) and body weight
- RCOC-specific dermal absorption and fish bioaccumulation factors (*BAF*)
- "Unit" exposure frequency and duration (e.g., 1 hr/d, 1 d/yr)

The exposure equations and assumptions applied were obtained from the following documents:

- EPA Risk Assessment Guidance for Superfund (RAGS) (1989)
- EPA Exposure Factors Handbook (2011)
- EPA Dermal Exposure Assessment (1992)

The equations used to calculate *RD* are presented below. Exposure assumptions are summarized in Tables 3-8 and 3-9.

$$\text{Ingestion of surface water} = \frac{C \left(\frac{\text{mg}}{\text{L}} \text{ or } \frac{\text{CFU}}{\text{L}} \right) \times IR_{s \text{ or } w} \left(\frac{\text{mL}}{\text{hr}} \right) \times CF \left(\frac{\text{L}}{\text{mL}} \right) \times ET_{s \text{ or } w} \left(\frac{\text{hr}}{\text{d}} \right) \times EF \left(\frac{\text{d}}{\text{yr}} \right) \times ED(\text{yr})}{BW (\text{kg}) \times AT(\text{d})}$$

where:

C = Unit concentration of RCOC (1 mg/L or 1 CFU/L)

IR_{s or w} = Incidental ingestion rate of surface water while swimming or wading (mL/hr; see Table 3-9)

CF = Conversion factor (0.001 L/mL)

ET_{s or w} = Exposure time during swimming or wading (hr/d; see Table 3-9)

EF = Exposure frequency (Unit value, 1 d/yr)

ED = Exposure duration (yrs; see Table 3-9)

BW = Body weight (kg; see Table 3-9)

AT = Averaging time (d; see Table 3-9)

Dermal exposure to surface water =

$$\frac{C \left(\frac{\text{mg}}{\text{L}} \text{ or } \frac{\text{CFU}}{\text{L}} \right) \times CF \left(\frac{\text{L}}{\text{mL}} \right) \times PC \left(\frac{\text{cm}}{\text{hr}} \right) \times SA_{s,w,f, \text{ or } sf} (\text{cm}^2) \times ET_{s,w,f, \text{ or } sf} \left(\frac{\text{hr}}{\text{d}} \right) \times EF \left(\frac{\text{d}}{\text{yr}} \right) \times ED(\text{yr})}{BW \times AT(\text{d})}$$

where:

C = Unit concentration of RCOC (1 mg/L or 1 CFU/L)

CF = Conversion factor (0.001 L/mL)

PC = Permeability constant (cm/hr; RCOC-specific: see Table 3-10)

SA_{s, w, f, or sf} = Surface area of exposed skin during swimming, wading, fishing, or shellfishing (cm²; see Table 3-9)

ET_{s, w, f, or sf} = Exposure time to surface water during swimming, wading, fishing, or shellfishing (hr/d; see Table 3-9)

EF = Exposure frequency (Unit value, 1 d/yr)

ED = Exposure duration (yrs; see Table 3-9)

BW = Body weight (kg; see Table 3-9)

AT = Averaging time (d; see Table 3-9)

$$\text{Ingestion of fish or shellfish} = \frac{C \left(\frac{\text{mg}}{\text{L}} \text{ or } \frac{\text{CFU}}{\text{L}} \right) \times BAF \left(\frac{\text{mg/kg}}{\text{mg/L}} \right) \times IR_F \left(\frac{\text{kg}}{\text{d}} \right) \times EF \left(\frac{\text{d}}{\text{yr}} \right) \times ED(\text{yr})}{BW \times AT(\text{d})}$$

where:

C = Unit concentration of RCOC (1 mg/L or 1 CFU/L)

BAF = Fish bioaccumulation factor ((mg/kg)/(mg/L); RCOC-specific: see Table 3-10)

IR_F = Ingestion rate of fish or shellfish (kg/d; see Table 3-9)

EF = Exposure frequency (Unit value, 1 d/yr)

ED = Exposure duration (yrs; see Table 3-9)

BW = Body weight (kg; see Table 3-9)

AT = Averaging time (d; see Table 3-9)

Table 3-9. Exposure Assumptions for Calculating Relative Dose				
Parameter	Description	Value	Basis	Source
IR_s (mL/hr)	Incidental ingestion rate of surface water while swimming	16 mL/hr (adult) 37 mL/hr (child)	Average volume ingested while swimming in an outdoor pool, based on measurement of cyanuric acid in urine	(Dufour et al., 2006)
IR_w (mL/hr)	Incidental ingestion rate of surface water while wading	8 mL/hr (adult) 18.5 mL/hr (child)	Assumed to be one-half that for swimming	(Dufour et al., 2006)
ET_s (hr/d)	Exposure time while swimming	1 hr/d (adult) 0.85 hr/d (child)	King County Human Use Survey: mean event duration for swimming for an adult age 18–59 = 98 minutes vs. 84 minutes for child age 6–12	(King County, 2003)
ET_w (hr/d)	Exposure time while wading	1 hr/d (adult) 0.58 hr/d (child)	King County Human Use Survey: mean event duration for wading for an adult age 18–59 = 62 minutes vs. 36 minutes for child age 6–12	(King County, 2003)
ET_f (hr/d)	Exposure time to surface water while fishing	1 hr/d (adult) * 0.2 0.78 hr/d (child) * 0.2	King County Human Use Survey: mean event duration for fishing for an adult age 18–59 = 214 minutes vs. 167 minutes for child age 6–12; ET to surface water assumed to be 20% of time spent fishing (professional judgment)	(King County, 2003); professional judgment
ET_{sf} (hr/d)	Exposure time to surface water while shellfishing	Assumed to be same as wading	Assumed to be same as wading	Assumed to be same as wading

Table 3-9. Exposure Assumptions for Calculating Relative Dose

Parameter	Description	Value	Basis	Source
SA _s (cm ²)	Surface area of exposed skin while swimming	18,000 cm ² (adult) 6,600 cm ² (child)	Recommended default for full body exposure (50th percentile values)	(EPA, 2004)
SA _w (cm ²)	Surface area of exposed skin while wading	6,000 cm ² (adult) 2,200 cm ² (child)	Assumed to be one-third of value for full body exposure (approximately equal to forearms, hands, lower legs, and feet)	(EPA, 2004); professional judgment
SA _{sf} (cm ²)	Surface area of exposed skin while shellfishing	Assumed to be same as wading	Assumed to be same as wading	Assumed to be same as wading
SA _f (cm ²)	Surface area of exposed skin while fishing	2,250 cm ² (adult) 825 cm ² (child)	Assumed to be one-eighth of value for full body exposure (approximately equal to forearms and hands)	(EPA, 2004); professional judgment
IR _F (kg/d)	Ingestion rate of fish or shellfish	0.010, 0.042 (mean, 95th percentile adult) 0.7 X adult (child), shellfish was assumed to be 50% of fish	King County Human Use Survey, recreational self-caught freshwater fish consumption rates from Lake Washington and Lake Sammamish; no specific consumption data for shellfish but assumed to be 50% of fish based on relative catch rate and weight of fish and shellfish reported in Puget Sound Human Use Survey	(King County, 2002; 2003); professional judgment
ED (yr)	Exposure duration	9 yr (adult) 6 yr (child)	Recommended default for Central Tendency scenarios: Water contact	(EPA, 2004)
BW (kg)	Body weight	70 kg (adult) 22 kg (child)	Recommended default for adult; Mean of means of recommended values for body weight for child age 2–<7 years	(EPA, 1989) (adult); (EPA, 2008) (child)
AT (d)	Averaging time	3,285 d (adult) 2,190 d (child)	Equal to exposure duration, such that <i>RD</i> reflects an annual average daily intake rate	EPA, 1989 and professional judgment

Table 3-10. RCOC-Specific Assumptions for Calculating Relative Dose (*RD*)

RCOC	PC (cm/hr) [permeability constant for skin]	Source	BAF (mg/kg)/(mg/L) [bioaccumulation factor]	Source
Copper	0.001	EPA, 2004	36	EPA, 2002b
Zinc	0.0006	EPA, 2004	47	EPA, 2002b
PCBs	0.43	EPA, 2004	31,200	EPA, 2002b
PBDEs	0.03	EPA, 2004	4,450	NLM, 2013a
Bis(2-ethylhexyl) phthalate	0.025	EPA, 2004	130	EPA, 2002b
Dichlobenil	0.012	EPA, 2004 (based on data for dieldrin as surrogate)	22	NLM, 2013b

Table 3-10. RCOC-Specific Assumptions for Calculating Relative Dose (RD)

RCOC	PC (cm/hr) [permeability constant for skin]	Source	BAF (mg/kg)/(mg/L) [bioaccumulation factor]	Source
Fecal coliform	NA		NA	

NA = not available.

3.4.5 Determine Distance from Discharge Point to the Receptor Location

For each receptor type, the minimum distance from the discharge point to the receptor location was assigned a value equal to its approximate distance in kilometers (km), up to a maximum of 2 km (potential receptors beyond 2 km will not be considered).

3.4.6 Receptor Factors for Ecological Receptors

Ecological *RFs* were developed based on the presence and sensitivity of egg/breeding, juvenile, and adult life stages for eight fish species (bull trout, Chinook salmon, chum salmon, Coho salmon, cutthroat trout, pink salmon, sockeye salmon, and steelhead) in each of the water bodies of interest. These species represent important fish in Seattle both ecologically and as a human food source. Some of these species represent, in some locations, endangered or threatened species. Consideration of life stages reflects the differential sensitivities of different life stages. The fish species selected, and life stages included, in the *RFs* provide a representative range of presence and sensitivity of receptors in the receiving water bodies.

The source and basis of assumptions applied for each of these parameters are discussed below.

RFs for ecological receptors were calculated using the following equation:

$$RF_E = \sum_{species} (LP_{egg} \times S_{egg}) + (LP_{juv} \times S_{juv}) + (LP_{adult} \times S_{adult})$$

where:

RF_E = Ecological receptor factor

LP = Likelihood of presence for a given life-stage, for each species and location

S = Relative sensitivity of life-stage

3.4.7 Determine Likelihood of Presence of Species and Life-Stage

Assumptions regarding species and life-stage presence were based on data compiled by SeaRun and Ridolfi. Values were assumed to range from 1 (rarely present) to 5 (frequently present), or 0 if not present at all, as follows:

- 0: not present at all
- 1: if present during 1 month during a given season ("high" or "low")
- 3: if present during 2–3 months during a given season ("high" or "low")
- 5: if present during >3 months during a given season ("high" or "low")

The *LP* values assumed for each water body, season, species, and life stage are summarized in Table 3-11. Data to support these assumptions are presented in the attachment to this appendix.

Table 3-11. Assumed Likelihood of Presence (<i>LP</i>) of Fish Species and Life Stages, by Water Body and Season^a							
Receiving water body^b	Species	Low season (Feb–Sep)			High season (Oct–Jan)		
		Egg/breeding	Juvenile	Adult	Egg/breeding	Juvenile	Adult
Duwamish Waterway	Chinook salmon	0	5	5	0	1	3
Duwamish Waterway	Steelhead	0	5	5	0	0	3
Duwamish Waterway	Bull trout	0	0	5	0	0	0
Duwamish Waterway	Cutthroat trout	0	3	1	0	3	0
Duwamish Waterway	Coho salmon	0	3	5	0	0	1
Duwamish Waterway	Sockeye salmon	0	3	3	0	0	3
Duwamish Waterway	Chum salmon	0	5	3	0	0	3
Duwamish Waterway	Pink salmon	0	3	3	0	0	3
Portage Bay	Chinook salmon	0	3	3	0	0	1
Portage Bay	Steelhead	0	1	5	0	0	3
Portage Bay	Bull trout	0	0	3	0	0	0
Portage Bay	Cutthroat trout	0	0	3	0	0	3
Portage Bay	Coho salmon	0	3	3	0	0	3
Portage Bay	Sockeye salmon	0	3	5	0	0	3
Portage Bay	Chum salmon	0	0	0	0	0	0
Portage Bay	Pink salmon	0	0	0	0	0	0
Ship Canal	Chinook salmon	0	5	3	0	0	1
Ship Canal	Steelhead	0	3	5	0	0	3
Ship Canal	Bull trout	0	0	3	0	0	0
Ship Canal	Cutthroat trout	0	0	3	0	0	3
Ship Canal	Coho salmon	0	3	3	0	0	3
Ship Canal	Sockeye salmon	0	5	5	0	0	5
Ship Canal	Chum salmon	0	0	0	0	0	0
Ship Canal	Pink salmon	0	0	0	0	0	0
Longfellow Creek	Chinook salmon	0	0	3	0	0	3
Longfellow Creek	Steelhead	0	3	0	0	3	0
Longfellow Creek	Bull trout	0	0	0	0	0	0
Longfellow Creek	Cutthroat trout	3	1	0	3	3	0
Longfellow Creek	Coho salmon	0	1	3	0	3	3

Table 3-11. Assumed Likelihood of Presence (LP) of Fish Species and Life Stages, by Water Body and Season^a

Receiving water body ^b	Species	Low season (Feb–Sep)			High season (Oct–Jan)		
		Egg/breeding	Juvenile	Adult	Egg/breeding	Juvenile	Adult
Longfellow Creek	Sockeye salmon	0	0	0	0	0	0
Longfellow Creek	Chum salmon	0	0	0	0	0	0
Longfellow Creek	Pink salmon	0	0	0	0	0	0
Union Bay/Lake Washington	Chinook salmon	0	5	3	0	1	1
Union Bay/Lake Washington	Steelhead	0	3	5	0	0	0
Union Bay/Lake Washington	Bull trout	0	0	1	0	0	0
Union Bay/Lake Washington	Cutthroat trout	0	3	5	0	3	3
Union Bay/Lake Washington	Coho salmon	0	5	1	0	0	3
Union Bay/Lake Washington	Sockeye salmon	3	5	5	3	1	5
Union Bay/Lake Washington	Chum salmon	0	0	0	0	0	0
Union Bay/Lake Washington	Pink salmon	0	0	0	0	0	0
Thornton Creek	Chinook salmon	3	1	3	3	0	3
Thornton Creek	Steelhead	0	3	3	0	3	0
Thornton Creek	Bull trout	0	0	0	0	0	0
Thornton Creek	Cutthroat trout	3	3	3	3	0	3
Thornton Creek	Coho salmon	3	3	3	3	1	3
Thornton Creek	Sockeye salmon	0	0	3	0	0	3
Thornton Creek	Chum salmon	0	0	0	0	0	0
Thornton Creek	Pink salmon	0	0	0	0	0	0
Piper's Creek	Chinook salmon	0	1	0	0	0	0
Piper's Creek	Steelhead	3	3	0	3	3	0
Piper's Creek	Bull trout	0	0	0	0	0	0
Piper's Creek	Cutthroat trout	3	5	0	3	3	0
Piper's Creek	Coho salmon	0	0	3	0	1	3
Piper's Creek	Sockeye salmon	0	0	0	0	0	0
Piper's Creek	Chum salmon	0	3	3	0	3	3
Piper's Creek	Pink salmon	0	0	0	0	0	0

a. 0 = not likely, 1 = minimal, 3 = moderate, 5 = high. Based on data presented in the attachment to this appendix document.

b. Candidate LTCP or stormwater projects corresponding to water bodies are as follows:

Duwamish Waterway: CSO Outfall 99, CSO Outfall 107, CSO Outfall 111, South Park WQ Facility, SW Hinds SD StormFilter Vault, South Myrtle St. Shoulder Stabilization, South Myrtle St. StormFilter Vault. **Longfellow Creek:** NDS Partnering, Longfellow Bioretention; **Piper's Creek:** NDS Partnering, Piper's Cascades; **Portage Bay:** CSO Outfall 138; **Ship Canal:** CSO Outfall 139, CSO Outfall 140; **Thornton Creek:** NDS Partnering.

3.4.8 Determine Relative Sensitivity of Life-Stage

With regard to the relative sensitivity of life stages, the ranking was assumed to be as follows: egg/breeding > juvenile > adult (Hutchinson et al., 1998.; Mayer and Ellersieck, 1986). Specifically, the following factors were assumed:

- egg/breeding: most sensitive = 1
- juvenile: half as sensitive as embryotic stage = 0.5
- adult: order of magnitude less sensitive than embryotic stage = 0.1

Normalized RF_E s were then calculated by dividing the RF_E for each project and season by the maximum RF_E for all projects/seasons, such that RF_E s fell within the range 0 to 1.

3.5 Calculate Exposure Index Values

For each scenario, RCOC-specific EIVs were calculated by dividing the Pre-project concentration by the appropriate water criterion and multiplying by the relative change in load and the RF . The calculation yields a unitless value.

3.6 Calculate Sums of EIVs

For each candidate LTCP and stormwater project, RCOC- and season-specific EIVs were summed for humans and ecological receptors separately. For humans, separate EIVs were computed for toxics (which were evaluated using chronic WQCs) and fecal coliform (which were evaluated using acute WQCs). At each location, annual EIVs were then calculated by algebraically summing the EIVs for each season as follows:

$$Annual\ EIV = \frac{(EIV_{Oct-Jan} \times 4\ months) + (EIV_{Feb-Sep} \times 8\ months)}{12\ months}$$

The estimated EIVs are summarized in Tables 3-12 through 3-14 and Figures 3-1 through 3-4.

Because project EIVs are relative and a consistent method was used for developing the inputs to the EIV calculations, a sensitivity analysis was not deemed necessary.

Table 3-12. Human EIVs for Toxics by Project Outfall, Annual

Project	Receiving water body	Sum of [(Cpre/WQC-human) × (relative change in load)]	Average RF_H	Human EIV
CSO Outfall 99	Duwamish Waterway	1.6	0.20	0.39
CSO Outfall 107	Duwamish Waterway	48.4	0.20	13.2
CSO Outfall 111	Duwamish Waterway	0.42	0.27	0.16
CSO Outfall 138	Portage Bay	0.93	0.27	0.13
CSO Outfall 139	Ship Canal	0.056	0.22	0.0061
CSO Outfall 140	Ship Canal	0.55	0.27	0.080
Longfellow Cascades	Longfellow Creek	12.2	0.07	0.27
NDS Partnering: Thornton Creek	Thornton Creek	24.5	0.17	3.8
NDS Partnering: Piper's Creek	Piper's Creek	6.3	0.13	0.89
NDS Partnering: Longfellow Creek	Longfellow Creek	5.4	0.07	0.12
Piper's Cascades	Piper's Creek	20.0	0.18	3.8
South Myrtle St. Shoulder Stabilization	Duwamish Waterway	4.6	0.25	1.6
South Park WQ Facility	Duwamish Waterway	308.7	0.26	116.6
Street Sweeping Expansion Arterials	Multiple	Not calculated		
Street Sweeping Expansion Residential	Multiple	Not calculated		
SW Hinds SD StormFilter Vault	Duwamish Waterway	99.2	0.26	36.2
South Myrtle St. StormFilter Vault	Duwamish Waterway	39.5	0.25	13.7
U Village Filterrras	Union Bay/Lake Washington	2.6	0.71	2.0

Table 3-13. Human EIVs for Fecal Coliform by Project Outfall, Annual

Project	Receiving water body	[(Cpre/WQC-human) × (relative change in load)]	RF_H	Human EIV
CSO Outfall 99	Duwamish Waterway	2.4	0.12	0.18
CSO Outfall 107	Duwamish Waterway	17.0	0.11	1.3
CSO Outfall 111	Duwamish Waterway	0.15	0.14	0.019
CSO Outfall 138	Portage Bay	6.0	0.41	2.0
CSO Outfall 139	Ship Canal	0.36	0.34	0.093
CSO Outfall 140	Ship Canal	3.6	0.43	1.4
Longfellow Cascades	Longfellow Creek	8.5	0.12	1.1
NDS Partnering: Thornton Creek	Thornton Creek	37.8	0.18	7.0
NDS Partnering: Piper's Creek	Piper's Creek	9.6	0.12	1.2
NDS Partnering: Longfellow Creek	Longfellow Creek	4.1	0.12	0.52
Piper's Cascades	Piper's Creek	30.9	0.17	5.3
South Myrtle St. Shoulder Stabilization	Duwamish Waterway	0.19	0.13	0.024
South Myrtle St. StormFilter Vault	Duwamish Waterway	5.2	0.13	0.67
South Park WQ Facility	Duwamish Waterway	62.4	0.13	8.3
Street Sweeping Expansion Arterials	Multiple	Not calculated		
Street Sweeping Expansion Residential	Multiple	Not calculated		
SW Hinds SD StormFilter Vault	Duwamish Waterway	14.5	0.13	1.9
U Village Filterrras	Union Bay/Lake Washington	4.7	0.68	3.2

Table 3-14. Ecological EIVs by Project Outfall, Annual

Project	Receiving water body	Sum of [(Cpre/WQC-Eco) × (relative change in load)]	RF_E	Eco EIV
CSO Outfall 99	Duwamish Waterway	0.010	0.74	0.0057
CSO Outfall 107	Duwamish Waterway	0.54	0.74	0.35
CSO Outfall 111	Duwamish Waterway	0.0051	0.74	0.0038
CSO Outfall 138	Portage Bay	0.15	0.32	0.039
CSO Outfall 139	Ship Canal	0.0090	0.44	0.0031
CSO Outfall 140	Ship Canal	0.089	0.44	0.035
Longfellow Cascades	Longfellow Creek	1.5	0.41	0.61
NDS Partnering: Thornton Creek	Thornton Creek	2.8	0.87	2.5
NDS Partnering: Piper's Creek	Piper's Creek	0.72	0.74	0.54
NDS Partnering: Longfellow Creek	Longfellow Creek	0.60	0.41	0.24
Piper's Cascades	Piper's Creek	2.4	0.74	1.8
South Myrtle St. Shoulder Stabilization	Duwamish Waterway	0.026	0.74	0.019
South Myrtle St. StormFilter Vault	Duwamish Waterway	0.19	0.74	0.14
South Park WQ Facility	Duwamish Waterway	2.6	0.74	1.9
Street Sweeping Expansion Arterials	Multiple	Not calculated		
Street Sweeping Expansion Residential	Multiple	Not calculated		
SW Hinds SD StormFilter Vault	Duwamish Waterway	0.49	0.74	0.36
U Village Filterrras	Union Bay/Lake Washington	0.41	0.76	0.32

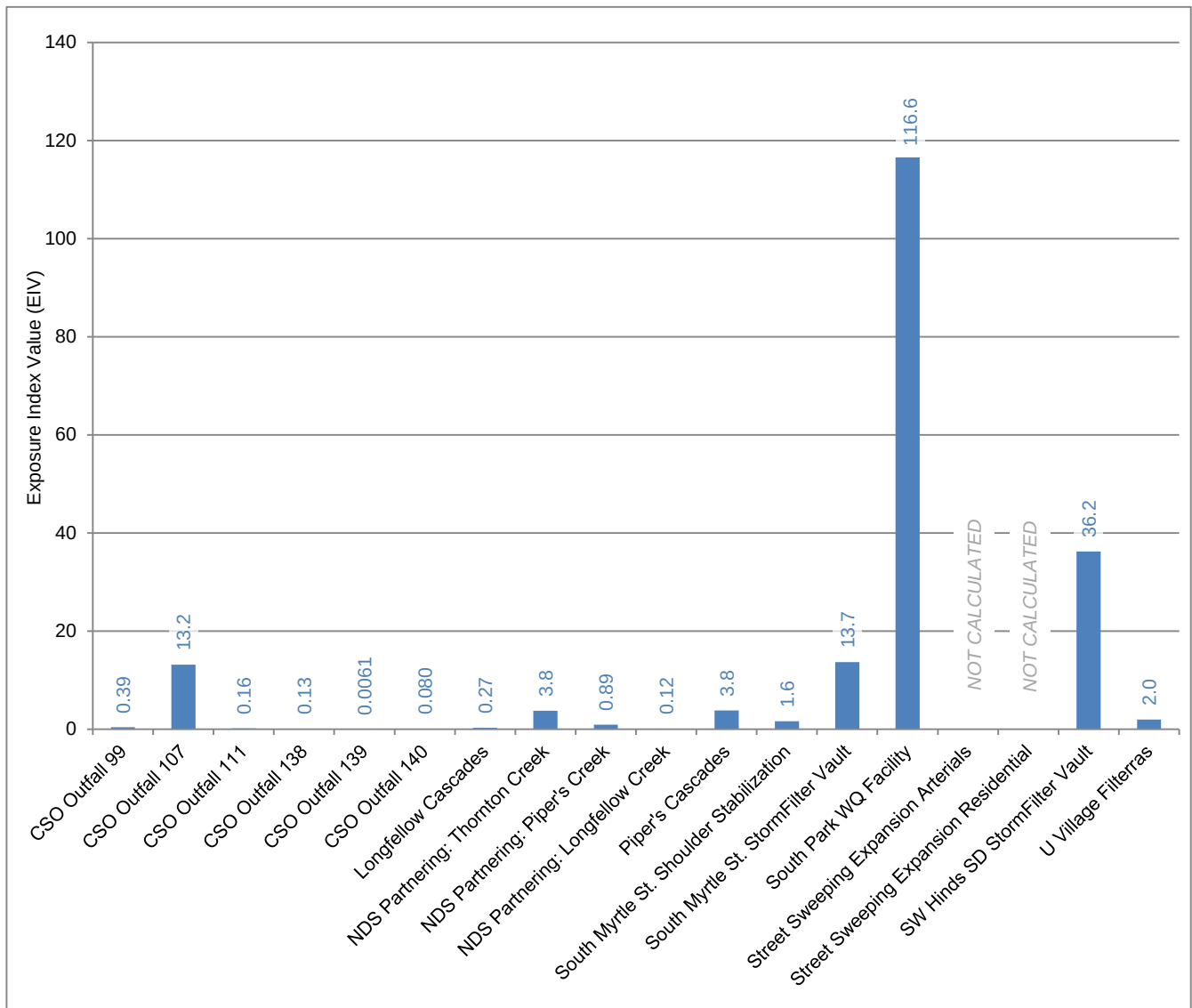


Figure 3-1. EIVs for human toxics

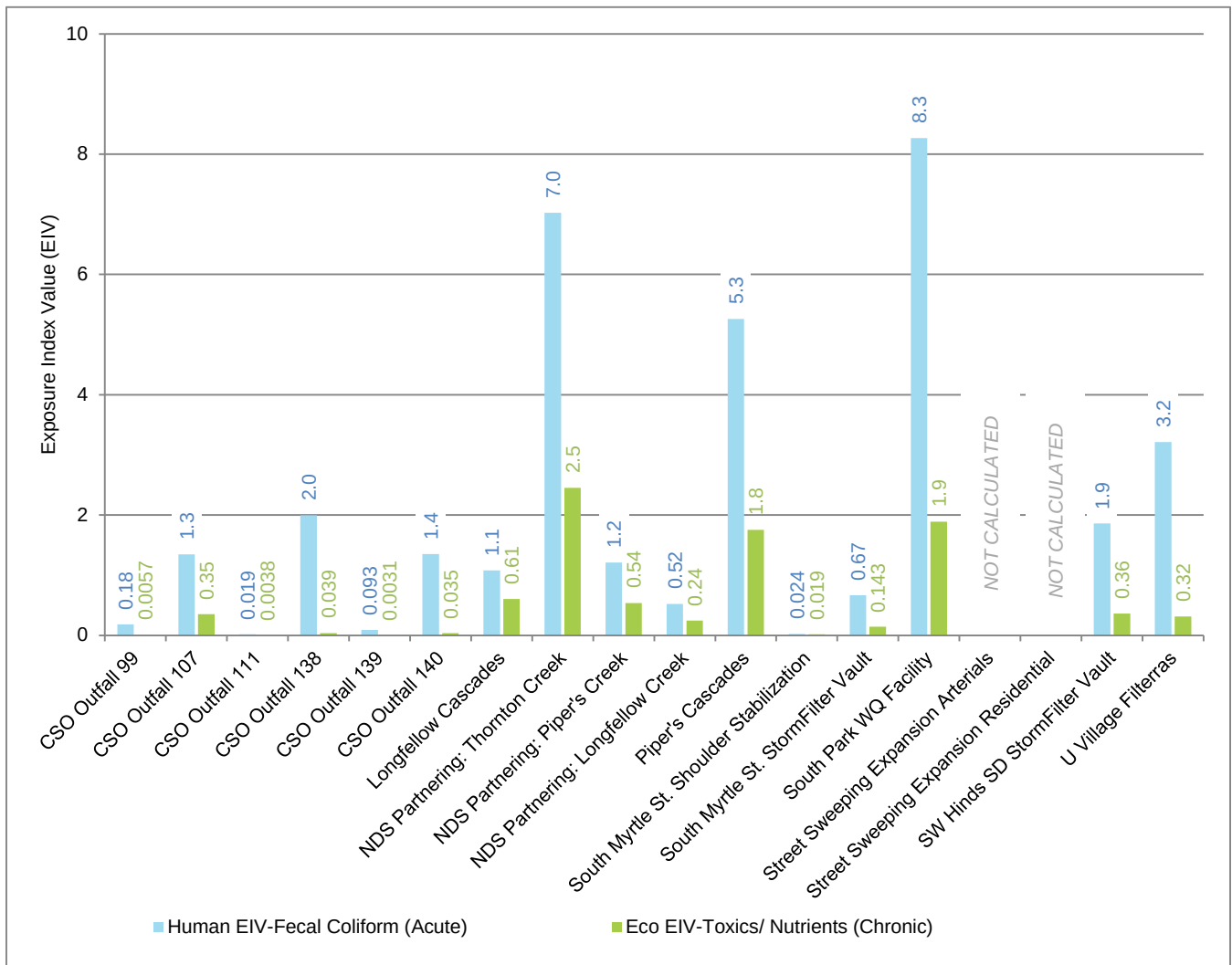


Figure 3-2. EIVs for human fecal coliform and ecological toxics and nutrients

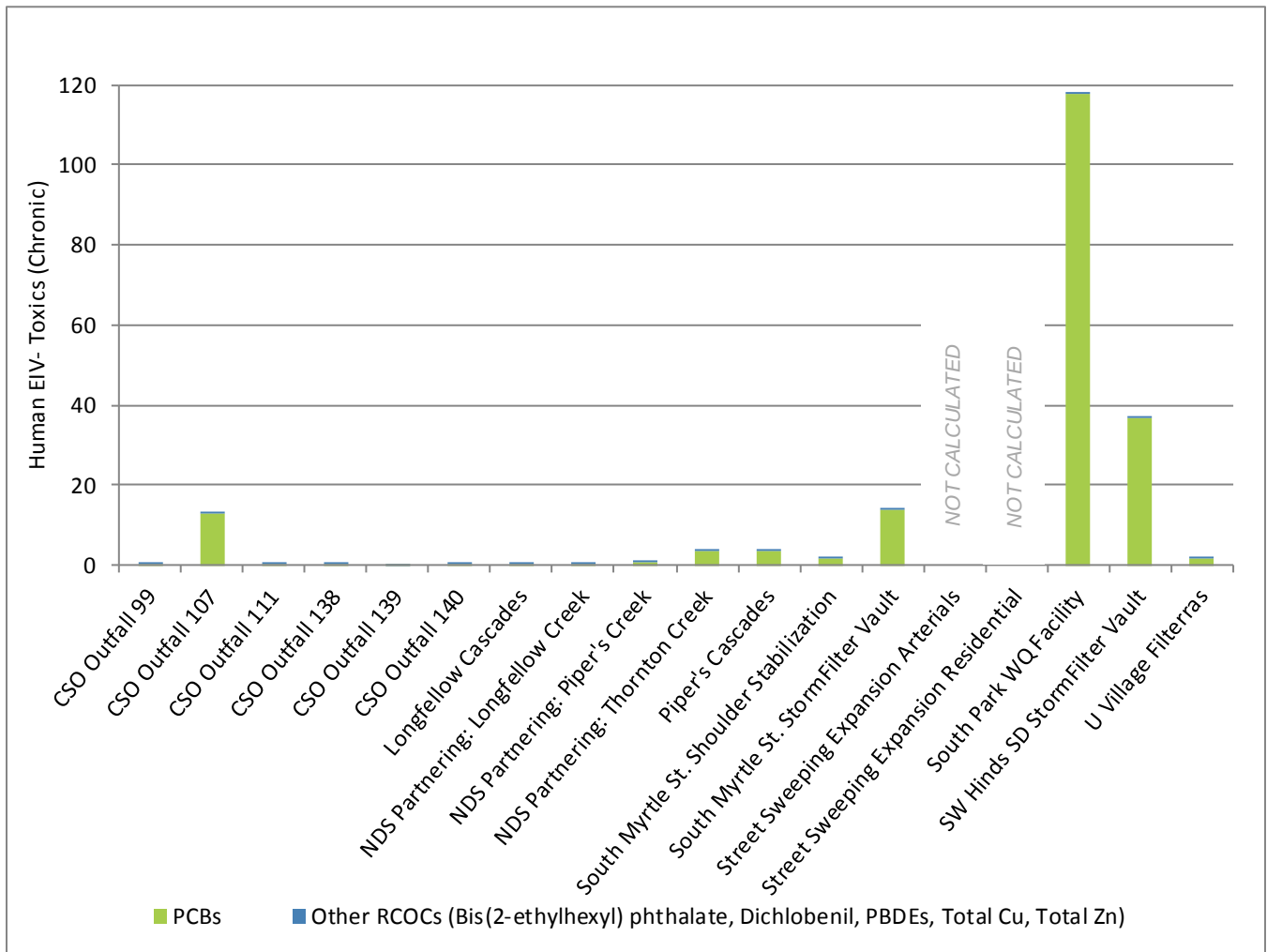


Figure 3-3. Relative contribution of specific RCOCs to human-toxics EIVs

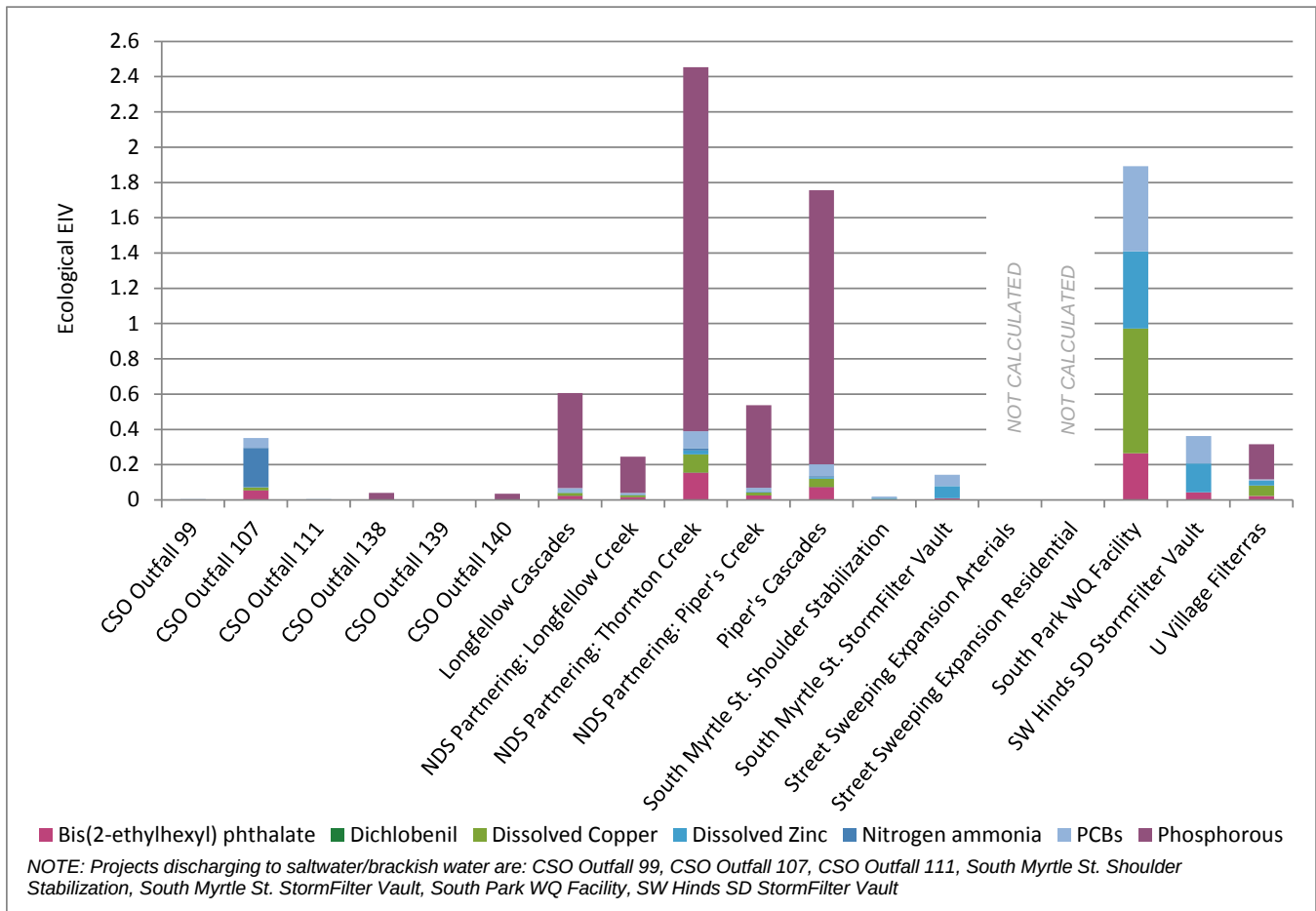


Figure 3-4. Relative contribution of specific RCOCs to ecological EIVs

Chapter 4

Conclusions

The Exposure Assessment (EA) was conducted to assess relative hazard reductions and the estimated impact on receiving waters resulting from changes in discharges of Representative Constituents of Concern (RCOCs) associated with each candidate stormwater or LTCP project. The EA tool is a mathematical model that provides a science-based metric by which the City of Seattle's proposed project outcomes can be compared, and is based on standard risk assessment methodologies.

The EA tool's output is termed the exposure index value, or EIV. Separate EIVs were calculated for human and ecological receptors for each RCOC associated with each project. EIVs were then summed separately for human and ecological receptors for each project. As formulated, a higher EIV indicates that implementing a particular project would have relatively greater impact on reducing hazards in comparison to other projects with lower EIVs.

Because estimates of actual concentrations at points of exposure (e.g., in receiving water) to human or ecological receptors that result from decreases in effluent load are not available, the output of the EA reflects an approximate estimate of changes in *relative* exposure, not actual exposure or risk, induced by changes in effluent releases. These estimates allow for a comparison of the relative benefit of the candidate LTCP or stormwater projects.

Based on this analysis, the following observations were noted:

- PCBs are the main drivers of estimated human EIVs for toxics. Specifically, PCBs contribute at least 92 percent to each EIV estimate. The next-most significant contributor is bis(2-ethylhexyl)phthalate, which contributes up to 8 percent of the EIV estimates.
- At freshwater locations, phosphorus is the main contributor to estimated ecological EIVs. At these locations, phosphorus contributes from 63 to 90 percent of the estimated EIV. Other RCOCs also contribute significantly at these locations, at levels that vary by location, specifically bis(2-ethylhexyl)phthalate, dissolved copper, dissolved zinc, nitrogen ammonia, and PCBs.
- At saltwater/brackish locations (i.e., on the Duwamish Waterway), bis(2-ethylhexyl)phthalate, dissolved copper, dissolved zinc, nitrogen ammonia, and PCBs contribute to ecological EIVs.
- The highest overall ranked project, based on the estimated human-toxics EIV, is the stormwater project associated with the South Park WQ Facility on the Duwamish Waterway ($EIV_H = 116.6$). The highest-ranked candidate LTCP project is CSO Outfall 107, also on the Duwamish Waterway ($EIV_H = 13.2$).
- The highest overall ranked project based on the estimated fecal coliform EIV for humans is also the stormwater project associated with the South Park WQ Facility on the Duwamish Waterway ($EIV_{FC} = 8.3$). The highest-ranked candidate LTCP project is CSO Outfall 138 on Portage Bay ($EIV_{FC} = 2.0$).
- The highest overall ranked project based on the estimated ecological EIV is the stormwater project associated with NDS Partnering on Thornton Creek ($EIV_E = 2.5$). The highest-ranked candidate LTCP project is CSO Outfall 107 on the Duwamish Waterway ($EIV_E = 0.35$).

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Chapter 5

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Attachment H-1: Fish Species Presence Matrix

Sheet 7: Fish Species Presence Matrix (Source: SeaRun Consulting)

NOTE: Juvenile salmonids are dependent on the shoreline/shore near outfalls. Adults are independent/deep water: outfalls may not present exposure risk.

NOTE: Juvenile column refers to fish spawned in-system, not migratory. Adult column includes large juveniles that are suspected migrants

NOTE: Underline/bold indicates primary migration months

NOTE: Numbers in parentheses refer to comments and references, not data values

ABBREVIATIONS: * = not ESA species x = presumed present, no specific data
NP=Not Present AR = AR's KC data

Species Considered	Present in:		Elliott Bay		Reference	Adult	Ref.
	Fresh	Marine	Egg/Breeding	Juvenile			
Chinook salmon	yes	yes	NP	D,J, F, <u>M, A</u> , <u>M, J</u> , J, A, S	(4, 13 = M-S, 8 = M-A)	D,J,F or All mos.	(8a)
Steelhead	yes	yes	NP	F,M,A,M	(8a)	D,J,F(8a), M,J,J,A,N (22)	(8a, 22)
Bull trout	yes	yes	NP	NP	(20, 8)	x, Apr (9a)	(22, 19, 9a)
Cutthroat trout*	yes	yes	NP	A,M,J,J,A,S	(20, 25)	All mos.	
Coho salmon*	yes	yes	NP	<u>J</u> ,J,A	(17, (8)	All mos.	
Sockeye salmon*	yes	yes	NP	NP in nearshore	(8)	J,J,A	
Chum salmon*	yes	yes	NP	<u>A,M,J</u> ,J,A, S, O	(17, 8)	x	(8)
Pink salmon*	yes	yes	NP	x	(8)	J,A,S,O	(8)
3 Rockfish Spp.	no	yes	?	x SPRING-SUMMER	(22)	x	(22)
Marbled Murrelet	yes	yes	NP	x	(22)	x	(22)
Killer Whale	no	yes	NP	A,S,O,N,D,J,F,M,A	(22)	A,S,O,N,D,J,F,M,A	(22)
Steller sea lion	can be	yes	NP	x	(22)	x	(22)
Humpback Whale	no	yes	NP	M,J,J,S	(22)	M,J,J,S	(22)
<u>Spp. Not Considered</u>							
Eulachon	yes	yes	NP	NP		x	(22)
Green sturgeon	yes	yes	NP	NP			
Pacific Herring*	no	yes	NP	NP			
Smelt*	no	yes	NP	NP	(22)	x	
Sandlance*	no	yes	NP	NP	(22)		

* = not ESA species Notes to references listed here

(8a) yearlings+subadults

(9a) subadult caught in beach seine 1998

Sheet 7: Fish Species Presence Matrix (Source: SeaRun Consulting)

Species Considered	Duwamish River				
	Egg/Breeding	Juvenile	Ref.	Adult	Ref
Chinook salmon	NP	J, F, <u>M</u> , A, <u>M</u> , <u>J</u> , <u>J</u> , A, S	(4, 13, 8)	J,J,A,S,O,N	(13)
Steelhead	NP	F, M, A, M, J	(14, 8)	N,D,J,F,M,A (20),M,J.J(8a)	(20, 8a, (11a)
Bull trout	NP (24)	NP	(20, 8, 24)	A,M,A,S, visitors	(19, 20, 22, 24)
Cutthroat trout*	NP	x	(8)	A	(8a)
Coho salmon*	NP	A,M,J	(8)	J,F,M,A,M	(8a)
Sockeye salmon*	NP	M,A (few)	(8)	x	(8)
Chum salmon*	NP	F, <u>M</u> , <u>A</u> , <u>M</u> .J.J	(8)	x	(8)
Pink salmon*	NP	M,A (few)	(8)	x	(8)
3 Rockfish Spp.	NP	NP		NP	
Marbled Murrelet	NP	NP		NP	
Killer Whale	NP	NP		NP	
Steller sea lion	NP	NP	(20)	NP	
Humpback Whale			(20)		
<u>Spp. Not Considered</u>					
Eulachon	NP	NP			
Green sturgeon	NP	NP			
Pacific Herring*	NP	NP			
Smelt*	NP	NP			
Sandlance*	NP	NP			

* = not ESA species

(14) hatchery releases into Green River, 9-day residence time

(11a) N,D,J,F,M,A,M is Green R. instream & spawning per WDFW 2002 data.

Sheet 7: Fish Species Presence Matrix (Source: SeaRun Consulting)

Species Considered	Shilshole Bay (either L WA or Elliott Bay origin)		Lake Union/Ship Canal			
	Juvenile	Ref	Egg/Breeding	Juvenile	Ref	Adult
Chinook salmon	<u>M,J,J,A,S,O</u>	(17, 21a,e; 6)	NP	<u>M,J,J,A</u>	(6)	<u>J,J,A,S,O</u>
Steelhead	A,M	(18)	NP	A,M	(18)	<u>N,D,J,F,M,A,M,J</u>
Bull trout	M, J	(19, 22, 24c)	NP	NP		M,J,J, strays
Cutthroat trout*	A,M,J,J,A,S	(25, 21d, h)	NP	?		x LATE WIN-EARLY SPRING
Coho salmon*	<u>M,J,J,A</u> , S?, O?	(17, 18, 21b,f)	NP	M,J, J	(16)	<u>A,S,O,N</u>
Sockeye salmon*	June	(17)	NP	<u>A,M,J,J</u>	(16, 18)	<u>M,J,J,A,S,O</u> (18), N,D,J,F
Chum salmon*	<u>M,J,J,A,S,O</u> --Elliott Bay	(17, 21c,g)	NP	NP	(18)	(18), missing re
Pink salmon*			NP	NP		NP
3 Rockfish Spp.			NP	NP		NP
Marbled Murrelet			NP			
Killer Whale			NP			
Steller sea lion			NP			
Humpback Whale						
<u>Spp. Not Considered</u>						
Eulachon			NP			
Green sturgeon						
Pacific Herring*	<u>J,J,A</u>	(17)	NP			
Smelt*			NP			
Sandlance*	M,J	(17)	NP			

* = not ESA species (18) LWSC pass time average 2 d Chin, 4 d sockeye, >1 wk coho; LWA pass time 2.9 d Chin, 85 d sockeye

(16) June, July along shore & littoral zone

(21a) Carkeek Park M,J,J,A,S in 2001; May-Oct 2002

(21b) Carkeek Park J,A only in 2001, May-Aug 2002

(21c) Carkeek Park May only in 2001 & 2002

(21d) Carkeek Park J,J,A,S in 2001; M,J 2002

(21e) Golden Gardens May-Aug 2001; Jun-O 2002

(21f) Golden Gardens J,J 2001; May-Aug 2002

(21g) Golden Gardens May-Jun 2002 (no data : .

(21h) Golden Gardens May-S 2002 (no data 2001)

(24c) Shilshole Bay in May

(6) Chinook:moved through Portage Bay in fewer than 24 hours;

spent one day to two weeks in Lake Union; moved through the Fremont Cut in fewer than 24 hours; and,

spent hours to a week or more in Salmon Bay and near the locks

(15) hold at Locks for weeks, move thru Canal in 1 day

(18b) Chin ave. 1 d in LWSC, sockeye ave. 4 d in LWSC

(24b) in fish ladder May, June

Sheet 7: Fish Species Presence Matrix (Source: SeaRun Consulting)

Species Considered	Lake Washington				
	Egg/Breeding	Juvenile	Ref	Adult	Ref
Chinook salmon	NP	J,F,M, A,M,J,J ,A	(16)	J,A,S,O	(7a,18c)
Steelhead	NP	A,M ,J	(18)	M,A,M ,J	(18)
Bull trout	NP	NP (only subadult strays)	(24a)	N,D,J,F,M,A,M,A strays	(11a, 7, 19, 22, 24a)
Cutthroat trout*	NP	X		LATE WIN-EARLY SPRING	
Coho salmon*	NP	A, M , J,J	(18)	S,O,N	(18)
Sockeye salmon*	X	J, F,M,A ,M, J + all year	(16, 18)	All year	(18d)
Chum salmon*	NP	NP	(18)	NP-strays	(7)
Pink salmon*	NP	NP		NP-strays	(7)
3 Rockfish Spp.	NP	NP		NP	
Marbled Murrelet	NP	possibly present	(26)	possibly present	(26)
Killer Whale	NP				
Steller sea lion	NP				
Humpback Whale					
<u>Spp. Not Considered</u>					
Eulachon	NP				
Green sturgeon	?				
Pacific Herring*	NP				
Smelt*	NP				
Sandlance*	NP				

* = not ESA species (24a) March, May (1985) fish were subadults >300 mm FL
 (26) presence based on use of coastal lakes and predation on sockeye and other salmonids
 (18c) Chin 2-5 d before entering rivers
 (7a) Adult Chin spend 2.9 d in L. WA
 (18d) spend 85 d below thermocline
 (11a) LW winter stlhd migration Nov-May includes instream spawning Mar-May.
 Data from WDFW et al. (2002)
 (23) one 24" female steelhead carcass in Thornton Creek in 2004.

Sheet 7: Fish Species Presence Matrix (Source: SeaRun Consulting)

Species Considered	Thornton Creek						Pipers Creek					
	Egg/Breeding	Ref	Juvenile	Ref	Adult	Ref	Egg/Breeding	Ref	Juvenile	Ref	Adult	Ref
Chinook salmon	x	(1a)	<u>by June</u>	(1b, 2)	X	(7, 22)	NP		Jul '99=6 (22), NP (1, 2)	(1,2, 22)	NP	(7b, 2)
Steelhead	NP		x	(1b, 3)	F,M	(22, 23)	x	(1c)	summer	(1d, 7, 23)		
Bull trout	NP		NP		NP		NP		NP		NP	
Cutthroat trout*	x		F, <u>Sept</u>	(2, 3, 5, 7)	X	(7)	x		summer, Aug., S,O, winter, F,M	(2, 3, 5)		
Coho salmon*	x		F, Aug, O	(2, 3)	x	(7, 22)	?		Oct	(2, 3)	x	(7, 22)
Sockeye salmon*					x	(7)	NP					
Chum salmon*	NP		NP		NP	(7)	?		x	(7)	x	(7c)
Pink salmon*	NP		NP		NP	(7)	NP					
3 Rockfish Spp.	NP		NP		NP		NP		NP		NP	
Marbled Murrelet	NP											
Killer Whale	NP											
Steller sea lion	NP											
Humpback Whale												
<u>Spp. Not Considered</u>												
Eulachon	--						--					
Green sturgeon	--						--					
Pacific Herring*	--						--					
Smelt*	--						--					
Sandlance*	--						--					

* = not ESA species

(1a) 19 redds counted 2000-2005, 1 in 2006

(1c) 3-4 possible redds 2001-2006

(1d) 1 juv 2006

(1b) no juv caught J, A, S, M, A 2005-2011

(2) No PS Chin redds or smolts 2001-6

(3) RBT observed 2005-6

(7b) 1 Chin adult in 1998

(5) summer and winter surveys

(7c) Minter Cr Hatch fingerling releases

(12) McCarthy implied pre-spawner mort 2007 poster

Sheet 7: Fish Species Presence Matrix (Source: SeaRun Consulting)

Species Considered	Longfellow Creek				
	Egg/Breeding	Juvenile	Ref	Adult	Ref
Chinook salmon				x	(22)
Steelhead		x	(3)		
Bull trout	NP	NP			
Cutthroat trout*	x	Aug	(2, 3, 6)		
Coho salmon*		Aug	(2, 3)	x	(12, 22)
Sockeye salmon*					
Chum salmon*					
Pink salmon*					
3 Rockfish Spp.	NP	NP		NP	
Marbled Murrelet					
Killer Whale					
Steller sea lion					
Humpback Whale					
<u>Spp. Not Considered</u>					
Eulachon					
Green sturgeon					
Pacific Herring*					
Smelt*					
Sandlance*					

* = not ESA species

(6) summer only

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Appendix I: Development of Integrated Plan



Protecting Seattle's Waterways

Volume 3 – Integrated Plan

Appendix I: DEVELOPMENT OF INTEGRATED PLAN

Final
May 29, 2015



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List of Abbreviations

Term	Definition
m	micron/micrometer
BMP	best management practice
BOD	biochemical oxygen demand
CESF	chitosan-enhanced sand filtration
CSO	combined sewer overflow
EIV	exposure index value
ESA	Endangered Species Act
GAC	granular activated carbon
I/I	infiltration and inflow
LTCP	Long-Term Control Plan
MAUT	Multi-Attribute Utility Theory
MODA	Multiple Objective Decision Analysis
NDS	Natural Drainage Systems
O&M	operations and maintenance
PBDE	polybrominated diphenyl ether
PCB	polychlorinated biphenyl
PS	pump station
RCOC	Representative Constituent of Concern
R/D	research and development
ROW	right-of-way
TAPE	Technology Assessment Protocol – Ecology
SDOT	Seattle Department of Transportation
SMARTS	Simple Multi-Attribute Rating Technique with Swings
TSS	total suspended solids
WTD	(King County) Wastewater Treatment Division
WWTF	wastewater treatment facility

Summary

The Consent Decree allows the City of Seattle (City) the opportunity to prepare an Integrated Plan as an alternative to the Long-Term Control Plan (LTCP). According to Section V.B. paragraph 20 of the Consent Decree, the Integrated Plan must propose water quality improvement project(s) “that will result in significant benefits to water quality beyond those that would be achieved by implementation of the approved CSO [combined sewer overflow] Control Measures only.” The Consent Decree requires that the City describe the benefits of the proposed projects in terms of reductions in pollutant loads and exposure to human and ecological receptors.

The City developed its Integrated Plan based on these Consent Decree requirements. The City first compared the water quality benefits of the candidate stormwater projects with the water quality benefits of the candidate LTCP projects. This allowed the City the opportunity to identify any stormwater projects that might not contribute significant benefits to water quality over and above the projected benefits of the deferred LTCP projects. The City also evaluated the candidate stormwater projects based on other factors, such as level of treatment (pretreatment, basic, or enhanced) and proximity to other planned stormwater quality projects. Based on these evaluations, the City decided to retain 10 of the candidate stormwater projects for further evaluation.

The City then scored and ranked the candidate stormwater projects using Multiple Objective Decision Analysis (MODA). In keeping with the Consent Decree, MODA gave primary consideration to the expected water quality benefits of each project. MODA also considered criteria relevant to other City priorities and values. MODA helped the City compare the stormwater projects with regard to their overall benefits.

Based on the water quality comparisons and MODA, the City selected a suite of stormwater projects for implementation by 2025 and LTCP projects for deferral until 2028–30.

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CHAPTER 1

Comparison of Candidate LTCP and Stormwater Projects

The City of Seattle (City) selected candidate stormwater projects that would take advantage of opportunities in key drainage basins and receiving water bodies. In contrast, the City identified relatively small Long-Term Control Plan (LTCP) projects as potential candidates for deferral. The intent was to identify candidate stormwater projects that would provide significant water quality benefits as compared to the deferred LTCP projects.

1.1 Pollutant Load Reduction

The City compared the projected pollutant load reductions for the candidate stormwater projects with the projected load reductions for the candidate LTCP projects. As shown in Table 1-1, for all Representative Constituents of Concern (RCOCs) except ammonia-N, the highest-ranked candidate projects are all stormwater projects. CSO Outfall 107, the largest candidate LTCP project, would provide the largest ammonia-N load reduction of the candidate projects. Figure 1-1 compares the estimated RCOC load reductions for each candidate stormwater project with the estimated load reductions for CSO Outfall 107. As shown in the figure, most of the stormwater projects provide greater load reduction for most RCOCs because they would treat or reduce larger volumes than the candidate LTCP projects (see Figure 1-2).

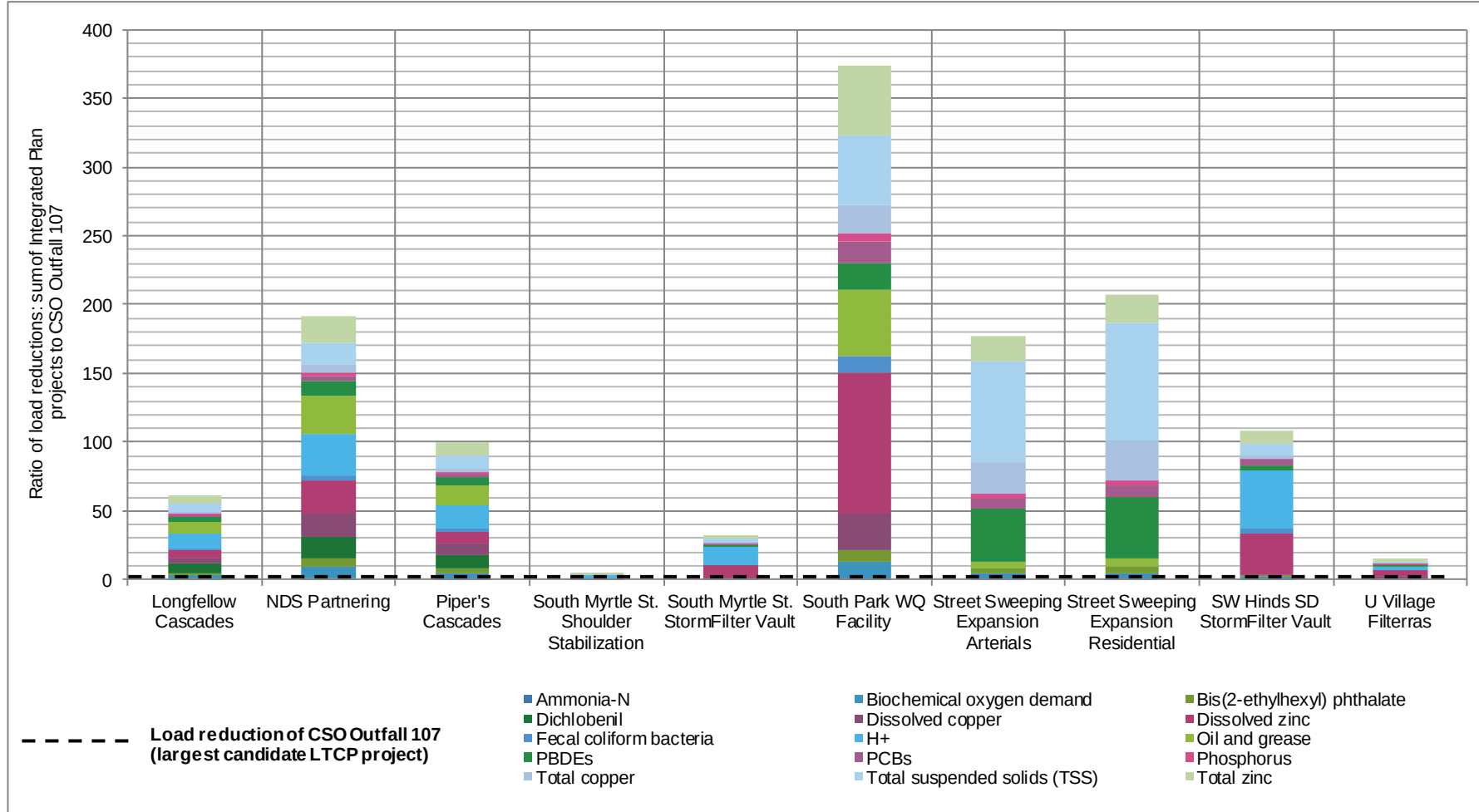


Figure 1-1. Comparison of candidate stormwater projects to largest candidate LTCP project load reductions

Table 1-1. Average Pollutant Load Reductions for Candidate LTCP and Stormwater Projects																
Candidate project	Volume treated/ reduced	Ammonia-N	BOD	Bis(2-ethylhexyl) phthalate	Dichlobenil	Dissolved copper	Dissolved zinc	Fecal coliform	H+	Oil and grease	PBDEs	PCBs	Phosphorus	Total copper	Total suspended solids	Total zinc
	MG/yr	Reduction (kg/yr)	Reduction (kg/yr)	Reduction (kg/yr)	Reduction (kg/yr)	Reduction (kg/yr)	Reduction (kg/yr)	Reduction (billion CFU/yr)	Reduction (kg/yr)	Reduction (kg/yr)	Reduction (kg/yr)	Reduction (kg/yr)	Reduction (kg/yr)	Reduction (kg/yr)	Reduction (kg/yr)	Reduction (kg/yr)
CSO Outfall 99	0.17	0.78	12	0.0015	0.000070	0.0032	0.012	651	0.000073	2.2	0.000038	0.000032	0.37	0.0084	20	0.026
CSO Outfall 107	1.1	19	82	0.035	0.00029	0.027	0.14	4,346	0.00049	15	0.00025	0.00046	6.6	0.22	494	0.57
CSO Outfall 111	0.0086	0.15	0.64	0.00027	0.000003	0.00021	0.0011	34	0.0000038	0.11	0.0000020	0.0000036	0.05	0.0017	4	0.0044
CSO Outfall 138	0.091	0.43	6.8	0.00081	0.000041	0.0018	0.0067	360	0.000040	1.2	0.000021	0.000018	0.21	0.0046	11	0.015
CSO Outfall 139	0.0057	0.027	0.42	0.00005	0.000003	0.00011	0.00042	22	0.0000025	0.075	0.0000013	0.0000011	0.013	0.00029	0.69	0.0009
CSO Outfall 140	0.051	0.24	3.8	0.00045	0.000023	0.0010	0.0038	201	0.000023	0.67	0.000012	0.000010	0.12	0.0026	6	0.0081
Longfellow Cascades	5.0	2.8	237	0.063	0.0019	0.12	0.71	6,212	0.00510	129	0.0010	0.00062	5.1	0.34	2,645	3.4
NDS Partnering	35	9.2	684	0.22	0.0048	0.46	3.2	17,910	0.015	396	0.0029	0.0018	14	1.3	7,704	11
Piper's Cascades	8.3	4.7	370	0.11	0.0031	0.22	1.2	9,734	0.0081	204	0.0017	0.0010	8.4	0.58	4,382	6
South Myrtle St. Shoulder Stabilization.	0.10	0.086	8.7	0.0021	0.000015	0.0024	0.16	125	0.00062	3.4	0.000033	0.000069	0.09	0.027	142	0.24
South Myrtle St. StormFilter	3.1	0.0	56	0.0098	0.0	0.0	1.29	3,232	0.0064	1.3	0.00025	0.00056	1.4	0.13	1,092	1.4
South Park WQ Facility	74	0.0	1,088	0.29	0.0	0.71	14	52,700	0.0	702	0.0047	0.0069	46	4.5	24,741	29
Street Sweeping Expansion Arterials	1527	N/A	337	0.14	N/A	N/A	N/A	2,100	N/A	69	0.0096	0.0033	24	5.2	36,200	10
Street Sweeping Expansion Residential	986	N/A	366	0.16	N/A	N/A	N/A	2,560	N/A	84	0.011	0.0040	28	6.3	41,900	12
SW Hinds SD/ StormFilter	14	0.0	213	0.045	0.0	0.0	4.1	11,496	0.021	0.0	0.0011	0.0019	6.0	0.44	4,191	5
U Village/Filterras	3.0	0.0	64	0.014	0.0	0.043	0.54	1,395	0.0014	0.0	0.00022	0.00014	0.87	0.18	676	1

The top-performing stormwater projects treat or reduce much larger volumes than the candidate LTCP projects (Figure 1-2). Four of the six candidate LTCP projects have volume reductions that are one to two orders of magnitude smaller than CSO Outfall 107. Most of the candidate stormwater projects, therefore, would provide considerably greater load reductions for most RCOCs when compared to the four smallest candidate LTCP projects. Moreover, the larger candidate stormwater projects treat or reduce much larger volumes than the candidate LTCP projects from February through September, when human exposure is more likely.

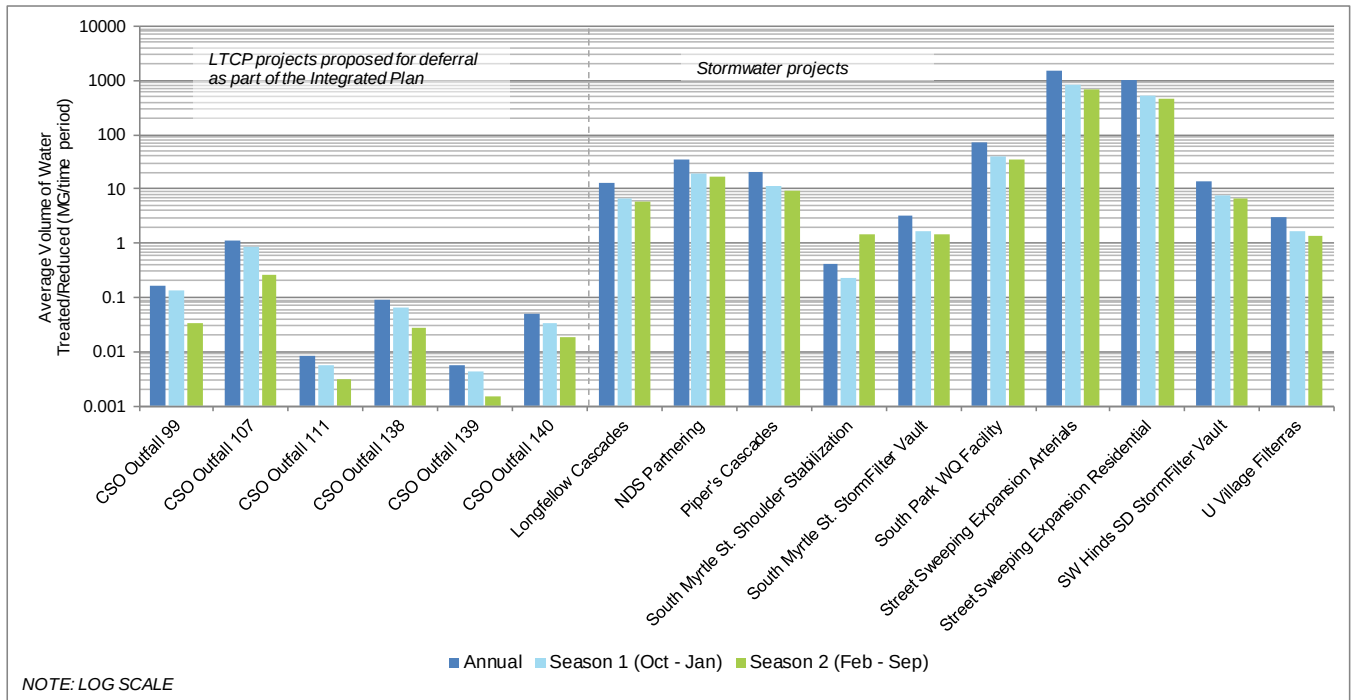


Figure 1-2. Average volume of water treated or reduced from the candidate LTCP and stormwater projects

Figure 1-3 through Figure 1-17 compare the estimated pollutant load reductions for each of the RCOCs.

Total PCBs. The exposure assessment found that polychlorinated biphenyls (PCBs) were the major driver for the human-chronic exposure index values (EIVs) at all locations, and contributed to the ecological EIVs at several locations. Figure 1-3 indicates that most of the candidate stormwater projects would provide more PCB removal, on an average annual basis, than the largest of the candidate LTCP projects (CSO Outfall 107).

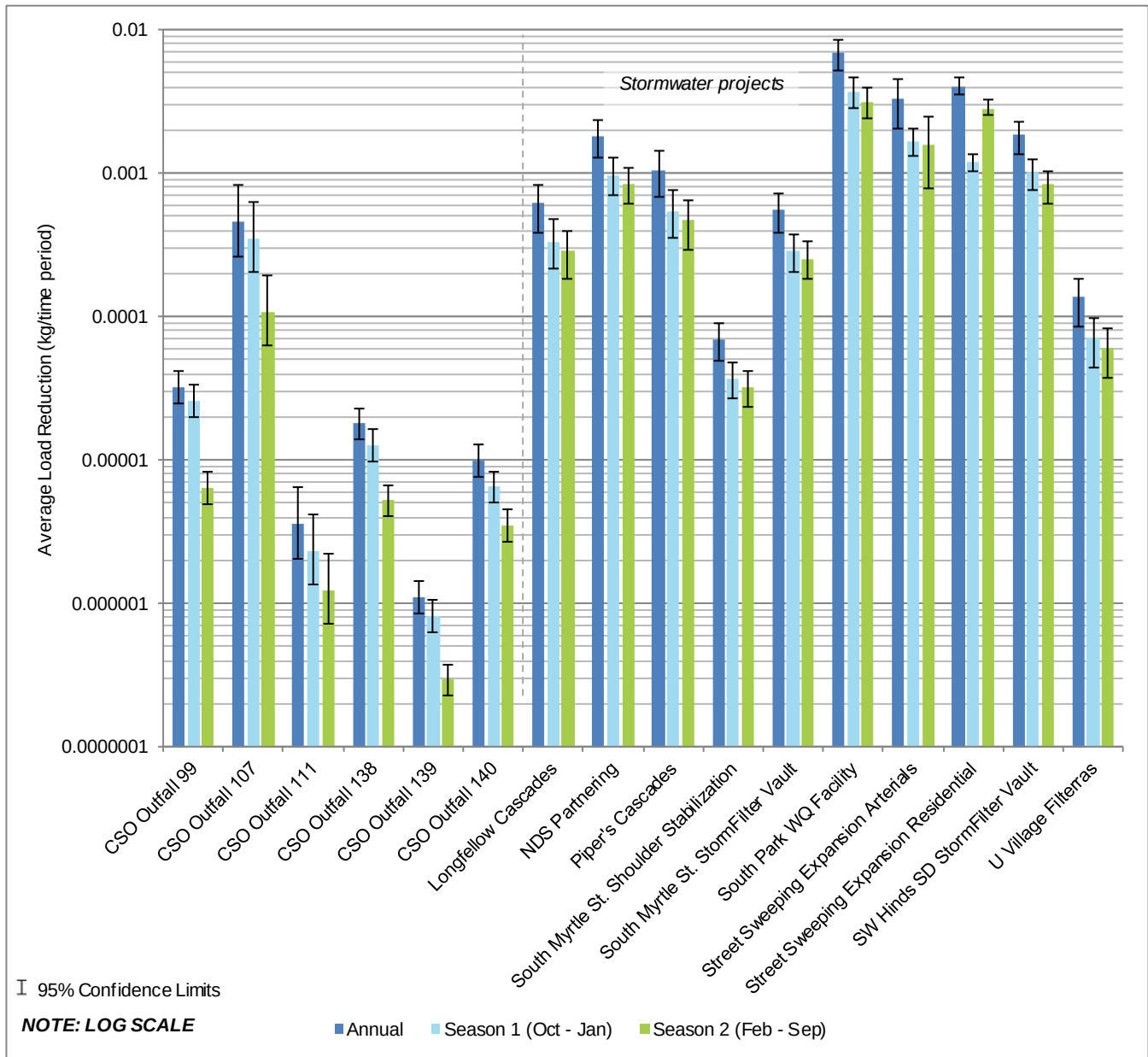


Figure 1-3. Average PCB load reduction from the candidate LTCP and stormwater projects

Note: Exposure assessment found that PCBs were the most important RCOC for human exposure over the long term.

Fecal Coliform Bacteria. Fecal coliform was identified as a key driver for human-acute EIVs. Figure 1-4 shows that half of the candidate stormwater projects would provide more fecal coliform reduction than the best candidate LTCP project (CSO Outfall 107). These five stormwater projects treat much larger discharge volumes than any of the candidate LTCP projects.

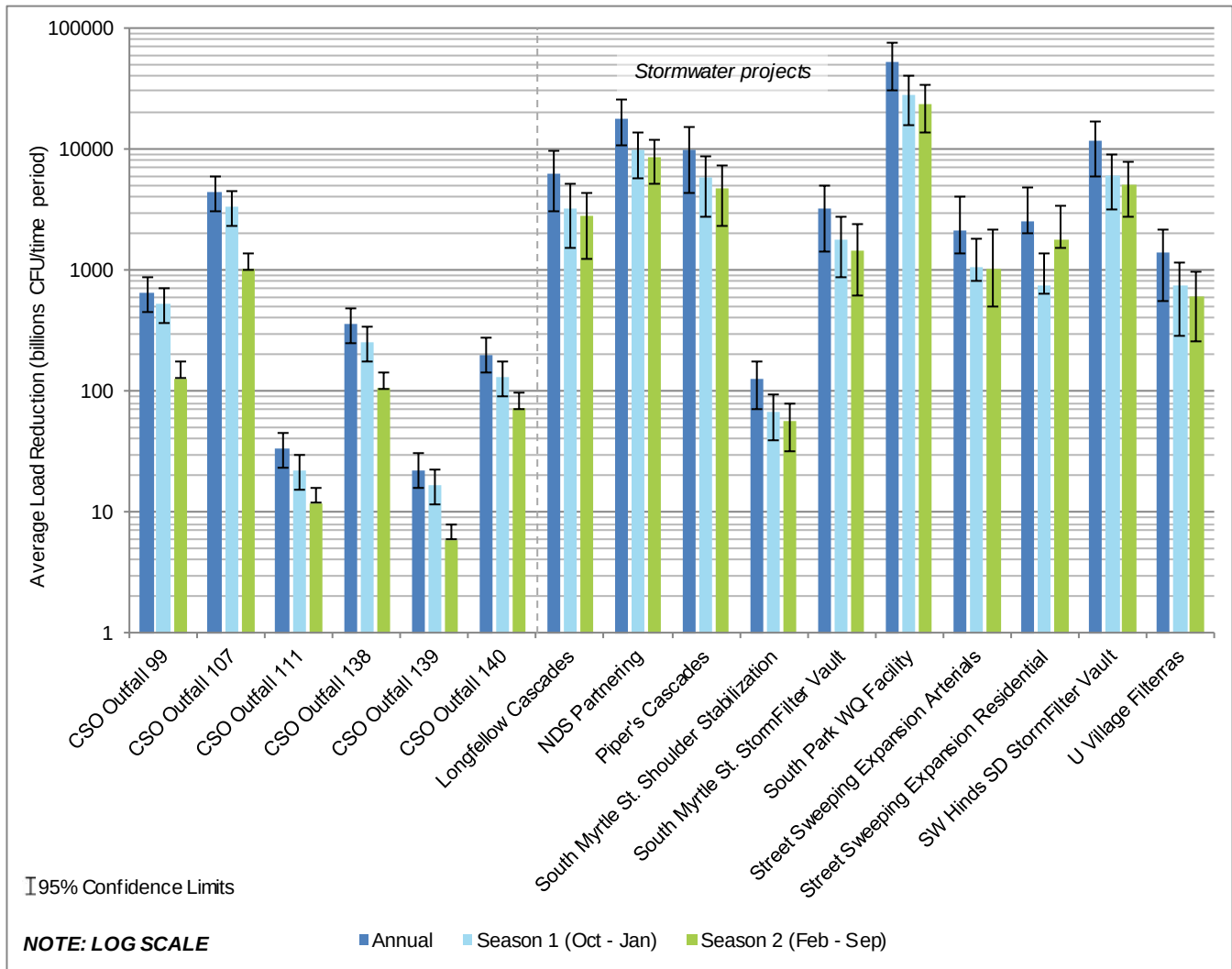


Figure 1-4. Average fecal coliform load reduction from the candidate LTCP and stormwater projects

Dissolved Zinc. The exposure assessment identified dissolved zinc as a driver for ecological EIVs at several locations. Figure 1-5 shows that most of the candidate stormwater projects would provide more dissolved zinc reduction than the best candidate LTCP project (CSO Outfall 107).

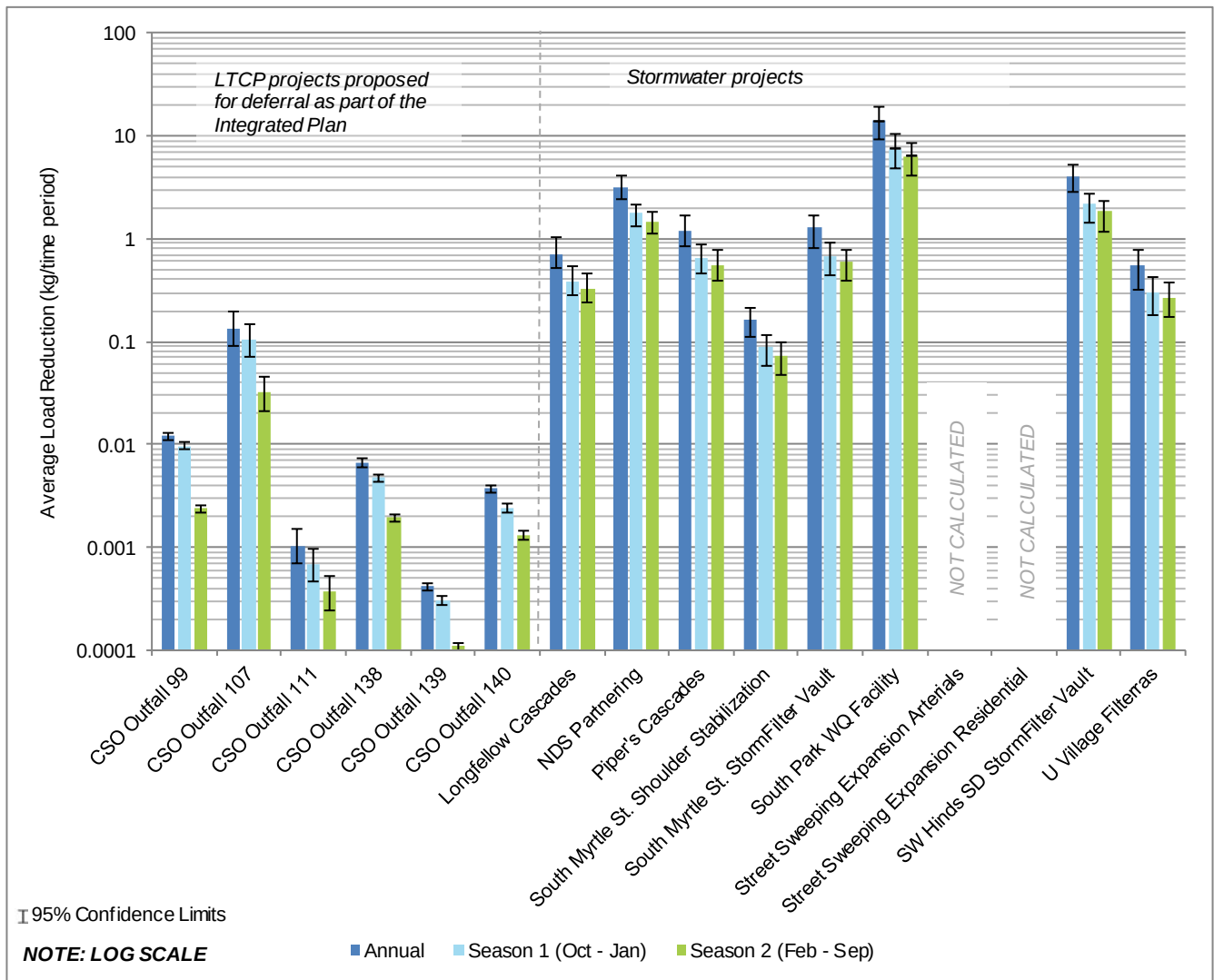


Figure 1-5. Average dissolved zinc load reduction from the LTCP and stormwater projects

Phosphorus. The exposure assessment found that total phosphorus was a major driver for the ecological EIVs at freshwater discharge locations. The candidate stormwater projects that discharge to freshwater bodies (NDS Partnering, Piper's Cascades, Longfellow Cascades, U Village Filterrras, portions of the street sweeping) would provide more average annual phosphorus reduction than the LTCP projects that discharge to freshwater bodies (CSO Outfalls 138, 139, 140). See Figure 1-6 for the estimated phosphorus load reductions for the candidate LTCP and stormwater projects.

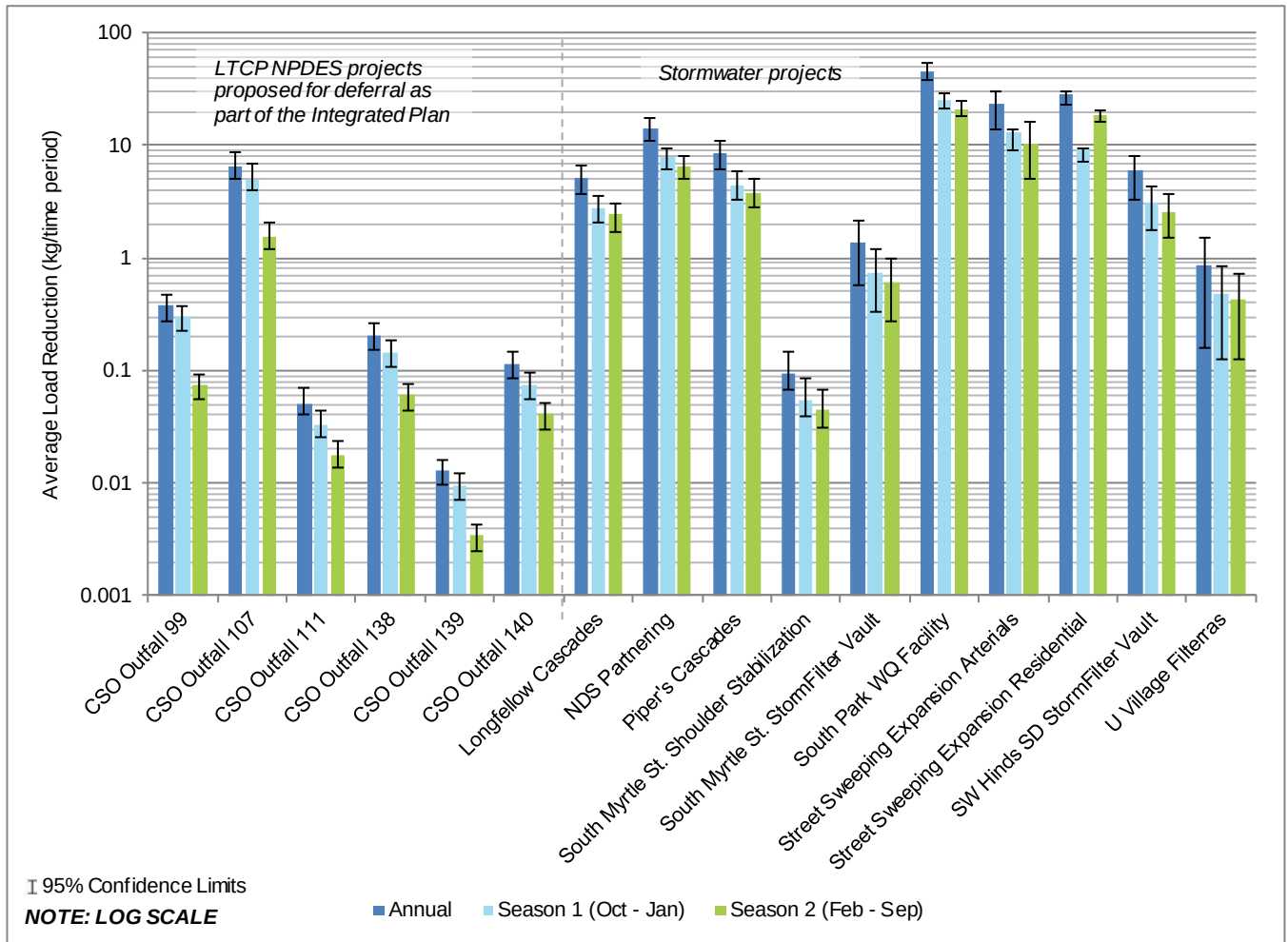


Figure 1-6. Average phosphorus load reduction from the candidate LTCP and stormwater projects

Ammonia-N. The exposure assessment indicated that ammonia contributed to the ecological EIVs at several discharge locations. The pollutant loads modeling assumed that only the stormwater projects that provide volume reduction would reduce ammonia-N loads. As shown in Figure 1-7, four of the candidate stormwater projects are expected to provide appreciable ammonia reoval.

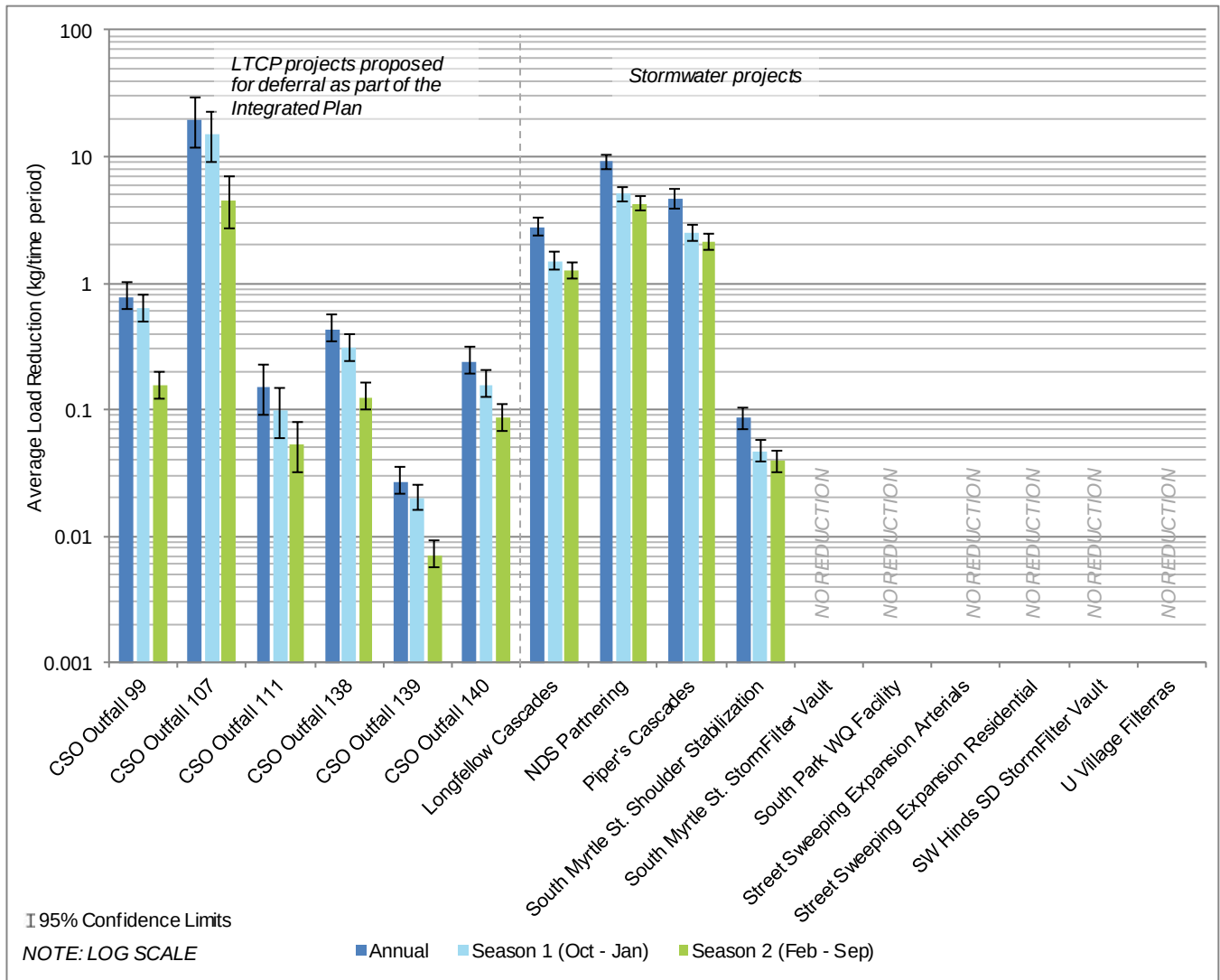


Figure 1-7. Average ammonia-N load reduction from the candidate LTCP and stormwater projects

Dissolved Copper. The exposure assessment found that dissolved copper contributed to the ecological EIVs at some locations. Figure 1-8 compares the load reduction results for dissolved copper. Five of the candidate stormwater projects have higher estimated dissolved copper removal than the largest candidate LTCP project (CSO Outfall 107), while four of the candidate stormwater projects are expected to provide little or no dissolved copper removal.

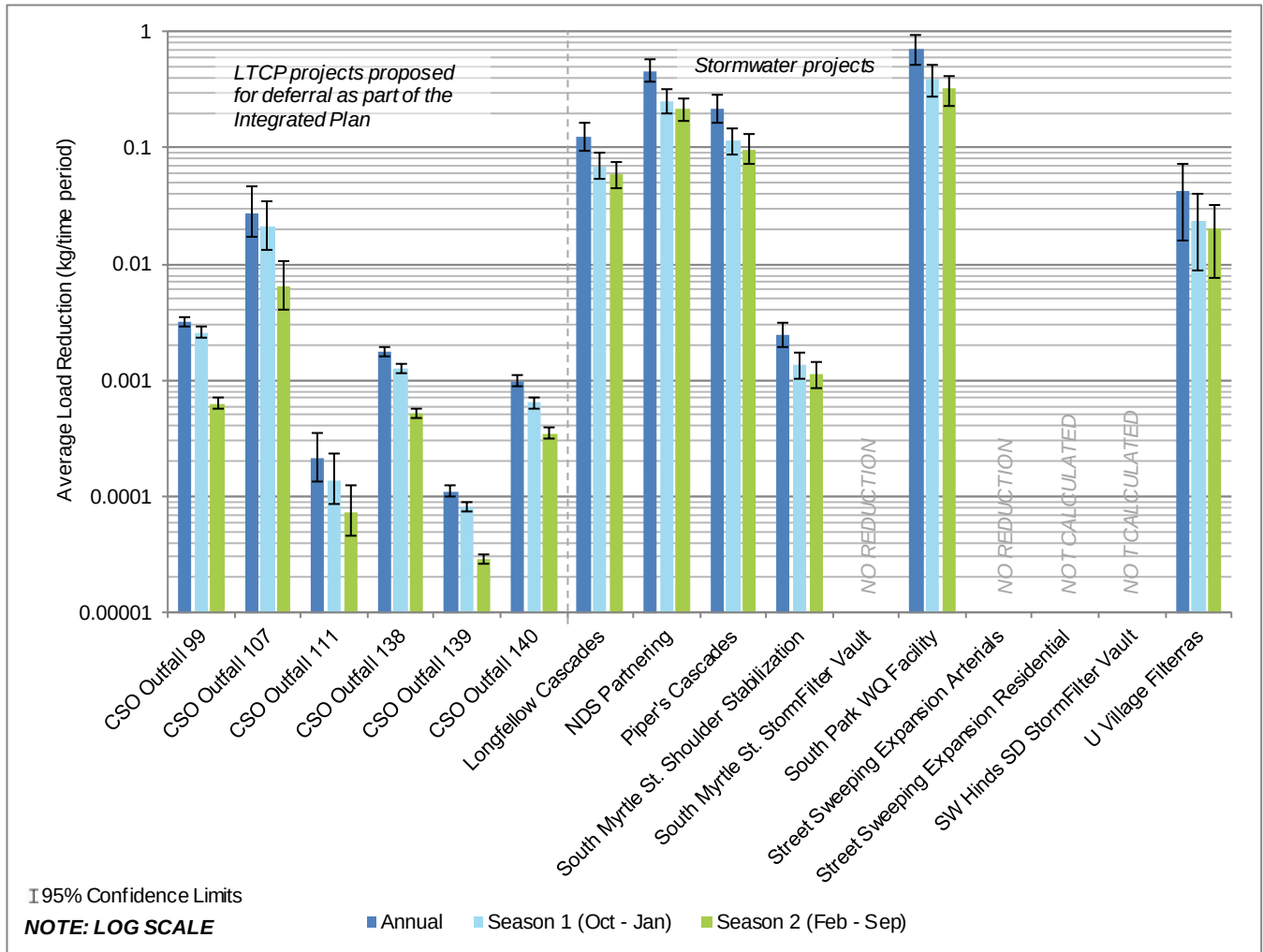


Figure 1-8. Average dissolved copper load reduction from the candidate LTCP and stormwater projects

Biochemical Oxygen Demand. Figure 1-9 compares the candidate stormwater and LTCP projects based on biochemical oxygen demand (BOD) reduction. Most of the stormwater projects have higher estimated annual BOD load reductions than the largest of the candidate LTCP projects for deferral (CSO Outfall 107).

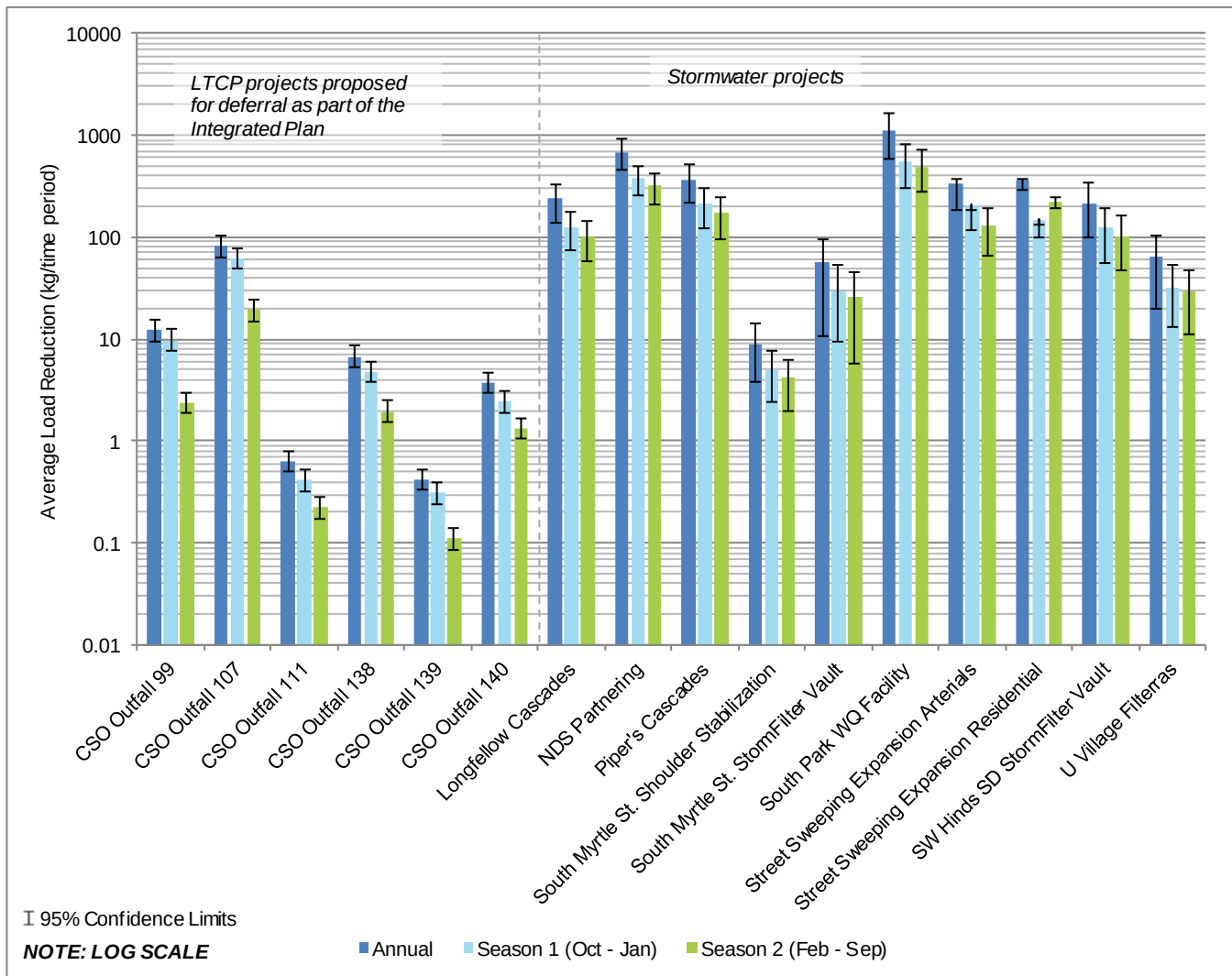


Figure 1-9. Average BOD load reduction from the candidate LTCP and stormwater projects

Bis(2-ethylhexyl)phthalate. The exposure assessment found that bis(2-ethylhexyl)phthalate contributed to the human and ecological EIVs at several locations. Figure 1-10 presents the loads modeling results for bis(2-ethylhexyl)phthalate. Seven of the candidate stormwater projects have higher estimated bis(2-ethylhexyl)phthalate annual load reductions than the largest candidate LTCP project (CSO Outfall 107).

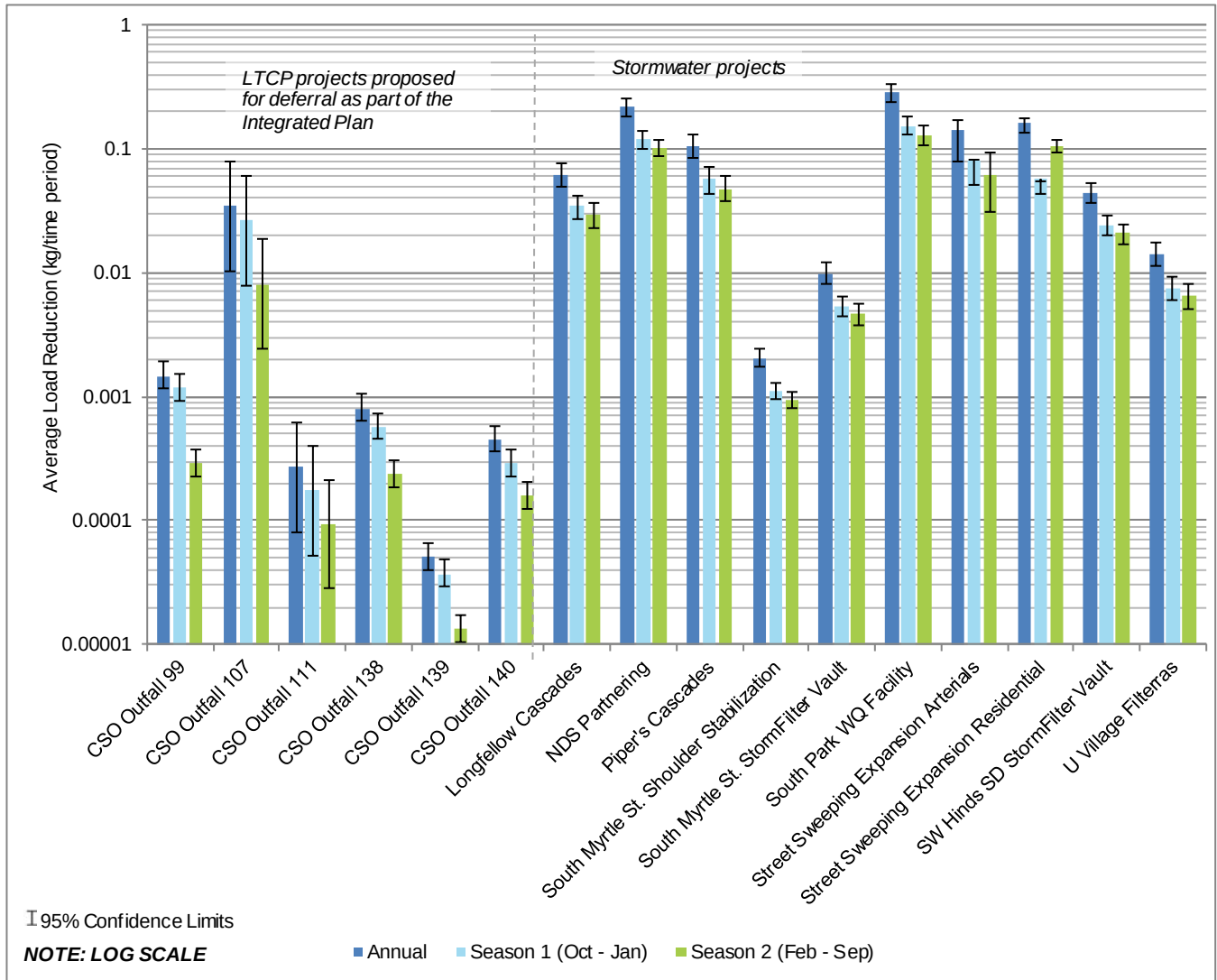


Figure 1-10. Average bis(2-ethylhexyl)phthalate load reduction from the candidate LTCP and stormwater projects

Dichlobenil. Figure 1-11 shows the loads modeling results for dichlobenil. The City assumed that dichlobenil would be removed only by the four candidate stormwater projects that include infiltration: Longfellow Cascades, Natural Drainage Systems (NDS) Partnering, Piper's Cascades, and South Myrtle St. Shoulder Stabilization. Three of these projects would provide larger load reduction than the largest LTCP project (CSO Outfall 107).

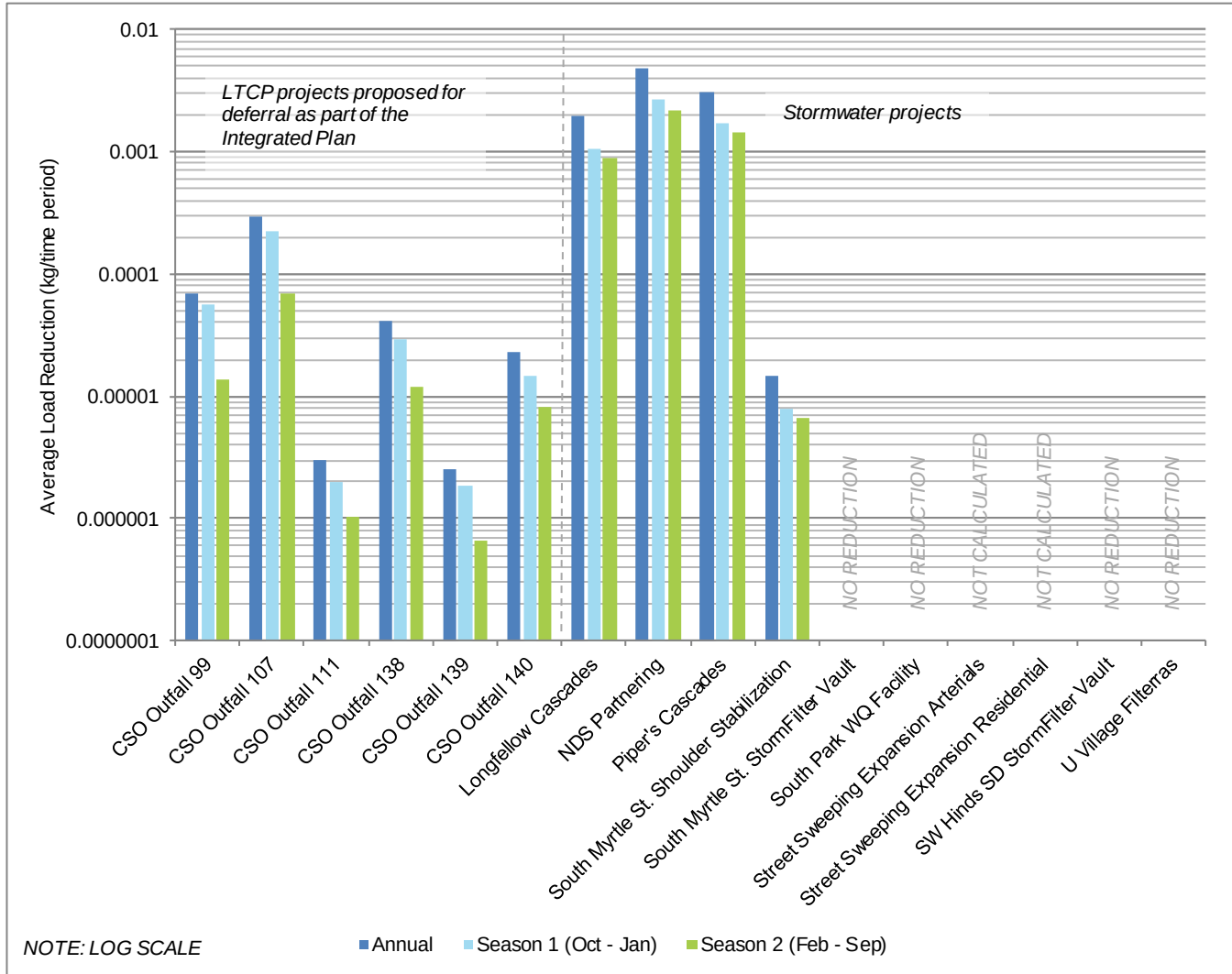


Figure 1-11. Average dichlobenil load reduction from the LTCP and stormwater projects

Note that due to insufficient data, UCL and LCL values were unable to be calculated for dichlobenil.

H+. Figure 1-12 indicates that seven of the candidate stormwater projects would provide greater reductions in H+ annual loads compared to the largest LTCP project (CSO Outfall 107).

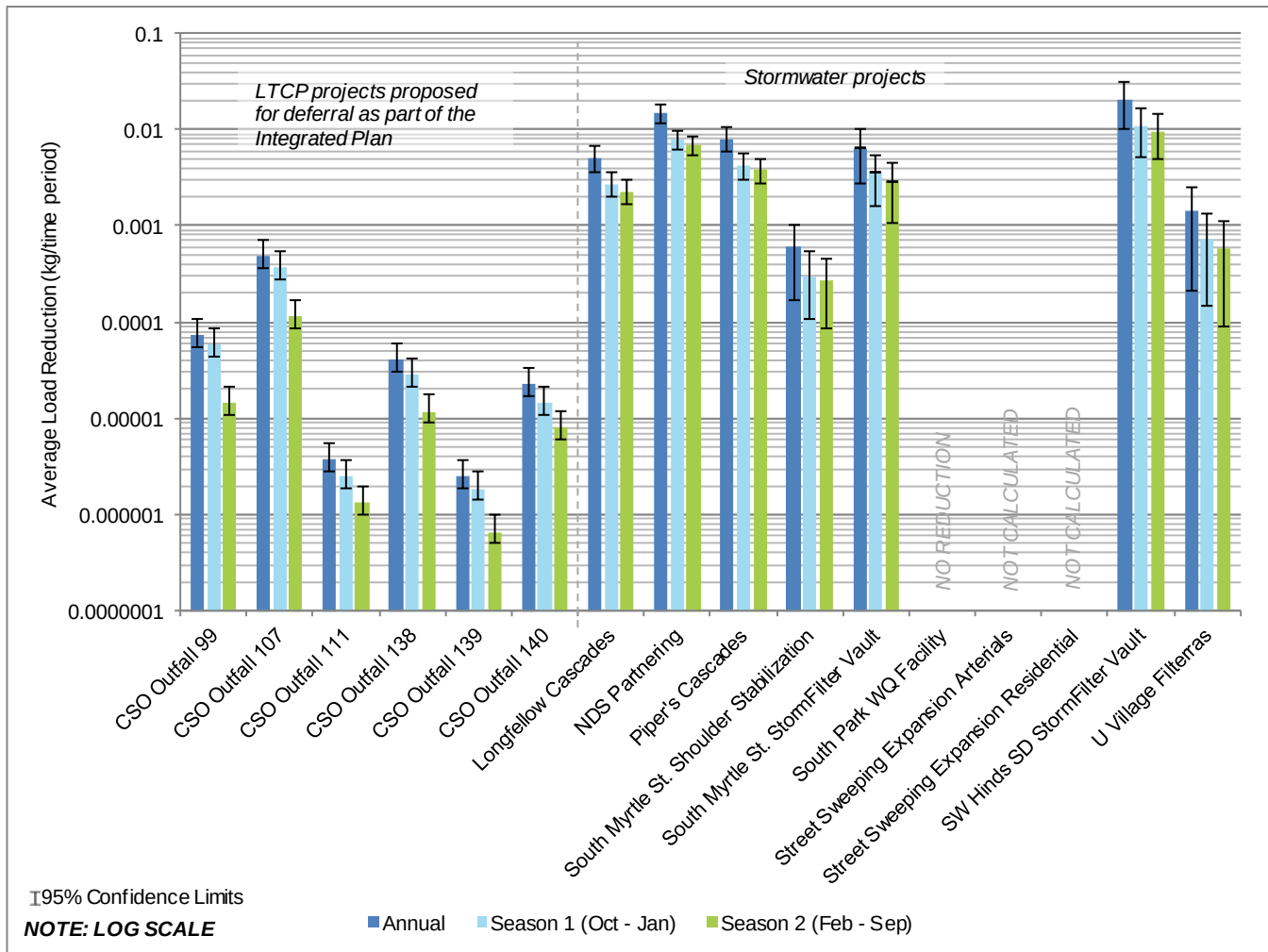


Figure 1-12. Average H+ load reduction from the LTCP and stormwater projects

Oil and Grease. Figure 1-13 compares the estimated oil and grease load reductions for the candidate LTCP and stormwater projects. Six of the candidate stormwater projects would provide more annual loads reduction in oil and grease than the largest candidate LTCP project (CSO Outfall 107).

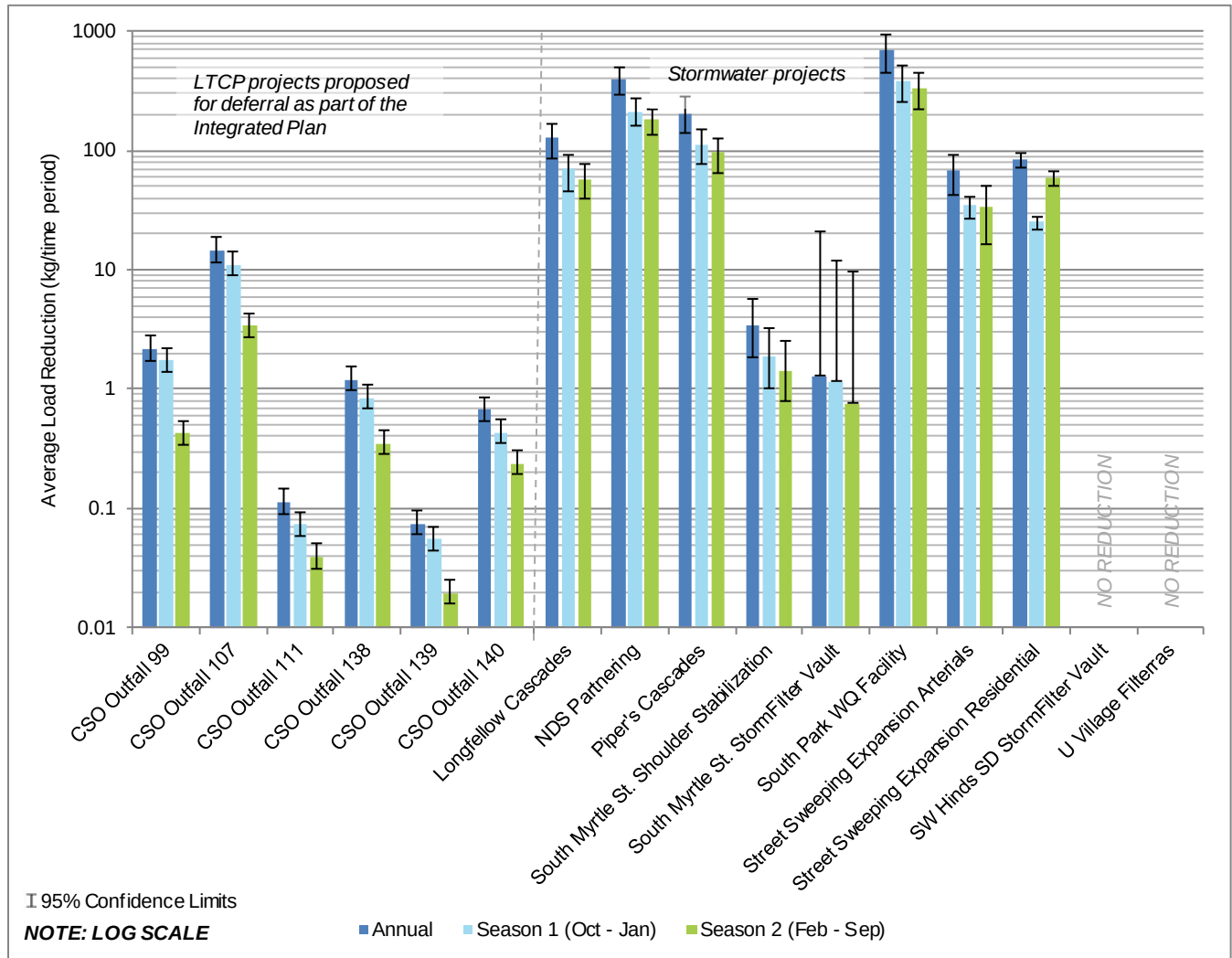


Figure 1-13. Average oil and grease load reduction from the candidate LTCP and stormwater projects

PBDEs. Figure 1-14 presents the load reduction estimates for polybrominated diphenyl ethers (PBDEs). Seven of the candidate stormwater projects have higher PBDE load reductions than the largest candidate LTCP project (CSO Outfall 107).

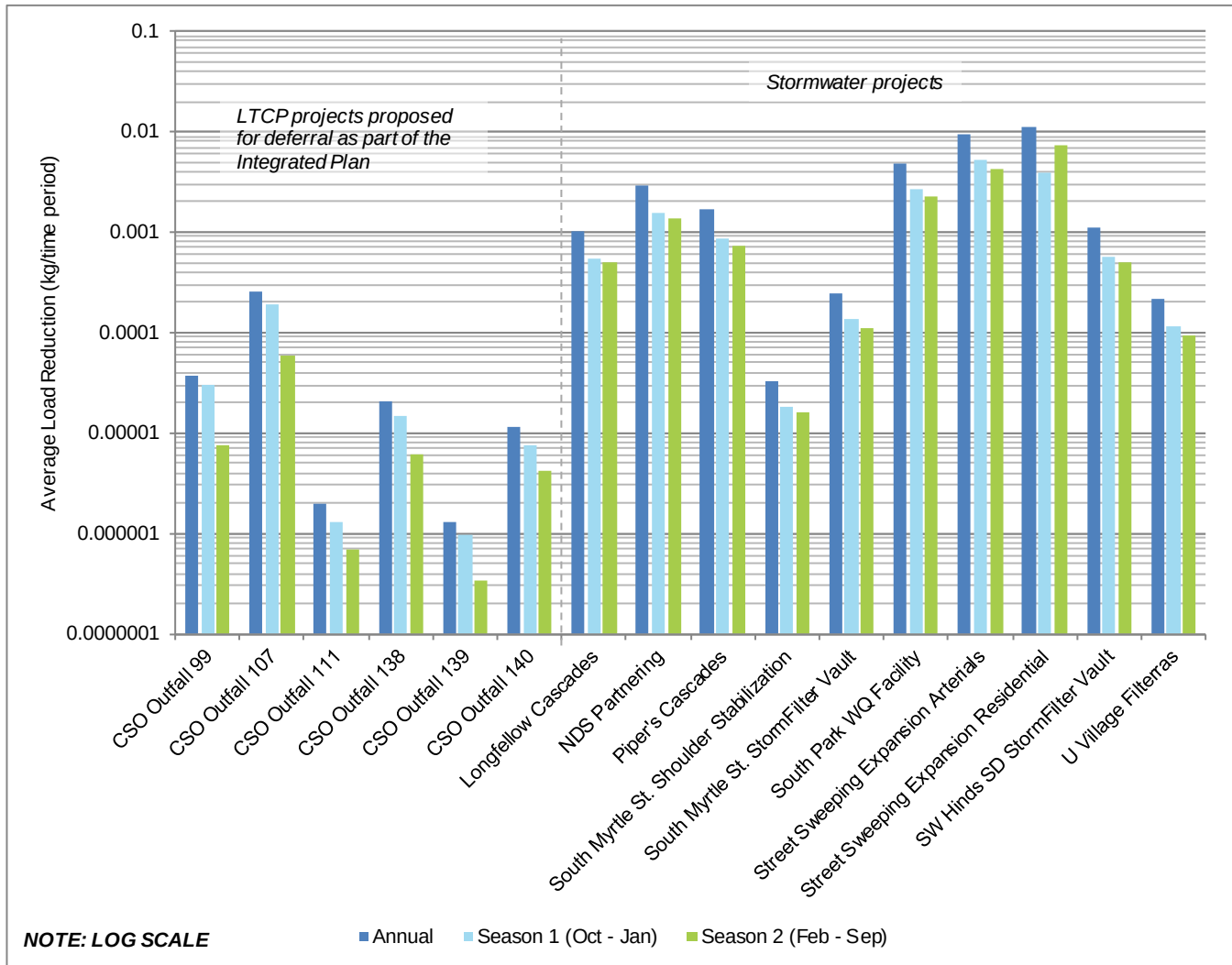


Figure 1-14. Average PBDE load reduction from the candidate LTCP and stormwater projects

Note that due to insufficient data, UCL and LCL values were unable to be calculated for PBDEs.

Total Copper. As shown in Figure 1-15, seven of the candidate stormwater projects would provide more total copper removal than the largest of the candidate LTCP projects (CSO Outfall 107).

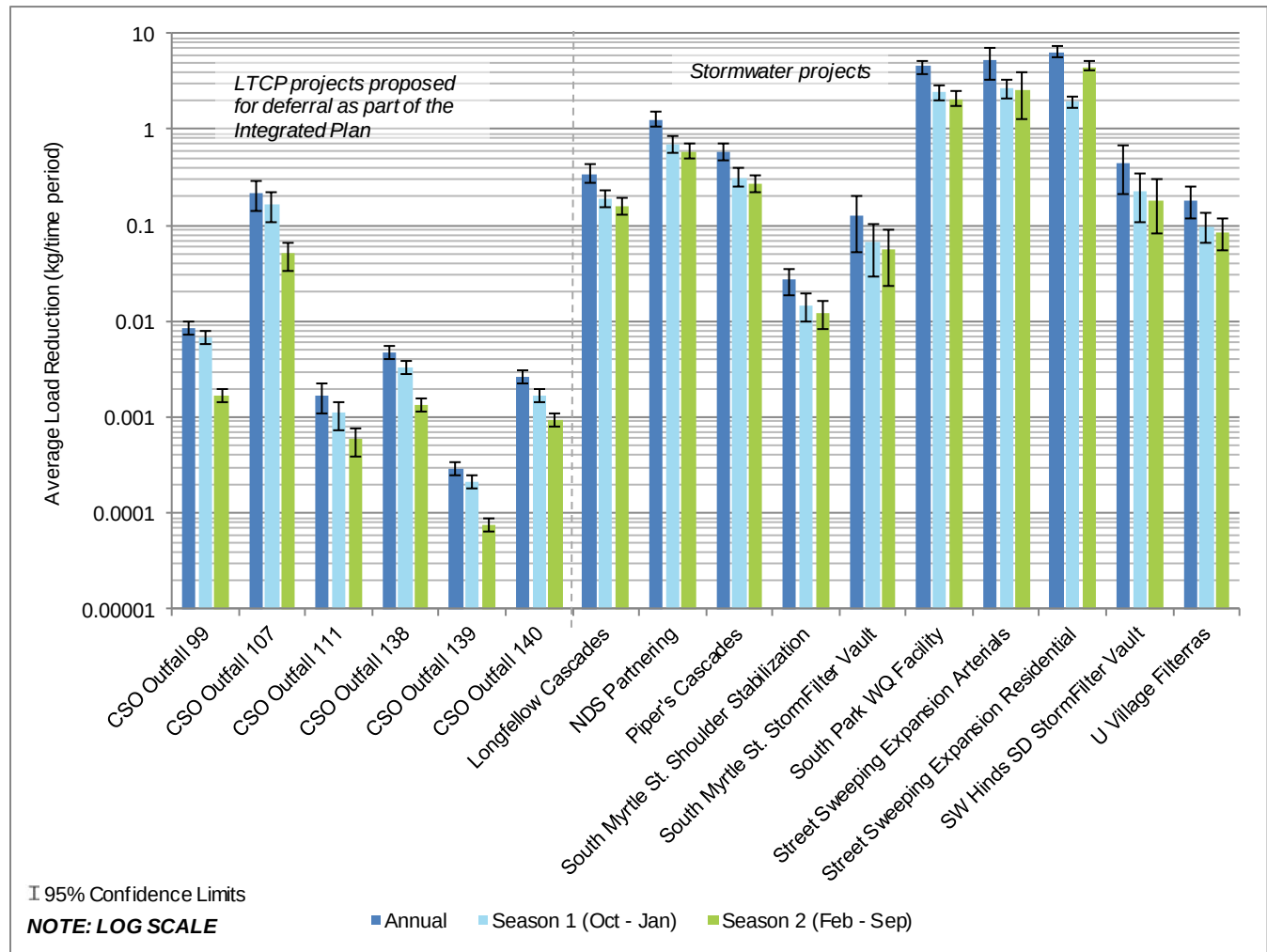


Figure 1-15. Average total copper load reduction from the candidate LTCP and stormwater projects

Total Suspended Solids. Figure 1-16 presents the total suspended solids (TSS) loads modeling results for the candidate LTCP and stormwater projects. Eight of the candidate stormwater projects have higher estimated TSS annual load reductions than the largest candidate LTCP project (CSO Outfall 107).

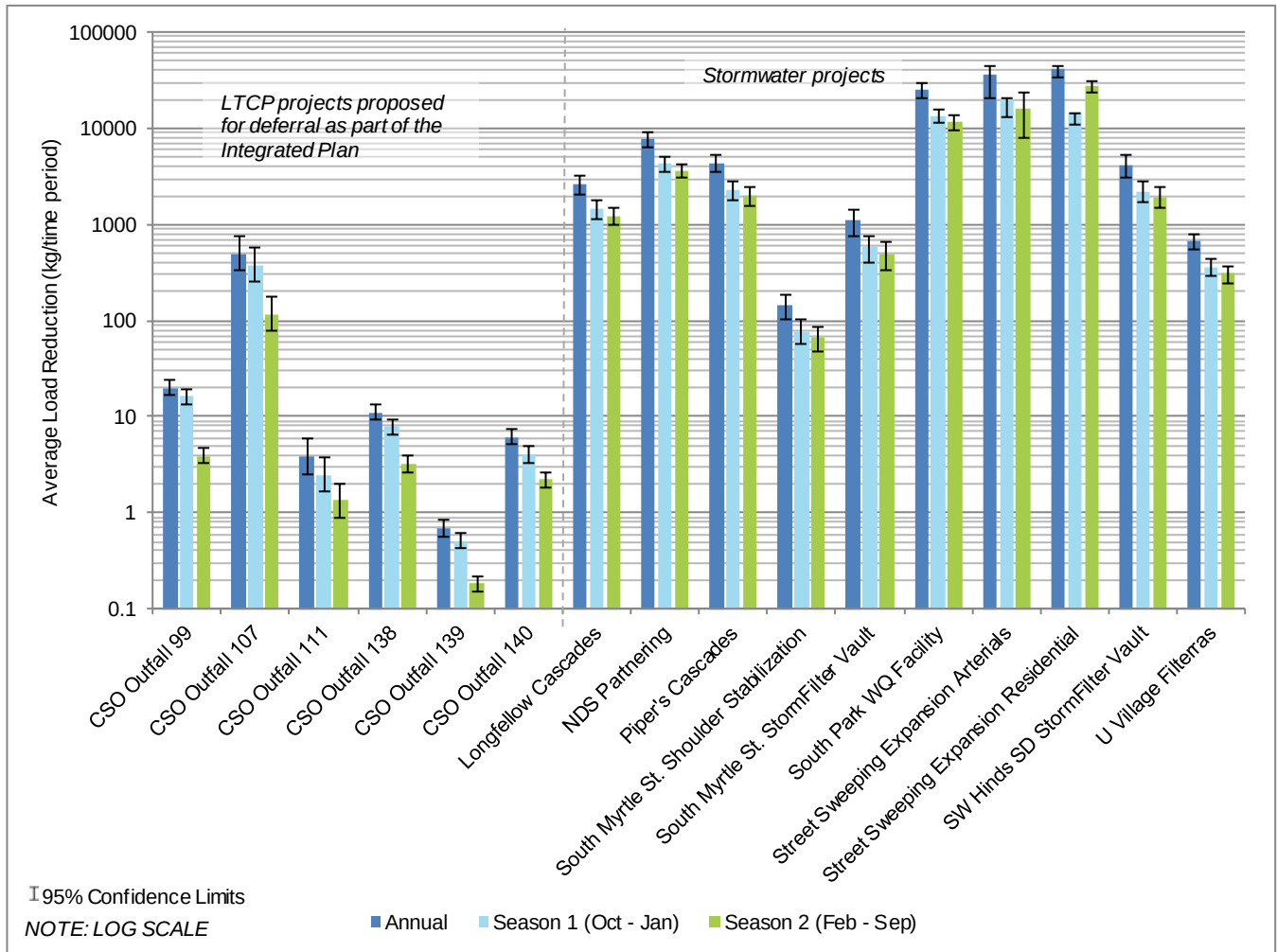


Figure 1-16. Average TSS load reduction from the candidate LTCP and stormwater projects

Total Zinc. Figure 1-17 compares the load reduction estimates for zinc. Nine of the candidate stormwater projects would provide more total zinc removal than the largest of the candidate LTCP projects (CSO Outfall 107).

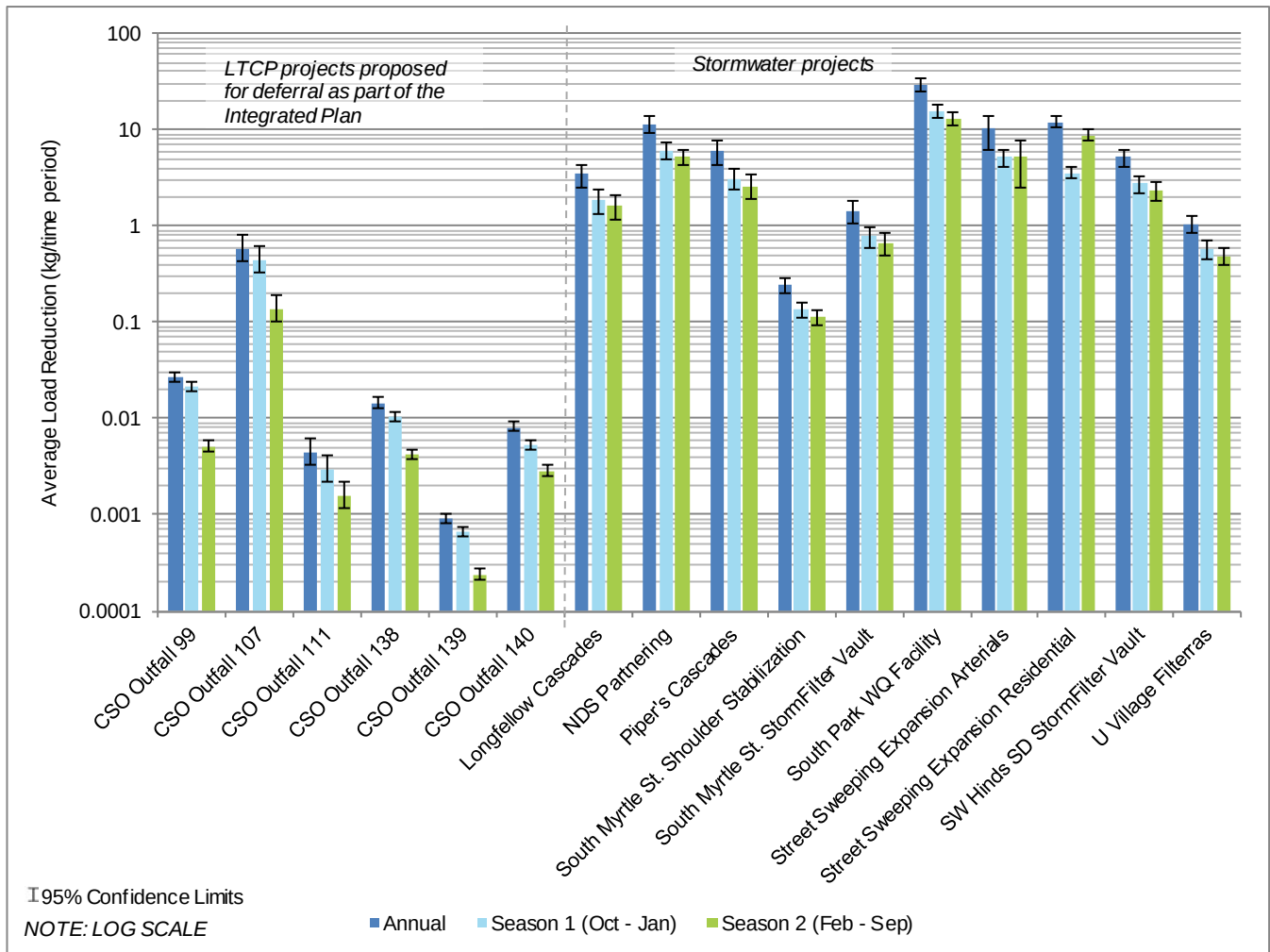


Figure 1-17. Average total zinc load reduction from the candidate LTCP and stormwater projects

1.2 Relative Exposure Reductions for Candidate Projects

The City used the pollutant loads reduction results, together with information on local receiving water bodies, to estimate the potential relative reductions in exposure of human and ecological receptors associated with the candidate LTCP and stormwater projects. Human and ecological EIVs were calculated for the candidate LTCP and structural stormwater projects to estimate the relative exposure reductions. The City used the EIVs to compare the candidate projects and select the projects to include in the Integrated Plan.

EIVs were not calculated for the candidate street sweeping programs because the EIV receptor factors are based on the outfall location, and runoff from the swept streets would affect more than 100 outfalls throughout the city. Section 1.3 explains the approach used to evaluate the potential reductions in exposure that would result from the candidate street sweeping programs.

Table 1-2 lists the EIVs for the candidate stormwater and LTCP projects. The highest (best) EIVs were associated with candidate stormwater projects. The South Park WQ Facility project had the highest EIVs for human receptors while the NDS Partnering project had the highest EIV for ecological receptors among all of the candidate stormwater and LTCP projects. Of the LTCP projects only, CSO Outfall 107 had the highest human-chronic (toxics) and ecological EIVs, and CSO Outfall 138 had the highest fecal coliform EIV.

Figure 1-18 compares the EIVs for the candidate stormwater projects to the highest EIVs for the candidate CSO projects (CSO Outfall 107 and CSO Outfall 138). As shown in the figure, the human and ecological EIVs for the South Park WQ Facility are many times higher than the highest EIVs for the candidate CSO projects. The ecological EIVs for the NDS Partnering and Piper's Cascades projects were several times higher than the ecological EIVs for the highest candidate CSO project (CSO Outfall 107).

PCBs were by far the most important driver for human-toxics EIVs, and contributed to ecological EIVs at some locations. Phosphorus was the main contributor to ecological EIVs at freshwater locations. Dissolved zinc, dissolved copper, bis(2-ethylhexyl)phthalate, and ammonia-N also contributed to the ecological EIVs at some locations.

Appendix H of the Integrated Plan provides a detailed description of the EIV methods and results.

Table 1-2. Comparison of EIVs for Candidate LTCP and Stormwater Projects, by Project

Candidate project	Receiving water body	Human				Ecological	
		Toxics		Fecal coliform		Toxics/nutrients	
		EIV	Rank	EIV	Rank	EIV	Rank
CSO Outfall 99	West Waterway of the Duwamish River	0.39	10	0.18	13	0.0057	14
CSO Outfall 107	East Waterway of the Duwamish River	13	4	1.3	8	0.35	7
CSO Outfall 111	Duwamish River	0.16	12	0.019	16	0.0038	15
CSO Outfall 138	Portage Bay	0.13	13	2.0	5	0.039	11
CSO Outfall 139	Portage Bay	0.0061	16	0.093	14	0.0031	16
CSO Outfall 140	Portage Bay	0.080	15	1.4	7	0.035	12
Longfellow Cascades	Longfellow Creek	0.27	11	1.1	10	0.61	4
NDS Partnering: Thornton Creek	Thornton Creek	3.8	6	7.0	2	2.5	1
NDS Partnering: Piper's Creek	Piper's Creek	0.89	9	1.2	9	0.54	5
NDS Partnering: Longfellow Creek	Longfellow Creek	0.12	14	0.52	12	0.24	9
Piper's Cascades	Piper's Creek	3.8	5	5.3	3	1.8	3
South Myrtle St. Shoulder Stabilization	Lower Duwamish Waterway	1.6	8	0.024	15	0.019	13
South Myrtle St. StormFilter Vault	Lower Duwamish Waterway	14	3	0.67	11	0.14	10
South Park WQ Facility	Lower Duwamish Waterway	117	1	8.3	1	1.9	2
Street Sweeping Expansion Arterials	Multiple	N/A ^a					
Street Sweeping Expansion Residential	Multiple	N/A ^a					
SW Hinds SD StormFilter Vault	Lower Duwamish Waterway	36.2	2	1.9	6	0.36	6
U Village Filtertass	Lake Washington Ship Canal/Lake Union	2.0	7	3.2	4	0.32	8

a. EIVs were not calculated for street sweeping because the receptor factors are based on the outfall location, and runoff from the swept streets would enter many outfalls throughout the city.

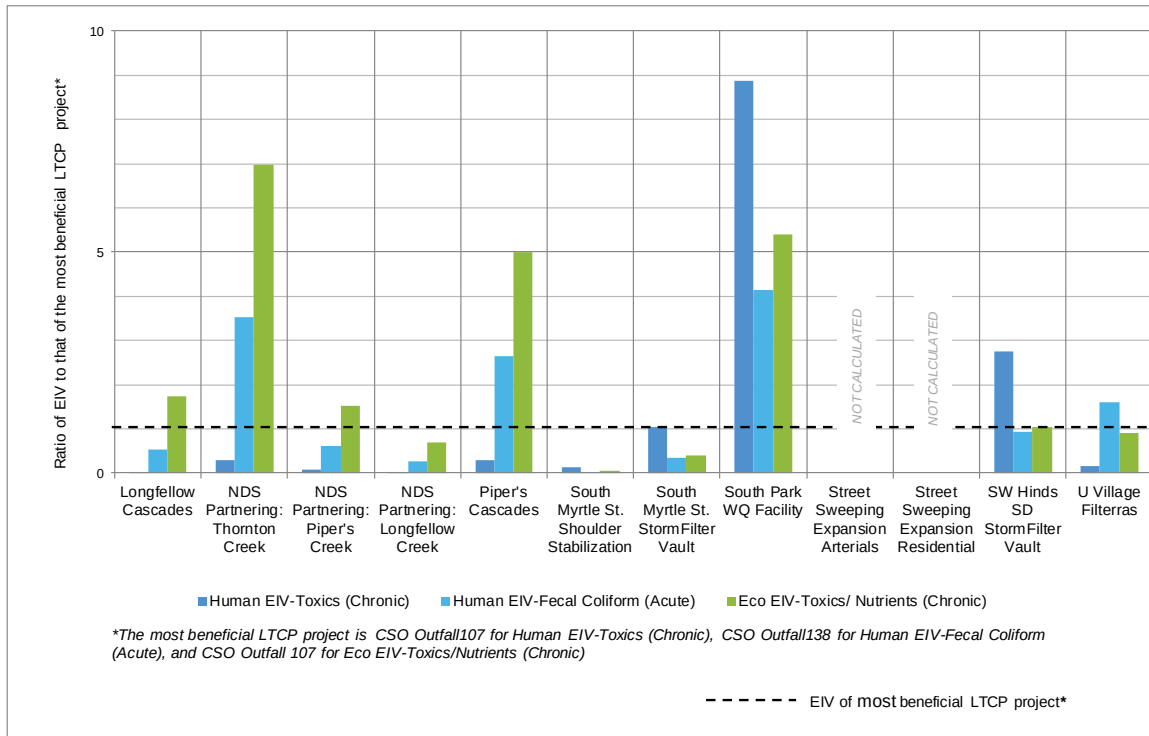


Figure 1-18. Ratio of candidate stormwater project EIVs to most beneficial LTCP project EIVs

EIVs were not calculated for the candidate street sweeping programs because the EIV receptor factors are based on the outfall location, and runoff from the swept streets would affect more than 100 outfalls throughout the city.

1.3 Relative Exposure Reductions for Candidate Street Sweeping Programs

EIVs were not calculated for the candidate street sweeping programs because the EIV receptor factors are based on the outfall location, and runoff from the swept streets would affect numerous outfalls and water bodies throughout the city. Therefore, a more qualitative approach was used to evaluate the potential reductions in exposure that would result from the candidate street sweeping programs.

Table 1-1 above and Figures 1-3 and 1-6 show that the candidate street sweeping programs would provide much larger reductions in PCBs and phosphorus than the candidate LTCP projects. PCBs were found to be the key driver for human-toxics EIVs at all locations. Phosphorus was the key driver for ecological EIVs at freshwater locations, while PCBs were an important contributor to ecological EIVs at several saltwater/brackish locations. These results suggest that the candidate sweeping programs would provide substantial reductions in human exposure to toxics and ecological exposure to nutrients and toxics as compared to the candidate LTCP projects.

The pollutant loads modeling results indicate that neither of the candidate street sweeping programs would provide as much fecal coliform load reduction as CSO Outfall 107. However, both sweeping programs would provide more fecal coliform load reduction than any of the other candidate LTCP projects. The loads modeling results also indicate that the candidate sweeping programs would provide appreciable reductions in human exposure to fecal coliform. Moreover, the loads reductions from sweeping would benefit water bodies throughout the city.

CHAPTER 2

Multiple Objective Decision Analysis

The City used MODA to compare the candidate stormwater projects and programs for potential inclusion in the Integrated Plan. This section summarizes the MODA methods and results.

2.1 Methodology Overview

The City often uses MODA to help make decisions regarding projects or programs. For the Integrated Plan, the City used MODA to compare candidate stormwater projects based on their expected water quality benefits as well as other criteria important to the community.

MODA is a generalized term often used for a suite of analytical techniques referred to in the literature as Multi-Attribute Utility Theory (MAUT) (Keeney et al., 1976). MAUT is derived from the basic von Neumann-Morgenstern axioms of preference (Von Neumann and Morgenstern, 1947) and thus upon a utility function, which allows the comparison of risky outcomes through the computation of expected utility. The specific form of MAUT used in the Integrated Plan is a simplified form called the Simple Multi-Attribute Rating Technique with Swings (SMARTS) (Edwards and Barron, 1994).

The MODA methodology for the Integrated Plan involved the following steps:

1. Establish evaluation criteria
2. Develop measurement scales and assign draft scores
3. Establish relative value weights
4. Normalize scores and calculate results
5. Perform sensitivity analysis

These steps are described below.

2.2 Establish Evaluation Criteria

The Integrated Plan team developed evaluation criteria during a series of workshops facilitated by the same MODA specialists who supported the LTCP decision-making process. Through these workshops the team developed criteria that represent the City values and objectives relevant to making decisions about the Integrated Plan. The criteria are:

1. Performance risk
2. Flexibility
3. Relationship with other agencies (tribes, King County)
4. Water quality
5. Other positive environmental outcomes
6. Construction impacts (short-term)
7. Community impacts (long-term)
8. Environmental/social justice
9. Ease of operations and maintenance (O&M) and safety

For each criterion, a number of questions were developed, to be answered, as a means to evaluate how well each candidate project met the criteria. Table 2-1 lists the criteria and questions and provides a comparison to the MODA criteria used for the candidate LTCP projects. The responses to the criteria questions, considered in the evaluation of each of the candidate stormwater projects, are provided in Table 2-2 through 2-13.

Table 2-1. Comparison of Evaluation Criteria from Integrated Plan and Long-Term Control Plan				
Integrated plan		LTCP		Major differences in evaluation criteria
Criterion	Questions	Criteria	Questions	
1. Performance Risk	How flexible does the system perform in response to varying flow and pollutant characteristics above and below the design point?	1. Technical Complexity and Performance Risk	Does implementation require complex overall system controls? How many individual CSO facilities are needed to implement control strategy? How do King County Boundary Conditions impact City CSO facility operations?	Integrated Plan focuses on performance of the system; LTCP criteria focuses on complexity of controls, number of CSO facilities, and King County impact on operations.
2. Flexibility	What are the intervention opportunities to address under-performance, changes in rainfall patterns, and/or increases in temperature and drought situations?	2. Flexibility	Can the alternative meet changing control criteria and flow conditions?	None.
3. Relationship with Other Agencies	To what extent does the alternative enhance long-term relationships with Puget Sound area tribes and King County WTD?	5. King County Concurrence on Joint Projects	Does King County agree to implement a Joint King County/City Project(s) by September 1, 2013, and confirm in writing?	Integrated Plan considers relationship with King County and tribes; LTCP only focuses on relationship with King Co.
4. Water Quality	Based on the Pre-project concentration for each RCO and water quality criteria for the receiving water body, how does the load reduction for the project compare to the load reduction for the largest candidate CSO project for deferral LTCP project (CSO Outfall 107)?	None.	None.	Integrated Plan has water quality as an independent criteria; LTCP does not.

Table 2-1. Comparison of Evaluation Criteria from Integrated Plan and Long-Term Control Plan

Integrated plan		LTCP		Major differences in evaluation criteria
Criterion	Questions	Criteria	Questions	
5. Other Positive Environmental Outcomes	Does the project help meet the City's Green Goal by reducing stream flow rates, and/or does the project add green space and habitat? Does the project or program have an impact on carbon dioxide emissions (climate pollution)?	9. Environmental	Will the construction impact wetlands, streams, shorelines, habitats, and/or endangered species?	Integrated Plan focuses on City's green goals; LTCP criteria are broader in scope.
6. Construction Impacts (short-term)	What level of disruption will occur during project construction?	6. Construction Impacts (Short-Term)	What level of disruption will occur? Are the cumulative construction impacts significant?	None.
7. Community Impacts (longer-term)	Does the project support (visual) connection to water system? Does the project support citizen stewardship of project/facility? Does it support formal education? What lasting impact will the project and its O&M activities have on the neighborhood, either positive (culturally relevant, sidewalks, water access, bike paths, traffic calming, visual appeal), or negative (odor, noise, visual)?	7. Community Impacts (Long-Term)	Can the facility be designed to be compatible with the community, and how will O&M activities impact the community?	Integrated Plan specifically includes supporting educational opportunities; LTCP does not.
8. Environmental/Social Justice	Who and where? Will location of project address the historical inequity (e.g., address problems that were historically "underreported")? Does it protect a current use by socioeconomic class (e.g., fishing in Duwamish/Green Lake)? Will project siting affect an already heavily impacted area (e.g., South Park has transfer station)?	8. Environmental/Social Justice	What are the project's overflow and operation impacts and benefits? Does the project result in unequal impacts and benefits to historically underserved communities and low-income populations during construction or operation of the facility?	None.

Table 2-1. Comparison of Evaluation Criteria from Integrated Plan and Long-Term Control Plan

Integrated plan		LTCP		Major differences in evaluation criteria
Criterion	Questions	Criteria	Questions	
9. Ease of O&M and Safety	Beyond any cost implications, what are the implications for City staff to operate the system assuming adequate resources are available? Beyond any cost implications, what are the implications for City staff to maintain the system assuming adequate resources are available? Assuming safety and security are addressed appropriately during design, what safety concerns remain?	10. Ease of O&M and Safety	What level of staffing is required for operation and shutdown (how often is the facility used, how long is the facility in use, how many operators are required, what level of operator experience is required, what are travel times)? What are peak staff required? Does the facility have access requirements in the ROW or require confined space entry? Are traffic control procedures required? Does access require a street use permit or lane closure?	None.
None.	None.	3. Constructability	Are construction risks associated with the alternative significant? What are the expected permitting/regulatory/land use compliance complexities and how difficult is it expected to be to obtain permits and approvals?	Not specifically addressed in Integrated Plan criterion.
None	None	4. Consent Decree Compliance Schedule	Does the alternative meet the City's Consent Decree Construction Completion Milestone Date of Dec 31, 2025?	Not specifically addressed in Integrated Plan criterion.

Table 2-2. Evaluation Criteria for Street Sweeping Expansion Residential

Evaluation criteria	Project evaluation information
1. Performance Risk	1. Removal rates based on less than 1 year of monitoring data from one source, but representative of Seattle area. 2. Seattle-specific pollutant removal rates available for almost all RCOCs. 3. Limited research documenting the correlation between pollutant removal and reduction in stormwater concentrations. Significant experience exists related to the treatment mechanism and maintenance needs. 4. Does not address some pollutants; single removal mechanism.
2. Flexibility	Technology is fixed and cannot be adapted to changing water quality standards.
3. Relationship with Other Agencies	Results in reduction of pollutants in stormwater from streets tributary to combined and partially separated sewers. Targets residential areas that carry less pollutants than industrial areas. Project will not create additional risks to the tribes' salmon recovery plans and natural resource protection goals. While the Duwamish Waterway, Lake Washington, Lake Union, and Puget Sound are high-priority water bodies, the project does not appear to provide much benefit to salmon recovery because it will not reduce flow or enhance or provide habitat. However, it will help eliminate contaminants in stormwater over a large area, which is a component of salmon recovery that is important to area tribes.
4. Water Quality	Water quality score was calculated using the relevant water quality criteria.
5. Other Positive Environmental Outcomes	Project will not manage flow. The project does not provide terrestrial habitat.
6. Construction Impacts (short-term)	No construction impacts.
7. Community Impacts (longer-term)	Not clear that project addresses current concern of particular neighborhood(s) but improves upon amenities used in a variety of neighborhoods; during sweeping high visibility around the city during day; outreach re: parking/moving cars provides education opportunity but may not be particularly culturally relevant; operation requires staff on site regularly but only when sweeper is active on particular residential street; traffic and noise could require mitigation; cleaner streets visible; longer-term benefits less visible.
8. Environmental/Social Justice	Improves water quality of waterways in underserved communities and contributes to efforts to protect current use. Daytime sweeping could be disruptive and affect public transportation, traffic, and parking for residents and businesses. Sweeping is loud and dusty.
9. Ease of O&M and Safety	Rating criteria not really applicable to stormwater. Does require operator, so more like active treatment than passive treatment, but sweeping done by SDOT crews. Assumed sweeper trucks require frequent maintenance. Work in ROW. Sweeper dust impacts pedestrians.

Table 2-3. Evaluation Criteria for Street Sweeping Expansion Arterials

Evaluation criteria	Project evaluation information
1. Performance Risk	1. Removal rates based on less than 1 year of monitoring data from one source, but representative of Seattle area. 2. Seattle-specific pollutant removal rates available for almost all RCOCs. 3. Limited research documenting the correlation between pollutant removal and reduction in stormwater concentrations. Significant experience exists related to the treatment mechanism and maintenance needs. 4. Does not address some pollutants; single removal mechanism.
2. Flexibility	Technology is fixed and cannot be adapted to changing water quality standards.
3. Relationship with Other Agencies	Results in reduction of pollutants in stormwater tributary to combined and partially separated areas. Targets industrial areas that are the most polluted categories. Project will not create additional risks to the tribes' salmon recovery plans and natural resource protection goals. While the Duwamish Waterway, Lake Washington, Lake Union, and Puget Sound are high-priority water bodies, it does not appear that the project will provide much benefit to salmon recovery because it will not reduce flow or enhance or provide habitat. However, it will help eliminate contaminants in stormwater over a large area, which is a component of salmon recovery that is important to area tribes.
4. Water Quality	Water quality score was calculated using the relevant water quality criteria.
5. Other Positive Environmental Outcomes	Project will not manage flow. The project does not provide terrestrial habitat.
6. Construction Impacts (short-term)	No construction impacts.
7. Community Impacts (longer-term)	May be less visible because sweeping occurs during night; may require less mitigation than the Street Sweeping Expansion Residential project because it occurs on the arterials; not clear that project addresses current concern of particular neighborhood(s) but improves upon amenities used in a variety of neighborhoods; outreach re: parking/moving cars provides education opportunity but may not be particularly culturally relevant; operation requires staff on site regularly but only when sweeper is active on particular arterial street; traffic and noise could require mitigation; cleaner streets visible; longer-term benefits less visible.
8. Environmental/Social Justice	Improves water quality of waterways in underserved communities and contributes to efforts to protect current use. Nighttime sweeping could minimize impact disruption on traffic. But will impact parking and/or create noise that could potentially be disruptive to residents in the area.
9. Ease of O&M and Safety	Rating criteria not really applicable to stormwater. Does require operator, so more like active treatment than passive treatment, but sweeping done by SDOT crews. Assumed sweeper trucks require frequent maintenance. Work in ROW. Sweeper dust impacts pedestrians.

Table 2-4. Evaluation Criteria for South Park WQ Facility

Evaluation criteria	Project evaluation information
1. Performance Risk	1. Removal rates available for some RCOCs from full-scale chitosan-enhanced sand filtration (CESF) at NBF; representative of Seattle area; consistent performance is expected with CESF. Where data not available, filled with fairly conservative assumptions. 2. Over half the RCOCs have data drawn from other sources, such as the International BMP database or professional judgment. 3. Removal mechanism well understood and documented. 4. Commitments to active maintenance protocol are implied in selecting a CESF; appears to address wide range of pollutants.
2. Flexibility	Coagulant type, dosing can be adjusted. Could add GAC to improve performance but that would increase costs substantially. Not affected by changes in rainfall, drought, temperature, etc. Can add additional treatment technology onto facility if needed.
3. Relationship with Other Agencies	• Project addresses localized flooding in an area of both separate sewers and partially separated sewers and treatment of stormwater prior to discharge to the Duwamish Waterway. Benefits to King County are reduction in potential inflow as a result of better flood protection and removal of pollutants from the Duwamish Waterway, a high-priority water body for King County. • Project will not create additional risks to the tribes' salmon recovery plans and natural resource protection goals. The Duwamish Waterway is a high-priority water body. Although it does not appear that the project will provide much benefit to salmon recovery because it will not reduce flow or enhance or provide habitat, it will treat contaminants in stormwater, which is a component of salmon recovery that is important to area tribes, particularly in the Lower Duwamish Waterway because it provides important rearing and osmoregulation habitat for salmonids.
4. Water Quality	Water quality score was calculated using the relevant water quality criteria.
5. Other Positive Environmental Outcomes	Project will not manage flow. Project includes landscaping/native vegetation along shoreline.
6. Construction Impacts (short-term)	Most work will be outside ROW. Small amount along S Riverside Drive and 7th Avenue S road end. But >6 months and lots of truck traffic.
7. Community Impacts (longer-term)	Minimal staff visits facility; provides lasting benefits to users of the Duwamish Waterway; partially visible but no public access to facility; facility located in commercial/industrial areas; no particular education opportunity.
8. Environmental/Social Justice	Above ground. Improves water quality in an underserved community and contributes to efforts to protect current use by the community. Located in heavily impacted area. Concerns with impact on traffic and disruption to businesses, residents, and commuters in nearby neighborhoods. Construction will be during daylight hours and is expected to be long and loud.
9. Ease of O&M and Safety	• Assume operations contracted out and remote operation likely (e.g., CESF). • Assume frequent maintenance for solids handling. • All work outside of ROW in secure/industrial location.

Table 2-5. Evaluation Criteria for NDS Partnering

Evaluation criteria	Project evaluation information
1. Performance Risk	1. International BMP database effluent concentration was used based on the results of at least three studies, each with at least three data points. 2. International BMP database data available for approximately 2/3 of RCOCs, supplemented with unit process/chemical properties understanding for remaining. 3. Non-proprietary vegetated system; performance and maintenance needed of individual designs are a function of design decisions and media properties; performance and maintenance understood to a somewhat lesser degree than proprietary systems. 4. Addresses wide range of RCOCs via various treatment mechanisms and volume reduction. Well-designed vegetated system can be self-sustaining between maintenance cycles.
2. Flexibility	Changes in rainfall, drought, and temperature could stress plants and require more frequent weeding and/or plant replacement. Changing filter media in existing facilities would require excavation and replanting. Could add downstream treatment (e.g., media filter, pond) if suitable sites and sufficient funds are available. Can adapt by changing media in bioretention.
3. Relationship with Other Agencies	• The installation of bioswales will attenuate peak flows as well as remove pollutants. The benefit to King County will be a function of the actual location of the installed swales. King County is supportive of the use of bioretention swales. • Project will not create additional risks to the tribes' salmon recovery plans and natural resource protection goals. The projects will provide benefit to salmon recovery because they will reduce flow, which will enhance or provide habitat in mainstem water bodies to these tributaries. The swales will also provide terrestrial habitat and additional pervious areas along developed and paved streets. Piper's Creek, Thornton Creek, and Longfellow Creek are not high-priority water bodies for ESA-listed species but they are tributaries flowing into high-priority water bodies.
4. Water Quality	Water quality score was calculated using the relevant water quality criteria.
5. Other Positive Environmental Outcomes	Project will reduce flow over a fairly large area and provide terrestrial habitat.
6. Construction Impacts (short-term)	Same for all NDS Partnering projects. Impacts ROW in high-density residential area; however, short construction period.
7. Community Impacts (longer-term)	High visibility in a variety of neighborhoods right in front of homes and businesses; opportunity for education that is culturally relevant; notable positive lasting benefits for residents.
8. Environmental/Social Justice	Dependent on feasibility of project site. Impacts/benefits on historically underserved communities vary depending on which neighborhood is selected. Sites of high community acceptance may not be communities with high percentages of underserved populations.
9. Ease of O&M and Safety	• Totally passive, no operational requirements. • The City typically maintains vegetation four times per year. • Used same rank for all NDS Partnering projects. Project in ROW, accessible to public.

Table 2-6. Evaluation Criteria for SW Hinds SD StormFilter Vault

Evaluation criteria	Project evaluation information
1. Performance Risk	1. International BMP database effluent concentration was used based on the results of at least three studies, each with at least three data points. 2. International BMP database data available for approximately 2/3 of RCOCs, supplemented with unit process/chemical properties understanding for remaining. 3. Proprietary filter device, method of removal well understood and documented. 4. Known performance.
2. Flexibility	Could increase maintenance frequency to reduce clogging/bypass. Manufacturer is not conducting research and development (R/D) on new media for filters so flexibility is limited.
3. Relationship with Other Agencies	• The project will not impact flows to King County. It will reduce pollutant discharged to 190 acres tributary to the Duwamish Waterway, a high-priority water body for the King County. • Project will not create additional risks to the tribes' salmon recovery plans and natural resource protection goals. While the Duwamish Waterway is a high-priority water body, it does not appear that the project will provide much benefit to salmon recovery because it will not reduce flow or enhance or provide habitat.
4. Water Quality	Water quality score was calculated using the relevant water quality criteria.
5. Other Positive Environmental Outcomes	Project will not manage flow. The project does not provide terrestrial habitat.
6. Construction Impacts (short-term)	Vault in a parking lot in an industrial area. Only one business impacted.
7. Community Impacts (longer-term)	Below ground: limited visibility; some opportunities for educational signage; regular maintenance on site required in area where people shop and live; long-term benefit but may not address particular neighborhood concerns.
8. Environmental/Social Justice	Below ground. Impact on traffic and parking and disruption to residents and businesses are short-term. Project provides benefits to historically underserved communities.
9. Ease of O&M and Safety	• Totally passive, no operational requirements. • Maintenance requirements uncertain. The City has found these can clog frequently. Manufacturer typically underestimates maintenance needs. • All work outside of ROW in secure location. Confined space requirements.

Table 2-7. Evaluation Criteria for South Myrtle St. Shoulder Stabilization

Evaluation criteria	Project evaluation information
1. Performance Risk	1. International BMP database effluent concentration was used based on the results of at least three studies, each with at least three data points. 2. International BMP database data available for approximately 2/3 of RCOs, supplemented with unit process/chemical properties understanding for remaining. 3. Non-proprietary vegetated system; performance and maintenance needed of individual designs are a function of design decisions and media properties; performance and maintenance understood to a somewhat lesser degree than proprietary systems. 4. Provides less diverse treatment mechanisms than bioretention; does not treat some constituents; Well-designed vegetated system can be self-sustaining between maintenance cycles.
2. Flexibility	Cannot be modified easily. Not affected by changes in rainfall, drought, temperature, etc.
3. Relationship with Other Agencies	• The project will not impact flows and loadings to King County. It will reduce pollutants discharged to the Duwamish Waterway, a high-priority water body for the King County. • Project will not create additional risks to the tribes' salmon recovery plans and natural resource protection goals. The project will provide benefit to salmon recovery because it will reduce flow, which will enhance or provide habitat in a high-priority mainstem water body. The swale will also provide terrestrial habitat and additional pervious area along developed and paved streets. However, this is a small area of treatment compared to the larger area of the Duwamish Waterway.
4. Water Quality	Water quality score was calculated using the relevant water quality criteria.
5. Other Positive Environmental Outcomes	While the project will reduce flow, the Duwamish Waterway is not a flow-impacted water body. The terrestrial habitat that will be provided is a small footprint. Treats a small amount of flow.
6. Construction Impacts (short-term)	Impacts ROW in an industrial area; however, short construction period.
7. Community Impacts (longer-term)	Visible but located on dead-end street in area where people visiting or seeking it out is low; minimal staff will be present infrequently; project alleviates current concern and will have notable positive lasting benefit.
8. Environmental/Social Justice	Project site is in an isolated area. Minimal impact to residents. Project provides benefits to historically underserved communities.
9. Ease of O&M and Safety	• Totally passive, no operational requirements. • Biofiltration swale pretty straightforward maintenance. The larger question is, will the City actually maintain? • Swale in ROW, but physical barrier between road and swale. Industrial location. Not much public use.

Table 2-8. Evaluation Criteria for Piper's Cascades

Evaluation criteria	Project evaluation information
1. Performance Risk	1. International BMP database effluent concentration was used based on the results of at least three studies, each with at least three data points. 2. International BMP database data available for approximately 2/3 of RCOCs, supplemented with unit process/chemical properties understanding for remaining. 3. Non-proprietary vegetated system; performance and maintenance needed of individual designs are a function of design decisions and media properties; performance and maintenance understood to a somewhat lesser degree than proprietary systems. 4. Addresses wide range of RCOCs via various treatment mechanisms and volume reduction. Well-designed vegetated system can be self-sustaining between maintenance cycles.
2. Flexibility	Changes in rainfall, drought, and temperature could stress plants and require more frequent weeding and/or plant replacement. Changing filter media would require excavation and replanting. Could add downstream treatment (e.g., media filter, pond) if suitable sites and sufficient funds are available. Can adapt by changing media in bioretention.
3. Relationship with Other Agencies	- The project is a nominally separated area with high levels of infiltration and inflow (I/I) that are discharged to King County's Carkeek Park pump station (PS) and wastewater treatment facility (WWTF). Project could potentially modify groundwater flow and coincident rates of I/I. - Project will not create additional risks to the tribes' salmon recovery plans and natural resource protection goals. The project will provide benefit to salmon recovery because it will reduce flow, which will enhance or provide habitat in mainstem water bodies to these tributaries. The swales will also provide terrestrial habitat and additional pervious areas along developed and paved streets. Piper's Creek is not a high-priority water body for ESA-listed species, but it is a tributary to a high-priority water body.
4. Water Quality	Water quality score was calculated using the relevant water quality criteria.
5. Other Positive Environmental Outcomes	Project will reduce flow over a large area and provide terrestrial habitat.
6. Construction Impacts (short-term)	Impacts ROW in high-density residential area; however, short construction period.
7. Community Impacts (longer-term)	High visibility; high opportunity for education that is culturally relevant; high visibility in a variety of neighborhoods right in front of homes and businesses; notable positive lasting benefits for residents.
8. Environmental/Social Justice	Dependent on feasibility of project site. Impacts/benefits on historically underserved communities vary depending on which neighborhood is selected. Smaller percentage of people from underserved communities residing in project site.
9. Ease of O&M and Safety	- Totally passive, no operational requirements. - The City typically maintains vegetation four times per year. - Project in ROW, accessible to public.

Table 2-9. Evaluation Criteria for Longfellow Cascades

Evaluation criteria	Project evaluation information
1. Performance Risk	1. International BMP database effluent concentration was used based on the results of at least three studies, each with at least three data points. 2. International BMP database data available for approximately 2/3 of RCOCs, supplemented with unit process/chemical properties understanding for remaining. 3. Non-proprietary vegetated system; performance and maintenance needed of individual designs are a function of design decisions and media properties; performance and maintenance understood to a somewhat lesser degree than proprietary systems. 4. Addresses wide range of RCOCs via various treatment mechanisms and volume reduction. Well-designed vegetated system can be self-sustaining between maintenance cycles.
2. Flexibility	Changes in rainfall, drought, and temperature could stress plants and require more frequent weeding and/or plant replacement. Changing filter media would require excavation and replanting. Could add downstream treatment (e.g., media filter, pond) if suitable sites and sufficient funds are available. Can adapt by changing media in bioretention.
3. Relationship with Other Agencies	- The project is located in a combined/partially separated area. The facility will reduce peak flows and reduces pollutants. - Project will not create additional risks to the tribes' salmon recovery plans and natural resource protection goals. The project will provide benefit to salmon recovery because it will reduce flow, which will enhance or provide habitat in mainstem water bodies to these tributaries. The swales will also provide terrestrial habitat and additional pervious areas along developed and paved streets. Longfellow Creek is not a high-priority water body for ESA-listed species, but it is a tributary to a high-priority water body.
4. Water Quality	Water quality score was calculated using the relevant water quality criteria.
5. Other Positive Environmental Outcomes	Project will reduce flow and provide terrestrial habitat. However, the project footprint is fairly small.
6. Construction Impacts (short-term)	Impacts ROW in high-density residential area; however, short construction period.
7. Community Impacts (longer-term)	High visibility; high opportunity for education that is culturally relevant; high visibility in a variety of neighborhoods right in front of homes and businesses; notable positive lasting benefits for residents.
8. Environmental/Social Justice	Dependent on feasibility of project site. Impacts/benefits on historically underserved communities vary depending on which neighborhood is selected. Sites of high community acceptance may not be communities with high percentages of underserved populations.
9. Ease of O&M and Safety	- Totally passive, no operational requirements. - The City typically maintains vegetation four times per year. - Project in ROW, accessible to public.

Table 2-10. Evaluation Criteria for South Myrtle St. StormFilter Vault

Evaluation criteria	Project evaluation information
1. Performance Risk	1. International BMP database effluent concentration was used based on the results of at least three studies, each with at least three data points. 2. International BMP database data available for approximately 2/3 of RCOCs, supplemented with unit process/chemical properties understanding for remaining. 3. Proprietary filter device, method of removal well understood and documented. 4. Known performance.
2. Flexibility	Could increase maintenance frequency to reduce clogging/bypass. Manufacturer is not conducting R/D on new media for filters so flexibility is limited.
3. Relationship with Other Agencies	• This provides treatment to a small industrial area prior to discharge to the Duwamish Waterway, a King County high-priority water body. • Project will not create additional risks to the tribes' salmon recovery plans and natural resource protection goals. While the Duwamish Waterway is a high-priority water body, it does not appear that the project will provide much benefit to salmon recovery because it will not reduce flow or enhance or provide habitat.
4. Water Quality	Water quality score was calculated using the relevant water quality criteria.
5. Other Positive Environmental Outcomes	Project will not manage flow. The project does not provide terrestrial habitat.
6. Construction Impacts (short-term)	Vault on cul-de-sac in industrial area. Only one business impacted.
7. Community Impacts (longer-term)	Below ground: limited visibility; some opportunities for educational signage; regular maintenance on site required in area where people shop and live; long-term benefit but may not address particular neighborhood concerns.
8. Environmental/Social Justice	Below ground. Impact on traffic and parking and disruption to residents and businesses are short-term. Project provides benefits to historically underserved communities.
9. Ease of O&M and Safety	• Totally passive, no operational requirements. • Maintenance requirements uncertain. The City has found these can clog frequently. Manufacturer typically underestimates maintenance needs. • All work outside of ROW in secure location. Confined space requirements.

Table 2-11. Evaluation Criteria for U Village Filtreras

Evaluation criteria	Project evaluation information
1. Performance Risk	1. International BMP database effluent concentration was used based on the results of at least three studies, each with at least three data points. 2. International BMP database data available for approximately 2/3 of RCOCs, supplemented with unit process/chemical properties understanding for remaining. 3. Proprietary filter device, method of removal well understood and documented. 4. Known performance.
2. Flexibility	Changes in rainfall, drought, and temperature could stress plants. Could increase mulch maintenance frequency to reduce clogging/bypass. However, changing media in existing facilitates would require excavation and replanting.
3. Relationship with Other Agencies	• Project targets treatment of roadway runoff in a partially separated area with eventual discharge to Portage Bay. • Project will not create additional risks to the tribes' salmon recovery plans and natural resource protection goals. While Lake Union is a high-priority water body, it does not appear that the project will provide much benefit to salmon recovery because it will not reduce flow or enhance or provide habitat.
4. Water Quality	Water quality score was calculated using the relevant water quality criteria.
5. Other Positive Environmental Outcomes	Project will not manage flow. However, the project provides a small amount of terrestrial habitat.
6. Construction Impacts (short-term)	Impacts ROW of a high-traffic arterial with a bus route; however, short construction period.
7. Community Impacts (longer-term)	Highly visible; provides education opportunity; minimal staff will be present infrequently; notable positive lasting benefit for residents; improves upon existing neighborhood conditions.
8. Environmental/Social Justice	Treatment facility is below ground. Selected site will be dependent on feasibility of project site. Impact on traffic and parking and disruption to residents and businesses are short-term. Project provides benefits to populations who are historically underserved.
9. Ease of O&M and Safety	• Totally passive, no operational requirements. • All work in ROW in secure location.

2.3 Develop Measurement Scales and Assign Draft Scores

A measurement scale describes the extent to which a project meets each evaluation criterion. The Integrated Plan team developed measurement scales of 1 to 5 for each criterion (except water quality). The worst potential outcome was given a score of 1 and the best possible outcome was given a score of 5. For the water quality criterion, the score was calculated based on the Pre-project concentration, Post-project load reductions, and applicable water quality criteria. The measurement scales and scoring for each of the nine criteria are described below.

Criterion 1. Performance Risk

Description. How flexible is the project in terms of responding to varying flow and pollutant characteristics above and below the project location?

Measurement Scale. Constructed scale, 5 is best outcome; 1 is worst outcome.

Best = 5	Medium = 3	Worst = 1
- High confidence: Monitoring data available to document system performance (e.g., Technology Assessment Protocol – Ecology [TAPE] or other comparable program) for most Consent Decree parameters under varying flow and quality conditions - Project performance can be easily measured (e.g., inlet/outlet monitoring) - Treatment mechanisms and maintenance needs are well understood and documented	- Medium confidence: Monitoring data available (e.g., TAPE or other comparable program) for typical stormwater pollutants (conventionals and metals) under varying flow and quality conditions - Technology has been tested and used in other stormwater or other wet weather applications - Treatment mechanisms and maintenance needs well understood	- Low confidence: Minimal or conflicting data available on technology performance - Technology has been tested, but not widely used in stormwater or other wet weather applications - Treatment mechanisms and maintenance needs understood, but not well documented - Project performance not easily measured (e.g., disperse systems)

Criterion 2. Flexibility

Description. What are the intervention opportunities to address under-performance, changes in rainfall patterns, and/or increases in temperature and drought situations?

Measurement Scale. Constructed scale, 5 is best outcome; 1 is worst outcome.

Best = 5	Medium = 3	Worst = 1
Can be easily modified to meet potential future regulatory requirements or changes in CSO/stormwater quality with low capital expenditure	Can be modified to meet potential future regulatory requirements or changes in CSO/stormwater quality with additional treatment train and/or modifications to filter media	Cannot be modified, requires rebuild to meet future regulatory requirements or changes in CSO/stormwater quality

Criterion 3. Relationship with Other Agencies

Description. To what extent does the project enhance long-term relationships with Puget Sound area tribes and King County Water Treatment Division (WTD)? The score for this criterion was the average of the scores given for the two sub-criteria that follow.

Relationship with the Tribes

Description. Enhances long-term relationships with Puget Sound area tribes.

Measurement Scale. Constructed scale, 5 is best outcome; 1 is worst outcome.

Best = 5	Medium = 3	Worst = 1
Supports and enhances Puget Sound area tribes' salmon recovery plans and natural resource protection goals	Does not create additional risks to Puget Sound area tribes' salmon recovery plans and natural resource protection goals	Creates additional risks to Puget Sound area tribes' salmon recovery plans and natural resource protection goals

Relationship with King County

Description. Enhances long-term relationship with King County WTD.

Measurement Scale. Constructed scale, 5 is best outcome; 1 is worst outcome.

Best = 5	Medium = 3	Worst = 1
Reduces hydraulic and/or pollutant loading to WTD system; does not require special operation of WTD facilities: reduces risk on achieving permit compliance	No change on loading to WTD; no additional risks on WTD facility performance or permit compliance	Increases hydraulic and/or pollutant loading to WTD system; requires additional operational commitment from WTD; has potential to impact permit compliance

Criterion 4. Water Quality

Description. To what extent does the candidate project contribute water quality benefits beyond those that would be achieved by the deferred LTCP projects? The project score for this criterion was determined in the following manner.

For each RCOC, a weight was calculated as the ratio of the Pre-project concentration to the water quality criteria:

$$Weight_{RCOC} = \frac{Pre-project\ concentration_{RCOC}}{Water\ quality\ criteria_{RCOC}}$$

The water quality criterion used was either marine or fresh water, based on the receiving water body of the project. PCBs has two criteria: ecological and human health. The PCBs criterion used to calculate the weight was based on human health because it is more conservative (i.e. lower).

Next, the load reduction for each RCOC was normalized to the largest candidate LTCP project (CSO Outfall 107):

$$Normalized\ load\ reduction_{RCOC} = \frac{Load\ reduction\ project_{RCOC}}{Load\ reduction\ CSO\ Outfall\ 107_{RCOC}}$$

For each RCOC, the weight was multiplied by the normalized load reduction, and then summed to provide the project water quality score.

$$Water\ quality\ score_{project} = \sum (weight * normalized\ load\ reduction)_{RCOC}$$

Criterion 5. Other Positive Environmental Features

Description. Does the project help meet the City's Green Goal by reducing stream flow rates, and/or does the project add green space and habitat?

Measurement Scale. Constructed scale, 5 is best outcome; 1 is worst outcome.

Best = 5	Medium = 3	Worst = 1
- Project reduces flow/volume to a flow-impacted water body - Project provides substantive terrestrial habitat	- Project reduces flow/volume to a flow-impacted water body - Project does not provide terrestrial habitat	- Project will not manage flow - Project does not provide terrestrial habitat

Criterion 6. Construction Impacts (Short-Term)

Description. What level of disruption will occur during project construction?

Measurement Scale. Constructed scale, 5 is best outcome; 1 is worst outcome.

Best = 5	Medium = 3	Worst = 1
Construction impacts will be relatively minor compared to other major City infrastructure projects. Impacts are generally consistent with the following: - Project is located in lightly populated area and will affect a small number of businesses/residents (1–5) - Project is located far from residents and no asthma or health impacts are likely - Project will have low neighborhood intensity - Project is located on a low traffic street - Construction activities involve minor excavation and disruption to streets and adjacent properties - Construction will last less than 3 months	Construction impacts will be similar to other major City infrastructure projects. Impacts are generally consistent with the following: - Project is located in lightly populated area and will affect a small number of businesses/residents (6–15) - Some actions are necessary to mitigate the potential for asthma or health impacts - Project will have moderate neighborhood intensity - Project is located on an arterial, but not a major transportation corridor - Construction activities involve significant excavation and disruption to streets and adjacent properties - Construction will last 3–6 months	Construction impacts will be similar to many other major City infrastructure projects. Impacts are generally consistent with the following: - Project is located in a densely populated area and will affect more than 15 businesses/residents (>15) - The potential for asthma or health impacts cannot be mitigated completely - Project will have high neighborhood intensity - Project is located on an arterial that serves as a major transportation corridor - Heavy construction activities will occur such as heavy excavation, heavy equipment use, pile driving, and disruption to streets and adjacent properties - Construction will last more than 6 months

Criterion 7. Community Impacts (Longer-Term)

Description. What lasting impact will the project and its O&M activities have on the neighborhood, either positive (culturally relevant, sidewalks, water access, bike paths, traffic calming, visual appeal), or negative (odor, noise, visual). Note: This is not meant to include construction impacts. This project supports (visual) connection to a water system, citizen stewardship of a project or facility, and/or formal education.

Measurement Scale. Constructed scale, 5 is best outcome; 1 is worst outcome.

Best = 5	Medium = 3	Worst = 1
- Facility is compatible with and culturally relevant to the surrounding community and minimal staff will be present infrequently - Completed project or ongoing program alleviates a current concern of residents or will have a notable positive lasting benefit for residents and/or visitors to the site - Project is visible and provides a strong opportunity for education that is culturally relevant	- Facility and grounds can be designed to screen facility, and minimal staff visits are necessary - Traffic, odor, and noise from the facility would require mitigation to be acceptable to the community - Project does not alleviate a current concern but improves upon existing neighborhood conditions - Project is visible and may provide some opportunity for education, but it will not be achieved readily and/or the opportunity may not be particularly culturally relevant	- Facility will impact the community negatively and there would be staff on site regularly - Traffic odor and noise from the facility would require significant mitigation to be acceptable to the community - No significant improvement to amenities desired by the neighborhood - Project is hidden from view and provides no particular opportunity for education

Criterion 8. Environmental/Social Justice

Description. Who and where? Will the location of the project address the historical inequity (e.g., address problems that were historically “underreported”)? Will the project protect a current use by a socioeconomic class (e.g., fishing in Duwamish/Green Lake)? Will facility siting affect an already heavily impacted area (e.g., South Park has a transfer station)?

Measurement Scale. Constructed scale, 5 is best outcome; 1 is worst outcome.

Best = 5	Medium = 3	Worst = 1
- Alternative provides substantial culturally relevant benefits to historically underrepresented and low-income populations - Project will not add to ongoing negative effects to an area already heavily impacted	- Alternative provides some culturally relevant benefits to historically underrepresented and low-income populations - Project has the potential to provide some ongoing negative effects to an area already heavily impacted, but those effects can be mitigated effectively	- Alternative provides no culturally relevant benefits to historically underrepresented and low-income populations - Project likely to provide some ongoing negative effects that cannot be mitigated effectively to an area already heavily impacted

Criterion 9. Ease of O&M and Safety

The score for this criterion was the average of the scores given for the three sub-criteria that follow (operations, maintenance, and safety).

Operations (9a)

Description. Beyond any cost implications, what are the implications for City staff to operate the system assuming that adequate resources are available?

Measurement Scale. Constructed scale, 5 is best outcome; 1 is worst outcome.

Best = 5	Medium = 3	Worst = 1
Passive system, no crew required to operate	- Active treatment/operations, can be remotely operated, onsite operator(s) not required - Vendor service contract available for operation - City crews can be trained easily	- Active treatment/operations, onsite operator(s) required - No vendor service available - City crews need specialized training or certifications

Maintenance (9b)

Description. Beyond any cost implications, what are the implications for City staff to maintain the system assuming that adequate resources are available?

Measurement Scale. Constructed scale, 5 is best outcome; 1 is worst outcome.

Best = 5	Medium = 3	Worst = 1
- Maintenance requirements/frequency well established and consistent with City standard practices (e.g., one–two times per year) - Quarterly inspections - Requires no special skills, knowledge, or equipment for City crews to maintain	- Maintenance requirements/frequency not well established, but on the order of requiring maintenance two–four times per year - Monthly inspections - Requires special equipment	- Requires maintenance more than two times per year - Requires special equipment, skills, training, or licensing and/or heavy lifting or intense physical labor - Requires inspections more frequent than monthly - Large underground structure requiring regular structural inspections (e.g., every 5 years)

Safety to City Staff and Public (9c)

Description. Assuming that safety and security are addressed appropriately during design, what safety concerns remain?

Measurement Scale. Constructed scale, 5 is best outcome; 1 is worst outcome.

Best = 5	Medium = 3	Worst = 1
Project would result in few safety concerns that would need to be mitigated. At least two of the following exist: • Outside ROW or does not require traffic control/flagging to access • No confined-space entry to operate or maintain • Little potential for inadvertent contact by public	Project would result in some safety concerns that would need to be mitigated. One or more of the following exists: • Facility located in ROW and traffic control/flagging needed, but no police support • Confined-space entry may be required, but not for routine maintenance • Few public safety areas in relatively low use area or; can be designed to minimize risk (e.g., short ponding duration to minimize mosquito concerns; vegetation selected to minimize public access, e.g., NW 110th Cascades system)	Project would result in many safety concerns that would need to be mitigated. Two or more of the following exists: • Facility located in ROW and traffic control/flagger/police support required • Confined-space entry required for routine operations • Some public safety concerns: Project located in high-use area (e.g., residential neighborhood) or attractive nuisance concerns (e.g., biofiltration swale/biological removal cells that encourage access) and community has expressed concerns about safety (e.g., drowning hazard from stormwater ponding)

2.4 Assign Draft Scores

The Integrated Plan team assigned scores using the 1–5 measurement scale for each criterion except water quality. Scores for each criterion were assigned based on each team member’s knowledge of the project. For water quality, a measurement scale was not used to develop the score. The score was determined based on the Pre-project concentration of each RCOC, the water quality criterion for that RCOC, and the project load reduction.

The scoring process did not always result in one project with a score of 1 and one with a score of 5 because some criteria did not vary appreciably among the projects. Many projects have scores clustered around the midpoint of the range (i.e., scores of 3). Table 2-12 shows the MODA scores for the candidate stormwater projects.

Table 2-12. MODA Scores for Integrated Plan Alternative Projects

Evaluation criteria	Street Sweeping Residential ^a	Street Sweeping Arterials ^a	South Park WQ Facility	NDS Partnering	SW Hinds St. SD StormFilter Vault	South Myrtle St. Shoulder Stabilization	Piper's Cascades	Longfellow Cascades	South Myrtle St. StormFilter Vault	U Village Filterrras
1. Performance Risk	3.5	3.5	4.0	4.0	4.0	3.5	4.0	4.0	4.0	4.0
2. Flexibility	3.0	3.0	3.5	3.5	2.0	1.0	3.5	3.5	2.0	2.0
3. Relationship with Other Agencies	4.0	4.5	4.5	4.5	3.0	4.0	4.0	4.0	3.5	3.0
4. Water Quality	17,135	20,800	28,687	4,307	9,093	343	2,410	1,458	3,527	372
5. Other Positive Environmental Outcomes	1.0	1.0	1.5	5.0	1.0	3.0	5.0	4.5	1.0	1.5
6. Construction Impacts (Short-Term)	5.0	5.0	3.0	3.0	4.0	4.0	3.0	3.0	4.0	4.0
7. Community Impacts (Long-Term)	2.0	2.0	2.0	5.0	2.5	2.5	5.0	5.0	2.5	4.5
8. Environmental/Social Justice	2.5	3.0	3.0	3.0	3.5	3.5	3.0	3.5	3.5	3.5
9. Ease of O&M and Safety	3.5	3.5	3.0	3.5	3.0	4.5	3.5	3.5	3.0	4.5

a. The street sweeping technology used to reduce the stormwater pollutant load was developed to address air quality, specifically the reduction of fine fugitive dust from roadways. The street sweeping for water quality program sweepers are PM10-certified, meaning that they are capable of collecting and holding particulate matter sized less than 10 μm . The South Coast Air Quality Management District, a leader in the nation's efforts to reduce air pollution emissions, developed the certification process. When operating as designed, there will be no visible dust. See <http://www.aqmd.gov/rules/siprules/sr1186.pdf> for additional information.

2.5 Establish Relative Weights

Relative value weights are subjective expressions of the relative value of each criterion within the context of the decision being made. This leads to the concept of swing weighting (as described in SMARTS), in which a trained facilitator helps groups consider the relative importance of each criterion and the extent to which each criterion varies among projects when establishing weights.

Weights were determined at an Integrated Plan team meeting where a trained facilitator led City senior managers using a modified Delphi process in which managers provided weights, the weights were shown to the group, and the differences were discussed. Weights were assigned based on the relative importance of the criterion and the extent to which the scores for the criterion varied among the candidate projects. The discussion resulted in a consensus set of weights that were used in the evaluation. Table 2-13 presents the consensus weights used for the MODA evaluation of the candidate stormwater projects. The water quality criterion was given the greatest weight.

Table 2-13. Criteria Weights		
Evaluation criterion	Relative value weight	Percent of total
1. Performance risk	18	10%
2. Flexibility	12	7%
3. Relationship with other agencies	4	2%
4. Water quality	100	54%
5. Other positive environmental outcomes	8	4%
6. Construction impacts (short-term)	8	4%
7. Community impacts (longer-term)	8	4%
8. Environmental/social justice	8	4%
9. Ease of O&M and safety	18	10%

2.6 MODA Results

All scores were normalized to a 0–1 scale using linear transformation. The normalized scores were multiplied by the relative value weight for each criterion, then multiplied by 100 (a scalar for presentation), and summed over all criteria, resulting in a total value score for each project. As typically conducted at the City, cost was not a weighted parameter. The City and its advisor's experience with weighting has demonstrated that technical staff are typically not comfortable (or skilled) at making explicit tradeoffs between cost and non-monetary criteria. Cost is addressed by comparing non-monetary value against cost in a value-cost tradeoff analysis.

The results of the analysis for the evaluated projects are summarized in Table 2-14, which shows the total score for each project and the project rank. The results of the analysis are also shown on Figure 2-1 as a stacked bar chart where each bar represents the contribution to the score from each criterion. As shown, the South Park WQ Facility provides the highest overall non-monetary value. Water quality and performance risk impacts contributed the most value to the South Park WQ Facility project. The two street sweeping projects provided the next-highest overall value. Their overall value score was also dominated by its performance on the water quality criterion.

Table 2-14. MODA Results

Candidate project/program	Total score	Rank
South Park WQ Facility	79	1
Street Sweeping Expansion Arterials	64	2
Street Sweeping Expansion Residential	57	3
NDS Partnering	41	4
SW Hinds SD StormFilter Vault	40	5
Piper's Cascades	37	6
Longfellow Cascades	35	7
U Village Filterrras	30	8
South Myrtle St. StormFilter Vault	30	9
South Myrtle St. Shoulder Stabilization	27	10

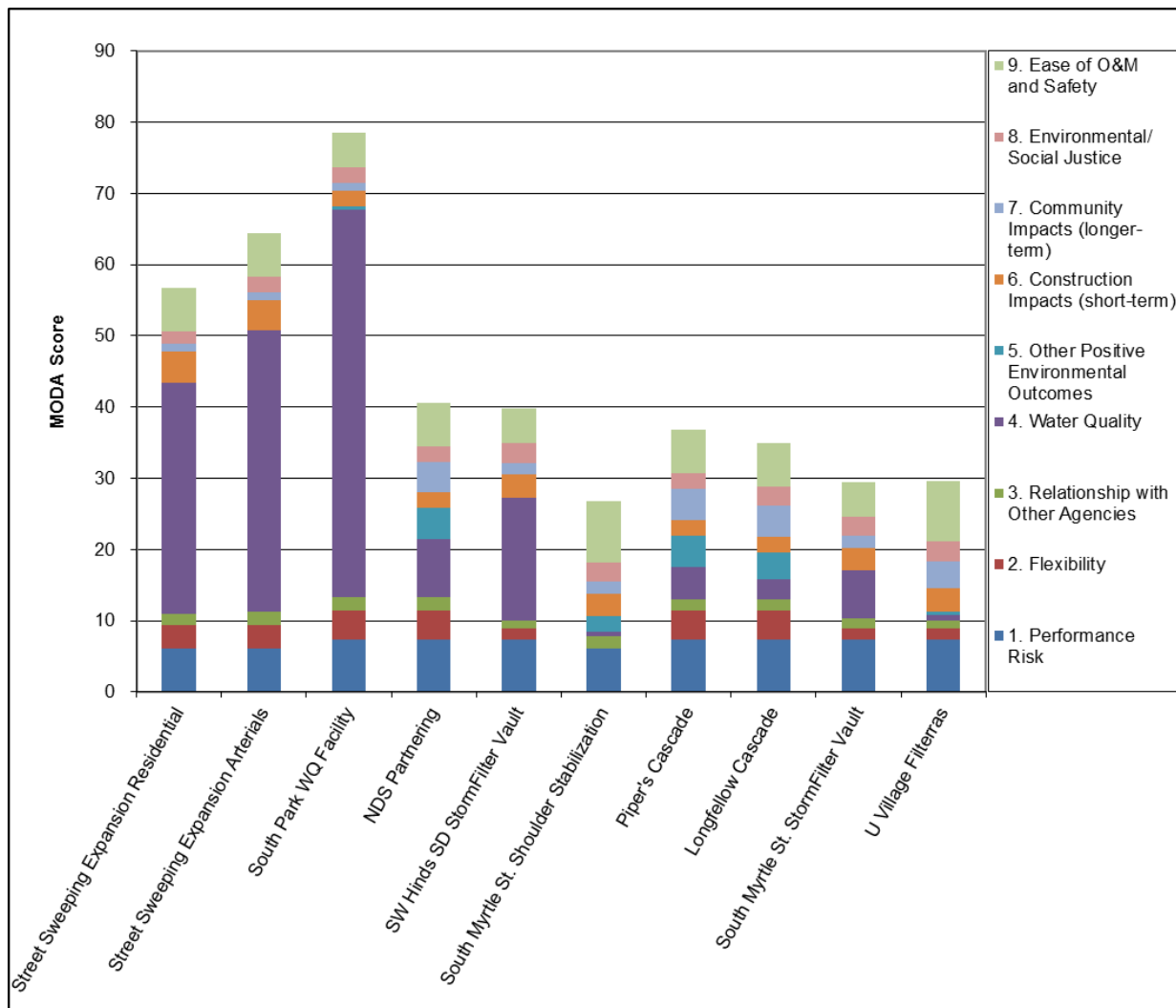


Figure 2-1. MODA results

2.7 Sensitivity Analysis

A sensitivity analysis was conducted to provide additional insight for decision making. The sensitivity analysis involved varying the criteria weights, recalculating the project score, and comparing the results. The City reviewed the results of the sensitivity analysis and decided that the MODA scores did not need to be adjusted.

CHAPTER 3

References

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Appendix J: Stormwater Project Fact Sheets



Protecting Seattle's Waterways

Volume 3 – Integrated Plan

Appendix J: STORMWATER PROJECT FACT SHEETS

Final

May 29, 2015



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NDS Partnering

Project name	NDS Partnering																								
Project type	Green stormwater infrastructure (GSI): bioretention with routing to infiltration																								
Objective	Reduce geomorphically significant flows and loads of polychlorinated biphenyls (PCBs), metals, bacteria, and other pollutants to Longfellow, Piper's and Thornton creeks																								
Description	The Natural Drainage Systems (NDS) Partnering project entails using bioretention (i.e., engineered rain gardens), the most commonly used GSI management practice, within various basins that drain to Longfellow, Piper's and Thornton creeks. This project would entail modifications to 4 miles of rights-of-way to manage flow and provide water quality treatment for polluted urban runoff. Projects would be designed to infiltrate into native soil where appropriate. Where complete reliance on infiltration is technically infeasible, systems would be augmented with underdrains. The "partnering" aspect of the program relates to how the project sites will be selected. NDS Partnering project sites comprise only 4 percent of the potentially feasible residential streets within the watersheds, allowing significant flexibility in project site selection. The site selection approach will involve information exchange with neighborhood groups and other public agencies about the program, and selection of project sites based on input from these groups.																								
Location	The project is located in three areas of the city: the Longfellow Creek drainage basin in West Seattle, the Piper's Creek drainage basin in northwest Seattle, and the Thornton Creek drainage basin in northeast Seattle. See Figures J-1 through J-3 for project locations and receiving water bodies.																								
Tributary area	City rights-of-way within Longfellow, Piper's and Thornton creeks have a combined impervious area of more than 1,200 acres within the fully separated portions of their watersheds. Adjacent parcels also direct runoff to these rights-of-way. In total, runoff from more than 2,200 acres of currently unmanaged impervious surfaces is directed from rights-of-way to Longfellow, Piper's and Thornton creeks. GSI approaches within these rights-of-way have the potential to manage polluted runoff from more than 1,100 acres. <table><tr><th rowspan="2">Watershed</th><th rowspan="2">Available impervious area for GSI, acres</th><th colspan="2">Tributary area to NDS Partnering GSI</th></tr><tr><th>Impervious, acres</th><th>Total (impervious and pervious), acres</th></tr><tr><td>Longfellow Creek</td><td>150</td><td>6.5</td><td>557</td></tr><tr><td>Piper's Creek</td><td>215</td><td>7.5</td><td>160</td></tr><tr><td>Thornton Creek</td><td>745</td><td>30</td><td>2,703</td></tr><tr><td>Total</td><td>1,110</td><td>44</td><td>3,420</td></tr></table>			Watershed	Available impervious area for GSI, acres	Tributary area to NDS Partnering GSI		Impervious, acres	Total (impervious and pervious), acres	Longfellow Creek	150	6.5	557	Piper's Creek	215	7.5	160	Thornton Creek	745	30	2,703	Total	1,110	44	3,420
Watershed	Available impervious area for GSI, acres	Tributary area to NDS Partnering GSI																							
		Impervious, acres	Total (impervious and pervious), acres																						
Longfellow Creek	150	6.5	557																						
Piper's Creek	215	7.5	160																						
Thornton Creek	745	30	2,703																						
Total	1,110	44	3,420																						

Project name	NDS Partnering
Basis of design/assumptions	<i>Site Characteristics</i> GIS data were used to exclude potentially unsuitable areas within each watershed, identified based on the following criteria: • Areas already mitigated by previous GSI projects • Street slope >7% • Low infiltration potential: areas where infiltration likely not feasible due to high groundwater or shallow bedrock • Steep slopes, steep slope buffer, or known landslide potential • Known contaminated soils The remaining areas of each watershed were identified as potentially feasible for bioretention. Most blocks deemed potentially feasible for bioretention are in areas with informal drainage systems (i.e., lacking curbs and gutters). <i>Site Constraints</i> Due to the large number of potential NDS project sites, sites were not visited as part of the Integrated Plan development. Site constraints have not been identified. <i>Basis of Design</i> Bioretention will be sized to capture 80% of the average annual runoff volume generated from the tributary area. It was assumed that 50% of the runoff volume captured by the NDS Partnering facilities will infiltrate into native soil beneath the facilities while the remainder will be collected in underdrains. The underdrains will collect the portion of the treated stormwater that does not infiltrate and convey it to a City stormwater conveyance system or underground injection control (UIC) structure. <i>Project Elements</i> One of two types of template blocks will be constructed at each project site: dispersed block and full right-of-way reconstruction. A dispersed block template includes minor conveyance upgrades along the block, one sidewalk, and installation of a bioretention system. • Bioretention system sizing: Capture 80% average annual volume • Average sizing factor: 4% • Assumed street length: 600 linear feet • Impervious area to be managed: 39,000 square feet • Bioretention bottom area: 1,560 square feet • Conveyance improvements: 350 linear feet • Sidewalk: Constructed on one side of the street • Project streets constructed with this template: 27 • Project streets needing underdrains: 13.5 • Underground Injection Controls (UIC): None A right-of-way reconstruction template includes conveyance upgrades along a full block, one sidewalk, and installation of a bioretention system. • Bioretention system sizing: Capture 80% average annual volume • Average sizing factor: 2.6% • Assumed street length: 600 linear feet • Impervious area to be managed: 101,400 square feet (2.6 upstream blocks) • Bioretention bottom area: 2,640 square feet • Conveyance improvements: 600 linear feet • Sidewalk: Constructed on one side of the street • Project streets constructed with this template: 6 • Project streets needing underdrains: 3 • UICs: 6 • UIC depth: 60 to 90 feet

Project name	NDS Partnering
Recommended predesign refinements	Prior to design, the following should be completed: • Identify blocks that are potentially feasible for bioretention • Perform community outreach to encourage residents to nominate blocks as candidates for NDS and determine community goals (mobility, traffic calming, and beautification) • Prioritize project locations based on stormwater goals, including ability to manage flow from upstream blocks and space available for bioretention cells (including identification of right-of-way area and setback requirements) • Develop concept design block, based on community engagement and technical considerations, including geotechnical analysis (i.e., infiltration testing, depth to groundwater and hydraulic restrictive layer, evaluation of adjacent slopes and structures)
Average volume of water treated or reduced	35 million gallons per year; -NDS Partnering-Longfellow Creek: 5.4 MG/yr -NDS Partnering-Piper's Creek: 6.2 MG/yr -NDS Partnering-Thornton Creek: 23.9 MG/yr

Loads reduction

Longfellow Creek Annual Loads Reduction			
RCOC	Lower confidence limits	Mean	Upper confidence limits
PCBs (kg/yr)	0.00020	0.00027	0.00035
Fecal coliform (billion CFU/yr)	1,686	2,715	3,833
Phosphorus (kg/yr)	1.7	2.1	2.6
Total copper (kg/yr)	0.16	0.20	0.24
Total zinc (kg/yr)	1.4	1.7	2.0
TSS (kg/yr)	1,017	1,173	1,352

Piper's Creek Annual Loads Reduction			
RCOC	Lower confidence limits	Mean	Upper confidence limits
PCBs (kg/yr)	0.00020	0.00032	0.00043
Fecal coliform (billion CFU/yr)	1,625	3,159	4,580
Phosphorus (kg/yr)	1.9	2.6	3.2
Total copper (kg/yr)	0.16	0.19	0.23
Total zinc (kg/yr)	1.4	1.9	2.3
TSS (kg/yr)	1,080	1,306	1,602

Thornton Creek Annual Loads Reduction			
RCOC	Lower confidence limits	Mean	Upper confidence limits
PCBs (kg/yr)	0.00089	0.00121	0.00159
Fecal coliform (billion CFU/yr)	7,338	12,037	17,064
Phosphorus (kg/yr)	7.6	9.5	11.8
Total copper (kg/yr)	0.73	0.88	1.08
Total zinc (kg/yr)	6.4	7.8	9.5
TSS (kg/yr)	4,382	5,225	6,085

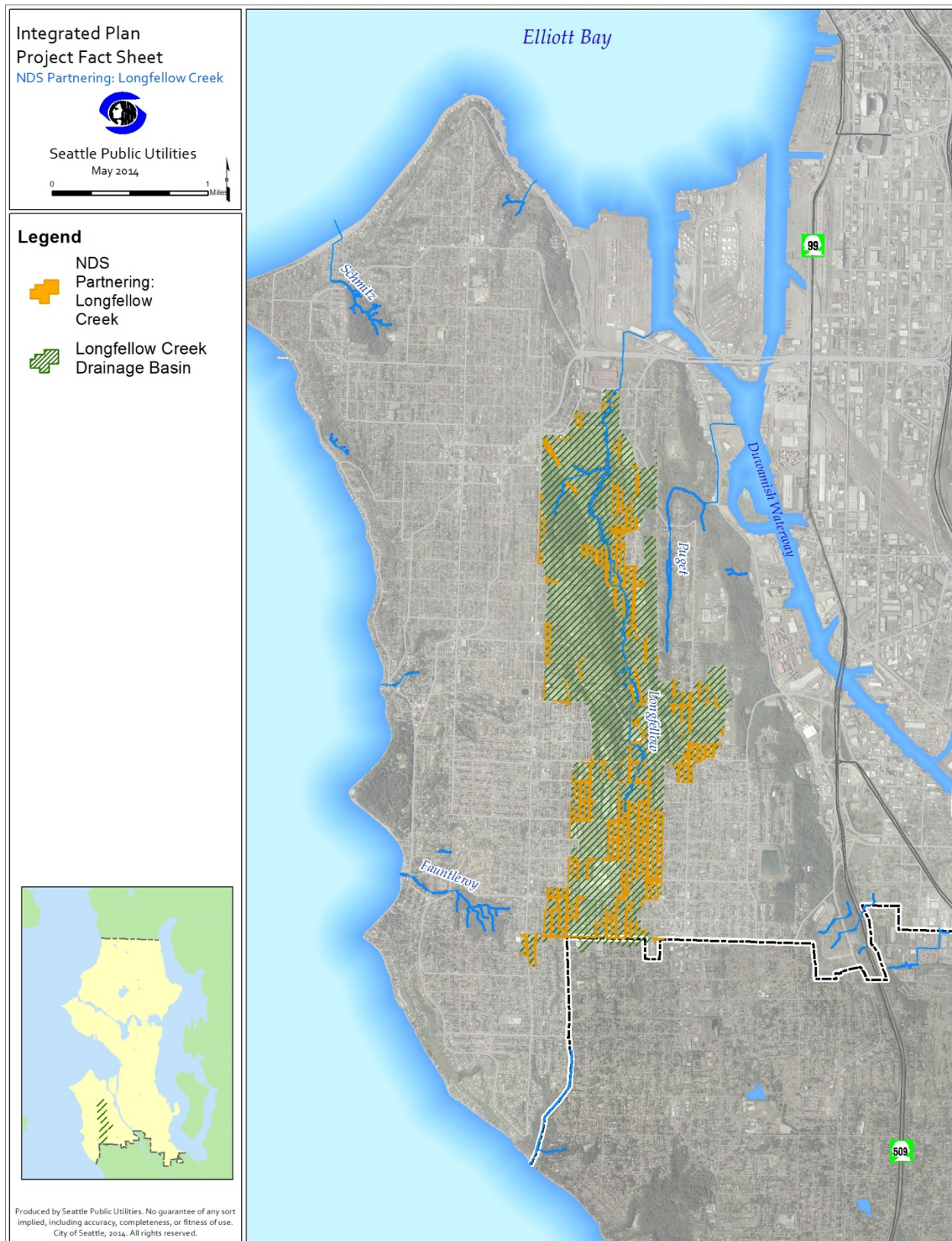


Figure J-1. Project location: NDS Partnering Longfellow Creek

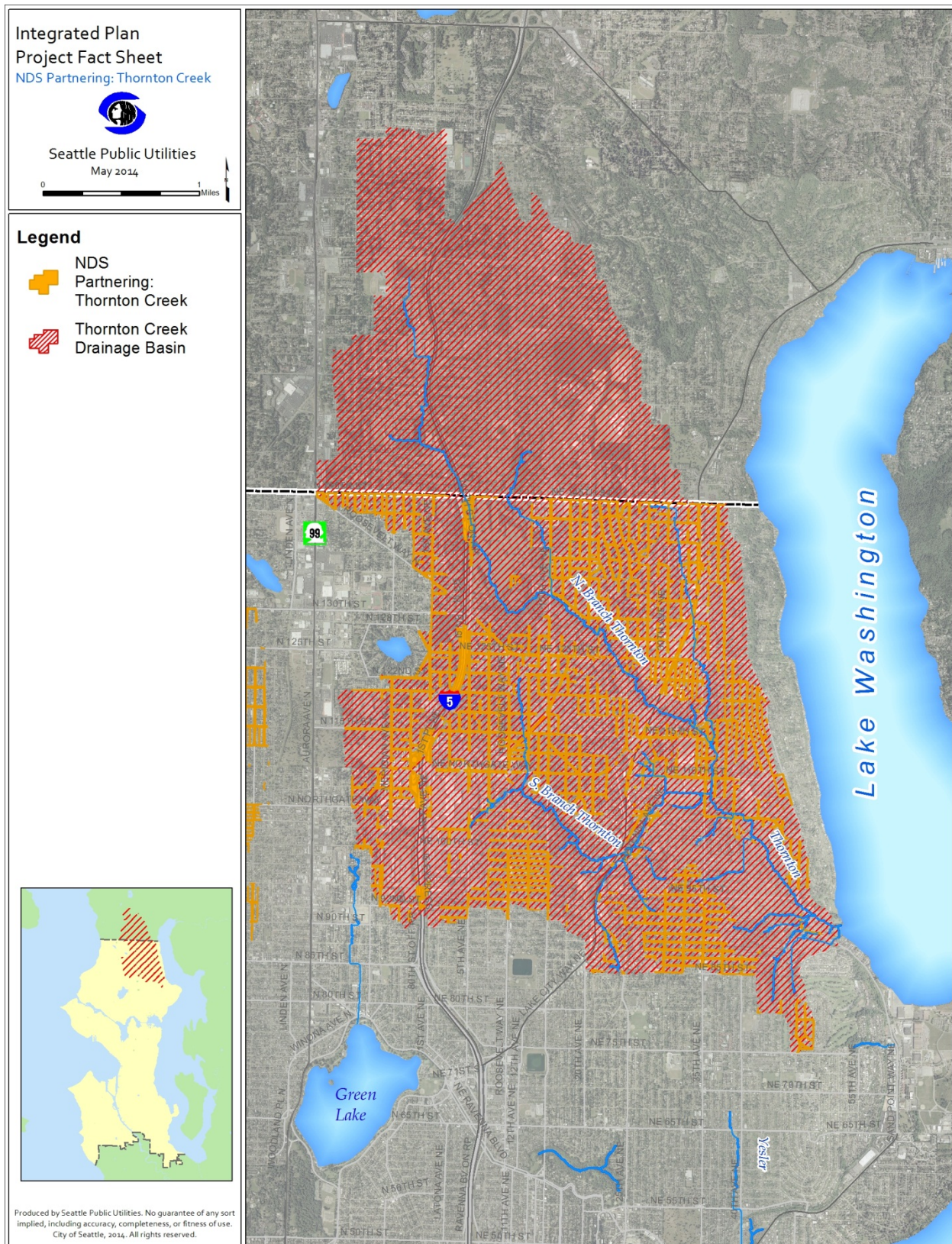


Figure J-3. Project location: NDS Partnering Thornton Creek

Project name	NDS Partnering
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Project Cost Estimate

Unit Cost Escalation to Today			
Description	ENR CCI Index		
Estimate Unit Cost Index ENR CCI (Seattle), Sept 2011	9056.6		
Current ENR CCI Index (Seattle), November 2012	9423.77		
Unit Cost Adjustment	1.041		
Market Conditions % (Set by SPU Finance office) ¹	0.0%		
Current Seattle WA Sales Tax rate ²	0.0%		
Agency	Total Costs	Pipe/Horz Conveyance	Green Stormwater Infrastructure
	\$ 11,110,500	\$ -	\$ 11,110,500
Subtotal	\$ 11,110,500	\$ -	\$ 11,110,500
Retrofit Costs	\$ -	\$ -	\$ -
Other Misc Mitigation Items	\$ -	\$ -	\$ -
Street Use Permit	\$ 111,105	\$ -	\$ 111,105
Permit Fees	\$ 111,105	\$ -	\$ 111,105
Construction Line Item Pricing (Sept 2011 Dollars)	\$ 11,332,710	\$ -	\$ 11,332,710
Construction Line Item Pricing (See above for ENR Index Data)	\$ 11,792,000	\$ -	\$ 11,792,000
Adjustment for Market Conditions ¹	\$ -	\$ -	\$ -
Construction Bid Amount	\$ 11,792,000	\$ -	\$ 11,792,000
Sales Tax ²	\$ -	\$ -	\$ -
Construction Contract Amount	\$ 11,792,000	\$ -	\$ 11,792,000
Crew Construction Cost	\$ 2,240,480	\$ -	\$ 2,240,480
Miscellaneous Hard Costs	\$ 589,600	\$ -	\$ 589,600
Hard Cost Total	\$ 14,622,080	\$ -	\$ 14,622,080
Soft Cost % ³		49%	49%
Soft Cost Amount	\$ 7,165,000	\$ -	\$ 7,165,000
Property Cost (Per SPU Real Estate)	\$ -	\$ -	\$ -
Base Cost	\$ 21,787,080	\$ -	\$ 21,787,080
Construction Contingency % ⁴		40%	25%
Construction Contingency Amount	\$ 5,447,000	\$ -	\$ 5,447,000
Management Reserve % ⁵		25%	15%
Management Reserve Amount	\$ 3,268,000	\$ -	\$ 3,268,000
Allowance for Indeterminates %		25%	0%
Allowance for Indeterminates Amount	\$ -	\$ -	\$ -
Total Project Costs, 2012 Dollars⁶	\$ 30,500,000	\$ -	\$ 30,500,000
Present Values Costs in 2014 Dollars			
Capital	\$ 24,500,000		
O&M	\$ 2,800,000		
Total Project Costs¹¹	\$ 27,200,000		
Notes:			
¹ SPU Finance office to provide market condition adjustment			
² WA State Dept of Revenue 3 Qtr 2011 Seattle Tax Rate of 9.5% is excluded for GSI			
³ Soft Cost % for large drainage or wastewater projects (TCP>\$5M) is 49% per SPU guidelines.			
⁴ Contingency for SPU Initiation ranges from 25% to 40% of Base Cost.			
⁵ Management Reserve for SPU Initiation ranges from 10% to 25% of Base Cost.			
⁶ Total Project Dollar values are rounded to the nearest \$10,000.			
⁷ Street use permit is 1% of Subtotal (line 20)			
⁸ Permit Fees is 5% of Subtotal (line 20)			
⁹ Construction Crew Cost is 19% of the Construction Contract Amount			
¹⁰ Misc Hard Cost (survey, geotech) is 5% of the Construction Contract Amount			
¹¹ Present value costs in 2014 dollars over 100 years at 3%			

South Park WQ Expansion

Project name	South Park WQ Facility
Project type	Basic, Active Treatment (e.g., chitosan-enhanced sand filtration [CESF])
Objective	Reduce loads of polychlorinated biphenyls (PCBs), metals, bacteria, and other pollutants to the Duwamish Waterway.
Description	The South Park Water Quality (WQ) Facility would entail an end-of-pipe treatment system (e.g., regional) using a CESF system that would be installed in the 7th Avenue S drainage system. The treatment facility would be co-located with a new stormwater pump station that the City of Seattle (City) plans to build in order to reduce flooding in the 7th Avenue S drainage system. This project would take advantage of the opportunity to integrate water quality treatment with flood control.
Location	The project is located in south Seattle, adjacent to the Duwamish Waterway. See Figure J-4 for project location and receiving water body.
Tributary area	The current South Park drainage area is approximately 238 acres, about 145 acres (61 percent) of which is impervious. In the future, the drainage area could be expanded to encompass up to 278 acres and the impervious area could increase to approximately 219 acres (79 percent) due to new development and conversion of existing residential areas to high-density residential or industrial uses.
Basis of design/assumptions	<i>Site Characteristics</i> This project is located in the 7th Avenue S storm drainage basin, in a predominantly commercial/industrial area. <i>Site Constraints</i> The treatment system sizing is limited due to the land available for the facility <i>Basis of Design</i> - Average annual runoff: 89 MG/yr - BMP capture efficiency (% of average annual runoff treated): 83% (74 MG/yr treated) <i>Project Elements</i> Basic CESF system components include: - chemical storage/feed - sedimentation/flocculation basin - sand filters - solids handling facility - supervisory control and data acquisition (SCADA) equipment
Recommended predesign refinements	Prior to design, the following should be completed: - land acquisition - refine tributary area to the facility - collect flow monitoring data to calibrate flow model - characterize baseflow - use calibrated model and baseflow estimates to confirm/refine facility sizing

Project name	South Park WQ Facility			
Average volume of water treated or reduced	74 million gallons per year			
Loads reduction	Annual Loads Reduction			
	RCOC	Lower confidence limits	Mean	Upper confidence limits
	Total zinc (kg/yr)	24.5	29.0	34.4
	Total copper (kg/yr)	3.8	4.5	5.2
	Fecal coliform (billion CFU/yr)	31,000	52,700	74,200
	PCBs (kg/yr)	0.0052	0.0069	0.0086
	Phosphorus (kg/yr)	38.3	45.5	53.5
	TSS (kg/yr)	20,935	24,741	29,086

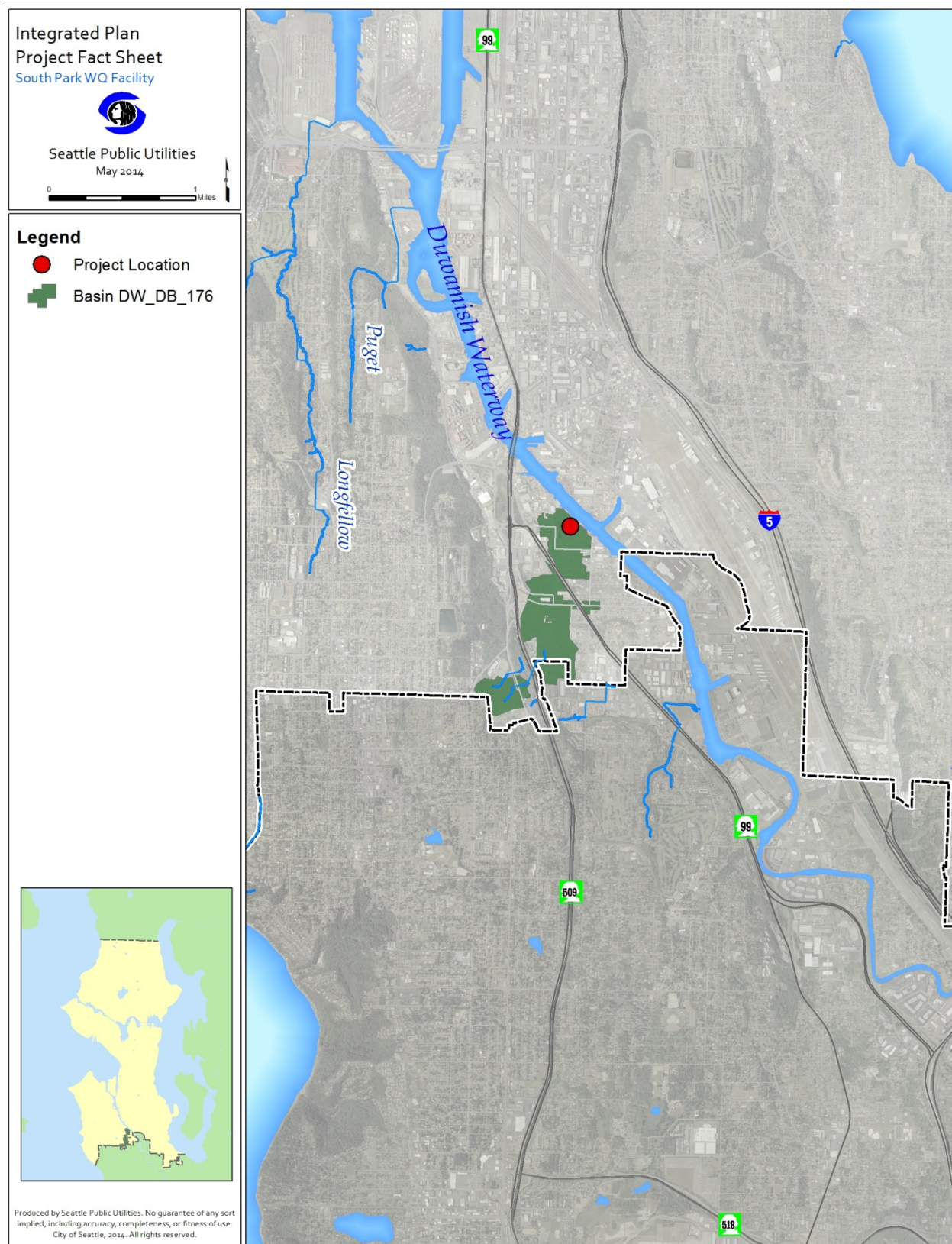


Figure J-4. Project location: South Park Water Quality Facility

Project name South Park WQ Facility

Project Cost Estimate

Unit Cost Escalation to Today		
Description	ENR CCI Index	
Estimate Unit Cost Index ENR CCI (Seattle), Sept 2011	9056.6	
Current ENR CCI Index (Seattle), November 2012	9423.77	
Unit Cost Adjustment	1.041	
Market Conditions % (Set by SPU Finance office) ¹	0.0%	
Current Seattle WA Sales Tax rate ²	9.5%	
Agency	Total Costs	South Park Water Quality Facility Basic Active Treatment
	\$ -	\$ -
Subtotal	\$ -	\$ -
Retrofit Costs	\$ -	\$ -
Other Misc Mitigation Items	\$ -	\$ -
Street Use Permit ⁶	\$ -	\$ -
Permit Fees ⁷	\$ -	\$ -
Construction Line Item Pricing (Sept 2011 Dollars)	\$ -	\$ -
Construction Line Item Pricing (See above for ENR Index Date)	\$ -	\$ -
Adjustment for Market Conditions ¹	\$ -	\$ -
Construction Bid Amount	\$ -	\$ -
Sales Tax ²	\$ -	\$ -
Construction Contract Amount	\$ 8,636,373	\$8,636,373
Construction Crew Cost	\$ 1,640,911	\$ 1,640,911
Miscellaneous Hard Costs	\$ 431,819	\$ 431,819
Hard Cost Total	\$ 10,709,103	\$ 10,709,103
Soft Cost % ³	49%	49%
Soft Cost Amount	\$ 5,247,000	\$ 5,247,000
Property Cost (Per SPU Real Estate)	\$ -	\$ -
Base Cost	\$ 15,956,103	\$ 15,956,103

Project name South Park WQ Facility

Project Cost Estimate (continued)

Allowance for Indeterminates % ¹⁰	25%	25%
Allowance for Indeterminates Amount	\$ 3,989,000	\$ 3,989,000
Construction Contingency % ⁴	40%	40%
Construction Contingency Amount	\$ 6,382,000	\$ 6,382,000
Management Reserve % ⁵	25%	25%
Management Reserve Amount	\$ 3,989,000	\$ 3,989,000
Total Project Costs, 2012 Dollars	\$ 30,320,000	\$ 30,320,000
Present Values Costs in 2014 Dollars		
Capital	\$ 24,300,000	
O&M	\$ 10,500,000	
Total Project Costs¹¹	\$ 34,800,000	
Notes:		
¹ SPU Finance office to provide market condition adjustment		
² WA State Dept of Revenue 3 Qtr 2011 Seattle Tax Rate of 9.5%		
³ Soft Cost is 49% per SPU guidelines.		
⁴ Management Reserve for SPU Options Analysis ranges from 10% to 25% of Base Cost.		
⁵ Total Project Dollar values are rounded to the nearest \$10,000.		
⁶ Street use permit is 1% of Subtotal.		
⁷ Permit Fees is 1% of Subtotal.		
⁸ Construction Crew Cost is 19% of the Construction Contract Amount		
⁹ Misc Hard Cost (survey, geotech) is 5% of the Construction Contract Amount		
¹⁰ Allowance for Indeterminates is 25% of Base Cost.		
¹¹ Present value costs in 2014 dollars over 100 years at 3%		

Note: Cost estimate is based on a pump station design flow rate of 11 cubic feet per second.

References

Seattle Public Utilities. 2014. South Park Hydraulic Modeling Report. September 2014.

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Street Sweeping Expansion Arterials

Project name	Street Sweeping Expansion Arterials
Program type	Street sweeping, weekly, evening arterial sweeping
Objective	Reduce loads of polychlorinated biphenyls (PCBs), metals, bacteria, and other particulate-bound pollutants to multiple receiving water bodies.
Description	The Street Sweeping Expansion Arterials program would be done in addition to the current Street Sweeping for Water Quality Program, a partnership between Seattle Public Utilities and Seattle Department of Transportation. The existing program would be expanded by increasing the: • route coverage from 83 percent to approximately 85 percent of curbed arterials, for a total of 25 routes • sweeping frequency from biweekly to weekly, for some routes (21 routes will be swept on a weekly basis, and 4 routes will be swept on a biweekly basis) • sweeping season from 40 to 48 weeks per year
Location	The program affects arterials throughout the city. See Figure J-5 for program location and receiving water bodies.
Tributary area	1,736 acres (10,600 annual curb-miles), including streets and adjacent sidewalks

Project name	Street Sweeping Expansion Arterials
Basis of design/assumptions	<i>Site Characteristics</i> The streets that will be swept are arterials, citywide. <i>Site Constraints</i> There are no known site constraints. <i>Basis of Design</i> The program was developed based on the Street Sweeping for Water Quality Program, which began February 2011. • Average street width: 41.7 feet • Street area: 1,422 acres • Sidewalks: 314 acres, 100% connected to roads • Effective area or area draining to municipal separate storm sewer system: 1,736 acres • Average annual runoff: 4,687 acre-feet/year • Washoff load: 12 percent of total load removed • Washoff pollutant load removed: 36,200 kg/yr • Street sweeping pick-up rates were estimated based on: - o sample results from the sweepings temporarily stored in the stockpiles located in the designated bins - o productivity metrics (curb-miles swept within and without the storm sewer system) - o disposal facility scale readings - o efficiency factor of 64 percent, to account for reduced pickup rates for more frequent sweeping - o reduction factor of 25 percent, to account for reduced flexibility when operating at full capacity <i>Project Elements</i> • One new regenerative sweeper • One additional street sweeping route, for a total of 25 routes • Sweeping frequency of biweekly (4 routes) and weekly (21 routes) • Sweeping season from 40 to 48 weeks per year for all routes
Recommended predesign refinements	Route optimization

Project name	Street Sweeping Expansion Arterials																																			
Average volume of water treated or reduced	1,527 million gallons per year (based on estimated runoff from swept streets)																																			
Loads reduction	<table><tr><th colspan="4">Annual Loads Reduction</th></tr><tr><th>RCOC</th><th>Lower confidence limits</th><th>Mean</th><th>Upper confidence limits</th></tr><tr><td>PCBs (kg/yr)</td><td>0.0020</td><td>0.0033</td><td>0.0045</td></tr><tr><td>Fecal coliform (billion CFU/yr)</td><td>1,380</td><td>2,100</td><td>3,970</td></tr><tr><td>Phosphorus (kg/yr)</td><td>13.7</td><td>23.7</td><td>29.6</td></tr><tr><td>Total copper (kg/yr)</td><td>3.3</td><td>5.2</td><td>7.2</td></tr><tr><td>Total zinc (kg/yr)</td><td>6.3</td><td>10.2</td><td>13.7</td></tr><tr><td>TSS equivalent (kg/yr)</td><td>20,700</td><td>36,200</td><td>44,700</td></tr></table> N/A = not available				Annual Loads Reduction				RCOC	Lower confidence limits	Mean	Upper confidence limits	PCBs (kg/yr)	0.0020	0.0033	0.0045	Fecal coliform (billion CFU/yr)	1,380	2,100	3,970	Phosphorus (kg/yr)	13.7	23.7	29.6	Total copper (kg/yr)	3.3	5.2	7.2	Total zinc (kg/yr)	6.3	10.2	13.7	TSS equivalent (kg/yr)	20,700	36,200	44,700
Annual Loads Reduction																																				
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Total zinc (kg/yr)	6.3	10.2	13.7																																	
TSS equivalent (kg/yr)	20,700	36,200	44,700																																	
Loads reduction by receiving water body	<table><tr><th>Receiving Water Body</th><th>Distribution of Load Reduction</th></tr><tr><td>Direct discharge</td><td>3%</td></tr><tr><td>Lower Duwamish Waterway</td><td>30%</td></tr><tr><td>Lake Washington Ship Canal/Lake Union</td><td>20%</td></tr><tr><td>Lake Washington</td><td>18%</td></tr><tr><td>Longfellow Creek</td><td>3%</td></tr><tr><td>Piper's Creek</td><td>1%</td></tr><tr><td>Elliott Bay</td><td>6%</td></tr><tr><td>Puget Sound</td><td>10%</td></tr><tr><td>Thornton Creek</td><td>9%</td></tr></table>				Receiving Water Body	Distribution of Load Reduction	Direct discharge	3%	Lower Duwamish Waterway	30%	Lake Washington Ship Canal/Lake Union	20%	Lake Washington	18%	Longfellow Creek	3%	Piper's Creek	1%	Elliott Bay	6%	Puget Sound	10%	Thornton Creek	9%												
Receiving Water Body	Distribution of Load Reduction																																			
Direct discharge	3%																																			
Lower Duwamish Waterway	30%																																			
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Thornton Creek	9%																																			

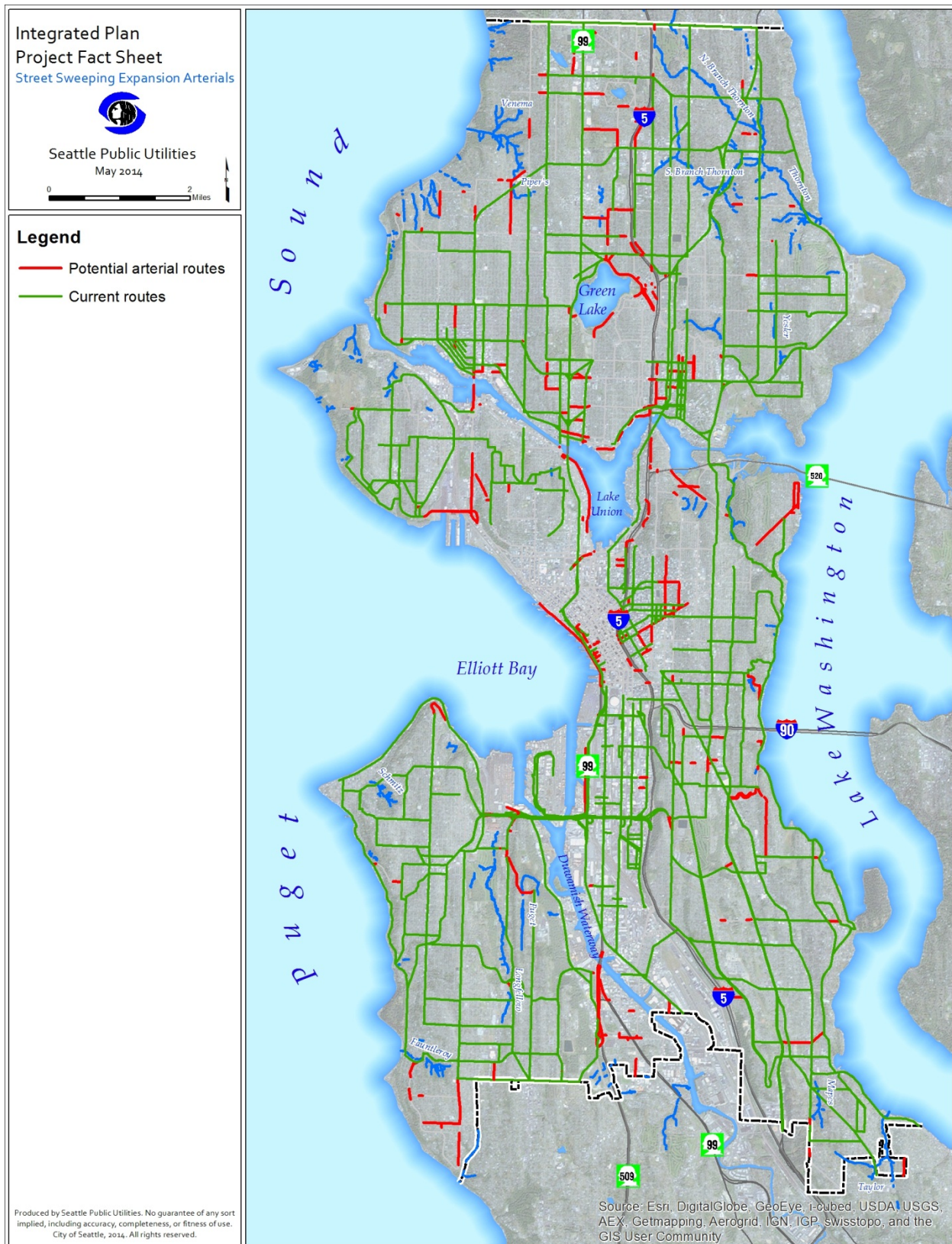


Figure J-5. Project location: Street Sweeping Expansion Arterials

Project name	Street Sweeping Expansion Arterials
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Project Cost Estimate

Item	Costs
New sweepers	\$ 300,000
Design	\$ 25,000
Commissioning	\$ 10,000
Post-Construction Monitoring	\$ 270,000
Total	\$ 605,000
Annual Operations and Maintenance	
Sweeping and disposal costs	\$ 748,645
Program overhead	\$ 86,250
Total	\$ 834,895





Protecting Seattle's Waterways

Volume 4 Draft Programmatic Environmental Impact Statement

May 29, 2014





City of Seattle
Seattle Public Utilities

May 29, 2014

Dear Affected Agencies, Tribes, Organizations and Interested Parties:

The City of Seattle (City) is pleased to issue the Draft Environmental Impact Statement (Draft EIS) for the Plan to Protect Seattle's Waterways.

The City is preparing a comprehensive strategy, called the Plan to Protect Seattle's Waterways (Plan), to reduce overflows and the discharge of pollutants from combined sewers and stormwater runoff. The City must correct this problem to protect public health and the environment, and comply with the federal Clean Water Act, state regulations, and a Consent Decree with the Washington State Department of Ecology, the U.S. Environmental Protection Agency, and the U.S. Department of Justice. This Draft EIS is one of four volumes included in the Plan. The Executive Summary is Volume 1, the Long Term Control Plan (LTCP) is Volume 2, the Integrated Plan is Volume 3, and the Draft EIS is Volume 4.

This programmatic EIS discloses the construction and operational impacts associated with implementation of each Plan alternative:

- The No Action Alternative – completes only the combined sewer overflow (CSO) reduction projects currently planned or underway by the City, leaving 22 CSO outfalls uncontrolled;
- The Long Term Control Plan Alternative – completes CSO reduction projects needed to control the remaining 22 CSO outfalls,
- The Integrated Plan Alternative – also completes CSO reduction projects needed to control the remaining 22 CSO outfalls and implements additional projects to reduce stormwater pollution.

The Long Term Control Plan Alternative includes four options, any of which would control the remaining 22 CSO outfalls and meet regulatory requirements:

- Neighborhood Storage Option – All storage projects would be completed independently by the City, with one option providing storage in tanks/pipes, and the other a combination of a tunnel and tanks/pipes.
- Shared West Ship Canal Tunnel Option – Where feasible, storage projects would be completed jointly by the City and King County. This option includes storage tanks/pipes and a shared City/King County tunnel for storage of flows from three of the largest CSO areas.
- Shared Ship Canal Tunnel Option – This option includes a large shared City/King County tunnel for storage from seven of the largest CSO areas, as well as storage tanks and pipes.
- Shared Storage Option – The City and King County would complete shared storage projects in the Ship Canal, Portage Bay and Lake Washington areas.

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Any shared projects between the City and King County would be implemented in accordance with joint project agreements between the two agencies.

Impacts are evaluated at a programmatic level, to provide a comprehensive evaluation of potential impacts and mitigation associated with implementation of the Plan. Site-specific project evaluations will be conducted at a later date, when additional information is available.

Environmental elements covered in the EIS include Earth and Groundwater, Air Quality and Odors, Surface Water, Biological Resources, Energy and Climate Change, and Environmental Health. Noise and Vibration, Land Use and Visual Quality, Recreation, Historic and Cultural Resources, Transportation, Utilities, and Socioeconomics and Environmental Justice are also evaluated.

Key issues associated with the alternatives and options include potential construction-related impacts, particularly traffic, noise, and other community impacts during construction periods that could range from roughly one year to as much as seven years, depending upon the size of the project. Possible long term impacts include a potential for odor and noise at storage facilities, and potential operational implications for the region's wastewater system. Appropriate design and mitigation, along with coordination with potentially affected agencies and organizations, will reduce the potential for significant impacts.

A public meeting on the Plan and a public hearing on the Draft EIS will be held Tuesday, June 24, 2014 starting at 6:00 pm at the Lake Washington Rowing Club, 910 N. Northlake Way, Seattle. The public hearing will begin at 6:30 pm. The public, interested agencies, and tribal governments are invited to review and comment on the Plan and proposed alternatives during the public meeting. Public testimony and written comments on the Draft EIS will be accepted during the public hearing. Additional information on the Plan, public meeting and public hearing, and other opportunities to comment on the Plan can be found in the Fact Sheet and at www.seattle.gov/CSO.

Thank you for your interest in the Plan to Protect Seattle's Waterways.

Sincerely,



Betty Meyer

SEPA Responsible Official

Fact Sheet

Name of Proposal

Plan to Protect Seattle's Waterways (the Plan)

Proponent

City of Seattle (City): Seattle Public Utilities (SPU)

Location

Projects included in the Plan would be located throughout the City of Seattle in the following areas:

- Ship Canal Neighborhoods
- Lake Washington Neighborhoods
- Longfellow Creek/ Duwamish Neighborhoods
- Elliott Bay/ Lake Union Neighborhoods
- Piper's Creek Neighborhoods
- Thornton Creek Neighborhoods

Purpose

The objective of this proposal is to adopt a Plan to reduce overflows and the discharge of pollutants from combined sewers and stormwater runoff, in order to protect public health and the environment and to comply with federal and state regulations. When implemented, the Plan would bring Seattle into compliance with state and federal combined sewer overflow (CSO) regulations and a Consent Decree with the Washington State Department of Ecology, the U.S. Environmental Protection Agency, and the U.S. Department of Justice. Specifically, the Plan would achieve the following objectives:

- Identify areas of Seattle where projects are needed to reduce combined sewer overflows.
- Evaluate alternatives for reducing combined sewer overflows in these areas.
- Identify additional areas where projects to reduce stormwater pollution would improve water quality.
- Recommend a schedule for designing and constructing projects.
- Estimate program costs and associated impacts on SPU customer bills.
- Consider regulatory, public and stakeholder input.

Proposed Alternatives

SPU identified the following alternatives for evaluation in this EIS:

- No Action Alternative
- Long-Term Control Plan Alternative
- Integrated Plan Alternative

No Action Alternative: Under the No Action Alternative, the City would not implement the Plan. Progress would be made in reducing the number and volume of CSOs through implementation of previously planned CSO control projects identified in the City's National Pollutant Discharge Elimination System (NPDES) Waste Discharge Permit. Most of these projects were identified in the 2010-2015 Implementation Plan for the *2010 CSO Reduction Plan Amendment* (2010 Plan Amendment). These projects are currently funded and are scheduled for implementation, and they will occur regardless of whether the Plan is implemented. The City would also continue to implement a portion of two of its CSO reduction strategies: combined sewer system improvements and Natural Drainage Systems (called 'Green Infrastructure' in the LTCP). However, the City would not implement any additional projects to further reduce CSOs or reduce stormwater pollution. Under the No Action Alternative, the City would not be in compliance with the Consent Decree. SEPA requires that the No Action Alternative be included, and serves as a baseline for comparison with the action alternatives.

Long-Term Control Plan Alternative: The Long-term Control Plan (LTCP) Alternative is focused solely on controlling all remaining uncontrolled CSO outfalls. As a planning-level document, the LTCP presents a comprehensive strategy to reduce the remaining uncontrolled CSO discharges in the city. The City must address these CSOs to protect public health and the environment, and comply with the Clean Water Act and state regulations. The City would implement the projects identified in the LTCP Alternative from 2016 through 2025.

There are four potential combinations of storage facilities, referred to as "options" under the LTCP that are evaluated in this EIS. Any of these four options would meet the Plan objectives. The options were developed under one of two basic concepts: the City meets its Consent Decree-mandated CSO control requirements through implementation of independent (City only) control projects, or the City participates in one or more shared projects with King County to take advantage of potential cost /impact reduction opportunities. The options vary in terms of the number, size, and potential location of storage facilities considered.

- Neighborhood Storage Option (independent, City only implementation)
 - Neighborhood Tanks/Pipes, or
 - Neighborhood West Ship Canal Tunnel plus Tanks/Pipes
- Shared West Ship Canal Tunnel Option (Shared King County / City implementation)
- Shared Ship Canal Tunnel Option (Shared King County /City implementation)
- Shared Storage Option (Shared King County / City implementation)

Integrated Plan Alternative: The Integrated Plan Alternative includes control of all remaining uncontrolled CSO outfalls and reduction of stormwater pollution. Stormwater that enters the City's separate stormwater system is a major contributor to surface water quality issues. The objective of the Integrated Plan is to implement stormwater pollution management projects that would provide greater benefits to surface water quality than those provided by

the LTCP CSO reduction strategies alone. The Integrated Plan represents a more comprehensive approach to water quality management by integrating stormwater pollution management with CSO reduction strategies.

Under the Integrated Plan Alternative, the City would still build the CSO reduction projects included in one of the four LTCP options outlined above. However, the City would delay the completion of some of the CSO control projects until 2030, while high-benefit stormwater treatment technology projects would be completed prior to 2025. Six projects to control CSO discharges into the lower Duwamish, Portage Bay and Ship Canal waterways would be constructed between 2028 and 2030.

Under the Integrated Plan Alternative, the City would implement three programs/projects in Seattle neighborhoods to reduce pollution from stormwater runoff in areas that are not part of the combined sewer system, using a combination of stormwater treatment technologies. These programs/projects include:

- Natural Drainage System (NDS) Partnering
- Arterial Street Sweeping Expansion
- South Park Water Quality Facility

Selection of a Preferred Alternative

Foremost in the development of the Plan is the need to comply with the Consent Decree and meet federal and state regulatory requirements. In order to comply with the Consent Decree, the City must select and implement an LTCP option. The option that is selected as the preferred alternative could have smaller elements than those described in the draft LTCP/Integrated Plan. For example, smaller flow diversions could become small storage tanks. However, the major CSO control measure, such as Shared Storage Tanks along the Ship Canal or the Shared Ship Canal Tunnel would not change. An Integrated Plan is an optional approach that is not required, but can be used to satisfy the Consent Decree.

The City will continue to solicit input on the Plan from the public and other stakeholders, during and following the Draft EIS comment period. Identification of a preferred alternative is expected to occur following release of the Final EIS in late 2014.

Timing of Additional Environmental Review

The analysis presented in this EIS is programmatic in nature. The EIS has been prepared to disclose probable significant adverse impacts associated with the Plan to Protect Seattle's Waterways. As individual projects are identified, site-specific environmental review will be conducted prior to implementation. Depending on the preferred alternative and the amount of time needed to obtain regulatory approval of the Plan, some projects and actions would be ready for site-specific environmental review starting in 2016.

Required Approvals or Permits

Because a preferred alternative has not been selected, it is not possible to present a complete list of approvals and permits that would be required for future projects. It is possible to identify the most common types of approvals and permits that would generally be required for the types of projects presented in this document. These approvals and permits are listed below by jurisdictional agency.

- Federal
 - Section 10/404 permit--U.S. Army Corps of Engineers
 - Endangered Species Act consultation--National Marine Fisheries Service and/or U.S. Fish and Wildlife Service
- State
 - National Pollutant Discharge Elimination System (NPDES) construction stormwater general permit--Ecology
 - Section 401 water quality certification--Ecology
 - Shoreline conditional use permit, or variance--Ecology
 - Hydraulic project approval--Washington Department of Fish and Wildlife (WDFW)
 - Section 106 National Historic Preservation Act or Executive Order 05-05 consultation--Department of Archaeology and Historic Preservation
- City
 - Environmentally critical areas approval--Department of Planning and Development (DPD)
 - Master Use Permit--DPD, Seattle City Council, as appropriate
 - Floodplain development permit---DPD
 - Shoreline Management Program permit--DPD
 - Building and related permits--DPD
 - Clearing and grading permit--DPD
 - State Environmental Policy Act (SEPA) compliance--Seattle Public Utilities
 - Initiative 42 approval (park lands conversion)--Seattle City Council
 - Street use permit--Seattle Department of Transportation

Authors and Principal Contributors to this EIS

This Draft EIS has been prepared under the direction of Seattle Public Utilities. The following consulting firms provided research and analysis associated with this EIS:

- **ESA** - lead EIS consultant, document preparing; writing of all EIS sections
- **CH2M Hill** - engineering support
- **Brown and Caldwell** - engineering support
- **Herrera Environmental Consultants** – analysis of water resources
- **Heffron Transportation, Inc.** – transportation analysis
- **PRR** – public outreach

Project Proponent and Lead Agency

City of Seattle
Seattle Public Utilities
700 5th Avenue, Suite 4900
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Seattle, WA 98124-4018

Project Information / Background Data Contact Person

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Long Term Control Plan Manager
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Date of Issuance of this Draft EIS

May 29, 2014

Submit EIS Comments to:

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Seattle Public Utilities
Seattle Municipal Tower, Suite 4900
P.O. Box 34018
Seattle, WA 98124-4018
betty.meyer@seattle.gov

Due Date of Draft EIS Comments

Comments on the Draft EIS are invited and must be postmarked or emailed on or before midnight on June 30, 2014. Comments must be addressed to the SEPA Responsible Official noted above.

Date of Draft EIS Public Hearing

A public meeting on the Plan and a public hearing on the Draft EIS will be held Tuesday, June 24, 2014 starting at 6:00 p.m. at the Lake Washington Rowing Club, 910 N Northlake Way, Seattle, WA. The public hearing will begin at 6:30 p.m.

The purpose of the public hearing is to provide an opportunity for individuals, agencies, and organizations to review information concerning the Draft EIS and to present oral or written comments on the Draft EIS.

Availability of the Draft EIS and Background Materials

The Draft EIS is available for viewing at the following locations:

- Seattle Public Utilities, Director's Office Main Reception Area, Seattle Municipal Tower, Suite 4900, 700 Fifth Avenue, Seattle, Washington
- Seattle Central Library, General Reference Section
- Online at www.seattle.gov/CSO

The Draft EIS can be downloaded for free from the City's website www.seattle.gov/CSO or purchased on CD for \$10 or in paper form for \$170. Purchased copies will be mailed upon receipt of a check made payable to Seattle Public Utilities.

Additional background materials can be viewed on the City's website: www.seattle.gov/CSO.

They may also be viewed in paper form by arranging a time with Ed Mirabella at the number or email listed above.

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CHAPTER 1 Summary.....	1-1
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List of Abbreviations

Term	Definition	Term	Definition
BMP	best management practice	MUTCD	<i>Manual on Uniform Traffic Control Devices</i>
BNSF	Burlington Northern Santa Fe	NIDCD	National Institute on Deafness and Other Communication Disorders
BPA	Bonneville Power Administration	NMFS	National Marine Fisheries Service
CFR	Code of Federal Regulations	NPDES	National Pollutant Discharge Elimination System
City	City of Seattle	PCB	polychlorinated biphenyl
CSO	Combined Sewer Overflow	PHS	Priority Habitat and Species
DAHP	Washington Department of Archaeology and Historic Preservation	The Plan	The Plan to Protect Seattle's Waterways
dB	decibel	PPCPs	pharmaceuticals and personal care products
dBA	decibels on the A-weighted scale	PSCAA	Puget Sound Clean Air Agency
DDE	dichlorodiphenyldichloroethylene	PSE	Puget Sound Energy
DHHS	Department of Health and Human Services	RCW	Revised Code of Washington
DNRP	King County Department of Natural Resources and Parks	RPZ	Restricted Parking Zone
DPD	Seattle Department of Planning and Development	SDOT	Seattle Department of Transportation
DPS	Distinct Population Segment	SEPA	State Environmental Policy Act
Ecology	Washington State Department of Ecology	SMC	Seattle Municipal Code
EIS	Environmental Impact Statement	SODO	South of Downtown neighborhood
EDCs	endocrine-disrupting compounds	SPU	Seattle Public Utilities
EPA	Environmental Protection Agency	SR	State Route
ESU	Evolutionarily Significant Unit	TBM	Tunnel Boring Machine
FHWA	Federal Highway Administration	TMDL	Total Maximum Daily Load
GHG	greenhouse gas	USFWS	U.S. Fish and Wildlife Service
GIS	Geographic Information System	WAC	Washington Administrative Code
I-5	Interstate 5	WDFW	Washington Department of Fish and Wildlife
I-90	Interstate 90	WDNR	Washington Department of Natural Resources
LTCP	Long-Term Control Plan	WNHP	Washington National Heritage Program
LUST	leaking underground storage tank	WSDOT	Washington State Department of Transportation
MG	million gallons		
MGD	million gallons per day		
MG/yr	million gallons per year		
MODA	Multiple Objective Decision Analysis		
MS4	municipal separate storm sewer system		
MTCA	Model Toxics Control Act		

Glossary

Term	Definition
Alternative	There are 3 alternatives for the Plan to Protect Seattle's Waterways: 1. The LTCP Alternative is focused solely on reducing CSOs under an approved Long-term Control Plan (LTCP), 2. The Integrated Plan Alternative includes reduction of both CSOs and stormwater pollution, 3. The No Action Alternative, which provides a baseline for comparison of potential effects of the Plan alternatives, as required by the State Environmental Policy Act (SEPA).
Anadromous Fish	Fish species, such as salmon, which are born in fresh water, spend most of their lives in salt water, and return to fresh water to spawn.
Best Management Practice (BMP)	A method, activity, or procedure for reducing the amount of pollution entering a water body.
Carbon Monoxide	A colorless and odorless toxic gas.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act.
CFS	Flow rate in Cubic Feet per Second.
Code of Federal Regulations (CFR)	A compilation of federal laws.
Combined Sewers	Conveyance systems designed to carry both wastewater and stormwater.
Combined Sewer Overflow(CSO)	During rainfall events, the volume of the stormwater entering a combined sewer system often is far greater than the capacity of the conveyance system and, as a result, the untreated sewage and stormwater mixture empties directly into receiving waters through designated overflow points.
Combined Sewer System (CSS)	The wastewater collection and conveyance system owned or operated by the City, including all pipes, force mains, gravity sewer segments, pump stations, lift stations, interceptors, diversion structures, maintenance holes, and appurtenances thereto, designated to collect and convey municipal sewage, including residential, commercial, and industrial wastewaters, and stormwater, through a single-pipe system to King County's wastewater treatment plants, King County's CSO treatment plants, or to permitted CSO outfalls.

Consent Decree	A written agreement entered in federal court on July 3, 2013, between the City of Seattle, Washington State Department of Ecology, the EPA, and the United States Department of Justice that describes the actions that The City must take to address violations of the Clean Water Act.
Control Status	Whether an outfall meets the Consent Decree's definition of "greatest reasonable reduction" of CSOs; an average of no more than one overflow occurrence per outfall per year determined on a 20 year moving average.
Controlled	The control of a CSO outfall in accordance with WAC 173-245-020(22).
Critical Habitat	Habitat which is essential for the conservation of a threatened or endangered species.
CSO Control Measure	A project, action, or other activity set forth in the City's Long-Term Control Plan or any Supplemental Compliance Plan, provided for in Section V.B. of the Consent Decree, that controls CSO outfall.
CSO Outfall	The water structure from which a CSO is discharged into a receiving water.
CWA	Clean Water Act; passed by Congress in 1972, meant to restore and maintain the integrity of the nation's waters.
Designated Receiving Water	Waters determined by SPU as having sufficient capacity to receive discharges of drainage water such that a site discharging to the designated receiving water is not required to implement flow control. Includes the Duwamish River, Puget Sound, Lake Washington, Lake Union, Elliott Bay, Portage Bay, Union Bay, and the Lake Washington Ship Canal.
Dewatering	The pumping of groundwater from an excavated area so the area to facilitate construction.
DNRP	King County Department of Natural Resources and Parks
Early Action Projects	The Consent Decree mandates that the City shall implement all CSO control measures necessary to reduce discharges from CSO outfalls in the North and South Henderson Areas.
Ecology	The State of Washington Department of Ecology.
Endocrine-Disrupting Compounds	Natural and synthetic compounds that are known to disrupt hormone systems in animals.
Environmental Impact Statement (EIS)	A document that discloses the probable significant adverse environmental impacts of a proposed project or planning, discusses reasonable mitigation of identified impacts, and evaluates alternatives to the project and/or proposal. EISs are required under certain circumstances by the Washington State Environmental Policy Act (SEPA).

Environmental Justice	The fair treatment of people of all races and incomes with respect to actions affecting the environment. Fair treatment implies that there is equity of the distribution of benefits and risks associated with a proposed project and that one group does not suffer disproportionate adverse effects.
Erosion	The wearing away of land surfaces by wind or water. Erosion can be intensified by land clearing processes. Sediment is a product of stream erosion.
Fecal Coliform	A group of bacteria that are passed through the fecal excrement of humans, livestock, and wildlife.
Green (Stormwater) Infrastructure	Systems and practices that use or mimic natural processes to infiltrate, evapotranspire, and/or harvest stormwater on or near the site where it is generated. Green infrastructure may include, but is not limited to, green roofs, downspout disconnection, trees and tree boxes, rain gardens, vegetated swales, pocket wetlands, infiltration planters, vegetated median strips, permeable pavements, reforestation, and protection and enhancement of riparian buffers and floodplains.
Groundwater	Water that infiltrates into the earth and is stored in the soil and rock within the zone of saturation below the earth's surface. Groundwater is created by rain, which soaks into the ground and flows down until it is collected at a point where the ground is not permeable. Groundwater then usually flows laterally toward a river, lake, or ocean. It is often used for supplying wells and springs.
Historic Property	Any building, site, district, structure, or object (that has archeological or cultural significance) included in, or eligible for inclusion in, the National Register.
Impaired Waters	Waters whose beneficial uses are impaired by pollutants.
Launching Portal	A primary portal used to insert a tunnel boring machine for excavation of tunnels. Lining and ventilation operations would also occur at these portals.
Lead	A toxic metal found in the emissions from motor vehicles and industrial sources.
Long Term Control Plan (LTCP)	The Long Term Control Plan under development by the City in accordance with Section V.B. of the CD, as well as any additional remedial measures for eliminating or reducing the City's CSOs included in any Supplemental Compliance Plan developed and implemented in accordance with Section V.B. of the CD.
LTCP Option	An overall CSO Control Strategy which ultimately will resolve all SPU uncontrolled outfalls; the four possible Options are: Neighborhood Storage, Shared Storage, Shared West Ship Canal Tunnel, Shared Ship Canal Tunnel.

Natural Drainage System	A method that uses soil to absorb stormwater and slow the rate that it enters the sewer system. Examples include rain gardens, porous pavement, and cisterns.
Neighborhood	A term used in this EIS to characterize the potential affected areas. (Note: this term is not used in Volume 2, LTCP.)
Nitrogen Dioxide	A highly reactive gas formed from the emissions of motor vehicles, power plants, and off-road equipment. Nitrogen dioxide contributes to ground-level ozone and fine particle pollution and has adverse effects on the respiratory system.
Open Cut	See “trenching”.
Ozone	An atmospheric pollutant created by chemical reactions of other pollutants in the air when exposed to sunlight.
Partially Separated Stormwater System	Street drainage system that routes runoff to separate storm sewers and conveys the remaining drainage in a combined sewer.
Pharmaceuticals and Personal Care Products	Prescription and over-the-counter drugs, illicit drugs, other pharmaceutical substances (diagnostic agents and inert ingredients), and products such as shampoo, soap, fragrances, and lotions.
Pile	A large pole driven into the earth to support a building or other superstructure.
The Plan	The Plan to Protect Seattle’s Waterways, includes 4 Volumes: Executive Summary, Long Term Control Plan, Integrated Plan, and Environmental Impact Statement.
Priority Habitats and Species	The Priority Habitats and Species list is a catalog of habitats and species considered to be priorities for conservation and management. The list is published by the Washington Department of Fish and Wildlife.
Pump Station	A structure that houses pumps and other equipment for lifting stormwater or wastewater in pipes to higher elevations so that it can continue to flow by gravity
Rain Garden	Small vegetated depressions with designed soil mixes that retain runoff for subsequent infiltration or delayed release to the combined sewer system.
Receiving Water	Any body of water which receives CSO and stormwater discharges.
Recovery Portal	A primary portal used to remove tunnel boring machines during construction of tunnels.
Salmonids	The common name for several species of fish of the family Salmonidae. The family includes salmon, trout, and char.
Sensitive Receptors	Noise-sensitive locations including residences, schools, hospitals, and nursing homes.

Shared	A reduction strategy that is implemented by Seattle Public Utilities and King County Department of Natural Resources and Parks (DNRP).
State Environmental Policy Act (SEPA)	A Washington State law (Chapter 43.21C RCW) that requires state agencies and local governments to consider environmental impacts when making decisions regarding certain activities, such as development proposals over a certain size, and comprehensive plans. As part of this process, environmental impacts are documented and opportunities for public comment are provided.
Storm Drain	A system of gutters, pipes, or ditches used to carry stormwater from surrounding lands to streams, lakes, or other receiving water. Also refers to the end of the pipe where the stormwater is discharged.
Storm Sewer	A pipe (separated from sanitary sewers) that carries only stormwater runoff from buildings and land surfaces.
Stormwater Runoff	Stormwater is rain and melting snow that runs off surfaces that cannot readily absorb water, such as streets, rooftops, and parking lots. As stormwater runs across these hard surfaces, it picks up pollutants such as oil, grease, and metals, carrying them through the City's storm drain system to our lakes, streams, rivers, and Puget Sound. It also flows into the combined sewer system and causes overflows of raw sewage and polluted stormwater into Seattle waterways.
Sulfur Dioxide	A highly reactive gas emitted by fossil fuel combustion at power plants and industrial facilities. Sulfur dioxide has adverse effects on the respiratory system.
Superfund Sites	Site designated by the EPA as having uncontrolled hazardous materials. EPA develops plans for a long-term cleanup process for each Superfund site.
Surface Water	Any water, including fresh water and salt water, on the surface of the earth.
Trenching	A method for installing pipe near the surface, also called "open cut." The trenching method consists of three stages: digging a trench and stockpiling excavated materials; installing pipe in the trench; and backfilling the trench and restoring the surface.
Truck Trip	A trip made by a truck hauling materials or workers for construction projects.
Tunneling	Method used for excavating a tunnel within the earth and installing pipes. A tunnel boring machine (TBM) is inserted through a launching portal and retrieved from a recovery portal.

CHAPTER 1

Summary

This summary highlights the major components of the Draft Environmental Impact Statement (EIS) for the **Plan to Protect Seattle's Waterways** (the Plan). It provides an overview of the Plan, discusses the main features of the alternatives, and summarizes the potential adverse impacts and proposed measures for reducing the potential adverse impacts of each Plan alternative.

1.1 What is the Plan to Protect Seattle's Waterways and why is it needed?

Sewers in the City of Seattle carry raw sewage and other wastewater away from neighborhoods for treatment at King County's West Point Treatment Plant before discharge to Puget Sound. When it rains, some of these same sewers also carry untreated stormwater from neighborhood roofs, foundation drains, and some streets. During heavy rains, if the amount of raw sewage and untreated stormwater exceeds the sewer system capacity, the excess flow discharges into local waterways. These "combined sewer overflows," or CSOs, are a public health and environmental concern. In addition, stormwater runoff from streets, parking lots, and buildings contributes a wide range of pollutants to the city's waters.

The objective of this proposal is to adopt a Plan to reduce overflows and the discharge of pollutants from combined sewers and stormwater runoff, in order to protect public health and the environment and to comply with federal and state regulations.

1.2 What Alternatives does this EIS Consider?

The Draft EIS is a programmatic or plan-level evaluation, assessing the broad, comprehensive implications and impacts associated with adoption and implementation of the Plan. Additional project-level evaluations will be conducted in accordance with the City's State Environmental Policy Act (SEPA) ordinance when additional project details are available, and as such this EIS is part of a phased review SEPA process.

The Draft EIS evaluates two Plan alternatives and a No Action Alternative. The two Plan alternatives represent different ways of achieving the objectives of the Plan.

The **LTCP Alternative** is focused solely on reducing CSOs under an approved Long Term Control Plan (LTCP). As a planning-level document, the LTCP presents a comprehensive strategy to reduce the remaining uncontrolled CSO discharges in the city. The City must address these CSOs to protect public health and the environment, and comply with the Clean Water Act and state regulations. The City would implement the projects identified in the LTCP Alternative from 2016 through 2025, to comply with federal requirements, including a federal Consent Decree.

What is the Consent Decree?

The Consent Decree is a written agreement between the City of Seattle, Washington State Department of Ecology, U.S. Environmental Protection Agency, and the U.S. Department of Justice that describes the actions that the City of Seattle must take to address violations of the Clean Water Act.

The **Integrated Plan Alternative** includes reduction of CSOs and stormwater pollution. Stormwater that enters the City's separate stormwater system is a major contributor to surface water quality issues. The objective of the Integrated Plan is to implement stormwater pollution management projects that would provide greater benefits to surface water quality than those provided by the LTCP CSO reduction strategies alone. The Integrated Plan represents a more comprehensive approach to water quality management by integrating stormwater pollution management with CSO reduction strategies.

Previously, the City implemented CSO control measures and stormwater management as separate and distinct programs. Recognizing that polluted runoff has a big impact on surface water quality, the Consent Decree allows the City to prepare a plan that integrates CSO control projects with stormwater control projects. Under the Consent Decree, the City may submit an Integrated Plan that proposes stormwater control projects and defers certain CSO control projects, provided that the stormwater projects will result in significant benefits to surface water quality beyond those that would be achieved by implementation of CSO controls alone, and the CSO control projects deferred would be completed by a specific date after 2028.

The **No Action Alternative** provides a baseline for comparison of potential effects of the Plan alternatives, as required by SEPA. Under the No Action Alternative, progress will be made in controlling CSOs through implementation of previously planned CSO control projects identified in the City's National Pollutant Discharge Elimination System (NPDES) Waste Discharge Permit (WA0031682) and included in the 2010-2015 Implementation Plan for the *2010 CSO Reduction Plan Amendment* (2010 Plan Amendment). These projects are currently funded and are scheduled for implementation, and they will occur regardless of whether the Plan is implemented.

The City would also continue to implement a portion of two of its CSO reduction strategies, combined sewer system improvements and Natural Drainage Systems (called 'Green Infrastructure' in the LTCP). However, the City would not implement any additional CSO reduction or stormwater control projects beyond those that are currently funded and slated for implementation. Under the No Action Alternative, untreated sewage and stormwater in excess of current regulations would continue to discharge into Lake Washington, the Lake Washington Ship Canal (Ship Canal), the Duwamish River, and Puget Sound when the capacity of the existing systems is exceeded. Under the No Action Alternative, the City would not be in compliance with the Consent Decree.

1.3 What is included in the LTCP Alternative?

The LTCP Alternative uses a combination of traditional storage facilities and sewer system improvements to reduce CSOs in 11 CSO areas throughout Seattle. For the purpose of this EIS, CSO areas within the City's service area have been grouped into what are referred to as "neighborhoods". In *Volume 2, LTCP* these are referred to as CSO areas only. Figure 1-1 illustrates the neighborhoods relative to designated CSO areas and outfalls. The LTCP also explores opportunities to partner with King County on collaborative projects to control both agencies' CSOs. These Plan area neighborhoods include:

- **Ship Canal Neighborhoods**—Ballard, Fremont/Wallingford, Magnolia;
- **Lake Washington Neighborhoods**—North Union Bay, Portage Bay, Montlake, and Leschi
- **Longfellow Creek/Duwamish Neighborhoods**—Delridge, Duwamish, and East Waterway; and
- **Elliott Bay/Lake Union Neighborhoods**—Central Waterfront part.

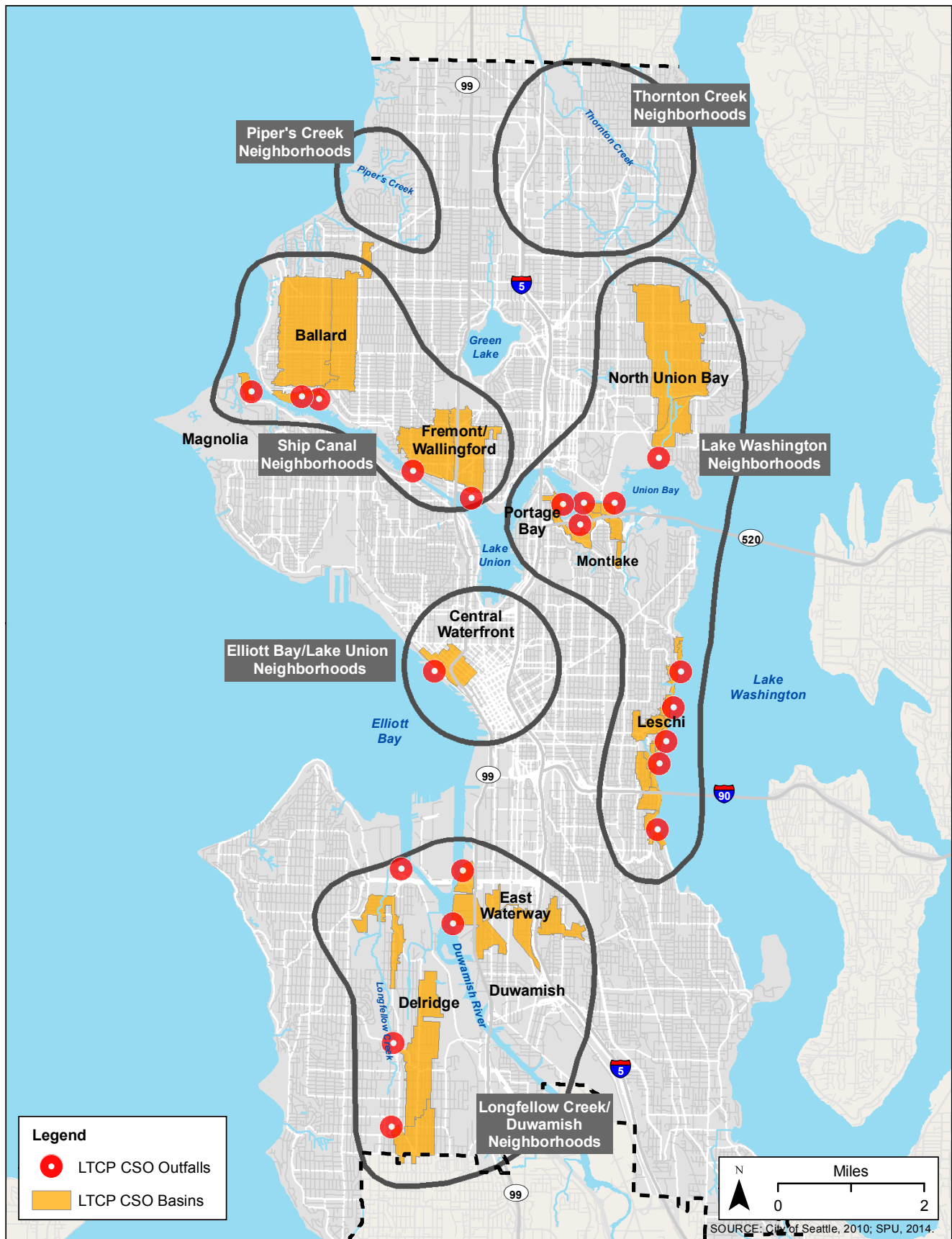


Figure 1-1 Plan Area Neighborhoods.

1.4 What are the options for implementing the LTCP Alternative?

There are four potential combinations of storage facilities, referred to as “options,” that could meet U.S. Environmental Protection Agency (EPA) requirements for an LTCP that are evaluated in this EIS. These options were developed under one of two basic concepts; the City meets its Consent Decree-mandated control requirements through implementation of independent (City only) control projects, or the City participates in one or more shared projects with King County to take advantage of potential cost/impact reduction opportunities. These options vary in terms of the number, size, and potential location of storage facilities considered.

- Neighborhood Storage Option (City only implementation)
 - Neighborhood Tanks/Pipes
 - Neighborhood West Ship Canal Tunnel
- Shared Storage Option (Shared City/King County implementation)
- Shared West Ship Canal Tunnel Option (Shared City/King County implementation)
- Shared Ship Canal Tunnel Option (Shared City/King County implementation)

Under the **Neighborhood Storage Option**, the City would build underground storage facilities in Ballard, Fremont/Wallingford, Magnolia, Portage Bay, Montlake, Leschi, Central Waterfront, Duwamish, Delridge, and East Waterway CSO areas, and sewer system improvements in the North Union Bay CSO area. This option involves building the largest number of storage facilities throughout the city.

There are two variations in the Neighborhood Storage Option: one would provide storage in tanks/pipes only, and the other would include a tunnel (Neighborhood West Ship Canal Tunnel) in combination with tanks and pipes. The storage tank/pipe option involves the greatest number of affected locations. The Neighborhood West Ship Canal Tunnel Option was developed because the two CSO areas with the largest storage volumes (Ballard and Fremont/Wallingford) are relatively close to one another. The Neighborhood West Ship Canal Tunnel Option likely reduces the number of facilities and neighborhood impacts.

Implementation of the North Union Bay sewer system improvements will require City coordination with King County because additional flows will be transferred to the King County system. Specifically, the City and King County will need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.

Under the **Shared Storage Option**, the City and King County would jointly build larger but fewer storage tanks in three CSO areas: Fremont/Wallingford/King County 3rd Avenue West CSO; North Union Bay/King County University Regulator CSO; and Montlake/Leschi/King County Montlake Regulator. These three shared storage projects were recommended in the approved 2012 King County CSO plan. In the Duwamish CSO area, the City would divert flows to a treatment facility proposed by King County. All other CSO areas would have the same storage facilities as proposed under the Neighborhood Storage Option.

Prior to implementing any shared projects between the City and King County, a shared project agreement would need to be signed between the two agencies. Specifically, the City and King County would need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.

The **Shared West Ship Canal Tunnel Option** combines three of the largest CSO areas into a single deep tunnel. The West Ship Canal Tunnel is proposed as a shared option because the three CSO areas (two from the City and one from King County) with the largest control volumes are relatively close to one another. The tunnel would

extend from Fremont/Wallingford to Ballard and would provide the storage needed to address sewage overflows in Ballard, Fremont/Wallingford, and King County's 3rd Avenue West CSO basins. The tunnel would eliminate the need for a separate King County CSO project at an outfall near 3rd Avenue West.

Prior to implementing any shared projects between the City and King County, a shared project agreement would need to be signed between the two agencies as noted above.

Within this option, the remaining CSO areas would be controlled by their respective neighborhood control measures except for Magnolia and East Waterway where flow diversions to King County's system are proposed. Any City flow diversion projects would require coordination with King County. Specifically, the City and King County would need to analyze the impacts of the proposed flow diversion projects on the downstream system and agree on an approach to address those impacts.

The **Shared Ship Canal Tunnel Option** combines the control volumes from six City CSO areas along the Ship Canal and Lake Washington, and three of the largest King County CSO areas along the Ship Canal in a deep tunnel extending from the University District to Fremont/Wallingford. The tunnel would provide the storage needed to address sewage overflows in the City's CSO areas of Ballard, Fremont/Wallingford, Portage Bay, Montlake, North Union Bay, and Leschi. The tunnel would also eliminate the need for three separate King County CSO projects at outfalls near Pacific Street (University Regulator), Montlake Avenue (Montlake Regulator), and 3rd Avenue West.

The remaining City CSO areas (Magnolia, Duwamish, East Waterway, and the northernmost Delridge CSO basin) would be diverted to King County under the assumption that flow diversions could be incorporated into mutual interagency agreements. The Central Waterfront and the southern Delridge CSO neighborhoods would continue to be served by their respective neighborhood control measures.

Prior to implementing any shared projects between the City and King County, a shared project agreement would need to be signed between the two agencies. Specifically, the City and King County would need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.

Table 1-1 illustrates the total number of CSO storage facilities that would be constructed under the four LTCP options, either by City-only, King County-only, or as shared facilities. As shown in the table, the opportunity to construct shared facilities reduces the total number of facilities constructed by both the City and King County and reduces impacts to the neighborhoods slated for several major storage facilities. More detailed information can be found in *Volume 2, LTCP*.

Table 1-1. CSO Storage Facilities Constructed under LTCP Options

	Neighborhood Storage		Shared West Ship Canal Tunnel	Shared Ship Canal Tunnel	Shared Storage
	Neighborhood Tanks/Pipes	Neighborhood West Ship Canal Tunnel			
City-only CSO Facilities	18	16	14	3	9
King County-only CSO Facilities	9	9	8	6	6
Shared Facilities			1	1	3
TOTAL	27	25	23	10	18

1.5 How will the City and King County coordinate on CSO projects?

The City recognizes the importance of strong coordination with King County in controlling CSOs in the City. All of the proposed LTCP options have elements which may have an impact on King County's downstream wastewater system. Three of the proposed LTCP options include shared City/King County projects along the Ship Canal. Several of the proposed LTCP options include sewer system improvements which will convey additional wastewater volume to the downstream King County system. Regardless of which LTCP option is selected, coordination between the City and King County is critical to successfully designing, constructing, and eventually operating the proposed CSO control projects in the City.

The City and King County are continuing to work together closely to analyze and recommend LTCP options that are more cost-effective, produce better environmental outcomes, and minimize disruption to communities. King County must also reach its own independent conclusions about the benefits of a shared project to the regional system, and the implications of such as project to its own Long Term Control Plan and Consent Decree. Selection of a shared City/King County project will be dependent on the City's and County's analytical results as well as a number of joint factors mutually agreed upon in a City/County Coordination Plan. These factors include such things as which agency will be responsible for the design/construction/operations of the shared facility, each agency's project cost-share, operational and implementation roles and responsibilities, the process for dispute resolution, and the ability to fulfil regulatory and contractual obligations. If the City and King County choose to implement a shared City/King County project, then a shared project agreement between the two agencies will be necessary prior to designing and constructing the project. In addition, the City and King County will analyze the impacts of any recommended project on the downstream King County system and agree on an approach to addressing those impacts prior to constructing the project.

1.6 What is included in the Integrated Plan Alternative?

Under the Integrated Plan Alternative, the City would implement three stormwater control programs/projects in Seattle neighborhoods to address stormwater runoff in areas that are not part of the combined sewer system, using a combination of stormwater treatment technologies. These programs/projects include:

- Natural Drainage System (NDS) Partnering
- Arterial Street Sweeping Expansion
- South Park Water Quality Facility

These three programs/projects would collectively reduce the volume of polluted stormwater runoff discharging into the following waterways: Duwamish Waterway, Lake Washington, Piper's Creek, Thornton Creek, Longfellow Creek, and Lake Union/Ship Canal. The City is focusing stormwater control projects in these areas to meet the Integrated Plan objectives established by the Consent Decree.

Under the Integrated Plan Alternative, the City would still build CSO reduction projects using one of the four LTCP options outlined above. However, the City would delay the completion of some of the CSO control projects until 2030, while high-benefit stormwater treatment technology projects would be completed prior to 2025. Six CSO projects to control discharges into the lower Duwamish, Portage Bay and Ship Canal waterways would be constructed between 2028 and 2030.

The stormwater control programs/projects are summarized below.

1.6.1 NDS Partnering

Natural Drainage System (NDS) Partnering, a flow control and stormwater treatment best management practice (BMP), involves using natural drainage systems, such as engineered rain gardens within various basins that drain to Piper's, Thornton, and Longfellow Creeks. Piper's Creek ultimately discharges to Puget Sound; Thornton Creek discharges to Lake Washington; and Longfellow Creek discharges to the Duwamish River and then into Puget Sound.

Projects implemented under this program would involve reconstructing City rights-of-way to manage flow and provide water quality treatment for polluted urban runoff, primarily using bioretention facilities such as engineered rain gardens. Project locations would be identified by site factors and a community-nomination process. Projects would be designed to infiltrate into native soil where appropriate. Where complete reliance on infiltration is not technically feasible, systems would be augmented with underdrains.

Project locations would be prioritized based on stormwater management goals; however, community partnering goals (mobility, traffic calming, and beautification) would also be accomplished as a secondary benefit. As a first step to NDS Partnering, the City would develop a program for encouraging residents or community groups to nominate their block(s) as a candidate for NDS. Candidate blocks must be among the blocks identified by the City as potentially feasible for bioretention; the majority of these blocks are part of informal drainage systems (i.e., lacking curbs and gutters). If the Integrated Plan Alternative is selected, NDS Partnering would be implemented in six phases during 2020-2025.

1.6.2 Arterial Street Sweeping Expansion (Weekly Arterial Sweeping)

Street sweeping, a source control BMP, removes pollutants from roadways before they wash off into sewers and local waterways.

The City would expand its existing arterial street sweeping programs by adding new routes, increasing the frequency of sweeps, and employing new technologies. The arterial sweeping project would be expandable and adaptable to meet future needs. The proposed arterial street sweeping expansion has several benefits:

- Targets removal of pollutants from roadways, the City's stormwater management highest priority.
- Prevents a significant amount of solids/sediment and associated contaminants from reaching receiving waters, thereby improving receiving water quality and substrate conditions.
- Can be more cost-effective than removing pollutants after they have entered the drainage system.
- Provides reduced clogging of stormwater collection and conveyance systems, improved aesthetics, and improved air quality.

The proposed program expansion would:

- Increase the route coverage from 83 to approximately 85 percent of curbed arterials (for a total 10,600 annual curb-miles), by adding one route, for a total of 25 routes.
- Increase the sweeping season from 40 to 48 weeks per year.
- Increase the sweeping frequency from biweekly to weekly for some routes: 21 routes will be swept on a weekly basis and four routes will be swept on a biweekly basis.

Because most existing development and roadways in the city were constructed before stormwater controls were required, runoff from many areas discharges directly to receiving waters without treatment. Retrofitting these existing systems to improve stormwater quality is often difficult and in many cases, retrofitting is not feasible due to physical site constraints (e.g., utility conflicts, grade restrictions, and tidal influence). Street sweeping can provide effective pollutant load reductions in area where retrofitting is impractical. If the Integrated Plan Alternative is selected, the expanded arterial sweeping program would begin in 2016.

1.6.3 South Park Water Quality Facility

The South Park Water Quality Facility would treat stormwater prior to discharge into the Duwamish Waterway. The end-of-pipe facility would treat approximately 89 million gallons (MG) of stormwater runoff from the 7th Avenue S drainage system, which encompasses approximately 250 acres. The City identified the South Park location as a high priority for stormwater pollutant reduction because of the sensitivity of the Duwamish Waterway. The facility would be built in the same location as a new stormwater pump station the City plans to build to reduce flooding in this same area, creating an opportunity to leverage water quality and flood control projects.

Stormwater would be routed through a basic, active treatment system, such as chitosan-enhanced sand filtration (CESF), prior to discharge to the Lower Duwamish Waterway through an existing outfall.

1.7 What are the potential construction impacts?

Table 1-2 summarizes the identified potential construction impacts, as well as measures that the City would take to help reduce or minimize potential impacts associated with the LTCP, Integrated Plan, and No Action Alternatives. Those components that do not involve construction, such as street sweeping, are not included in the discussion.

The LTCP options include projects that would be implemented by the City independently, as well as projects that would be shared with King County. In addition to these options, King County is considering projects that would be implemented independently from the City. This EIS identifies those independent King County projects, but does not analyze them. As described in Section 1.10, constructing independent King County projects would add to overall cumulative impacts associated with the LTCP and Integrated Plan Alternatives.

This EIS programmatically addresses the impacts from independent City and shared City/King County projects. King County will address its independent projects separately, in accordance with its SEPA requirements. All projects implemented by both the City and King County will receive the appropriate project-level evaluation under SEPA.

1.8 What are the potential long term effects?

Table 1-3 summarizes the identified potential long term, operational impacts associated with the LTCP, Integrated Plan, and No Action Alternatives, as well as measures that the City would take to help reduce or minimize potential impacts. As described above, this EIS addresses the impacts from City projects constructed independently or jointly with King County. Independent King County projects will be addressed by the County, in accordance with their SEPA requirements.

1.9 Are there significant impacts that cannot be mitigated?

Implementation of the Plan would involve a wide range of short term impacts associated with the construction of numerous large infrastructure projects. Depending upon the size, location, and type of project, these impacts would include potentially substantial traffic impacts, including temporary road closures and traffic detours. Other construction-related impacts of potential significance include increases in noise and dust that could last from approximately one to seven years and potential disruptions of access to business, residential, or recreational facilities. These impacts, however, are expected to be reduced by compliance with all applicable regulations and permit requirements and as such would not be considered significant impacts under SEPA.

There are no significant long term or operational impacts associated with implementation of the Plan alternatives that cannot be mitigated. Implementation of the No Action Alternative would result in potentially significant long term adverse impacts to water quality and aquatic habitat in the Plan area. Non-compliance with the Consent Decree would be a result of this alternative.

1.10 Are there areas of controversy?

As with all major infrastructure projects, there are difficult decisions associated with implementation of the Plan. Compliance with the federal Consent Decree (between the City, U.S. Department of Justice, EPA, and Ecology) will require a significant commitment of funding to construct major water quality control projects and programs.

There may be concern that the commitment of funding for these projects would limit the City's ability to fund other water and non-water quality projects. The Consent Decree includes a date of 2025 for completion of the LTCP, which limits the City's flexibility in compliance with this legal requirement. However, there are likely to be questions from stakeholders about the LTCP and the Integrated Plan regarding prioritization of projects, tradeoffs, and coordination with other CSO and/or water quality managers in the region, particularly King County. The timing of project implementation is a potential concern, and a wide range of viewpoints can be expected. Deferral of six CSO control projects in the Duwamish, Portage Bay, and Ship Canal waterways may be controversial with some stakeholders.

Construction of storage projects in a highly developed city where limited undeveloped land is available will result in difficult siting decisions that could require short term or permanent impacts to existing land uses, including the potential for impacts to parks or recreational facilities, private properties, or community facilities. Construction-related traffic impacts will be of considerable concern to affected residents, business owners, travelers, and commuters. Depending upon the alternative implemented, some neighborhoods that have been the locations for previous major construction projects would experience construction-related impacts. The City will follow its policies regarding the siting of underground storage facilities, which gives preference for City-owned or other public property and rights of way, but there will likely be controversy as individual sites are identified.

1.11 How do cumulative impacts compare among the alternatives?

Cumulative impacts are those that could result from the combination of individual effects of multiple actions (projects) over time. Plan elements could be constructed in areas that may have recently been subject to large-scale construction projects or will be subject to construction of future planned projects. In addition, there is a potential for construction under the Plan implementation to coincide with the construction of other projects.

Other projects that could occur in the same neighborhoods or coincide with implementation of the LTCP include CSO control projects being constructed by the City and King County. King County's 2012 CSO Control Plan identifies several CSO control projects that would be located within LTCP neighborhoods, including one each in the North Union Bay, Montlake, and Fremont/Wallingford neighborhoods and five in the Longfellow Creek/Duwamish Neighborhoods. Other major construction projects that could be under construction simultaneously with LTCP CSO control projects include the Sound Transit U-Link Extension (to be completed in 2016), Lynnwood Link Extension (construction in 2018-2023), East Link Extension (construction in 2015-2021), Waterfront Project (Elliott Bay Seawall and Waterfront Seattle Core projects), the Alaskan Way Viaduct Replacement Project, WSDOT's SR-509 and SR-167 project, Colman Ferry Dock Replacement, Denny Way Substation and other new or expanded Seattle City Light substations throughout the City, City of Seattle capital projects, and roadway and transit improvements. These projects, in addition to numerous large-scale private developments located throughout the Plan area, will likely result in cumulative impacts to traffic, noise and dust that will present inconveniences and varying levels of annoyance to the local population.

In terms of the LTCP options, the **Neighborhood Storage Option** has the potential for construction-related cumulative impacts that would affect the broadest area, because it involves construction of the largest number of storage tanks and storage pipes in neighborhoods throughout the city. While many of these projects would be constructed within public rights-of-way, there would be construction-related traffic, road closures and/or traffic constraints, dust, odor, and other short term impacts that would last between one and five years. Many of these neighborhoods have been the location of major construction projects such as the SR 520 bridge, major roadway renovations, and large scale residential/commercial building, creating a high level of "construction fatigue". In addition to the projects constructed by the City, King County would construct additional storage tanks and storage

pipes in the Fremont/Wallingford, Montlake, and North Union Bay neighborhoods, adding to the construction-related impacts in those neighborhoods, including potential impacts to earth, air, noise, surface water, biological resources, land use, and transportation. This option would result in the highest potential for cumulative impacts resulting from construction of City and King County CSO projects.

The **Shared Storage Option** would affect fewer neighborhoods than the Neighborhood Storage Option because certain CSO control projects would be shared by the City and King County. The potential for cumulative impacts would be the same as under the Neighborhood Storage Option for the Longfellow Creek/Duwamish and Elliott Bay/Lake Union neighborhoods, but would be lower for the Fremont/Wallingford and Lake Washington neighborhoods because of the overall lower number of projects between the City and King County in those neighborhoods.

The **Shared West Ship Canal Tunnel Option** would have a potential for cumulative impacts similar to the Neighborhood Storage and Shared Storage Options. It would reduce impacts to the Ballard and Fremont/Wallingford neighborhoods associated with construction of storage tanks, but it would create longer duration and potentially more intense impacts (3.5 years or more) at the tunnel launch portal, which would likely be located along the Ship Canal in Ballard, and the recovery portal, which would likely be located in the Fremont/Wallingford neighborhood. Replacing storage tanks and pipes in the East Waterway and Magnolia neighborhoods with lower construction impact flow diversions would reduce the potential for cumulative impacts in these neighborhoods. As under the Neighborhood Storage Option, both the City and King County would be pursuing multiple storage projects in the Longfellow Creek/Duwamish neighborhoods.

The **Shared Ship Canal Tunnel Option** would have the lowest potential for construction-related cumulative impacts in terms of neighborhoods affected, because it would substantially reduce the number of storage facilities located throughout the city constructed by the City and King County. However, impacts would be concentrated for up to seven years at the portals. The tunnel launch portal would likely be located on the south side of the Ship Canal and the recovery portal would likely be located in the North Union Bay neighborhood. These neighborhoods have had, or will have, several large-scale projects constructed in recent years, including the renovation of Husky Stadium, Sound Transit U-Link Extension, and the SR 520 project, and have expressed concerns about additional large scale construction in their neighborhoods.

Implementing the **Integrated Plan Alternative** would not represent a substantive increase in cumulative impacts. The expansion of street sweeping on City arterials would not affect overnight parking and NDS Partnering would have minimal short-term construction-related and long-term impacts. Construction of the South Park Water Quality Facility would not result in extensive construction-related impacts. The facility is expected to be sited in an area with compatible land use, with a low potential to cause long term changes in use. Under the Integrated Plan Alternative, construction of LTCP projects would be delayed in some neighborhoods, potentially resulting in reduced or increased cumulative impacts depending on the neighborhood and project schedules.

The City would coordinate construction sequencing with other major planned projects to minimize the potential for cumulative impacts, but it is likely that some level of cumulative impact is unavoidable. Given the number of proposed projects throughout the City, it will be difficult to avoid overlapping with other construction projects in some areas. Close coordination with King County will be particularly key for all options to coordinate construction schedules. In addition, it will be important to coordinate with Seattle Department of Transportation (SDOT), Washington Department of Transportation (WSDOT), and other major utilities in the area.

Impacts of independent King County CSO control projects will be evaluated separately by King County in accordance with their SEPA requirements.

Tables 1-2 and 1-3, respectively summarize the construction and operation impacts associated with the LTCP, Integrated Plan, and No Action Alternatives. Impacts are described for City projects or projects shared by the City and King County; King County will evaluate impacts associated with their proposed facility in accordance with SEPA, as appropriate.

Table 1-2. Summary of Construction Impacts

Earth		
Long Term Control Plan Alternative	Key Findings	Construction activities and equipment have the potential to cause temporary impacts to earth and groundwater during construction of major projects involving substantial excavation, trenching, or tunneling and removal of large quantities of soil. Any areas that are disturbed during construction would be subject to increased erosion, and control measures would be required. Ground settlement from dewatering could cause settlement of nearby structures, roadways, and utilities. Vibration associated with tunneling operations could result in soil settlement along tunneling alignments. The primary differences in potential effects of the LTCP options are related to the amount of surface disturbance and excavation potentially required.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> Overall, this option has the second highest amount of surface disturbance for construction. Any areas that are disturbed during construction would be subject to increased erosion, and control measures would be required. Storage tanks constructed in the Ballard, Fremont/Wallingford, and East Waterway neighborhoods would require the most surface disturbance. Construction of storage pipes in the Leschi and Delridge neighborhoods have the potential to occur near steep slopes and known or potential landslide-prone areas. Projects near these zones would be at heightened risk for erosion and slope instability Ground settlement from dewatering could cause settlement of nearby structures, roadways, and utilities. Most projects would require significant dewatering. Impacts would be most dispersed under this option, which would result in the highest number of storage facilities constructed independently by the City. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)
	Shared Storage Option	This option would have the highest amount of surface disturbance for construction and second highest amount of excavation. However, the shared tanks would reduce the number of City and King County independently constructed CSO control facilities. Impacts would be similar to the Neighborhood Storage Option but would be concentrated in fewer locations. Larger shared storage facilities in Fremont/Wallingford, North Union Bay, and Montlake would require greater amounts of excavation and soil disposal. Construction of the shared storage tank in North Union Bay has increased potential to encounter organic or liquefiable soils, and dewatering has the potential to encounter contaminated groundwater or result in settlement of nearby structures due to the presence of historic landfill deposits and natural organic deposits.
	Shared West Ship Canal Tunnel Option	Construction of tunnel portals and movement of the tunnel boring machine could result in vibration and settling. The location of the portals and tunnel near liquefiable soils in Fremont and Ballard could result in soil settling. Geotechnical exploration and testing would be conducted during future project design to identify potential hazards along the tunnel alignment. Impacts from projects in the Lake Washington, Longfellow Creek/Duwamish, and Elliott Bay Neighborhoods would be similar to the Neighborhood Storage Option. Overall impacts would be reduced under this option compared to the Neighborhood Storage Option because the shared tunnel would reduce the number of City and King County independently constructed CSO control facilities.

Table 1-2. Summary of Construction Impacts

	Shared Ship Canal Tunnel Option	This option would have the highest amount of excavation and earthwork. The longer tunnel would require additional geotechnical exploration and testing during future project design, and has a greater potential to encounter earth hazards and to result in vibration and settling than the Shared West Ship Canal Tunnel because of its greater length. Impacts from projects in the Longfellow Creek/Duwamish and Elliott Bay Neighborhoods would be similar to the Neighborhood Storage Option. The geographic extent of impacts would be reduced the most under this option because the shared tunnel would result in the fewest number of City and King County independently constructed CSO control facilities.
Integrated Plan Alternative		Construction of storage pipes, tanks, and tunnels under the Integrated Plan Alternative would have the same impacts as under the LTCP Alternative, but construction would be delayed in some neighborhoods. In addition, minor construction-related impacts associated with construction of the South Park Water Quality Facility and its proximity to the Duwamish River would be a potential concern during construction. Depending on the specific site location, the soils at the site location may be susceptible to liquefaction and compaction. The City would take appropriate engineering measures to account for these hazards. Street sweeping does not involve construction, and would therefore not result in any short-term impacts. Impacts associated with NDS Partnering would be localized and of short duration, with limited footprint and depth. Individual NDS Partnering projects would be evaluated with respect to geological hazards, would be relatively small in size, and would be conducted with appropriate erosion control measures in place.
No Action Alternative		Projects constructed under ongoing sewer system improvement and NDS programs would generally have a limited footprint and depth, and are unlikely to result in substantial erosion or dewatering. Impacts associated with storage facilities associated with currently planned projects are evaluated in their respective site-specific SEPA evaluations.
Measures to reduce or minimize potential impacts		The City would: • Avoid construction on steep slopes, known and potential landslide zones, and areas with organic or liquefiable soils, where feasible. • Use appropriate shoring during construction. • Use erosion and runoff control measures, including retention of vegetation, replanting, ground cover, etc. • Comply with relevant federal, state, and local critical areas and groundwater requirements. • Dispose of soils at approved disposal sites. • Monitor settlement during dewatering and tunnel construction as appropriate.

Table 1-2. Summary of Construction Impacts

Air Quality		
Long Term Control Plan Alternative	Key Findings	Construction would not have a significant effect on air quality in the Seattle area, but may result in moderate localized impacts during the construction periods, largely related to vehicle emissions and dust. The primary differences in potential air quality and odor effects of the LTCP options are related to the length of construction period and estimated number of truck trips.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> This option has the most individual project locations. As a result, this option would have dispersed short term construction-related air and odor impacts in numerous neighborhoods throughout the city, with impacts likely to be most noticeable in residential areas. Storage tank construction in the largely residential Ballard and Fremont/Wallingford neighborhoods could last up to five years (Ballard) and 3.5 years (Fremont/Wallingford). Multiple storage pipes/tanks would be constructed in residential areas of Leschi. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)
	Shared Storage Option	Air quality impacts would occur at fewer sites than under the Neighborhood Storage Option. However, construction-related air quality impacts (largely vehicle emissions and dust) would occur for longer construction durations at the shared storage facility locations in Fremont/Wallingford, North Union Bay, and Montlake. Overall impacts would be reduced under this option because the shared tanks reduce the number of City and King County independently constructed CSO control facilities.
	Shared West Ship Canal Tunnel Option	Construction-related air quality impacts would occur at fewer sites than under the Neighborhood Storage and Shared Storage Options. However, impacts would be concentrated in fewer areas (Ship Canal Neighborhoods). Construction of the tunnel would require a substantially higher number of truck trips and associated emissions than storage facilities in Ballard and Fremont/Wallingford, resulting in more concentrated and longer duration impacts in these neighborhoods. Overall impacts would be reduced under this option because the shared tunnel would reduce the number of City and King County independently constructed CSO control facilities.
	Shared Ship Canal Tunnel Option	Compared to all other options, the Ship Canal Tunnel Option would have the fewest City and King County independently constructed CSO storage facilities, and therefore the fewest areas that would experience air quality and odor impacts. Construction of the tunnel would require a substantially higher number of truck trips and associated emissions in Ballard, Fremont/Wallingford, and the Lake Washington neighborhoods than would occur for storage facilities, resulting in the potential for noticeable impacts in these areas for several years.
Integrated Plan Alternative		Construction of CSO storage pipes, tanks, and tunnels under the Integrated Plan Alternative would have the same air emissions as under the LTCP Alternative, but construction would be delayed in some neighborhoods. The South Park Water Quality Facility would involve a small construction footprint, which would result in short-term, localized emissions. The facility would be located in an industrial area and any air emissions would not impact residential properties or other sensitive receptors. Temporary air quality and odor emissions associated with NDS Partnering projects would also be minor.

Table 1-2. Summary of Construction Impacts

No Action Alternative		Construction activity associated with ongoing sewer system improvements and NDS projects would produce dust and exhaust emissions that would be minimal, localized, and temporary.
Measures to reduce or minimize potential impacts		Mitigation measures would include: - Using measures to control dust, such as watering of construction surfaces, using temporary ground covers, sprinkling the site with approved dust palliatives, or using other temporary stabilization practices upon completion of grading. - Incorporating specifications into construction contracts that encourage use of well maintained construction vehicles to reduce vehicle emissions. - Encouraging contractors to offer carpooling options for employees. - When possible, using local building materials to reduce transport distances.
Surface Water		
Long Term Control Plan Alternative	Key Findings	Construction effects on surface water could include increased pollutants and sediments from site runoff and would require control measures. Construction of pipes, tanks, and portals could occur in proximity of sensitive receiving water bodies, including Lake Washington, the Ship Canal, and the Duwamish River. Discharges of dewatering water could introduce contaminants and sediments into local water bodies if not properly managed. The primary differences in potential effects of the LTCP options are related to the amount of surface disturbance and the amount of excavation potentially required.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> Construction effects on surface water could include increased pollutants and sediments from site runoff and would require control measures. Short term construction-related impacts to Salmon Bay, the Ship Canal, Portage Bay, North Union Bay, Lake Union, Lake Washington, the Duwamish River/East Waterway, and Elliott Bay could occur if site runoff controls do not function effectively. Overall, construction related impacts are expected to be minor because all construction will comply with applicable regulations and permit conditions. Discharges of dewatering water could introduce contaminants and sediments into local water bodies if not properly managed. The highest risk from dewatering is likely to be associated with the Ballard and Fremont/Wallingford storage tanks, because the larger facilities require deeper excavations, which could be more likely to encounter groundwater. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)
	Shared Storage Option	Impacts would be similar to the Neighborhood Storage Option but would occur in fewer locations in the Ship Canal and Lake Washington neighborhoods. This option reduces the overall number of facilities, but results in larger facilities with a greater potential for site runoff and dewatering impacts because of longer duration of construction and larger construction sites.
	Shared West Ship Canal Tunnel Option	This option involves construction of a deep tunnel shared with King County. Deep tunnels have less surface disruption than storage tanks and pipes, but would likely have dewatering impacts. The shared tunnel would eliminate impacts associated with construction of the City's proposed Ballard and Fremont/Wallingford facilities, as well as King County's 3rd Ave W regulator. Portal locations would be the focal point for potential surface water runoff impacts. These locations are not yet known but could include areas near Portage Bay and

Table 1-2. Summary of Construction Impacts

		Salmon Bay.
	Shared Ship Canal Tunnel Option	The shared tunnel would eliminate impacts associated with construction of the City's proposed Ballard, Fremont/Wallingford, Portage Bay, Montlake, and Leschi facilities, as well as King County's 3rd Ave W, Montlake, and University Regulators. Portal locations would be the focal point for potential surface water runoff impacts because of the duration of construction and larger construction area. While portal locations have not been determined, areas near the shorelines of Portage Bay, Union Bay, and Salmon Bay could be affected.
Integrated Plan Alternative		In addition to the impacts described for the LTCP Alternative, construction of the South Park Water Quality Facility could include increased potential for runoff into the Duwamish River and would require construction control measures. As noted above, the potential for impacts is low because the projects would comply with applicable regulations and permit conditions.
No Action Alternative		Construction activity associated with ongoing sewer system improvements and NDS projects is not expected to result in surface water impacts due to the limited construction areas.
Measures to reduce or minimize potential impacts		Compliance with the requirements of the Construction Stormwater General Permit issued by Ecology and the City of Seattle's stormwater code and manual would minimize potential surface water runoff and sedimentation. Dewatering impacts would be minimized by compliance with the King County Wastewater Discharge Permit requirements. Additional measures to minimize surface water runoff, dewatering, and spills include the following: • Limiting the area of construction disturbances. • Implementing stormwater best management practices identified in the City of Seattle's Stormwater Code (SMC 22.800 – 22.808), Director's Rule: 2009-004 SPU/16-2009 DPD, and Volume 2 Construction Stormwater Control Technical Requirements Manual to control erosion and sediment transport from the project sites. Typical measures include silt fencing, plastic sheeting, and straw wattles to prevent sediment discharge and wheel washing stations to prevent sediment from entering nearby roadways. • Providing water quality treatment as necessary to improve the quality of intercepted stormwater flows from adjacent impervious surfaces. • Developing and implementing a Construction Stormwater and Erosion Control Plan, including a Stormwater Pollution Prevention Plan and Spill Prevention and Countermeasures Plan, to reduce the potential for sediment, waste materials, construction-related leaks, and spills to contaminate surface water, groundwater, and stormwater runoff.

Table 1-2. Summary of Construction Impacts

Biological Resources		
Long Term Control Plan Alternative	Key Findings	No direct impacts to aquatic habitats, plants, and invertebrates would occur, and no indirect impacts to fish, including federally listed salmonids, are anticipated because no in-water construction would occur, or work within sensitive or critical aquatic habitats. The potential for direct losses of terrestrial habitat associated with facility construction would be minimal under both Plan alternatives, because the facilities are likely to be located in developed areas with low habitat value. Indirect impacts to wildlife would be associated with increased level of noise and human activity during construction. The primary differences in potential effects of the LTCP options are related to amount of construction activity (surface disturbance) and proximity to mapped priority habitats or species.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> CSO control projects would be constructed in urbanized areas. The potential for direct losses of terrestrial habitat associated with facility construction would be minimal. Indirect impacts to wildlife would be associated with increased level of noise and human activity during construction. Construction would occur in areas adjacent to mapped priority habitats in the Magnolia, Leschi, and Delridge neighborhoods. The total amount of surface disturbance and potential for direct impacts to habitat is second highest of all the storage options. This storage option has the most individual project locations compared to the other options, dispersed through a number of neighborhoods. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)
	Shared Storage Option	The total amount of surface disturbance that would occur is the highest of all options, which suggests a higher potential for habitat impacts. However, this option has the second to least number of individual project locations, and therefore, a lower potential to cause indirect impacts to wildlife through construction-related noise and activity. Impacts to priority species would potentially be higher under this option due to construction activity in proximity to priority habitats along the Lake Washington shoreline and Union Bay Natural Areas; however, impacts are not expected because all construction would comply with applicable permit requirements to protect habitat.
	Shared West Ship Canal Tunnel Option	In general, impacts would potentially be low under this option due to the concentration of construction in the Ship Canal Neighborhoods at fewer locations and the lower amount of surface disturbance than other options.
	Shared Ship Canal Tunnel Option	Overall disturbance would potentially be lower compared to all other options because this option eliminates the greatest number of City and King County independently constructed CSO storage facilities. However, impacts to priority species could potentially be higher due to construction activity lasting up to seven years in proximity to priority habitats along the Lake Washington shoreline and Union Bay Natural Area. It may be difficult to avoid siting portals in areas with high habitat value.

Table 1-2. Summary of Construction Impacts

Integrated Plan Alternative	Impacts would primarily be related to the LTCP option selected for implementation. Additional impacts associated with the Integrated Plan Alternative would be minimal. Most NDS partnering projects would likely occur in paved or developed rights-of-way in residential areas and would not affect wildlife habitat. The potential for direct losses of terrestrial habitat associated with NDS Partnering projects and South Park Water Quality Facility construction would be minimal. Indirect impacts to wildlife would be associated with short-term increased level of noise and human activity during construction, and are not expected to be significant.
No Action Alternative	Construction activities associated with ongoing sewer system improvements would temporarily cause elevated levels of noise and human activity that could disturb wildlife, if present, near the project. Natural Drainage System program projects and roadside rain gardens have minimal direct impact on wildlife and habitat due to their small footprint and location within public rights-of-way or private property, both of which are typically developed or landscaped.
Measures to reduce or minimize potential impacts	The City would undertake the following measures: • Site projects away from mapped priority habitats and species locations where possible. • Follow federal, state, and local permit conditions for managing construction site runoff and protecting habitats for federally listed species. • Retain site vegetation as much as possible. • Provide prompt revegetation with native species after construction is complete. • Adhere to development conditions within City of Seattle's Director Rule 5-2007 for construction within Great Blue Heron Management Areas and Colony Nesting Areas.

Energy and Climate Change

Long Term Control Plan Alternative	Key Findings	None of the LTCP options would have a significant impact on energy resources in the Seattle area. The primary difference in energy consumption and greenhouse gas (GHG) emissions between the options relates to the type of storage facility (e.g., tank or tunnel) and whether it is part of the Neighborhood Storage Option or one of the shared options. While the shared options would have higher energy consumption and GHG emissions per facility, there would be fewer new storage facilities built by the City and King County. Therefore, overall emissions would likely be lower.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> Construction-related energy consumption and GHG emissions would be lower than those estimated for the Shared Storage or Shared Ship Canal Tunnel Options. <i>Neighborhood West Ship Canal Tunnel:</i> Energy consumption would be similar, but GHG emissions would be slightly higher than those estimated for the Shared West Ship Canal Tunnel Option.

Table 1-2. Summary of Construction Impacts

	Shared Storage Option	Construction-related energy consumption and GHG emissions would be higher than those estimated for the Neighborhood Storage Option. However, overall impacts would be reduced under this option because the shared tanks reduce the number of King County independently constructed CSO control facilities.
	Shared West Ship Canal Tunnel Option	Construction-related energy consumption and GHG emissions would be lower than those estimated for the Shared Storage or Shared Ship Canal Tunnel Options. Overall impacts would be reduced under this option because the shared tunnel reduces the number of King County independently constructed CSO control facilities.
	Shared Ship Canal Tunnel Option	Construction-related energy consumption and GHG emissions associated with this option would be higher than those estimated for the Neighborhood Storage and Shared West Ship Canal Tunnel Options. However, overall impacts from both the City and King County projects would be the most reduced under this option because the shared tunnel reduces the greatest number of King County independently constructed CSO control facilities.
Integrated Plan Alternative		Construction of CSO storage pipes, tanks, and tunnels under the Integrated Plan Alternative would have the same energy use and GHG emissions as under the LTCP Alternative, but construction would be delayed in some neighborhoods. Construction of NDS Partnering projects and the South Park Water Quality Facility would add incrementally to the overall energy required for construction of the Plan.
No Action Alternative		Project construction under ongoing programs to implement sewer system improvements and NDS projects would have minor energy consumption and GHG emissions.
Measures to reduce or minimize potential impacts		The City would undertake the following measures to mitigate energy and GHG impacts: • Incorporating specifications into construction contracts that encourage the use of fuel-efficient construction equipment. • Minimizing engine idling during construction.

Environmental Health and Public Safety

Long Term Control Plan Alternative	Key Findings	Ground excavations and dewatering have the potential to encounter contaminated materials, and may require special handling methods depending on the site and type of materials encountered. Discharges of dewatering water could introduce contaminants and sediments into local waterways if not properly managed. In general, environmental health risks associated with construction under the LTCP options are low, and the potential for the public to encounter contaminated soils or groundwater is also low. Larger projects, such as storage tanks and tunnels, have a greater potential for environmental health and public safety impacts than smaller projects constructed in the right-of-way, such as storage pipes and flow diversions.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> Under this option, there is a higher potential for impacts in Ballard, Fremont/Wallingford, and the Duwamish/East Waterway neighborhoods from large excavations and dewatering outside of the right-of-way in potentially contaminated areas (typically industrial lands). Risks would be greatest for construction workers, and would generally be low for the public. Pre-design studies would be conducted to determine the extent of contamination and appropriate measures to minimize health risks. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below

Table 1-2. Summary of Construction Impacts

		– impacts would be similar)
	Shared Storage Option	The larger, shared storage facilities under this option in Fremont/Wallingford, North Union Bay, and Montlake would require higher volumes of excavation compared to the Neighborhood Storage Option. However, the geographic extent of the impact is limited because fewer facilities would be constructed. Construction required to implement flow diversions under this option would have a very low potential to cause environmental health and public safety impacts because excavation volumes would be minimal and dewatering would not be significant.
	Shared West Ship Canal Tunnel Option	Potential construction-related impacts in the Ship Canal Neighborhoods would be concentrated at the tunnel portals in the Fremont/Wallingford and Ballard neighborhoods. Potential impacts in other neighborhoods would be similar to those described for the Neighborhood Storage Option.
	Shared Ship Canal Tunnel Option	Potential impacts would be concentrated at the tunnel portals potentially located on the south side of the Ship Canal and in the North Union Bay neighborhood, areas that do not have known high levels of contamination. Potential impacts in other neighborhoods would be similar to those described for the Neighborhood Storage Option.
Integrated Plan Alternative		Construction of CSO storage pipes, tanks, and tunnels under the Integrated Plan Alternative would have the same potential for environmental health impacts as under the LTCP Alternative. In addition to the impacts outlined for the LTCP Alternatives, ground excavation and dewatering for the South Park Water Quality Facility would have the potential to encounter contaminated materials, with accompanying environmental health considerations, based on the history of industrial land uses in the Duwamish basin. Pre-design investigations would determine the potential for contamination at the construction site. Overall, potential public health impacts are expected to be low.
No Action Alternative		Construction activity associated with ongoing sewer system improvements and NDS programs is not expected to result in environmental health or safety impacts. The locations of sewer system improvement projects have largely been previously excavated; therefore, the risk of encountering contaminated soil is minimal. Excavation for rain gardens is unlikely to encounter contaminated material, but spills from construction equipment are possible. Overall, potential public health impacts are low.
Measures to reduce or minimize potential impacts		Measures would include: • Site-specific investigations and clean-up or pollution prevention plans. • Plans for sediment and groundwater handling, testing, and disposal. • Spill prevention and control plans.

Table 1-2. Summary of Construction Impacts

Noise and Vibration		
Long Term Control Plan Alternative	Key Findings	Construction of projects under the Plan alternatives would result in short-term moderate to substantial increases in noise, lasting from one to as much as seven years, depending upon the option selected. The primary differences in potential noise and vibration effects of the LTCP options are related to the amount of noise-generating earthwork and the length of construction period. In general, storage pipes/tanks would result in shorter duration, but more geographically distributed impacts, while the tunnels would result in longer duration impacts in relatively smaller areas.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> Construction of projects would result in short-term moderate to substantial increases in noise. This option would have the most dispersed noise and vibration impacts throughout the Plan area. Construction would occur in every CSO neighborhood, but would last longest in Ballard, Fremont/Wallingford, and East Waterway, where construction durations would range from one to five years. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)
	Shared Storage Option	Impacts would be similar to the Neighborhood Storage Option, but potentially higher intensity noise would be concentrated at fewer locations in Fremont/Wallingford, North Union Bay, and Montlake, for construction durations from three to 4.5 years.
	Shared West Ship Canal Tunnel Option	Potential construction-related impacts in the Ship Canal Neighborhoods would largely be concentrated at the tunnel portals in the Ballard and Fremont/Wallingford neighborhoods. After initial tunnel portal site construction, most work would occur underground, which would not produce noticeable street-level noise or vibration other than from trucks hauling tunnel spoils on roadways. The duration of these impacts would be 3.5 years. Potential for vibration impacts along the tunnel routes is likely to be a concern to property owners. Potential impacts in other neighborhoods would be similar to those described for the Neighborhood Storage Option.
	Shared Ship Canal Tunnel Option	Noise-generating construction sites in the Ship Canal and Lake Washington neighborhoods would largely be consolidated at the two tunnel portals, and would last for as long as seven years. Most activities would occur at the launch portal along the south side of the Ship Canal (near the Fremont Cut). Noise impacts could be experienced in the vicinity of the portal locations, particularly during night time construction. Potential for vibration impacts along the tunnel routes would likely be a concern to property owners.
Integrated Plan Alternative		Construction of CSO storage pipes, tanks, and tunnels under the Integrated Plan Alternative would have the same noise impacts as under the LTCP Alternative, but construction would be delayed in some neighborhoods. Noise and vibration impacts from the stormwater projects specific to the Integrated Plan Alternative would be minor. Construction of NDS Partnering projects is not likely to require high-impact noise equipment and construction noise would be of short duration. The South Park Water Quality Facility would generate typical construction noise similar to projects implemented under the LTCP Alternative.
No Action Alternative		Construction activity associated with ongoing sewer system improvements and NDS programs is not likely to require high-impact noise equipment, and construction noise would be of short duration.

Table 1-2. Summary of Construction Impacts

Measures to reduce or minimize potential impacts	Mitigation would include: • Identify potentially impacted receptors and buildings and determination of whether noise and vibration levels at those sites would exceed permitted levels. • Encourage noise-reducing measures, such as using sound-control devices on equipment, prohibiting equipment with unmuffled exhaust, minimizing idling time of equipment and vehicles, and installing acoustic barriers around stationary sources of construction noise. • Conduct on-site noise monitoring to ensure compliance with SMC provisions, if necessary. • Coordinate with Seattle City Light to ensure electrical power is available to construction sites during construction dewatering (to avoid using diesel powered generators). Mitigation for vibration impacts would be determined on a site-by-site basis depending on impacts. Mitigation measures could include shoring of impacted buildings, coordination of vibration-causing construction with sensitive activities in impacted buildings, or onsite vibration-minimizing practices.	
Land Use and Visual Quality		
Long Term Control Plan Alternative	Key Findings	CSO control projects included under the LTCP range from those that would be located in the public right-of-way or streets and cause little or no land use or visual impact to major infrastructure projects that could require acquisition of property or easements over the course of construction, which would range from approximately one to seven years, depending upon the project. The acquisitions/easements could be temporary to accommodate access to a site or a location for project staging, or they could be permanent for locating storage tanks or tunnels. Impacts to visual quality during construction would be minor under all LTCP options. The primary differences in potential effects of the LTCP options are related to the types of projects and their potential location and the length of construction.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> Due to the largest number of distributed CSO storage facilities, this option has the greatest number of areas that would experience temporary land use impacts. Construction could intermittently disrupt access to residences, businesses, and institutions, including (potentially) the University of Washington during the multi-year construction duration. Access disruption could affect businesses. Staging areas would prevent other uses during construction; however, uses could be restored following construction completion. Temporary easements would be needed from some private landowners, depending on the project. Acquisition-related impacts would potentially be greatest under this option because it would require the greatest number of project locations. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)

Table 1-2. Summary of Construction Impacts

	Shared Storage Option	Impacts would be similar to the Neighborhood Storage Option, but construction-related land use and visual quality impacts would be concentrated at fewer, larger project sites in the Ship Canal and Lake Washington neighborhoods of Fremont/Wallingford, North Union Bay, and Montlake. Construction could intermittently disrupt access to residences, businesses, and institutions, including (potentially) the University of Washington during the up to four years or longer construction duration.
	Shared West Ship Canal Tunnel Option	This option would reduce the number of areas affected by construction, but would concentrate construction-related land use impacts in fewer areas of the city (Ballard and Fremont/Wallingford). The tunnel is estimated to require 3.5 years to construct and up to four acres for construction staging. Much of this area could be sold back to private ownership following construction. In addition to land use and visual quality impacts from tunnel portal activity, dispersed impacts and disrupted access from microtunnel and open-cut construction in roadways throughout the Ship Canal Neighborhoods would occur.
	Shared Ship Canal Tunnel Option	Compared to the other options, the number of large storage facility construction sites would be reduced because this option would eliminate the greatest number of City and King County independently constructed CSO storage facilities. Overall, the need for property acquisition and the amount of interference with access to residences and businesses would be reduced. However, construction-related land use impacts would potentially be higher in the Ship Canal and Lake Washington Neighborhoods under this option because most of the construction activity during the up to seven-year construction period would be consolidated to the two tunnel portal sites located on the south side of the Ship Canal and in the North Union Bay neighborhood. As much as 6 acres could be required for construction staging, which would preclude other uses during the construction period. Much of this area could be sold back to private ownership following construction. In addition to land use and visual quality impacts from tunnel portal activity, dispersed impacts and disrupted access from microtunnel and open-cut construction in roadways throughout the Lake Washington and Ship Canal Neighborhoods would occur.
Integrated Plan Alternative		Construction impacts associated with certain CSO control facilities in the Delridge, East Waterway, Duwamish, Portage Bay, and Montlake neighborhoods would occur later (after 2028) under the Integrated Plan Alternative. As a result, these neighborhoods would experience fewer near-term land use and visual quality-related construction impacts, but these impacts would occur after 2028. Additional impacts specific to stormwater projects associated with the Integrated Plan Alternative are not expected. Most NDS Partnering projects are expected to occur within the Single Family zone, but could occur in other zones. Prior to installation of rain gardens, the City would need to apply for and obtain applicable land use permits and approvals. Depending on the site, easements could be required on a temporary basis to accommodate access to a site or a location for project staging. The South Park Water Quality Facility is expected to be located on City-owned property in an industrial-zoned area. Therefore, it is anticipated that a suitable site is available that would result in minimal land use and visual quality impacts during construction.
No Action Alternative		Construction activity would be limited to ongoing sewer system improvements and NDS programs. Construction related impacts to land use and visual resources are not anticipated from these ongoing programs.

Table 1-2. Summary of Construction Impacts

Measures to reduce or minimize potential impacts		Mitigation measures would include: • Prioritizing project locations on public property and in public rights-of-way; • Complying with federal, state, and local regulations regarding property acquisition and relocation assistance; • Following conditions of the Master Use Permit; and • Providing access to property and businesses during construction.
Recreation		
Long Term Control Plan Alternative	Key Findings	For all LTCP options, temporary impacts to recreation could occur if a facility is sited within a park, although the City would attempt to avoid siting facilities in parks. If construction or staging areas are located adjacent or nearby to a park, recreational use of the park could be disrupted by restricted access, noise, dust, and truck trips during peak construction periods. The primary differences in potential effects of the LTCP options are related to the types of projects and their potential location, amount of construction disturbance, and the length of construction.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> Temporary loss of recreational opportunities could occur if the CSO facility is located within the park. If construction or staging areas are located adjacent or nearby to a park, recreational use of the park could be disrupted by restricted access, noise, dust, and truck trips during peak construction periods. Because this option has the highest number of projects located throughout the city, it has a higher likelihood of having projects located adjacent to a park or recreational facility. This option would include construction of multiple storage pipes/tanks in the Lake Washington Neighborhoods, which have a higher concentration of parks than other neighborhoods. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)
	Shared Storage Option	Potential construction-related impacts to recreation would be lower than the Neighborhood Storage Option because fewer project sites would be required. Due to the larger area required for larger tanks, however, shared storage tanks could have a greater potential to impact recreation if located within or near parks. However, the use of shared storage tanks would reduce the overall number of parks that could potentially be affected by construction in the Ship Canal and Lake Washington Neighborhoods. In other neighborhoods, storage pipes or tanks would be replaced by flow diversions, which would have less potential to impact parks but could still impact informal recreation such as walking and biking.
	Shared West Ship Canal Tunnel Option	Impacts to recreation from construction would be similar to the Neighborhood Storage Option for most neighborhoods, but impacts in the Ballard and Fremont/Wallingford neighborhoods would be concentrated at portal locations, and construction durations would be up to 3.5 years. If located in or adjacent to a park or recreational facility, impacts from tunnel portal construction on recreation would be substantial and truck trips could disrupt access to the park. If located in a park, multiple acres of the park could be closed to recreation for several years. A substantially higher number of truck trips would be required as compared to storage tanks, which would have a greater likelihood of disrupting access to nearby parks and informal recreation opportunities.

Table 1-2. Summary of Construction Impacts

	Shared Ship Canal Tunnel Option	This option requires the fewest number of large construction sites, but the sites would be impacted during a relatively longer construction period, estimated at seven years. Tunnel portals have the potential to affect parks or athletic fields, particularly on the south side of the Ship Canal and in North Union Bay (University District). Potential impacts to parks or recreation facilities would be as described above for the Shared West Ship Canal Tunnel.
Integrated Plan Alternative		Construction impacts associated with certain CSO control facilities in the Delridge, East Waterway, Duwamish, Portage Bay, and Montlake neighborhoods would occur later (after 2028) under the Integrated Plan Alternative. As a result, these neighborhoods would potentially experience fewer near-term recreation impacts. Construction related impacts to recreation specific to stormwater projects under the Integrated Plan are expected to be minimal. NDS Partnering projects would be constructed within public rights-of-way, primarily along or in roadways, and could temporarily interfere with informal recreation such as walking and biking due to restricted access. The South Park Water Quality Facility is expected to be located in an industrial area on City-owned property, with no public access or recreational opportunities.
No Action Alternative		Recreation impacts from construction of ongoing programs under the No Action Alternative would be minor. Construction in the right-of-way for both sewer system improvements and for right-of-way rain garden projects could temporarily interfere with informal recreation due to restricted access.
Measures to reduce or minimize potential impacts		If a CSO facility were located in a park, impacts to recreation would be unavoidable. The City would attempt to avoid siting projects in parks. If locating outside of a park is not possible, impacts to recreational facilities could be further minimized through coordination with Seattle Parks, including coordinating construction timing with special events at the park; construction staging methods and siting; scheduling to avoid overlap with the construction of other projects in the vicinity; and advance public notice and signage. Parks and recreation features would be restored to the extent possible.
Historic, Cultural, and Archaeological Resources		
Long Term Control Plan Alternative	Key Findings	Construction under any of the LTCP options could have a potential adverse effect on historic, cultural, or archaeological resources in the Plan area. The primary difference in impacts relates to the amount of excavation in geological layers and their potential to encounter cultural resources. All options include similar, minimal potential for impacts on aboveground historic resources.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> Construction could have a potential adverse effect on historic, cultural or archaeological resources in the Plan area. This option would have a greater amount of excavation in geological layers with greater potential to encounter cultural resources than the tunnel options. Only a minimal potential for impacts to aboveground resources is anticipated. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)

Table 1-2. Summary of Construction Impacts

	Shared Storage Option	Potential for construction impacts to belowground historic and cultural resources would be similar to those described for the Neighborhood Storage Option. The Montlake neighborhood (where a shared storage tank would be constructed) contains known precontact and historic archaeological sites in proximity to the waterfront. Unknown belowground resources may also exist, and impacts resulting from tank construction would be permanent and irreversible if resources are encountered during construction. Impacts to aboveground resources would be the same as for the Neighborhood Storage Option.
	Shared West Ship Canal Tunnel Option	Because excavation for the tunnel portals would be deeper and therefore in geological layers with lower potential for encountering cultural resources, the tunnel options would have less potential to encounter cultural resources than the Neighborhood Storage Option or the Shared Storage Option. This option has the potential for temporary impacts to historic properties along the proposed tunnel alignment (vibration, dust, noise, and visual integrity). Historic structures may be more susceptible to damage from vibration.
	Shared Ship Canal Tunnel Option	This option has a similar potential for construction impacts on historic properties as the Shared West Ship Canal Tunnel Option.
Integrated Plan Alternative		Impacts are primarily associated with the LTCP option selected for implementation as described above. Additional impacts associated with the Integrated Plan alternative are minimal. Construction of the NDS Partnering projects would occur within previously disturbed public rights of way, and would not be likely to impact cultural or historic resources. For construction of the South Park Water Quality Facility, there is a potential to affect cultural resources. Site specific studies would be conducted as necessary to determine the potential for this impact.
No Action Alternative		Ongoing programs for sewer system improvements have the potential for construction impacts to historic properties depending on the locations of the improvements. Sewer system improvements and NDS projects generally would be anticipated to have very low potential to impact belowground resources because they would generally be constructed in previously disturbed areas.
Measures to reduce or minimize potential impacts		The City would conduct project-level cultural resource surveys prior to construction and consult with stakeholders to avoid, minimize, and mitigate potential impacts to identified resources.

Table 1-2. Summary of Construction Impacts

Transportation		
Long Term Control Plan Alternative	Key Findings	Construction of projects under the LTCP options would result in moderate to substantial adverse transportation impacts for temporary periods ranging from one to seven years. Potential construction-related transportation impacts would be highly visible and are of concern to local residents, business owners, and commuters. Transportation impacts would include increases in traffic volumes due to construction-generated truck trips and commute trips of construction workers, and roadway lane and sidewalk closures where construction activities take place. The primary differences in potential transportation impacts of the LTCP options are related to the length of construction period, estimated number of truck trips, and the road network in the affected neighborhood.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> Potential construction-related transportation impacts would be highly visible and would be of concern to local residents, business owners, and commuters in affected neighborhoods. Transportation impacts would include increases in traffic volumes due to construction-generated truck trips and commute trips of construction workers, and roadway lane and sidewalk closures where construction activities take place. Neighborhoods with limited number of route alternatives could experience adverse impacts from lane or road closures. The Neighborhood Storage Option would have the most dispersed transportation impacts because it would require roadway lane and sidewalk closures at a number of locations throughout the city to accommodate storage pipe and tank construction from City (and King County) independently constructed CSO storage facilities. Localized impacts would occur in certain areas (including Leschi, Montlake, and Magnolia) where the ability to accommodate lane closures for storage pipe construction is highly constrained due to a limited number of route alternatives. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)
	Shared Storage Option	Impacts would be similar to the Neighborhood Storage Option but concentrated at fewer locations. This option would eliminate or reduce transportation impacts in the Leschi neighborhood but would have increased transportation impacts in Fremont/Wallingford, North Union Bay, and Montlake. Arterials in the Montlake area are limited, so existing congestion levels would be exacerbated by lane closures and truck trips.
	Shared West Ship Canal Tunnel Option	Impacts in the Ship Canal Neighborhoods would be concentrated at two tunnel portal locations in Ballard and Fremont/Wallingford. Elements of the West Ship Canal Tunnel construction that would generate truck trips include tunnel excavation as well as construction of supporting pipeline, pump station, and micro-tunnels. Total construction trips are expected to be over 60,000 truck round trips for the West Ship Canal Tunnel Option, generated primarily in Ballard. Overall, this option would result in substantially more truck trips over a longer period in Ballard compared to the Neighborhood Storage and Shared Storage Options. With expected construction duration of 3.5 years, trucks generated by the tunneling are expected to average 60 per day. Anticipated increase in truck traffic is relatively low compared to typical background traffic on city arterials and is not expected to adversely affect roadway operations. However, at peak construction times, the truck trips could be noticeable to drivers.

Table 1-2. Summary of Construction Impacts

		Localized impacts in other neighborhoods would be the same or similar to those described for the Neighborhood Storage Option.
	Shared Ship Canal Tunnel Option	Total construction trips are expected to be over 100,000 truck round trips for the Shared Ship Canal Tunnel Option, generated primarily on the south side of the Ship Canal at the launch portal. With estimated construction duration of seven years, truck trips generated by the tunneling are expected to average 70 per day. Anticipated increase in truck traffic is relatively low compared to typical background traffic on city arterials and is not expected to adversely affect roadway operations. However, at peak construction times, the truck trips could be noticeable to drivers. Overall, this option would result in substantially more truck trips over a longer period south of the Ship Canal, where the launch portal would likely be located, compared to the other options. Impacts would be similar to the Neighborhood Storage Option for the Longfellow Creek/Duwamish and Elliott Bay Neighborhoods.
Integrated Plan Alternative		Construction impacts associated with certain CSO control facilities in the Delridge, East Waterway, Duwamish, Portage Bay, and Montlake neighborhoods would occur later (after 2028) under the Integrated Plan Alternative. As a result, these neighborhoods would experience fewer near-term transportation impacts. There would be localized impacts to the neighborhoods implementing NDS Partnering. These would include neighborhoods in the Piper's Creek, Thornton Creek, and Longfellow Creek areas. Neighborhoods would voluntarily sign up for the project, and impacts would be short-lived and localized, including generation of a small number of construction vehicle trips, and lane or sidewalk narrowings or closures adjacent to construction activities. The South Park Water Quality Facility is expected to be constructed on City-owned property in an industrially zoned neighborhood with adequate access. Construction related impacts should be minimal.
No Action Alternative		Project construction under ongoing programs to implement sewer system improvements and NDS projects requires only a small number of truck trips for each project. No impacts to transportation are anticipated under the No Action Alternative.
Measures to reduce or minimize potential impacts		Transportation-related mitigation measures would depend on the exact type and size of the proposed improvement, but could include the following. • Develop a Traffic Control Plan for any work within the public right-of-way that affects vehicular, transit, bicycle, or pedestrian traffic. • Avoid creating additional delay at congested intersections either by choosing construction truck routes that avoid these locations, or constructing during nonpeak times of day. • Maintain access for driveways and private roads. • Provide adequate off-street parking areas at designated staging areas for construction-related vehicles. • Provide onsite loading areas for removal and delivery of material. • Provide plan for construction workers to commute via alternative modes or ridesharing, to minimize added vehicle trips and parking demand at the site. • Maintain pedestrian and bicycle access and circulation during project construction. If construction encroaches on a sidewalk, a safe detour should be provided for

Table 1-2. Summary of Construction Impacts

	pedestrians at the nearest crosswalk. If construction encroaches on a bike lane, post warning signs that indicate bicycles and vehicles are sharing the roadway. • Provide traffic controls such as flaggers as appropriate. • Maintain access to transit services and coordinate with transit agencies (King County Metro, Sound Transit, Community Transit) if transit stop closures or route detours are needed. • Coordinate with the Seattle School District to ensure that access to school buses is maintained. • Post standard construction warning signs in advance of the construction area and at any intersection that provides access to the construction area. • Provide access for emergency vehicles at all times. • Provide written notification to contractors regarding appropriate routes to and from construction sites and weight and speed limits for local roads used to access construction sites. • Coordinate with the local neighborhoods to ensure that access to residences and businesses is adequately maintained, and that any additional potential issues unique to the neighborhood are identified and addressed. • Repair or restore the roadway right-of-way to its original condition or better upon completion of the work. • Comply with Seattle Department of Transportation requirements to schedule work on arterial streets and sidewalks outside of peak traffic hours unless otherwise authorized by the City Traffic Engineer. • Follow the Holiday Moratorium for construction, which indicates that no work shall be scheduled on streets or sidewalks within the Central Retail District and Pioneer Square from Thanksgiving Day through New Year's Day. <u>Barge Transport of Excavated Materials for Tunnel Options:</u> For the Shared West Ship Canal Tunnel Option and the Shared Ship Canal Tunnel Option, if the tunnel portals are located near Lake Washington, Elliott Bay, or the waterway that connects them, it could be possible to transport excavated material by barge rather than by truck. This could eliminate an estimated 16,000 construction truck trips) in Ballard with the Shared West Ship Canal Tunnel Option, and an estimated 32,000 construction truck trips south of the Ship Canal under the Shared Ship Canal Tunnel Option. Using barging as mitigation would require additional evaluations at the project level to determine feasibility of constructing ancillary facilities, including a conveyor system and a dock to support the barge, and to assess agency permit/approval feasibility.
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Table 1-2. Summary of Construction Impacts

Utilities		
Long Term Control Plan Alternative	Key Findings	Construction of storage tanks, pipes, tunnels, pump stations, and appurtenant facilities would occur in areas highly constrained by existing underground and overhead utilities and would require extensive coordination with existing utilities to avoid conflicts. The primary difference in impacts between the options relates to the number of new storage facilities constructed and the amount of new conveyance (pipelines) required to transport flows to the new storage facilities. Several of the options include flow diversions to King County facilities, which would necessitate coordination with King County to ensure that there are minimal impacts to King County facilities during construction. It would also be important to coordinate with the City's drinking water line of business to ensure that construction impacts to major water mains are avoided.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> This option has the greatest potential for construction-related impacts to utilities due to the number of new storage tanks to be constructed and the amount of conveyance required to transport flows to storage facilities. The storage facilities and associated conveyance lines would be located in areas and at underground elevations with existing utilities. The Ballard, Fremont, East Waterway, and Delridge neighborhoods have the largest number of proposed facilities, but all proposed facilities are located in areas with existing underground utilities. Coordination with all potentially affected facilities would be required. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar).
	Shared Storage Option	Large storage facilities would be constructed in neighborhoods with existing utilities, resulting in potential conflicts during construction. This option would include three shared storage facilities with King County as well as a proposed flow diversion to a King County facility, which would require close coordination to ensure that there are minimal impacts to King County facilities during construction.
	Shared West Ship Canal Tunnel Option	This option involves the City and King County sharing a deep tunnel. This option requires a high level of coordination with King County to avoid potential construction-related impacts. Deep tunnels tend to be constructed below many underground utilities, reducing the potential for utility conflicts. However, temporary electrical substations to power the tunnel boring machine and construction of tunnel portals and other associated facilities would require utility coordination and reconfiguration. This option would also include two flow diversions to King County facilities, necessitating close coordination with King County to ensure that there are minimal impacts to King County facilities during construction.
	Shared Ship Canal Tunnel Option	This option involves the City and King County sharing a deep tunnel, and includes four flow diversions to King County facilities. This option requires the highest level of coordination with King County, to avoid potential construction-related impacts.
Integrated Plan Alternative		Impacts to public utilities would be associated with localized below ground utilities potentially affected by conveyance line construction for the South Park Water Quality Alternative. There may be minor utility conflicts associated with NDS Partnering projects.
No Action Alternative		Construction-related impacts to utilities would occur under ongoing programs; however, impacts are expected to be lower than those expected to occur under the LTCP or Integrated Plan Alternatives.

Table 1-2. Summary of Construction Impacts

Measures to reduce or minimize potential impacts	Impacts to utilities would be reduced by early and ongoing coordination with all potentially affected utilities. The measures would include, but are not limited to, those listed below: • Coordinate with other utilities and transportation departments to plan for shared construction to avoid consecutive construction projects (CSO control projects, road construction, other underground utilities). • Provide advance notice and coordinate with affected utilities to minimize disruption of services. • Adhere to the City's design criteria for the clearance of water mains and other utilities as outlined in Section 1-07.17 of the City of Seattle's Standard Specifications for Road, Bridge and Municipal Construction. • For all LTCP options, the City would work together with King County to analyze and mitigate downstream operational and capital impacts to the King County System. If downstream impacts cannot be successfully mitigated, then there is the potential that the County will be required to build new or larger downstream capital facilities to accommodate the LTCP options. Even with adequate mitigation though, there would likely be an increase in the County's operations and maintenance (O&M) costs to account for the additional flows from the City's system.
Socioeconomics and Environmental Justice	
Long Term Control Plan Alternative	Key Findings Construction of the LTCP options could cause construction disturbance and modified access to community resources and businesses, resulting in temporary reduction in neighborhood cohesion. Temporary disruptions may be a particular hardship for some residents – particularly transit-dependent persons – due to disruptions to access and public transportation in project areas. There could be short-term impacts on existing economic conditions in the construction areas due to construction disturbance and temporary changes in the use of the land during construction. In some cases, these changes would be permanent, while in other cases, economic activity would largely be restored following construction. Although construction effects may be substantial, none of the LTCP options would cause disproportionately high and adverse effects on minority and low-income populations.
	Neighborhood Storage Option <i>Neighborhood (Tanks/Pipes):</i> Construction may cause construction disturbance and modified access to community resources and businesses, resulting in temporary reduction in neighborhood cohesion. The Neighborhood Storage Option has the greatest number of City and King County independently constructed CSO storage facilities, and therefore the greatest number of areas that would experience construction disturbance and modified access to community resources and businesses during the construction period. The neighborhoods that would be most affected include the Ballard, Fremont/Wallingford, Leschi, and Longfellow Creek/Duwamish neighborhoods. Although construction activity may be substantial, no potential disproportionately high and adverse effects on minority and low-income populations have been identified. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below

Table 1-2. Summary of Construction Impacts

		– impacts would be similar).
	Shared Storage Option	The Shared Storage Option would reduce the total number of new storage facilities required in the city (by both the City and King County) and would reduce the number of storage facilities that would be constructed as compared to the Neighborhood Storage Option. Fewer areas would experience construction disturbance and modified access to community resources or businesses, and there would be fewer areas where property acquisition is required. However, it would concentrate impacts at shared tank locations. The neighborhoods that have the highest potential to be affected include Fremont/Wallingford, North Union Bay, and Montlake. Disproportionate impacts to minority or low income populations are not expected.
	Shared West Ship Canal Tunnel Option	The Shared West Ship Canal Tunnel would eliminate the need for the City (and King County) independently constructed storage facilities in the Ship Canal Neighborhoods, and therefore fewer areas would experience construction disturbance and modified access to community resources or businesses. However, it would concentrate impacts at fewer locations in the Ship Canal Neighborhoods. The neighborhoods that have the highest potential to be affected include Ballard and Fremont/Wallingford. Disproportionate impacts to minority or low income populations are not expected.
	Shared Ship Canal Tunnel Option	The Ship Canal Tunnel Option would affect the fewest neighborhoods throughout the city, but it would also concentrate impacts in the Ship Canal and Lake Washington Neighborhoods. Overall, the potential to impact businesses and local economic activity would be reduced city-wide. Disproportionate impacts to minority or low income populations are not expected.
Integrated Plan Alternative		Construction impacts associated with certain CSO control facilities in the Delridge, East Waterway, Duwamish, Portage Bay, and Montlake neighborhoods would be delayed until (after 2028) under the Integrated Plan Alternative. As a result, these neighborhoods would experience fewer near-term socioeconomic impacts. Construction associated with NDS Partnering would cause minor and temporary impacts to the communities in which they're located, and could alter access to community resources. Project construction associated with the South Park Water Quality Facility could also alter access to community resources and result in short-term noise and other impacts in affected neighborhoods. However, the potential for impacts is minimal as the project is anticipated to be located in an industrial area.
No Action Alternative		Project construction under ongoing programs to implement sewer system improvements and NDS projects could alter access to community resources and result in short-term noise and other impacts in affected neighborhoods. However, these impacts would be very short term and would not affect the integrity of the neighborhoods. The No Action Alternative would require fewer disruptions in industrial and commercial areas, and fewer property acquisitions and displacements than would the LTCP or Integrated Plan Alternatives.
Measures to reduce or minimize potential impacts		The City would undertake the following measures to mitigate socioeconomic impacts: • Prioritizing project locations on public property and in public rights-of-way, • Complying with federal, state, and local regulations regarding property acquisition and relocation assistance, • Providing advance notification of construction activities, including any sidewalk and

Table 1-2. Summary of Construction Impacts

	street lane closures, to nearby residents, and • Preparing a traffic control plan including measures to address residential access, emergency vehicle access, road closures and detours, and temporary bus route changes. Additional measures to minimize impacts to environmental justice populations and organizations and businesses that serve them would include communicating information and obtaining feedback about construction activities, impacts, and mitigation at low-income housing sites and through social service providers. The project would also focus outreach to populations with limited English proficiency and to other populations susceptible to construction-related impacts.
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Table 1-3 summarizes operational impacts associated with the LTCP, Integrated Plan, and No Action Alternatives. As previously described, impacts are described for those projects and programs proposed by the City independently or working jointly with King County. Independent King County projects are identified but not discussed in this document. Impacts will be assessed by King County in accordance with their SEPA requirements.

Table 1-3. Summary of Operational Impacts

Earth		
Long Term Control Plan Alternative	Key Findings	Overall, the operational effects from the LTCP Alternative are expected to be minor. With the implementation of site-appropriate design, potential adverse impacts would be avoided and minimized.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> This option would have the most tanks and pipes located throughout the Plan area potentially at risk during a seismic event. However, storage facilities would be designed in accordance with seismic design standards, which are intended to minimize the long-term risks to the system. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar).
	Shared Storage Option	Impacts would be similar to the Neighborhood Storage Option but there would be fewer storage tanks and pipes potentially at risk during a seismic event.
	Shared West Ship Canal Tunnel Option	Impacts would be similar to the Neighborhood Storage Option but there would be fewer storage tanks and pipes potentially at risk during a seismic event. Tunnels are generally designed to avoid other underground developments and take advantage of stable glacial till layers. Operational effects are anticipated to be minor.
	Shared Ship Canal Tunnel Option	This option would have similar potential for impacts as the Shared West Ship Canal Tunnel Option. Additional flow diversions under this option would further reduce the number of storage facilities at potential risk.
Integrated Plan Alternative		In addition to the operational impacts of the selected LTCP option, the operational impacts of the stormwater projects specific to the Integrated Plan Alternative are anticipated to be minor. Depending on location selected, the South Park Water Quality Facility could be at risk for liquefaction in saturated soils; however, the facility would meet seismic design standards. NDS Partnering projects could cause erosion if not properly maintained. Street sweeping operations would not be expected to affect earth or groundwater.
No Action Alternative		Projects completed as part of the ongoing Natural Drainage System program and roadside rain garden programs could cause erosion if they are not properly maintained. Projects included in the City's NPDES Waste Discharge Permit and the 2010 Plan Amendment will meet seismic design standards.
Measures to reduce or minimize potential impacts		The City would undertake the following measures: • All sites would be maintained to prevent erosion. • Projects would be sited and designed to minimize seismic risk and potential for earth subsidence.

Table 1-3. Summary of Operational Impacts

Air Quality		
Long Term Control Plan Alternative	Key Findings	The net operational effects of the LTCP Alternative on air quality and odors would be minor in the Plan area. All facilities would be designed and maintained to minimize emissions of odorous compounds and would include odor control components as necessary.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> This option would have the highest number of potential odor-producing tanks and pipes located throughout the Plan area, including in or near residential areas in the Ship Canal, Lake Washington, and Longfellow Creek/Duwamish Neighborhoods. All facilities would be designed and maintained to minimize emissions of odorous compounds. Therefore, operational effects of the CSO control facilities on air quality and odors would be minor in the Plan area. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar).
	Shared Storage Option	Impacts would be similar to the Neighborhood Storage Option but there would be fewer potential odor-producing tanks and pipes in the Ship Canal Neighborhoods.
	Shared West Ship Canal Tunnel Option	The large tunnel would reduce the number of potential odor-producing storage facilities in the Ballard and Fremont/Wallingford neighborhoods. The large tunnel would have the greatest potential for odors at the downstream tunnel portal (likely located along the Ship Canal in the vicinity of Ballard), which would be controlled by an odor control facility. In neighborhoods where flow diversions would replace storage tanks/pipes, there would be less potential for odor impacts.
	Shared Ship Canal Tunnel Option	This option would have similar potential for impacts to the Shared West Ship Canal Tunnel Option, except that storage facilities with odor-producing potential would largely be eliminated in the Lake Washington Neighborhoods of Montlake, Portage Bay, and Leschi. The large tunnel would have the greatest potential for odors at the downstream tunnel portal (likely located along the south side of the Ship Canal), which would be controlled by an odor control facility. Additional flow diversions in Duwamish and Delridge would further reduce the number of potentially odor-producing storage facilities in those neighborhoods.
Integrated Plan Alternative		In addition to the operational impacts of the selected LTCP option, the air quality impacts of the stormwater projects specific to the Integrated Plan Alternative are anticipated to be minor. Similar to CSO storage facilities, the South Park Water Quality Facility has the potential to generate odors. However, this impact is expected to be minimal because stormwater has fewer odor generating compounds than wastewater or combined sewer overflows. Street sweeping has the potential to temporarily increase localized dust and emissions, but increases would be minimal and occurring at night. There are no operational air-related impacts associated with NDS Partnering.
No Action Alternative		No air quality impacts or increased odors are anticipated from the ongoing sewer system improvements and NDS programs.

Table 1-3. Summary of Operational Impacts

Measures to reduce or minimize potential impacts	The City would undertake the following measures: • All storage facilities would be designed with state-of-the-art odor control systems. • The City would operate storage facilities to minimize the potential for odors by limiting how long combined sewage is stored in the facilities, maintaining air space at slightly negative pressures, and scheduling maintenance of odor control systems during cold temperatures and periods of low flow.
Surface Water	
Long Term Control Plan Alternative	The LTCP Alternative would result in substantial pollutant loading reduction from existing uncontrolled CSO outfalls when compared with the No Action Alternative. Pollutant loadings from control of 22 currently uncontrolled CSOs would be substantively reduced and would come into compliance with the Clean Water Act and the requirements of the Consent Decree. The Ship Canal/Lake Union, Lake Washington, Duwamish River, Longfellow Creek, Elliott Bay and Puget Sound would receive reduced discharges from CSOs. The Integrated Plan Alternative would result in greater pollutant loading reductions than the LTCP Alternative.
Integrated Plan Alternative	Reduced pollutant loadings would be greater than those achieved by the LTCP alone because of the additional reductions achieved by stormwater projects. The Integrated Plan would provide greater reductions in total suspended solids, PCBs, total copper, total zinc, total phosphorus, and fecal coliform. Relative reductions would be highest for the Duwamish Waterway, which was identified as the highest priority water body by the Integrated Plan team because of the sensitivity of its resources within those water bodies. Deferral of six CSO projects would result in delayed reduction of loads that constitute less than 10 percent of the total CSO loads currently being discharged. These CSOs were identified for deferral primarily because they are already close to being controlled and have relatively low average annual discharge volumes. Discharges from the deferred CSOs into Portage Bay and the Duwamish Waterway would continue until the projects are constructed between 2028 and 2030.
No Action Alternative	Under the No Action Alternative, pollutant loadings to receiving water bodies would not be reduced beyond levels provided from construction of projects included in the 2010 CSO Control Plan and currently planned NDS projects. This alternative does not comply with the Consent Decree, and it would result in significant fines for the City. This alternative is not consistent with the City's Plan to Protect Seattle's Waterways.
Measures to reduce or minimize potential impacts	The Plan Alternatives are intended to reduce surface water impacts and comply with the Clean Water Act and the Consent Decree. Additional water quality benefits will be achieved through ongoing watershed management efforts, stormwater management programs, and other cooperative efforts with watershed managers throughout the region.
Biological Resources	
Long Term Control Plan Alternative	The LTCP Alternative would result in negligible to minor impacts from operation of the storage facilities in the Plan area. There would be long-term beneficial effects on fish and aquatic life from reducing CSOs. Implementation of the LTCP would reduce the volume of untreated sewage and stormwater runoff, thereby reducing the potential for related impacts on aquatic life. Implementation of the LTCP would comply with the Consent Decree as well as other federal and state requirements.

Table 1-3. Summary of Operational Impacts

Integrated Plan Alternative	In addition to the benefits associated with the LTCP CSO control facilities, there would be additional pollutant reductions to the Duwamish waterway, Thornton Creek, Piper's Creek, and Longfellow Creek. The expanded Street Sweeping program would also benefit Lake Union/Ship Canal, Elliott Bay and Puget Sound. Reductions in pollutant loading would benefit aquatic resources in these waterways. NDS Partnering would help reduce high flow pulses that can adversely affect aquatic life in the creeks.
No Action Alternative	The No Action Alternative would result in no additional improvements to CSO reductions in the Plan area, which could have long term adverse effects on fish and aquatic life including listed species.
Measures to reduce or minimize potential impacts	Because none of the Plan alternatives are expected to cause adverse impacts to biological resources, no mitigation measures are proposed.

Energy and Climate Change

Long Term Control Plan Alternative	Key Findings	The LTCP would have minor operational effects on energy use in the city. The greenhouse gas (GHG) emissions produced by operating and maintaining CSO facilities are not expected to cause appreciable climate change impacts. The City has incorporated climate change modeling in its development of Plan alternatives and would incorporate additional modeling in the design of individual CSO facilities to minimize risks from anticipated changes in precipitation and sea level rise.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> The CSO control facilities would have minor operational effects on energy use as a result of pumping and electrical equipment requirements. Although operating the CSO equipment can be energy intensive, most of the equipment operates infrequently, only during storm events. Therefore, the CSO equipment is expected to have a minor impact on energy use or demand in the Plan area. The GHG emissions produced by operating and maintaining CSO control facilities are expected to be minor. The City has incorporated climate change modeling in its development of Plan alternatives and would incorporate additional modeling in the design of individual CSO control facilities to minimize risks from anticipated changes in precipitation and sea level rise. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar).
	Shared Storage Option	The CSO facilities included in the Shared Storage Option would have somewhat higher electrical requirements than the City independent CSO facilities included in the Neighborhood Storage Option because of the greater energy requirements of the larger shared storage tanks. However, overall energy use would be expected to be lower because the shared tanks eliminate 10 City and 3 King County independently constructed CSO facilities.
	Shared West Ship Canal Tunnel Option	The Shared West Ship Canal Tunnel Option would potentially have a higher electrical requirement than the City neighborhood CSO facilities included in the Neighborhood Storage Option and the shared storage tanks included in the Shared Storage Option because of the electricity needed to pump the deeply stored water. However, overall energy use would still be minor and would be expected to be further reduced as this option eliminates 4 City and 1 King County independently constructed CSO facilities.

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	Shared Ship Canal Tunnel Option	The Shared Ship Canal Tunnel Option would have slightly higher than the West Ship Canal Tunnel because of the electrical energy requirements of the larger tunnel. However, overall energy use would be expected to be the most reduced under this option compared to the Neighborhood Storage Option because it eliminates 15 City and 3 King County independently constructed CSO facilities, the most of all the options.
Integrated Plan Alternative		In addition to the CSO control facilities under the LTCP, the South Park Water Quality Facility would use energy on an intermittent basis.
No Action Alternative		Energy requirements from operation of projects implemented under ongoing programs are minimal. Existing CSO control facilities located in areas prone to sea level rise could be flooded, reducing their ability to effectively handle CSO events.
Measures to reduce or minimize potential impacts		The City would undertake the following measures to reduce the impacts of CSO control facilities on energy and to protect the facilities from the risks of climate change: • Comply with state and city requirements related to energy efficiency of the new CSO control facilities. • Include evaluations of GHG emissions as required by the City in project-level SEPA analyses. • Incorporate climate change modeling into design of CSO control facilities. • Utilize the adaptation planning pathways incorporated in the City's <i>Sea Level Rise Planning Guidance for Capital Projects</i> (City of Seattle, 2011d) to design and locate CSO control facilities.
Environmental Health and Public Safety		
Long Term Control Plan Alternative		Overall, the LTCP Alternative is expected to reduce environmental health risks associated with CSOs by reducing untreated discharges. Reductions of CSO discharges to water bodies where water contact recreation occurs, including Lake Union, the Ship Canal, Lake Washington, and the Duwamish Waterway, would reduce the potential for CSO-related environmental health risks in those water bodies.
Integrated Plan Alternative		In general, reduction in environmental health risks would be greatest under the Integrated Plan Alternative. Pollutant load and human exposure evaluations conducted as part of the Integrated Plan indicated that pathogens and toxic organic and inorganic constituents would be reduced to a greater level under the Integrated Plan Alternative than the LTCP Alternative. Once the deferred CSO projects are implemented, they will add to the long term loading reduction achieved by the Integrated Plan Alternative. Residents have expressed concerns about health risks associated with rain gardens, including safety risks associated with ponded water, and potential for mosquito breeding. With proper design and maintenance, these issues are not expected to occur.
No Action Alternative		Under the No Action Alternative, water quality in surface waters throughout the Plan area would continue to be negatively impacted by CSO releases from uncontrolled outfalls. Contaminated water could continue to affect swimming beaches and fishing areas, causing environmental health impacts. The No Action Alternative is not compliant with the Consent Decree, and is not consistent with the City's Plan for Protecting Seattle's Waterways.
Measures to reduce or minimize potential impacts		As part of ongoing programs, the City undertakes the following measures to minimize impacts of NDS projects:

Table 1-3. Summary of Operational Impacts

		- The City maintains roadside rain gardens to prevent standing water and reduce the potential for mosquito breeding. - The City provides education and incentives to encourage property owners to maintain rain gardens.
Noise and Vibration		
Long Term Control Plan Alternative	Key Findings	The net operational effects of the LTCP Alternative would be minor in the Plan area. Noise would be intermittently generated under all options by pump stations and odor control facilities. All facilities would be designed and maintained to reduce noise to permissible levels.
	Neighborhood Storage Option	<i>Neighborhoods (Tanks/Pipes):</i> Because the Neighborhood Storage and Shared Storage Options would have the most pump stations and other facilities, they would have a higher potential for noise impacts. Some pump stations and mechanical facilities could be located in residential areas, particularly in the Lake Washington, Longfellow Creek/Duwamish, and Ship Canal Neighborhoods. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar).
	Shared Storage Option	Impacts would be similar to the Neighborhood Storage Option but there would be additional noise-generating pump stations and mechanical facilities.
	Shared West Ship Canal Tunnel Option	Because the Shared West Ship Canal Tunnel Option and the Shared Ship Canal Tunnel Option would have fewer pump stations and mechanical facilities than the Neighborhood and Shared Storage Options, they would have a lower potential for noise impacts.
	Shared Ship Canal Tunnel Option	Because the Shared West Ship Canal Tunnel Option and the Shared Ship Canal Tunnel Option would have fewer pump stations and mechanical facilities than the Neighborhood and Shared Storage Options, they would have a lower potential for noise impacts.
Integrated Plan Alternative		CSO storage pipes, tanks, and tunnels constructed under the Integrated Plan Alternative would have the same operational noise impacts as under the LTCP Alternative, but implementation would be delayed in some neighborhoods. Operation of the elements specific to the Integrated Plan Alternative would have minimal noise impacts. Natural drainage systems would not generate noise. Street sweeping, which would occur at night, would only occur on arterial streets and would not generate noise in excess of typical vehicle noise. The South Park Water Quality Facility could generate some operational noise from ventilation fans and maintenance activities. However, the facility would be located in an industrial area and operational noise would not impact residences or other sensitive receptors.
No Action Alternative		Operation of sewer system improvements and NDS projects implemented under ongoing programs would not generate noise.
Measures to reduce or minimize potential impacts		A noise analysis for each project would be performed during final design. Information on sensitive noise receiving properties and site-specific characteristics will be used to determine location-specific mitigation measures. Potential mitigation measures could include:

Table 1-3. Summary of Operational Impacts

		- Pump station and odor control facility designs would include attenuation measures for fan noise and pump and motor noise as needed to comply with noise levels specified by the City of Seattle and to address location-specific factors as determined during project design. - Facility vault access hatches would be designed to be relatively thick and to have seals at the perimeters to contain noise within the vault. - Pumps, standby generators, and odor control equipment would be located in below ground structures.
Land Use and Visual Quality		
Long Term Control Plan Alternative	Key Findings	Potential land use impacts associated with CSO control projects include conversion of land in residential, commercial, or industrial areas to public utility uses. These impacts differ between the options because of different property requirements of tanks as compared to tunnels. The completed facilities would primarily be constructed below ground; aboveground facilities would have minimal visual impacts with the use of site appropriate design and screening.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> This option would have the most storage tanks located throughout the Plan area with the potential to cause permanent land use changes. Private property or permanent easements could be acquired for any of the LTCP options, but would likely be greatest under the Neighborhood Storage (and Shared Storage Options). Current land uses would be permanently changed to become storage facilities, however, the tanks and associated equipment would primarily be underground. The presence of underground storage tanks would restrict certain future uses on top of the facility. While there is the potential to redevelop the surface area into certain beneficial uses, the previous land use at the site could be permanently altered. Typical uses for the tops of storage tanks include passive recreation, athletic fields and parking facilities. More area would be retained in ownership or by permanent easement by the City for a storage tank than for a tunnel. Ballard would have the largest storage tank (occupying an estimated 60,000 square feet (SF)). The completed facilities would be designed to visually blend with the surroundings, but it is likely that they would have a different appearance from pre-construction conditions. Storage pipes would be constructed in street rights-of-way, and would have less potential for land use changes. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar).
	Shared Storage Option	The impacts would be similar to the Neighborhood Storage Option. While fewer sites in the Ship Canal Neighborhoods would be used for storage tanks, and no tank would be sited in the East Waterway area, potential land use impacts from siting larger shared tanks could occur in the Lake Washington Neighborhoods. These tanks would occupy an estimated 35,000 SF (North Union Bay) and 40,000 SF (Montlake). There is a greater potential for conversion of residential lands for storage tanks in the Lake Washington Neighborhoods under this option. As noted above, more area would be retained in ownership or by permanent easement by the City for a storage tank than for a tunnel, and the presence of an underground tank restricts certain future uses of the site.

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	Shared West Ship Canal Tunnel Option	This option would have less potential for long-term land use impacts than both the Neighborhood Storage and Shared Storage Options since the tunnel would replace the need to site several storage tanks in the Ship Canal Neighborhoods (Ballard and Fremont/Wallingford), and less property would need to be retained following construction. In contrast to storage tanks, the City would be able to sell or lease approximately 75 percent of the tunnel launch portal lands in Ballard required for construction back to private ownership where it could be developed for zoned uses (e.g., industrial, commercial). Approximately 0.5 acre of the launch portal would be retained by the City to house the pump station, odor control, and permanent shaft for access and maintenance. All of the area used for the smaller, recovery end of the tunnel in Fremont/Wallingford would be retained by the City. Some additional areas would be retained for permanent shafts as required to accept flows from each contributing City and King County CSO area.
	Shared Ship Canal Tunnel Option	Similar to the Shared West Ship Canal Tunnel, less property would need to be retained following construction of the tunnel compared to the Neighborhood and Shared Storage Options. The City would be able to sell or lease approximately 75 percent of the tunnel launch portal lands on the south side of the Ship Canal required for construction back to private ownership where it could be developed for zoned uses (e.g., industrial, commercial). Approximately 0.5 acre would be retained by the City to house the pump station, odor control, and permanent shaft for access and maintenance. All of the area used for the smaller, recovery end of the tunnel in North Union Bay would be retained by the City. Compared to the Shared West Ship Canal Tunnel Option, the Ship Canal Tunnel would result in less potential for land use impacts in Ballard and more potential for land use impacts on the south side of the Ship Canal and in North Union Bay.
Integrated Plan Alternative		Stormwater projects constructed under the Integrated Plan are not expected to cause major long term impacts to land use. Long term land use impacts from NDS Partnering would be minimal, because the projects would be implemented in neighborhoods on a voluntary basis, and would be installed to blend with neighborhood character. The South Park Water Quality Facility would likely be sited in an industrial-zoned area, surrounded by industrial and commercial land uses. The visual impact of the facility is expected to be minimal.
No Action Alternative		Operation of sewer system improvements and NDS projects implemented under ongoing programs are not expected to result in land use or visual quality impacts. The planned CSO projects included in the City's NPDES Waste Discharge Permit and the 2010 Plan Amendment would have minor land use impacts. Visual quality impacts would be limited to the aboveground support facilities needed for the CSO projects and are also expected to be minor.
Measures to reduce or minimize potential impacts		The City would undertake the following measures to mitigate land use and visual quality impacts for all proposed projects: - Minimize the size of permanent aboveground facilities and design them to blend with the surroundings. - Locate and aim any artificial lighting away from adjacent roadways, residential areas, and water bodies. Use the minimum wattage necessary to provide the necessary illumination. - Sell or lease portal land in excess of what is needed back to private ownership.

Table 1-3. Summary of Operational Impacts

Recreation		
Long Term Control Plan Alternative	Key Findings	Overall, the operational effects from the LTCP Alternative on recreational activities are expected to be minor. Reductions in pollutant loading would benefit long term water quality and help maintain beneficial uses at area beaches. Water contact recreation in area water bodies would be enhanced by improved water quality in Lake Washington, Portage Bay, the Duwamish River, and Lake Union, in particular. Locating storage facilities in a park would constrain certain future uses of that area for park purposes. However, there is a potential to provide recreational facilities on top of storage tanks following construction.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> The Neighborhood Storage and Shared Storage Options would have the highest potential to cause park and recreation impacts because these options have the most tank facilities. Locating storage facilities in a park or its associated uses (such as parking) would constrain certain future uses of that area for park purposes. However, there is a potential to provide recreational facilities on top of storage tanks following construction. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar).
	Shared Storage Option	The impacts would be similar to the Neighborhood Storage Option. While fewer sites in the Ship Canal Neighborhoods would be used for storage tanks, potential recreation impacts from siting larger shared tanks could occur in the North Union Bay and Montlake neighborhoods if a tank is located in a park. The Montlake neighborhood, because of the relatively higher amount of parkland, including Montlake Boulevard (an Olmsted Park), has a greater potential to be affected under this option. The storage tank in North Union Bay would be located in proximity to the University of Washington Athletic Complex (including fields, a golf course, a ballpark, and an outdoor track) and the Union Bay Natural Area.
	Shared West Ship Canal Tunnel Option	This option would have less potential for long-term impacts to recreation than both the Neighborhood Storage and Shared Storage Options since the tunnel would replace the need to site several storage tanks in the Ship Canal Neighborhoods (Ballard and Fremont/Wallingford), with less potential for recreation impacts.
	Shared Ship Canal Tunnel Option	Compared to the Shared West Ship Canal Tunnel Option, the Ship Canal Tunnel would result in less potential for recreation impacts in Ballard and more potential for impacts on the south side of the Ship Canal and in North Union Bay if the tunnel portals are sited in a park or recreation area. Parks and recreation areas in these areas include athletic fields owned and operated by Seattle Pacific University and the University of Washington, as well as the Burke Gilman Trail, and numerous neighborhood parks.
Integrated Plan Alternative		Storage pipes, tanks, and tunnels constructed under the Integrated Plan Alternative would have the same recreation impacts as under the LTCP Alternative, but implementation would be delayed in some neighborhoods. Operation of the stormwater projects specific to the Integrated Plan Alternative is not expected to result in any additional adverse recreation impacts. Additional water quality improvements in the Plan area water bodies would have indirect benefits to recreation at swimming beaches, particularly in Lake Washington and Lake Union.

Table 1-3. Summary of Operational Impacts

No Action Alternative		The No Action Alternative would result in no additional improvements to water quality in the Plan area water bodies, with ongoing potential for adverse indirect effects on recreation at swimming beaches.
Measures to reduce or minimize potential impacts		The City would comply with the conditions of Initiative 42 (Ordinance No. 118477) related to siting public facilities in parks. Additional site-specific measures, including mitigation for project-related impacts, would be identified during project design.
Historic, Cultural, and Archaeological Resources		
Long Term Control Plan Alternative		Operation of projects implemented under the LTCP Alternative is anticipated to have no effect on historic, cultural, and archaeological resources within the Plan area.
Integrated Plan Alternative		No additional effects on historic, cultural, and archaeological resources within the Plan area are anticipated under the Integrated Plan Alternative.
No Action Alternative		Operation of projects implemented under ongoing programs is anticipated to have no effect on historic, cultural, and archaeological resources within the Plan area.
Measures to reduce or minimize potential impacts		No mitigation would be required.
Transportation		
Long Term Control Plan Alternative		Overall, the operational effects from vehicle trips generated by facility maintenance under the LTCP Alternative are expected to be minor.
Integrated Plan Alternative		Operation of the additional projects implemented under the Integrated Plan Alternative would have minimal transportation impacts. The South Park Water Quality Facility could generate occasional vehicle trips with minimal effect on roadway operations. Street sweeping would primarily occur at night when traffic volumes are low, and would not affect roadway operations or parking.
No Action Alternative		Completed projects under the No Action Alternative are not expected to cause transportation impacts.
Measures to reduce or minimize potential impacts		Because there would be no impacts to transportation, no mitigation measures are proposed.
Utilities		
Long Term Control Plan Alternative	Key Findings	Implementation of the LTCP will require close coordination with numerous utilities, in particular, wastewater and stormwater utilities within the service area. Because the City's collection system network sends wastewater to King County for treatment, coordination with King County will be particularly important. King County's West Point Treatment Plant would receive additional sewage flows as a result of Plan implementation. The high variability in flow rates within the sewer system associated with heavy storms could be challenging to manage at the King County West Point Treatment Plant. Based on City modeling, these additional flows will have little effect on the peak loading to King County's West Point Treatment Plant and may potentially reduce peak loading. However, annual average flows will increase, resulting in greater operational and maintenance costs. Seattle and King County will address the incremental cost of these flows in their sewage disposal agreement.

Table 1-3. Summary of Operational Impacts

		The potential implications to King County's combined sewer system vary depending upon the option implemented, as described below. In general the operational implications associated with shared options will require greater coordination with King County than the Neighborhood Storage Option.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> This option would generally have minimal operational impacts to utilities once construction is complete. However, this option would require the greatest length of sewer pipe construction, with accompanying maintenance requirements. Sewer system improvements in North Union Bay could have operational implications to King County, which would be resolved according to agreements negotiated with King County. Selection of this option would necessitate the need for King County to construct the largest number of independent storage facilities to meet regulatory requirements. <i>Neighborhood West Ship Canal Tunnel:</i> Impacts would be the same as described above.
	Shared Storage Option	Impacts would be similar to those described for the Neighborhood Storage Option. However, flow diversion projects in cooperation with King County would result in potential operational considerations for both King County and the City. Potential operational implications would be coordinated with King County to ensure that detrimental impacts do not occur.
	Shared West Ship Canal Tunnel Option	As described above, shared storage and flow diversion projects have operational implications to King County and the City. A large shared tunnel and flow diversions to King County in the East Waterway and Magnolia neighborhoods would be implemented in accordance with operational agreements between the City and King County. The Shared West Ship Canal Tunnel Option may reduce the operational complexity of controlling neighborhood storage tanks or shared storage tanks, as it provides one large storage facility for all flows to be managed through a single pump station discharging to King County's West Point Treatment Plant. Close coordination with King County would be needed to optimize operational benefits.
	Shared Ship Canal Tunnel Option	This option involves the City and King County sharing a deep tunnel, and includes four flow diversions to King County facilities. This option requires the highest level of coordination with King County, to reduce the potential for impacts. Extensive coordination between the City and King County would be conducted to develop operational agreements that are workable and efficient for both entities.
Integrated Plan Alternative		Impacts to public utilities would primarily be related to selection of an LTCP option. No additional impacts are expected to occur related to the implementation of Integrated Plan stormwater projects.
No Action Alternative		Implementation of the No Action Alternative would not comply with the Consent Decree, and could potentially result in significant fines for the City, with potential impacts to City ratepayers.
Measures to reduce or minimize potential impacts		For all LTCP options, the City would work together with King County to analyze and mitigate downstream operational and capital impacts to the King County System. If downstream impacts cannot be successfully mitigated, then there is the potential that the County will be required to build new or larger downstream capital facilities to accommodate the LTCP options. Even with adequate mitigation though, there would likely be an increase in the County's operations & maintenance (O&M) costs to account for the additional flows from the City's system.

Table 1-3. Summary of Operational Impacts

Socioeconomics and Environmental Justice	
Long Term Control Plan Alternative	The operational effects of the LTCP Alternative would be minor to moderately beneficial associated with improved water quality in area receiving waters, and there would be no adverse operational effects that would be predominantly borne by minority or low-income populations and underserved communities.
Integrated Plan Alternative	The operational effects of the additional Integrated Plan stormwater projects would be minor to moderately beneficial, and there would be no adverse operational effects that would be predominantly borne by minority or low-income populations and underserved communities.
No Action Alternative	CSO discharges would not be reduced beyond levels outlined in the City's NPDES Waste Discharge Permit and 2010 CSO Control Plan, so no further improvements in current environmental health risks would occur. These health risks are predominantly borne by low-income, tribal, and subsistence fishing communities. Sewer system improvements and NDS programs included in the No Action Alternative are not expected to cause socioeconomic or environmental justice impacts.
Measures to reduce or minimize potential impacts	The City would continue public participation efforts as projects are advanced consistent with the City's social and racial justice initiative.

1.12 Selection of a Preferred Alternative

Foremost in the development of the Plan is the need to comply with the Consent Decree and meet federal and state regulatory requirements. In order to comply with the Consent Decree, The City must select and implement an LTCP option. It is possible that the final option selected may include a combination of options or facilities presented in the EIS. An Integrated Plan is an optional approach that is not required by EPA, but can be used to satisfy the Consent Decree.

The Plan for Protecting Seattle's Waterways, which consists of the following four volumes, will be submitted to EPA and Ecology for review and comment:

- Volume 1: Executive Summary
- Volume 2: CSO Long Term Control Plan
- Volume 3: Integrated Plan
- Volume 4: Programmatic EIS

The City will also continue to implement a public process and outreach to solicit input from the public and other stakeholders, including input received during a public hearing for the EIS and a public meeting on the Plan. The City will weigh the results of its multiple objective decision analysis (MODA) for the LTCP and the Integrated Plan, address EPA and Ecology comments, and consider costs and input from the public and other stakeholders to identify a preferred alternative. Identification of a preferred alternative is expected to occur in early 2015 following release of the Final EIS.

CHAPTER 2

Introduction and Background

Seattle is served by a complex system of pipes that handle the stormwater and wastewater flows generated by businesses and residents. The pipes are part of one of three basic types of systems: a separate storm sewer system that carries stormwater only; a sanitary sewer system (SSS) that carries sewage only; and a combined sewer system (CSS), which conveys a mixture of sewage and stormwater (Figure 2-1).

During heavy rains, sewer pipes that carry a combination of untreated sewage and stormwater can be overwhelmed by stormwater, causing overflows into creeks, lakes, rivers, and Elliott Bay. These overflows are called “combined sewer overflows” or CSOs. These CSOs contribute pollutants to surrounding water bodies, impacting their quality and uses. In addition, stormwater runoff from streets, parking lots, and buildings in separate pipes contributes a wide range of pollutants to the city's waters.

As part of its **Plan to Protect Seattle's Waterways** (the Plan), the City of Seattle (City) is preparing a comprehensive strategy to reduce overflows and discharge of pollutants from combined sewers and stormwater runoff, in order to protect public health and the environment and to comply with federal and state regulations. When implemented, the Plan will bring Seattle into compliance with State of Washington CSO regulations and EPA requirements to have a Long Term Control Plan for reducing CSOs. Specifically, the Plan will achieve the following objectives:

- Identify areas of Seattle where projects are needed to reduce combined sewer overflows.
- Evaluate alternatives for reducing combined sewer overflows in these areas.
- Identify additional areas where projects to control and reduce polluted stormwater runoff will improve water quality.
- Recommend a schedule for designing and constructing projects.
- Estimate program costs and associated impacts on customer bills.
- Consider regulatory, public and stakeholder input.

As part of this process, the City is preparing a plan-level or “programmatic” environmental impact statement (EIS). This programmatic EIS evaluates the environmental impacts associated with the following three alternatives:

- The Long Term Control Plan (LTCP) Alternative, which is focused on reducing combined sewer overflows;
- The Integrated Plan Alternative, which includes reduction of both combined sewer overflows and stormwater pollution; and
- A No Action Alternative, as required by the State Environmental Policy Act (SEPA).

The alternatives are discussed in more detail in Chapter 3.

2.1 Seattle's Sewer System

Early sewer systems in Seattle and many other cities were designed to carry combined flows of sanitary sewage and stormwater runoff in the same pipe. The City's first combined sewer system was built in the early 1890s, in an effort to reduce the threat of waterborne diseases caused by sewers and cesspools that were discharging into lakes and Puget Sound. Many of these combined sewer systems remain in service today.

Beginning in the 1950s, new additions to Seattle's sewer system were designed as separated systems, with separate networks of pipes for sewage and stormwater. Since the 1960s, the City has undertaken a number of efforts to partially separate previously combined systems. In partially separated systems, stormwater from streets and parking lots is diverted into separate storm drains, but stormwater from other sources, mostly building roofs, still enters a combined system.

Today, Seattle's wastewater collection system is a combination of combined, partially separated, and separated areas (see Figure 2-1). About two-thirds of Seattle is served by a combined or partially separated sewer system (968 miles of pipe). Separated systems serve the other one-third (448 miles of pipe). The City conveys most of its wastewater to King County sewers for conveyance to County-operated treatment facilities.

2.2 Why are CSOs a problem?

Flows within both the sanitary sewer system and combined sewer system are sent to the West Point Wastewater Treatment Plant and are treated before being discharged to Puget Sound. Under dry weather conditions in Seattle, the combined sewer system typically has adequate capacity to handle the flows. During wet weather conditions, however, stormwater runoff from streets, parking lots, and roof drains is considerable and can cause the capacity of the sewer system to be exceeded. As long as the flow rates are within the capacity of the sewer system, all of the flows are conveyed to the wastewater treatment plant. However, if flow rates in the combined sewer exceed the capacity of the system, the excess flow of stormwater and untreated sewage is discharged into water bodies through permitted outfalls, resulting in a CSO.

The first image in Figure 2-2 depicts what occurs under heavy rain conditions in combined sewer systems. The separated and partially separated systems discharge mostly untreated stormwater into local water bodies.

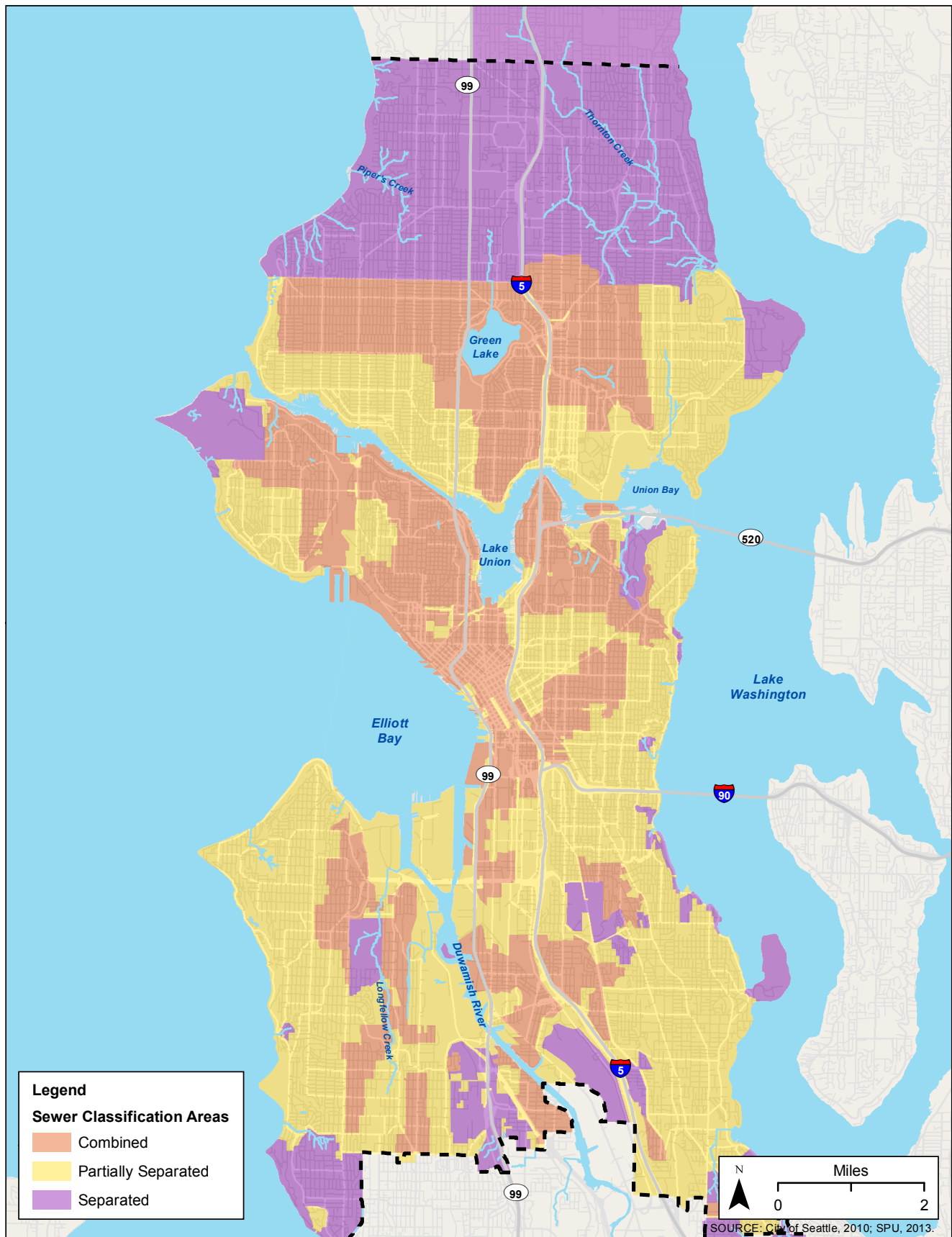
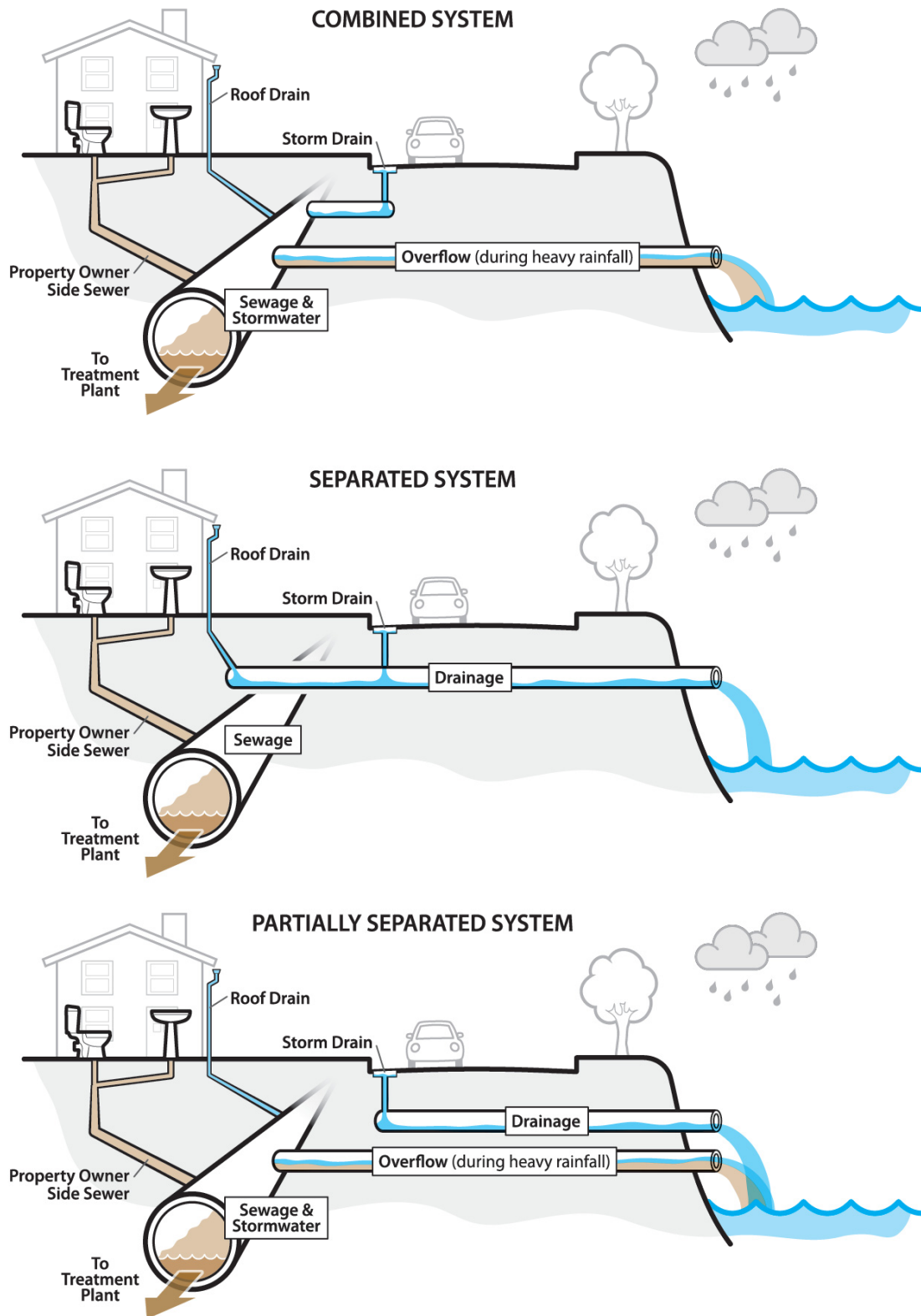


Figure 2-1 Seattle's Sewer and Drainage System.



SOURCE: SPU, 2014.

Figure 2-2. Sewer System Schematics.

CSOs release untreated wastewater and stormwater into a water body. Pollutants in these discharges include dissolved and particulate heavy metals and chemicals adsorbed (attached) to particles that settle to the bottom. Evidence suggests that CSOs can cause contamination of sediments near outfalls (King County, 2010) that could affect humans and/or fish coming in contact with those sediments. Additional information about potential environmental health risks associated with untreated CSO and stormwater discharges, and methods used to evaluate risks of exposure to contaminants of concern is included in Chapter 6 of *Volume 3, Integrated Plan*.

Human health risks can occur through swimming, scuba diving, wading, or fishing in waters that receive untreated CSO and stormwater discharges. People can be exposed to pathogens or other pollutants through direct contact with contaminated water or sediments (e.g., swimming or wading), ingestion of pathogen-containing water, or eating contaminated fish or shellfish. Pathogens of particular importance when considering CSOs include bacteria and viruses, which are present in untreated wastewater. Potentially toxic pollutants such as petroleum products or metals conveyed in stormwater are also important environmental health concerns in CSOs. CSO releases can contain pharmaceuticals, personal care products, and endocrine-disrupting chemicals.

2.3 Why is stormwater a problem?

Stormwater is rain and melting snow that runs off surfaces that cannot readily absorb water, such as streets, rooftops, and parking lots. As stormwater runs across these hard surfaces, it picks up pollutants such as oil, grease, and metals, carrying them through the City's storm drain system to lakes, streams, rivers, and Puget Sound. It also flows into the combined sewer system and can cause overflows of raw sewage and polluted stormwater into Seattle waterways. Recent scientific studies have determined that polluted stormwater runoff poses a significant impact to local water quality.

Both stormwater discharges and CSOs contain similar contaminants, but in different concentrations. As described for CSOs, stormwater contains bacteria, petroleum byproducts, toxic organics and metals, and other pollutants deposited on streets and other impervious surfaces. Stormwater discharges occur nearly every time it rains, while CSO events generally occur only during larger storms. Combined sewage includes the pollutants contained in stormwater but typically much higher levels of bacteria and other disease-causing pathogens, because the stormwater is mixed with sewage. In terms of overall volume of discharge, stormwater has a substantially greater volume on a regional scale, and a higher annual contribution to total pollutant loading in water bodies and environmental health considerations and similar to those described for CSOs. Additional information on constituents of concern in stormwater is included in Chapter 6 of *Volume 3, Integrated Plan*.

2.4 What is the regulatory framework for CSO control?

The regulatory basis for controlling CSOs stems from the federal Clean Water Act, EPA CSO Control Policy, state requirements, and the July 2013 federal court-ordered Consent Decree. Background on these requirements is included below.

2.4.1 Clean Water Act/NPDES Requirements

The federal Clean Water Act (33 United States Code 1251) requires water quality sufficient to allow people to swim, boat, fish, and enjoy our waterways. The law's requirements are intended to protect the environment, human health, and quality of life. Municipalities must obtain authorization to discharge wastewater, CSOs, and stormwater into surface water bodies. The Clean Water Act established the National Pollutant Discharge Elimination System (NPDES) program. The program limits the discharge of pollutants in order to meet water

quality criteria. In Washington, the NPDES program is administered by the Washington State Department of Ecology (Ecology). Ecology's regulations in the Washington Administrative Code (Chapter 173-220) govern individual NPDES permits, such as the City's wastewater collection system permit.

The City manages sewage and stormwater throughout Seattle. Stormwater is managed in accordance with NPDES municipal stormwater permit requirements, administered by Ecology. The City reports progress on its compliance activities annually to Ecology. The stormwater permit applies to the municipal separate storm sewers operated by the City within the geographic boundaries established by the permit.

The City's most recent wastewater NPDES permit (WA0031682) was issued on October 27, 2010 and modified on September 13, 2012; it allows wet weather discharges from permitted CSO outfalls. The permit also requires implementation of the "Nine Minimum Controls" to ensure adequate capacity and maintenance of the sewer system, defines monitoring requirements, establishes requirements for detailed reporting to Ecology, and allows discharges only as a result of precipitation events. The NPDES permit also defined the performance requirements for a controlled CSO outfall as one untreated discharge per year per outfall, on a moving 20-year average. In addition, the City must identify any improvements that have occurred since the last permit authorization. The City's next CSO NPDES permit will be issued in October 2015.

2.4.2 U.S. Environmental Protection Agency CSO Control Policy

EPA's Combined Sewer Overflow Policy is the national framework for control of CSOs through the NPDES permitting program. Published on April 19, 1994, the policy provides guidance on how communities with combined sewer systems can meet Clean Water Act goals in as flexible and cost-effective a manner as possible.

The policy has the following three main elements:

- Nine Minimum Controls;
- Long Term Control Plans; and
- Requirement to Meet Water Quality Standards.

The Nine Minimum Controls are measures that can reduce the prevalence and impacts of CSOs and that are not expected to require significant engineering studies or major construction. The CSO Policy included a deadline of January 1, 1997, for implementing the Nine Minimum Controls, which are listed below:

1. Proper Operation and Maintenance
2. Maximum Use of Collection System for Storage
3. Review and Modify Pretreatment Requirements
4. Maximize Flow to the Treatment Facility
5. Eliminate Dry Weather Overflows
6. Control of Solid and Floatable Materials in CSOs
7. Pollution Prevention
8. Public Notification Regarding CSO Occurrences and Impacts
9. Monitoring to Characterize CSO Impacts and Efficacy of CSO Controls

The next CSO control milestone established by the policy is the development of long-term CSO control plans. Long-term control plans are tools to help municipalities comply with the Clean Water Act, and they include the following elements:

1. Characterization, monitoring, and modeling of the combined sewer system;
2. Public participation;
3. Consideration of sensitive areas;
4. Evaluation of alternatives to meet Clean Water Act requirements using either the "presumption approach" or the "demonstration approach."
5. Cost/performance considerations;
6. Operational plan;
7. Maximizing treatment at the existing treatment plant;
8. Implementation schedule; and
9. Post-construction compliance monitoring program.

2.4.3 State Requirements

Washington state law (Revised Code of Washington 90.48.4802) requires local governments to achieve the greatest reasonable reduction in CSOs at the earliest possible date. The Washington Administrative Code (173-245-240) defines the "greatest reasonable reduction" as a long-term average of no more than one untreated discharge per year per outfall.

As stipulated in the City's most recent wastewater NPDES permit, the deadline agreed to by Ecology and the City for achieving the greatest reasonable reduction is December 31, 2025. On an annual basis, the City is required to report the duration and volume of each CSO discharge during the most recent year, steps taken during the most recent year to reduce CSOs, the CSO outfalls now meeting the definition of greatest reasonable reduction (a 20-year moving average of no more than one untreated discharge per year per outfall), and work planned for the next year to reduce CSOs. In 2015, the City is required to submit an updated plan to Ecology (the Long Term Control Plan), describing the remaining projects that will be implemented to reduce and bring CSOs under control.

2.4.4 Consent Decree

In July 2013, the City of Seattle entered into a Consent Decree with the Washington State Department of Ecology, the U.S. Environmental Protection Agency, and the U.S. Department of Justice. Requirements listed in the Consent Decree describe the actions that the City must take to address CSO overflows that violate the Clean Water Act. CSO outfalls must meet a performance standard to achieve the "greatest reasonable reduction" to be considered "controlled" in accordance with WAC 173-245-020(22). A "controlled" CSO has an average of not more than one untreated discharge event annually on a 20-year moving average. The Consent Decree has established a deadline of December 2025 for completion of all control measures.

What is the Consent Decree?

The Consent Decree is a written agreement between the City of Seattle, Washington State Department of Ecology, EPA, and the U.S. Department of Justice that describes the actions that the City of Seattle must take to address violations of the Clean Water Act.

The Consent Decree includes a number of requirements for control of CSOs, including implementation of early action CSO control program and measures, and the development and implementation of a long-term control plan and post-construction monitoring plan. Additional information on the Consent Decree and specific deadlines for meeting requirements is included in Chapter 1 of *Volume 2, LTCP*.

Until recently, EPA and Ecology have focused primarily on combined sewer systems when administering NPDES CSO discharge requirements. Seattle and other cities across the country have asked EPA for greater flexibility to make smart investments, using a range of tools to achieve federal and state water quality requirements, allowing jurisdictions to customize approaches to their specific situations. Recognizing the contribution of stormwater to water quality issues in local water bodies, and recognizing the overall benefits that can be achieved from a blend of stormwater and CSO control projects, the City's negotiated Consent Decree allows the City to propose a more flexible and integrated approach for Seattle's compliance with the Clean Water Act and state regulations. The Consent Decree still requires the City to submit an LTCP by 2015, but it allows the City to develop, as an alternative, an "Integrated Plan" that proposes stormwater control projects to be implemented by the City prior to construction of some CSO facilities.

The Consent Decree also includes a number of additional requirements for the Integrated Plan, including a pollutant load reduction analysis and an evaluation of projected benefits to water quality, ecology, and human health that would result from implementing the identified stormwater projects. The Integrated Plan must demonstrate that the proposed stormwater projects will provide greater water quality benefits compared to those CSO projects that would be deferred, and that they would meet the requirements of the Clean Water Act, the City's NPDES and municipal separate storm sewer system (MS4) permits, and EPA's CSO Control Policy.

The Consent Decree encourages the use of Green Infrastructure (referred to as natural drainage systems in this EIS) as appropriate to reduce or replace certain CSO control measures included in the LTCP based on demonstrated effectiveness, together with the traditional engineered measures, as long as these combined measures provide substantially the same or greater levels of control than the traditional CSO control measures alone. The Consent Decree requires construction to be completed on all CSO control measures included in the approved LTCP by December 2025, unless EPA and Ecology approve a different schedule as part of approving an Integrated Plan.

2.5 Seattle's Previous CSO Reduction Efforts

Planning for CSO control is a dynamic process that must respond to changing regulations and conditions. To date, the City has completed projects from five CSO control plans, beginning in 1980. Some of the projects involved maintenance or modification of existing sewer facilities. Others involved construction of diversion structures to direct flows away from CSO outfalls, or construction of storage facilities to store excess wastewater until flows decrease enough for the stored wastewater to be returned to the conveyance system. The major CSO reduction planning efforts are summarized in Table 2-1.

Table 2-1. Seattle's Previous CSO Reduction Efforts

Recent CSO Reduction Efforts	Description
1980 Facility Plan (201 Facilities Planning)	Included storage facilities for CSO reduction in high-priority areas (Longfellow Creek, Lake Washington and Puget Sound beaches) based on human contact potential and environmental protection.
1988 CSO Reduction Plan	Included storage facilities for CSO reduction in Portage Bay, Lake Union, the Ship Canal, Elliott Bay and the Duwamish River.
2001 CSO Reduction Plan Amendment	Proposed the implementation of various best management practices as a way to reduce the volume of CSOs prior to the implementation of additional storage projects. Reevaluated previously studied areas of Seattle and expanded the evaluation to include other areas.
CSO Reduction Plan Amendment 2005 Update	Evaluated the effectiveness of best management practice projects from the 2001 Amendment that had been completed, and revised cost estimates and schedules for remaining projects from the 2001 Amendment.
2010 CSO Reduction Plan Amendment	The 2010 CSO Reduction Plan Amendment was a regulatory requirement under WAC 173-245-090(2) and required as part of the City's wastewater NPDES permit (issued on November 30, 2005, and expired on November 30, 2010). Per the regulation, the plan must include three elements: (1) an assessment of the effectiveness of the CSO reduction plan to date; (2) a reevaluation of the CSO sites' projects priority ranking; and (3) a listing of projects to be accomplished in the next 5 years. The focus of the 2010 CSO Reduction Plan Amendment was CSO reduction projects in the timeframe of 2010-2015. The plan identified that by 2015, the City will accomplish the following projects: • Complete the construction of the Windermere CSO reduction project. • Substantially complete the construction of the Genesee CSO reduction project. • Initiate construction on the Henderson North CSO reduction project. • Construct green stormwater infrastructure projects in the Ballard CSO basin to measure the effectiveness of green solutions. • Complete the 2015 CSO Reduction Plan Amendment (the LTCP). The 2010 CSO Reduction Plan Amendment provided revised CSO baseline frequency and volume estimates and described CSO control alternatives (SPU, 2010).

2.6 Why do we need more CSO reduction efforts?

The City manages 87 CSO outfalls. Because of previous CSO reduction efforts, 52 are now characterized as “controlled,” meeting the Washington state standard of one overflow per year, on average. While Seattle has made great progress in reducing the number of CSOs over the years, a number of CSOs remain. In 2013, 38 MG of untreated sewage and stormwater discharged at CSOs managed by the City. Combined sewer overflows from the City’s combined sewer system currently discharge into Puget Sound, Elliott Bay, Lake Washington, Longfellow Creek, Duwamish Waterway, and Lake Union/Ship Canal.

Addressing the Remaining CSOs

Over the last 25 years, the City of Seattle has successfully reduced CSO discharge volumes into surrounding receiving waters by nearly 70 percent. However, there is still work to be done to control the remaining CSOs, and the final reduction in CSO volume is the most challenging.

CSOs present a range of public health and environmental concerns. Pollutants conveyed in CSOs can create human health risks from contact with water or consumption of fish/shellfish from areas of recent CSO discharge and can cause impacts to aquatic life. In extreme rainfall events, localized backups can occur. The high variability in flow rates within the sewer system associated with heavy storms can also cause operational problems at the wastewater treatment plant.

In addition to the environmental and public health concerns, the City of Seattle is required to control CSOs in order to comply with federal and state regulatory requirements. These requirements are further described below.

2.7 What is the Long Term Control Plan?

As part of its regulatory compliance efforts, the City must update its CSO Reduction Plan every five years. As described above, the City prepared its first plan in 1988 with amendments in 2001, 2005, and 2010, and has undertaken a number of CSO control efforts under those plans, including recent projects such as the Windermere, Genesee, and Henderson CSO control projects. The Long Term Control Plan (LTCP) is the City’s next update and presents a comprehensive program and schedule to reduce the remaining uncontrolled CSO discharges. The City must address these CSOs to protect public health and the environment, and to comply with the July 2013 Consent Decree and meet state and federal regulations for CSO control.

What is the LTCP?

The LTCP is an EPA-required Plan that defines a comprehensive program and schedule for implementing projects and measures to control overflows at the City’s remaining 22 uncontrolled CSO outfalls.

In 2013, 38 MG of untreated sewage and stormwater discharged from the City’s 87 managed outfalls, 35 of which are uncontrolled. Some of these uncontrolled CSO outfalls are being addressed separately through the 2010 CSO Reduction Plan Amendment projects (7 CSO outfalls to be controlled) and Consent Decree-required early action projects in the Henderson Basins (6 CSO outfalls to be controlled). Consistent with the Consent Decree, the remaining 22 uncontrolled outfalls will be controlled through implementation of the LTCP. The City used the previously approved 2010 CSO Reduction Plan Amendment as the foundation to prepare the LTCP. The Consent Decree indicates that the LTCP shall build upon the alternative analysis work that was performed as part of the amendment.

Figure 2-3 provides an overview of the surface water bodies in Seattle along with the location of the City’s

uncontrolled and controlled CSO outfalls. The uncontrolled CSO outfalls are addressed in this Plan and EIS.

The LTCP puts forth a cost-effective blend of both traditional storage and retrofit solutions to achieve reductions in the remaining uncontrolled CSO outfalls. The LTCP also explores opportunities to partner with King County on collaborative projects to control both agencies' CSOs.

Specifically, the LTCP will achieve the following objectives:

- Identify areas of the city where CSO control projects are required;
- Evaluate alternatives for reducing CSOs in affected areas;
- Select a preferred alternative (solution) for each affected area;
- Recommend a schedule for designing and constructing projects from 2016 to 2025;
- Estimate program costs and associated rate impacts;
- Provide an updated post-construction monitoring plan and schedule; and
- Consider public and stakeholder input.

A “**controlled**” CSO outfall has an average of not more than one untreated discharge event annually on a 20 year moving average.

An “**uncontrolled**” CSO is an outfall where the 20 year average exceeds the requirements of a controlled outfall.

The draft LTCP will be submitted to Ecology and EPA in late May 2014, accompanied by the Draft EIS, and the final LTCP will be submitted to EPA and Ecology in May 2015 as required by the Consent Decree. The LTCP will also be submitted as the 2015 CSO Reduction Plan Amendment to Ecology as required by the City's current NPDES permit. The solutions identified in the LTCP are to be approved by Ecology and EPA, and will be constructed in the years following 2015. Upon approval of the LTCP, projects to be completed between 2015 and 2020 will be included as requirements in the City's next wastewater NPDES permit.

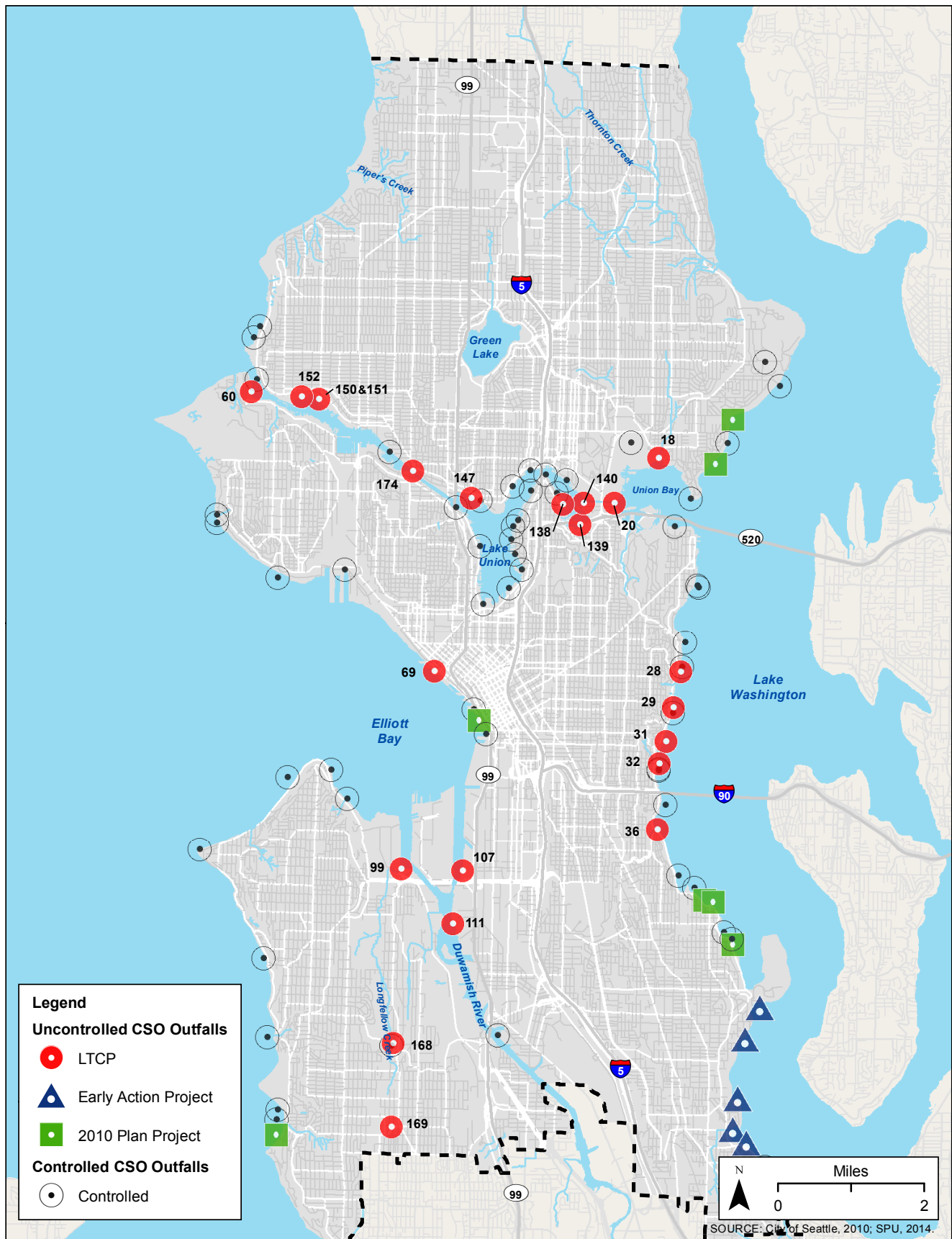


Figure 2-3 City Outfalls and Controlled Sites.

2.7.1 How does the LTCP fit in with other regional CSO control efforts?

Ownership, operation, and maintenance responsibilities for the sewage system in Seattle have been shared by the City and King County. The City is responsible for the sewage collection system within the city limits, serving contributing areas (basins) up to 1,000 acres in size, while King County is responsible for sewer trunk lines serving areas greater than 1,000 acres, and for regional treatment plants (Figure 2-4). Seattle's system of generally smaller pipelines feeds into King County's system of larger pipelines. King County and Seattle have established an agreement regarding ownership of each CSO outfall depending on its location within the conveyance network. The CSO outfalls and their control status are listed in each agency's respective NPDES permit.

King County has 14 remaining uncontrolled CSO sites in the city that discharge to Elliott Bay, the Duwamish River, and the Lake Washington Ship Canal. Because Seattle discharges its wastewater to King County for conveyance and treatment, and because both systems can affect one another hydraulically, the City and King County coordinate their CSO reduction efforts. Previous coordinated efforts have significantly reduced the volume of CSOs from both agencies' systems.

The LTCP continues to emphasize this coordinated approach and evaluates potential larger, shared City-King County projects in addition to smaller, neighborhood-specific projects. The City considers shared CSO control projects with King County if the projects are deemed to be cost-effective for ratepayers, provide a better environmental outcome, or if they have the potential to minimize disruption to nearby communities during construction. The City and King County are currently developing a Joint Operations and System Optimization Plan in accordance with the Consent Decree. A final plan is to be submitted for approval no later than March 1, 2016.

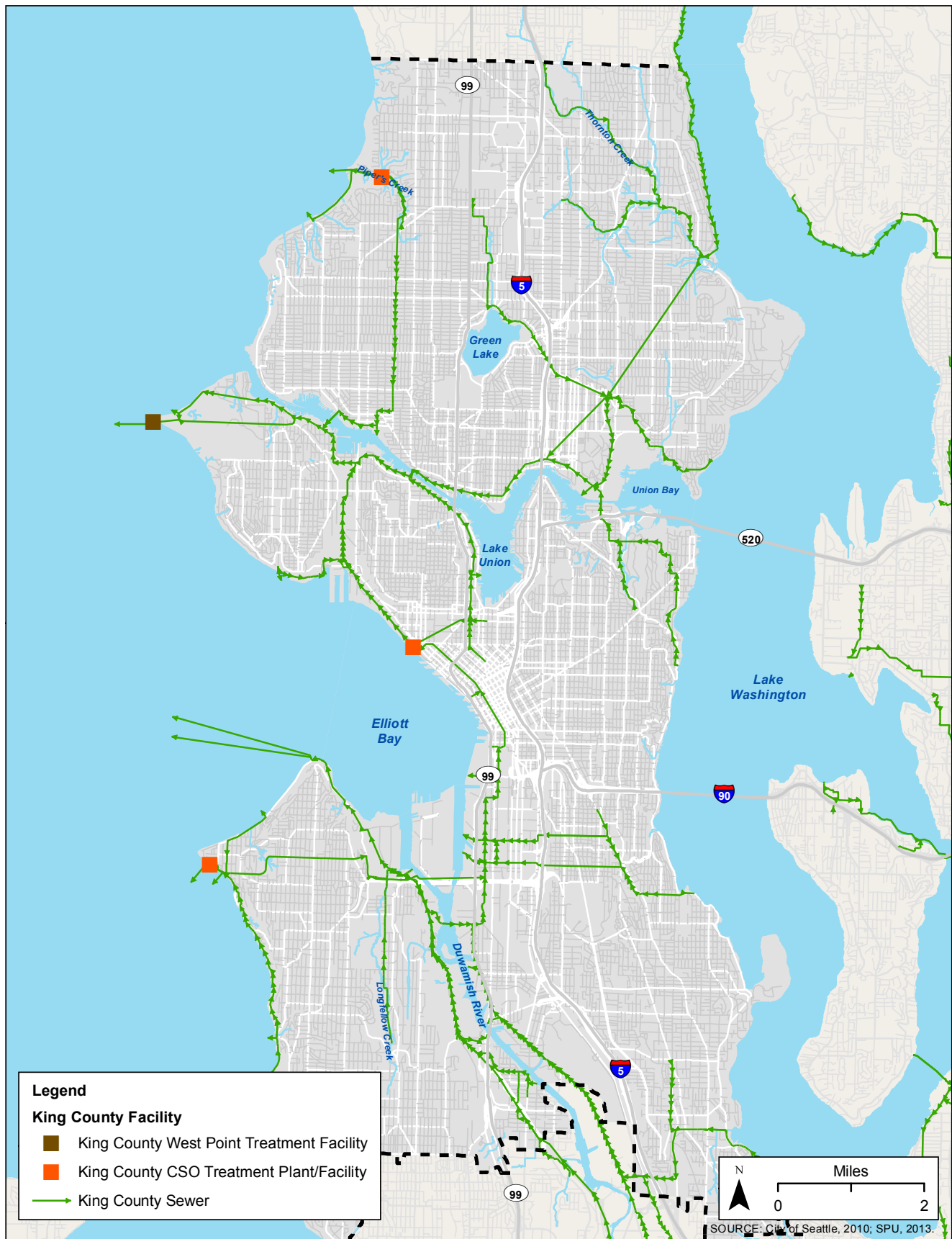


Figure 2-4 King County Wastewater Facilities.

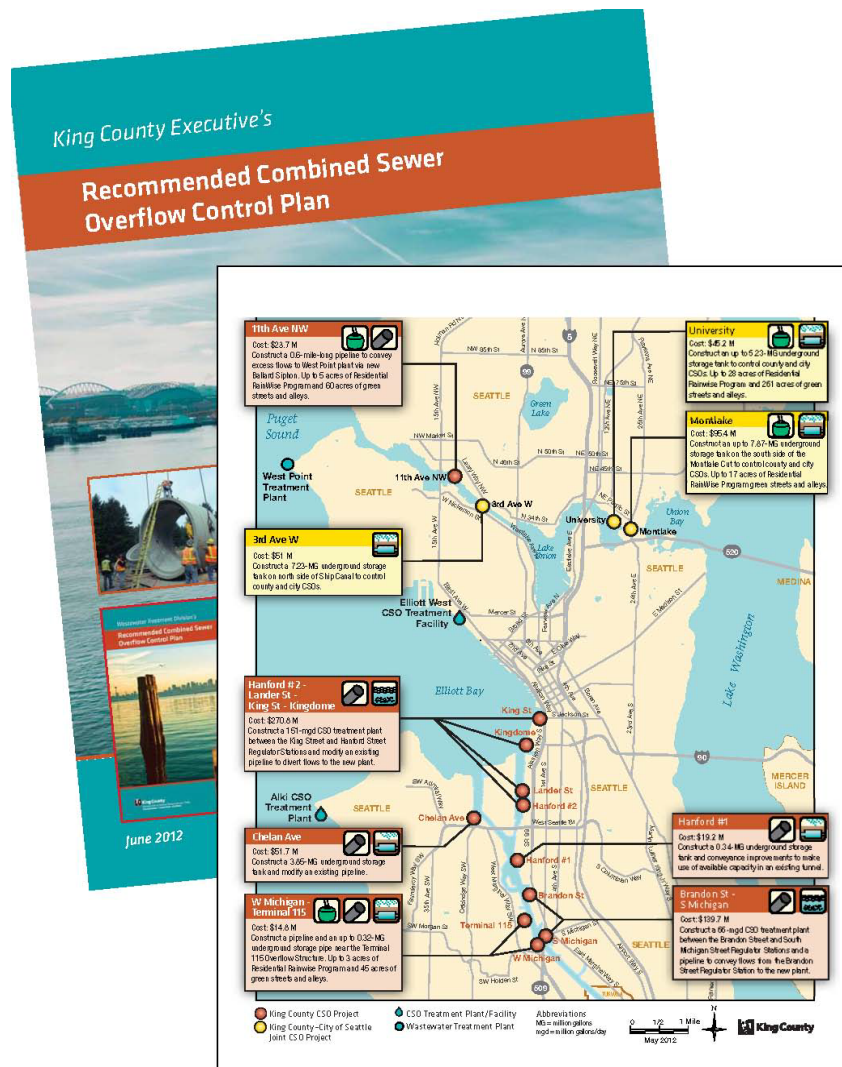


Figure 2-5. King County Combined Sewer Overflow Control Plan

King County has also amended its CSO control plan. The County's Long-Term Combined Sewer Overflow Control Plan Amendment (King County, 2012a), presents nine CSO control projects that will meet federal and state regulations by controlling the last remaining King County CSO locations to no more than one overflow per year on average at each location. King County's 2012 CSO Control Plan was approved on March 7, 2013. These final projects in the County's CSO control program are some of the most complex and expensive, which is also the case for the final projects included in the City's LTCP. The County's CSO program includes three potential shared projects with the City, in the Lake Washington and Ship Canal Neighborhoods.

In addition to the nine control projects, the County's plan includes a water quality assessment/environmental benefit study to confirm or possibly adjust some of the future recommended projects and schedules. As results from ongoing studies and monitoring efforts become available, King County and the City will continue to coordinate regarding the optimal shared approaches to CSO control. Once approved by EPA and Ecology, it is anticipated that King County will construct the control projects included in its Long-Term Combined Sewer Overflow Control Plan Amendment between 2015 and 2030, as specified in their Consent Decree.

2.8 What is the Integrated Plan?

The Integrated Plan is being evaluated in the EIS as an alternative to the LTCP. Whereas the LTCP focuses solely on reducing CSOs, the Integrated Plan meets the U.S. EPA's guidelines for integrating stormwater management and CSO control in one plan.

The Consent Decree allows the City to submit a plan that proposes stormwater projects and defers some CSO control projects, provided that the stormwater projects will result in significant benefits to water quality beyond those that would be achieved by implementation of CSO controls alone, and the CSO control projects deferred would be completed on a compliance schedule. In this way, the City would be able to focus first on investments that achieve the greatest environmental benefits. These stormwater projects would be in addition to the CSO control measures included in the approved LTCP.

The Integrated Plan identifies stormwater projects that will be completed by 2025, in addition to the CSO control projects that will be completed by 2025 and those CSO control projects to be deferred until after 2028. By prioritizing and sequencing projects in this way, greater water quality benefits may be achieved than by CSO control projects alone.

Why consider an Integrated Plan?

An Integrated Plan allows municipalities to prioritize sewage and stormwater reduction projects to obtain maximum water quality benefits more quickly. Often, the focus is on meeting each Clean Water Act requirement individually. As a result, we sometimes solve one problem at a time without full consideration of all Clean Water Act requirements. This can prevent municipalities from addressing the most serious water quality issues first.

2.9 How was this EIS developed?

Seattle Public Utilities is preparing this "programmatic EIS" to analyze the environmental impacts of the **Plan to Protect Seattle's Waterways** (the Plan). This draft programmatic EIS was prepared in compliance with the State Environmental Policy Act (SEPA), contained in Chapter 43.21C of the Revised Code of Washington, and the state SEPA rules, contained in Chapter 197-11 of the Washington Administrative Code.

SEPA requires state and local agencies to consider the likely environmental consequences of a proposal before approving or denying the proposal. The final programmatic EIS will be used to assist decision makers in assessing the environmental costs and benefits associated with adoption and implementation of the alternatives developed for the Plan.

The Plan will identify the general location, strategy, size, and number of facilities to reduce the remaining CSOs throughout the city. As a planning-level document, it is considered a "non-project proposal" under SEPA. Non-project review allows consideration of the "big picture" and will form the basis for subsequent project-specific review. A "programmatic EIS" examines the broad program-level issues related to the general location of CSO control projects, and how combinations of projects may collectively impact the environment. It differs from a

“project-specific EIS” in that it does not focus on specific project locations, design details, or precise footprints for individual CSO control projects.

The programmatic EIS is the first step in a phased environmental review for the Plan. Once the Plan is approved, the City will move forward with the identification and design of individual projects. Additional project-specific environmental review associated with these future projects would occur as appropriate during project level design. Projects proposed independently by King County will be evaluated by the County, in accordance with their SEPA policies and requirements.

2.10 How has the public been involved with the development of the Plan and EIS?

Public involvement is an important part of both the Plan and SEPA processes. In 2010, a Sounding Board was formed to guide the development of the LTCP. Sounding Board members consisted of city residents and other stakeholders who were recruited throughout the city to provide a diverse set of perspectives. The 13 members included six residents and seven stakeholders, who developed and applied criteria to make decisions about alternatives, reviewed and commented on elements of the LTCP, and provided guidance on public involvement activities.

In coordination with the Ballard District Council, the City also established a Stakeholder Advisory Group in 2013 to provide focused and detailed input on the elements of the LTCP that affect Ballard, Fremont, and Wallingford, including selecting an underground storage solution for sewage overflow control in Ballard, Fremont, and Wallingford and the appropriate role of natural drainage projects in Ballard. The nine-member group includes stakeholders in Ballard, Fremont, and Wallingford, including residents and residential property owners, small business owners, industrial businesses, and environmental and neighborhood groups. The group met five times in 2013 and 2014.

Consistent with the City of Seattle’s SEPA Policy and Procedures (Seattle Municipal Code 25.05), scoping was held to determine the range or “scope” of issues to study in the programmatic EIS. The purpose of scoping is to narrow the focus of the EIS to significant environmental issues, to eliminate insignificant impacts from detailed study, and to identify alternatives to be analyzed in the EIS. During scoping, the public is asked to comment on the range of proposed alternatives and the probable environmental issues.

Initial scoping was held in late 2011, and focused on the LTCP options. Scoping included an official comment period from September 26 through November 7, 2011. During initial scoping, the City hosted four scoping meetings/open houses and an online scoping meeting.

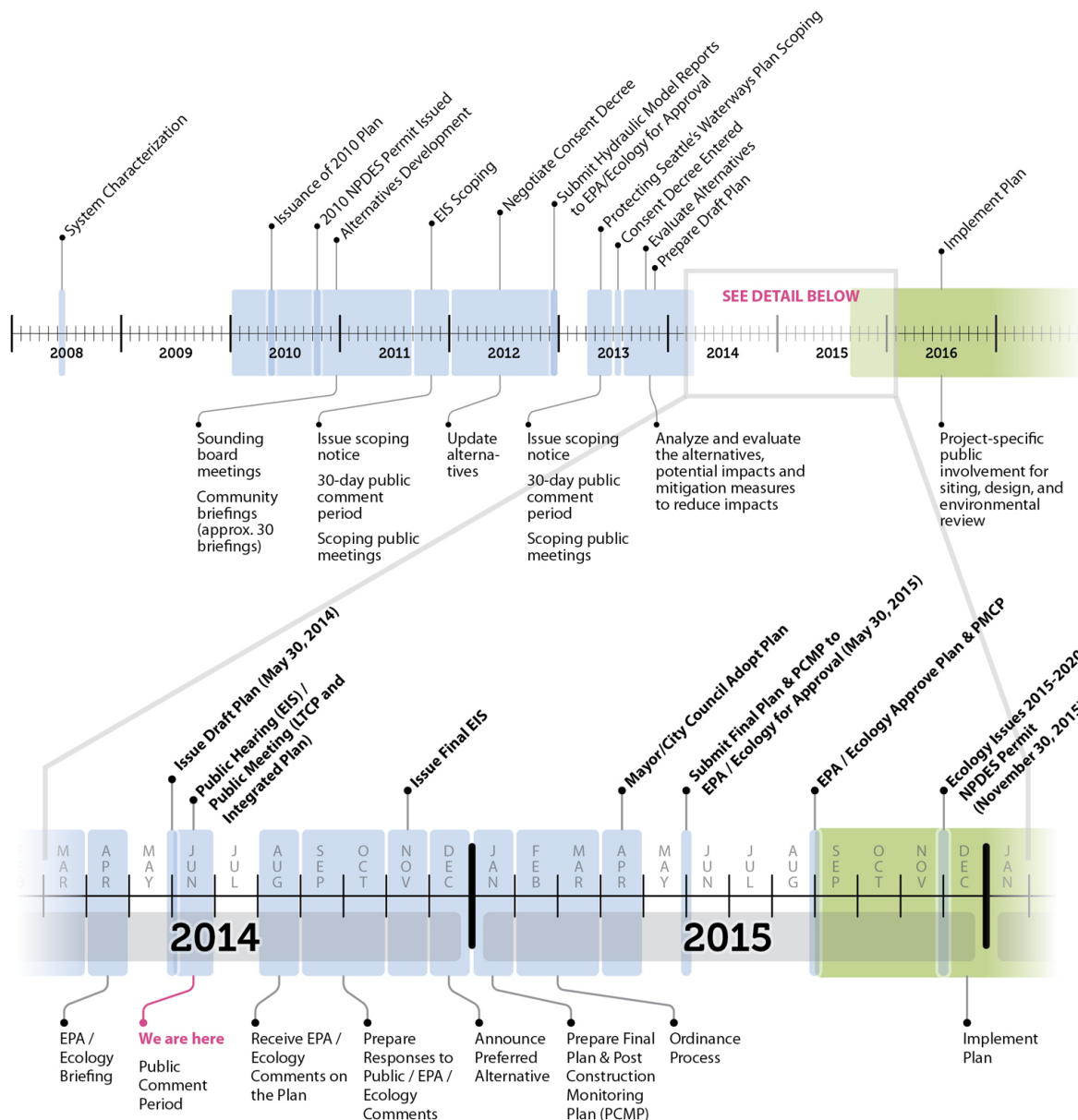
Subsequent Consent Decree negotiations expanded the Consent Decree to allow development of an Integrated Plan Alternative. As a result, the City reopened the SEPA scoping process in May 2013, to allow public and agency comment on the inclusion of the Integrated Plan as an alternative in the Plan. Scoping was conducted from May 20 through June 20, 2013, and included a scoping meeting/open house and an online survey/comment form. The 2012 and 2013 Scoping Reports are included in Appendix A along with a summary of how the comments have been incorporated into the EIS.

The purpose of these public meetings, webinars, and outreach materials was to develop a shared understanding of the problem the City needs to address, the options, and the potential impacts, and to gather public input on the options, potential project locations, and the scope of the EIS. In addition to the EIS, the City has released three

Community Guides, to provide information about the LTCP, the EIS process, and the Integrated Plan, and a video describing the alternatives and the EIS process. These Community Guides and video can be found on the City's website at www.seattle.gov/cso. The City also conducted more than 50 briefings for community organizations and stakeholder groups.

Issuance of this draft EIS initiates a 30-day public comment period. A public hearing for the EIS per Seattle Municipal Code will be held in June, 2014, as described in the Fact Sheet. Comments on the draft EIS will be addressed in the final EIS, along with appropriate changes to the EIS as needed. The final EIS is expected to be released in late 2014.

The final Plan will be submitted to EPA and Ecology for approval in May 2015. After approval of the LTCP, the City will work with local neighborhoods to select specific sites where facilities will be built. As part of the project siting process, Seattle Public Utilities will perform project-level environmental reviews. The project-level environmental review will help to inform decision makers about site-specific, project-level environmental impacts and mitigation measures.



SOURCE: Wayworks, 2014; SPU, 2014.

Figure 2-6. Plan Schedule

2.11 How is this programmatic EIS organized?

The **Plan to Protect Seattle's Waterways** covers numerous neighborhoods throughout Seattle. There are also numerous terms used to describe the potentially affected areas in the four Plan Volumes. For the EIS, the potentially affected areas are referred to as "Neighborhoods." Many of these neighborhoods are the locations of the "uncontrolled" CSO basins that are the subject of the LTCP. Basins are the areas that drain to identified CSO outfalls. Other neighborhoods are locations of potential stormwater projects that are part of the Integrated Plan.

Since many of the projects that would be constructed under the Plan are located in proximity to each other, these areas are organized by their larger “Neighborhood” area as shown in Table 2-2 and in Figure 2-6. Because specific project locations have not yet been determined, this EIS analyzes potential impacts by the larger Neighborhood area, or the individual neighborhood as appropriate.

Table 2-2. Quick Review of Plan Locations as used in this Document

Neighborhood	CSO Basin (Area)
Ship Canal Neighborhoods	
Ballard	CSO Outfall 150/151 CSO Outfall 152
Fremont/Wallingford	CSO Outfalls 147 & 174
Magnolia	CSO Outfall 060
Lake Washington Neighborhoods	
North Union Bay	CSO Outfall 018
Madison Park	CSO Outfall 024
Portage Bay	CSO Outfall 138
Leschi	CSO Outfalls 028; 029, 031, 032, 034, 035, 036
Longfellow Creek/Duwamish Neighborhoods	
Delridge	CSO Outfalls 099, 168, 169
Duwamish	CSO Outfall 111
East Waterway	CSO Outfall 107
Elliott Bay/Lake Union Neighborhoods	
Central Waterfront	CSO Outfall 069
Piper’s Creek Neighborhoods	
	Integrated Plan Alternative only
Thornton Creek Neighborhoods	
	Integrated Plan Alternative only

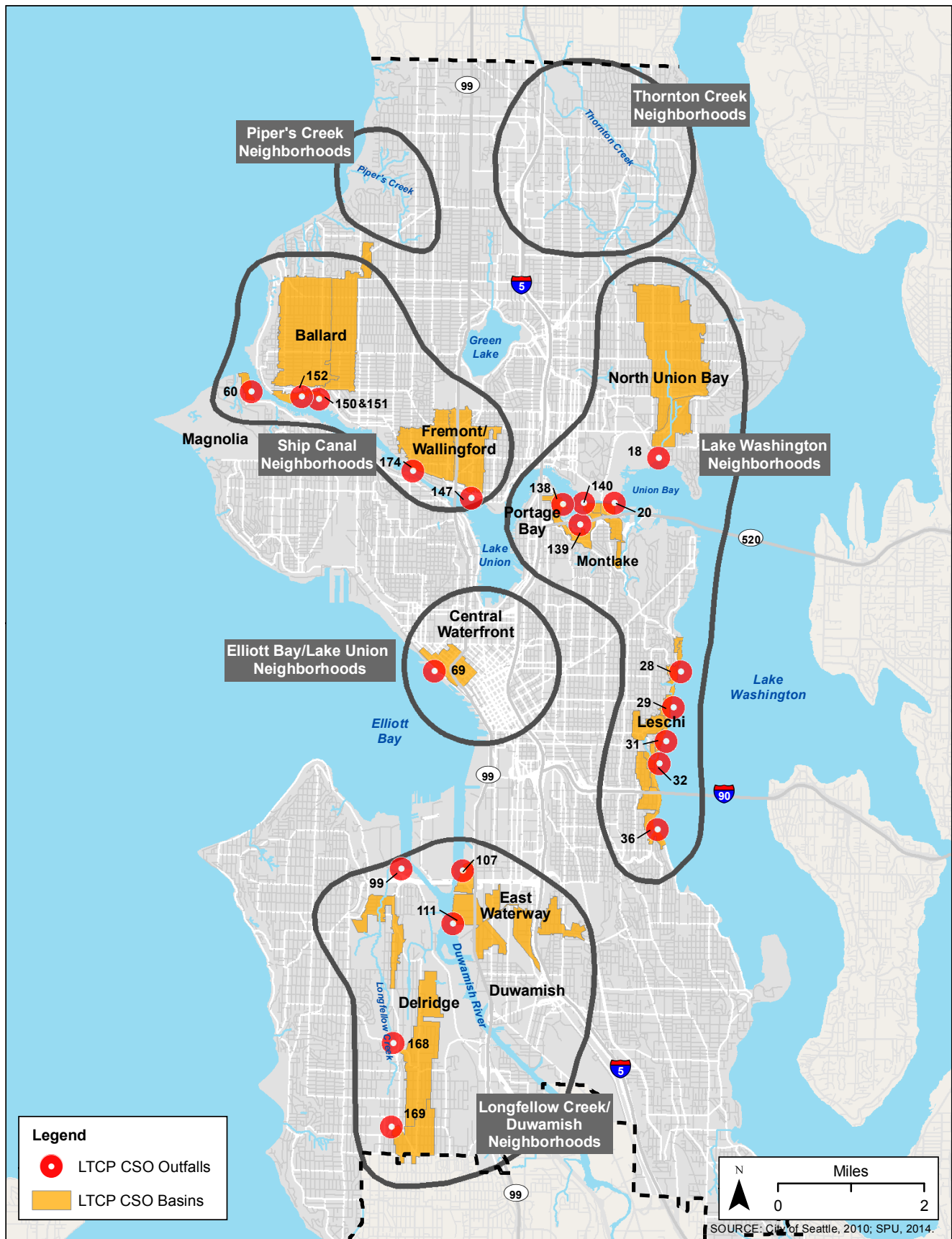


Figure 2-7 Plan Area Neighborhoods.

The following provides a Chapter by Chapter guide for how to access information in this document.

Table 2-3. Quick Road Map Through This Document

If You Want to:	Check Here:	Description and Other Related Information
Review a summary	Chapter 1	This stand-alone summary provides an understanding of why the City has prepared the Draft EIS, summary-level descriptions of the Plan alternatives, and a summary of the potential impacts of these actions, and potentially applicable mitigation measures.
Understand the background	Chapter 2	This chapter provides the background to understand the Plan's purpose and need, including a description of regulatory requirements.
Find out about the Plan Alternatives	Chapter 3	This chapter is the heart of the EIS and provides a description of the LTCP Alternative, Integrated Plan Alternative, and No Action Alternative. Additional information on the LTCP Alternative and options can be found in the LTCP, available in Volume 2 of the Plan. Additional information on the Integrated Plan Alternative can be found in the Integrated Plan, available in Volume 3 of the Plan.
Find out about existing conditions in the Plan area	Chapter 4	This chapter provides a general description of existing conditions (the affected environment) in the Plan Neighborhood areas. This description provides the basis for identifying the potential impacts described in Chapters 5 and 6.
Find out about potential impacts from construction in the Plan area, including your neighborhood	Chapter 5	This chapter provides a general description of the potential construction impacts under implementation of any of the Plan alternatives, as well as potentially applicable mitigation measures.
Find out about potential impacts from the ongoing operation of projects in the Plan area, including your neighborhood	Chapter 6	This chapter provides a general description of the potential operational impacts under implementation of any of the Plan alternatives, as well as potentially applicable mitigation measures.
Find out about cumulative impacts of Plan implementation in the Plan area.	Chapter 7	This chapter provides a general description of the impacts that may arise from the implementation of the Plan alternatives when added to other past, present, and reasonably foreseeable future actions.

CHAPTER 3

Plan Alternatives

The City is considering two different approaches in its Plan to Protect Seattle's Waterways (the Plan). These approaches are called alternatives and are considered at a programmatic level in this environmental impact statement (EIS).

One alternative would address combined sewer overflows only, referred to as the **Long Term Control Plan (LTCP) Alternative**. All LTCP Alternative projects would be constructed by 2025 to comply with the July 2013 Consent Decree and meet state and federal regulations for CSO control.

The second alternative, referred to as the **Integrated Plan Alternative**, would address both CSOs and stormwater pollution. This alternative meets the Consent Decree requirements for integrating stormwater management and CSO control into one plan, called an Integrated Plan. If the City chooses the Integrated Plan Alternative, it may delay completion of some CSO reduction projects until 2030. Both alternatives include implementation of CSO control projects.

Consistent with the State Environmental Policy Act (SEPA) requirements, the EIS also evaluates a **No Action Alternative**, which describes what would occur if the action alternatives are not implemented.

This chapter describes the alternatives, how the alternatives were developed, and the types of strategies that would be implemented under each, including descriptions of the general types of facilities and their locations.

3.1 No Action Alternative

SEPA requires that EISs must "present a comparison of the environmental impacts of the reasonable alternatives, and include the no action alternative" (Washington Administrative Code 197-11-440-(5) and SMC 25.05.440.D)). For this EIS, the No Action Alternative is defined as implementation of actions that have already been identified, evaluated, and funded for implementation through earlier planning efforts.

Under the No Action Alternative, substantial progress will be made in controlling CSOs through implementation of previously planned CSO control projects. These projects include those identified in the City's wastewater NPDES Permit (WA0031682) and include projects identified in the 2010-2015 Implementation Plan for the *2010 CSO Reduction Plan Amendment* (2010 Plan Amendment) and 'Early Action' projects identified by Consent Decree in the Henderson CSO

Alternatives Considered in the EIS

No Action Alternative

Long Term Control Plan
Alternative

Integrated Plan Alternative

The **No Action Alternative** is included in the draft EIS to provide an understanding of what would occur if the proposed action is not implemented, and to serve as a comparison to the action alternatives. The State Environmental Policy Act (SEPA) requires the evaluation of a No Action Alternative in an EIS, which at times may be more environmentally costly than the action alternatives, or may not be considered "reasonable" by other criteria. Still, it provides a benchmark to which the other alternatives may be compared.

basin. These projects are currently funded and are scheduled for implementation, and they will occur regardless of whether the Plan is implemented.

The City would also continue to implement a portion of two of its CSO reduction strategies, combined sewer system improvements and natural drainage systems (referred to as green infrastructure in the LTCP). However, the City would not implement any additional CSO reduction or stormwater control projects beyond those that are currently funded and slated for implementation.

Combined sewer system improvements and natural drainage systems alone will not be sufficient to reduce the volume and frequency of CSOs to meet federal and state regulations. If the City does not make additional improvements in the remaining uncontrolled basins addressed by the Plan, untreated sewage and stormwater in excess of current regulations would continue to be illegally discharged into Lake Washington, the Lake Washington Ship Canal, the Duwamish River, and Puget Sound when the capacity of the existing combined sewer systems is exceeded. Under the No Action Alternative, the City would not be in compliance with the Consent Decree.

The current and ongoing combined sewer system improvements, natural drainage, and storage projects included in the No Action Alternative are described below and shown on Figure 3-1.

3.1.1 Sewer System Improvements

The City has several ongoing programs to implement system improvements that optimize use of the City's existing infrastructure, largely through retrofits of existing facilities. Current and ongoing sewer system improvement programs and projects include the following:

- 2010 Plan Amendment Projects;
- CSO Retrofit Program;
- Outfall Rehabilitation Program.

The City's 2010 Plan Amendment specifies multiple sewer system improvements, which the City plans to implement by 2015. The City's CSO Retrofit Program is planning several CSO reduction retrofits that will reduce overflows or bring uncontrolled basins into control. Retrofits include raising overflow or storage weirs, replacing old flow control devices with newer technology, or separating sewers. The City initiated the CSO Retrofit Program in 2002; currently the Retrofit Program is funded at \$1 million to \$3.5 million annually through 2016.

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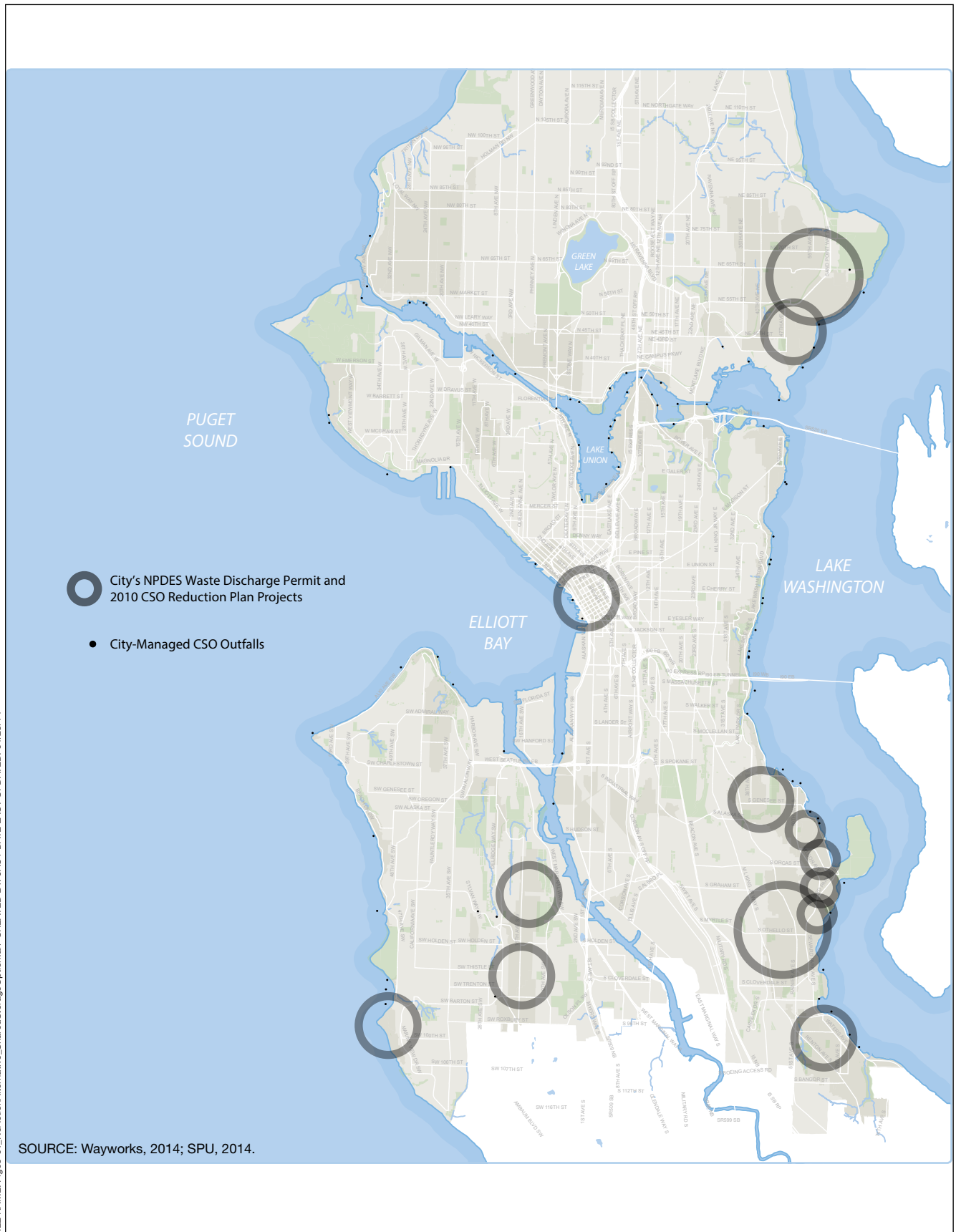


Figure 3-1. No Action Alternative Locations.

Some of the major retrofit projects include:

- *Windermere Jr.* Construction was completed in August 2012. Post Construction monitoring started Sept 2012 and will continue until September 2014. This retrofit will bring NPDES Basin 15 into compliance.
- *Basin 95 Retrofit.* Construction was completed in June 2013. Post Construction monitoring started July 2013 and will continue for 1 year. This retrofit will bring NPDES Basin 95 into compliance.
- *Delridge Retrofit.* Construction will be complete in December 2014. Post construction monitoring will start January 2015 and continue for 2 years. This project will bring basins 168 and 169 into compliance.

CSO outfalls are also being improved under the City's current program. Many of the outfalls in the combined sewer system have been in service since the first half of the 20th century. Although some have been taken out of service over time as system improvements have been made, others will need to remain in service and be maintained in good, operable condition. Because the outfalls are located in water bodies and sensitive areas, their management presents unique challenges different from the rest of the sewer system. To address this, the City is implementing an Outfall Rehabilitation Program to assess and prioritize the cleaning and renewal of outfalls where deficiencies are identified. The program will include planning, design, construction, and monitoring services focused on the repair, rehabilitation, replacement, and improvement of priority outfalls.

3.1.2 Natural Drainage Systems (Green Infrastructure)

In some areas, opportunities exist to use soil to infiltrate stormwater to groundwater or slow the rate of stormwater entering the sewer system. These strategies are referred to as natural drainage systems (NDS), (also referred to as green infrastructure (GI) in the LTCP).



Figure 3-2. Natural Drainage System Rain Garden

Natural drainage systems include options that can be installed in the public right-of-way and those that can be located on private property. These options include rain gardens, bioretention cells, cisterns, downspout disconnects, and pervious pavement in streets, alleys, and driveways. With the right type of soil and proper design, these solutions allow stormwater to soak into the ground and infiltrate into the groundwater, or slow the rate of stormwater entering the sewer system. The purpose is to reduce the amount of stormwater runoff and

Why use natural drainage systems?

Natural drainage systems (NDS), also referred to as green infrastructure (GI) in *Volume 2, LTCP* have several advantages because they:

- Reduce demand on existing pipes and sewage treatment facilities
- Avoid the need for (or reduce the size of) storage facilities
- Save energy and operating costs because stormwater does not need to be pumped to the treatment plant
- Provide opportunities for neighborhood improvements such as attractive landscaping, or pedestrian and bicycle safety projects

pollutants entering pipes and local water bodies. Natural drainage systems are consistent with the concept of sustainability and complement sewer system improvements as part of the City's approach to reducing pollution from stormwater and CSOs.

Reducing the volume of stormwater runoff frees up capacity in combined sewer systems, allowing more wastewater to be carried. This reduces CSO-related pollution from both untreated wastewater and stormwater. The ability of natural drainage systems to reduce the total volume of stormwater and the peak rate of flow is a significant benefit of natural drainage systems. Traditional strategies to manage stormwater in CSO basins, such as storage, address stormwater runoff only during heavy rains, whereas natural drainage systems receive stormwater runoff and provide benefits to the sewer system each time it rains. Reducing the volume of stormwater going into sewer pipes reduces the amount of pumping and treatment, saving energy and reducing the carbon footprint of the overall sewage system. It also allows more pipe capacity for conveying flows from other areas of the sewer network. If used in combination with CSO storage, natural drainage systems can reduce the size of structures needed to store stormwater.

The City is implementing a number of efforts to maximize the use of natural drainage systems, including development requirements to minimize impervious surfaces, stormwater rates to encourage reductions of impervious surfaces, and other voluntary programs.

3.1.2.1 What kind of natural drainage system programs are already underway in the city?

Two NDS programs are already underway in the City.

Seattle's **RainWise program** is a voluntary, incentive-style program that offers rebates to property owners who install rain gardens or other natural drainage systems on their properties. RainWise rain gardens on private property are designed to collect rooftop, parking lot, or driveway drainage that is currently conveyed directly to the combined sewer system. The rain gardens are small vegetated depressions with designed soil mixes that retain runoff for subsequent infiltration or delayed release to the combined sewer system. Other natural drainage systems for private property are detention cisterns and green roofs. Detention cisterns are tanks designed to collect rooftop runoff and slowly meter it back into the combined sewer system. Green roofs are areas of living vegetation installed on tops of buildings.

RainWise Implementation Basins

SPU Basin Name	Potential Drainage Area for RainWise (acres)
Ballard	21.0
Fremont/ Wallingford	5.5
Interbay	2.4
North Union Bay	17.7
Portage Bay	0.8
Montlake	0.9
Madison Park	0.2
Leschi	0.1
Delridge	9.7
Duwamish	1.3
Henderson	10.5
Genesee	1.1
Windermere	1.3
Total	71.7

The **Right-of-Way program** creates rain gardens in the public right-of-way, either in the existing planting strip adjacent to the sidewalk or by constructing curb bulb extensions into the street. This tool also includes retrofitting portions of alleys with permeable pavement.

Natural drainage systems have been implemented in the Ballard, North Union Bay, Delridge, and Windermere basins. Lessons learned from problems associated with previous installations in the Ballard neighborhood are being applied to all planned installations of natural drainage systems, to avoid similar problems. Current natural drainage system projects being planned include roadside rain gardens in the Ballard and Delridge neighborhoods with construction anticipated to start after 2015.

A more complete description of these programs can be found at www.seattle.gov/CSO.

3.1.2.2 How does the City decide when and where natural drainage systems will be implemented?

Factors that influence the choice of when and where to implement natural drainage systems include the type of sewer system currently in use; type of existing development; infiltration hazards; volume of overflow to be controlled; and local geological, topographic, or soil conditions.

Large-scale application of natural drainage systems is not appropriate in some areas because of existing conditions. For example, the existing plumbing system can be a significant limitation to using natural drainage systems within the right-of-way. Only those roadways that are physically plumbed to a combined sewer system can be retrofitted to potentially help with the CSO reduction strategy. Therefore, in areas with fully combined sewer systems, there is a larger suite of natural systems available that can be used in the right-of-way and on private property. In areas with partially separated systems, only private parcels contribute flows to the combined sewer system; therefore, natural drainage systems must be smaller scale facilities located on private property.

3.1.3 Storage Projects

Under the No Action Alternative, the City would not implement any new storage improvements in the CSO basins. Only construction of storage projects currently funded and scheduled for implementation under the City's NPDES Waste Discharge Permit No. WA0031682 and identified in the 2010 Plan Amendment and Consent Decree Early Action Program would proceed under the No Action Alternative.

Lake Washington was identified in the 2010 Plan Amendment as the number-one priority receiving water for CSO reduction, based on the volume of overflows into the lake and the potential for water quality improvements from CSO reduction. In particular, three basin areas – Windermere, Genesee, and Henderson – were identified as high priority to reduce the volume of overflows, and as such, were the first basins to be selected for implementation of storage facilities.

Table 3-1 lists the City's storage projects in the Windermere, Genesee, Henderson, and Central Waterfront basins that are currently scheduled for completion under the 2010 Plan Amendment, as summarized in the *2012 Annual CSO Report*. Together, these projects are expected to store approximately 5 million total gallons, with completion of the Windermere project in 2014, Genesee in 2015, Henderson in 2018, and Central Waterfront in 2018-2020. A more complete description of these projects can be found at www.seattle.gov/CSO.

Table 3-1. Storage Projects (2012 Annual CSO Report)		
CSO Basin/ Basin #	Project Description	Estimated Completion Date
Windermere		
13	Storage tank in Magnusson Park	2014
Genesee		
40/41	Storage tank at 49th Avenue South and Lake Washington Boulevard	2014
43	Storage tank at 53rd Avenue South and Lake Washington Boulevard	2014
Central Waterfront		
70, 71, 72	Increased conveyance to King County Elliott Bay Interceptor and storage	2018-2020
Henderson North		
44, 45	Storage tank in Seward Park	2018
Henderson South		
46, 47, 49, 171	Flow diversion project	2018 2015

3.2 Long Term Control Plan Alternative

The LTCP Alternative is focused solely on reducing CSOs under an approved Long Term Control Plan (LTCP). As a planning-level document, the LTCP presents a comprehensive strategy to reduce the remaining uncontrolled CSO discharges in the city. The City must address these CSOs to protect public health and the environment, and comply with the Clean Water Act and state regulations. The City would implement the projects identified in the LTCP Alternative from 2016 through 2025, to comply with federal requirements and the Consent Decree.

The LTCP Alternative would use a combination of three sewage overall reduction strategies – sewer system improvements (“Fix it First”), natural drainage systems (“Keep Stormwater Out”), and underground storage (“Store What’s Left”) – to reduce CSOs in 11 Seattle neighborhoods. Natural drainage systems (“Keep Stormwater Out”) are an integral part of Seattle’s comprehensive strategy to manage polluted runoff and CSOs, and as such, they are part of ongoing programs included in the No Action Alternative, and are described in Section 3.1.2.

The LTCP Alternative focuses solely on the combined sewer system and would reduce CSOs to an average of no more than one overflow per outfall per year on a 20-year rolling average by the year 2025. The LTCP also includes requirements for post construction monitoring, to determine if the performance standard has been met.

The City’s efforts to identify CSO reduction strategies were guided by a number of factors, including past use of CSO reduction strategies in the city, regional experience with CSO reduction strategies, and existing laws and regulations. Washington State’s CSO regulations provide an initial framework for the range of options that The

City is considering as part of its CSO reduction efforts. Within the framework provided by state and federal law, the City considered the results of extensive system modeling, public and stakeholder input, and the LTCP objectives and associated criteria. Using this information, the City evaluated the potential effectiveness of CSO reduction strategies for inclusion in the Plan and this EIS.

3.2.1 Sewer System Improvements – “Fix it First”

In some areas, the City can reduce CSOs by making minor modifications to the existing sewer system to make better and more reliable use of existing capacity. This type of modification (termed a retrofit) is generally significantly less expensive than other approaches and is relatively quick to implement.

Not all areas can be controlled using retrofits. In some areas, the sewer system is already operating under optimal conditions and the flow volume still exceeds the capacity of the system. In other areas, sewer system improvements may reduce CSOs in the basin but will not eliminate them.

The City has several ongoing sewer system improvement programs and projects. Many of these improvements would be implemented under any alternative and are further described in Section 3.1, No Action Alternative. The LTCP Alternative includes additional improvements to address the CSO basins that are not already addressed by these existing programs and projects.

The types of sewer system improvements being considered include adjusting flow-control structures, such as installing new gates that control combined sewer flow; redirecting flows to another City CSO area or facility; or increasing maintenance and monitoring activities. Sewer system improvements include improving existing structures, installing new sewer lines, and relocating underground structures.

Sewer system improvements have the potential to affect King County wastewater facilities, and as such will require close coordination with King County to ensure that the retrofits occur in accordance with agreed upon Guiding Principles adopted by the two agencies. Section 3.2.2.3 describes the process that the City will use to coordinate with the County.

3.2.2 Storage Projects – “Store What’s Left”

Storage facilities, such as underground pipes, tanks, and tunnels, hold excess combined stormwater and sewage during heavy storms. Storage facilities are the most effective way to reduce CSO volumes remaining after sewer system improvements and natural drainage systems have been employed. Additional storage facilities would enable the system to hold more stormwater and sewage flows until the flows can be transferred to wastewater treatment plants operated by King County. Because this approach results in increased flows to the County’s system, the City and the County would coordinate to reach agreement on the flows transferred.

Stormwater and sewage flows only enter the storage facilities during a storm event. Once an upstream monitoring device detects excessive flow from a storm event, excessive flows are diverted to the storage facility until it reaches capacity. After the storm event has passed, when there is capacity in the downstream sewers, the storage volume is pumped out of the storage facility and into the existing system for conveyance to the treatment plant. Stormwater and sewage flows are typically stored in the facility for the duration of the storm event and pumped as soon as possible into the downstream sewer system. The storage facility is designed to be emptied within 8-12 hours.

3.2.2.1 What types of underground storage facilities are being considered?

Underground storage facilities include traditional storage facilities such as oversized pipes, tanks, and tunnels as well as flow diversions. A flow diversion involves diverting flows from a City facility to a nearby King County facility through modifications within the pipe network such as new gravity interceptors, new pump station and forcemains, and new regulator/flow diversion structures.

Storage facilities can be located in the public right-of-way or on adjacent publicly owned or privately owned property. In general, tanks are used to store larger storage volumes (for example, 500,000 gallons or greater) while storage pipes are appropriate for smaller storage volumes (typically ranging from 10,000 to 500,000 gallons). Tunnels are typically more cost-effective to use for storage volumes greater than 5 MG. Storage tanks and tunnels require permanent dedicated sites, whereas a smaller storage pipe can more easily be built underneath the street in the right-of-way. The permanent sites for a tunnel are limited to areas retained at the tunnel construction (portal) sites. Following construction, approximately 75 percent of the tunnel construction sites can be restored after construction and surplussed for sale to private parties. The area above the tunnel would be held in easements only.

CSO storage pipes and tanks require associated infrastructure such as odor control, mechanical, electrical, and control systems; standby generator; pump station; air intakes; and odor control exhaust vents. These facilities may be placed in underground vaults or aboveground structures depending on the project and the local site characteristics. In general, the City prefers to place associated infrastructure underground where feasible. The actual infrastructure requirements will depend on the specific facility, and will be determined during project design. Minor modifications may be needed to the existing combined sewer system and new pipes may need to be added.



Figure 3-3. Storage Tunnel

CSO storage tunnels require drop shafts for flow connection to the tunnel between the tunnel portals, access shafts, and flow regulators to control the flow rate into the tunnel. Storage tunnels also require facilities for odor control and other systems, as described above for storage tanks. These are typically aboveground facilities, but may be located underground at added expense. Because a CSO storage tunnel is designed to both store and convey flows during storm events, they are designed to be drained and flushed following the storm event. Screens are installed at each drop structure to capture debris before it enters the tunnel, and would be cleaned periodically.

All storage facilities require at least some new pipelines to provide local connections to the facilities, and most require one or more pump stations. Larger facilities that would store flow from multiple neighborhoods would generally require more local connections and pump stations than smaller, neighborhood facilities.

In some neighborhoods, diversion of flow to a nearby existing King County interceptor or facility may be more cost-effective than construction of new storage. The diverted flows would be stored for treatment following the storm event. Since this approach would cause an increased volume of flow to the County's system, an agreement between the City and the County would be required. Flow diversions generally require new sewer pipelines and a

diversion structure with a weir to divert the flows. In addition, pump stations, forcemains, and facilities housing electrical equipment and odor control may be required.

3.2.2.2 How will the City decide where storage facilities will be located and how they will be sized?

As described for the No Action Alternative, the City will continue to implement sewer system improvements and natural drainage systems in the city. It is anticipated that as sewer system improvements and natural drainage system opportunities are identified and successfully implemented, the positive effects of these measures may ultimately be reflected in reduced sizes of storage facilities constructed under the LTCP. Using data from these ongoing programs, and other information on CSO flows, location of the existing conveyance system, and surface and subsurface features, the City will determine the location and sizing of storage facilities. In some neighborhoods, it may be more effective to build one large underground storage facility to meet storage needs. In other areas, it may be more effective to build two or three smaller facilities. Actual locations of storage projects will be identified during project design.

The City will conduct a siting process to select the optimal sites for building an underground storage facility or facilities. The siting process will engage affected stakeholders to ensure that the interests of the community are thoroughly considered. The City will conduct project-specific environmental review during the siting process to evaluate site-specific construction impacts and long-term environmental impacts of the underground storage facilities.

Sites for the storage facilities may include a range of property types, including private and publicly owned property, street rights-of-way, and open space. During project implementation, the City will define specific site selection criteria and priorities along with financial, engineering, and environmental/social considerations to identify, screen, and select sites for CSO control projects.

The City's policy for facility site selection gives highest priority for City-owned property, followed by other City or publicly owned property, commercial/industrial property, and then schools, residential properties, and other properties. The property owner's willingness to sell or convert the property to a CSO facility is an important consideration in the site selection process. All factors will be considered along with community input during the facility siting process.

3.2.2.3 Are there shared storage opportunities with King County?

King County also has combined sewer systems within the City of Seattle. Because of the interconnectedness of the City and King County wastewater collection systems, individual CSO control measures for either agency can potentially impact an overflow for the other. Consequently, potential shared CSO control measures exist in some areas where both agencies could be served by a common solution. In other areas, no common benefit exists and independent CSO control measures are indicated. Whether the selected CSO control measure is shared or independent, the potential effect on the flows between agencies will be carefully considered during the evaluation process.

King County began its CSO long term control planning in early 2010. Because the two agencies were preparing similar plans during the same period and the two agency's combined sewer systems were geographically and hydraulically linked, King County approached the City to identify potential collaborative opportunities. The two agencies evaluated 40 potential shared projects and identified four feasible shared storage projects to evaluate in each agency's respective LTCP: shared City Fremont/Wallingford/King County 3rd Avenue W Regulator storage,

shared City North Union Bay/King County University Regulatory storage, shared City Montlake/King County Montlake Regulatory storage, and a deep tunnel along the Ship Canal.

In addition to shared storage, the two agencies also looked at flow diversion opportunities for Montlake, Leschi, Magnolia, East Waterway, and Duwamish.

The City recognizes the importance of strong coordination with King County in controlling CSOs in the City. All of the proposed options have elements which may have an impact on King County's downstream wastewater system. Three of the proposed options include shared King County/City projects along the Ship Canal. Several of the proposed options include sewer system improvements which will convey additional wastewater volume to the downstream King County system. Regardless of which option is selected, coordination between the City and King County is critical to successfully designing, constructing, and eventually operating the proposed CSO control projects in the City.

The City and King County are continuing to work together closely to analyze and recommend options that are more cost-effective, produce better environmental outcomes, and minimize disruption to communities. King County must also reach its own independent conclusions about the benefits of a shared project to the regional system, and the implications of such a project to its own Long Term Control Plan and Consent Decree. Selection of a shared King County/City project will be dependent on the City's and County's analytical results as well as a number of joint factors mutually agreed upon in a City/County Coordination Plan. These factors include such things as which agency will be responsible for the design/construction/operations of the shared facility, each agency's project cost-share, operational and implementation roles and responsibilities, the process for dispute resolution, and the ability to fulfill regulatory and contractual obligations. If the City and King County choose to implement a shared City/King County project, then a shared project agreement between the two agencies will be necessary prior to designing and constructing the project. In addition, the City and King County will analyze the impacts of any recommended project on the downstream King County system and agree on an approach to addressing those impacts prior to constructing the project.

3.2.2.4 What are the LTCP Options?

The City evaluated numerous potential approaches to determine their effectiveness to meet the CSO performance standard, stay within budget and rate limits, and minimize environmental and community impacts. The result of this evaluation was four potential combinations of CSO control measures, referred to as "options," that could meet EPA requirements. These options vary in terms of the number, size, and potential location of storage facilities considered. These options were developed under one of two basic concepts: the City meets their Consent Decree-mandated control requirements through implementation of independent (City-only) control projects, or the City participates in one or more shared projects with King County to take advantage of potential cost/impact reduction opportunities.

SPU LTCP Storage Options:

- Neighborhood Storage Option
- Shared Storage Option
- Shared West Ship Canal Tunnel Option
- Shared Ship Canal Tunnel Option

Individual CSO control measures for each CSO neighborhood were developed by the City to support a **Neighborhood Storage Option** (City-only implementation). This option involves building the largest number of underground storage facilities throughout the city. The Neighborhood Storage Option would primarily include building storage tank and pipes throughout the city, but could include building a deep tunnel to cost-effectively combine flows from Ballard and Fremont/Wallingford in one storage facility, referred to as the *Neighborhood West Ship Canal Tunnel*.

One option under the shared project strategy is to combine facilities when both the City and King County must construct storage facilities in close proximity to one another. This is the **Shared Storage Option** (shared City/King County implementation). Under the Shared Storage Option, those CSO neighborhoods that are not part of the shared project will require implementation of City-only (neighborhood) control measures.

Another option under the shared project strategy is to consolidate CSO storage for six City storage facilities and three King County storage facilities in a deep tunnel. This is the **Shared Ship Canal Tunnel Option** (shared City/King County implementation). Under the Shared Ship Canal Tunnel Option, those CSO areas that are not part of the shared project will require implementation of City-only (neighborhood) control measures.

During development of the Shared Ship Canal Tunnel Option, the feasibility of another potentially cost-effective shared tunnel solution (combining storage volume requirements from Ballard, Fremont/Wallingford, and 3rd Avenue W Regulator) was identified and evaluated. This option became the **Shared West Ship Canal Tunnel Option** (shared City/King County implementation).

The following table (3-2) presents the Plan neighborhoods and illustrates how they fit into the four LTCP options. The LTCP options are graphically displayed on Figures 3-4 through 3-7. More detailed information can be found in *Volume 2, LTCP*.

Table 3-2. LTCP Options (2016 - 2025)

City LTCP CSO Neighborhood	Best Estimate Control Volume (MG)	Neighborhood Storage		Shared West Ship Canal Tunnel (KC/City) ¹	Shared Ship Canal Tunnel (KC/City) ²	Shared Storage (KC/City) ²
		Neighborhood Tanks/Pipes	Neighborhood West Ship Canal Tunnel			
Leschi	0.43	3 Storage Pipes and 1 Storage Tank			Storage Tunnel (27 MG)	King County/City Montlake Regulator Storage Tank (7.87 MG)
Montlake	0.22	3 Storage Pipes		1 Storage Pipe		
Portage Bay	0.11	1 Storage Pipe		King County/City Storage Tank (5.23 MG)		
North Union Bay	1.63	Sewer System Improvements		2 Storage Pipes		
Duwamish	0.01	1 Storage Pipe and In-line storage (retrofit)			Flow Diversion to King County Duwamish Interceptor	
East Waterway	0.50	1 Storage Tank		Flow Diversion to King County HLKK ⁴ Treatment Plant		
Magnolia	0.11	1 Storage Pipe		Flow Diversion to King County North Interceptor		1 Storage Pipe
Central Waterfront ³	0.13	1 Storage Pipe ³				
Ballard	6.00	1 Storage Tank	Storage Tunnel: (9.2 MG)	Storage Tunnel (13.4 MG)	Storage Tunnel (27MG)	1 Storage Tank (or dual Storage Pipes)
Fremont-Wallingford	3.24	1 Storage Tank				King County/City Storage (7.4 MG)
North Delridge	0.17	1 Storage Pipe			Flow Diversion to King County Harbor Trunk	1 Storage Pipe
South Delridge	0.50	2 Storage Pipes				

1. Eliminates King County Independent Storage Tank on South side of Ship Canal (3rd Ave West)
2. Eliminates King County Independent Storage Tanks on North and South sides of Ship Canal (3rd Ave West, University, and Montlake Regulator)
3. Will be constructed in coordination with the Seawall Phase 2 (2018 Earliest Start)
4. Handford , Lander, Kingdome, and King (HLKK)

3.2.2.4.1 Neighborhood Storage Option

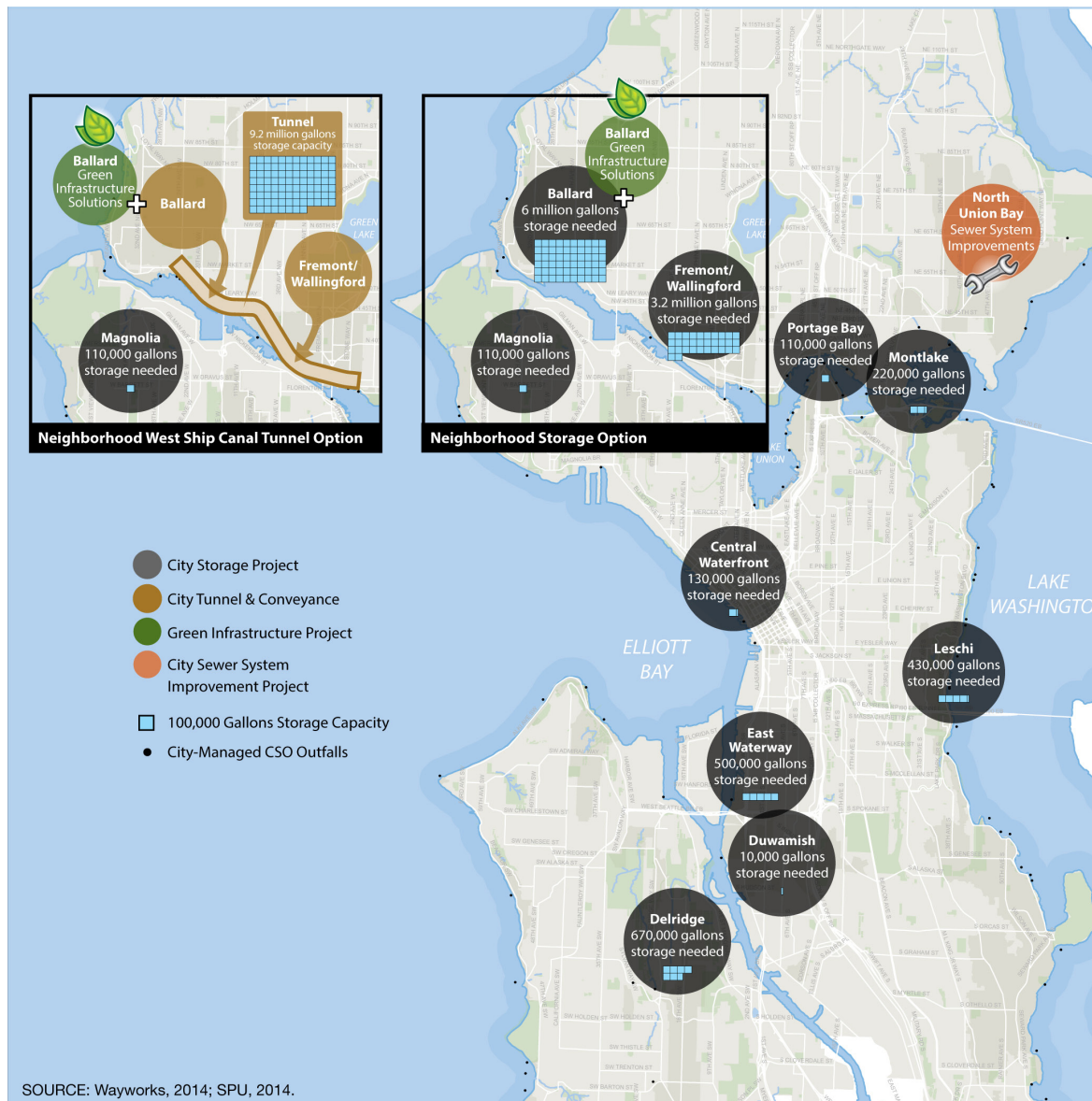


Figure 3-4. Neighborhood Storage Option

Under the **Neighborhood Storage Option**, the City would build underground storage facilities in Ballard, Fremont/Wallingford, Magnolia, Portage Bay, Montlake, Leschi, Central Waterfront, Duwamish, Delridge, and East Waterway CSO areas, and sewer system improvements in the North Union Bay CSO area. This option involved building the largest number of storage facilities throughout the city.

There are two variations in the Neighborhood Storage Option: one would provide storage in tanks/pipes only, and the other would include a tunnel (Neighborhood West Ship Canal Tunnel) in combination with tanks and pipes. The storage tank/pipe option involves the greatest number of affected locations. The Neighborhood West Ship Canal Tunnel Option was developed because the two CSO areas with the largest storage volumes (Ballard and Fremont/Wallingford) are relatively close to one another. The Neighborhood West Ship Canal Tunnel Option would

likely require fewer facilities and result in fewer neighborhood impacts compared to tanks/pipes only.

Implementation of the North Union Bay sewer system improvements will require City coordination with King County because additional flows will be transferred to the King County system. Specifically, the City and King County will need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.

3.2.2.4.2 Shared Storage Option

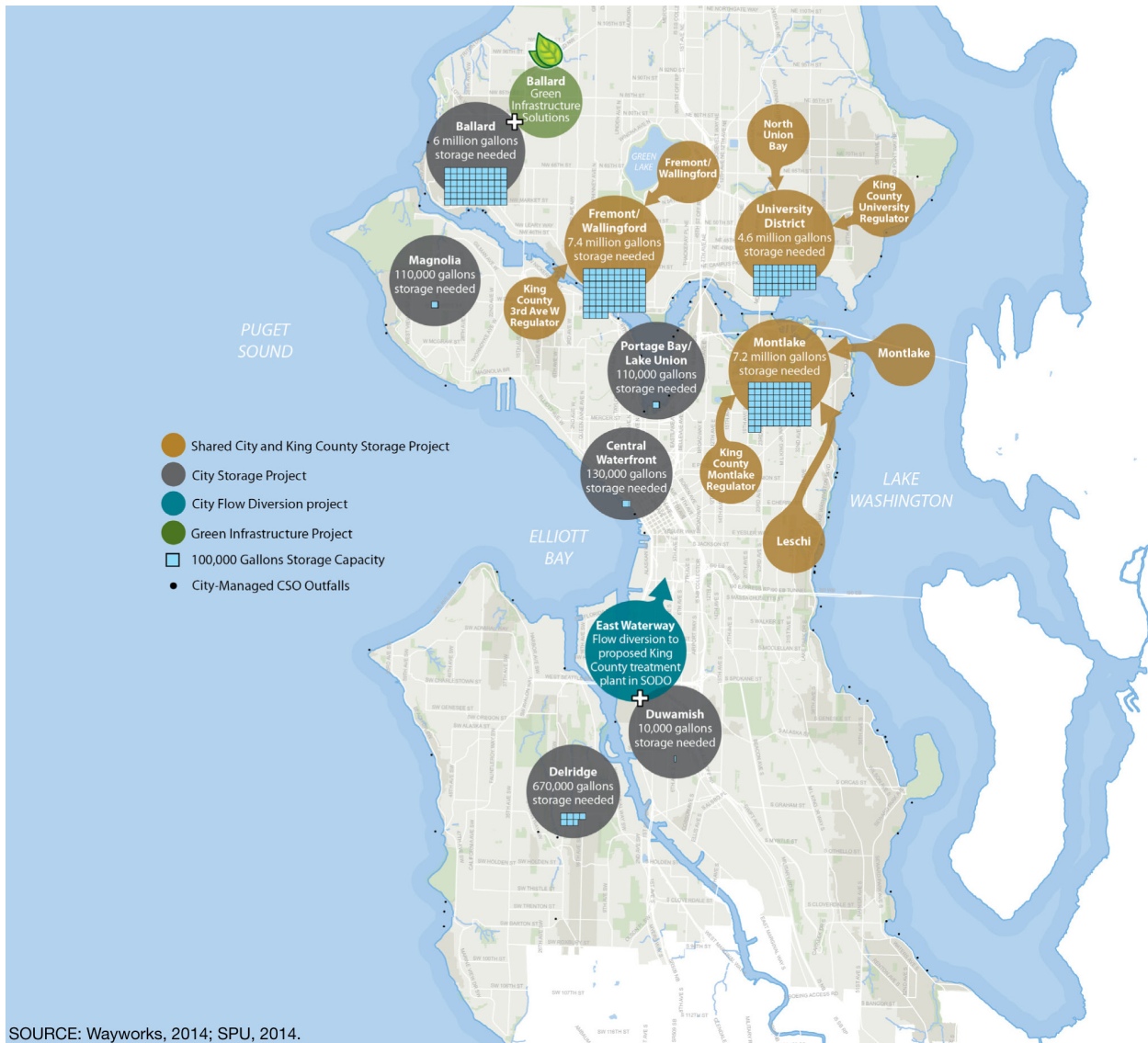


Figure 3-5. Shared Storage Option

Under the **Shared Storage Option**, the City and King County would jointly build larger but fewer storage tanks in three CSO areas: Fremont/Wallingford/King County 3rd Avenue West CSO; North Union Bay/King County University Regulator CSO; and Montlake/Leschi/King County Montlake Regulator. These three shared storage projects were recommended in the approved 2012 King County CSO plan. In the Duwamish CSO area, the City

would divert flows to a treatment facility proposed by King County. All other CSO areas would have the same storage facilities as proposed under the Neighborhood Storage Option.

Prior to implementing any shared projects between the City and King County, a shared project agreement would need to be signed between the two agencies. Specifically, the City and King County would need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.

3.2.2.4.3 Shared West Ship Canal Tunnel Option

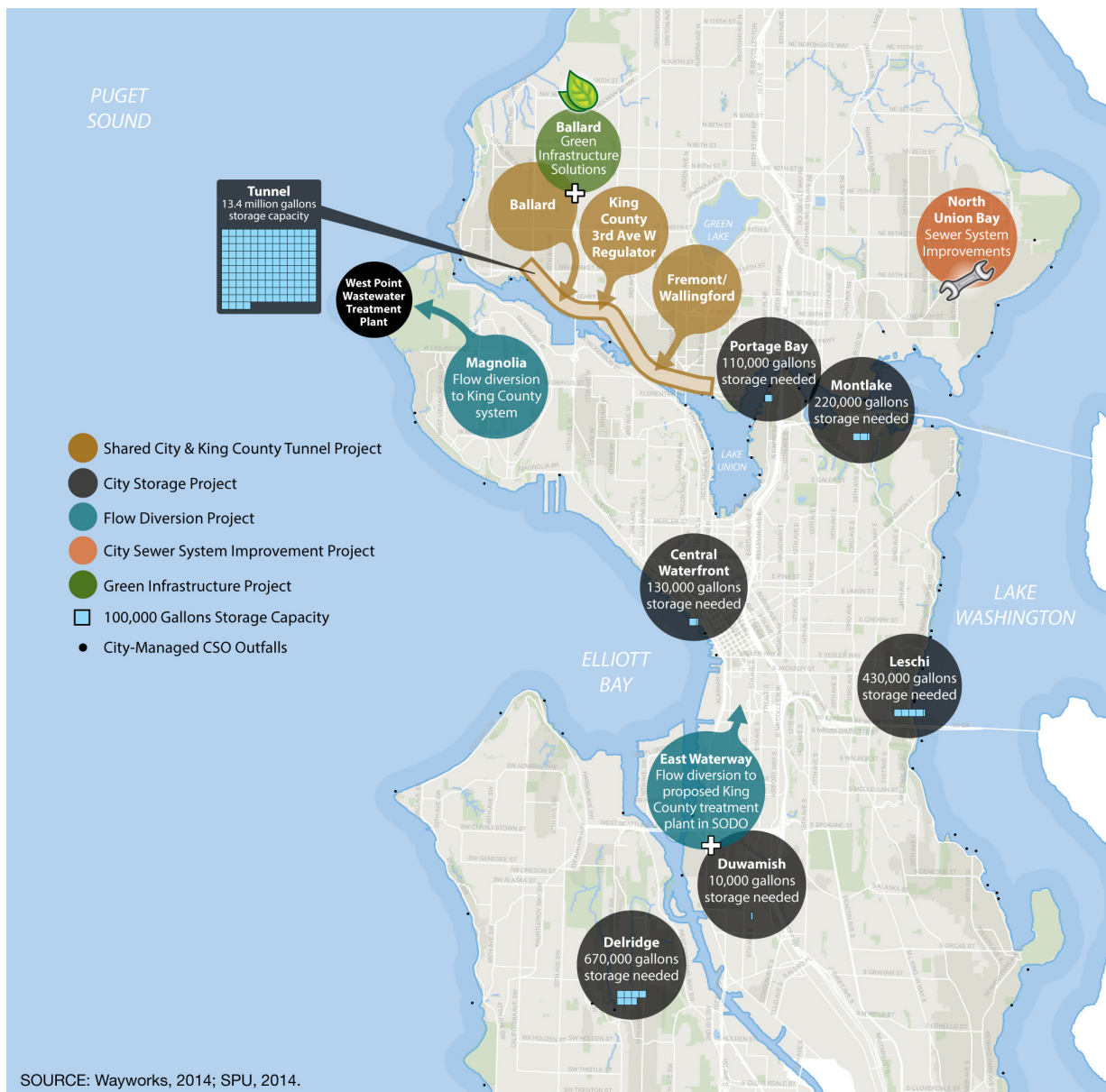


Figure 3-6. Shared West Ship Canal Tunnel Option

The **Shared West Ship Canal Tunnel Option** combines three of the largest CSO areas into a single deep tunnel. The West Ship Canal Tunnel is proposed as a shared option because the three CSO areas (two from the City and one from King County) with the largest control volumes are relatively close to one another. The tunnel would extend from Fremont/Wallingford to Ballard and would provide the storage needed to address sewage overflows in Ballard, Fremont/Wallingford, and King County's 3rd Avenue West CSO basins. The tunnel would eliminate the need for a separate King County CSO project at an outfall near 3rd Avenue West.

Prior to implementing any shared projects between the City and King County, a shared project agreement would need to be signed between the two agencies.

Within this option, the remaining CSO areas would be controlled by their respective neighborhood control measures except for Magnolia and East Waterway where flow diversions to King County's system are proposed. Any City flow diversion projects would require coordination with King County. Specifically, the City and King County would need to analyze the impacts of the proposed flow diversion projects on the downstream system and agree on an approach to address those impacts.

3.2.2.4.4 Shared Ship Canal Tunnel Option

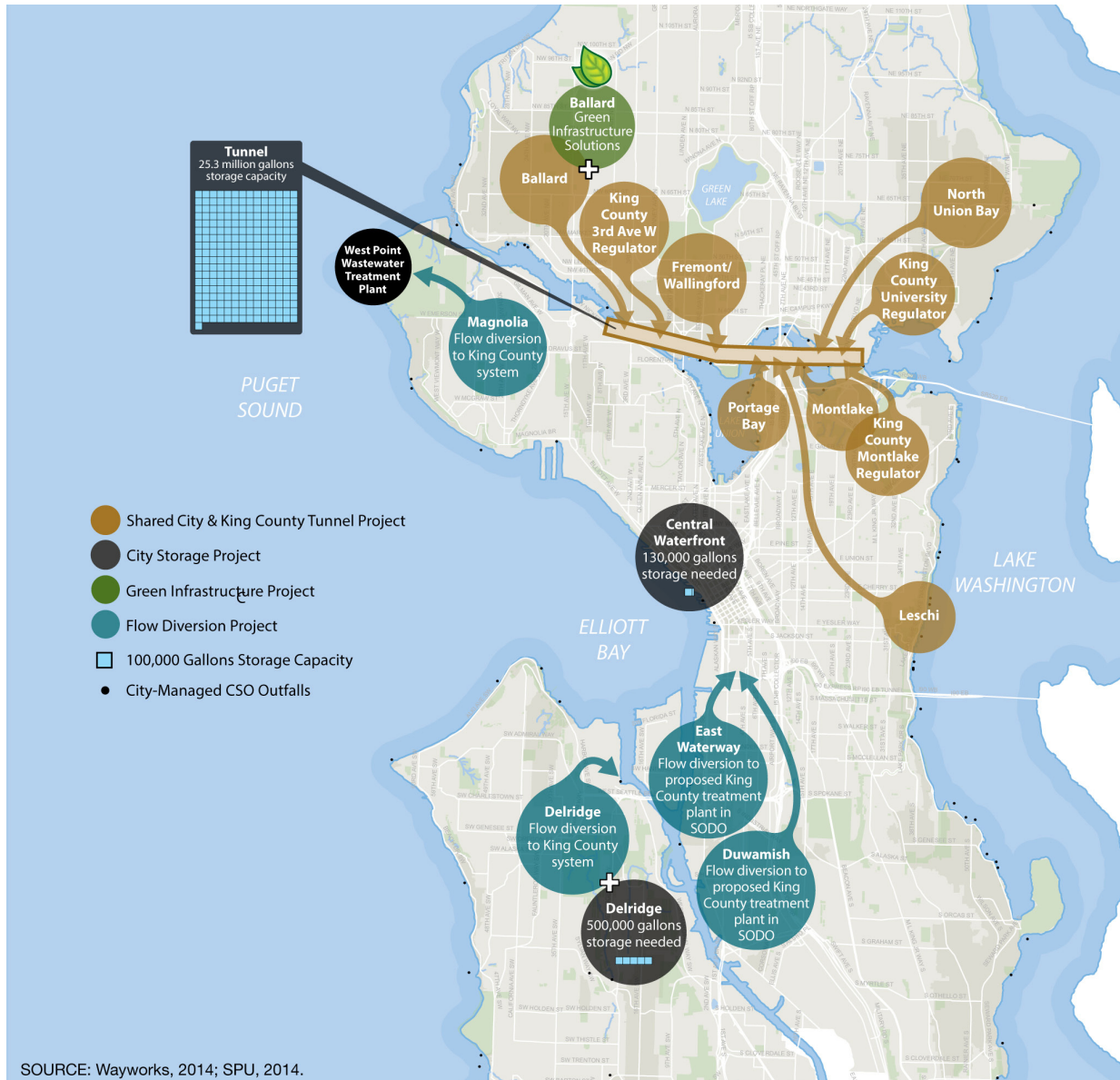


Figure 3-7. Shared Ship Canal Tunnel Option

The **Shared Ship Canal Tunnel Option** combines the control volumes from six City CSO areas along the Ship Canal and Lake Washington, and three of the largest King County CSO areas along the Ship Canal in a deep tunnel extending from the University District to Fremont/Wallingford. The tunnel would provide the storage needed to address sewage overflows in the City's CSO areas of Ballard, Fremont/Wallingford, Portage Bay, Montlake,

North Union Bay, and Leschi. The tunnel would also eliminate the need for three separate King County CSO projects at outfalls near Pacific Street (University Regulator), Montlake Avenue (Montlake Regulator), and 3rd Avenue West.

The remaining City CSO areas (Magnolia, Duwamish, East Waterway, and the northernmost Delridge CSO basin) would be diverted to King County under the assumption that flow diversions could be incorporated into mutual interagency agreements. The Central Waterfront and the southern Delridge CSO neighborhoods would continue to be served by their respective neighborhood control measures.

Prior to implementing any shared projects between the City and King County, a shared project agreement would need to be signed between the two agencies. Specifically, the City and King County would need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.

3.3 Integrated Plan Alternative

As described in Chapter 2, stormwater that enters the city's separate stormwater system is a major contributor to water quality issues. An approach that allows the City to integrate stormwater pollution management with CSO reduction strategies would lead to greater improvement of water quality, and represents a more comprehensive approach to water quality management.

Under the Integrated Plan Alternative, the City would implement stormwater pollution reduction projects in Seattle neighborhoods to address stormwater runoff in areas that are not part of the combined sewer system, using a combination of stormwater treatment technologies. These projects would reduce polluted stormwater runoff into the Duwamish Waterway, Lake Washington, Piper's Creek, Thornton Creek, Longfellow Creek, and Lake Union/Ship Canal. The City is focusing stormwater control projects in these areas to meet the Integrated Plan objectives established by the Consent Decree.

The City would also build CSO reduction projects using one of the four LTCP options outlined above for the LTCP Alternative. However, the City would delay the completion of some of the CSO control projects until 2030, while high-benefit stormwater treatment technology projects would be completed prior to 2025. Six CSO projects to control discharges into the lower Duwamish, Portage Bay and Ship Canal waterways would be constructed between 2028 and 2030. CSO control projects that would be delayed are located in the following neighborhoods: North Delridge, East Waterway, Duwamish, Portage Bay (Figure 3-8). These CSOs discharge to the lower Duwamish Waterway and Portage Bay, and Ship Canal. The City is required to propose a specific date for completing all CSO control projects to the EPA and Ecology.

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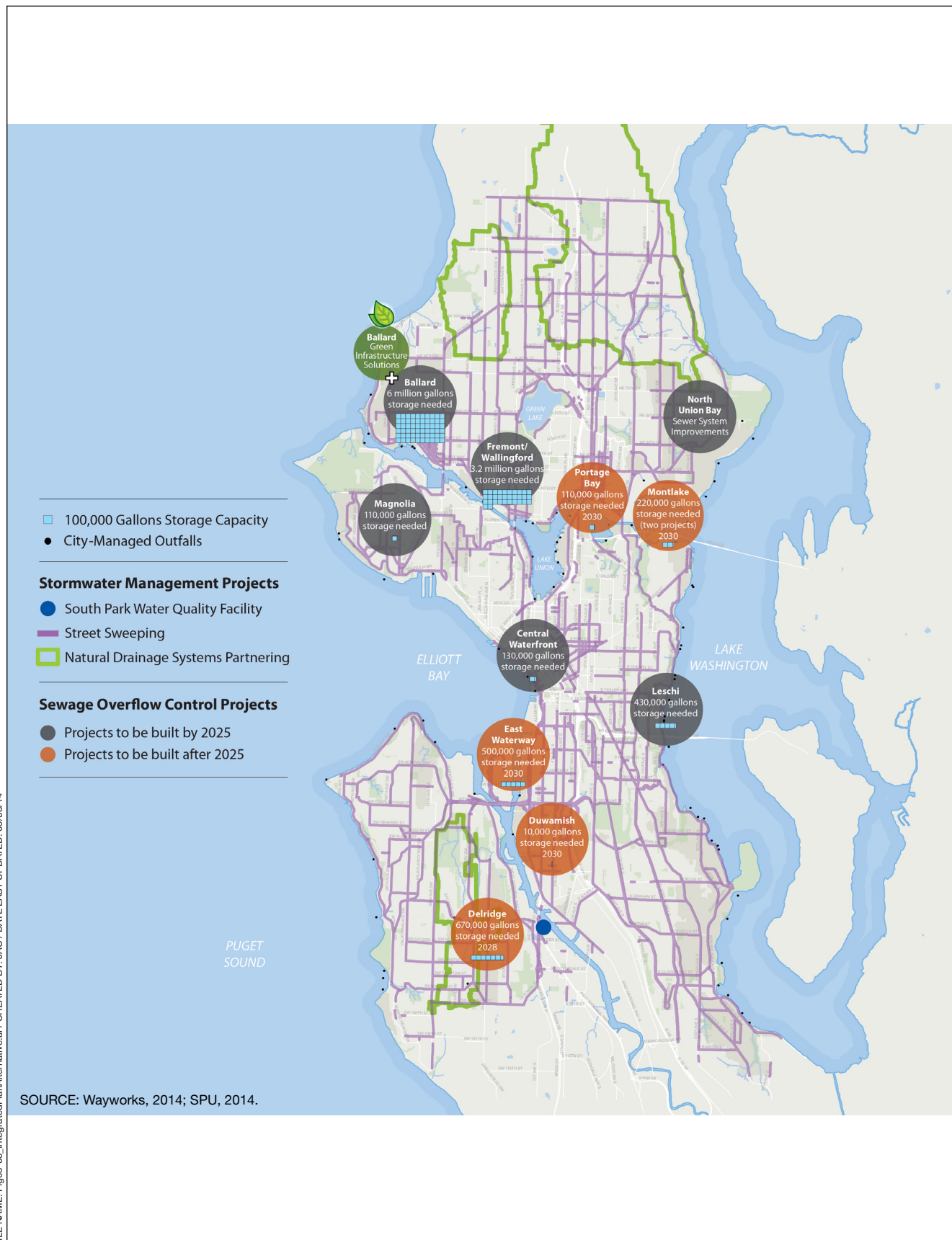


Figure 3-8 Integrated Plan Alternative.

3.3.1 How were the Integrated Plan Stormwater Projects/Programs Identified?

The planning process for the Integrated Plan focused on identifying stormwater pollution reduction projects in high-priority basins that can meet the intent of the Consent Decree to “*result in significant benefits to water quality beyond those that would be achieved by implementation of CSO Control Measures only.*”

The Consent Decree requires that the City describe the benefits of the proposed stormwater pollution reduction projects/programs in terms of reductions in pollutant loads and exposure to human and ecological receptors. In addition, the Consent Decree requires a cost-benefit analysis for the proposed projects. The City developed its Integrated Plan Alternative based on these requirements.

Identification of potential Integrated Plan stormwater projects/programs started with basin ranking to identify high-priority basins where water quality improvements are needed the most. The high-priority drainage basins that were analyzed for potential stormwater projects for the Integrated Plan included the following water bodies:

- Duwamish Waterway;
- Lake Washington;
- Lake Union; and
- Longfellow, Thornton, and Piper’s Creeks.

Next, stormwater projects/programs were identified for each priority basin by completing the following steps:

- Identifying characteristics of the priority ranked basins;
- Identifying each receiving water body and its primary pollutants of concern;
- Calculating pollutant and flow estimates for each basin;
- Using basin-specific information and knowledge of stormwater treatment technologies to identify potential locations for stormwater treatment; and
- Estimating costs for each of the stormwater treatment alternatives.

Finally, these projects and programs were evaluated against the CSO control projects to identify where significant benefits to water bodies in and around Seattle could be achieved by implementing the stormwater pollution reduction programs and projects now, and deferring completion of certain CSO control projects until 2030.

Further information is included in *Volume 3, Integrated Plan*.

3.3.2 Integrated Plan Alternative Stormwater Projects/Programs

The Integrated Plan Alternative consists of three stormwater pollution reduction projects or programs that would be implemented before 2025: Natural Drainage Systems (NDS) Partnering; South Park Water Quality Facility, and Arterial Street Sweeping Expansion. As described above, these projects/programs are in addition to projects that would be implemented under one of the four LTCP options. The difference being, six of the CSO control projects would be deferred under the Integrated Plan Alternative. These deferred CSO control projects would be constructed between 2028 and 2030. In keeping with the Consent Decree, the three stormwater projects would provide significant benefits to water quality beyond those that would be achieved by implementing the CSO control projects alone. Figure 3-8 shows the proposed stormwater project locations and the CSO control projects that would be deferred under this alternative.

The three stormwater projects/programs can generally be described in terms of three stormwater pollution reduction strategies: source control best management practices (BMPs), flow control BMPs, and stormwater treatment BMPs. Natural Drainage Systems Partnering and South Park Water Quality Facility involve flow control and stormwater treatment BMPs. The third project, Arterial Street Sweeping Expansion, is a source control BMP.

3.3.2.1 South Park Water Quality Facility

The South Park Water Quality Facility would reduce pollutant loading from approximately 74 MG of stormwater each year by installing an end-of-pipe treatment system in South Seattle adjacent to the Duwamish Waterway. The facility would treat stormwater from the City's 250-acre 7th Avenue S drainage system. A treatment facility is considered in this basin because stormwater is a significant contributor of contaminants to the Duwamish Waterway in this location. Because of the sensitivity of the receiving water this location emerged as a high priority for stormwater pollutant reduction. The facility would be built in the same location as a new stormwater pump station the City plans to build to reduce flooding in this same area, creating an opportunity to leverage water quality and flood control projects.

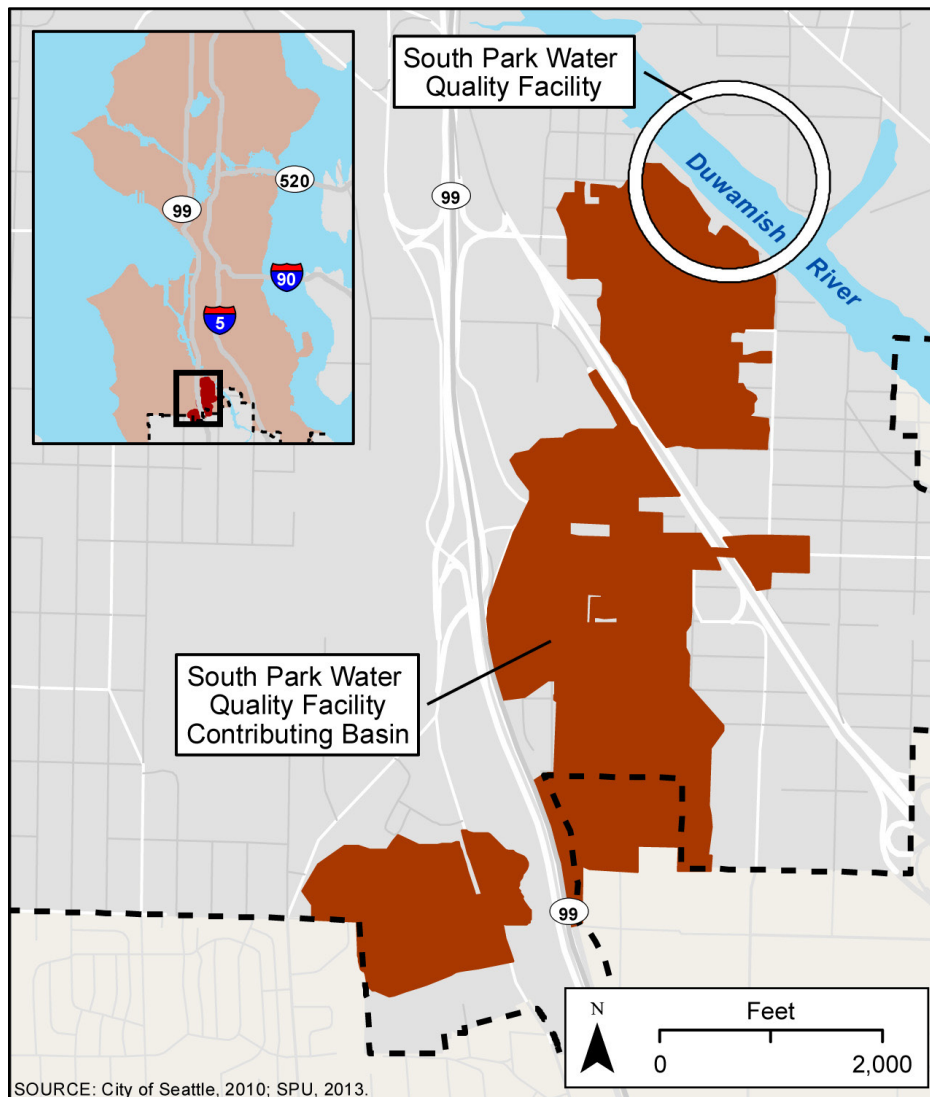


Figure 3-9. South Park Water Quality Facility

Stormwater would be routed through a basic, active treatment system such as chitosan-enhanced sand filtration (CESF) to remove a variety of pollutants prior to discharge to the Lower Duwamish Waterway through an existing outfall. This basic, active treatment would treat an average volume of approximately 74 MG per year from a drainage area of approximately 250 acres. If the Integrated Plan Alternative is selected, the South Park Water Quality Facility would be constructed by 2024 following project-specific environmental review and design.

3.3.2.2 Natural Drainage Systems Partnering

Natural Drainage System (NDS) Partnering, a flow control and stormwater treatment BMP, involves using natural drainage systems, such as engineered rain gardens, within various basins that drain to Piper's, Thornton, and Longfellow Creeks (Figure 3-10). Piper's Creek ultimately discharges to Puget Sound; Thornton Creek discharges to Lake Washington; and Longfellow Creek discharges to the Duwamish River and then into Puget Sound.

Projects implemented under this program would involve reconstructing City rights-of-way to manage flow and provide water quality treatment for polluted urban runoff primarily using bioretention facilities such as engineered rain gardens. Project locations would be identified by site factors and a community-nomination process. Projects would be designed to infiltrate into native soil where appropriate. Where complete reliance on infiltration is not technically feasible, systems would be augmented with underdrains.

Flow Control and Stormwater Treatment BMPs

These technologies typically control the volume, rate, and duration of stormwater runoff, or remove the pollutants by settling, separation, filtration, biological uptake, and absorption. Typical flow control BMPs include infiltration technologies and flow routing. Typical stormwater treatment BMPs include both active and passive facilities, such as treatment facilities, filtering systems, and natural drainage systems (e.g., rain gardens or bioretention).

Project locations would be prioritized based on stormwater management goals; however, community partnering goals (mobility, traffic calming, and beautification) would also be achieved as a secondary benefit. As a first step to NDS Partnering, the City would develop a program for encouraging residents or community groups to nominate their block(s) as candidates for NDS. Candidate blocks must be among the potential blocks identified by the City as potentially feasible for bioretention; the majority of these blocks are part of informal drainage systems (i.e., lacking curbs and gutters). Projects would be designed to infiltrate into native soil where appropriate. Where complete reliance on infiltration is not technically feasible, systems would be augmented with underdrains.

In summary, the following would be involved with selecting appropriate NDS Partnering project sites within these basins:

- Identify blocks that are potentially feasible for bioretention;
- Prioritize project locations based on stormwater goals;
- Conduct community outreach to encourage residents to nominate blocks as candidates for NDS and determine community goals (mobility, traffic calming, and beautification);
- Review right-of-way area, setback requirements, and locate utilities to determine bioretention sites; and
- Conduct geotechnical analysis (infiltration testing, depth of groundwater and hydraulic restrictive layer, erosion evaluation, evaluation of adjacent slopes and structures) to confirm site suitability and collect necessary information for detailed design.

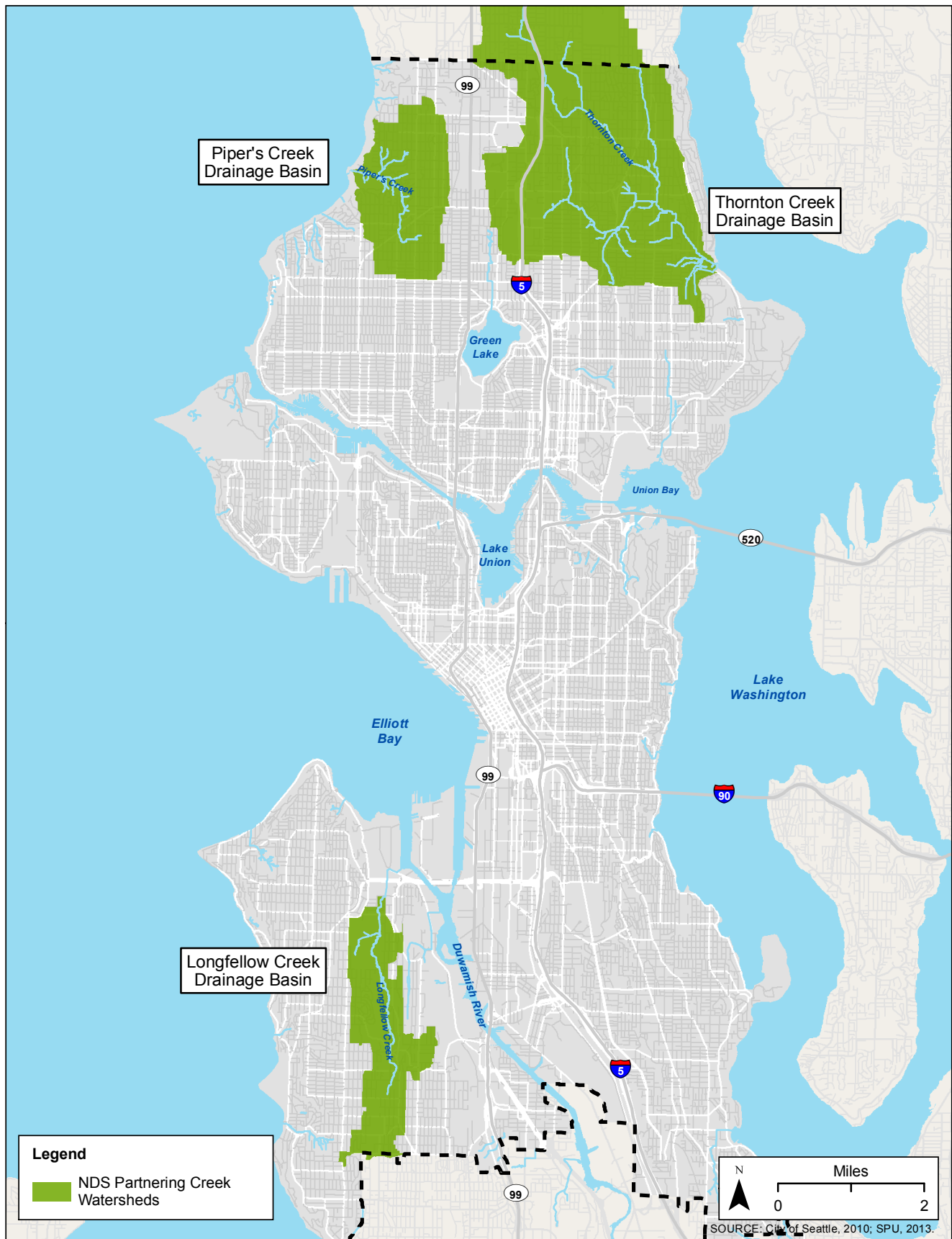


Figure 3-10 NDS Partnering.

3.3.2.3 Arterial Street Sweeping Expansion (Weekly Arterial Sweeping)

Street sweeping, a source control BMP, removes pollutants from roadways before they wash off into sewers and our local waterways. On most arterials, street sweeping is primarily conducted during the night.

The City's existing Street Sweeping for Water Quality Program started in 2011. It is a partnership between Seattle Public Utilities (SPU), which sets the program direction, provides water quality expertise, and funds routes that discharge directly to receiving waters, and the Seattle Department of Transportation (SDOT), which provides operational expertise, street sweeping services, and funding for routes that drain to a sewage treatment plant. Under the current sweeping schedule, 16 routes are swept every other week and six are swept weekly covering 415 curb miles each week, of which 73 percent drain directly to surface waters.

Source Control BMPs

These technologies typically prevent stormwater pollution or adverse impacts from occurring. For the Integrated Plan Alternative, the City's existing street sweeping program would expand the area, frequency and duration of the City's arterial street sweeping/program.

Seattle Public Utilities would expand its existing arterial street sweeping program by adding new arterial routes and increasing the frequency of sweeps. The citywide project would be designed to be expandable and adaptable to meet future needs. This approach has several benefits:

- Targets removal of pollutants from roadways
- Prevents a significant amount of solids/sediment and associated contaminants from reaching receiving waters, thereby improving water quality and substrate conditions.
- Provides reduced clogging of stormwater collection and conveyance systems, improved aesthetics, and improved air quality.

The program expansion would:

- Increase the route coverage from 83 to approximately 85 percent of curbed arterials (for a total 10,600 annual curb-miles), by adding 1 route, for a total of 25 routes
- Increase the sweeping season from 40 to 48 weeks per year
- Increase the sweeping frequency from biweekly to weekly for some routes: 21 routes will be swept on a weekly basis and 4 routes will be swept on a biweekly basis

Percent of total pollutant removal from expanded street sweeping (by receiving water)

Lake Washington	26%
Duwamish Waterway	22%
Lake Union	12%
Puget Sound South	12%
Thornton Creek	10%
Puget Sound Central/Elliott Bay	7%
Ship Canal/Salmon Bay	6%
Longfellow Creek	3%
Puget Sound North	0.8%

Because most existing development and roadways in the city were constructed before stormwater controls were required, runoff from many areas discharges directly to receiving waters without treatment. Retrofitting these existing systems to improve stormwater quality is often difficult and in many cases, retrofitting is not feasible due to physical site constraints (e.g., utility conflicts, grade restrictions, and tidal influence). Street sweeping can provide effective pollutant load reductions in area where retrofitting is impractical. If the Integrated Plan Alternative is selected, the expanded arterial sweeping program would begin in 2016.

More detailed information can be found in *Volume 3, Integrated Plan*.

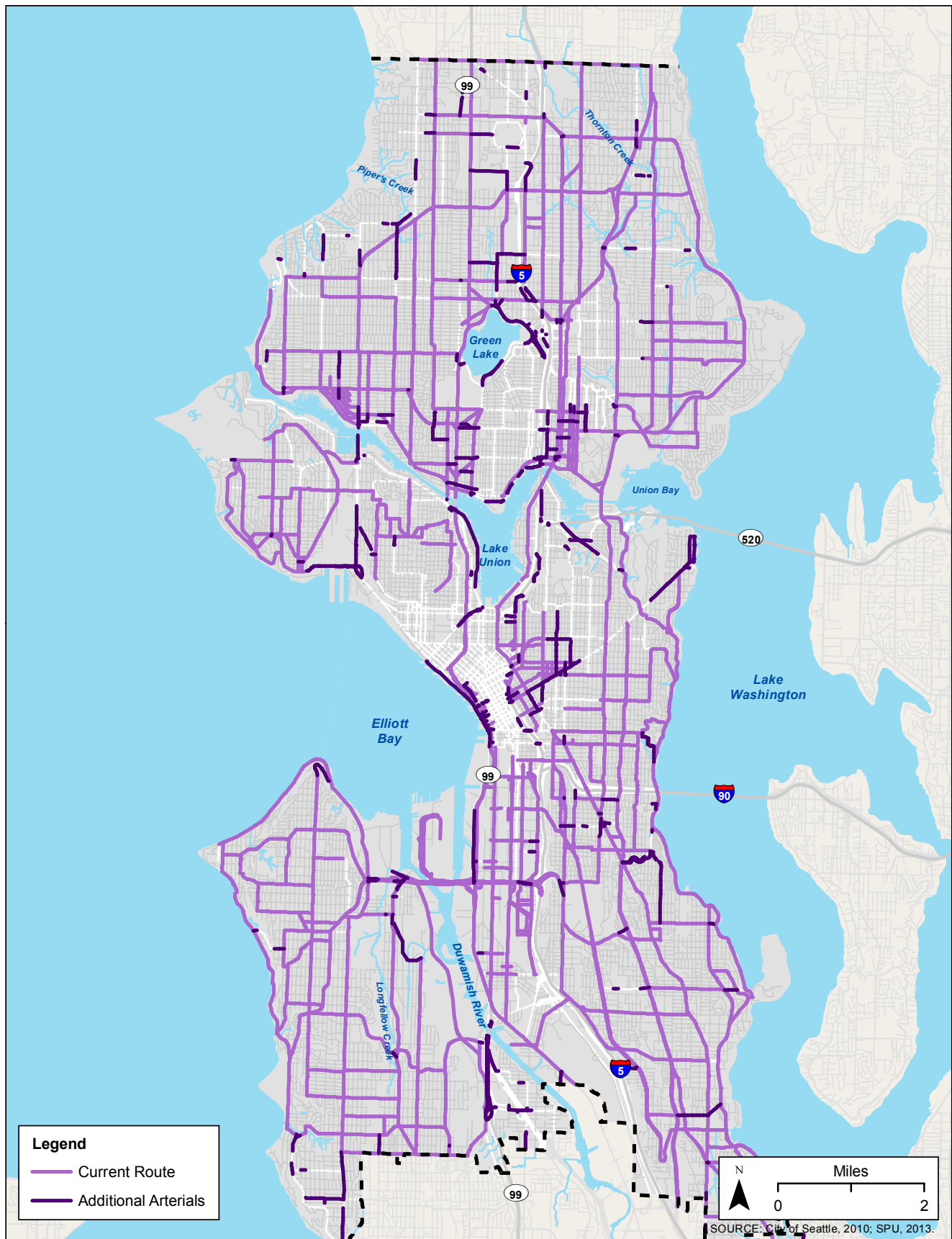


Figure 3-11 Arterial Street Sweeping Expansion.

3.4 Selection of a Preferred Alternative

Foremost in the development of the Plan is the need to comply with the Consent Decree and meet federal and state regulatory requirements. In order to comply with the Consent Decree, the City must select and implement an LTCP option. It is possible that the final option selected may include a combination of options or facilities presented in the EIS. The option that is selected could have some of the smaller elements modified (flow diversions could become storage tanks), but the major control measures (storage tanks or tunnels) would not change.

An Integrated Plan is an optional approach that is not required by EPA, but can be used to satisfy the Consent Decree.

The Plan for Protecting Seattle's Waterways, which consists of the following four volumes, will be submitted to EPA and Ecology for review and comment:

- Volume 1: Executive Summary
- Volume 2: CSO Long Term Control Plan
- Volume 3: Integrated Plan
- Volume 4: Programmatic EIS

The City will also continue to implement a public process and outreach to solicit input from the public and other stakeholders, including input received during a public hearing for the EIS and a public meeting on the Plan. The City will weigh the results of its MODA analysis for the LTCP and the Integrated Plan, address EPA and Ecology comments, and consider costs and input from the public and other stakeholders to identify a preferred alternative. Identification of a preferred alternative is expected to occur in early 2015 following release of the Final EIS.

CHAPTER 4**Affected Environment**

The Plan area includes large portions of the city of Seattle in a densely developed urban setting. As a result, the Plan has the potential to affect many elements of the built and natural environment. This chapter identifies important features of the Plan area that could be affected by construction or operation of the implemented Plan.

4.1 Earth and Groundwater**4.1.1 What is the regulatory setting for earth and groundwater?****4.1.1.1 Earth**

The City's environmentally critical areas code (Seattle Municipal Code 25.09) regulates development within geologic hazard areas.

Development within these hazard areas is subject to restrictions during design and construction. Development on steep slopes is not permitted in most cases. Environmentally critical areas such as streams and wetlands are discussed in Section 4.4, Biological Resources. The City of Seattle has adopted erosion and sediment control standards for all projects involving land disturbance. The requirements are discussed in Section 4.3, Surface Water.

4.1.1.2 Groundwater

The Washington State Department of Ecology (Ecology) regulates groundwater quality under the Water Quality Standards for Groundwaters of the State of Washington (Washington Administrative Code 173-200). These standards list the maximum concentrations of contaminants that are allowed in groundwater and prohibit further groundwater contamination.

Construction that requires excavation below the groundwater table typically requires dewatering. Dewatering involves pumping to remove groundwater from the excavated area during construction. Depending on the volume and quality of the groundwater, it may be pumped to a tanker truck or discharged to the sanitary sewer system or other approved discharge location. The City of Seattle regulates dewatering discharges to sewers under Seattle Municipal Code 22.802 through 22.805, and Joint Director's Rule DPD DR 3-2004/SPU DR 02-04. These requirements would apply to construction projects that include temporary groundwater withdrawal or discharge.

What is included in this section?

This section includes information on the geology, soils, and groundwater in the Plan area, and their relevance to CSO control and stormwater projects. This section also describes the regulations that apply to these resources.

Geologic hazard areas regulated by the City include:

- Liquefaction-prone areas are susceptible to loss of strength during earthquakes.
- Landslide-prone areas include steep slopes (slopes with grades of 40 percent or greater). Under Seattle's environmentally critical areas ordinance, development on steep slopes is not permitted in most cases.
- Peat settlement-prone areas.
- Seismic hazard areas are subject to ground shaking and impacts from ground displacement.
- Volcanic hazard areas are subject to inundation by mud and debris flows or related flooding resulting from volcanic activity.

4.1.2 What is the geologic setting of the Plan area?

Seattle is situated within the Puget Sound Lowland, a basin located between the Olympic Mountains to the west and the Cascade Range to the east (Troost et al., 2003; Troost and Booth, 2008). Seattle's unique geology results from the movement of materials caused by tectonic, volcanic, glacial, fluvial (river), coastal, and gravity-driven processes, as well as human-induced changes. The range of processes at work creates a degree of geological variation and complexity uncommon in most major cities. This complexity presents serious challenges for construction and development projects. Subsurface conditions may vary greatly and unpredictably over short distances, and project planners frequently must contend with multiple geological concerns for a single project. Seattle Public Utilities Geotechnical Engineering has prepared geotechnical reports for all neighborhoods in the Plan area with the exception of the Central Waterfront neighborhood (SPU 2012a, 2012b, 2012c, 2012d).

4.1.2.1 Which geologic processes have affected the Plan area?

The dominant geological process that contributed to Seattle's current landforms is the repeated cycle of glacial advance and retreat. At least seven glaciations have impacted the Seattle area within the last 2.4 million years (Troost and Booth, 2008) leaving behind complex geologic materials, in addition to eroding, reworking, and burying evidence of previous glaciations.

Seismic processes have also affected the Plan area, which is in a seismically active region located near the Cascadia Subduction Zone, a collision boundary where the Juan de Fuca tectonic plate dives beneath the North American plate. Of six known surface faults within Puget Sound, the Seattle Fault Zone is of particular relevance because Seattle sits astride this fault. This east-west trending fault runs roughly parallel to Interstate 90 from southern Bainbridge Island, through south Seattle, across Lake Washington, and into the Bellevue area and beyond (Figure 4-1).

4.1.3 What groundwater resources are present in the Plan area?

Depth to groundwater in the Plan area varies depending on the specific location. Numerous areas with shallow groundwater are present, as evidenced by springs that emerge from hillsides throughout the city. Information on groundwater depth in a particular area may be available from borings conducted for other development projects. Detailed information about the quantity and quality of groundwater in the Plan area is unavailable.

Groundwater quality in the Plan area is affected by historical and current releases of contaminants. Existing groundwater contamination sites are discussed in Section 4.6, Environmental Health and Public Safety.

4.1.4 How can geologic hazards affect facility construction and operation?

The presence of geologic hazards can affect the siting, design, construction, and operation of CSO and stormwater facilities. Geologic hazards in the Plan area are illustrated in Figure 4-1 and summarized as follows:

- Areas with loose, saturated soils that are prone to liquefaction present challenges for construction. These types of soils can shift or settle over time, causing problems for facilities built on them. Areas containing peat are prone to compression and can also settle following construction.
- Steep slopes that are prone to landslides can also have a high potential for erosion, particularly if vegetation is disturbed, causing problems during and after construction. Eroded sediment can also enter water bodies and degrade aquatic habitats.
- Areas containing artificial fill or lands substantially modified by humans may be challenging due to adverse or unpredictable soil characteristics. The construction potential of artificial fill depends on

technique and material type of the fill. Fill that is unsuited to construction may need to be removed or remediated to prevent problems such as settlement or expansion.

- Areas that have impermeable soils or extensive impervious paved surfaces are more susceptible to accumulating large volumes of water, which can create excessive runoff that results in flooding or other related problems.

4.1.5 How does surface geology affect natural drainage systems?

Natural drainage systems, described in Chapter 3, generally require soils that allow rain to infiltrate the ground rather than accumulating on the surface. The permeability of the soil directly affects infiltration rates. Permeability is a measure of a soil's ability to transmit water (and air) and depends on several factors including soil texture, soil structure, and compactness. Generally speaking, soils with higher proportions of fine-grained sediments such as clay and silt have less space between the soil particles and are less permeable than soils with more coarse-grained sediments such as sand and gravel. Soils that have been compacted (beneath the massive weight of glacial ice, for example) also have less space between soil particles and tend to be less permeable than uncompacted soils.

Figure 4-2 shows estimated soil infiltration characteristics based on mapped geological units (Troost and Booth, 2008). Areas with low potential infiltration, steep slopes, peat deposits, and near-surface groundwater present potential challenges for natural drainage systems. Areas with moderate infiltration potential, mostly glacial till, may have infiltration characteristics unsuitable for some types of natural drainage systems. Areas of high infiltration potential include zones of Vashon advance outwash, Vashon recessional outwash, and most other Holocene geological units.

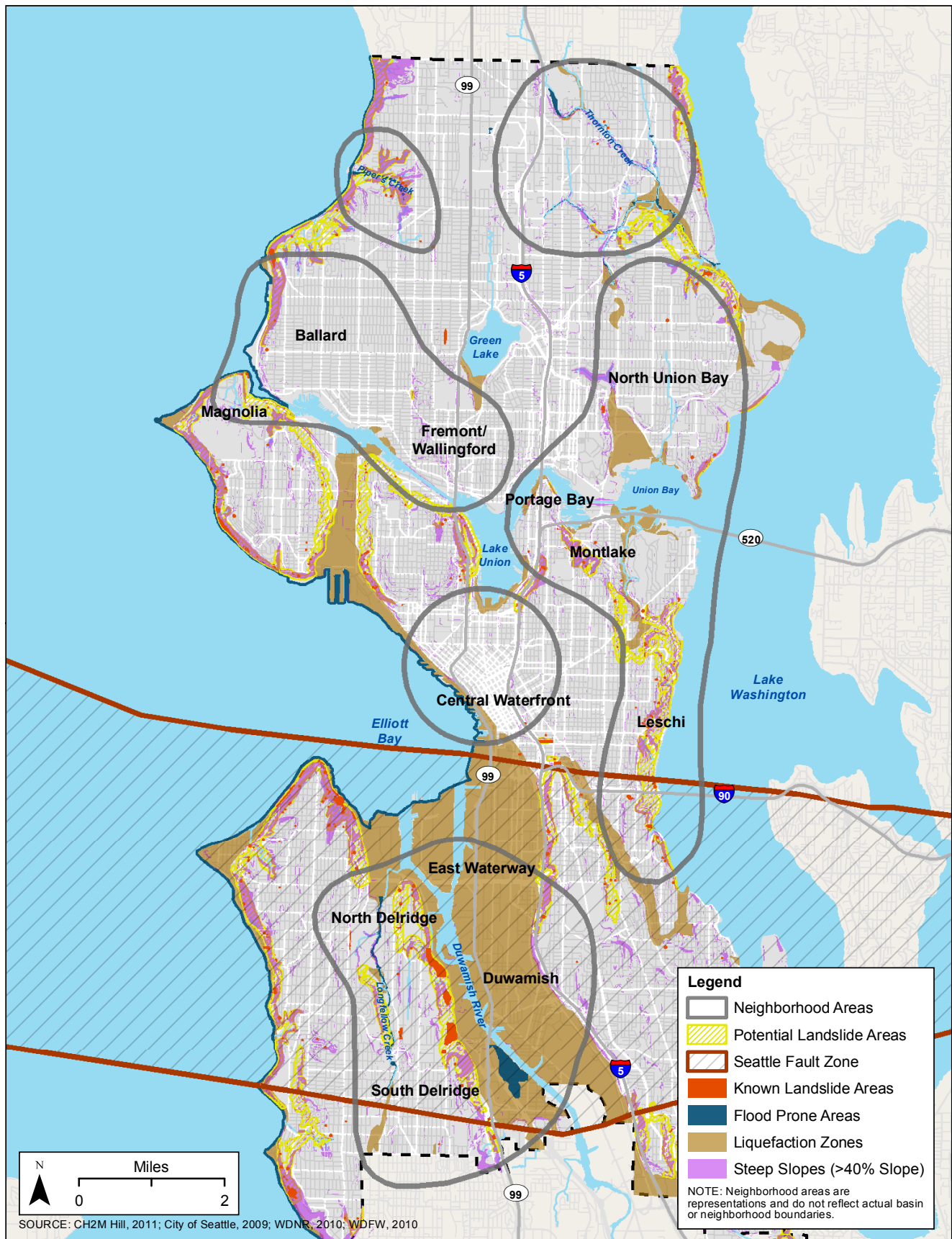


Figure 4-1 Geologic and Flood Hazard Areas.

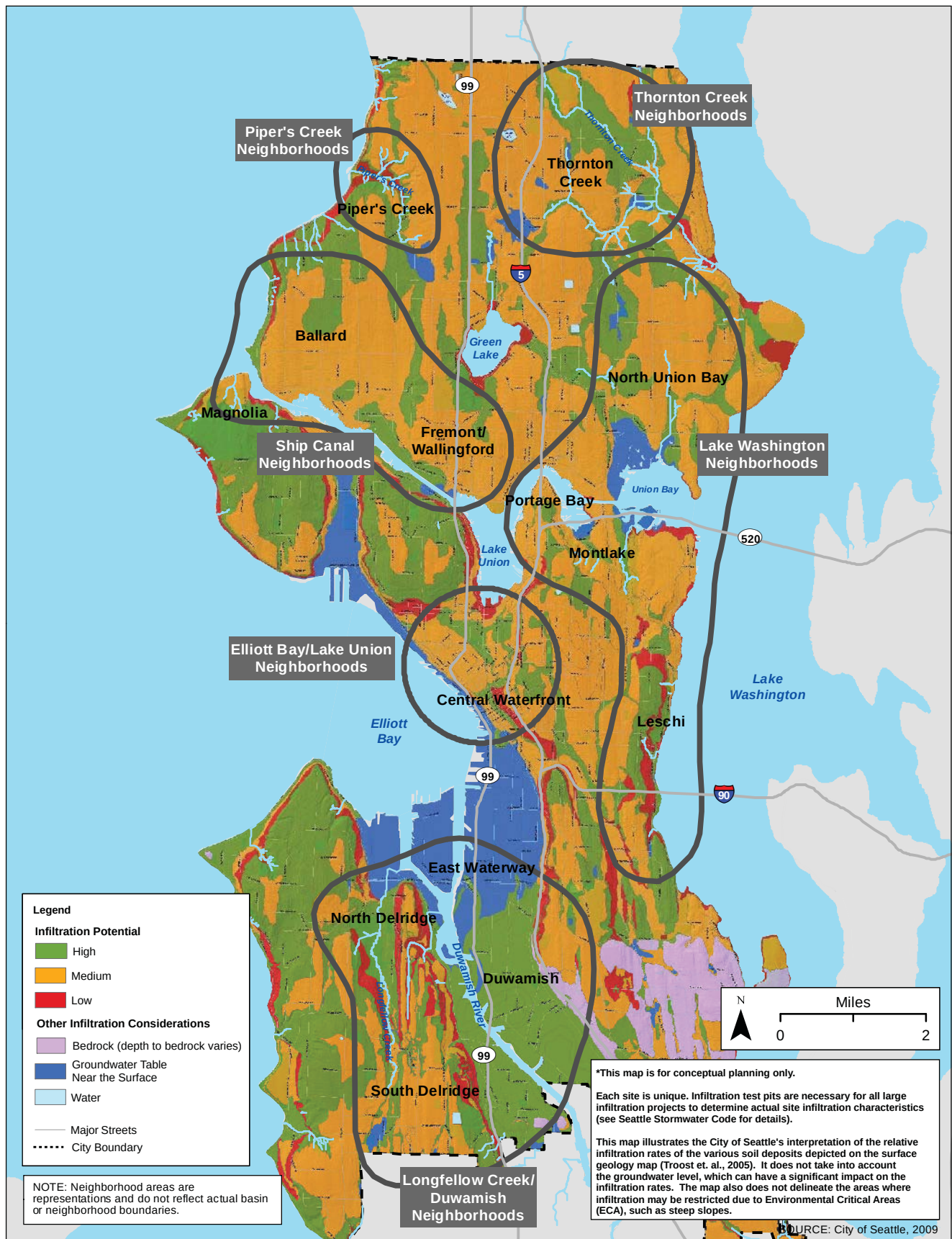


Figure 4-2 Groundwater Infiltration Potential.

4.1.6 How does groundwater affect construction?

The presence of a high groundwater table means that dewatering would likely be necessary during construction. The amount of dewatering required depends upon the depth and duration of construction activities. Because there are many underground storage tanks and known leaking underground storage tanks throughout the Plan area, there is a potential for encountering contaminated groundwater. Contaminated groundwater poses a risk to worker safety and requires approved treatment and disposal methods. Shallow groundwater could also constrain the ability to implement natural drainage systems that rely on infiltration.

4.1.7 What geologic hazards or limitations are present in Plan neighborhoods?

Table 4-1 summarizes the geologic hazards present in Plan neighborhoods.

Table 4-1. Summary of Geologic Hazards and Limitations in Plan Neighborhoods	
Neighborhood	Geologic Hazards or Limitations
Ship Canal Neighborhoods	
Ballard Magnolia	- Steep slopes and landslide potential on the periphery are challenges to construction and operation. - Areas of fill may require removal or remediation. - Most of area has low potential infiltration because of glacial till. - Commercial/industrial areas near the Ship Canal have a high potential for encountering contaminated groundwater sites due to historic activity and known leaking underground storage tanks.
Fremont/Wallingford	- Relatively few construction/operation hazards, apart from liquefaction risk south of Green Lake. - Large areas of glacial till limit the potential for infiltration. - Commercial/industrial areas near the Ship Canal have a high potential for encountering contaminated groundwater sites due to historic activity and known leaking underground storage tanks.
Lake Washington Neighborhoods	
Leschi	- Steep, landslide-prone slopes overlooking Lake Washington. - Location atop Seattle Fault Zone puts area at risk for shallow crustal earthquake and surface rupture. - Infiltration potential limited in some areas due to steep slopes.
Montlake	- Substantial steep slope/landslide-prone area in south and west. - Small area of liquefiable peat soil at Lake Union. - Infiltration limited by widespread glacial till.
North Union Bay	- Liquefiable peat soils in Union Bay Natural Area. - Steep slopes in Ravenna Park and above Matthews Beach. - Area of liquefiable soil at Lake Washington. - Reduced infiltration potential due to glacial till.
Portage Bay	- Relatively limited hazard areas apart from steep slopes. - Reduced infiltration potential due to presence of lower permeability glacial sediments.

Table 4-1. Summary of Geologic Hazards and Limitations in Plan Neighborhoods

Neighborhood	Geologic Hazards or Limitations
Longfellow Creek/Duwamish Neighborhoods	
Delridge	- Multiple areas presenting construction and operation challenges including extensive steep slope/landslide-prone areas, artificial fills, peat, and liquefiable soils along Duwamish River and Longfellow Creek. - Location atop Seattle Fault Zone puts area at risk for shallow crustal earthquake and surface rupture. - High groundwater; high infiltration potential farther to the south of this area.
Duwamish/East Waterway	- Extensive hazard areas including steep slope/landslide-prone areas along western flank of Beacon Hill, and liquefiable artificial fill and peat soils west of Beacon Hill in the Industrial District. - Location atop Seattle Fault Zone puts area at risk for shallow crustal earthquake and surface rupture. - Low-lying Industrial District has high groundwater. - Industrial areas have a particularly high concentration of known contaminated sites, so there is a high potential to encounter contaminated groundwater in this area.
Elliott Bay/Lake Union Neighborhoods	
Central Waterfront	- Extensive areas with artificial fill and regraded soils that are highly susceptible to liquefaction. - Widespread presence of impervious paved surfaces preventing infiltration. - Due to historic activity and high concentration of known leaking underground storage tanks in this area, there is a high potential to encounter contaminated groundwater.
Piper's Creek Neighborhoods	
	- Liquefaction area in Carkeek Park. - Extensive steep slope areas, potential slide areas, and known slide areas throughout the neighborhood.
Thornton Creek Neighborhoods	
	- Potential and known slide areas along Lake Washington and in the Meadowbrook and Maple Leaf areas of the neighborhood. Additional known slide areas near NE 125th Street and 15th Ave NE. - Liquefaction areas in Meadowbrook area and in/near Jackson Park Golf Course. - Steep slope areas throughout neighborhood, especially near Lake Washington.

4.2 Air Quality and Odors

4.2.1 What is the regulatory setting for air quality?

The federal Clean Air Act defines the Environmental Protection Agency's (EPA's) responsibilities for protecting and improving the nation's air quality. Under the Clean Air Act, EPA sets limits on certain air pollutants, including how much pollution can be present in the air anywhere in the United States.

What is included in this section?

This section describes the regulations governing air quality, general air quality in the Puget Sound region, and potential sources of odor from CSO reduction and stormwater projects.

In Washington State, responsibility for implementing the Clean Water Act has been delegated to the Washington State Department of Ecology. Locally, air quality is monitored by the Puget Sound Clean Air Agency (PSCAA), a separate organization with jurisdiction over King, Kitsap, Pierce, and Snohomish Counties. The PSCAA works in cooperation with EPA and Ecology and also implements specific air quality requirements such as dust control.

EPA has set federal standards for six "criteria air pollutants." These criteria air pollutants include fine and coarse particulate matter, ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, and lead. PSCAA and Ecology monitor and regulate levels of these pollutants to ensure the region meets federal air quality standards.

4.2.2 Why is air quality a concern?

Construction of major facilities can generate particulates, carbon monoxide, and ozone-creating compounds, which can be of concern to air quality.

- Dust, dirt, soot, and smoke are all considered "particulate matter." These materials are easily inhaled into the lungs and pose a host of serious health effects. They represent the most important criteria air pollutant challenge facing the region.
- Carbon monoxide is a colorless, odorless, toxic gas commonly formed when carbon-containing fuel is not burned completely. Motor vehicles are the main source of carbon monoxide in the Puget Sound region.
- Ozone is a pungent-smelling, colorless gas produced in the atmosphere when nitrogen oxides and volatile organic compounds chemically react under sunlight. The highest ozone levels occur on hot summer afternoons.

The other three of the six criteria pollutants are sulfur dioxide, nitrogen dioxide, and lead.

- Sulfur dioxide is a colorless, corrosive gas produced by burning fuels containing sulfur such as coal and oil. It is also created by industrial processes such as smelters, paper mills, power plants, and steel manufacturing plants.
- Nitrogen dioxide is a reddish brown gas that comes from motor vehicles. Other sources include industrial boilers and processes, home heaters, and gas stoves.
- Lead is a highly toxic metal that was used for many years in household products, automobile fuel, and industrial chemicals. Since the phase-out of lead in fuel and the closure of the Harbor Island lead smelter, airborne lead is no longer a public health concern in the Puget Sound region.

4.2.3 What about odors?

The major sources of odors in the Plan area include vehicle emissions, industrial discharges, and rail-related emissions. Vehicle exhaust fumes consist largely of carbon monoxide and sulfur compounds, and they are most noticeable during peak traffic hours on major roadways.

Odors are also generated by wastewater facilities. Odorous compounds in municipal wastewater systems consist mainly of reduced sulfur and nitrogen-based compounds including hydrogen sulfide, methyl mercaptan, and ammonia. The parts of a CSO system that can create odors include wastewater pipelines, maintenance holes, pump stations, storage facilities, and outfalls. Wet weather results in significant inflows of stormwater to the combined sewer system. This stormwater dilutes the concentration of sulfur and nitrogen compounds in wastewater, lowers the temperature, and increases the velocity through the conveyance system. These factors reduce the potential for significant odors. However, long conveyance distances or increased storage times may cause stagnation, oxygen deprivation, and accompanying odors in wastewater facilities.

4.2.4 What is the existing air quality in the Plan area?

According to PSCAA (2012), air quality in King County was generally good in 2012 (the year with the most recent published data). The air quality index rating in King County was “good” for 86 percent of the year, “moderate” for 13 percent of the year, and “unhealthy for sensitive groups” 1 percent of the year. However, the Puget Sound area as a whole is designated as a maintenance area for carbon monoxide. A pollutant associated with motor vehicle emissions, carbon monoxide is further controlled in many urban areas through air quality conformity regulations.

4.3 Surface Water

4.3.1 What are the regulations that govern surface water?

The overarching regulatory driver governing surface water is the federal Clean Water Act, which has resulted in water quality standards for surface water bodies. In Washington State, these regulations are implemented by the Washington Department of Ecology, including standards and limits for discharges into surface waters of the state.

The Clean Water Act serves as the overall legal and regulatory framework for CSO management, as described in Chapter 1. The Clean Water Act resulted in the adoption of EPA’s Combined Sewer Overflow Policy in 1994. The LTCP has been prepared consistent with the requirements of EPA’s Combined Sewer Overflow Policy.

Table 4-2 briefly describes state and local regulations for water quality, and permits for discharges to surface waters in the Plan area.

What is included in this section?

This section describes surface water resources in the Plan area with a focus on water quality. The section includes a summary of the regulatory setting for surface water, and a description of Plan area water bodies and existing water quality.

Table 4-2. Surface Water Related Regulations and Permits

Statute	Lead Agency	Regulated Activities
State of Washington		
Water Quality Standards for Surface Waters of Washington State	Ecology	Standards for surface water quality in Washington State are established by Ecology (WAC 173-201A). The purpose of the standards is to identify designated beneficial uses, establish specific criteria, and establish policies for anti-degradation to protect the state's surface water bodies.
Clean Water Act Section 401 Water Quality Certification	Ecology	Actions subject to federal permits that result in pollutant discharge must obtain a water quality certification demonstrating that the action complies with all applicable water quality standards.
Construction Stormwater NPDES* General Permit	Ecology	Required for construction activities that disturb 1 acre or more of land and discharge stormwater to surface waters. Requires implementation of a stormwater pollution prevention plan, water quality monitoring, and record keeping and reporting protocols.
Phase I Municipal Stormwater NPDES* Permit	Ecology	The City of Seattle is covered under the Phase I municipal stormwater NPDES permit issued in June 2012 (Ecology, 2012b). Authorizes stormwater and in some cases other discharges to surface water and groundwater. The City is required to establish and implement a comprehensive stormwater management program, including regulations for development projects. Compliance with the City's stormwater code (and accompanying technical manuals for stormwater flow control and treatment) and construction stormwater controls ensure that projects meet the requirements of the Phase I municipal stormwater NPDES permit.
City of Seattle		
SMC 22.800 Stormwater Code (SMC 22.800) and Stormwater Manual (2009)	City of Seattle	Specifies stormwater treatment and flow control requirements for new and redevelopment projects and requirements for protecting water resources during construction. New and redevelopment projects not discharging to the combined sewer system that create or replace more than 5,000 square feet of pollution-generating impervious surface must provide stormwater treatment for pollution-generating pervious and impervious surfaces on the site. All projects are required to use green stormwater infrastructure to the maximum extent feasible. Oil control is required for stormwater runoff from targeted areas subject to heavy traffic usage.

* National Pollutant Discharge Elimination System

4.3.2 What are the surface water resources within the Plan area?

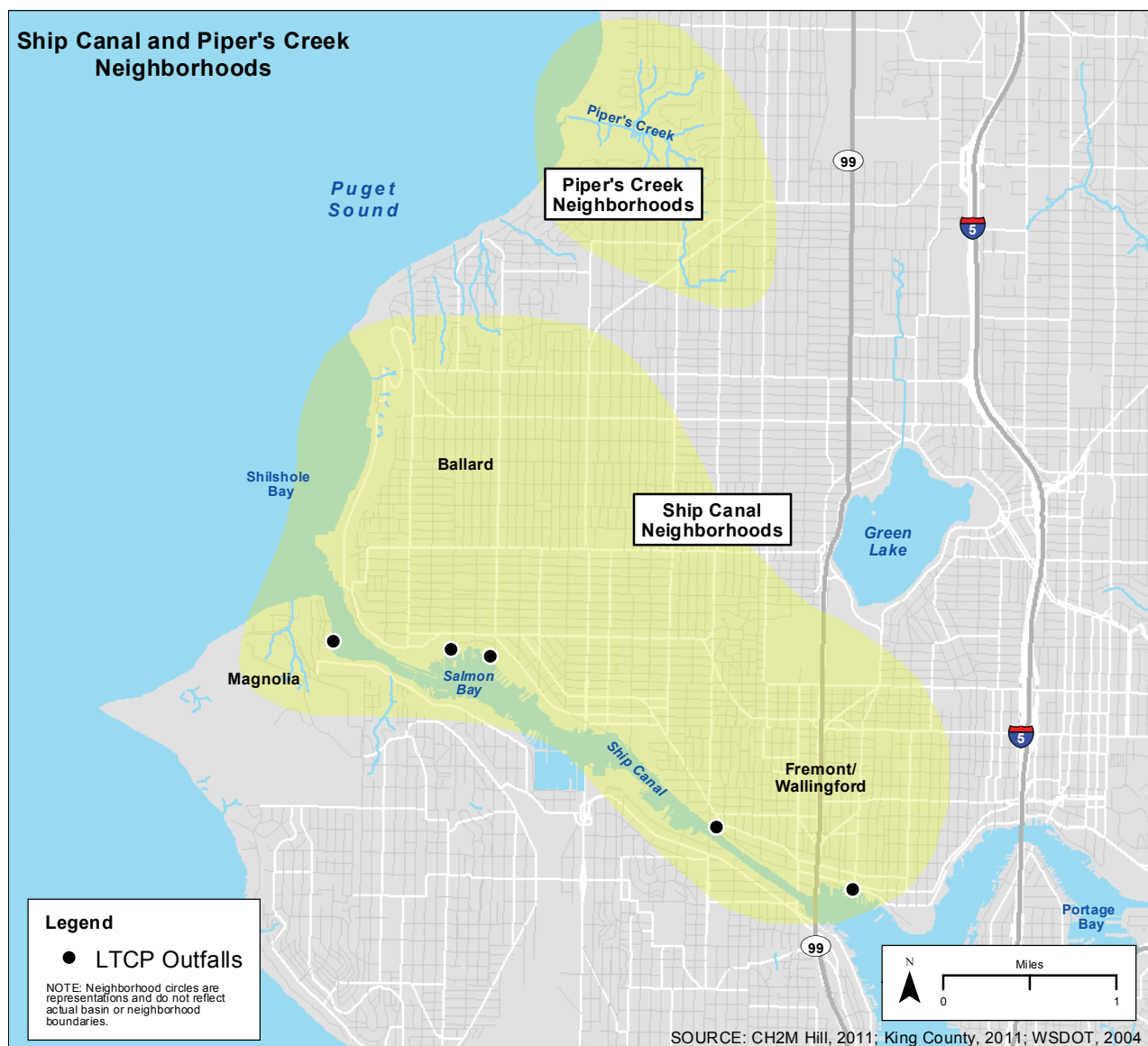
Water bodies in the Plan area neighborhoods include Puget Sound, Elliott Bay, Lake Washington and the Ship Canal, Lake Union, the Duwamish River, Longfellow Creek, Piper's Creek, and Thornton Creek. The receiving water bodies in the Plan area are described below and illustrated in Figures 4-3 through 4-6, Biological Resources. Stormwater discharges to these water bodies are regulated under the municipal stormwater NPDES permit.

The City's Stormwater Code classifies all receiving waters in the Plan area except Longfellow Creek as Designated Receiving Waters. New development does not require flow control protection for stormwater runoff because these water bodies have sufficient capacity to receive discharges without causing flooding or physical damage. Stormwater discharges to Longfellow Creek are expected to meet the pre-developed "pasture" standard. All stormwater discharges to the combined sewer system are required to meet the peak control standard

established by the City's stormwater manual. Treatment is required for stormwater runoff that doesn't involve discharge to the combined sewer system. All projects are required to use green stormwater infrastructure to the maximum extent feasible.

Additional detail about surface waters in the Plan area is included in Chapter 2 of *Volume 3, Integrated Plan*.

FILE NAME: Fig. 04-03_SurfaceQuality_ShipCanal.ai / CREATED BY: JAC / DATE LAST UPDATED: 05/06/14



Puget Sound

Aquatic Use Classification:
Extraordinary

Recreation Classification:
Primary Contact

Overall Water Quality:
Good

Maximum Temperatures:
9.6 – 14.5 °C

Minimum DO:
2.5 – 8.1 mg/L

Impaired 303d Category 5 List at LTCP Outfalls:
Fecal coliform (Outfalls 57, 59)

Ship Canal/Lake Union

Aquatic Use Classification:
Core Summer Habitat

Recreation Classification:
Extraordinary Primary Contact

Overall Water Quality:
Fair

Maximum Temperatures:
20.6 – 23.3 °C

Minimum DO:
7.3 – 9.3 mg/L

Impaired 303d Category 5 List at LTCP Outfalls:
Fecal coliform, total phosphorus, lead, aldrin (Outfalls 20, 138, 139, 140)

Piper's Creek

Aquatic Use Classification:
Core Summer Habitat

Recreation Classification:
Extraordinary Primary Contact

Overall Water Quality:
Fair

Maximum Temperatures:
13.0 – 16.0 °C

Minimum DO:
7.5 – 10.3 mg/L

Impaired 303d Category 5 List at LTCP Outfalls:
None (no Outfalls)

SOURCE: Ecology, 2013b.

Figure 4-3. Ship Canal Neighborhoods - Surface Water Quality.

FILE NAME: Fig. 04-04_SurfaceWaterQuality_LakeWashington.ai / CREATED BY: JAC / DATE LAST UPDATED: 05/06/14

Thornton Creek

Aquatic Use Classification:
Spawning/Rearing

Recreation Classification:
Primary Contact

Overall Water Quality:
Fair

Maximum Temperatures:
15.0 – 17.6 °C

Minimum DO:
7.3 – 9.1 mg/L

**Impaired 303d Category 5 List
at LTCP Outfalls:**
Temperature, dissolved oxygen
(No Outfalls), fecal coliform

Ship Canal/Lake Union

Aquatic Use Classification:
Core Summer Habitat

Recreation Classification:
Extraordinary Primary Contact

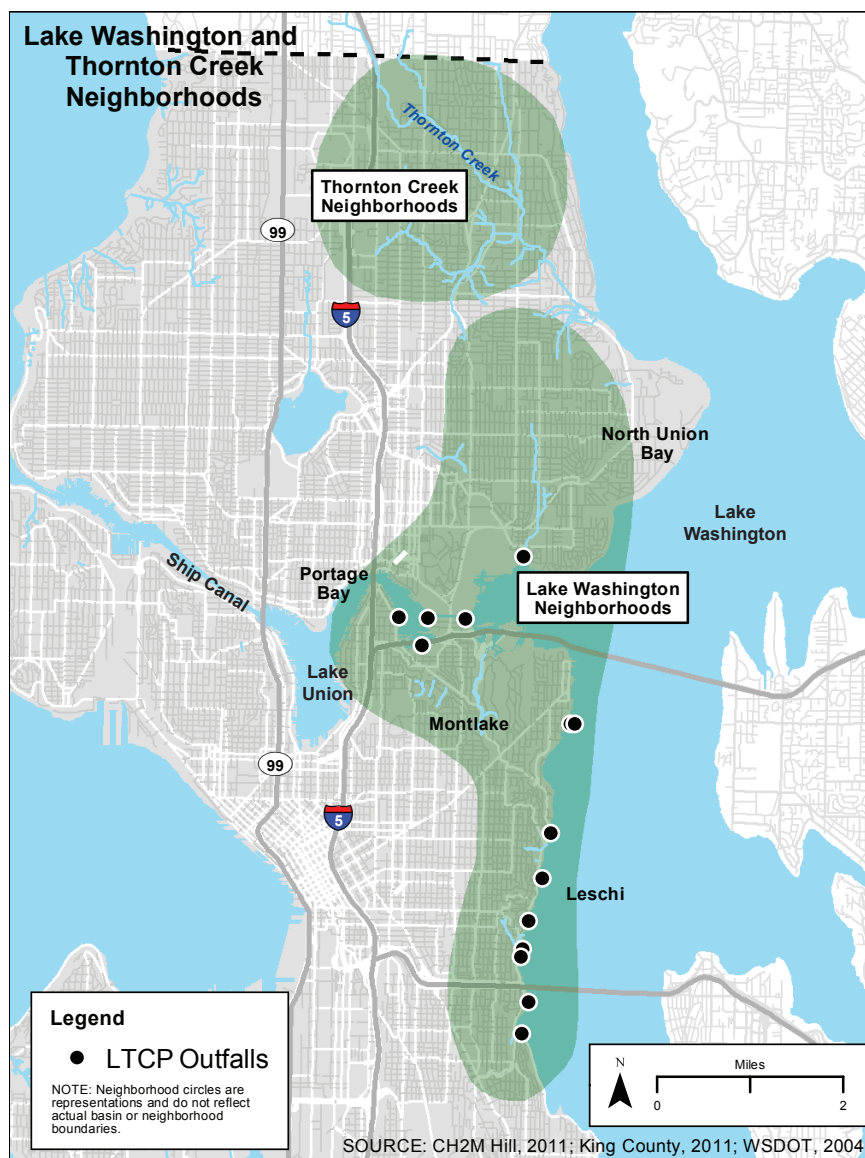
Overall Water Quality:
Good

Maximum Temperatures:
20.6 – 23.3 °C

Minimum DO:
7.3 – 9.3 mg/L

**Impaired 303d Category
5 List at LTCP Outfalls:**
Fecal coliform, total phosphorus,
lead, aldrin (Outfalls 20, 138, 139, 140)

SOURCE: Ecology, 2013b.



Lake Washington

Aquatic Use Classification:
Core Summer Habitat

Recreation Classification:
Extraordinary Primary Contact

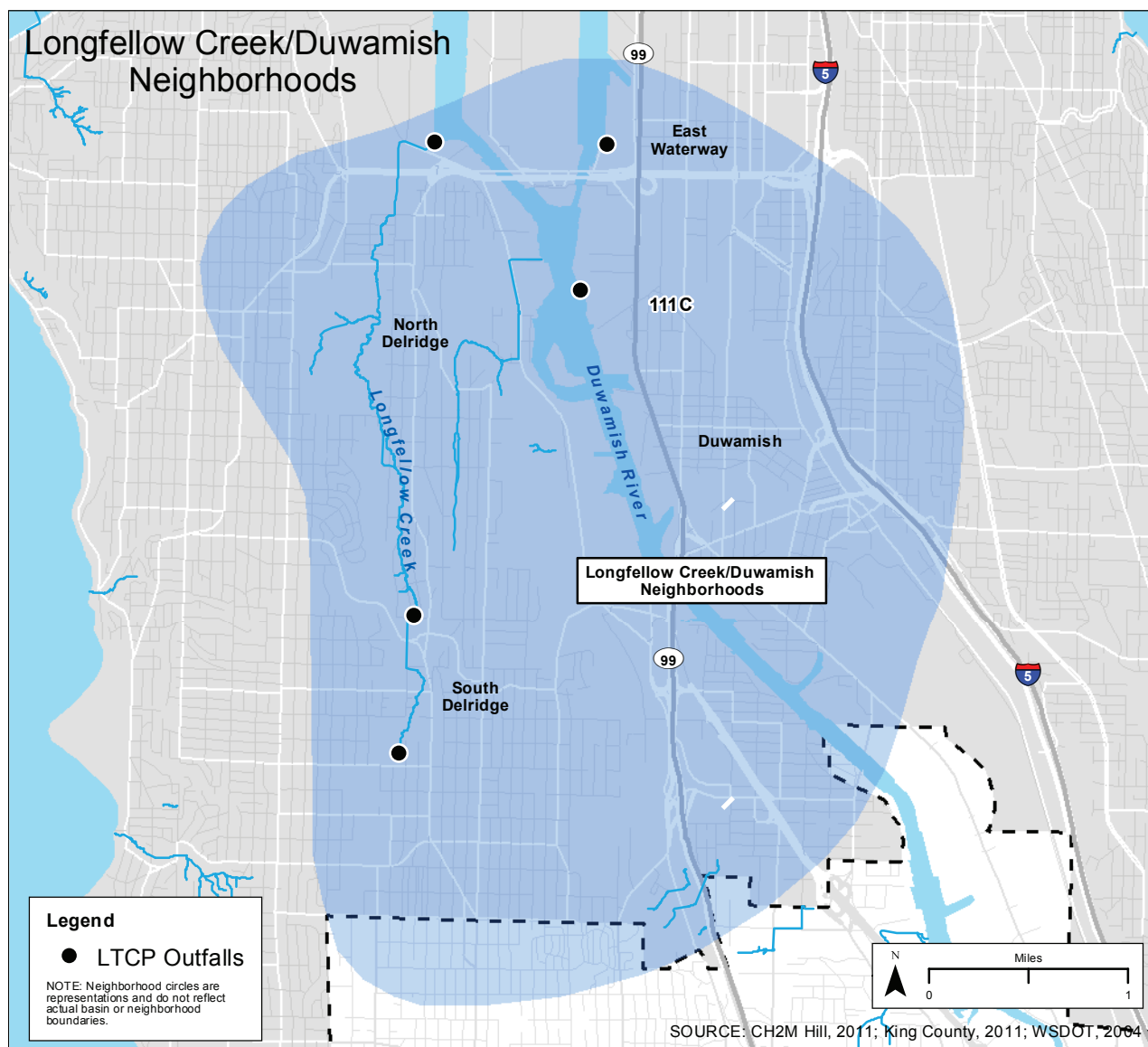
Overall Water Quality:
Good

Maximum Temperatures:
20.9 – 23.6 °C

Minimum DO:
7.3 – 9.1 mg/L

**Impaired 303d Category 5 List
at LTCP Outfalls:**
Fecal coliform (Outfall 36)

Figure 4-4. Lake Washington Neighborhoods - Surface Water Quality.



Longfellow Creek

Aquatic Use Classification:

Spawning/Rearing

Recreation Classification:

Primary Contact

Overall Water Quality:

Moderate

Maximum Temperatures:

12.0 – 19.2 °C

Minimum DO:

6.5 – 9.1 mg/L

Impaired 303d Category 5 List at LTCP Outfalls:

Fecal coliform, dissolved oxygen (Outfall 168, 169)

Duwamish River

Aquatic Use Classification:

Rearing/Migration Only

Recreation Classification:

Secondary Contact

Overall Water Quality:

Good

Maximum Temperatures:

17.0 – 23.2 °C

Minimum DO:

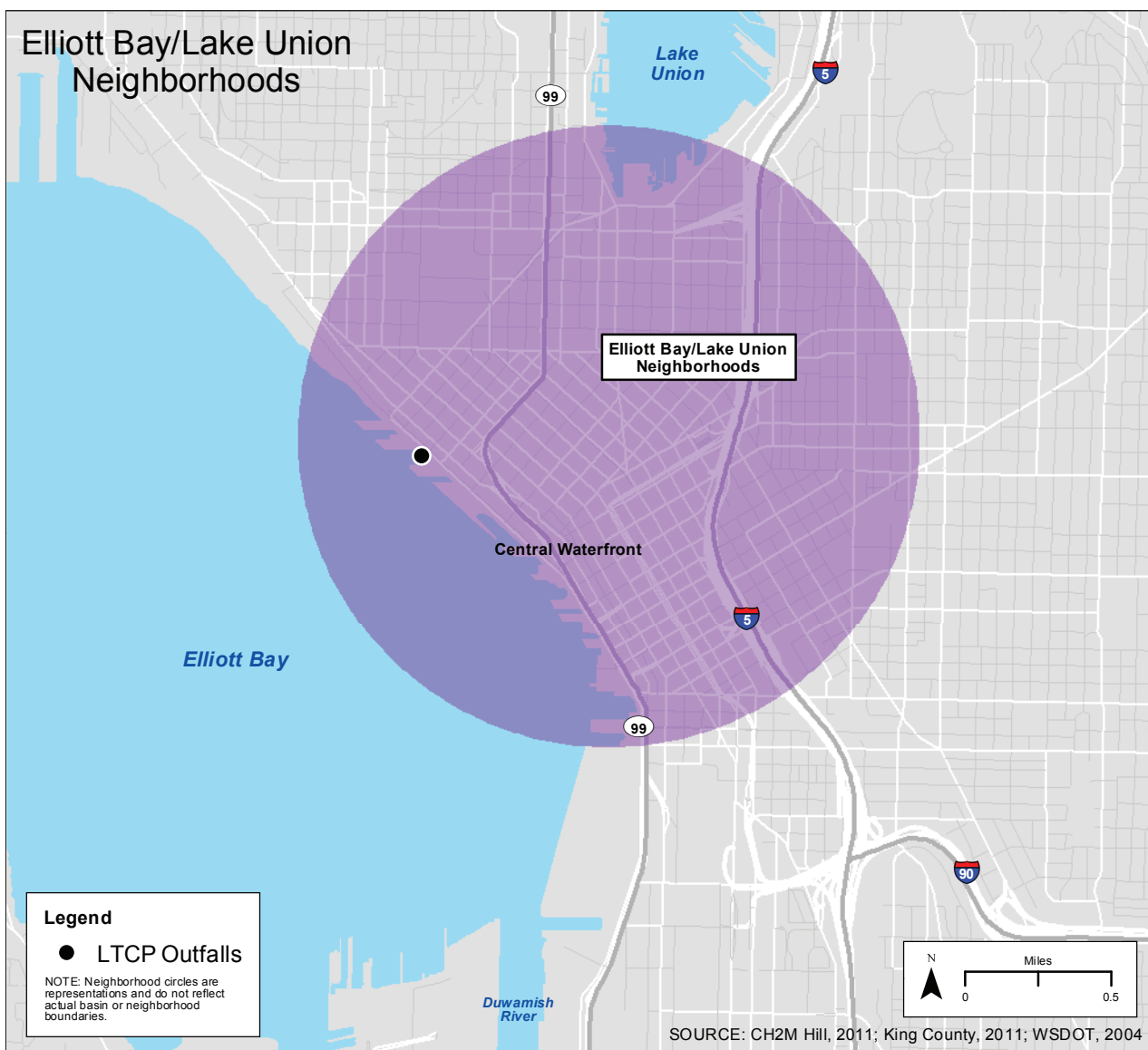
5.9 – 8.1 mg/L

Impaired 303d Category 5 List at LTCP Outfalls:

Fecal coliform, dissolved oxygen, tissue PCBs (Outfall 99); sediment bioassay (Outfall 111)

SOURCE: Ecology, 2013b.

Figure 4-5. Longfellow Creek/Duwamish Neighborhoods - Surface Water Quality.



Elliott Bay

Aquatic Use Classification:
Excellent

Recreation Classification:
Primary Contact

Overall Water Quality:
Good

Maximum Temperatures:
13.1 – 16.2 °C

Minimum DO:
5.8 – 8.0 mg/L

**Impaired 303d Category 5 List
at LTCP Outfalls:**
Fecal coliform (Outfalls 70, 71, 72);
sediment bioassay (Outfalls 71, 72)

Lake Union

See Figure 4-3

SOURCE: Ecology, 2013b.

Figure 4-6. Elliott Bay/Lake Union Neighborhoods - Surface Water Quality.

4.3.2.1 Puget Sound

Puget Sound is a fjord-like estuary that stretches from Hood Canal to north of Admiralty Inlet. Freshwater flows influence water circulation in this portion of Puget Sound. Two main freshwater bodies flow into Puget Sound in the Plan area, the Green/Duwamish River, which enters Elliott Bay, and the Cedar River (Lake Washington drainage basin), which flows into the Sound through Lake Washington and the Ship Canal.

4.3.2.2 Elliott Bay

Elliott Bay is a partially enclosed embayment that is bordered on the north, east, and south sides by urbanized areas of Seattle and by Puget Sound on the west. The eastern shoreline borders the Elliott Bay/Lake Union Neighborhoods. The southern portion of Elliott Bay near the Longfellow Creek/Duwamish Neighborhoods is heavily altered by industrial facilities including Harbor Island.

4.3.2.3 Lake Washington

Lake Washington is bordered on the west by the Lake Washington Neighborhoods. The Lake Washington drainage system has been highly altered and now drains through the Lake Washington Ship Canal rather than its historical outlet through the Duwamish River (Chrzastowski, 1983). Most of the lake shoreline in the Plan area is developed for residential uses. Lake levels are regulated by the Corps of Engineers through operation of the Lake Washington Ship Canal (Corps of Engineers, 2012a, 2012b).

4.3.2.4 Ship Canal/Lake Union

The Lake Washington Ship Canal system is an 8.6-mile-long navigable waterway, completed in 1934, connecting Shilshole Bay in Puget Sound to Union Bay in Lake Washington. The Ship Canal includes several interconnected waterways—Hiram M. Chittenden Locks (Ballard Locks), Salmon Bay, Salmon Bay Waterway, Fremont Cut, Lake Union, Portage Bay, and Montlake Cut. The Ship Canal borders the Ship Canal Neighborhoods on the west end and the Lake Washington Neighborhoods on the east end. Lake Union is a freshwater lake that receives most of its inflow from Lake Washington via the Montlake Cut and Portage Bay.

4.3.2.5 Duwamish River

The Duwamish River originates at the confluence of the Green and Black Rivers near Tukwila and flows northwest for approximately 12 miles, splitting at the southern end of Harbor Island to form the East and West Waterways before discharging into Elliott Bay. The Duwamish River flows through the Longfellow Creek/Duwamish Neighborhoods. The downstream portion of the Duwamish River serves as a major shipping route for bulk and containerized cargo. A portion of the lower Duwamish River is maintained as a federal navigation channel by the Corps of Engineers.

4.3.2.6 Longfellow Creek

Seattle's second largest watershed, the Longfellow Creek basin, is located in West Seattle in the Delridge area. The creek is 4.6 miles long and drains to the Duwamish River near Harbor Island through a 3,250-foot culvert (SPU, 2007). Approximately one-third of the main channel length is piped.

4.3.2.7 Thornton Creek

Thornton Creek and its many tributaries flow through the northeast part of Seattle, forming the city's largest watershed. The creek flows adjacent to the northern boundary of the North Lake Union area and drains to Lake Washington at Matthews Beach Park. Some of the stream flows through culverts, but a section in the Northgate area has been daylighted in recent years.

4.3.2.8 Piper's Creek

Piper's Creek is located in Carkeek Park in northwest Seattle and flows directly to Puget Sound. The mainstem of the creek is approximately 2 miles long, including the major tributary Venema Creek. Additional smaller tributaries drain into the park from an upland plateau.

4.3.3 What is the water and sediment quality of Plan area water bodies?

Ecology has established beneficial uses for each water body in the Plan area. Use designations differ for marine and fresh waters (Figures 4-3 to 4-6). Aquatic life use is rated higher in Puget Sound (extraordinary) than Elliott Bay (excellent). These marine water bodies are both designated for shellfish harvesting and primary contact recreation (such as swimming), although shellfish harvesting is prohibited for all marine beaches in Seattle due to potential contamination by fecal bacteria and other pollutants. Aquatic life and recreational uses for the freshwater bodies are highest (core summer habitat and extraordinary primary contact) for Lake Washington, Ship Canal/Lake Union, the small lakes, and all streams draining to lakes, followed by Longfellow Creek (spawning/rearing and primary contact), and the Duwamish River (rearing/migration and secondary contact). All freshwater bodies are designated for water supply uses with the exception that the Duwamish River is not designated for domestic water supply.

Water quality standards developed by Ecology under the Washington Administrative Code 173-201A set limits that are intended to protect aquatic life and recreational uses. The standards depend on the specific use designation for each water body, and they vary for fresh waters (streams, rivers, and lakes) and marine waters (Ecology, 2012a). Numeric standards are established for conventional parameters (common pollutants such as high temperature, low dissolved oxygen, pH, and turbidity), some toxic substances (mostly metals and some organic chemicals), and fecal bacteria.

Under Section 303(d) of the Clean Water Act, Ecology is required to prepare a water quality assessment and develop a list of surface waters (marine and fresh water) that are impaired. This list is periodically prepared by Ecology and submitted to EPA for review and approval. The Section 303(d) list identifies five categories of water quality impairments:

- Category 1 – meets tested standards for clean waters
- Category 2 – waters of concern
- Category 3 – insufficient data
- Category 4 – polluted waters that do not require the establishment of a total maximum daily load (TMDL) for targeted pollutant(s) to allow the achievement of the surface water quality standards
- Category 5 – polluted waters that require a TMDL program to establish maximum allowable pollutant discharges (Ecology, 2014)

Figure 4-7 summarizes water quality characteristics from Ecology's 2008 303(d) list including any impaired water bodies classified as Category 4 or Category 5 waters. The primary pollutants of concern in surface water bodies of the Plan area include bacteria, nutrients such as nitrogen and phosphorus, and toxic constituents such as metals and organic compounds. When concentrations of these pollutants exceed water and sediment quality

standards, they may impair aquatic life and recreational uses. Additional information on water and sediment quality is included in Chapter 2 of *Volume 3, Integrated Plan*.

4.3.3.1 Marine Water Quality

Puget Sound waters are classified as extraordinary and Elliott Bay waters are classified as excellent under Washington Administrative Code 173-201A. In general, the overall water quality in Puget Sound and Elliott Bay is good based on water quality parameters such as bacteria, nutrients, temperature, chlorophyll, dissolved oxygen, solids, and transparency. However, fecal coliform bacteria have exceeded allowable levels in some areas of these marine waters that are included on the 303(d) list of impaired waters.

Water quality in the Duwamish River is good based on the water quality index of conventional parameters, and presents no risk to aquatic life based a low level of risk from harmful chemicals (Figure 4-5) (King County, 2009). The Duwamish River is included on Ecology's 303(d) list as containing several areas of impaired waters for fecal coliform bacteria, dissolved oxygen, and ammonia.

4.3.3.2 Fresh Water Quality

King County has characterized water in the Ship Canal and Lake Union as fair for most parameters important to fish and wildlife (temperature, dissolved oxygen, pH, and nutrients) and to humans (fecal coliform bacteria) (Figures 4-3 and 4-4). The water in these areas is flushed rapidly with good quality outflow from Lake Washington. Some areas are on the 303(d) list for total phosphorus, fecal coliform bacteria, lead, or aldrin.

The water in Lake Washington is characterized as having good quality for most parameters important to fish and wildlife (temperature, dissolved oxygen, pH, nutrients, and metals) and to humans (fecal coliform bacteria) (Figure 4-4) (King County 2009). However, water quality is considered to be impaired for fecal coliform bacteria in some areas of the lake.

Longfellow Creek has fair water quality based on the water quality index of conventional parameters. The creek has a number of water quality problems, including nitrogen and phosphorus concentrations, bacteria and metal concentrations in storm flow, dissolved oxygen, temperature, and fecal coliform bacteria (Figure 4-5). Thornton Creek has poor water quality, primarily due to elevated levels of fecal coliform bacteria. Piper's Creek is also rated as fair based on the water quality index. Water quality impairments include fecal coliform bacteria (Longfellow, Thornton, and Piper's Creeks), temperature (Thornton Creek), and dissolved oxygen (Longfellow and Thornton Creeks).

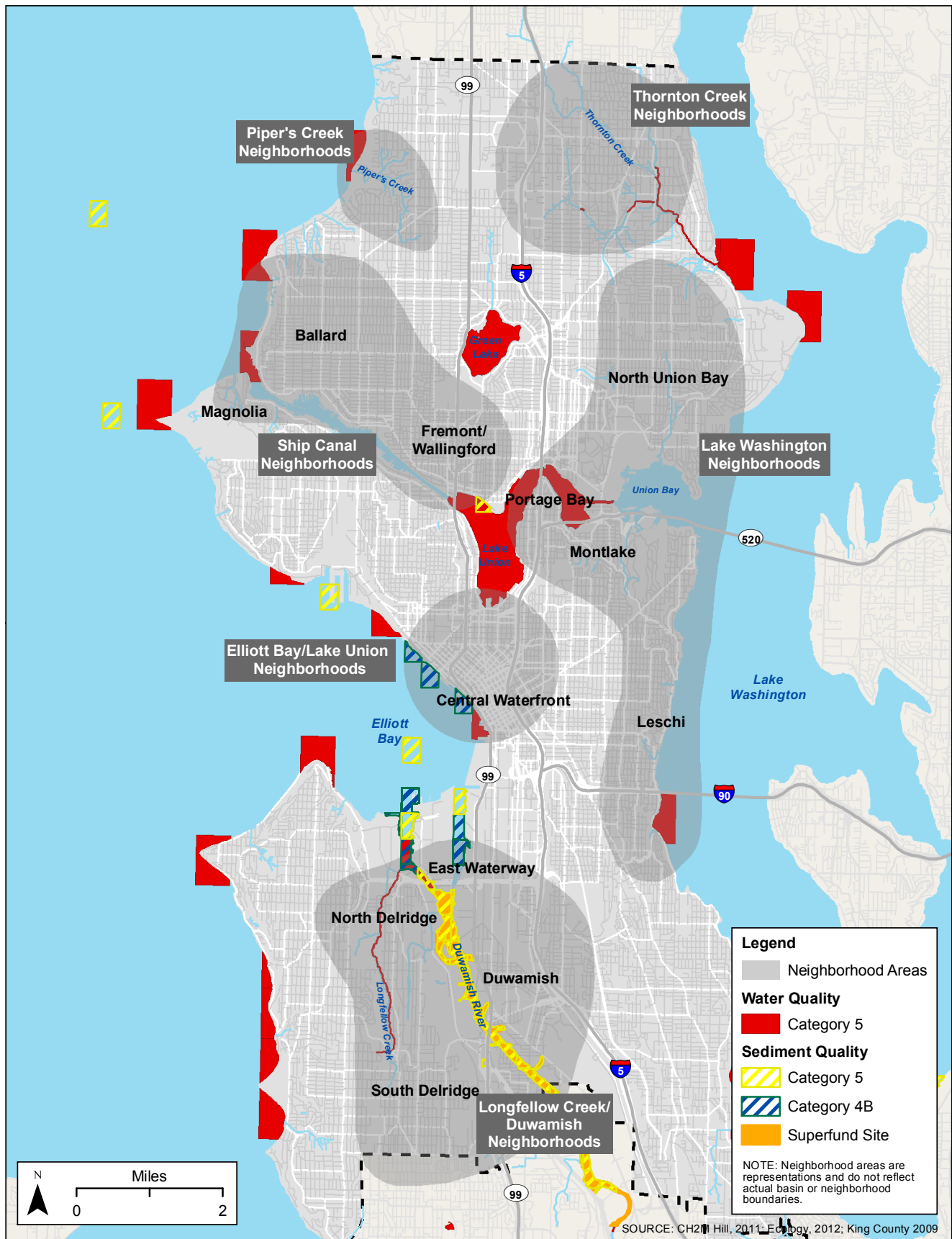


Figure 4-7 Water Quality and Sediment Quality (303(d) & 305(b)).

4.3.3.4 Sediment Quality

King County characterizes sediment quality as good in Lake Washington, poor in Lake Union and Duwamish River, and fair or not rated in the remaining water bodies (King County, 2012b). Figure 4-7 illustrates the water bodies that are listed on the Ecology 303(d) list for having polluted sediments.

The lower Duwamish Waterway is listed as a Superfund site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and as a Model Toxics Control Act (MTCA) site (Ecology, 2013c). The CERCLA and MTCA listings are for bottom sediments that contain elevated concentrations of polychlorinated biphenyls (PCBs), carcinogenic polycyclic aromatic hydrocarbons (CPAHs), arsenic, dioxins, and furans.

Sediment quality data for streams and small lakes include a limited amount of data for Thornton Creek (SPU, 2007). Sediment quality is rated as a potential problem caused by occasional exceedances of freshwater sediment guidelines for organic chemicals and the pesticide derivative DDE.

4.3.4 What are the sources of surface water pollutants in the Plan area?

Stormwater runoff is the leading pollution threat to surface waters. The primary contaminants in stormwater are bacteria, nutrients, sediment, and toxic chemicals (Ecology, 2011). Other pollution sources include CSOs, groundwater, wastewater treatment plants, and direct air deposition (Ecology and King County, 2011). Additional detail about contaminants in stormwater and CSOs, along with annual discharge volumes, is included in Chapter 6, *Volume 3, Integrated Plan*.

4.4 Biological Resources

4.4.1 What is the regulatory setting for biological resources?

A number of federal, state, and local regulations and permits relate to the protection of fish, aquatic resources, plants, and animals (Table 4-3). Projects that involve federal funding or permits from a federal agency trigger the need to comply with federal regulations. The Plan itself does not trigger federal regulations, but individual projects implemented under the Plan could be required to comply depending on their funding sources and permitting requirements.

What is included in this section?

This section describes the distribution and habitat conditions for fish, aquatic resources, and terrestrial plants and animals in the Plan area. This section also describes regulations aimed at protecting biological resources. Section 4.3 describes surface water resources and water quality issues that affect aquatic habitats.

Table 4-3. Regulations and Permits for Biological Resources

Statute	Lead Agency	Regulated Activities
Federal		
Endangered Species Act	National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS)	Protects species identified as endangered or threatened along with critical habitat required for the conservation of those species. NMFS has authority over anadromous fishes, marine mammals, marine reptiles, and other fish species, while the USFWS has authority over terrestrial wildlife and resident fish species that inhabit inland waters. Requires that federal actions do not jeopardize the continued existence of any threatened, endangered, or proposed species or result in the destruction or adverse modification of critical habitat. To comply with the Act, project proponents are required to consult with the federal agencies regarding the effect of their projects on listed species.
Magnuson-Stevens Fishery Conservation Act	NMFS	Requires federal agencies to consult with NMFS on activities that may adversely affect Essential Fish Habitat for federally managed fish species within a 200-mile zone offshore of the United States.
Marine Mammal Protection Act	NMFS	Prohibits injury or harm to marine mammals in U.S. waters. NMFS has authority over whales, dolphins, porpoises, seals, and sea lions, while the USFWS has authority over walrus, manatees, otters, and polar bears. The USDA is responsible for managing marine mammals in captivity.
Migratory Bird Treaty Act	USFWS	Protects many of the most common birds in the Plan area as well as birds that are listed as threatened or endangered. USFWS has authority to regulate most aspects of the taking, possession, transportation, sale, purchase, barter, exportation, and importation of migratory birds. As of March 2010, there are 1,007 species protected under the Act (Federal Register Vol. 75, No. 39). Species whose occurrences in the United States are strictly the result of intentional human introduction are not protected under the Act. Of particular concern are activities that affect birds nesting on bridges, buildings, signs, illumination poles, and other structures in areas planned for construction.

Table 4-3. Regulations and Permits for Biological Resources

Statute	Lead Agency	Regulated Activities
Bald and Golden Eagle Protection Act	USFWS	Specifically protects bald and golden eagles and makes it unlawful to take, import, export, sell, purchase, or barter any bald or golden eagles, their parts, products, nests, or eggs. "Take" includes pursuing, shooting, poisoning, wounding, killing, capturing, trapping, collecting, molesting, or disturbing eagles. To avoid potential disturbance to bald eagles, the National Bald Eagle Management Guidelines (USFWS, 2007) provide recommendations that will likely avoid take for a list of activities.
State of Washington		
State Hydraulic Code (Chapter 220-110 WAC)	Washington Department of Fish and Wildlife (WDFW)	Protects fish life and their habitat through regulation of activities in streams and lakes. WDFW administers state rules through its Hydraulic Project Approval (HPA) program. An HPA must be obtained from WDFW before work is conducted that uses, obstructs, diverts, or changes the natural flow or bed of state waters. The conditions of an HPA can be designed to protect fish, shellfish, and their habitat.
Priority Habitats and Species Program	WDFW	Provides information on documented locations of fish and aquatic resources, terrestrial plants and animals, and habitats that are listed or defined as priority. Priority species are those species that are: state endangered, threatened, sensitive, or candidate species; animal aggregations considered vulnerable; and species of recreational, commercial, or tribal importance that are vulnerable (WDFW, 2008). Priority habitats are habitat types or elements of habitat with unique or significant value to a diverse assemblage of species. A priority habitat may consist of a unique vegetation type (e.g., shrub-steppe) or dominant plant species, a described successional stage (e.g., old-growth forest), or a specific habitat feature (e.g., cliffs).
Natural Heritage Program	Washington Department of Natural Resources (WDNR)	Provides information for listed plant species or those that are defined as rare. Also maintains information on rare ecological communities and priority species.
City of Seattle		
Environmentally Critical Areas Ordinance (Seattle Municipal Code [SMC] 25.09)	City of Seattle Department of Planning and Development (DPD)	Protects and regulates activities on or adjacent to critical areas in the City. Critical areas include: geologic hazard areas, flood-prone areas, wetlands, fish and wildlife habitat conservation areas (FWHCAs) and abandoned landfills. FWHCAs are wildlife habitats that are mapped or designated by WDFW, corridors connecting priority habitats, or areas that support species of local importance. FWHCAs and wetlands are typically protected by a buffer in which development, including clearing and other land disturbing activities, is prohibited or restricted. Riparian corridors, a type of FWHCA, include all areas within 100 feet of the ordinary high water mark of a watercourse. Parcels containing riparian corridors and shoreline habitat are also subject to the general development standards in SMC 25.09.060 and specific development regulations in SMC 25.09.200, as well as regulations regarding tree and vegetation alteration and pesticide use.

Table 4-3. Regulations and Permits for Biological Resources

Statute	Lead Agency	Regulated Activities
SEPA Plants and Animals Policy (SMC 25.05.675.N)	DPD	City policy to minimize or prevent loss of wildlife habitat. Allows DPD to grant, condition or deny construction and use permit applications for public or private proposal that are subject to environmental review.
Shoreline Master Program (SMC 23.60)	DPD	Regulates water bodies above a threshold size as well as lands within 200 feet of the ordinary high water mark of those water bodies. Regulations include restrictions on development in the shoreline zone, requirements for maintaining native vegetation, and development standards.
Tree Protection Ordinance (SMC 25.11) and specific environmental policies related to trees (SMC 25.05.675)	DPD	Trees in Seattle are specifically valued and legally protected under various regulations in addition to the environmentally critical areas code. "Exceptional trees" are specifically protected and defined as a tree or group of trees that constitutes an important community resource because of its unique historical, ecological, or aesthetic value. Prior to construction at any site, a survey for exceptional trees would need to be conducted by a licensed arborist as required under SMC 25.11.

4.4.2 What types of aquatic and terrestrial habitat are present in the Plan area?

This section describes the types of aquatic and terrestrial habitat present in the Plan area and the species that may potentially occur as year-round residents or as migrants. This section focuses on species present in Plan neighborhoods and in the vicinity of CSO outfalls within the marine waters of Puget Sound (Elliott Bay and Salmon Bay) as well as freshwater/estuarine systems including the lower Duwamish River, Lake Washington, Lake Union, and the Ship Canal upstream of the Hiram M. Chittenden Locks (Ballard Locks).

To characterize these biological resources, the project team reviewed GIS data for the Plan area. Data sources included aerial imagery, the City's GIS data for environmentally critical areas (wetlands, streams, and riparian corridors) and the WDFW's Priority Habitats and Species (PHS) information. The *Seattle Biological Evaluation* was also reviewed for information about biological resources in the City (City of Seattle, 2012).

This review is a general summary for the purposes of identifying biological resources that could be affected by implementation of the Plan. Additional resources could exist but are not identifiable at the coarse scale of the GIS data. As with most construction projects conducted in the city, projects proposed under the Plan would require site-specific analysis to determine the presence of sensitive or protected plants, habitats, fish, or wildlife.

The Plan area contains diverse fish and wildlife habitats and species (City of Seattle, 2012). The largest patches of terrestrial wildlife habitat are found in public parks, shorelines, and steep slope areas that are undeveloped. Both marine and freshwater environments are present in the Plan area resulting in substantial diversity for aquatic species. For example, Puget Sound has documented occurrences of 188 fish species representing 72 families (Pietsch and DeVaney, 2012). Some of these marine species use freshwater habitats during part of their life cycles (salmonids, lampreys, sturgeon). The freshwater environments of the Plan area (as described in Section 4.3) are known to support an additional 31 fish species.

Table 4-4 lists the aquatic and terrestrial habitats including WDFW priority habitats documented within each of the Plan neighborhoods (WDFW, 2012a). The following sections briefly describe each habitat type.

Table 4-4. Aquatic and Terrestrial Habitats in the Plan Area

Plan Neighborhood	Ship Canal	Ballard	Fremont	Wallingford	Magnolia	Lake Washington	Portage Bay	Montlake	North Union Bay	Leschi	Longfellow Creek/Duwamish	Delridge	East Waterway	Duwamish	Elliott Bay/Lake Union	Central Waterfront	Piper's Creek	Thornton Creek
HABITATS																		
Nearshore		X			X								X	X		X	X	
Riparian Corridors		X			X			X		X		X					X	X
Freshwater Wetlands		X	X		X			X	X	X		X		X			X	X
Forest		X	X	X	X			X		X		X		X			X	X
Natural Areas		X			X		X	X	X	X		X		X		X	X	X
Landscaped Areas		X	X	X	X		X	X	X	X		X		X		X	X	X

4.4.2.1 Nearshore

The nearshore zone includes shoreline, intertidal and subtidal habitats along Puget Sound. Shoreline habitats include riparian vegetation and bluffs that erode and supply sediment to adjacent beaches. Intertidal and subtidal areas consist of rocky substrate, native vegetation (such as eelgrass and macroalgae) or habitat-forming species (such as oyster reefs and sea pens). Nearshore areas provide important aquatic habitat for fish and other aquatic species.

WDFW designated priority aquatic species most likely to be found in the vicinity of CSO outfalls include Chinook salmon, coho salmon, chum salmon, pink salmon, sockeye salmon, coastal cutthroat trout, steelhead, bull trout, rockfish species, sole species, California sea lion, harbor seal, mollusks, and Dungeness crab. Priority terrestrial species that use nearshore areas include bald eagle, peregrine falcon and great blue heron.

Other aquatic species that use estuarine and nearshore habitats in the Plan area may include marine mammals (primarily restricted to the marine waters of Puget Sound and to some extent the lower Duwamish River), reptiles (Pacific pond turtle), crustaceans (crab and shrimp), mollusks, and numerous bird species that forage in aquatic areas and shorelines (such as, marbled murrelet, gulls, terns, cormorants, common murre, great blue heron).

Nearshore habitats occur along the Puget Sound shorelines in the Plan Area. Estuarine zones, a subset of nearshore habitat mapped by WDFW, are shown on Figures 4-8 through 4-11. The Ship Canal Neighborhoods have the most nearshore habitat compared to other neighborhoods.

How do aquatic animals use habitats in the Plan area?

As shown on Figures 4-8 through 4-11, fish and other aquatic animals use the habitats of the Plan area for several different activities, including the following:

- Migration—travel to and from the ocean;
- Breeding areas;
- Foraging—feeding;
- Haulout areas—areas where marine mammals come out of the water and rest;
- Spawning—fish breeding;
- Rearing—areas where juvenile fish feed and grow to adulthood;
- Overwintering—areas where fish species spend the winter before migrating to summer areas; and
- Holding—areas where fish pause in their migration upstream or downstream.

4.4.2.2 Riparian Corridors

Riparian corridors are vegetated corridors present along streams. Within the Plan area, riparian corridors are typically vegetated with deciduous trees and shrubs with a few conifer trees. Native plants common to riparian corridors in the Plan area include red alder, big-leaf maple, Indian plum, and horsetail. Common aquatic plants include rushes, sedges, common cattail, duckweed, water lily, and pondweed. Nonnative invasive aquatic plants such as Eurasian milfoil are present in some areas. Some riparian corridors in the City are wide and densely vegetated, while most are narrow and constrained by urban development. Riparian areas provide important wildlife habitat including forage, cover, and complex habitat structure. This habitat supports a wide variety of terrestrial species such as songbirds, woodpeckers, and raptors. Riparian corridors also benefit aquatic habitats by providing shade, large wood, and organic material to streams.

Riparian corridors mapped by the City are shown on Figures 4-8 through 4-11. Riparian habitats occur throughout the Plan area. The Longfellow Creek/Duwamish Neighborhoods have the greatest amount of this habitat type.

4.4.2.3 Freshwater Wetlands

Freshwater wetlands in Seattle are associated with lake edges, streams and their riparian corridors, and scattered low-lying areas. Emergent, scrub-shrub, and forested wetlands are present, with scrub-shrub wetlands being the most common. Plant species common to emergent wetlands include reed canarygrass (nonnative), common cattail, and soft rush. Scrub-shrub and forested wetlands support many of the same plant species as riparian corridors, but also include dogwood, willow, and other water-tolerant species. In addition to supporting aquatic wildlife and amphibian species, wetlands in the City provide habitat for terrestrial songbird species and raptors.

Freshwater wetlands mapped by the City are shown on Figures 4-8 through 4-11. The largest wetland complexes are located in the Lake Washington Neighborhoods.

4.4.2.4 Forest

Forested communities are present in scattered patches throughout the city. Forests can be dominated by conifers (such as Douglas fir) or deciduous trees (such as big-leaf maple) or support a mixture of conifer and deciduous species. Forested areas are typically associated with steep slopes, top of bluffs, greenbelts, and other pockets of undeveloped land. Plant species common to forested habitats in Seattle include Douglas fir, western red cedar, vine maple, and swordfern. Forested habitats are important for woodpeckers, raptors, songbirds, crows, and jays. The largest patches of forest occur in the Lake Washington Neighborhoods.

4.4.2.5 Natural Areas

Natural areas support intact or natural vegetation (both native and nonnative) that is not formally landscaped. Parks and other public lands in the City support natural areas. Natural areas can contain mapped and unmapped riparian corridors and wetlands as well as forested habitats, but they can also contain grass or shrub areas that are not maintained or mowed.

Natural areas are present in all Plan neighborhoods and provide habitat for a wide variety of urban wildlife species. WDFW classifies some natural areas as "Urban Natural Open Space," a priority habitat type characterized as a biodiversity area or corridor that is relatively important to various species of native fish and wildlife (Figures 4-8 through 4-11).

4.4.2.6 Landscaped Areas

Landscaped areas provide habitat for wildlife despite their level of development and human presence. Landscaped gardens, golf courses, and recreational parks provide food and water sources, shelter, and other habitat elements important for terrestrial wildlife. Species that use landscaped areas are usually those that can tolerate some level of ongoing human disturbance.

4.4.3 What habitats and priority species occur in each Plan neighborhood?

The following sections summarize the types of habitat and priority species that have been documented by WDFW in each of the Plan neighborhoods.

4.4.3.1 Ship Canal Neighborhoods

The Ship Canal Neighborhoods are unique in that they contain both freshwater and marine environments supporting a wide array of species. Of particular note are species that use both environments to complete their life cycles such as Pacific salmon, steelhead, bull trout, and lamprey. From Puget Sound, these species enter the Ship Canal via the fish ladder at the Hiram M. Chittenden Locks and move through Lake Washington to tributary streams to complete their reproductive cycles. Mapped natural areas that support forested habitats and wetlands are present in Discovery and Golden Gardens Parks. Nesting bald eagles have been documented in both parks and along the Puget Sound shoreline. Great blue herons form nesting colonies in the southern portion of the area in Kiwanis Park, and at the north end in the North Beach or Blue Ridge area. Purple martins use hollow gourds that have been installed along the shoreline.

The marine waters adjacent to the Ballard area support numerous marine fish species; invertebrates such as clams and Dungeness crab; marine mammals such as California sea lion and harbor seal; and a wide variety of seabird species including marbled murrelet, common murre, waterfowl, and gulls.

The Fremont and Wallingford neighborhoods are densely developed and lack terrestrial habitats except for the landscaped or natural areas in Lower Woodlands Park and the Woodland Park Zoo. The freshwater portion of the Ship Canal adjacent to these neighborhoods is primarily used as a migratory corridor for anadromous fish species such as bull trout, Pacific salmon, and steelhead. No spawning or reproduction of these species is anticipated in the Ship Canal Neighborhoods due to lack of suitable habitat.

4.4.3.2 Lake Washington Neighborhoods

The Lake Washington Neighborhoods are located adjacent to the freshwater environments of the Ship Canal, Lake Union, and Lake Washington. Riparian corridors are present in the Leschi area along Mount Baker, Frink, and Madrona Creeks, which flow down an east-facing slope to Lake Washington. These stream corridors are also connected to forested or wetland habitats in public parks or natural areas. Both resident and anadromous fish species are present, including Chinook salmon, coho salmon, sockeye salmon, coastal cutthroat trout, rainbow trout/steelhead, and bull trout. Sensitive fish species both rear and migrate in Lake Washington. In 2009, nesting peregrine falcons were documented at the west end of the I-90 floating bridge (WDFW, 2012a).

The Montlake area includes a number of mapped wetlands, riparian corridors (Interlaken Creek), and natural areas. These relatively intact corridors connect these habitats and the Portage Bay and Lake Washington shorelines. These aquatic habitats support regular concentrations of waterfowl and foraging opportunities for other seabirds (primarily gulls and cormorants) (WDFW, 2012a). The area near the SR-520 crossing of Lake Washington contains abundant rooted aquatic vegetation and adjacent wetland habitats that likely support Pacific chorus frog, red-legged frog, and bull frog (invasive species). The aquatic habitat near SR-520 may also support

populations of Pacific pond turtle. However, the Pacific pond turtle is a state endangered species that has been extirpated from most of its range in Washington. Since 1990, the Woodland Park Zoo and WDFW have administered a collaborative program to enhance the survival of pond turtles that combines protection of nests in the wild and hatchling capture and release in the Puget Sound lowlands (Hays et al., 1999).

The Washington Park Arboretum contains stands of coniferous and deciduous forest intermixed with landscaped grasslands. Nesting bald eagles and great blue herons are regularly observed in this area.

North Union Bay contains several urban streams with mapped riparian corridors (Yesler, Ravenna, and Matthews Creeks). A large wetland complex is present at the south end of the area along the Lake Washington shoreline. This area, known as the Union Bay Natural Area, supports diverse wetland and upland habitats that support terrestrial wildlife species as well as waterfowl, amphibians, and aquatic species. Bald eagles have been documented nesting in this area and great blue herons are common. Restoration of the Union Bay Natural Area has been occurring since 1990. Projects have focused on creating forest, wetland, and grassland habitats over nearly 15 of the 75 acres.

4.4.3.3 Longfellow Creek/Duwamish Neighborhoods

The Longfellow Creek/Duwamish Neighborhoods drain to the tidally influenced portion of the lower Duwamish River, an area that supports multiple sensitive fish species. Urbanization has reduced the quality and quantity of aquatic and riparian habitats within the Longfellow Creek drainage area, but restoration efforts are ongoing. The Delridge area contains two riparian corridors surrounding Longfellow and Puget Creeks. Although the corridors are surrounded by development and are narrow in places, they are adjacent to natural areas that support forested habitats and wetlands such as Longfellow Creek Green Space, Roxhill Bog, and Puget Park. Camp Long Park contains intact mixed coniferous-deciduous forest that provides habitat for a variety of songbirds, woodpeckers, crows and jays, owls, and other raptors. The West Seattle Golf Course provides habitat for some species due to its proximity to Camp Long. Along the eastern edge of the Delridge area, the West Duwamish Green Space provides forested habitat and a continuous connection between multiple riparian corridors. The greenbelt supports nesting bald eagles and great blue herons. Osprey nest on elevated structures west of the Duwamish River, and peregrine falcons have been recorded on the 1st Avenue S bridge over the river. The Duwamish River provides a migratory corridor for adult salmonids during their annual upstream migrations to spawning areas in the Green River and tributaries. The Duwamish River also provides important habitat for juvenile salmonids as they outmigrate to Puget Sound. Marine mammals also use the lower Duwamish River as well as breeding populations of gulls and potentially other seabirds; foraging seabirds such as cormorants and gulls; and waterfowl concentrations. Invertebrates and fish that can tolerate brackish water are likely also present (sculpin, flatfish, crab). Sensitive mollusk species are not anticipated due to the highly developed nature of the shoreline. It is likely that sensitive crustacean species may venture into the lower Duwamish River on occasion. Restoration of fish and wildlife habitats along the Duwamish River has been occurring since the 1980s, including over 25 acres of intertidal and wetland habitat.

The industrial nature of the Duwamish area limits terrestrial wildlife habitat. In the eastern portion of the East Duwamish Greenbelt, west-facing slopes support deciduous and mixed coniferous-deciduous forest, seep wetlands, snags (dead standing trees), and shrub habitat. These slopes provide habitat for roosting and foraging raptors such as red-tailed hawk. Nesting ospreys have been documented near Martin Luther King Way. Jefferson Park and Jefferson Park Golf Course, located on the eastern edge of the Duwamish area, likely provide habitat for some terrestrial wildlife species.

Piper's Creek

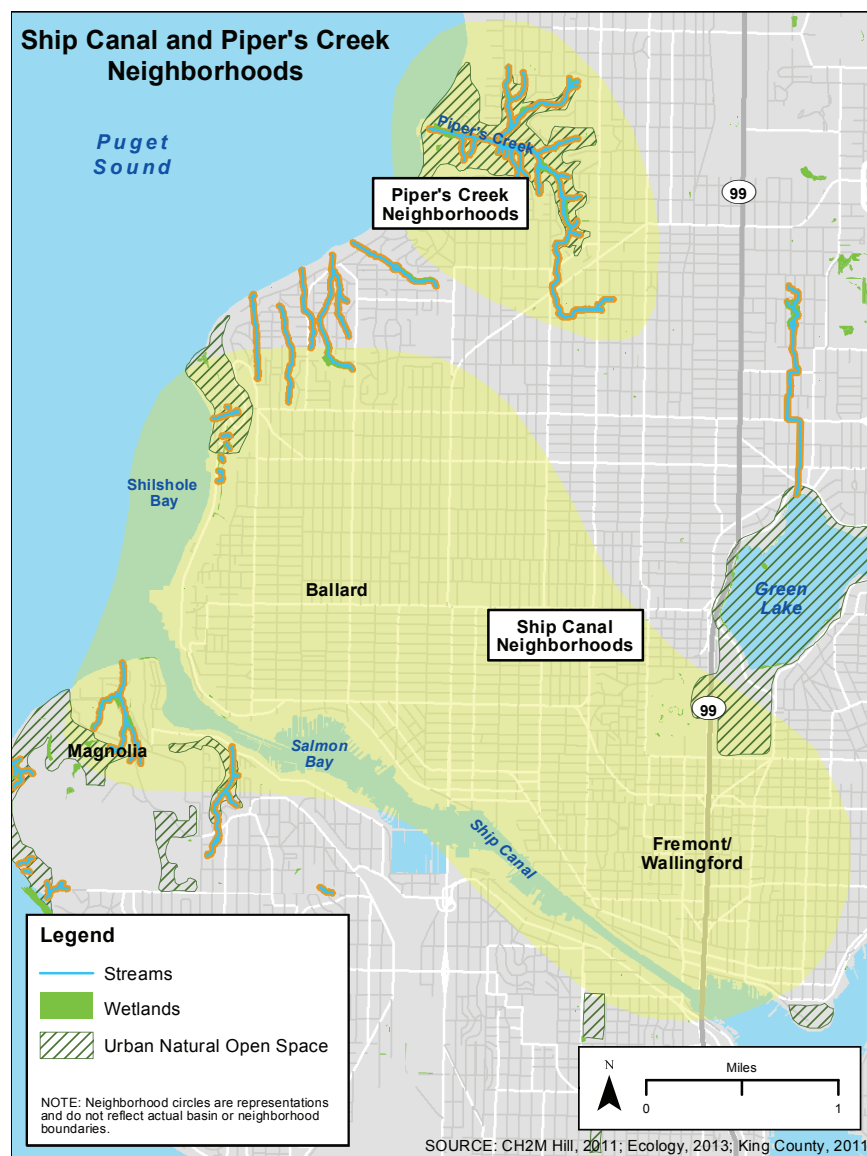
Chinook salmon (T)	OCCURRENCE / MIGRATION
Coho salmon	SPAWNING / REARING / MIGRATION
Coastal cutthroat trout (resident)	OCCURRENCE / MIGRATION
Steelhead (T)	OCCURRENCE / MIGRATION
Chum salmon	OCCURRENCE / MIGRATION

Shilshole Bay

Chinook salmon (T)	MIGRATION
Steelhead (T)	MIGRATION
Bull trout (T)	FORAGING / MIGRATION
Coho salmon	MIGRATION
Sockeye salmon	MIGRATION
Chum salmon	MIGRATION
Pink salmon	OCCURRENCE / MIGRATION
Coastal cutthroat trout (sea-run/resident)	OCCURRENCE / MIGRATION / FORAGING

T = Threatened
E = Endangered

SOURCE: WDFW, 2012; Ecology, 2013; King County, 2009.



Ship Canal

Chinook salmon (T)	OCCURRENCE / MIGRATION
Steelhead (T)	OCCURRENCE / MIGRATION
Bull trout (T)	OCCURRENCE / MIGRATION
Coho salmon	OCCURRENCE / MIGRATION
Sockeye salmon	OCCURRENCE / MIGRATION
Coastal cutthroat trout (sea-run/resident)	OCCURRENCE / MIGRATION

Figure 4-8. Ship Canal Neighborhoods - Fish and Wildlife Species and Habitats.

Lake Union/Union Bay

Chinook salmon (T)	OCCURRENCE / MIGRATION
Steelhead (T)	OCCURRENCE / MIGRATION
Bull trout (T)	OCCURRENCE / MIGRATION
Coho salmon	OCCURRENCE / MIGRATION
Sockeye salmon	OCCURRENCE / MIGRATION
Coastal cutthroat trout (sea-run/resident)	OCCURRENCE / MIGRATION
Pacific pond turtle	OCCURRENCE

Thornton Creek

Chinook salmon (T)	SPAWNING / REARING / MIGRATION
Coho salmon	SPAWNING / REARING / MIGRATION
Sockeye salmon	SPAWNING / REARING / MIGRATION
Coastal cutthroat trout (resident)	OCCURRENCE / MIGRATION
Steelhead (T)	OCCURRENCE / MIGRATION

T = Threatened
E = Endangered

SOURCE: WDFW, 2012; Ecology, 2013; King County, 2009.

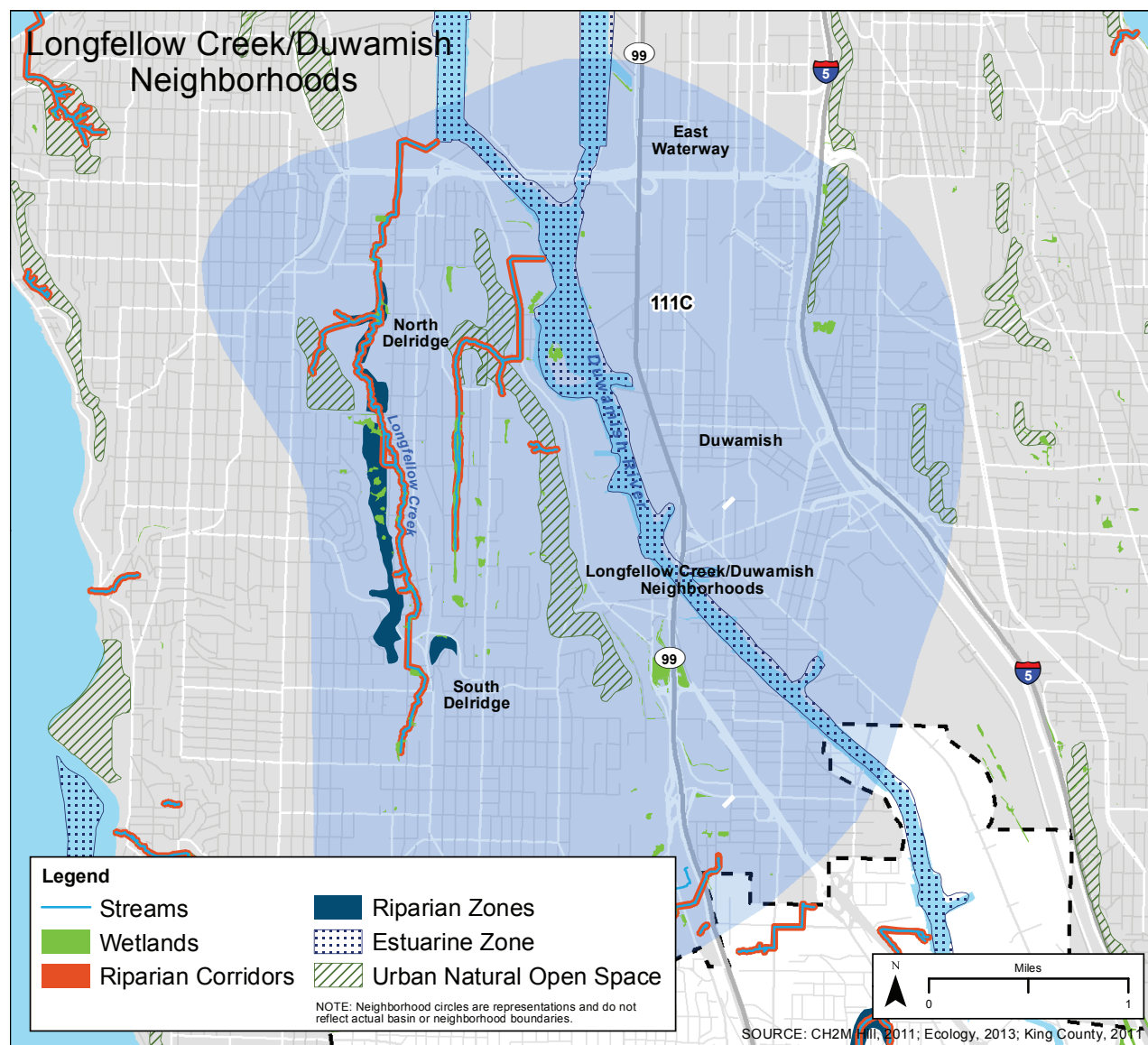


Lake Washington

Chinook (T)	MIGRATION / HOLDING / REARING
Steelhead (T)	MIGRATION / TRIBUTARY SPAWNING
Bull trout (T)	MIGRATION / FORAGING / OVERWINTERING
Coho salmon	MIGRATION / TRIBUTARY SPAWNING
Sockeye salmon	MIGRATION / REARING / SPAWNING
Coastal cutthroat trout	OCCURRENCE / MIGRATION
Pacific pond turtle	OCCURRENCE
Waterfowl concentrations	BREEDING / REGULAR CONCENTRATIONS

Figure 4-9. Lake Washington Neighborhoods - Fish and Wildlife Species and Habitats.

FILE NAME: Fig04-10_Fish_and_Wildlife_Longfellow-Duwamish.ai / CREATED BY: JAC / DATE LAST UPDATED: 04/28/14



Longfellow Creek

Chinook Salmon (T)	OCCURRENCE / MIGRATION
Steelhead (T)	OCCURRENCE / MIGRATION
Coho salmon	SPAWNING / REARING / MIGRATION
Coastal cutthroat trout (resident)	OCCURRENCE / MIGRATION

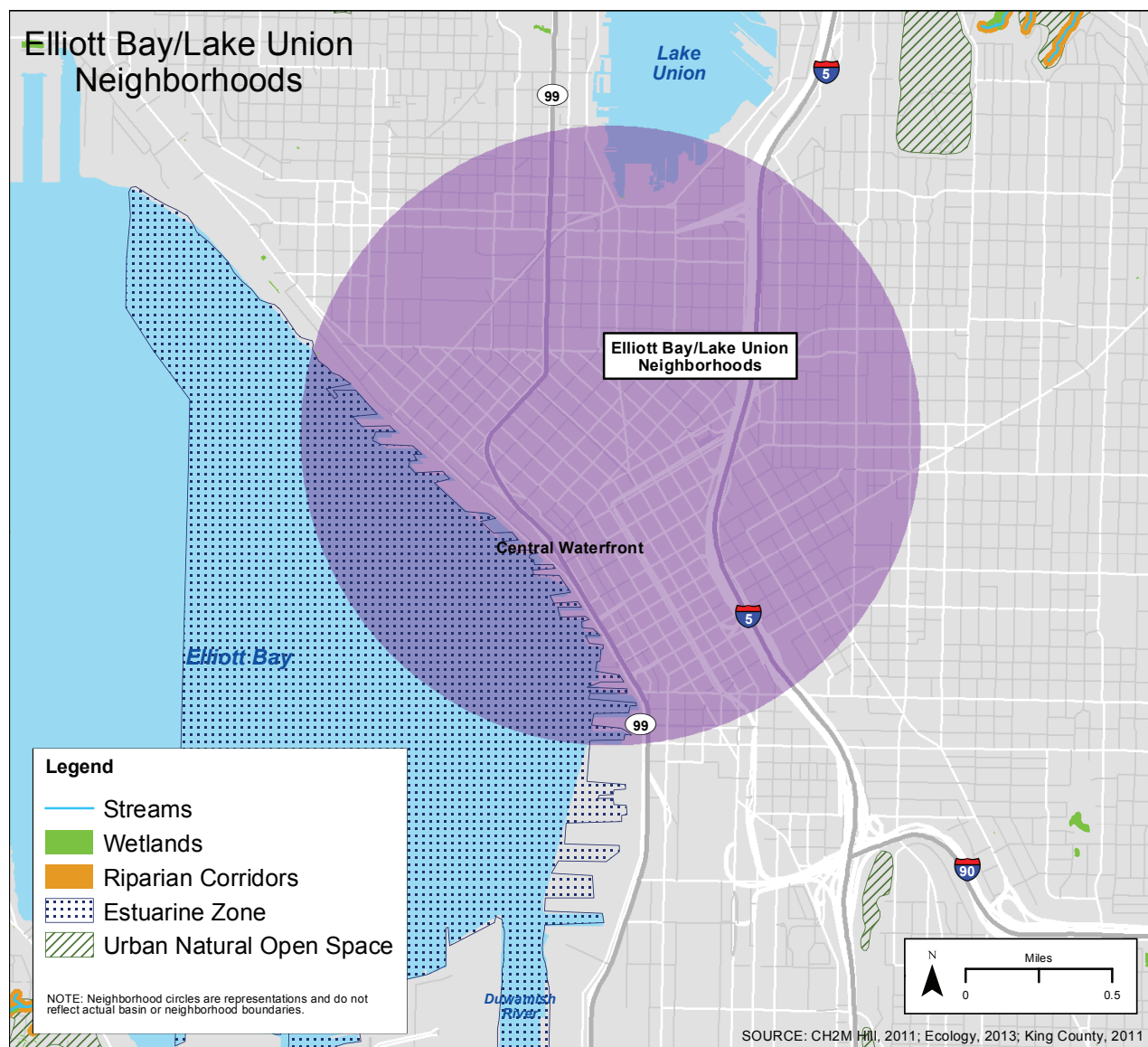
T = Threatened
E = Endangered

SOURCE: WDFW, 2012; Ecology, 2013; King County, 2009.

Duwamish River

Chinook salmon (T)	OCCURRENCE / MIGRATION
Steelhead (T)	OCCURRENCE / MIGRATION
Bull trout (T)	FORAGING / OVERWINTERING
Coho salmon	OCCURRENCE / MIGRATION
Sockeye salmon	OCCURRENCE / MIGRATION
Chum salmon	OCCURRENCE / MIGRATION
Pink salmon	OCCURRENCE / MIGRATION
Coastal cutthroat trout (sea-run/resident)	OCCURRENCE / MIGRATION
California sea lion	FORAGING / HAULOUT AREAS
Steller's sea lion (T)	POTENTIAL HAULOUT AREAS
Harbor seal	FORAGING
Alcids	BREEDING

Figure 4-10. Longfellow Creek/Duwamish Neighborhoods - Fish and Wildlife Species and Habitats.



Elliott Bay

Chinook salmon (T)	REARING / FORAGING / MIGRATION
Steelhead (T)	MIGRATION
Bull trout (T)	FORAGING / OVERWINTERING / MIGRATION
Coho salmon	OCCURRENCE / MIGRATION
Sockeye salmon	OCCURRENCE / MIGRATION
Chum salmon	OCCURRENCE / MIGRATION
Pink salmon	OCCURRENCE / MIGRATION

T = Threatened
E = Endangered

SOURCE: WDFW, 2012; Ecology, 2013; King County, 2009.

Lake Union

See Figure 4-9

Coastal cutthroat trout (sea-run)	OCCURRENCE
Rockfish (all species) (T, E)	OCCURRENCE
Southern Resident killer whale (E)	OCCURRENCE
Humpback whale (E)	OCCURRENCE
California sea lion	FORAGING
Harbor seal	FORAGING
Marbled murrelet (T)	FORAGING

Figure 4-11. Elliott Bay/Lake Union Neighborhoods - Fish and Wildlife Species and Habitats.

4.4.3.4 Elliott Bay/Lake Union Neighborhoods

The Elliott Bay/Lake Union Neighborhoods are highly developed and contain minimal vegetation and terrestrial wildlife habitat. Denny Park contains large trees and supports the largest patch of natural habitat. Landscaped parks in Central Waterfront Seattle provide habitat for species tolerant of human activities and noise. Peregrine falcons have nested on buildings (mainly the Chase Bank Tower) most years since 1994 when the first nest box was installed. Nesting activity was last observed in 2009 (WDFW, 2012a).

Aquatic species in these neighborhoods are primarily those associated with the marine environment of Elliott Bay (Puget Sound). This includes all sensitive fish, mammal, and bird species potentially occurring in Puget Sound as shown on Figure 4-11, and other marine birds such as common murre, cormorants, gulls, and terns as well as invertebrates including mollusks, crustaceans, sea stars, and sea cucumbers. Species such as humpback whale, Dall's porpoise, geoduck, and Steller sea lion may occur on rare occasion in Elliott Bay.

4.4.3.5 Piper's Creek

The Piper's Creek area is developed for residential uses with the exception of the mainstem of the creek, which lies wholly within Carkeek Park, a mapped natural area that supports forested habitats and wetlands (Figure 4-12). The mouth of Piper's Creek at Puget Sound supports intertidal habitat for invertebrates, mollusk species, and foraging opportunities for seabirds. Bald eagles and great blue herons likely use the mouth and adjacent shoreline for foraging although no nests are mapped in the area.

4.4.3.6 Thornton Creek

The Thornton Creek area is also densely developed. Portions of Thornton Creek and its tributaries contain areas of forested and riparian habitat. Near the outlet to Lake Washington, a great blue heron rookery is present and bald eagles likely use the large trees along the shoreline.

Thornton Creek itself is a mix of open and culverted reaches that support both resident and anadromous fish species, including fall-run Chinook salmon, coho salmon, sockeye salmon, and resident coastal cutthroat trout (WDFW, 2012a; 2012b). Numerous restoration projects in the Thornton Creek drainage basin have been undertaken to improve habitat for fish and other aquatic species.

4.4.4 What federally listed endangered and threatened species and critical habitat are present in the Plan area?

Table 4-5 summarizes information about the species in the Plan area that are listed under the federal Endangered Species Act, including the date of listing, status (threatened or endangered), and whether critical habitat has been designated in the Plan area.

Table 4-5. Federally Listed Species in the Plan Area

Federally Listed Species	Date Listed	Status¹	Critical Habitat in Plan Area
Chinook salmon Puget Sound Evolutionarily Significant Unit (ESU)	1999	T	Yes
Steelhead Puget Sound Distinct Population Segment (DPS)	2007	T	No ²
Bull trout Coastal-Puget Sound DPS	1999	T	Yes
Eulachon (Columbia River smelt) Southern DPS	2010	T	No
Bocaccio rockfish Puget Sound DPS	2010	E	No ²
Canary rockfish Puget Sound DPS	2010	T	No ²
Yelloweye rockfish Puget Sound DPS	2010	T	No ²
Southern Resident killer whale	2005	E	Yes
Humpback whale	1970	E	No
Steller sea lion	1990	T	No
Marbled murrelet	1992	T	No

¹ T = threatened; E = Endangered

² No critical habitat has yet been designated for the species

Generally, water bodies in the Plan area provide listed fish species with habitat for upstream migration, outmigration to the sea, rearing, holding, and foraging (Figures 4-8 through 4-11). In addition, the nearshore areas of Puget Sound, the Ship Canal, Lake Union, Union Bay, Lake Washington, and the Duwamish River are designated as critical habitat for Chinook salmon. Eulachon are infrequent users of marine waters adjacent to the Plan area. All three rockfish species could occur in the Plan area, especially in Elliott Bay adjacent to the Elliott Bay/Lake Union Neighborhoods where larval rockfish have been documented.

Of the marine mammals, the Southern Resident killer whale is most likely to use Puget Sound. Puget Sound, including the nearshore adjacent to the Plan area, has been designated as killer whale critical habitat. Steller sea lions are not commonly seen in Puget Sound, but they could use haulout areas that are also used by the more common California sea lion. California sea lion haulout areas are located in nearshore habitat of the Ship Canal and Elliott Bay/Lake Union Neighborhoods, as well as the lower Duwamish River area of the Longfellow Creek/Duwamish Neighborhoods. Humpback whales are rare in Puget Sound, but they could use marine habitats near the Plan area.

The marbled murrelet is a seabird that forages in marine waters and nests in trees within inland forests. No nesting habitat exists in the Plan area, but marbled murrelets likely forage in Puget Sound adjacent to the Ship Canal, Longfellow Creek/Duwamish, Elliot Bay/Lake Union and Piper's Creek Neighborhoods.

No populations of threatened or endangered plant species are currently documented in the Plan area (WNHP, 2012).

4.5 Energy and Climate Change

4.5.1 What is the regulatory setting for energy and climate change?

Federal, state, and local regulations apply to energy consumption by buildings and infrastructure. Most of these regulations apply to occupied buildings and would not be applicable to CSO control or stormwater facilities. However, some of the standards included in the energy codes may serve as guidelines for construction of buildings associated with projects under the Plan.

What is included in this section?

This section discusses the regulatory setting, and sources and providers of energy within the Plan area. This section also provides information on climate change, including the regulatory framework for assessing impacts of climate change and greenhouse gas emissions, the existing sources of emissions in the Plan area, and potential risks associated with climate change.

There are relatively few mandatory regulations pertaining to greenhouse gases at either a federal or state level. Mandatory regulations apply primarily to large emitters such as petroleum refineries and aluminum manufacturers, and these typically require quantifying rather than reducing greenhouse gas emissions. State and many local governments have developed and continue to refine policies aimed at reducing emissions, with these policies typically focused largely on government actions rather than the private sector.

4.5.2 What is the energy setting of the Plan area?

Energy that powers existing development in the Plan area is supplied by Seattle City Light (electricity) and Puget Sound Energy (natural gas). Electricity is generally supplied by overhead power lines and natural gas through pipelines within street rights-of-way. Most of Seattle's electricity comes from the Seattle City Light hydropower facilities on the Skagit River and from Boundary Dam on the Pend Oreille River. The remaining hydropower comes from a mix of sources, including long-term contracts with the Bonneville Power Administration (BPA).

Natural gas is transported into the Puget Sound Energy (PSE) distribution area through large pipelines with sources in British Columbia, Alberta, and Rocky Mountain states. Smaller PSE-owned pipelines deliver natural gas to the Plan area.

4.5.2.1 CSO Control and Stormwater Facilities and Energy Consumption

CSO control facilities are designed to use gravity as much as possible for conveyance, but these systems typically require some level of energy to operate. Electric pumps and ventilation equipment are the main energy-consuming components of CSO facilities. Operation of CSO equipment can be energy intensive, but the equipment operates infrequently, only during and after storm events.

Construction of new CSO control and stormwater facilities under the Plan would require large quantities of construction materials. Energy is used to manufacture and transport these materials to the construction sites. Large construction projects, such as those envisioned under the Plan, require substantial amounts of energy to fuel construction equipment, worker vehicles, and other support services.

4.5.3 What is the climate change and greenhouse gas emissions setting of the Plan area?

Seattle's greenhouse gas emissions originate from three main sources: transportation, buildings, and industry. Transportation accounts for 62 percent of emissions, with two-thirds of transportation emissions coming from cars and trucks. Energy use in buildings accounts for 21 percent, and industrial operations and processes make up the remaining 17 percent of emissions (City of Seattle, 2008).

4.5.3.1 Risks Associated with Climate Change

Recognized risks associated with climate change in Washington include increased sea levels, reduced snowpack, changes in water availability, changes in timing of streamflows, increased forest fires, increased winter precipitation, and decreased summer precipitation. Sea level rise and increases in the timing and amount of runoff and precipitation are the risks most likely to directly affect existing CSO control facilities and the anticipated design and sizing of future CSO control and stormwater facilities. Except for sea level rise, the risks from climate change are likely to be similar for all of the neighborhoods.

Why are greenhouse gases considered?

Global climate change refers to changes in average climatic conditions on Earth as a whole, including changes in temperature, wind patterns, precipitation, and storms. Gases that trap heat in the atmosphere are often called "greenhouse gases." These gases are emitted by both natural processes and human activities. The accumulation of greenhouse gases in the atmosphere regulates the Earth's temperature. Emissions from human activities, such as electricity production and vehicle use, have elevated the concentration of these gases in the atmosphere, leading to higher ambient temperatures.

Carbon dioxide is the most abundant greenhouse gas and the primary one emitted by the combustion of fossil fuels.

Climate change projections for the Pacific Northwest and specifically the state of Washington have been developed by the Climate Impacts Group at the University of Washington (Climate Impacts Group, 2009). Three of the studies included in the Climate Change Impacts Assessment evaluated the impacts on water management issues in the Puget Sound region (Vano et al. 2009, Rosenberg et al. 2009, and Elsner et al., 2009).

Overall precipitation is expected to increase in the Puget Sound region between now and the 2080s by a range of 0.2 percent to 4.9 percent (Vano et al., 2009). Most of the increased precipitation would occur during the cool season (October to March) while warm season precipitation would decrease. This would result in overall wetter winters and drier summers, changing the current patterns of runoff from a springtime peak caused by snowmelt to a winter peak caused by rainfall. Timing of flooding in the Puget Sound region is also expected to shift, with increased flooding in the January to March period and decreased flooding from April to May.

Changes in precipitation and timing would also affect soil moisture and infiltration rates, which in turn would affect stormwater runoff. Modeling indicates that snowpack will decrease, resulting in a decrease in the amount of water stored as snow (Elsner et al., 2009). The reduced winter snowpack and earlier snowmelt will reduce summer soil moisture levels in the mountains and coastal drainages west of the Cascades. As a result, runoff is predicted to increase.

One of the Climate Impact Group's studies specifically evaluated impacts of climate change on stormwater infrastructure (Rosenberg et al., 2009). Future climate changes may alter the intensity or duration of precipitation, affecting how existing stormwater and combined sewer systems function and requiring changes in how facilities are designed. Models generally indicate that peak discharges will increase, but there is a lack of consistency about the predicted amount of increase. There is even more uncertainty associated with predictions for the

frequency of peak discharges. Rosenberg et al. conclude that the design standards used for stormwater design will need to adapt to changes specific to individual regions.

Another risk to utilities associated with climate change is sea level rise. Increases in sea level will affect where outfalls and other facilities can be located. The City of Seattle has prepared a draft map of sea level rise potential in Seattle for 2050 (SPU, 2013b). The map shows that areas most at risk for sea level rise include low-lying areas of the Duwamish River basin, Golden Gardens Park, West Point, Alki Point, and various areas along the West Seattle shoreline. As a result, portions of the Duwamish and Central Waterfront areas face greater potential risks from the effects of sea level rise than the other Plan neighborhoods.

4.6 Environmental Health and Public Safety

4.6.1 What are the regulations that govern environmental health?

In general, regulations governing environmental health are focused on minimizing the potential for exposure to chemicals or contaminants that could be harmful to humans or wildlife. The Environmental Public Health Division of the Washington State Department of Health (DOH) leads this effort, working with local governments and agencies in the areas of drinking water, food safety, shellfish protection, wastewater management, health risk assessments, and other areas. Regulations in these areas are implemented by the DOH.

What is included in this section?

This section summarizes environmental health regulations in the Plan area and identifies environmental health concerns that would need to be considered in assessing the impacts of proposed facilities,

Washington State Water Quality Standards (WAC 173-201A) have been developed to protect human and environmental health. These regulations, along with the requirements enforced by DOH, provide the regulatory framework for environmental health.

4.6.2 What are the relevant environmental health concerns in the Plan area?

Existing environmental health concerns in the Plan area that are relevant to the analysis of the Plan alternatives include untreated CSO and stormwater discharges and contaminated soil and groundwater sites.

Untreated CSOs and stormwater include dissolved and particulate heavy metals and chemicals adsorbed (attached) to particles that settle to the bottom. Evidence suggests that untreated CSOs and stormwater can cause contamination of sediments near outfalls (King County, 2010) that could affect humans and/or fish coming in contact with those sediments. Additional information about potential environmental health risks associated with untreated CSO and stormwater discharges is included in Chapter 6, *Volume 3, Integrated Plan*.

Public health risks can occur through swimming, scuba diving, wading, or fishing in waters that receive untreated CSO discharges. People can be exposed to pathogens or other pollutants through direct contact with contaminated water or sediments (e.g., swimming or wading), ingestion of pathogen-containing water, or eating contaminated fish or shellfish. Pathogens present in untreated discharges include bacteria and viruses. Potentially toxic pollutants such as petroleum products or metals also are conveyed in untreated CSO and stormwater discharges. CSO releases can contain pharmaceuticals, personal care products, and endocrine-disrupting chemicals. Additional information on exposure risks associated with contaminants in CSOs and stormwater is included in Chapter 7, *Volume 3, Integrated Plan*.

Contaminated soil and groundwater can present environmental health risks to humans or animals that come in contact with the contaminated materials. Exposure can occur during or following construction. In addition, cleaning up contaminated soil can significantly increase the cost and schedule requirements for development of a site, and this is a major consideration during facility siting, design, and construction.

4.6.3 Are there potentially contaminated sites located in the Plan area?

Figure 4-12 illustrates documented contaminated sites within the Plan area. The Washington State Department of Ecology's Toxics Cleanup Program maintains a database of contaminated sites and leaking underground storage tanks (LUSTs) within the state. The database includes information on current and past cleanup sites as well as voluntary cleanup sites, covering a wide range of contaminants, such as petroleum products and byproducts, solvents, and other hazardous wastes.

In general, LUSTs are associated with gas stations or other automotive uses, causing contamination of soil and groundwater with petroleum or benzene. However, some LUSTs in industrial areas are associated with other uses or contaminants. Ecology tracks all cleanup sites for contamination of groundwater, surface water, soil, sediment, air, and bedrock.

The EPA maintains a database of Superfund sites, which are locations with uncontrolled hazardous materials. The lower Duwamish Waterway is listed as a Superfund site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and as a Model Toxics Control Act (MTCA) site (Ecology, 2013c). Seattle has several other listed Superfund sites. The Lockheed West Seattle site is at the north end of the Delridge area and is listed for historic releases of metals, PCBs, and petroleum products into Elliott Bay. Additionally, Harbor Island, located at the mouth of the Duwamish River directly adjacent to the Delridge and Duwamish areas, is listed as a Superfund site for contamination in soil, groundwater, and sediments.

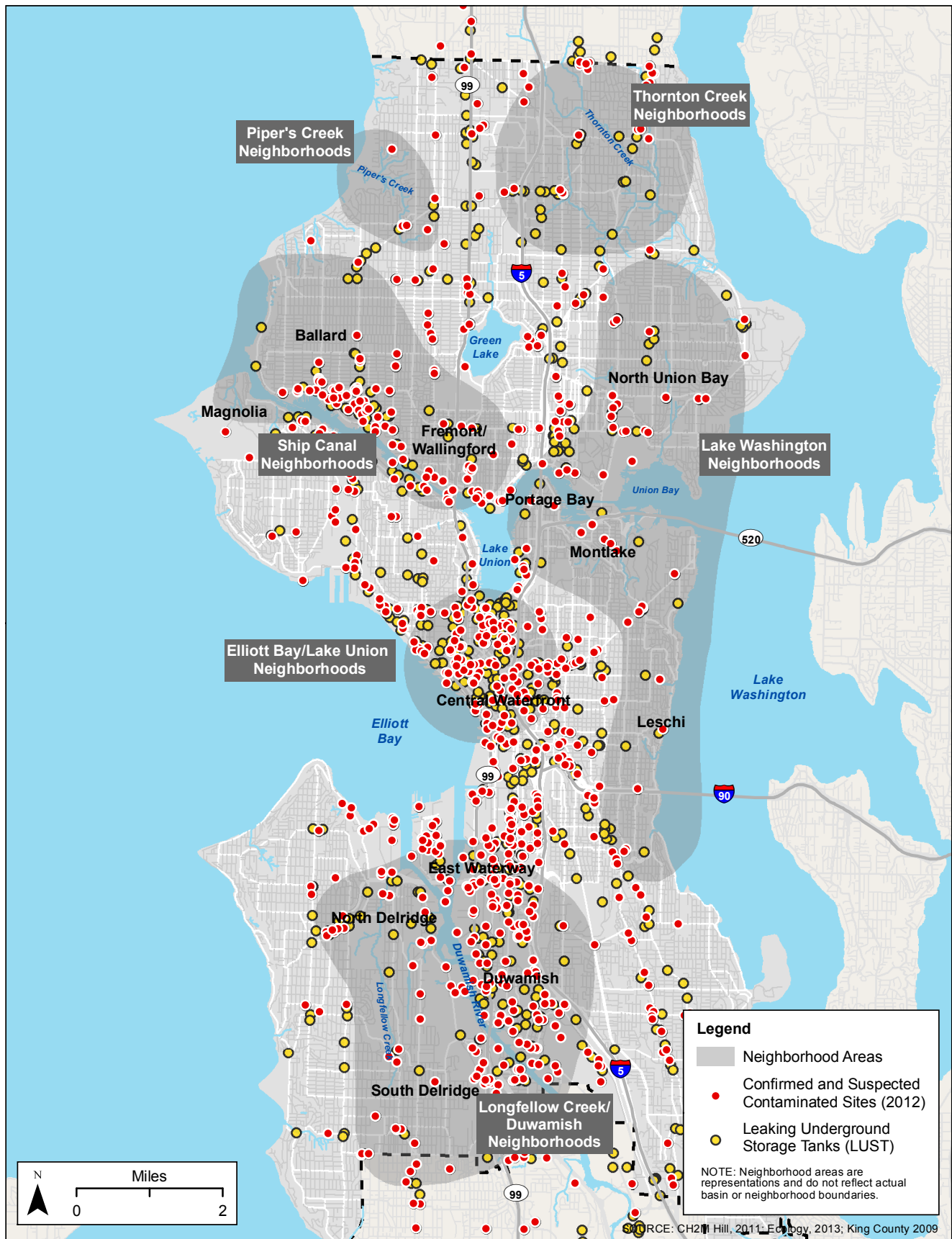


Figure 4-12 Contaminated Sites & Leaking Underground Storage Tanks.

4.7 Noise and Vibration

4.7.1 What is noise?

Noise can be defined as unwanted sound. However, sound is measurable, whereas noise is subjective. The relationship between measurable sound and human irritation is the key to evaluating noise impacts.

Noise is typically measured in units called decibels (dB). For the purposes of environmental analysis, noise is often quantified as “A-weighted”decibels (dBA), which correspond to the frequencies that are audible to the human ear. A whisper measures about 30 dBA, while a typical conversation is in the range of 50 to 60 dBA, and a jet taking off at a distance of 200 feet measures about 120 dBA. The human ear perceives an increase of 10 dBA as a doubling of the noise level; an increase of 3 dBA or less is barely perceptible, and an increase of 5 dBA or more is noticeable. Noise levels drop off sharply with distance from the noise source.. Hearing loss can begin to occur with prolonged exposure to noise at 85 dB. For context, normal conversation is approximately 60 dB and the noise from heavy city traffic can reach 85 dB (NIDCD, 2008).

4.7.2 What is vibration?

Ground-borne vibration is a small but rapidly fluctuating motion transmitted through the ground. Vibrations can result during construction associated with large equipment, blasting, excavation, pile driving, and tunneling operations. Vibration can be quantified in terms of the mechanical motion of the medium (e.g., floor) through which it is perceived. The magnitude of vibration is typically reported in velocity or acceleration. For a vibrating floor, velocity represents the speed of the floor movement; acceleration represents the rate at which the speed changes. As vibration transmits through the ground, it is attenuated (lessens) with distance. The attenuation rate varies depending on the medium through which the vibration travels.

4.7.3 What is the regulatory setting for noise and vibration?

4.7.3.1 City Noise Regulations (SMC 25.08.410, SMC 25.08.420)

The Seattle Municipal Code (SMC) defines the maximum permissible sound levels within residential, commercial, and industrial districts (SMC 25.08.410) (Table 4-6), along with permissible modifications (SMC 25.08.420).

Table 4-6. Maximum Permissible Environmental Noise Levels (dBA)			
Type of Noise Source	Type of Receiving Property		
	Residential (day/night)	Commercial	Industrial
Rural	52/42	55	57
Residential	55/45	57	60
Commercial	57/47	60	65
Industrial	60/50	65	70

Source: SMC 25.08.410

Noise from construction activities is allowed to exceed the maximum permissible sound levels between 7:00 a.m. and 10:00 p.m. on weekdays, and between the hours of 9:00 a.m. and 10:00 p.m. on weekends. The limits may be exceeded by 25 dBA for equipment on construction sites. The SMC also states that impact equipment, such as

pavement breakers, jackhammers, and others that create impulse noise, may exceed the maximum permissible sound levels in any one-hour period, but may not exceed the following:

- 90 dBA continuously;
- 93 dBA for 30 minutes;
- 96 dBA for 15 minutes; or
- 99 dBA for 7.5 minutes (SMC 25.08.425).

SMC 25.05.675 establishes specific environmental policies for noise, including the policy that the City will minimize or prevent adverse noise impacts from new developments and uses. The City can require assessments of noise impacts and require mitigation as part of environmental review for a project. Mitigation measures could include reducing the size of the project, setting time limits on operation, and buffering or landscaping to reduce offsite noise impacts.

4.7.3.2 State Vibration Regulations (WAC 296-52-67065)

The City does not regulate vibration, but vibration caused by CSO-related construction will be subject to state vibration regulations. The Washington Administrative Code sets maximum limits on ground vibrations for dwellings, public buildings, schools, churches, commercial sites, cofferdams, piers, underwater structures, and institutional buildings near blasting sites (WAC 296-52-67065 Vibration and Damage Control). Vibration limits are measured in maximum allowable peak particle velocity.

4.7.4 What are the existing noise conditions in the Plan area?

A description of sound levels for individual Plan neighborhoods is provided below. Major noise sources generally include commercial and industrial areas, railways, and major roads. Sensitive receptors include residences, schools, hospitals, and nursing homes.

4.7.4.1 Ship Canal Neighborhoods

The Ship Canal Neighborhoods are primarily residential with areas of mixed-use commercial and relatively low noise levels. Traffic on local arterials and overhead airplane traffic are the predominant noise sources. Light-industrial areas are located in the neighborhoods, primarily near the Ship Canal. Sensitive receptors include Swedish Medical Center in Ballard and many public and private schools.

4.7.4.2 Lake Washington Neighborhoods

Most neighborhoods are residential, but many commercial corridors are present. Noise from SR-520 and Interstate 5 is audible in these neighborhoods, as is overhead airplane traffic. In addition to residences and numerous public and private schools, major sensitive receptors include the University Medical Center and Children's Hospital and Medical Center in North Union Bay. The Montlake area includes a number of recreational facilities, including the Washington Park Arboretum, where natural, lower noise levels are important considerations for park visitors.

4.7.4.3 Longfellow Creek/Duwamish Neighborhoods

The neighborhood includes industrial areas near the Duwamish Waterway including the Industrial District, the principal industrial area of Seattle and one of the largest and most intensely developed manufacturing/industrial areas in the Pacific Northwest. Other major noise producers are I-5, SR-99, and the Spokane Street Viaduct in

the Duwamish neighborhood. The remaining parts of the neighborhoods are primarily residential with several public and private schools as sensitive receptors.

4.7.4.4 Elliott Bay/Lake Union Neighborhoods

The Central Waterfront is mostly commercial, with industrial uses adjacent to Elliott Bay. Traffic levels are very high in the neighborhood, including I-5, SR-99, and ferry terminal traffic. Major sports stadiums (Century Link Field and Safeco Field) directly south of the neighborhood also contribute to traffic and noise. The Central Waterfront has fewer sensitive receptors than other Plan area neighborhoods, but it does contain several schools.

4.7.4.5 Piper's Creek

The Piper's Creek area is mostly residential, with commercial uses along Holman Road. Major noise sources include Holman Road and the Burlington Northern-Santa Fe Railroad, which runs through Carkeek Park along Puget Sound. Sensitive receptors include Carkeek Park and schools.

4.7.4.6 Thornton Creek

The Thornton Creek area is largely residential with several commercial areas, including Northgate Mall and its surrounding commercial uses. Major sources of traffic noise include I-5, SR-522 (Lake City Way), 15th Avenue NE, and NE Northgate Way. Sensitive receptors include many schools in the area.

4.8 Land Use and Visual Quality

4.8.1 What is the regulatory setting for land use?

4.8.1.1 Seattle Comprehensive Plan Policies

The City of Seattle Comprehensive Plan (DPD 2005) provides policies that guide the adoption of development regulations and inform policy decisions regarding development within the City. The most salient goals and policies relevant to the Plan are listed below, along with a summary of the subject matter:

Utilities

- UG1: Provide reliable and affordable service while acknowledging the City's goals of environmental stewardship, social equity, economic development, and public health protection
- UG2: Maintain the service reliability of the City's utility infrastructure
- U15: Prioritize CSO projects according to frequency, volume, and location sensitivity
- U18: Work with neighborhood and community representatives in siting facilities
- U20: Incorporate accessible open space in the siting and design of City utility facilities

Environment

- EG1: Protect and improve air, land, and water quality for people and wildlife
- EG4: Recognize and enhance the value of aquatic areas

What is included in this section?

This section provides information on land and shoreline use characteristics, plans, and policies in the Plan area. This section also discusses existing conditions related to visual quality in the Plan area—the overall bulk and scale of structures, light and glare, and views.

- EG5: Pursue the long-term health of Seattle's receiving waters by taking actions that address flooding, water quality, habitat and barriers to fish passage
- EG6: Minimize the number and extent of CSO events
- E4: Protect and retain trees that enhance historical, cultural, environmental and aesthetic character
- E23: Protect and retain trees and tree canopy that enhance Seattle's historical, cultural, environmental and aesthetic character.

4.8.1.2 Seattle Land Use Code

The Seattle Land Use Code (Seattle Municipal Code (SMC) Chapter 23) includes use regulations and development standards for siting public facilities. Public facilities required for CSO control and stormwater facilities are generally permitted outright in all zones in the city with the exception of Residential Single-Family zones as illustrated in Table 4-7. In Residential Single-Family zones, the City Council must approve siting public facilities such as CSO control and stormwater facilities on private property.

In zones other than Residential Single-Family, City Council approval is also required if a public facility project does not meet a specific development standard, such as setbacks, height, or landscaping, required in the zone in which the project is located. This process is referred to as a "Council Waiver or Modification of a Development Standard" and is similar to the Council Conditional Use Permit process.

Table 4-7. Land Use Code Requirements for CSO control and Stormwater Facilities

Zoning District	Use Requirements	Seattle Municipal Code Section
Residential Single-Family	Requires Council Conditional Use	23.51A.002
Multi-Family	Permitted outright	23.45
Residential Commercial	Permitted outright	23.46
Commercial	Permitted outright	23.47A
Seattle Mixed	Permitted outright	23.48
Downtown - Downtown Harborfront 1 - Downtown Harborfront 2	Subject to Shoreline Management Program requirements Permitted outright	23.48 23.49
Industrial	Permitted outright	23.50

The City evaluates potential impacts to land use through its Master Use Permit process. The Seattle Department of Planning and Development (DPD) evaluates Master Use Permit applications using specific criteria provided in the Seattle Municipal Code.

Common Master Use Permits required for CSO control and stormwater facilities include the following:

- Land Use/Type V Master Use Permit – Waiver/Modification of Development Standards for Public Facility
- Land Use/Type IV Master Use Permit – Council Conditional Use Permit
- Land Use/Type II Master Use Permit – Environmentally Critical Area Exceptions
- Land Use/Type II Master Use Permit- Shoreline Substantial Development Permit
- Land Use/Master Use Permit – State Environmental Policy Act (SEPA) Project Conditioning based on Seattle’s SEPA Policies (Seattle Municipal Code 25.05)
- Land Use/Master Use Permit - Variance

Construction within city streets or rights-of-way would require a Utility Major Permit or Street Improvement Permit from the Seattle Department of Transportation according to Seattle Municipal Code 15.32. This would include construction of storage pipes, conveyance lines, and flow transfers constructed in city streets or rights-of-way under the LTCP options, and construction of NDS projects under the Integrated Plan Alternative. The Seattle Department of Transportation, in consultation with the City, would determine which permit applies for each project. Construction in streets and drives in parks would require a permit from Seattle Parks and Recreation. All of these permits include conditions on construction and requirements for street improvements and/or restoration.

4.8.1.3 Seattle’s Shoreline Master Program

Seattle’s Shoreline Master Program (Seattle Municipal Code Chapter 23.60) includes policies and regulations governing development and uses on and adjacent to marine and freshwater shorelines. In the Plan area, these shorelines (or Shoreline District) consist of the areas extending 200 feet landward from the following bodies of water: Elliott Bay and other waters of Puget Sound, Lake Washington, Lake Union, Lake Washington Ship Canal, Duwamish River, and associated wetlands and floodplains. These areas are subject to shoreline development standards that must be met in addition to zoning requirements.

Additional requirements for shoreline areas establish the types of land uses permitted and development regulations governing building size and other standards. All development within the Shoreline District, including the development of CSO control and stormwater facilities, must be consistent with the policies of the State Shoreline Management Act and Seattle's Shoreline Master Program.

The City's Shoreline Master Program classifies shoreline zones into 11 categories, known as shoreline designations (Table 4-8). These designations are based on the both the level of existing shoreline development and the City's goals for preserving and enhancing shorelines. Shorelines in the Plan neighborhoods include a mix of all of these shoreline designations.

The City of Seattle is in the process of updating its Shoreline Master Program. The City Council adopted the updated Shoreline Master Program in January 2013. The code update is awaiting approval from the Washington State Department of Ecology. It is not anticipated that the Shoreline Master Program will change substantially from the version adopted by the Council. Therefore, this section describes the adopted version.

Table 4-8 summarizes the requirements for utility lines and utility service uses in the City's shorelines. Utilities lines are generally allowed by permit or permitted as a special use in most shoreline designations. In the Conservancy Preservation (in water) designation and the Conservancy Recreation designation, utility lines are allowed as a special use if no reasonable alternative location exists. These two shoreline designations are located along the Puget Sound and Lake Washington shorelines in several of the Plan neighborhoods.

The Shoreline Master Program includes two regulations specific to utility lines in the Shoreline District.

- All new utility lines must be located outside the Shoreline District to the extent possible (Seattle Municipal Code 23.60A.217B).
- Pipelines carrying materials intrinsically harmful or potentially injurious to aquatic life or water quality must have shutoff facilities and use other appropriate best management practices to prevent and contain such materials from entering the water or the ground.

Utility service uses include facilities used for treating and storing stormwater and CSOs. These uses are prohibited in the Conservancy Navigation, Conservancy Preservation, and Conservancy Waterway shoreline designations. In all other designations, they are allowed if they reasonably require a shoreline location to operate. The Conservancy Navigation designation encompasses all the area on the water side of the ordinary high water mark. Areas of Conservancy Preservation are located throughout the Plan neighborhoods. Conservancy Waterways are located along the Lake Union and Portage Bay shorelines.

The decision on a Shoreline Substantial Development Permit for utility lines and utility service uses is made by the Director of DPD as defined in Seattle Municipal Code 23.60A, Subchapter I: Purpose and Policies.

Shoreline Management Act

Seattle's Shoreline Master Program implements the State Shoreline Management Act created by citizen referendum in 1972. The major policy areas of the Shoreline Management Act are as follows:

- Preferred uses are those that are water-oriented including single-family residences, ports, shoreline recreational uses, and water-dependent industrial and commercial developments.
- Environmental protection is required for shoreline natural resources to ensure no net loss of ecological function.
- Public access to the shoreline is promoted by requiring a public access element in local Shoreline Master Programs and requiring that new development must maintain public access.

Table 4-8. Shoreline Master Program Requirements for Utility Service Uses and Utility Lines

Shoreline Designation	Utility Service Uses	Utility Lines
Conservancy Management	Utility services are allowed if they reasonably require a shoreline location to operate.	Allowed by permit
Conservancy Navigation	Prohibited	Special Use
Conservancy Preservation	Prohibited	Utility lines are allowed on dry land as a special use and are allowed in water as a shoreline conditional use if no reasonable alternative location exists.
Conservancy Recreation	Utility service uses for treating and storing stormwater or combined sewage are allowed as a shoreline conditional use if they reasonably require a shoreline location to operate.	Utility lines are allowed as a special use, if no reasonable alternative location exists.
Conservancy Waterway	Prohibited	Special Use
Urban Commercial	Utility service uses are allowed if they reasonably require a shoreline location to operate.	Allowed by permit
Urban General	Utility service uses are allowed if they reasonably require a shoreline location to operate.	Allowed by permit
Urban Harborfront	Utility service uses are allowed as a special use on waterfront lots and are allowed on upland lots, if they reasonably require a shoreline location to operate.	Special use on waterfront lots and allowed by permit on upland lots.
Urban Industrial	Utility service uses are allowed if they reasonably require a shoreline location to operate.	Allowed by permit
Urban Maritime	Utility service uses are allowed if they reasonably require a shoreline location to operate.	Allowed by permit
Urban Residential	Utility service uses are allowed if they reasonably require a shoreline location to operate.	Allowed by permit

4.8.1.4 Environmentally Critical Areas

The City of Seattle regulates several kinds of environmentally critical areas under Seattle Municipal Code Chapter 25.09. Within the Plan neighborhoods these include geologic hazard areas, fish and wildlife habitat conservation areas, and wetlands. Environmentally critical areas are discussed in more detail in Section 4.1, Earth and Groundwater; and Section 4.4, Biological Resources.

4.8.2 What is the regulatory setting for visual quality?

The City of Seattle regulates aspects of visual quality through its Land Use Code and Environmental Policies, discussed below. The City's Shoreline Master Program also protects the visual quality of the shoreline zone through additional building development standards and requirements to protect view corridors. View corridor protection includes maintaining a view of the water from the public right-of-way, meeting minimum size requirements, prohibiting structures, and limiting parking in the corridor (Seattle Municipal Code 23.60.170). Any facilities constructed under the Plan would meet these requirements.

4.8.2.1 Seattle Municipal Code Title 23 Land Use Code

The Land Use Code (Title 23 of the Seattle Municipal Code) regulates visual quality through development standards for different zoning classifications. The development standards include building height restrictions, lot coverage and setbacks, landscaping and screening, and façade requirements. These restrictions and requirements are intended to ensure that new development will be consistent with existing land uses. Public facilities located in residential zones must be compatible in bulk to the surrounding community, and landscaping must be used to ensure the compatibility of public facilities with surrounding uses (Seattle Municipal Code 23.51A).

The Land Use Code includes provisions to minimize light and glare by requiring that exterior lighting must be shielded and directed away from adjacent uses. In residential zones, light and glare controls must be used for public facilities to ensure compatibility with surrounding uses (Seattle Municipal Code 23.41A).

4.8.2.2 Environmental Protection Policies

The City's Environmental Policy on Height, Bulk and Scale (Seattle Municipal Code 25.05.675G) states that development must be "reasonably compatible with the general character" of the area. The City can limit height, modify building bulk and facades, and reposition development to minimize bulk impacts. The Light and Glare policy states that lighting must minimize or prevent hazards and other adverse impacts (Seattle Municipal Code 25.05.675K). The City can place limits on the lighted area, intensity, location, angle, or hours of illumination and can require landscaping to shield the lighting from adjacent properties.

The City also has a Public View Protection policy (Seattle Municipal Code 25.05.675.P) that seeks to protect public views of significant natural and human-made features seen from viewpoints, parks, scenic routes, and view corridors. The policy protects views of Mount Rainier, the Olympic and Cascade Mountains, the Downtown skyline, and major bodies of water including Puget Sound, Lake Washington, Lake Union, and the Ship Canal. The City has inventoried the views from these public areas in an atlas (City of Seattle, 2002).

Important viewpoints in the Plan area include Gasworks Park in the Fremont/Wallingford area and Myrtle Edwards and Olympic Sculpture Parks in the Central Waterfront area. The policy also requires protection of public views of the Space Needle from numerous locations throughout the City. Because the specific locations of proposed facilities are not yet known, more detailed analysis relating to view protection would be conducted when site details have been determined.

4.8.3 What are the existing and anticipated future land and shoreline use characteristics in the Plan area?

The Plan area is located entirely within the city of Seattle. Land use patterns in the Plan area typify urban levels of development and reflect historic land use patterns in Seattle. Figures 4-13 through 4-16 depict existing land use

and zoning in the Plan area. Developed land uses in the Plan area are predominantly single-family residential and multi-family residential, followed by commercial and industrial uses. Industrial uses are located primarily within the Longfellow Creek/Duwamish Neighborhoods. Public street rights-of-way in the Plan area are used by industrial, commercial, and vehicle traffic as well as by cyclists and pedestrians. With the exception of the Delridge area, all of the Plan neighborhoods include portions of the City's Shoreline District and shoreline habitat designated as environmentally critical areas. Figures 4-13 through 4-16 show existing land use and zoning for the Plan neighborhoods.

Future land use in the Plan area is guided by the City of Seattle Comprehensive Plan. The Plan area is almost fully developed. Therefore, the amount of impervious surface area is unlikely to increase significantly in the future. Redevelopment is expected to occur within Seattle, with some neighborhoods experiencing more redevelopment than others, particularly in Seattle's designated urban villages, neighborhood areas where future growth is intended to match the existing character of the neighborhood. Zoning in the city reflects Comprehensive Plan designations and is generally consistent with current development.

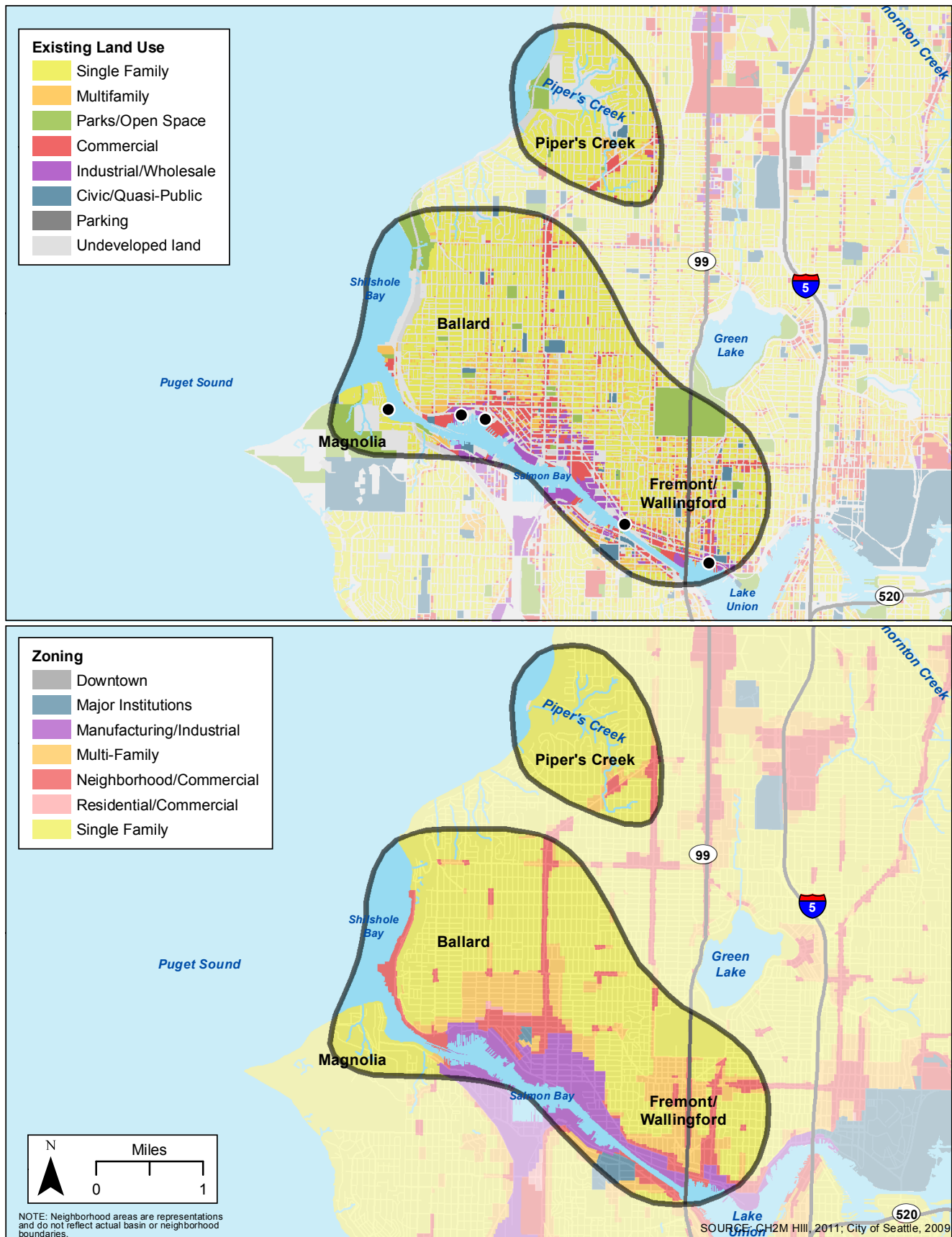


Figure 4-13 Existing Land Use and Zoning: Ship Canal and Piper's Creek Neighborhoods.

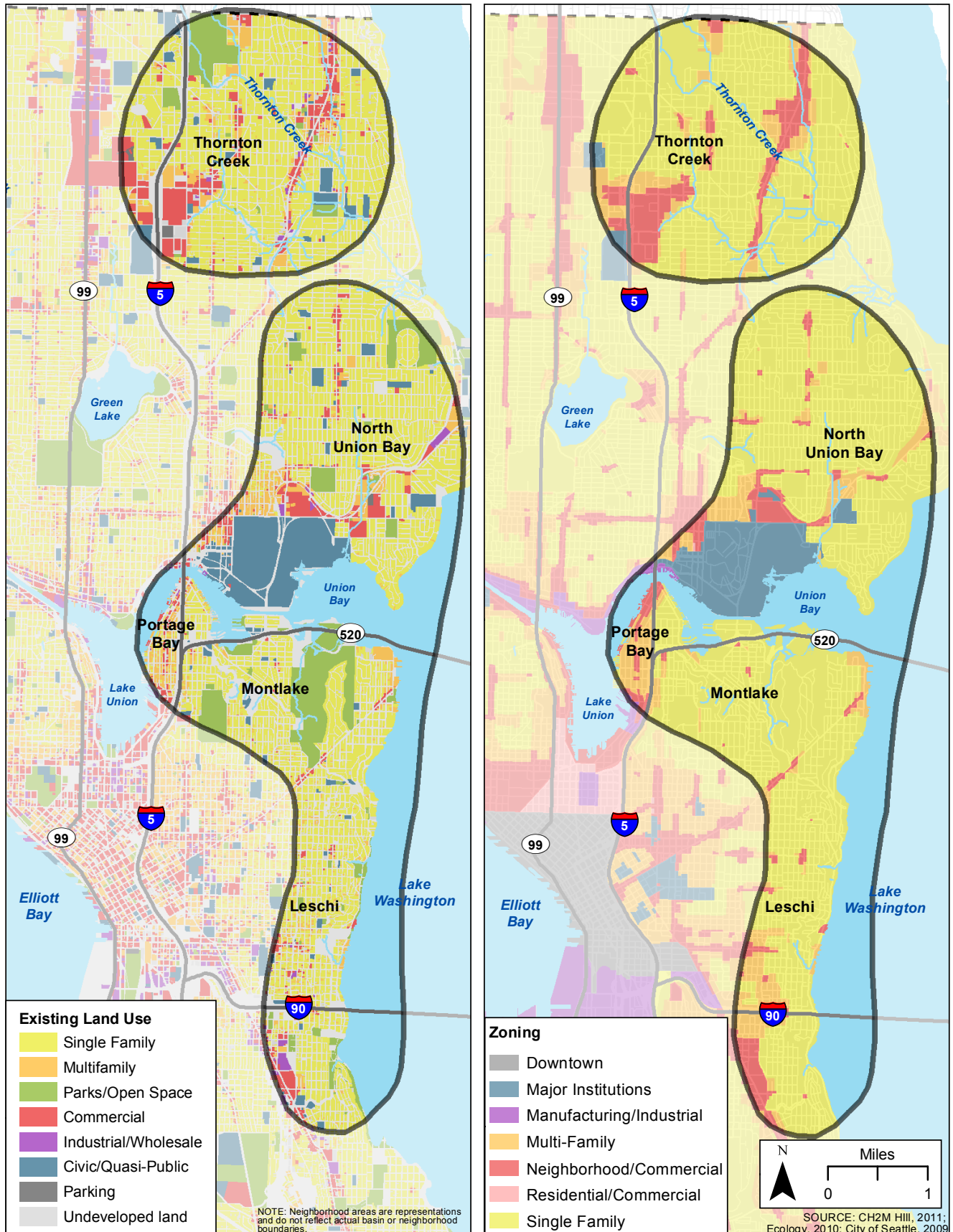


Figure 4-14 Existing Land Use and Zoning: Lake Washington and Thornton Creek Neighborhoods.

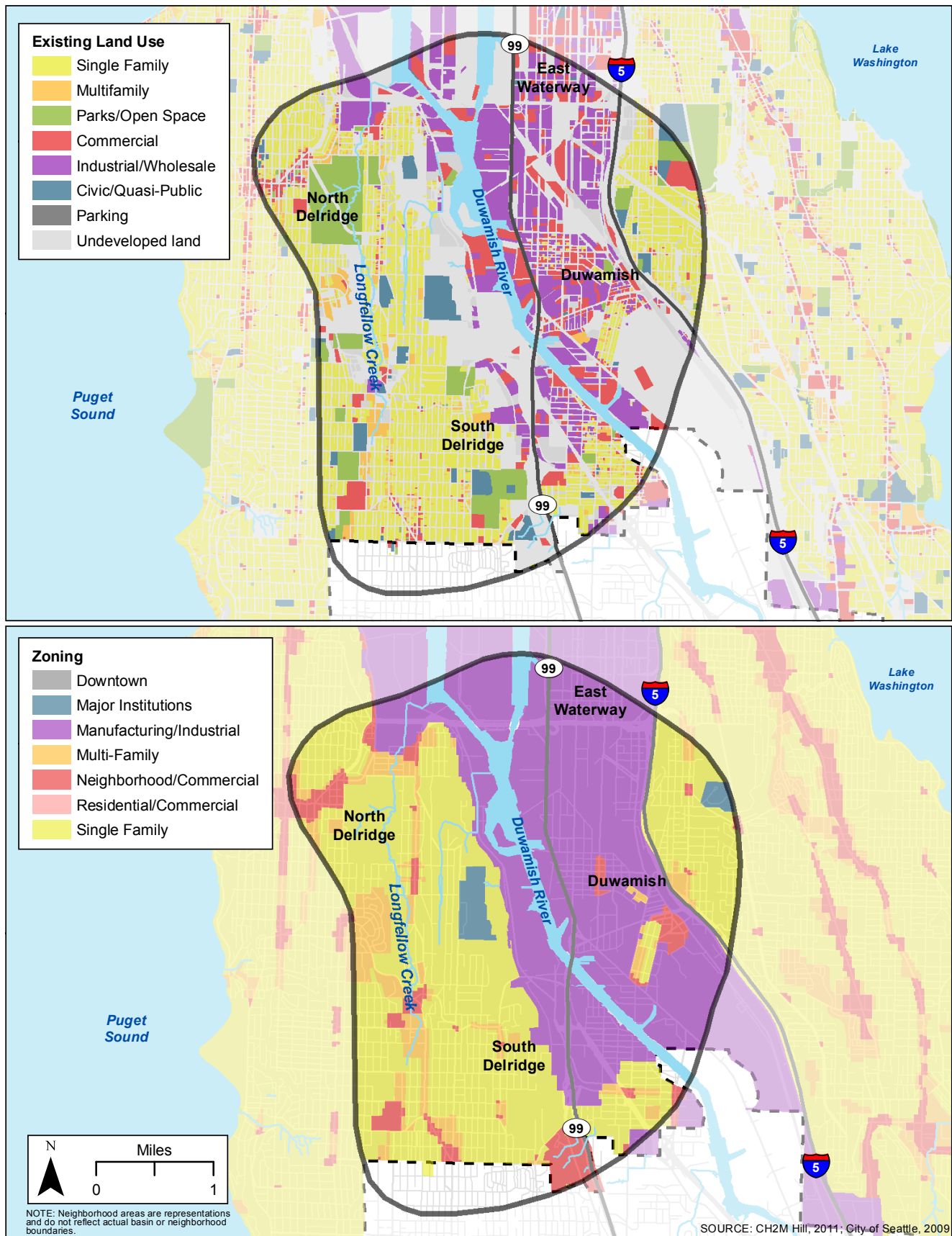


Figure 4-15 Existing Land Use and Zoning: Longfellow Creek/Duwamish Neighborhoods.

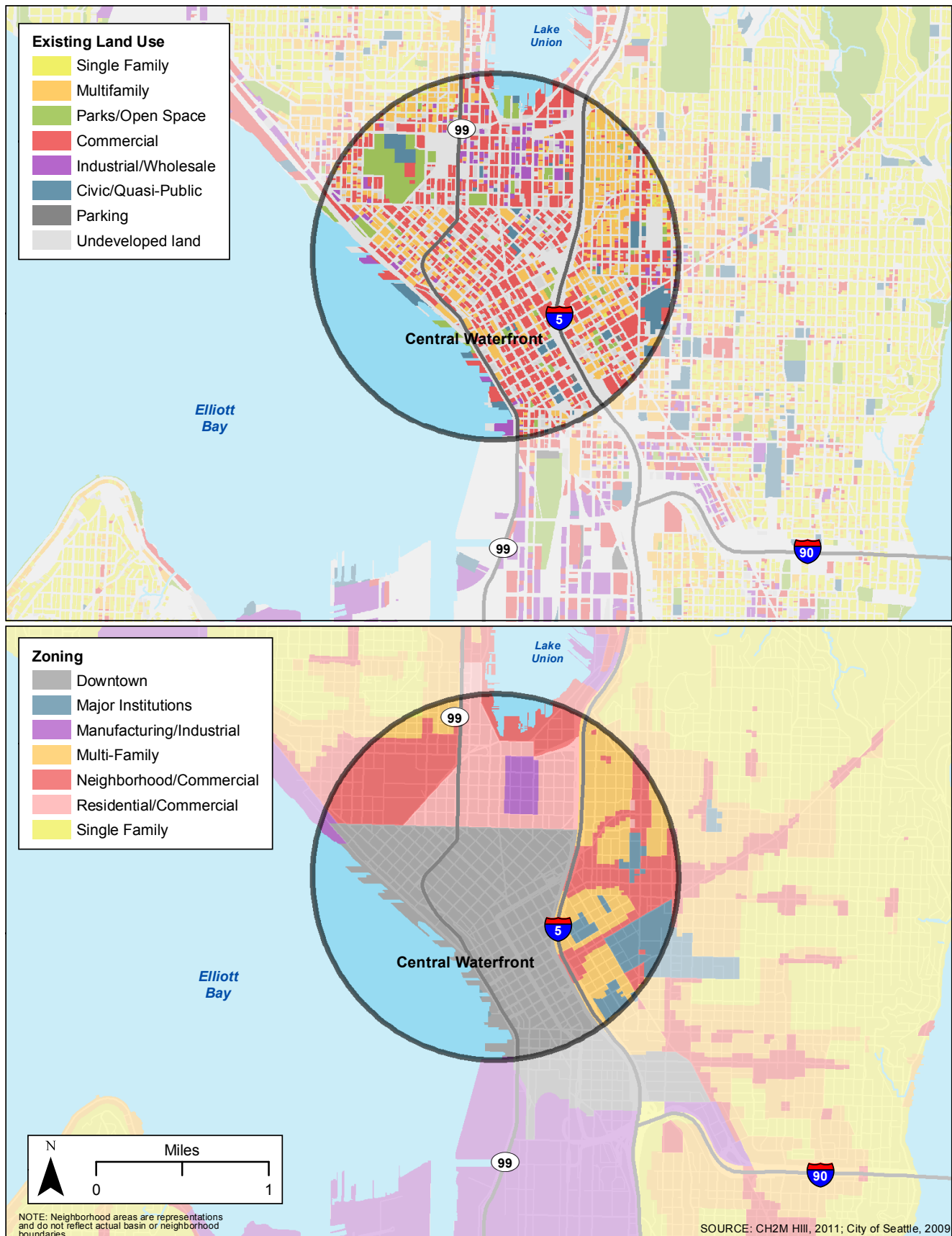


Figure 4-16 Existing Land Use and Zoning: Elliott Bay/Lake Union Neighborhoods.

4.8.4 What are the existing visual characteristics of the Plan area?

Seattle is noted for its views of the surrounding mountains and water bodies as well as structures such as the Space Needle and downtown skyline. These views are an integral part of the city's environmental quality. As described above, the Land Use Code protects public views of Mount Rainier, the Olympic and Cascade Mountains, the downtown skyline and major bodies of water, and from some locations, the Space Needle.

Each of the Plan neighborhoods offers different views of these features, as summarized in Table 4-9.

Table 4-9. Public Views from Plan Neighborhoods	
Plan Neighborhoods	Significant Public Views
Ship Canal	
Ballard	Mount Rainier, Olympic Mountains, Cascade Mountains, Puget Sound, Ship Canal
Fremont	Cascade Mountains, Ship Canal, Lake Union
Wallingford	Cascade Mountains, Ship Canal, Lake Union
Lake Washington	
North Union Bay	Mount Rainier, Cascade Mountains, Ship Canal, Lake Washington
Portage Bay	Ship Canal, Lake Washington
Lake Union	Olympic Mountains, Cascade Mountains, Ship Canal, Lake Union
Montlake	Cascade Mountains, Ship Canal, Lake Union, Lake Washington
Union Bay	Mount Rainier, Cascade Mountains, Lake Washington
Leschi	Mount Rainier, Cascade Mountains, Lake Washington
Longfellow Creek/Duwamish	
Delridge	Puget Sound, Olympic Mountains, Cascade Mountains, Downtown Skyline
Duwamish	Puget Sound, Downtown Skyline
Elliott Bay/Lake Union	
Central Waterfront	Mount Rainier, Olympic Mountains, Puget Sound, Downtown Skyline
Piper's Creek	
Piper's Creek	Mount Rainier, Olympic Mountains, Puget Sound, Downtown Skyline
Thornton Creek	
Thornton Creek	Mount Rainier, Cascade Mountains, Lake Washington

4.9 Recreation

4.9.1 What are the adopted plans and policies for parks and recreation in the Plan area?

4.9.1.1 Seattle Parks and Recreation 2011 Development Plan

In 2011, the City of Seattle adopted the *Parks and Recreation 2011 Development Plan* which identifies goals, objectives, and policies for the park and recreation system and discusses priorities for acquisition and development projects through 2017. The *2011-2016 Capital Improvement Program* includes over 100 capital projects at City parks, from minor maintenance projects to major renovation and development of new parks.

What is included in this section?

This section provides an overview of the distribution and types of park and recreational opportunities within the Plan area. This section also identifies adopted goals, policies, and plans aimed at protecting and enhancing recreational resources. Section 4.6, Environmental Health and Public Safety, describes issues related to water contact recreation. Section 4.11, Transportation, further addresses bicycle paths and trails.

4.9.1.2 Plans for Individual Parks

Some City parks have Vegetation Management Plans designed to guide development while maintaining and improving vegetation. Parks within the Plan area that have Vegetation Management Plans include the Burke Gilman Trail in the Ship Canal, Lake Washington, and Thornton Creek Neighborhoods; Discovery Park, Golden Gardens Park, and Woodland Park in the Ship Canal Neighborhoods; Lake Washington Boulevard and Ravenna Woods in the Lake Washington Neighborhoods; Camp Long in the Longfellow Creek/Duwamish Neighborhoods; and Carkeek Park in the Piper's Creek Neighborhoods.

4.9.1.3 Joint Use Agreement with Seattle School District

Over one-third of the schools in the Seattle Public Schools district adjoin parks land or facilities. Seattle Parks and Recreation and the Seattle School District have a Joint Use Agreement for facility use. Each agency has agreed to make its buildings and grounds available for use by the other agency after the space requirements for its own programs have been met.

If projects implemented under the Plan were to impact parks subject to the Joint Use Agreement, they would need to be coordinated with the School District. Parks subject to the agreement within the Plan area include Ballard Playground, Soundview Playfield, B. F. Day Playground, and Wallingford Playground in the Ship Canal Neighborhoods; Laurelhurst Playfield, View Ridge Playfield, Leschi Park, and Madrona Park in the Lake Washington Neighborhoods; High Point Playfield, Cleveland Playfield, and Jefferson Park in the Longfellow Creek/Duwamish Neighborhoods; Sacajawea Park and Meadowbrook Park in the Thornton Creek area; and Carkeek Park in the Piper's Creek area.

4.9.1.4 Ordinance No. 118477

Any construction in a park would have to comply with the requirements of Initiative 42 (Ordinance No. 118477) related to siting public facilities in parks. The ordinance states the following:

“ no [park] land or facility shall be sold, transferred, or changed from park use to another usage, unless the City shall first hold a public hearing regarding the necessity of such a transaction and then enact an ordinance finding that the transaction is necessary because there is no reasonable and practical alternative and the City shall at the same time or before receive in exchange land or a facility of

equivalent or better size, value, location and usefulness in the vicinity, serving the same community and the same park purposes."

The ordinance also allows any person to seek review in Superior Court if park land is changed to another use.

4.9.2 What recreational properties and activities exist in the Plan area?

The Plan area includes a wide range of recreational properties and facilities. Parks and sites with designated public access within the Plan area are shown on Figure 4-17.

Most of the recreational properties in the Plan area are owned and managed by Seattle Parks and Recreation and the Port of Seattle. The City of Seattle parks and recreation system comprises a variety of parks, open space, boulevards and trails, lakes and creeks, recreational, cultural, environmental and educational facilities, and a broad variety of programs. The Parks and Recreation Department is responsible for the operation and maintenance of 430 parks, 185 athletic fields, 151 outdoor tennis courts, 112 neighborhood play areas, 26 community centers, 11 off-leash areas, 10 swimming pools, and 4 golf courses. City parks include pocket parks and neighborhood parks primarily designed for local residents, and large parks that attract tourists and visitors from the other areas of the city and the region. Major parks and attractions in the Plan area are listed in Table 4-10.

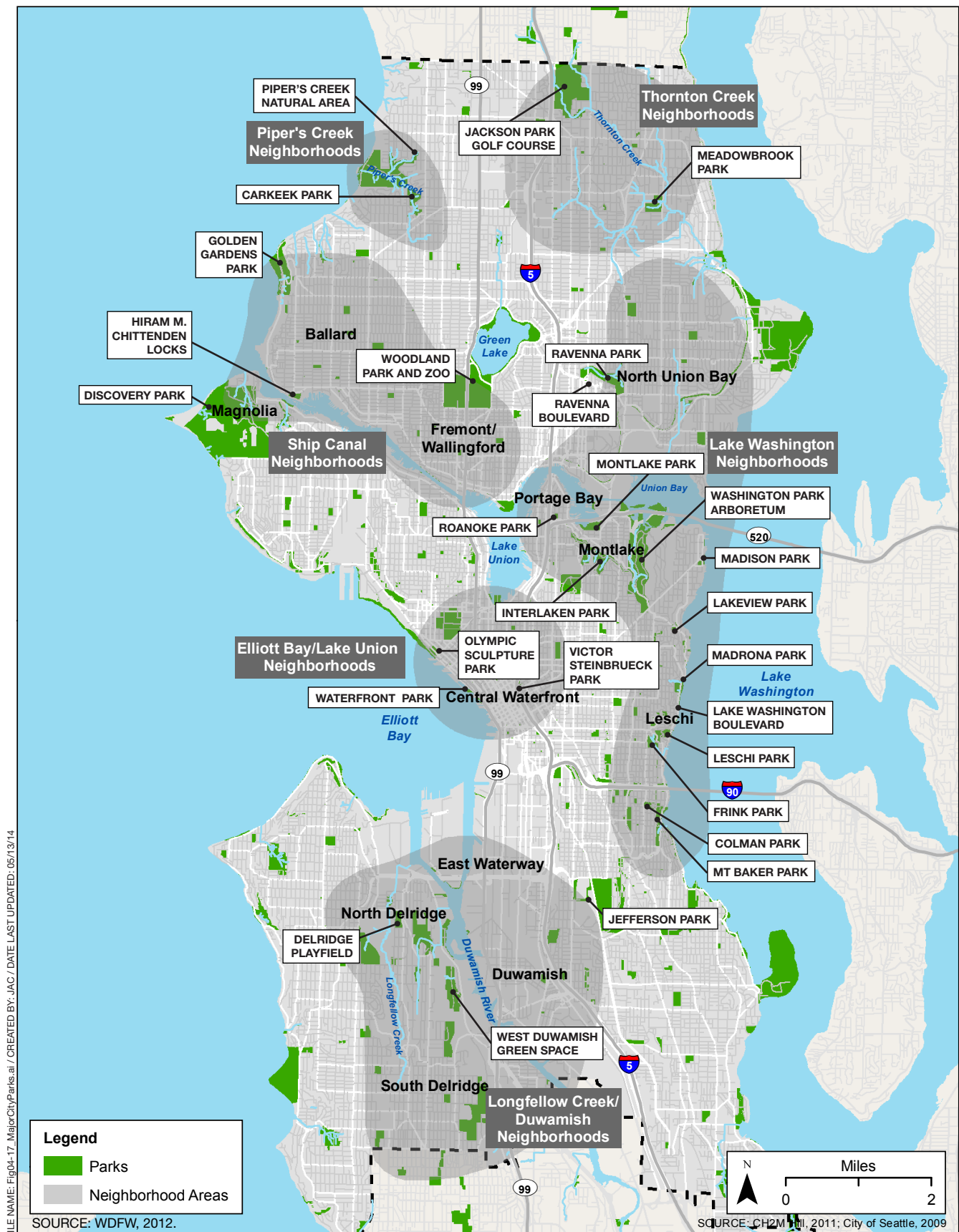


Figure 4-17 Major Parks within the Plan Area.

Table 4-10. Major Seattle Parks by Plan Neighborhood	
Plan Neighborhoods	Major Parks and Attractions
Ship Canal	
Ballard	Golden Gardens Park, Hiram M. Chittenden Locks, Burke Gilman Trail
Fremont/Wallingford	Woodland Park, Woodland Park Zoo, Burke Gilman Trail
Magnolia	Discovery Park
Lake Washington	
North Union Bay	Ravenna Park, Ravenna Boulevard, Burke Gilman Trail, Union Bay Natural Area, University of Washington Athletic Complex
Portage Bay	Roanoke Park
Montlake	Montlake Park, Interlaken Park, Washington Park Arboretum
Leschi	Madrona Park, Leschi Park, Lake Washington Boulevard, Mount Baker Park, Frink Park, Colman Park
Longfellow Creek/Duwamish	
Delridge	West Duwamish Green Space, Longfellow Creek Green Space, Delridge Playfields, Duwamish Trail, Alki Trail
Duwamish	Jefferson Park, Chief Sealth Trail
Elliott Bay	
Central Waterfront	Aquarium, Olympic Sculpture Park, Piers 62 and 63, Victor Streinbrueck Park, Waterfront Park, Myrtle Edwards Park
Piper's Creek	
Piper's Creek	Carkeek Park, Piper's Creek Natural Area
Thornton Creek	
Thornton Creek	Jackson Park Golf Course, Meadowbrook Park and Pond, Burke Gilman Trail, Thornton Creek Park, North Acres Park

Several of the parks located within the Plan area were designed by the influential landscape design firm led by the Olmsted Brothers, including Woodland Park in the Fremont/Wallingford area; Washington Park and Arboretum and Interlaken Park in the Montlake area; Madrona Park, Frink Park, Mt. Baker Park, and Colman Park in the Leschi area; and Jefferson Park in the Duwamish area. The Olmsted Brothers also designed a number of boulevards within the Plan area, including Lake Washington, Interlaken, Montlake, and Washington Park Boulevards. Numerous other parks throughout the city, including some in Plan neighborhoods, were influenced or suggested by the Olmsted Brothers.

Seattle Parks and Recreation maintains several public swimming beaches. Three of these beaches are within the Lake Washington Neighborhoods: Madison Park, Madrona, and Mount Baker Beaches.

Some parks in Plan neighborhoods, including Ravenna Park, the Mt. Baker Boat Facility, Gas Works Park, and Discovery Park, have National Park Service Land and Water Conservation Fund grants. These grants provide funds for acquisition and development of recreation areas. The Port of Seattle has more than 60 acres of parks and public access sites. These include bicycle and pedestrian trails, picnic areas, habitat restoration areas, fishing piers, and shoreline access. Within the Plan area, most of these sites are located in the Elliott Bay/Lake Union and Longfellow Creek/Duwamish Neighborhoods.

In 2008, Seattle voters passed a Parks and Green Spaces Levy. A number of park projects funded by the levy have been completed and several are planned for the future. The levy also funds an Opportunity Fund. Several upcoming projects funded by the levy and the Opportunity Fund would take place in Plan neighborhoods, including the Threading the Needle park project in Ballard at the 24th Avenue street end.

Schools have recreational facilities such as athletic fields and playgrounds that are generally open to the public. Most Plan neighborhoods include water access or waterfront recreation, and all neighborhoods include opportunities for passive recreation.

Public and private marinas can be found in the Ship Canal, Lake Washington, Longfellow Creek/Duwamish, and Elliott Bay/Lake Union Neighborhoods. Private or public golf courses can be found in the Lake Washington Neighborhoods (Broadmoor Golf Club and University of Washington Golf Range) and Longfellow Creek/Duwamish Neighborhoods (West Seattle Recreation Center and Jefferson Park Golf Course).

The Seattle Department of Transportation maintains a 450-mile bikeway network in the city made up of separate pathways, marked streets, and connectors. Separate bicycle pathways in the Plan area include the Burke Gilman Trail in the Ship Canal and Lake Washington Neighborhoods and Thornton Creek area; Elliott Bay Trail in the Elliott Bay/Lake Union; Mountains to Sound Trail in the Lake Washington; and Duwamish Trail, Alki Trail, and Chief Sealth Trail in the Longfellow Creek/Duwamish Neighborhoods. These trails are illustrated in Figure 4-20 in Section 4-20, Transportation.

There are 17 adopted Green Streets in Downtown Seattle and 15 adopted Neighborhood Green Streets. A Green Street is a street right-of-way that, through a variety of design and operational treatments, gives priority to pedestrian circulation and open space over other transportation uses. The treatments may include sidewalk widening, landscaping, traffic calming, and other pedestrian-oriented features. Among their many functions, Green Streets create open space opportunities in residential areas that may be otherwise lacking public open spaces. Neighborhood Green Streets are designated through neighborhood plans or other City adoption processes.

4.10 Historic, Cultural, and Archaeological Resources

4.10.1 What is the regulatory setting for cultural resources?

Cultural resources are evaluated under different regulations depending on funding, permitting, and land ownership. These federal, state, and local regulations are summarized in Table 4-11.

What is included in this section?

This section includes information on the regulations that apply to historic, cultural, and archaeological resources in the Plan area. It also provides a brief history of Seattle and summarizes the known cultural resources in the Plan area.

Table 4-11. Regulations and Permits for Historic, Cultural and Archaeological Resources

Statute	Lead Agency	Regulated Activities
Federal		
National Historic Preservation Act, Section 106 of 16 USC 470s	Funding or permitting agency	Requires lead federal agency to “take into account the effect of the undertaking on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register.” The lead federal agency will require the proponent to identify historic properties that may be potentially affected, assess the effects, and seek ways to avoid, minimize, or mitigate any adverse effects on historic properties.
State of Washington		
State Environmental Policy Act (SEPA)	Ecology	Requires that cultural resources within a proposed project area must be identified, and that measures must be proposed to reduce or control impacts on these resources. Under SEPA, the Department of Archaeology and Historic Preservation (DAHP) provides formal opinions on the significance of sites and the impact of proposed projects on such sites.
Indian Graves and Records (RCW 27.44), Abandoned and Historic Cemeteries and Historic Graves (RCW 68.60), Archaeological Sites and Resources (RCW 27.53), and Discovery of Human Remains (RCW 27.44)	DAHP	These laws contain clauses regarding the inadvertent discovery of cultural resources or human remains during activities such as construction.
Executive Order 05-05	DAHP	Establishes a review process by DAHP and affected Tribes for state-funded capital or land acquisition.
City of Seattle		
Historic Preservation Program (SMC 25.12)	Landmarks Preservation Board	Reviews and must approve proposed alterations to City of Seattle Landmarks. Issues a Certificate of Approval for any changes.

4.10.2 What is the history of the area?

Central Puget Sound and Lake Washington were inhabited for thousands of years prior to the arrival of EuroAmericans. The shorelines, freshwater streams, rivers, and lakes were seasonally and permanently inhabited by Native American people. These areas were utilized for food gathering, fishing, hunting, and procuring other resources. Upland areas were also utilized, though probably less intensively. Several significant archaeological sites within the Plan area demonstrate the long Native American occupation of the Puget Sound region.

EuroAmerican settlement of Seattle began with the arrival of the Denny Party in 1851. The city developed in several historic periods roughly divided into the Frontier Period (1850-1889), the Developmental Period (1890-1940), the Metropolitan Period (1941-1968), and the Modern Period (1969-present).

Historic resources are generally not considered eligible to the National Register of Historic Places until they are 50 years old. Because construction of projects implemented under the Plan is not anticipated until 2016 at the earliest, this means that the termination of the Metropolitan Period for the Plan would be 1966.

Because different areas of the city grew at separate paces, there is variation among the neighborhoods in terms of the timing of their historic periods. For example, the Elliott Bay Neighborhoods entered into the Developmental Period following the Great Seattle Fire in 1889, while other areas that lacked streetcars or utilities remained functionally in the Frontier Period. Seattle grew through annexation and many of today's neighborhoods began as small incorporated towns.

Both aboveground and buried cultural resources related to the historic uses described below could be present in each of the neighborhoods.

4.10.2.1 Ship Canal Neighborhoods

In general, the growth of railroads in the 1890s led to the development of the Ship Canal Neighborhoods. Magnolia, Wallingford, and Brooklyn (now part of the University District) were annexed in 1891, while Ballard was annexed to the city in 1907. The Ship Canal Neighborhoods were significantly impacted by the creation of the Ship Canal between 1911 and 1934. Development of neighborhoods north of 80th Street did not occur until after 1912 when roads were constructed. Early industries in these neighborhoods included shingle mills, fishing, and ship building.

4.10.2.2 Lake Washington Neighborhoods

Beginning around 1869 and continuing into the early 1900s, this group of neighborhoods developed over a broader period of time than other neighborhoods in the Plan area. As with the Ship Canal Neighborhoods, the Lake Washington Neighborhoods grew through annexation. The Lake Washington Neighborhoods were

Evaluation Criteria for Listing in the National Register of Historic Places.

The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association and

(a) that are associated with events that have made a significant contribution to the broad patterns of our history; or

(b) that are associated with the lives of persons significant in our past; or

(c) that embody distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

(d) that have yielded, or may be likely to yield, information important in prehistory or history. (36 CFR 60.4)

influenced by the construction of the Ship Canal between 1911 and 1934. The University of Washington moved to its present location in 1895 and developed substantially by 1909 when it hosted the Alaska-Yukon-Pacific Exposition.

4.10.2.3 Longfellow Creek/Duwamish Neighborhoods

As with other neighborhoods, growth occurred through annexation: West Seattle and Columbia City were annexed in 1907 while Georgetown was annexed in 1910. The Duwamish River was reworked through dredging and straightening between 1909 and 1920, which influenced the development of the neighborhoods. Flooding became less prevalent and industry took over the reclaimed land. Industries in these neighborhoods included steel mills, shipping, breweries, and ship building.

4.10.2.4 Elliott Bay/Lake Union Neighborhoods

The Elliott Bay/Lake Union Neighborhoods were the earliest areas developed within Seattle following the arrival of the Denny Party in late 1851. The depth of Elliott Bay was an essential factor in locating the heart of the new city because timber was viewed as a major export. Logging and milling were among the earliest industries, but other commerce soon grew to supply the increasing population. The first post office was established in 1852 quickly followed by a private school. The town was platted in 1853 within three original homesteads of Arthur Denny, Carson Boren, and Dr. David S. Maynard; this established the present day street grid (Bagley, 1916).

The Elliott Bay/Lake Union Neighborhoods are among the most substantially altered neighborhoods in Seattle. Elliott Bay was filled over the course of many years, piers were built out over the water, and the land was regraded numerous times.

4.10.2.5 Piper's Creek

The Piper's Creek area was not annexed until 1940 and 1954. This area was considered remote during the Frontier and Developmental Periods. The area's small shoreline-focused communities expanded with the introduction of improved road access. Early industries revolved around logging and milling, followed by agricultural and residential use of cleared lands.

4.10.2.6 Thornton Creek

The Thornton Creek area includes portions of Lake City and Cedar Park. These areas were annexed by Seattle in 1953-1954 and saw substantial growth during the Metropolitan and Modern Periods. At the turn of the century, these areas were remote forested areas with limited roads. Early industries were tied to logging and milling, with small communities located along the western shore of Lake Washington. As roads into the area were improved, development increased.

4.10.3 What is the study area for cultural resources for the Plan?

The study area for cultural resources for the Plan is defined as the "neighborhoods" depicted on Figure 4-2. The study area does not include water bodies because no in-water work is expected. The project team reviewed the Seattle Landmarks register and the state cultural resources database for each Plan neighborhood in March 2012 to assess the presence of historic register properties, recorded archaeological and historic sites, cemeteries (including municipal cemeteries, historic/inactive cemeteries, and individual historic and Native American gravesites), and "historic properties" (defined as buildings and structures 50 years of age or older). The project team also reviewed the Washington State Archaeological Predictive Model developed by DAHP to identify potential locations of unknown buried precontact (or prehistoric) cultural resources. The Predictive Model

categorizes most of the Plan area as having a moderate to very high probability for buried precontact cultural resources. Prior to any development in moderate to very high probability areas, cultural resources surveys are recommended (moderate probability areas) or highly advised (high probability and very high probability areas).

Previous cultural resources investigations have been conducted within the Plan area. In general, the few systematic surveys that have been conducted have been for infrastructure projects such as highway, light rail, or utility construction. Because there have been few previous investigations, the Predictive Model has not been refined in these areas.

All of the Plan neighborhoods were developed more than 50 years ago and they all contain numerous historic properties. However, not all of these are historically significant. Historic properties with demonstrated significance exist in all Plan neighborhoods and include properties listed on the National Register of Historic Places or as designated Seattle Landmarks. City of Seattle historic districts exist within the Ship Canal, Lake Washington, and Elliott Bay/Lake Union Neighborhoods. National Register districts exist in all neighborhoods except for Longfellow Creek/Duwamish. Cultural resources have been identified within a variety of settings in each neighborhood including road corridors, parks, and commercial areas. In some instances, the resource is the road corridor itself, as is the case for Queen Anne Boulevard or Lake Washington Bicycle Path, which are designated Seattle Landmarks.

Several parks and boulevards in the Plan area were designed by the nationally recognized landscape architects Frederick Law Olmsted and John Charles Olmsted. These historic parks and boulevards are described in more detail in Section 4.9, Recreation.

Several of the archaeological sites recorded within the Plan area are of particular significance including the Duwamish No. 1 Site, a 2,000-year-old winter camp and food processing site (Campbell, 1981; URS Corporation and BOAS, Inc., 1987) and *St'it'uchi*, a Native American Traditional Cultural Property on the shores of Lake Washington that is eligible for listing on the National Register of Historic Places. Cemeteries are located in all of the neighborhoods except for Piper's Creek.

4.10.4 What cultural resources are likely to be located within the Plan area?

The land within the Plan area has been subject to earthquakes, river migration, and sea level changes which have affected the preservation of cultural resources. For example, an earthquake 1,100 years ago caused Alki Point to rise 10 feet in elevation and West Point to sink 10 feet in elevation (to below sea level). The drainage patterns in the Duwamish-Green River Valley have undergone numerous changes (Troost et al., 1995; Lewarch et al., 1996).

Human modification of the landscape has also greatly impacted the preservation of cultural resources, including changes in the elevation of Lake Washington (lower since the construction of the Ship Canal), the straightening of the Duwamish River, and massive regrades in the Elliott Bay/Lake Union Neighborhoods. Due to the complex, intertwined natural and cultural histories of Seattle, archaeological resources in any given area may be deeply buried, shallowly buried, exposed at the surface, or previously eroded/destroyed by natural and human processes. Buried cultural resources could include Native American sites such as encampments, resource procurement sites, food processing sites, or features such as fish weirs, or historic buried resources such as foundations, historic abandoned infrastructure (roads and utilities), privies, and dumps.

4.11 Transportation

4.11.1 What are the relevant adopted plans, policies, and regulations?

Transportation impacts associated with the Plan are anticipated to result primarily from construction. Table 4-12 describes transportation standards and regulations related to construction within public road rights-of-way.

In addition to the standards and regulations described in the table, there are regulations that apply to work near rail facilities. The Washington State Department of Transportation (WSDOT) oversees freight and passenger rail service throughout the state, but it does not have jurisdiction over rail infrastructure. Any work near rail facilities must be coordinated directly with the owners of the railroads. A 3-mile segment of railroad in Ballard is owned by the Ballard Terminal Railroad. All other railroads in the Plan area are owned by the Burlington Northern-Santa Fe (BNSF) Railway.

What is included in this section?

This section describes federal, state, and local transportation plans and policies that are relevant to the Plan. It summarizes the existing transportation system, including roadways, parking, transit, and nonmotorized facilities, within the areas that could be affected by the Plan projects. It also describes major transportation capital improvement projects that are either planned or underway in the Plan area.

Table 4-12. Regulations, Guidelines and Permits for Transportation Projects in Seattle

Statute or Guideline	Lead Agency	Regulated Activities
Federal		
Manual on Uniform Traffic Control Devices (MUTCD)	Federal Highway Administration (FHWA)	Defines standards used by road managers nationwide to install and maintain traffic control devices on all public streets, highways, bikeways, and private roads open to public traffic. The MUTCD is a compilation of national standards for all traffic control devices, including road markings, highway signs, and traffic signals. It is updated periodically to accommodate the nation's changing transportation needs and address new safety technologies, traffic control tools, and traffic management techniques. The MUTCD includes standards for signs, flagging, and barricades in temporary construction work zones.
State of Washington		
Work Zone Traffic Control Guidelines	Washington State Department of Transportation (WSDOT)	WSDOT has jurisdiction over state highways and ramp intersections. Work conducted within the right-of-way of state highways must be coordinated with WSDOT. The WSDOT <i>Work Zone Traffic Control Guidelines</i> (WSDOT, 2012c) are based on the standards set forth in the MUTCD.

Table 4-12. Regulations, Guidelines and Permits for Transportation Projects in Seattle

Statute or Guideline	Lead Agency	Regulated Activities
City of Seattle		
Traffic Control Manual for In-Street Work	City of Seattle Department of Transportation (SDOT) Traffic Management Division	Defines the basic principles and standards for work performed within a street right-of-way so that work areas are safe and congestion is minimized; motorized and nonmotorized traffic is warned, controlled, and protected; and all traffic is expedited through the work zone to the extent possible. The manual defines requirements for traffic control plans, including pedestrian and bicycle access, detours, parking, and construction scheduling requirements, among other requirements. Work near King County Metro facilities (including trolley wires and bus stops) must be coordinated with Metro. A traffic control plan is required prior to the commencement of work in the public right-of-way when: • The project will impact pedestrian or vehicle movements on an arterial street; or • The project will impact pedestrian or vehicle movements in a high-impact area as defined by the City Traffic Engineer; or • Traffic control cannot be made to exactly match sketches in the Traffic Control Manual; or • Other special circumstances exist as determined by the City Traffic Engineer.

4.11.2 What are the existing transportation characteristics of the Plan area?

The existing transportation system includes roadways, parking facilities, transit, rail, Port of Seattle facilities, and nonmotorized facilities, described in the following sections.

4.11.2.1 Roadways

Figure 4-18 shows the Seattle roadway system and highlights the freeways, arterials, and collectors that serve the Plan area. All roadways in Seattle have designated functional classifications, which depend on the types of trips the roadways serve and the relative levels of traffic volumes they carry.

Each roadway within Seattle has been designated with one of the following classifications (City of Seattle, 2005):

- **Interstate Freeways** provide the highest capacity and least impeded traffic flow for longer vehicle trips (includes I-5 and I-90).
- **Regional Arterials** provide for travel between regions, carry traffic through the city, and serve important traffic generators, such as regional shopping centers, a major university, or sports facilities.
- **Principal Arterials** serve as primary routes for moving traffic through the city, connecting urban centers and urban villages to one another or to the regional transportation network (includes SR-99 and SR-520).
- **Minor Arterials** distribute traffic from principal arterials to collector arterials and local access streets.
- **Collector Arterials** collect and distribute traffic from principal and minor arterials to local access streets or provide direct access to destinations.

- **Commercial (Local) Access Streets** directly serve commercial and industrial land uses and provide localized traffic circulation.
- **Residential (Local) Access Streets** provide access to neighborhoods and other streets.
- **Alleys** provide access to the rear of residences and businesses and are not intended for through trips. Where a continuous alley network exists, it is the preferred corridor for utility facilities.

These functional classifications represent varying levels of emphasis on mobility and access. For example, freeways and arterials provide a high degree of mobility and have more limited access to adjacent land uses, accommodating larger traffic volumes at higher speeds. In contrast, residential and commercial access streets provide a high degree of access to adjacent land and are not intended to serve through traffic, carrying smaller traffic volumes at lower speeds. Collectors generally provide a more balanced emphasis on traffic mobility and access to land uses. The Plan neighborhoods have a variety of types of streets that consist of arterials, collectors, and local access streets.

In addition, the City has designated some of Seattle's arterial streets as Major Truck Streets. They accommodate substantial freight movement through the city and connect to major freight traffic generators (City of Seattle, 2005). Roadway characteristics and potential issues for Major Truck Streets would be similar to those of any other arterial roadway, but the streets would likely carry more truck traffic.

The City of Seattle conducts regular counts of Average Daily Traffic (ADT) on arterials and collectors throughout the city. The ADT may range from under 2,000 vehicles per day on a minor collector roadway to greater than 80,000 vehicles per day on a major arterial roadway. The City does not typically conduct regular counts on local access streets. However, since these streets primarily serve adjacent residential or commercial developments, they are expected to carry relatively low traffic volumes.

Drawbridges are located over the Ship Canal, Portage Bay, and Duwamish River. These bridges open regularly to allow marine vessels to pass through, resulting in vehicle delays and queues in the adjacent areas.

4.11.2.2 Parking

Parking supply and demand in Seattle varies greatly from neighborhood to neighborhood. In some neighborhoods there is ample parking, and in others, parking is extremely scarce and additional limitations would be of concern to residents. Public parking is typically provided on-street. Where on-street parking is allowed, it may be unrestricted, or it may be restricted during certain times of day. In higher density or commercial areas where available parking is limited, the City controls on-street parking through the use of Restricted Parking Zones (RPZs) or metered parking. RPZs may restrict the length of time or time of day when drivers may park without a permit. In neighborhoods where commercial parking demand can typically be accommodated with the available supply, on-street parking is allowed with no restrictions or cost. Private parking for residential, commercial, industrial, and institutional development is typically provided in off-street surface lots or garages.

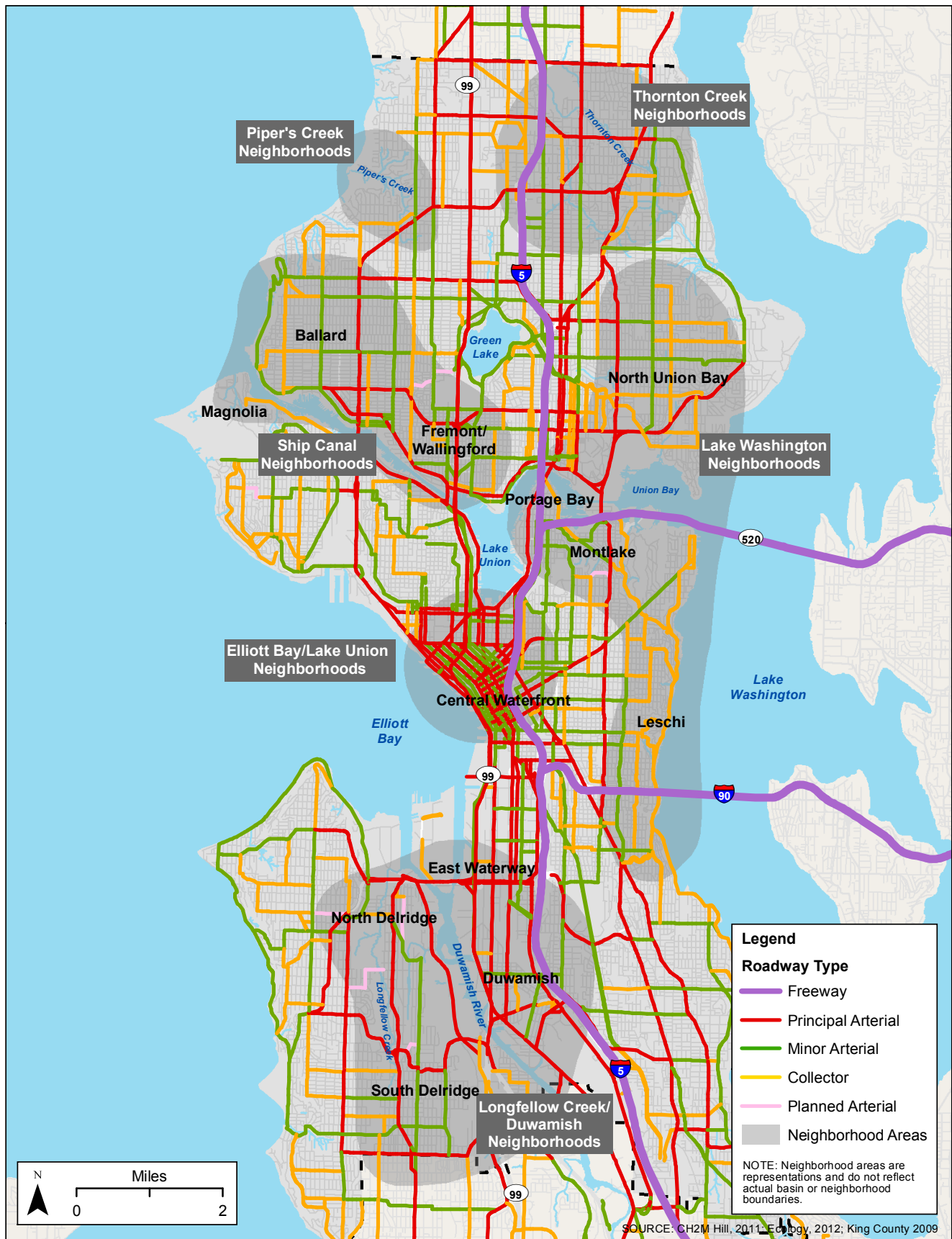


Figure 4-18 Roadways Serving Plan Area Neighborhoods.

4.11.2.3 Transit

Transit service in Seattle is provided by bus, streetcars, light rail, commuter rail, ferries, and water taxis. Figure 4-19 illustrates transit service in the Plan area.

4.11.2.4 Passenger and Freight Rail

Railroads in Seattle include the Ballard Terminal Railroad and BNSF lines. The Ballard Terminal Railroad operates trains on 3 miles of track on the north side of Salmon Bay in the Ballard area. All other railroad tracks in Seattle are owned by BNSF. The BNSF tracks are generally north-south in orientation and are located on the west side of Seattle in the Ship Canal, Longfellow Creek/Duwamish, and Elliott Bay/Lake Union Neighborhoods.

Amtrak also operates passenger rail on the BNSF tracks through Seattle. The Amtrak Cascades route operates daily trains from Seattle to Portland; Vancouver, BC; Los Angeles; and Chicago. In Seattle, passenger trains are boarded at the King Street Station, south of the Central Waterfront area.

4.11.2.5 Port of Seattle

The Port of Seattle marine port is located between the Central Waterfront and Duwamish neighborhoods. In addition to freight rail traffic, the Port of Seattle generates freight truck traffic that travels between the port and the regional highway system. Cruise ships also operate out of Port of Seattle facilities in the Central Waterfront area between May and October.

4.11.2.6 Nonmotorized Facilities

Many areas throughout Seattle have sidewalk networks or paved pedestrian pathways, but some do not, particularly in areas that are beyond the original city limits. Signalized intersections typically include marked crosswalks with pedestrian signals. Marked crosswalks are provided at some stop-controlled intersections and mid-block locations. All intersections that do not have marked crosswalks are still considered to be legal pedestrian crossings.

In addition to sidewalks, nonmotorized facilities in Seattle include pathways and trails that are separated from roadways, painted on-street bicycle lanes, and roadway lanes that are marked with “sharrows” indicating that motorists should share the lane with bicyclists. In addition, some roadways without bicycle pavement markings are designated as bicycle routes that may be either signed or unsigned (City of Seattle, 2011b). Figure 4-20 shows the major bicycle facilities that serve the Plan area.

Many neighborhoods in Seattle include parks, libraries, recreational facilities, schools and universities, and commercial development that can generate substantial pedestrian and bicycle traffic. Areas with a mixture of residential and commercial development often have a greater share of pedestrian and bicycle travel. Neighborhoods that consist primarily of low-density residential or commercial development typically have less nonmotorized activity.

The parking characteristics of a neighborhood can also affect pedestrian and bicycle traffic. In neighborhoods where parking supply is limited, parking is more likely to have time restrictions or pricing. Residents may own fewer cars, and more people may choose transit or nonmotorized modes of travel. People who drive and park in these areas are likely to stay parked in one spot and walk between destinations.

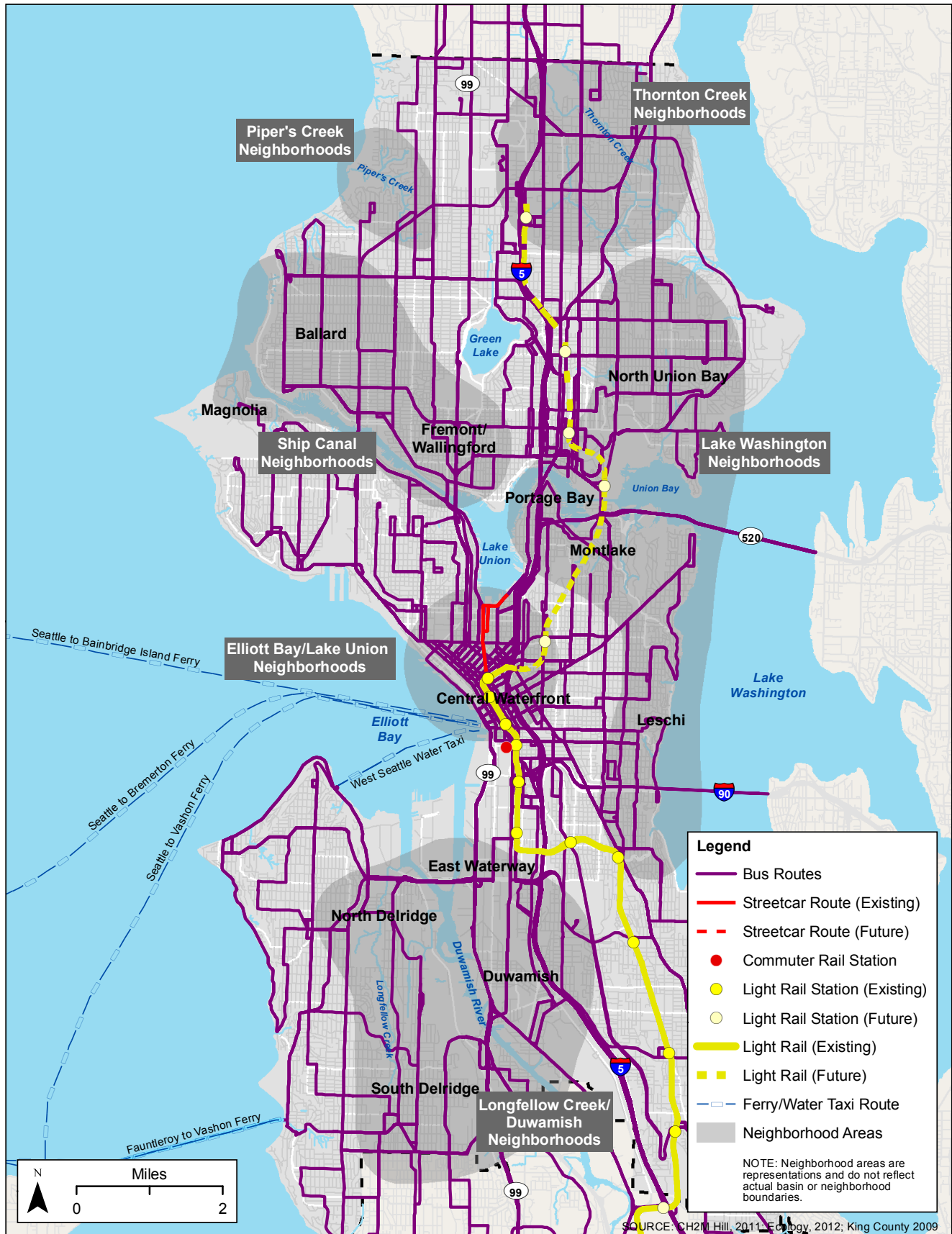


Figure 4-19 Transit Serving Plan Area Neighborhoods.



Figure 4-20 Non-Motorized Facilities Serving Plan Area Neighborhoods.

4.11.3 What transportation facilities are present in each Plan neighborhood?

4.11.3.1 Ship Canal Neighborhoods

In the Ship Canal Neighborhoods, the Ballard, Fremont, and Wallingford commercial districts and the area surrounding Seattle Pacific University have the most transportation activity. These areas are served by major roadways and also tend to have higher levels of transit service, as well as pedestrian and bicycle activity. Major off-road trails along the Ship Canal and Shilshole Bay to Golden Gardens Park are used by many pedestrians and bicyclists. Table 4-13 summarizes transportation characteristics in the Ship Canal Neighborhoods.

Table 4-13. Ship Canal Neighborhoods Transportation Characteristics	
Facilities	Transportation Characteristics
Roadways	Streets with highest traffic volumes: • Holman Road, 15th Avenue NW • NW Market Street/N 46th Avenue • Leary Avenue NW • NW Leary Way/N 36th Street • Aurora Ave (SR-99) • Market Street/N 46th Avenue • Fremont Avenue • W Nickerson Street • 3rd Avenue W
Bridges	Ballard Bridge—drawbridge at 15th Avenue NW Fremont Bridge—drawbridge at Fremont Avenue N Aurora Avenue Bridge
Parking	Parking constrained in commercial districts, near: • Lincoln High School, • Seattle Pacific University On-street parking limited: • Along NW Market Street west of 15th Avenue NW • Two-block area south of Ballard Commons Park • Near Ballard Locks • Along Seaview Avenue NW • Restricted in Fremont including prohibitions during peak commute periods or all day Parking in residential neighborhoods—generally available and unrestricted
Transit	Bus routes—principal and minor arterials, RapidRide on 15th Avenue NW
Railroads	Ballard Terminal Railroad from BNSF mainline along Seaview and Shilshole Avenues to its terminus at NW 40th Street/6th Avenue NW BNSF track crosses Ship Canal west of Ballard Locks and runs north roughly parallel to Seaview Avenue Railroad spur between the rail yard and Ship Canal east of Ballard Bridge

Table 4-13. Ship Canal Neighborhoods Transportation Characteristics	
Facilities	Transportation Characteristics
Nonmotorized Facilities	Sidewalk system—generally complete High levels of bicycle and pedestrian activity: • Ballard commercial district, Ballard Locks, Golden Gardens Park • Fremont and Wallingford commercial districts, Woodland Park and Woodland Park Zoo • Near Seattle Pacific University Trails: • Burke Gilman Trail • Ship Canal Trail south of Ship Canal between Fremont and Ballard Bridges

4.11.3.2 Lake Washington Neighborhoods

The University of Washington and surrounding University District are served by three major roadways with a high concentration of transit service and substantial pedestrian and bicycle activity. Parking is limited in this area. Vehicular and nonmotorized traffic is also high on the roadways adjacent to Lake Washington in the North Union Bay and Leschi neighborhoods. Other parts of the Lake Washington Neighborhoods generally experience lower levels of traffic, but roads tend to be narrow or curved, with fewer options for alternate routes. Two major transportation construction projects are also occurring in the University District and Montlake neighborhoods: the SR-520 floating bridge replacement and the University Link extension of Sound Transit light rail. Table 4-14 summarizes transportation characteristics in the neighborhoods.

Table 4-14. Lake Washington Neighborhoods Transportation Characteristics	
Facilities	Transportation Characteristics
Roadways	Streets with highest traffic volumes: • SR-520 • I-90 (no access from neighborhoods) • 24th Avenue E • Harvard Avenue E • E Roanoke Street • Montlake Boulevard NE • 25th Avenue NE • Sand Point Way • NE Pacific Street Residential streets are narrow and curved in many areas
Bridges	Montlake—drawbridge over Canal between Portage and Union Bays
Parking	On-street parking: • Generally available and unrestricted outside University District • Permits required near University to prevent overflow parking • Constrained south of NE 55th Street and west of 25th Avenue NE • Limited on narrow and curved roadways • Prohibited on busier streets during peak commute periods • Prohibited on street approaches to the Lake Union waterfront

Table 4-14. Lake Washington Neighborhoods Transportation Characteristics	
Facilities	Transportation Characteristics
Transit	Bus routes: • Principal and minor arterials • Highest concentration in and near the University
Railroads	None
Nonmotorized Facilities	Sidewalk system—generally complete High levels of bicycle and pedestrian activity: • University of Washington • Ravenna Park • Along Lake Washington • Washington Park Arboretum • Neighborhood commercial districts

4.11.3.3 Longfellow Creek/Duwamish Neighborhoods

The highest level of transportation activity in the Longfellow Creek/Duwamish Neighborhoods occurs in localized areas surrounding commercial districts, the industrial area in Duwamish, and recreational areas in Delridge. The West Seattle Bridge, crossing Harbor Island and the Duwamish River, provides the major connection between these two areas. The Duwamish industrial area experiences lower levels of pedestrian activity but serves as a major hub for freight-related activity. Its roads serve major truck traffic, and freight rail lines also traverse the area. The Delridge area is primarily residential, with higher traffic volumes, transit service, and nonmotorized travel occurring near commercial strips along major roadways, parks, recreational facilities scattered throughout the area, and South Seattle Community College. Table 4-15 summarizes transportation characteristics in the neighborhoods.

Table 4-15. Longfellow Creek/Duwamish Neighborhoods Transportation Characteristics	
Facilities	Transportation Characteristics
Roadways	Streets with highest traffic volumes: • West Seattle Bridge and Spokane Street • 35th Avenue SW • Delridge Way SW • West Marginal Way • East Marginal Way (SR-99) • 1st, 4th and 6th Avenues S • Airport Way S
Bridges	West Seattle Bridge—primary access between west and north/central Seattle
Parking	On-street and residential parking: • Generally available and unrestricted • Limited on north-south streets north of S Spokane Street, Delridge Way SW, commercial pockets on major area roadways, and commercial portions of Beacon Avenue S and 15th Avenue S • Industrial and commercial areas west of I-5 serviced by on-site surface lots

Table 4-15. Longfellow Creek/Duwamish Neighborhoods Transportation Characteristics	
Facilities	Transportation Characteristics
Transit	Bus routes: • Principal arterials • Highest concentration along West Seattle Bridge, SW Avalon Way, Delridge Way SW, and East Marginal Way
Railroads	BNSF lines in Duwamish running primarily north-south with limited east-west road crossings Major rail yard south of West Seattle Bridge
Nonmotorized Facilities	Sidewalk system—generally complete High levels of bicycle and pedestrian activity: • South Seattle Community College • West Seattle Recreation Center • Puget Park • Riverview Playfield • Jefferson Park Trails: • Duwamish Trail • Alki Trail • North-south parkway between 4th Avenue and 6th Avenue S, connecting S Royal Brougham Way to S Forest Street • Chief Sealth Trail

4.11.3.4 Elliott Bay/Lake Union Neighborhoods

The entire Elliott Bay/Lake Union area experiences very high levels of transportation activity. All Central Waterfront roadways carry notable levels of vehicular traffic. The Central Waterfront and Downtown neighborhoods serve as Seattle's major transit hub, with bus transit, light rail, streetcar, commuter rail, ferries, and water taxis all converging in this area. Parking is generally available because it is priced and tightly controlled; parking is provided on-street and in private surface lots and garages. Many pedestrians and bicyclists also travel in the Central Waterfront area. A major transportation construction project is occurring in the Central Waterfront area: the replacement of the Alaskan Way Viaduct (SR-99) with a bored tunnel. Table 4-16 summarizes transportation characteristics in the Elliott Bay/Lake Union Neighborhoods.

Table 4-16. Elliott Bay/Lake Union Neighborhoods Transportation Characteristics	
Facilities	Transportation Characteristics
Roadways	Streets with highest traffic volumes: • I-5 with ramps at E Denny Way, Olive Way, University Street, Madison Street, James Street, and Yesler Way • SR-99 • Denny Way • Battery Street • Stewart Street, James Street • 1st through 6th Avenues
Parking	Generally available, but controlled and priced Surface parking lots and garages located throughout Central Waterfront On-street parking prohibited on several major streets
Transit	Bus routes throughout Central Waterfront Light rail serves areas to the east and south of Central Waterfront Ferry and water taxi service to the south of Central Waterfront
Railroads	BNSF surface from tunnels at north end of Central Waterfront, at grade along the waterfront roughly parallel to Alaskan Way and Elliott Avenue
Nonmotorized Facilities	Sidewalk system—generally complete High levels of bicycle and pedestrian activity throughout Elliott Bay Trail

4.11.3.5 Piper's Creek

In the Piper's Creek area, transportation activity is highest in the commercial areas concentrated in the southeast along Holman Road NW and Greenwood Avenue N. The commercial areas are served by principal arterials with transit service and pedestrian and bicycle activity. The remainder of the area consists mainly of residential access streets with a more rural character defined by gravel or grass street edges with intermittent sidewalks and curbs. Carkeek Park has numerous trails connecting down to the Puget Sound shoreline. Table 4-17 summarizes transportation characteristics in the Piper's Creek area.

Table 4-17. Piper's Creek Transportation Characteristics	
Facilities	Transportation Characteristics
Roadways	Streets with highest traffic volumes: • Holman Road NW • Greenwood Avenue N • 3rd Avenue NW • 8th Avenue NW • 15th Avenue NW • NW 100th Place
Parking	Parking in commercial areas primarily off-street in private lots with some on-street (parallel or angle) parking along shoulders on or near Greenwood Avenue N Parking in residential neighborhoods mostly off-street with some on-street along gravel shoulders or along curbside where curbs exist. Parking is generally available and unrestricted
Transit	Bus routes—principal and minor arterials
Railroads	BNSF mainline along the Puget Sound shoreline along the west edge of Carkeek Park
Nonmotorized Facilities	Sidewalk system—intermittent with complete sidewalks along major arterials; incomplete in residential areas with some segments of curb and sidewalk along a few roadways Sharrows on segments of 3rd Avenue NW and 8th Avenue NW as well as NW 100th Place

4.11.3.6 Thornton Creek

The Thornton Creek area has substantial transportation activity, particularly in the Northgate and Lake City commercial districts. The Northgate Mall area, Northgate Transit Center, and Lake City Way NW corridor all generate high levels of pedestrian and transit activity. The area also has large residential neighborhoods including Maple Leaf, Victory Heights, Pinehurst, Lake City, Northgate, and Haller Lake. Table 4-18 summarizes transportation characteristics in the neighborhoods.

Table 4-18. Thornton Creek Transportation Characteristics	
Facilities	Transportation Characteristics
Roadways	Streets with highest traffic volumes: • I-5 • NE Northgate Way • Lake City Way NE • NE 125th Street • Roosevelt Way NE/Pinehurst Way NE/15th Avenue NE
Parking	Majority of commercial parking served by off-street surface lots and structures with some on-street parking along Lake City Way NE Residential parking is served by both off-street and on-street supply that is generally available and unrestricted
Transit	Northgate Transit Center Bus routes along principal arterials
Nonmotorized Facilities	Sidewalk system—intermittent with complete sidewalks along major arterials; incomplete in residential areas with some segments of curb and sidewalk along several roadways High levels of nonmotorized activity: • Northgate Mall vicinity • Lake City Way commercial area • Northgate Transit Center • Nathan Hale High School • Meadowbrook Park

4.12 Utilities

4.12.1 What is included in this section?

This section describes plans and policies relating to utilities (largely wastewater and water utilities) within the Plan area. It summarizes existing public utilities that could be affected by the LTCP and discusses proposed future utilities within the Plan area.

The City provides wastewater service, domestic water, and storm drainage within the city limits. The City also provides water service to much of King County either directly or through other purveyors. A number of investor-owned utilities provide energy, communications, and other utilities to the city, including natural gas, telephone, cable, and steam. Seattle City Light provides electricity to the city and areas within King County. City utilities are overseen by the Mayor and the City Council.

4.12.2 What are the relevant adopted plans, policies, and regulations?

4.12.2.1 City of Seattle Comprehensive Plan

The City of Seattle is in the process of updating the City's Comprehensive Plan, anticipated to be adopted in 2015. The current *2005 City of Seattle Comprehensive Plan* has a Utilities Element which sets out goals and policies for the City's utilities. Goals include: providing reliable service at lowest cost consistent with the City's aims; maintaining service reliability; maximizing efficient use of resources; minimizing the cost and inconvenience of trenching activities; operating utilities consistent with regional growth plans; and achieving universal access to state-of-the-art technology and telecommunication services. The Comprehensive Plan also includes specific policies relating to service, infrastructure, capital expenditure planning, environmental stewardship, facility siting and design, and utility relationships.

The Utilities Element of the Comprehensive Plan includes the following goals related to the provision of stormwater management and wastewater services:

UG1: Provide reliable service at lowest cost consistent with the City's aims of environmental stewardship, social equity, economic development, and the protection of public health.

UG2: Maintain the service reliability of the City's utility infrastructure.

UG4: Minimize the cost and public inconvenience of road and right-of-way trenching activities.

The following policies within the Utilities Element address the siting, design, construction, and maintenance of stormwater and wastewater facilities:

U3: Maintain the reliability of the City's utility infrastructure as the first priority for utility capital expenditures.

U17: Coordinate with state and federal agencies to reduce illegal discharges into water by both permitted and non-permitted sources.

U18: Work with neighborhood and community representatives in siting utility facilities.

U19: Continue to subject all above-grade City utility capital improvement projects to review by the Seattle Design Commission.

U20: Consider opportunities for incorporating accessible open space in the siting and design of City utility facilities.

The following policies within the Utilities Element address CSOs specifically:

U15: Strive to correct instances of combined sewer overflows by prioritizing remedial action according to the frequency and volume of the overflows and the sensitivity of the locations where the overflows occur.

U16: Work cooperatively with King County to identify and expeditiously address combined sewer overflows for which the County maintains responsibility.

4.12.2.2 City of Seattle Consent Decree

As described in Section 2.4.4, in July 2013, the City of Seattle entered into a Consent Decree with the Washington State Department of Ecology, the U.S. Environmental Protection Agency, and the U.S. Department of Justice. Requirements listed in the Consent Decree describe the actions that the City must take to address CSO overflows that violate the Clean Water Act. CSO outfalls must meet a performance standard to achieve the “greatest reasonable reduction” to be considered “controlled” in accordance with WAC 173-245-020(22). A “controlled” CSO has an average of not more than one untreated discharge event annually on a 20-year moving average. The Consent Decree has established a deadline of December 2025 for completion of all control measures.

The Consent Decree includes a number of requirements for control of CSOs, including Implementation of early action CSO control program and measures, and the development and implementation of a long-term control plan and post-construction monitoring plan.

The Consent Decree requires the City to submit an LTCP by 2015, but it allows the City to develop, as an alternative, an “Integrated Plan” that proposes stormwater control projects to be implemented by the City prior to construction of some CSO facilities. The Consent Decree includes a number of additional requirements for the Integrated Plan, including a pollutant load reduction analysis and an evaluation of projected benefits to water quality, ecology, and human health that would result from implementing the identified stormwater projects. The Integrated Plan must demonstrate that the proposed stormwater projects will provide greater water quality benefits compared to those CSO projects that would be deferred, and that they would meet the requirements of the Clean Water Act, the City’s NPDES and municipal separate storm sewer system (MS4) permits, and EPA’s CSO Control Policy.

The Consent Decree encourages the use of Green Infrastructure (referred to as natural drainage systems in this EIS) as appropriate to reduce or replace certain CSO control measures included in the LTCP based on demonstrated effectiveness, together with the traditional engineered measures, as long as these combined measures provide substantially the same or greater levels of control than the traditional CSO control measures alone. The Consent Decree requires construction to be completed on all CSO control measures included in the approved LTCP by December 2025, unless EPA and Ecology approve a different schedule as part of approving an Integrated Plan.

4.12.2.3 City of Seattle NPDES Stormwater Management Program

The City developed a Stormwater Management Program as part of compliance with its 2007 Phase 1 Municipal Stormwater Permit through the National Pollutant Discharge Elimination System (NPDES). As part of permit compliance, the City submits an annual report that documents actions and activities that have been undertaken to comply with permit requirements. Ten components of the Surface Water Management Plan (SWMP) require reporting, including legal authority, mapping, coordination, public participation, runoff controls, structural controls, source controls, illicit connections and discharges, operation and maintenance, and education and outreach. The City's SWMP covers the separate storm sewer system and the partially separated system only. As described in more detail in Chapter 2, the combined sewer system is subject to a separate NPDES permit. Refer to Section 4.3.1.

4.12.2.4 City of Seattle Wastewater NPDES Permit (WA0031682)

The City's most recent wastewater NPDES permit (WA0031682) was issued on October 27, 2010 and modified on September 13, 2012; it allows wet weather discharges from permitted CSO outfalls. The permit also requires implementation of the "Nine Minimum Controls" to ensure adequate capacity and maintenance of the sewer system, defines monitoring requirements, establishes requirements for detailed reporting to Ecology, and allows discharges only as a result of precipitation events. The NPDES permit also defined the performance requirements for a controlled CSO outfall as one untreated discharge per year per outfall, on a moving 20-year average. In addition, the City must identify any improvements that have occurred since the last permit authorization. The City's next CSO NPDES permit will be issued in October 2015.

4.12.2.5 King County Long-term Combined Sewer Overflow Control Plan Amendment and Consent Decree

As described in Section 2.7.1, King County's Long-term CSO Control Plan Amendment (King County, 2012a) presents nine projects to control King County's 14 remaining uncontrolled CSO locations. Four projects would be built in the Lake Washington Ship Canal/Montlake Cut area and five in the Duwamish River/Elliott Bay area. King County's LTCP Amendment describes possible collaboration with the City of Seattle on three of the nine projects in the Lake Washington Ship Canal/Montlake Cut area.

King County entered a consent decree with the U.S. Department of Justice and EPA (filed July 3, 2013) that ensures its CSO control plan is completed by 2030. King County had already committed to limiting CSOs to one per year at each outfall by 2030 through its adopted policies and a 2011 Agreement with the Department of Ecology.

Links to King County's Long-term Combined Sewer Overflow Control Plan Amendment, consent decree, and relevant CSO control policies can be found on their website.

<http://www.kingcounty.gov/environment/wastewater/CSO.aspx>

4.12.3 What utilities are located in the Plan area?

Public utilities potentially affected by implementation of the Plan include storm drainage and combined sewers, wastewater, and water supply. Other utilities not related to the Plan, including electricity and communications networks, are located throughout the Plan area, but are not addressed in this EIS.

4.12.3.1 Storm Drainage and Combined Sewers

The City's drainage infrastructure includes a separate storm drainage system, a partially connected system, and the combined sewer system, each of which serves approximately one-third of the geographical area of Seattle. Additional information about the drainage infrastructure is provided in Chapter 2.

4.12.3.2 Wastewater (Sewers)

Figure 2-1 illustrates the major wastewater facilities within the Plan area. The City provides wastewater collection within the city through sewer pipes that typically run along streets, and routes the untreated wastewater to collection and treatment facilities owned and operated by King County. The City's wastewater collection system sends wastewater flows to King County's West Point Wastewater Treatment Plant for treatment. King County owns and operates several major wastewater siphons that run underneath the Ship Canal and the Duwamish Waterway, including siphons crossing the Ship Canal in Ballard, Fremont, and Montlake, and two siphons crossing the Duwamish.

Because the City's wastewater collection system sends wastewater flows to King County for treatment, it will be important for any construction-related flow modifications to be coordinated closely with King County. Ongoing discussions with King County will continue, and agreements will be negotiated prior to implementing the Plan.

4.12.3.3 Water Supply

The City provides water to city residents. Major water lines owned and operated by the City cross the Ship Canal at Fremont, near I-5, and at Montlake. Major water lines also cross the Duwamish Waterway at four points: two lines from Harbor Island to West Seattle, a line from Harbor Island to the Duwamish area, and a line near the SR-99 crossing. The water supply for neighborhoods north of the Ship Canal is from the Tolt River watershed. Water for neighborhoods south of the Ship Canal is supplied from the Cedar River watershed.

4.13 Socioeconomics and Environmental Justice

4.13.1 What is environmental justice?

Environmental justice is an approach that is meant to promote decisions that are fair to all segments of the population, and avoid decisions that can have disproportionately greater negative human health and environmental effects on low-income or minority communities than on the population as a whole.

Negative effects associated with large municipal projects or programs can include disruptions in community cohesion, restricted access to a publicly funded facility, safety concerns, higher exposures to hazardous materials, raised noise levels, increased water and air pollution, and other adverse effects. Environmental justice evaluations also consider how projects can be developed to benefit low-income or minority communities, which have historically been disproportionately affected by human health and environmental hazards. To address both positive and potential negative effects of proposals, effective environmental justice approaches emphasize ways to involve affected communities through the planning process.

What is included in this section?

This section addresses the existing social and economic conditions that are relevant to the Plan area. Social and economic conditions such as population, demographic characteristics, community character, housing, and economic conditions are considered in an effort to understand the nature of the communities that would experience potential impacts through implementation of the Plan. Primary sources of information include the 2010 U.S. Census and the City of Seattle.

4.13.2 What's the relationship between CSOs and socioeconomic and environmental justice concerns?

Combined sewer overflows can pose human health risks to those who are directly or indirectly exposed to them. In many communities, environmental justice populations tend to be located in closer proximity to CSO outfalls than more affluent populations (Snider, 2002). This is not always the case, however, and in cities such as Seattle, affluent communities tend to be located along the city shorelines in some of the areas where CSO outfalls are located. As a result, the potential for direct exposure to environmental and human health threats from CSOs is more evenly spread across the populations.

Direct exposure to CSOs occurs primarily through swimming or wading in waters that have received CSO discharges. Indirect exposure to CSOs is primarily from the consumption of fish. This indirect exposure disproportionately affects low-income, tribal, and subsistence fishing communities, and immigrant families for whom fishing the Duwamish River, the Lake Washington system, and Puget Sound is rooted in cultural traditions. While CSOs are one source of contamination, contaminated sediments from a century of urban and industrial waste are also a significant source of contamination in these waterways.

4.13.3 What is the regulatory setting for socioeconomic and environmental justice?

While SEPA does not require analysis of environmental justice, existing local policies support the concept of environmental justice, and many of the projects implemented through the Plan may need to comply with federal environmental justice regulations during their individual project-level environmental review processes. Further, the City recognizes that CSO-related infrastructure projects have the potential to cause disproportionate impacts to environmental justice populations. Therefore, the City has prepared this environmental justice analysis to promote the principles of environmental justice, continue current environmental justice efforts, and facilitate future environmental justice analyses for projects as may be required under federal environmental justice regulations.

The Plan must be approved by EPA in compliance with the consent decree. Therefore, this assessment also considers EPA's

Environmental Justice

The concept of environmental justice acknowledges that the quality of our environment affects the quality of our lives and that minority and low-income populations should not suffer disproportionately high and adverse effects from projects.

Although SEPA, as a state regulation, does not specifically require the analysis of environmental justice in an Environmental Impact Statement, a discussion of it is included in recognition of the City of Seattle's Race and Social Justice Initiative.

Seattle's Race and Social Justice Initiative

The Race and Social Justice Initiative is a citywide effort to realize the vision of racial equity. The initiative works within the City of Seattle government and with community leaders to get to the root cause of racial inequity: institutional racism.

The initiative is led by the Seattle Office of Civil Rights and an interdepartmental team of City of Seattle staff. All elected officials in Seattle have endorsed and are promoting the initiative.

Environmental justice populations

include minority and low-income populations. Minority populations are defined as individuals listed in the 2010 U.S. Census identifying themselves as Black or African American, American Indian and Alaskan Native, Asian, Native Hawaiian or Pacific Islander, "other race," or Hispanic or Latino (a person of Mexican, Puerto Rican, Cuban, Central or South American, or other Spanish culture or origin, regardless of race).

Low-income populations are defined as individuals listed in the 2010 U.S. Census whose median household income is at or below the United States Department of Health and Human Services (DHHS) poverty guidelines, which are updated periodically in the Federal Register by the DHHS under the authority of 42 United States Code 9902(2).

environmental justice goals and policies. In 1992, EPA created an Office of Environmental Justice to ensure that environmental justice was being integrated into the framework of EPA policies, programs, and activities. Subsequently, the National Environmental Justice Advisory Council was created in 1993 to attain further cooperation on environmental justice issues (EPA, 2011b). Further, EPA has established Environmental Justice Action Plans to measure progress on governmental environmental justice initiatives (EPA, 2011b).

4.13.4 What are the existing characteristics of the Plan area?

4.13.4.1 Population, Employment, and Housing

The City of Seattle covers about 84 square miles of land with a total population of 608,600 in the City of Seattle, as reported in the 2010 U.S. Census.

The City of Seattle had approximately 462,000 jobs, as reported in the 2010 U.S. Census, and an unemployment rate of 7.3 percent as of March 2012 (Employment Security Department, 2012). Most of the city's employed residents are working in various services, government, retail, education, and finance/insurance/real estate industries (City of Seattle, 2011a). The largest employer in the city is the University of Washington.

Demographic characteristics of the Plan neighborhoods are shown in Figures 4-21 through 4-24. The total number of households in the city was 305,522 based on the 2010 U.S. Census. Of this total, 48 percent were owner-occupied and 52 percent were renter-occupied. Within the Plan area, the total number of households was 103,424, of which 51 percent were owner-occupied and 49 percent were renter-occupied. While median house value and median household income in the overall Plan area are slightly higher than the city as a whole, there is a great deal of variation within the Plan neighborhoods.

4.13.4.2 Environmental Justice Populations

The environmental justice study area is equivalent to the Plan area, which is defined by the basin boundaries within the six neighborhood areas addressed by the Plan. For a "programmatic" analysis, the census tracts represent an appropriate scale to determine study area characteristics.

What is a Census Tract?

Census tracts are small, relatively permanent statistical subdivisions of a county. The tracts typically have between 2,500 and 8,000 people and are designed to be homogeneous in population characteristics, economic status, and living conditions. The size of the census tract varies depending on population density. The tracts are intended to be maintained over a long period of time so that statistical comparisons can be made from one census to another.

Using the most recent available data from the 2010 U.S. Census, Figures 4-25 and 4-26 summarize the minority and low-income population characteristics for the census tracts in the Plan area. The population characteristics of the Plan area residents are similar to those of the city as a whole, although the Plan area residents are somewhat less diverse.

The census tracts with the greatest percentage of minority residents are located in the East Waterway, South Delridge, and Thornton Creek neighborhoods. Certain census tracts in these areas had more than 60 percent minority residents, and in the Duwamish area, more than 80 percent. Because of this neighborhood-scale analysis, some smaller communities with higher percentages of minority populations may not be apparent.

The percentage of persons below the poverty threshold in the city as a whole (13 percent) is slightly higher than the percentage in the Plan area (11.3 percent). The census tracts with the highest percentages of low-income residents are located in the Central Waterfront, Delridge, Duwamish, and Fremont/Wallingford neighborhoods.

Further information on the economic and population characteristics of the Plan neighborhoods is summarized in Table 4-19.

Table 4-19. Plan Neighborhoods Population and Economic Characteristics	
Population and Economic Characteristics	
Ship Canal	
Ship Canal Neighborhoods have fewer minority residents and residents living at or below the poverty level compared to the city as a whole.	
Lake Washington	
Lake Washington Neighborhoods include some of the most affluent neighborhoods of the city and of the Plan area as a whole, with the exception of University District where student population characteristics strongly influence census data. Most areas, including Portage Bay and North Union Bay, have fewer minority residents and residents living at or below the poverty level compared to the city as a whole, and to other neighborhoods within the Plan area.	
Longfellow Creek/Duwamish	
The Duwamish area is largely industrial and commercial in nature, with minimal residential areas. Though the daytime work force population is very large, few residents live in this portion of the Plan area. Many of the streets lack curb, gutter, and sidewalks, which creates potential safety issues for pedestrians. The Longfellow Creek/Duwamish area is more likely to have minority populations, and people living at or below the poverty level compared to other neighborhoods in the Plan area. Certain census tracts within this area have the highest percentage of minority residents in the Plan area.	
Elliott Bay/Lake Union	
Compared to the rest of the city, a larger percentage of residents in the Central Waterfront area rent rather than own. The area population is dominated by weekday employees and tourists. A number of social service agencies are clustered in the Central Waterfront area. Certain census tracts within this area have high percentages of low-income and minority residents.	
Piper's Creek	
The Piper's Creek area has fewer minority residents and residents living at or below the poverty level compared to the city as a whole.	
Thornton Creek	
The Thornton Creek area has fewer residents living at or below the poverty level compared to the city as a whole. Certain tracts have higher percentages of minority residents than the city as a whole.	

FILE NAME: Fig. 04-21_Demographics_ShipCanal.ai / CREATED BY: JAC / DATE LAST UPDATED: 04/29/14

Piper's Creek

16,404 Total Population

12,549	White
518	African American
115	American Indian
1,521	Asian
36	Native Hawaiian
717	Other
905	Hispanic (Of Any Race)
3,855	Persons of Color

Number of Households: 7,910

Owner Occupied: 66%

Renter Occupied: 34%

Median House Value: \$444,700

Median Rent: \$993

Median Household Income: \$72,937

Ballard

32,502 Total Population

27,505	White
518	African American
190	American Indian
1,424	Asian
59	Native Hawaiian
1,144	Other
1,581	Hispanic (Of Any Race)
4,997	Persons of Color

Number of Households: 17,394

Owner Occupied: 53%

Renter Occupied: 47%

Median House Value: \$475,560

Median Rent: \$1,003

Median Household Income: \$68,542

Fremont/Wallingford

19,226 Total Population

15,775	White
414	African American
99	American Indian
1,232	Asian
25	Native Hawaiian
800	Other
837	Hispanic (Of Any Race)
3,451	Persons of Color

Number of Households: 4,837

Owner Occupied: 38%

Renter Occupied: 62%

Median House Value: \$501,400

Median Rent: \$1,045

Median Household Income: \$64,396

Magnolia

6,001 Total Population

4,972	White
87	African American
25	American Indian
446	Asian
13	Native Hawaiian
229	Other
217	Hispanic (Of Any Race)
1,029	Persons of Color

Number of Households: 2,903

Owner Occupied: 68%

Renter Occupied: 32%

Median House Value: \$600,600

Median Rent: \$988

Median Household Income: \$88,828

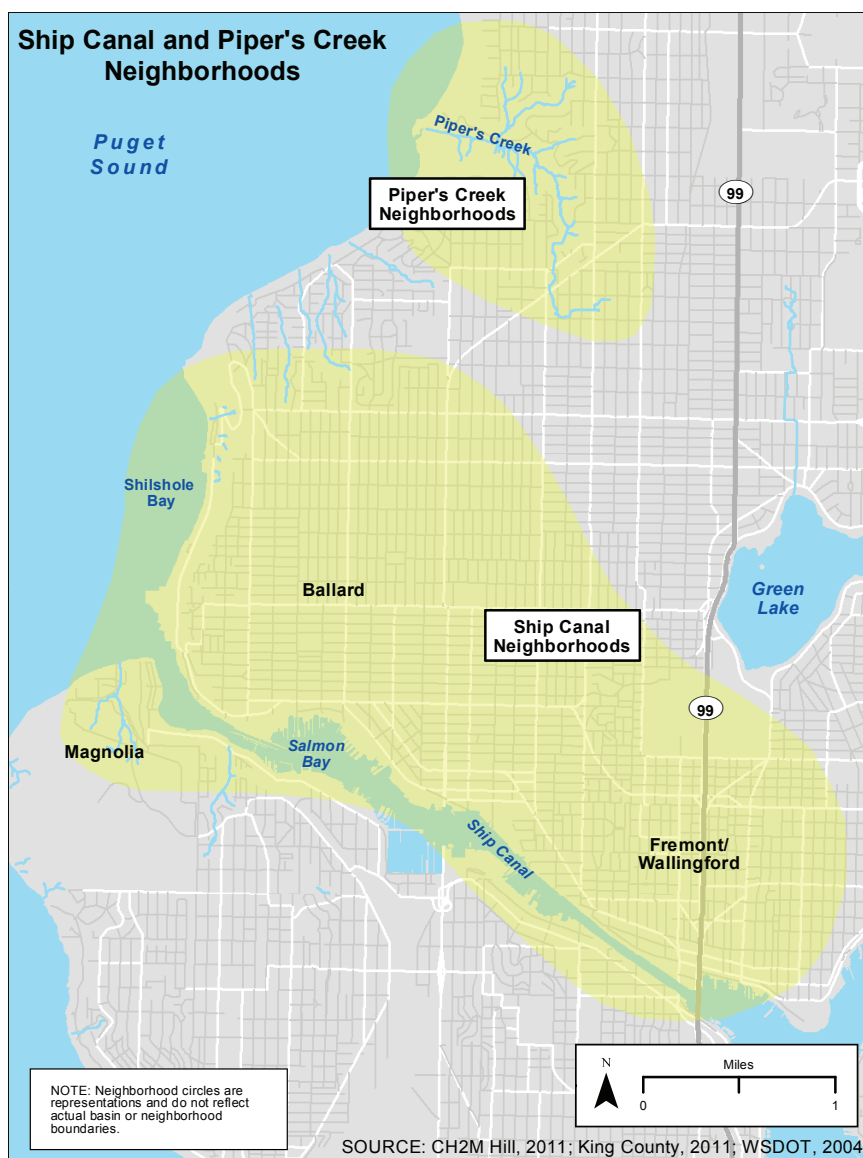


Figure 4-21. Ship Canal Neighborhoods - Demographic Characteristics.

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Portage Bay

4,796 Total Population

3,990	White
72	African American
7	American Indian
371	Asian
7	Native Hawaiian
162	Other
174	Hispanic (Of Any Race)
806	Persons of Color

Number of Households: 3,093

Owner Occupied: 42%

Renter Occupied: 58%

Median House Value: \$672,600

Median Rent: \$993

Median Household Income: \$67,984

Montlake

3,848 Total Population

3,220	White
89	African American
12	American Indian
235	Asian
3	Native Hawaiian
155	Other
110	Hispanic (Of Any Race)
628	Persons of Color

Number of Households: 1,597

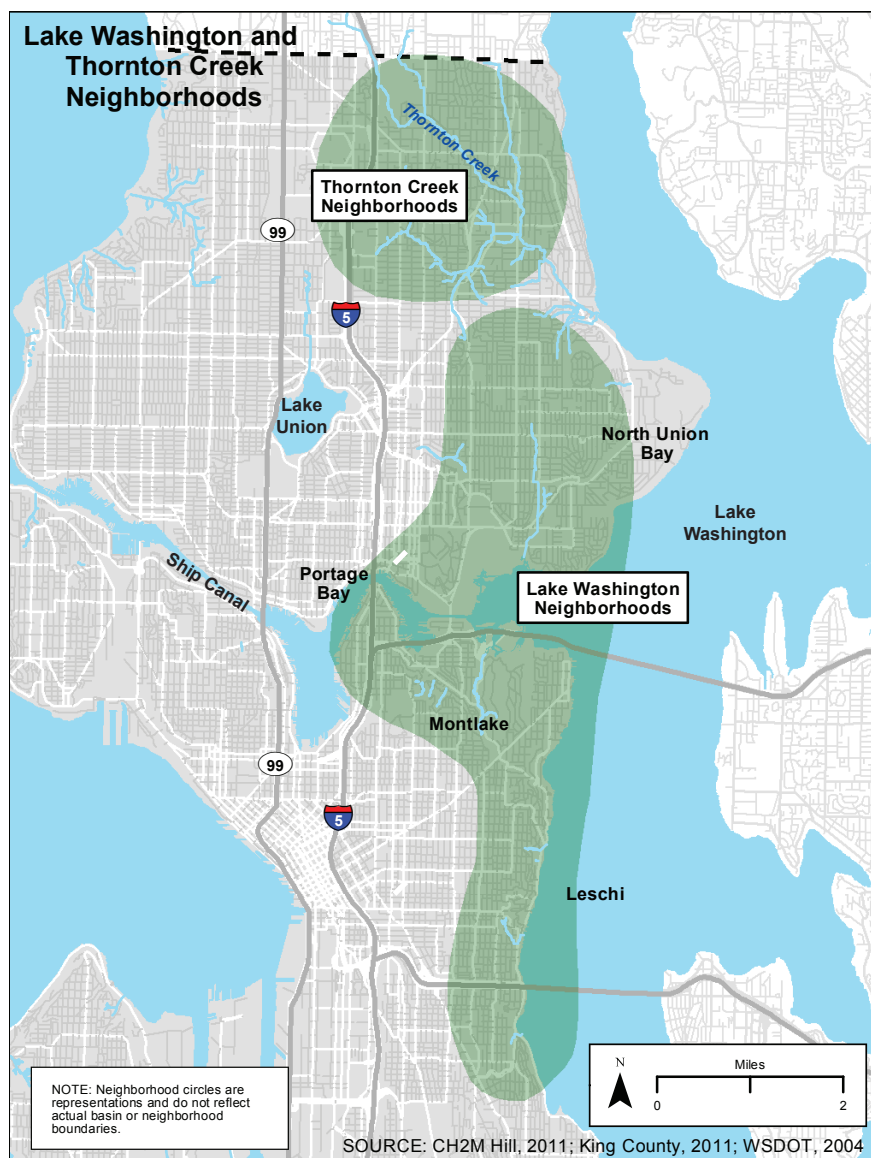
Owner Occupied: 82%

Renter Occupied: 18%

Median House Value: \$778,800

Median Rent: \$1,705

Median Household Income: \$130,820



Leschi

19,383 Total Population

11,262	White
4,146	African American
84	American Indian
1,796	Asian
50	Native Hawaiian
9817	Other
1,005	Hispanic (Of Any Race)
8,121	Persons of Color

Number of Households: 8,672

Owner Occupied: 66%

Renter Occupied: 34%

Median House Value: \$575,375

Median Rent: \$918

Median Household Income: \$87,255

North Union Bay

23,209 Total Population

18,625	White
349	African American
74	American Indian
2,288	Asian
35	Native Hawaiian
993	Other
790	Hispanic (Of Any Race)
4,584	Persons of Color

Number of Households: 10,002

Owner Occupied: 70%

Renter Occupied: 30%

Median House Value: \$621,320

Median Rent: \$1,011

Median Household Income: \$88,744

SOURCE: US Census, 2010.

Figure 4-22. Lake Washington Neighborhoods - Demographic Characteristics.

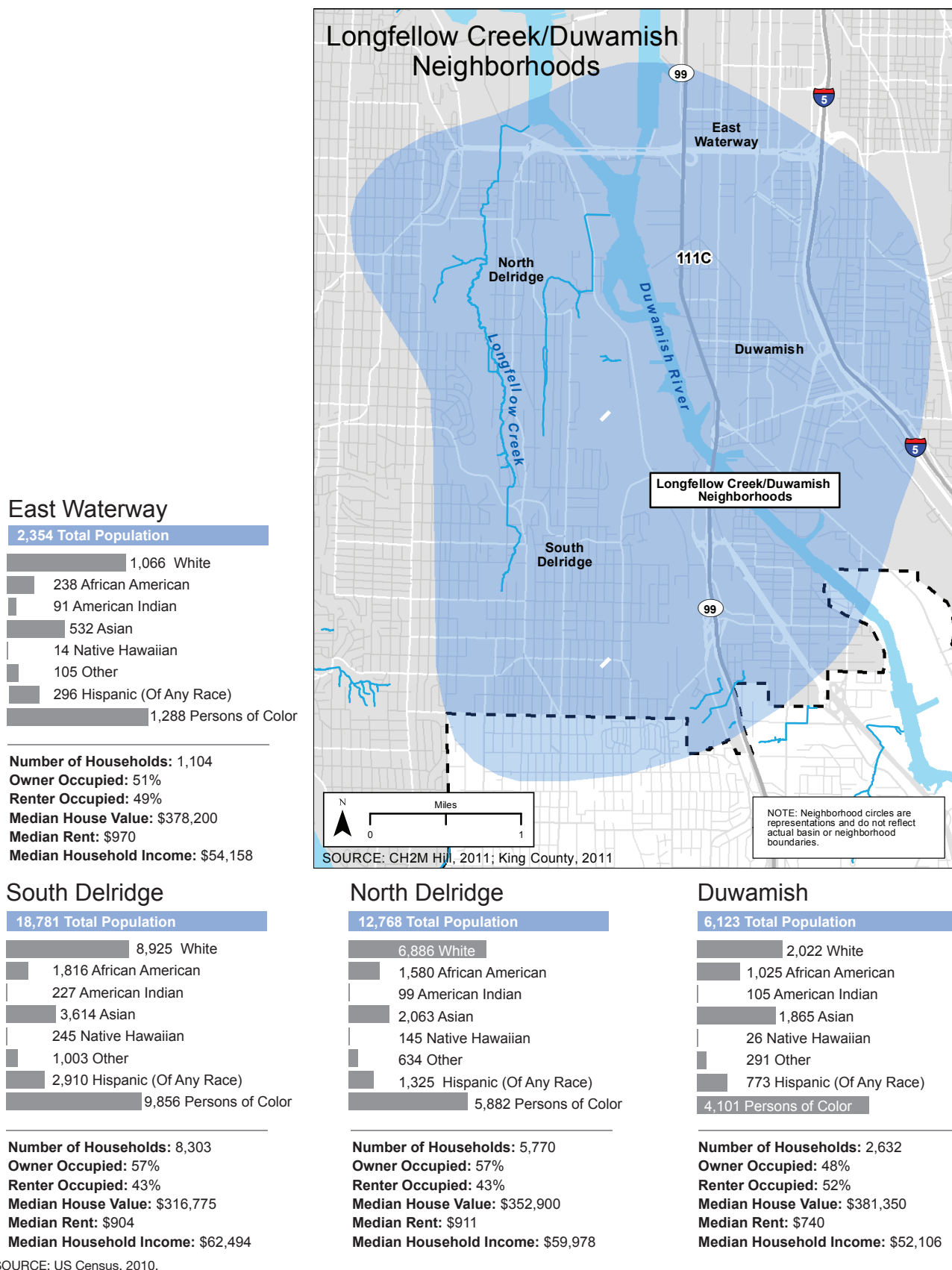
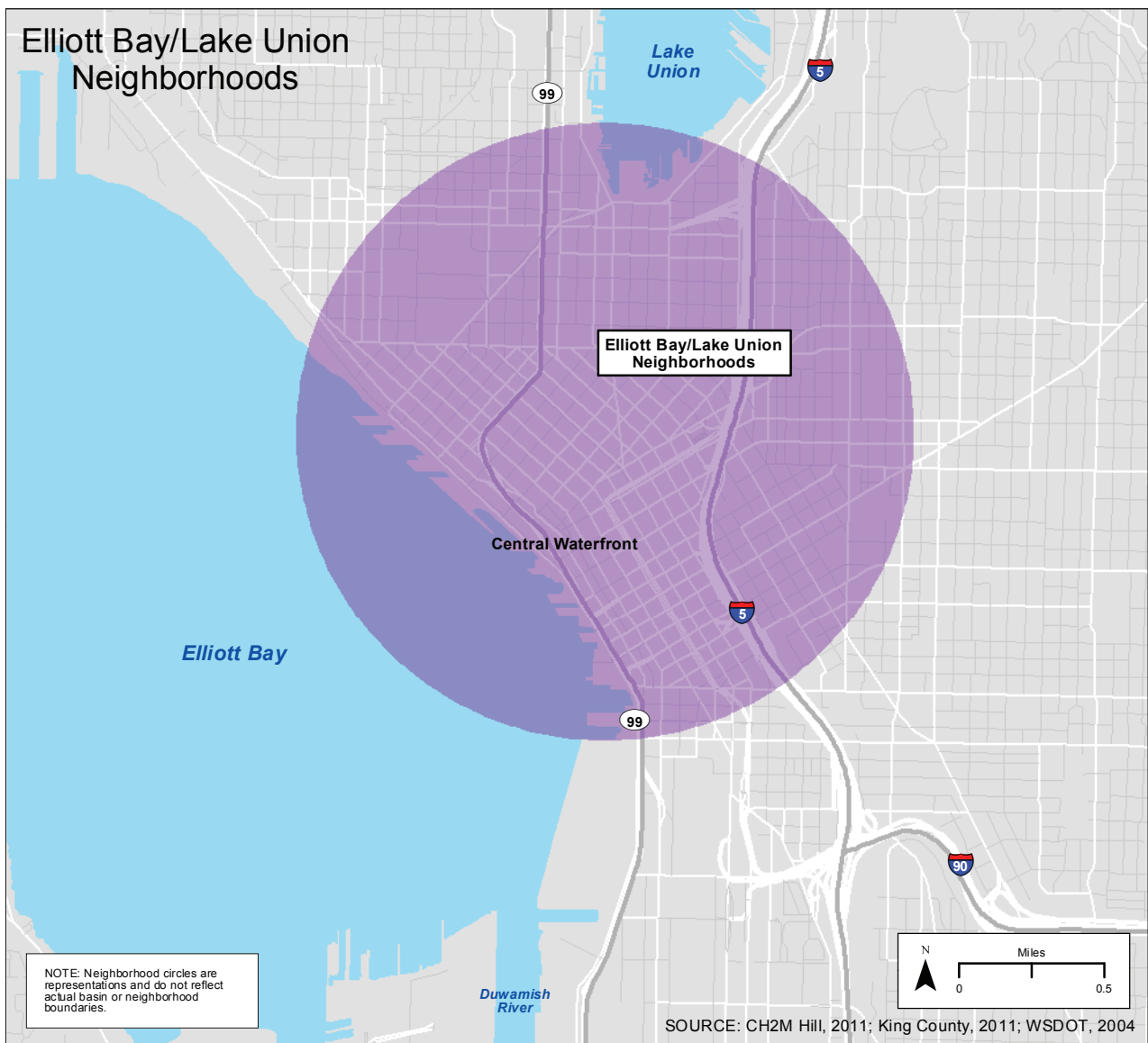


Figure 4-23. Longfellow Creek/Duwamish Neighborhoods - Demographic Characteristics.



Central Waterfront

13,919 Total Population

9,301	White
980	African American
162	American Indian
1,946	Asian
51	Native Hawaiian
548	Other
901	Hispanic (Of Any Race)
4,618	Persons of Color

Number of Households: 11,590

Owner Occupied: 20%

Renter Occupied: 80%

Median House Value: \$481,067

Median Rent: \$963

Median Household Income: \$51,294

SOURCE: US Census, 2010.

Figure 4-24. Elliott Bay/Lake Union Neighborhoods - Demographic Characteristics.

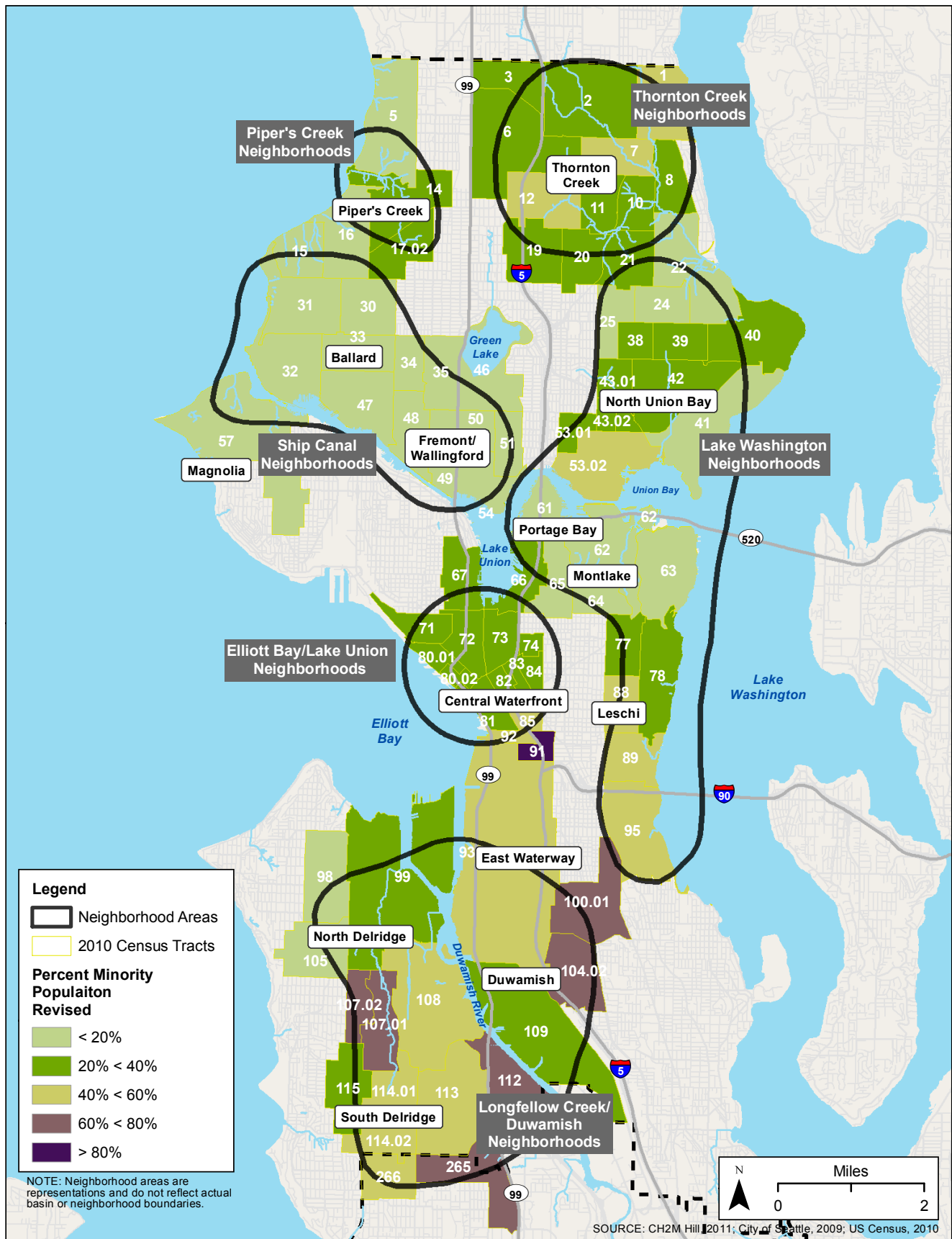


Figure 4-25 Minority Populations.

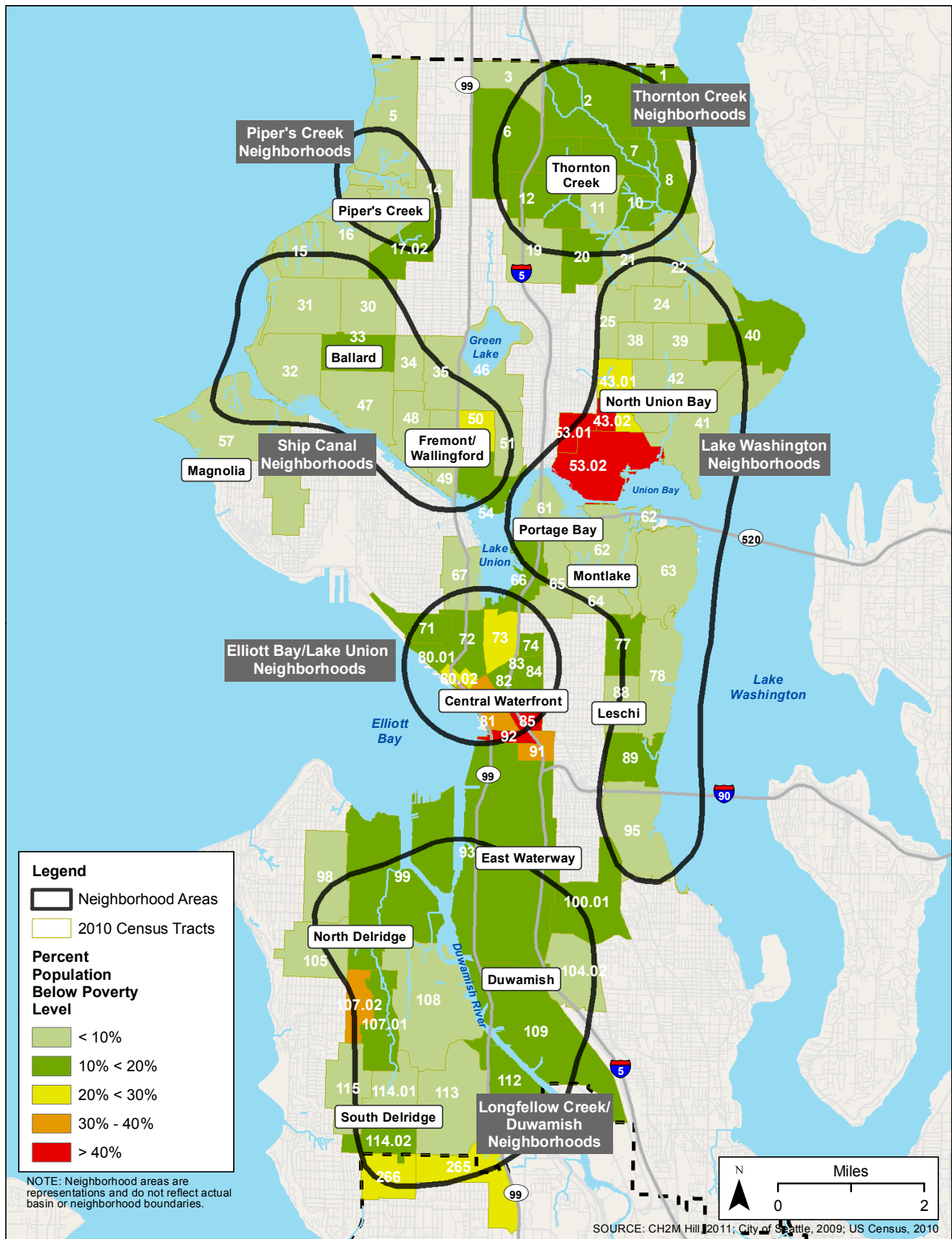


Figure 4-26 Low Income Populations.

CHAPTER 5

Construction Impacts and Mitigation

5.1 Introduction

5.1.1 What is included in this chapter?

This chapter discusses how construction of the projects under the Plan would affect the environment in the Plan area. The alternatives are compared to the extent that differences in their construction methods, timing, and effects can be determined at a programmatic level.

Construction of projects under the Plan would occur over a total period of nine years for the LTCP Alternative and 15 years or more for the Integrated Plan Alternative. Within this overall timeframe, specific construction activities would affect portions of the Plan area for varying amounts of time.

Both the LTCP Alternative and the Integrated Plan Alternative would implement one of the four LTCP options, though some of these CSO control projects would be deferred under the Integrated Plan Alternative. This chapter begins with a general description of construction activities associated with the types of projects included in the LTCP options, and types of stormwater projects specific to the Integrated Plan Alternative. Following this is a discussion of how construction would affect the resources in the Plan area. Since project and site-specific details are not known at this time, the analysis takes a programmatic approach and evaluates resources on a larger, Plan- and neighborhood-scale rather than at a site-level scale (the scale at which project-specific impacts would occur).

As described in Chapter 3, the No Action Alternative includes ongoing sewer system improvements and natural drainage systems under the City's Right-of-Way program and RainWise to reduce CSOs and infiltrate stormwater runoff. Planned projects identified in the City's NPDES Waste Discharge Permit would also be implemented. Most of these projects are identified in the 2010-2015 Implementation Plan for the *2010 CSO Reduction Plan Amendment* (2010 Plan Amendment). Those projects have either been completed or will undergo separate SEPA analysis, as appropriate, and are not discussed further in this EIS.

5.1.2 What are the typical construction scenarios that would occur under the LTCP options?

CSO control projects included under the LTCP options – and common to both the LTCP Alternative and the Integrated Plan Alternative – would involve construction of a combination of sewer system improvements, flow diversions, and underground storage. The general project areas for these CSO control projects under the LTCP options are shown on Figures 5-1 through 5-3. Because this is a plan-level evaluation, project details and construction methods have not yet been defined. However, the information provided in Table 5-1 and the descriptions provided below are a reasonable estimate of the nature, extent, and duration of anticipated construction activities under the types of projects being considered. Actual construction activities would vary as determined during subsequent, project-specific review.

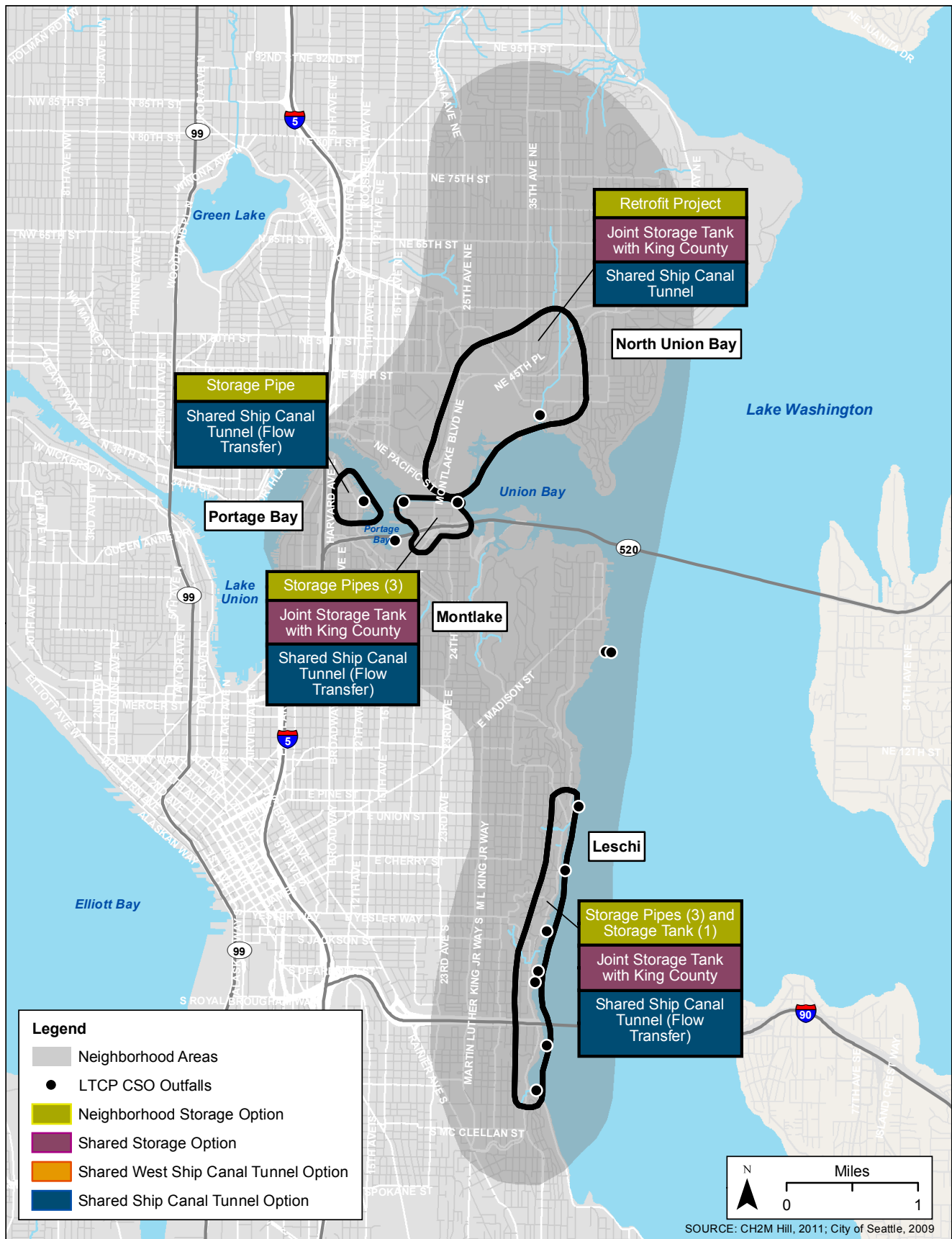


Figure 5-2 General Project Areas – Lake Washington Neighborhoods.

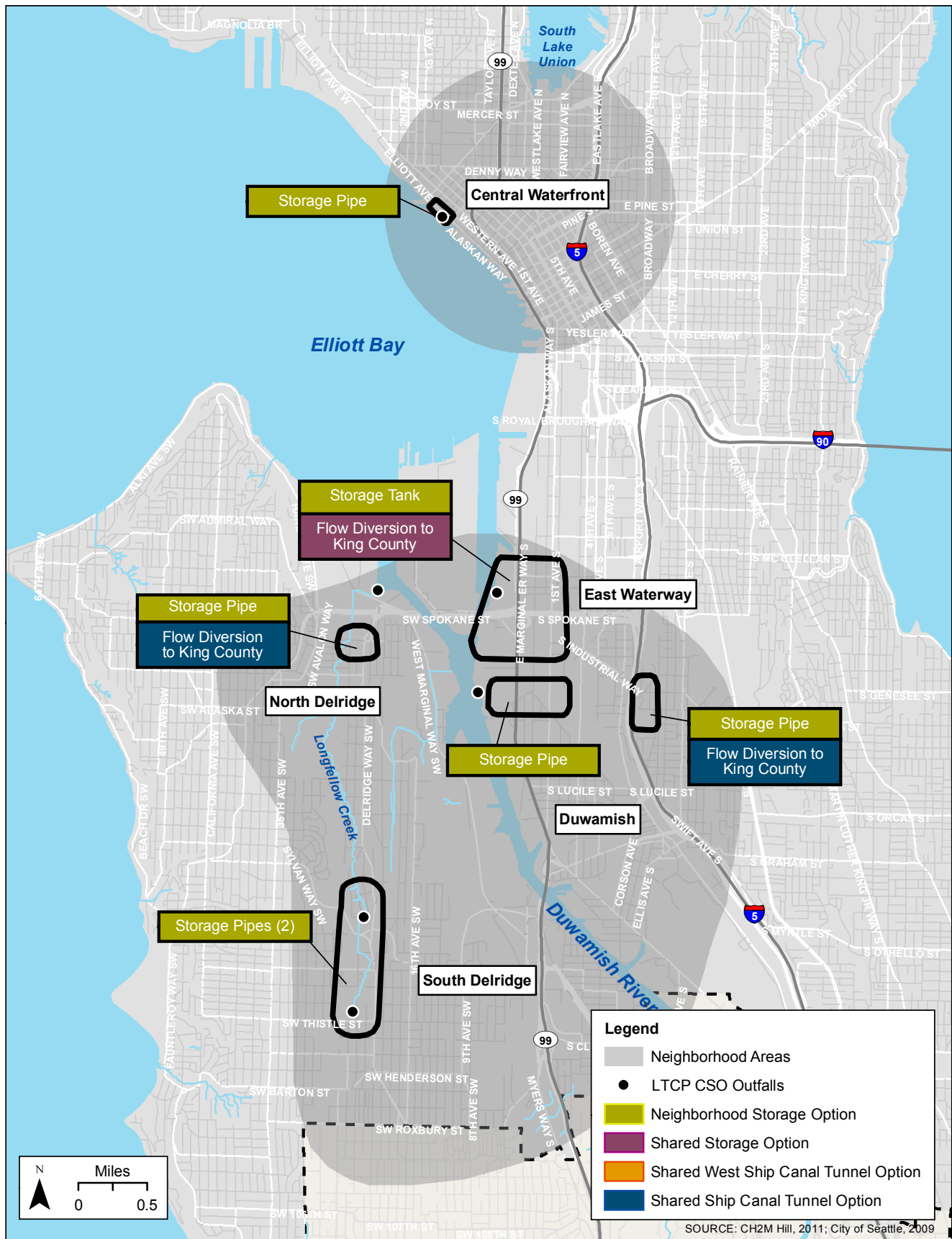


Figure 5-3 General Project Areas – Longfellow Creek/Duwamish & Elliott Bay/Lake Union Neighborhoods.

Table 5-1. LTCP Alternative Options – Estimated Project Details¹

	CSO Control Measure	Potential Property	Description	Storage Facility Dimensions	Pump Stations	Construction Duration (years)	Excavation Quantities (CY)	Surface Disturbance (acre)	Truck Trips	Concrete (CY)
Neighborhood Storage Option										
Ship Canal Neighborhoods										
Ballard	Storage Tank	Private Property	Construct an offline storage tank to divert and convey combined sewer flows to and from storage.	Tank - 275 ft x 225 ft x 26 ft deep	1	5	76,000	2	12,000	16,690
	Or Neighborhood Tunnel	Same or similar details as Shared West Ship Canal Tunnel Option below								
Fremont / Wallingford	Storage Tank	City or Private Property	Construct an offline storage tank to divert and convey combined sewer flows to and from storage.	Tank – 235 ft x 75 ft wide x 26 ft deep	3	3.5	39,000	2	7,000	6,800
	Or Neighborhood Tunnel	Same or similar details as Shared West Ship Canal Tunnel Option below								
Magnolia	Storage Pipe	ROW	Construct an offline storage pipe in street ROW. A new flow diversion structure with an overflow weir and real-time control gate would also be installed. All of the stored flow would discharge back into the existing sewer system within 12 hours after a storm event.	Pipe Length 530 ft Pipe Diameter - 6 ft	1	1.5	3,000	0.2	600	320
<i>Ship Canal Neighborhoods (Tanks/Pipes) Construction Detail Totals*</i>							120,000 CY	4 acres	19,500 trips	24,000 CY
<i>Ship Canal Neighborhoods (Neighborhood West Ship Canal Tunnel) Construction Detail Totals*</i>							165,000 CY	4 acres	51,500 trips	51,000 CY

¹ All details estimated for main storage facility components only (e.g., storage tank construction and tunnel launch and retrieval portal construction). Additional construction would be required for associated conveyance systems, especially for shared options involving transfer of flows from one neighborhood to another.

Table 5-1. LTCP Alternative Options – Estimated Project Details¹

	CSO Control Measure	Potential Property	Description	Storage Facility Dimensions	Pump Stations	Construction Duration (years)	Excavation Quantities (CY)	Surface Disturbance (acre)	Truck Trips	Concrete (CY)
Lake Washington Neighborhoods										
North Union Bay	Sewer System Improvement	ROW	Minor construction (e.g., flow gates work inside underground vaults/chambers).							
Portage Bay	Storage Pipe	ROW	Construct an offline storage pipe in street ROW. A new flow diversion structure with an overflow weir and real-time control gate would also be installed. All of the stored flow would discharge back into the existing sewer system within 12 hours after a storm event.	Pipe Length - 210 ft Pipe Diameter - 10 ft		1.5 years	5,000	0.2	900	270
Montlake	Storage Pipes (3)	ROW	Construct offline storage pipes in street ROWs.	Pipe Length – 75 to 200 ft Pipe Diameter – 5 to 12 ft	1	1.5 years	7,000	0.4	1,400	220
Leschi	Storage Pipes (3) and Storage Tank (1)	Storage Pipes in ROW, Storage Tank in City or Private Property	Construct three storage pipes in ROWs and one storage tank in City or private property.	Pipe Lengths - 120 to 210 ft Pipe Diameters – 3 to 7 ft Tank – 65 ft long x 60 ft wide x 15 ft deep	2	2 years	14,000	0.6	2,000	1,780
<i>Lake Washington Neighborhoods Construction Detail Totals*</i>							26,000 CY	1 acre	4,500 trips	2,500 CY
Longfellow Creek/Duwamish Neighborhoods										
North Delridge	Storage Pipe	ROW	Construct offline storage pipe in street ROW.	Pipe Length - 210 ft Pipe Diameter - 12 ft	1	1.5	6,000	0.2	800	830
South Delridge	Storage Pipes (2)	ROW	Construct two offline storage pipes in street ROWs. A new flow diversion structure with an overflow weir and real-time control gate would also be installed. All stored flow would discharge to the existing sewer system within 12 hours after a storm event.	Pipe Length - 450 to 550 ft Pipe Diameters – 9 to 10 ft	2	1.5	12,000	0.8	2,300	1,480

Table 5-1. LTCP Alternative Options – Estimated Project Details¹

	CSO Control Measure	Potential Property	Description	Storage Facility Dimensions	Pump Stations	Construction Duration (years)	Excavation Quantities (CY)	Surface Disturbance (acre)	Truck Trips	Concrete (CY)
Duwamish	Storage Pipe and In-Line Storage	ROW	Construct an offline storage pipe in street ROW. Modify two existing CSO control structures to be used as inline storage facilities.	Pipe Length - 100 ft Pipe Diameter - 5 ft	2	1.5	2,000	0.1	500	480
East Waterway	Storage Tank	City or Private Property	Construct offline storage tank; construct a diversion structure with real-time control gate.	90 ft long x 50 ft wide x 15 ft deep	1	2	14,000	0.8	2,600	4,370
<i>Longfellow Creek/Duwamish Neighborhoods Construction Detail Totals*</i>							34,000 CY	2 acres	6,000 trips	7,000 CY
Elliott Bay/Lake Union Neighborhoods										
Central Waterfront	Storage Pipe	ROW	Construct offline storage pipe in street ROW; an access shaft will be located in the ROW.	Pipe Length - 600 ft Pipe Diameter - 6 ft		2 years	5,000	0.1 acre	900	60
<i>Elliott Bay/Lake Union Neighborhoods Totals*</i>							5,000	0.1 acre	900	60
Neighborhood Storage Option (Tanks/Pipes) Totals*							185,000 CY	7.5 acres	31,000 trips	33,500 CY
Neighborhood West Ship Canal Tunnel Totals*							230,000 CY	7.5 acres	63,000 trips	60,000 CY

Table 5-1. LTCP Alternative Options – Estimated Project Details¹

	CSO Control Measure	Potential Property	Description	Storage Facility Dimensions	Pump Stations	Construction Duration (years)	Excavation Quantities (CY)	Surface Disturbance (acre)	Truck Trips	Concrete (CY)
Shared Storage Option										
Ship Canal Neighborhoods										
Ballard	Same as Neighborhood Storage Option									
Fremont / Wallingford	Shared Storage Facility with King County 3 rd Ave W (Total 7.4 MG)	ROW	The City and King County would jointly build a storage facility in street ROW to store flows from the City's Fremont/Wallingford basins and the King County 3 rd Avenue West Regulator. The facility will have a southern discharge point near the Fremont Siphon and be sloped upward to the north.	3,000 ft long x 21 ft diameter	2	3	113,000	3	11,000	11,100
Magnolia	Same as Neighborhood Storage Option									
Ship Canal Neighborhoods Construction Details Totals*							192,000 CY	5 acres	24,000 trips	28,000 CY
Lake Washington Neighborhoods										
North Union Bay	Shared Storage Tank with King County University Regulator (Total 5.23 MG)	City or Private Property	The City and King County would jointly build a storage tank in City or private property. New diversion structures will be built to divert flow into storage, and the tank will be emptied by an effluent pump station.	185 ft long x 185 ft wide x 18 ft deep	1	4	89,000	3	16,200	22,300
Portage Bay	Same as Neighborhood Storage Option									
Montlake	Shared Storage Tank with King County	City or Private Property	The City and King County would jointly build a storage tank in City or private property. New diversion structures will be built to divert flow into storage, and the tank will be emptied by an effluent pump station. Several existing City pump stations will be upgraded, and a portion of an existing City sewer mainline will be replaced and/or increased in size.	200 ft long x 200 ft long x 25 ft deep	5	4.5	92,000	2	15,600	15,400
Leschi	Montlake Regulator (Total 7.87 MG)									
Lake Washington Neighborhoods Construction Details Totals*							186,000 CY	5 acres	33,000 trips	38,000 CY

Table 5-1. LTCP Alternative Options – Estimated Project Details¹

	CSO Control Measure	Potential Property	Description	Storage Facility Dimensions	Pump Stations	Construction Duration (years)	Excavation Quantities (CY)	Surface Disturbance (acre)	Truck Trips	Concrete (CY)
Longfellow Creek/Duwamish Neighborhoods										
North Delridge	Same as Neighborhood Storage Option									
South Delridge	Same as Neighborhood Storage Option									
Duwamish	Same as Neighborhood Storage Option									
East Waterway	Flow Diversion to King County HLKK Treatment Plant	ROW	Some conveyance construction – minor compared to storage projects.		1	1	5,000	0.4	1,100	2,400
<i>Longfellow Creek/Duwamish Neighborhoods Construction Details Totals*</i>							25,000 CY	1.5 acre	4,700 trips	5,200 CY
Elliott Bay/Lake Union Neighborhoods										
Central Waterfront	Same as Neighborhood Storage Option									
<i>Elliott Bay/Lake Union Neighborhoods Totals*</i>							5,000 CY	0.1 acre	900 trips	60 CY
Shared Storage Option Totals*							408,000 CY	12 acres	61,900 trips	71,500 CY

Table 5-1. LTCP Alternative Options – Estimated Project Details¹

	CSO Control Measure	Potential Property	Description	Storage Facility Dimensions	Pump Stations	Construction Duration (years)	Excavation Quantities (CY)	Surface Disturbance (acre)	Truck Trips	Concrete (CY)
Shared West Ship Canal Tunnel Option										
Ship Canal Neighborhoods										
Ballard	Shared Deep Tunnel with King County	City or Private Property	The City and King County would jointly build a deep offline storage tunnel along the west end of the Ship Canal from Ballard to Fremont/Wallingford. The tunnel would provide the storage capacity needed to address sewage overflows in the Ballard and Fremont/Wallingford Neighborhoods.	2.7 miles long x 13 ft diameter	1 in Ballard	3.5	162,000	4 (launch and retrieval portals only)	50,900	32,800
Fremont / Wallingford										
Magnolia	Flow Diversion to King County North Interceptor	ROW	Some conveyance construction – minor compared to storage projects.		1	< 0.5	600	0.2	300	1,000
<i>Ship Canal Neighborhoods Construction Details Totals*</i>							163,000 CY	4 acres	51,000 trips	34,000 CY
Lake Washington Neighborhoods										
North Union Bay	Same as Neighborhood Storage Option									
Portage Bay	Same as Neighborhood Storage Option									
Montlake	Same as Neighborhood Storage Option									
Leschi	Same as Neighborhood Storage Option									
<i>Lake Washington Neighborhoods Construction Details Totals*</i>							26,000 CY	1 acre	4,300 trips	2,300 CY
Longfellow Creek / Duwamish Neighborhoods										
North Delridge	Same as Neighborhood Storage Option									

Table 5-1. LTCP Alternative Options – Estimated Project Details¹

	CSO Control Measure	Potential Property	Description	Storage Facility Dimensions	Pump Stations	Construction Duration (years)	Excavation Quantities (CY)	Surface Disturbance (acre)	Truck Trips	Concrete (CY)
South Delridge	Same as Neighborhood Storage Option									
Duwamish	Same as Neighborhood Storage Option									
East Waterway	Same as Shared Storage Option									
<i>Longfellow Creek/Duwamish Neighborhoods Construction Details Totals*</i>							83,000 CY	1.5 acre	3,700 trips	5,200 CY
Elliott Bay/Lake Union Neighborhoods										
Central Waterfront	Same as Neighborhood Storage Option									
<i>Elliott Bay/Lake Union Neighborhoods Total*</i>							5,000 CY	0.1 acre	900 trips	60 CY
Shared West Ship Canal Tunnel Option Totals*							276,600 CY	7 acres	60,100 trips	41,300 CY

Table 5-1. LTCP Alternative Options – Estimated Project Details¹

	CSO Control Measure	Potential Property	Description	Storage Facility Dimensions	Pump Stations	Construction Duration (years)	Excavation Quantities (CY)	Surface Disturbance (acre)	Truck Trips	Concrete (CY)
Shared Ship Canal Tunnel Option										
Ship Canal Neighborhoods										
Ballard	Shared Deep Tunnel with King County (see South Ship Canal)									
Fremont / Wallingford										
South Ship Canal	Shared Deep Tunnel with King County (+NUB, Portage Bay, Montlake, Leschi)	City or Private Property	The City and King County would jointly build a deep offline storage tunnel along the east end of the Ship Canal from south side of Ship Canal to North Union Bay. The tunnel would provide the storage needed to address sewage overflows in Ballard, Fremont/Wallingford, Portage Bay, Montlake, North Union Bay, and Leschi Neighborhoods.	2.9 miles long x 18 ft diameter	2 in Ballard 2 in Montlake 1 in Leschi (upgrade only) 1 in Queen Anne	7	465,000	4 (launch and retrieval portals only)	106,200	70,700
Magnolia	Same as West Ship Canal Tunnel Option									
Ship Canal Neighborhoods Construction Details Totals*							465,600 CY	4.2 acres	106,500 trips	71,700 CY
Lake Washington Neighborhoods										
North Union Bay	Shared Deep Tunnel with King County (see Ballard and Fremont/Wallingford) – all construction details included under Ship Canal Neighborhoods									
Portage Bay										
Montlake										
Leschi										
Longfellow Creek/Duwamish Neighborhoods										
North Delridge	Flow Diversion to King County	ROW	Some conveyance construction – minor compared to storage projects.			1	5,400	0.8	1,200	4,000

Table 5-1. LTCP Alternative Options – Estimated Project Details¹

	CSO Control Measure	Potential Property	Description	Storage Facility Dimensions	Pump Stations	Construction Duration (years)	Excavation Quantities (CY)	Surface Disturbance (acre)	Truck Trips	Concrete (CY)
South Delridge	Same as Neighborhood Storage Option									
Duwamish	Flow Diversion to King County	ROW	Some conveyance construction – minor compared to storage projects.			1	14,000	1	3,000	6,300
East Waterway	Same as Shared Storage Option									
Longfellow Creek/Duwamish Neighborhoods Construction Details Total*							36,400 CY	3 acres	5,600 trips	14,200 CY
Elliott Bay/Lake Union Neighborhoods										
Central Waterfront	Same as Neighborhood Storage Option									
Elliott Bay/Lake Union Neighborhoods Totals*							5,000 CY	0.1 acre	900 trips	60 CY
Shared Ship Canal Tunnel Option Totals*							507,000 CY	7.3 acres	113,000 trips	86,000 CY

*Numbers are an estimate of the project totals.

5.1.2.1 Sewer System Improvements

Sewer system improvements typically include minor modifications to the existing underground system components, such as modifying existing flow-regulating equipment and installing electrical/control systems. Construction would occur at existing access points but may involve small areas of surface disturbance to access the system.

5.1.2.2 Flow Transfers and Flow Diversions

Flow transfers and flow diversions involve constructing varying lengths of gravity sewer pipeline connections, generally within paved street rights-of-way, or pumped force mains/pump stations. Construction activities are similar to those described below for associated pipelines. Flow transfers involve transferring flow within the City's sewer system. Flow diversions involve diverting flows to King County's sewer system.

5.1.2.3 Storage Tanks and Pipes

Underground storage tanks and pipes are constructed using common open-cut excavation techniques. The key steps in the construction process would be as follows: (1) surface preparation; (2) excavation, dewatering, and shoring; (3) concrete tank structure or pipe installation; (4) backfilling and compacting; (5) mechanical and electrical equipment installation; and (6) surface restoration. Surface preparation could involve removing existing structures (such as fences), sawcutting and removing pavement, or removing vegetation from the surface of the excavation area. Dewatering could include well points or dewatering sump pumps to lower the groundwater level to allow installation of structures or pipelines. Excavation would be done using a backhoe or excavator. Other equipment could include jackhammers, pavement saws, vibratory hammer, crane, graders, and loaders. Excavated soil of suitable quality would be stockpiled for later reuse as backfill. Where excavated soil is not of suitable quality, engineered fill could be trucked to the site for backfilling. Excess soil would be hauled offsite for disposal.



Figure 5-4. Storage Tank Construction

Depending on the site, construction could require grading and construction of an access road and staging areas for construction office trailers, equipment and materials storage, and temporary stockpiling. Excavation typically

requires shoring and associated supports or dewatering systems. Equipment installation could require crane, welding, and delivery trucks. Upon completion of tank construction, the area above the tank would be restored, or public amenities provided where appropriate. For storage pipes located within paved roadways, surface restoration would involve repaving the area with new asphalt or concrete pavement.

5.1.2.4 Storage Tunnels

Tunnel construction would typically occur in three 8-hour shifts, operating six days a week with a seventh day for maintenance of tunneling equipment. Tunneling operations typically take place 24 hours a day to maximize efficiency, since most activities occur underground and cause limited surface disturbance. However, surface activities at the tunnel portals could be suspended during nighttime shifts, depending on the location. Depending on the size and depth of the tunnel, construction could last one to five years.

Surface construction activities would be focused at two locations (the launch and recovery tunnel portals) for the duration of tunnel construction. The launch portal would serve as the main access for installation of equipment as well as for removal of tunnel spoils. Access shafts for connecting the tunnel to existing sewers would also be constructed along the tunnel alignment.

Tunneling would be performed using the best available tunneling technology and ground improvement methods to minimize ground settlement. For deep-bore tunnel construction in the Seattle area, pressurized-face tunnel boring machines are typically used to mine below the groundwater table and minimize surrounding ground movements and ground subsidence above the tunnel. This is accomplished by maintaining pressure on the tunnel face to balance ground and water pressures.

Spoils from tunnel excavations are typically removed from the tunnel face and deposited outside the portal using various methods, such as a conveyor belt, front-end loader, hoppers, or tunnel train (also known as a muck train).

The conveyor system transporting the muck from the tunnel would be enclosed once the muck leaves the bored tunnel, reducing the potential for dust and noise, as well as improving the appearance of the work area. Excavated material stockpiled outside the portal is then loaded onto trucks or barges (if applicable) and transported offsite.

Other related tunneling equipment includes a tunnel ventilation fan, muck removal equipment, dewatering and groundwater treatment system, etc. Depending on the tunnel design, vent shafts could be required at certain locations along the tunnel alignment, with associated surface disturbance occurring outside of the tunnel portal areas.



Figure 5-5. Tunnel Boring Machine

Tunnel construction would start at the tunnel launch portal, which would serve as the primary staging area for tunnel construction. This large construction staging area would provide laydown areas for materials, maintenance workshops, storage areas for excavated spoils and precast-concrete segments, along with parking and field offices. The launch portal site would also require a temporary electrical substation and electrical systems to provide power to the tunnel boring machine (TBM). This extension of electrical systems to feed the machine could require improvements to the Seattle City Light electrical distribution system facilities outside the project area.

Removal and transport of tunnel spoils would generally occur at the launch portal, as would equipment storage and deliveries. Tunnel portal construction could require grading and construction of an access road and staging areas for construction office trailers, equipment and materials storage, and temporary stockpiling. Tunnel construction would include excavation and construction of the tunnel launch and recovery portal. Depending on the depth, size, and location of the tunnel, the portal entry could require shoring and associated supports or dewatering systems.

Removal of the tunnel boring machine would generally occur at a second tunnel portal entry or machine recovery shaft. Construction of the tunnel recovery portal would be similar to the launch portal except the construction staging area would be smaller.

5.1.2.5 Associated Pipelines

New pipelines would be required for many of the storage options to convey flows to and from the new storage facilities. Larger, shared tanks and tunnels would require more conveyance connections than smaller, neighborhood tanks and tunnels in order to transfer flows from other basins. Both force mains and gravity pipelines would be required. Construction of pipelines would be accomplished using standard pipeline installation methods, generally the open-cut trench method (also referred to as the cut-and-cover construction method) where feasible. In general, cut-and-cover pipeline construction would progress at a rate of approximately 50 to 100 feet per day depending on traffic conditions, the length and size of the pipe segment, number of utility crossings, traffic congestion, and any restrictions on work schedules. Staging areas could be required at intervals for equipment laydown and for stockpiling backfill and spoils from the trench, but disruption associated with pipeline installation would generally be limited to one section at a time rather than the entire length of the alignment.

The key steps in the cut-and-cover construction process would be as follows: (1) surface preparation, (2) trench excavation and shoring, (3) pipe installation, (4) trench backfilling and compacting, (5) pipeline testing, and (6) surface restoration. Surface preparation could involve removing structures (such as fences), sawcutting and removing pavement, or removing vegetation from the surface of the trench area. Equipment used could include jackhammers, pavement saws, mowers, graders, and loaders. Trench excavation would be done using a backhoe or excavator, and excavated soil of suitable quality would be stockpiled along the trench for later reuse as backfill. Where excavated soil is not of suitable quality, engineered fill could be trucked to the site for backfilling. Excess soil would be hauled offsite for disposal. Pipeline testing could require air testing or water testing equipment including pumps and water supply equipment.

The depth and width of the trench would depend on the size of the pipeline to be installed. Shoring would be required for trenches over five feet deep. If groundwater is encountered during trench excavation, dewatering would typically be required so that the pipe could be installed in dry conditions.

For pipelines located within paved roadways, surface restoration would involve repaving the area with new asphalt or concrete pavement.

5.1.2.6 Associated Pump Stations

Underground pump stations are constructed using common open-cut excavation techniques. The key steps in the construction process would be as follows: (1) surface preparation; (2) excavation, dewatering, and shoring; (3) belowgrade concrete structure; (4) backfilling and compacting; (5) mechanical and electrical equipment installation; and (6) surface restoration. Surface preparation could involve removing existing structures (such as fences), sawcutting and removing pavement, or removing vegetation from the surface of the excavation area. Dewatering could include well points or dewatering sump pumps to lower the groundwater level to allow structure installation. Excavation would be done using a backhoe or excavator. Other equipment used for this activity could include jackhammers, pavement saws, vibratory hammer, crane, graders, and loaders. Excavated soil of suitable quality would be stockpiled for later reuse as backfill. Where excavated soil is not of suitable quality, engineered fill could be trucked to the site for backfilling. Excess soil would be hauled offsite for disposal. Equipment installation could require crane, welding, and delivery trucks.

Depending on the site, construction could require grading and construction of an access road and staging areas for construction office trailers, equipment and materials storage, and temporary stockpiling. Excavation typically requires shoring and associated supports or dewatering systems. Upon completion of pump station construction, the area above ground would be restored or public amenities provided where appropriate. For storage pipes located within paved roadways, surface restoration would involve repaving the area with new asphalt or concrete pavement. Depending on the size of the pump station, construction could last one to two years.

5.1.3 What are the general construction scenarios for stormwater projects that would occur under the Integrated Plan Alternative?

Construction associated with NDS Partnering projects and the South Park Water Quality Facility involve some of the same general types of construction activities associated with the LTCP Alternative projects. NDS Partnering projects would generally include the following activities: excavation, soil importing, drain / pipe work, site grading, landscaping, and paving. The South Park Water Quality Facility would generally include the following activities: excavation, relocation of utilities, demolition, site grading, landscaping mechanical/process system work, electrical work, and instrumentation and controls. No construction would be required to expand street sweeping.

5.1.4 How were construction impacts estimated for the LTCP options?

To evaluate impacts at a programmatic level, certain estimated construction details were used as a proxy to compare the potential for impacts among the LTCP options, which involve larger, more complex construction activities than the stormwater projects of the Integrated Plan. Construction details were estimated for main project components only. For example, the area of surface disturbance was estimated for construction of the storage facility sites only. For many of the projects – especially shared projects that would involve combining flows from different areas – there would be additional surface disturbance related to constructing pipelines and pump stations to transfer flows from other basins, and access portals for tunnels.

Estimated construction details include: (1) number of truck trips; (2) amount of excavated material; (3) overall size of the construction footprint (amount of surface disturbance); and (4) length of construction period. For the LTCP options, these construction details were estimated as follows:

Truck trips. Project components requiring numerous truck trips could affect air quality, energy and climate change, recreation, transportation, socioeconomics, and environmental justice. The main components of the LTCP options were estimated to have the following numbers of truck trips during project construction:

- Sewer system improvements: minor number of truck trips (not estimated)
- Flow diversion: 200 to 3,000 truck trips
- Storage pipes: 600 to 2,300 truck trips
- Storage tanks: 2,600 to 12,000 (City-only); or 11,000 to 16,000 (shared) truck trips
- Shared West Ship Canal Tunnel: 60,000 truck trips
- Shared Ship Canal Tunnel: 106,000 truck trips

Excavation quantities. Project components requiring a substantial amount of earthwork (excavation) could affect earth, air quality, and surface water. The main components of the LTCP options were estimated to have the following amounts (cubic yards or CY) of excavation during project construction:

- Sewer system improvements: minor quantities (not estimated)
- Flow diversion: 600 to 14,000 CY
- Storage pipes: 2,000 to 14,000 CY
- Storage tanks: 14,000 to 76,000 CY (City-only); or 89,000 to 113,000 CY (shared)
- Shared West Ship Canal Tunnel: 162,000 CY
- Shared Ship Canal Tunnel: 465,000 CY

Surface disturbance. The larger the surface disturbance area of a project, the greater the potential for impacts to environmental resources discussed in this EIS. The main components of the LTCP options were estimated to have the following levels of surface disturbance during construction:

- Sewer system improvements: minor amount of surface disturbance (not estimated)
- Flow diversion: 0.2 to 1 acre
- Storage pipes: 0.1 to 0.8 acre
- Storage tanks: 0.8 to 2 acres (City-only); or 2 to 3 acres (shared)
- Shared West Ship Canal Tunnel: 4 acres (launch and retrieval portals only)
- Shared Ship Canal Tunnel: 4 acres (launch and retrieval portals only)

Duration. Project construction ranges in length from a few months to seven years. The longer the duration of construction, the greater the potential for impacts to most of the resources considered in this EIS. The main components of the LTCP options were estimated to have the following construction durations:

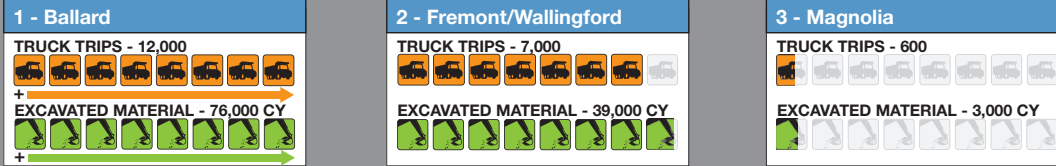
- Sewer system improvements: minor construction duration (not estimated)
- Flow diversion: 4 months to 1 year
- Storage pipes: 1.5 to 2 years
- Storage tanks: 2 to 5 years
- Shared West Ship Canal Tunnel: 3.5 years
- Shared Ship Canal Tunnel: 7 years

From the estimated construction details listed above, the total estimated truck trips and excavation quantities were summarized at the neighborhood level for each LTCP option (Figures 5-6 through 5-9).

LTCP Options Potential Construction Details¹

SHIP CANAL NEIGHBORHOODS

A - NEIGHBORHOOD STORAGE OPTION



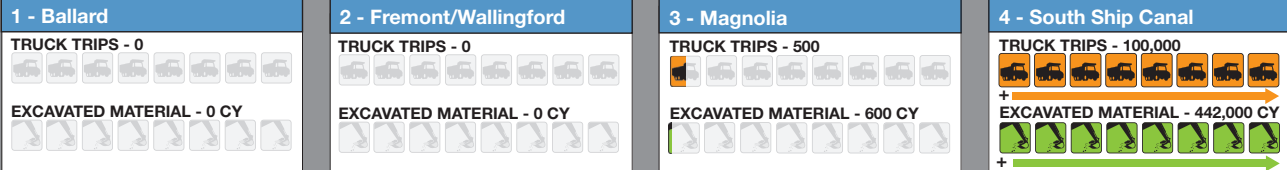
B - SHARED STORAGE OPTION



C - SHARED WEST SHIP CANAL TUNNEL OPTION



D - SHARED SHIP CANAL TUNNEL OPTION



¹All details are approximate, based on plan-level information only; reflects construction for the City and shared facilities only.

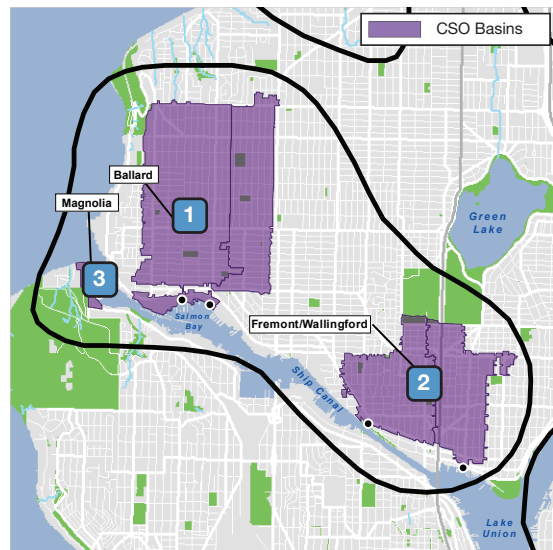
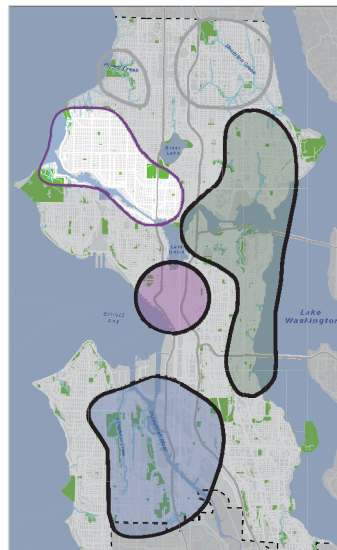
LEGEND



1 = 1,000 Truck Trips



1 = 5,000 cy Excavated Material



SOURCE: SPU, 2013; CH2M Hill, 2013.

Figure 5-6. LTCP Options Potential Construction Details - Ship Canal Neighborhoods.

LTCP Options Potential Construction Details¹

LAKE WASHINGTON NEIGHBORHOODS

A - NEIGHBORHOOD STORAGE OPTION

1 - North Union Bay	2 - Portage Bay	3 - Montlake	4 - Leschi
TRUCK TRIPS - 0 	TRUCK TRIPS - 900 	TRUCK TRIPS - 1,400 	TRUCK TRIPS - 2,000 
EXCAVATED MATERIAL - 0 CY 	EXCAVATED MATERIAL - 5,000 CY 	EXCAVATED MATERIAL - 7,000 CY 	EXCAVATED MATERIAL - 14,000 CY 

B - SHARED STORAGE OPTION

1 - North Union Bay	2 - Portage Bay	3 - Montlake	4 - Leschi
TRUCK TRIPS - 16,200  + EXCAVATED MATERIAL - 89,000 CY  +	TRUCK TRIPS - 900  + EXCAVATED MATERIAL - 5,000 CY  +	TRUCK TRIPS - 15,500  + EXCAVATED MATERIAL - 92,000 CY  +	TRUCK TRIPS - 0  + EXCAVATED MATERIAL - 0 CY  +

C - SHARED WEST SHIP CANAL TUNNEL OPTION

1 - North Union Bay	2 - Portage Bay	3 - Montlake	4 - Leschi
TRUCK TRIPS - 0 	TRUCK TRIPS - 900 	TRUCK TRIPS - 1,400 	TRUCK TRIPS - 2,000 
EXCAVATED MATERIAL - 0 CY 	EXCAVATED MATERIAL - 5,000 CY 	EXCAVATED MATERIAL - 7,000 CY 	EXCAVATED MATERIAL - 14,000 CY 

D - SHARED SHIP CANAL TUNNEL OPTION

1 - North Union Bay	2 - Portage Bay	3 - Montlake	4 - Leschi
TRUCK TRIPS - 6,000 	TRUCK TRIPS - 0 	TRUCK TRIPS - 0 	TRUCK TRIPS - 0 
EXCAVATED MATERIAL - 23,000 CY 	EXCAVATED MATERIAL - 0 CY 	EXCAVATED MATERIAL - 0 CY 	EXCAVATED MATERIAL - 0 CY 

¹All details are approximate, based on plan-level information only; reflects construction for the City and shared facilities only.

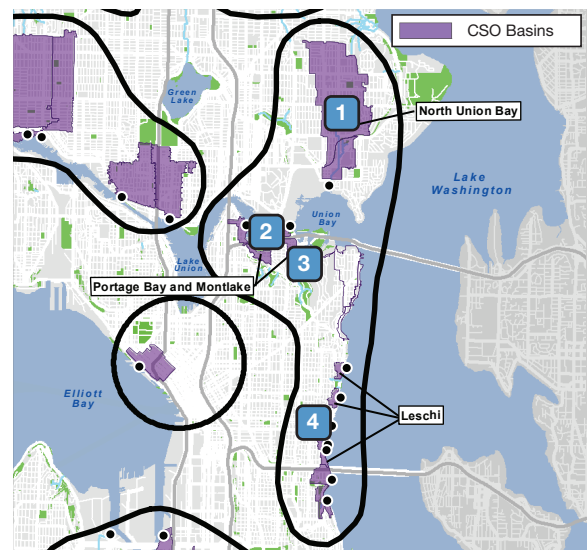
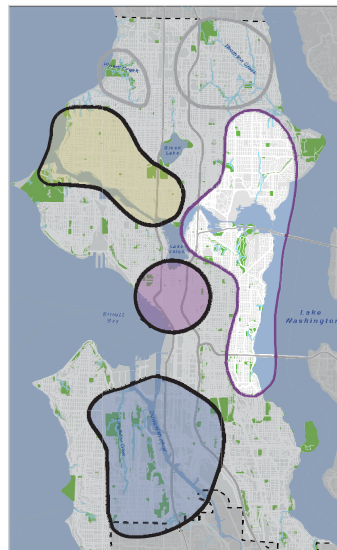
LEGEND



1 = 1,000 Truck Trips



1 = 5,000 cy Excavated Material



SOURCE: SPU, 2013; CH2M Hill, 2013.

Figure 5-7. LTCP Options Potential Construction Details - Lake Washington Neighborhoods.

LTCP Options Potential Construction Details¹

LONGFELLOW CREEK/DUWAMISH NEIGHBORHOODS

A - NEIGHBORHOOD STORAGE OPTION

1 - North Delridge	2 - South Delridge	3 - Duwamish	4 - East Waterway
TRUCK TRIPS - 800      	TRUCK TRIPS - 2,300      	TRUCK TRIPS - 500      	TRUCK TRIPS - 2,600      
EXCAVATED MATERIAL - 6,000 CY      	EXCAVATED MATERIAL - 12,000 CY      	EXCAVATED MATERIAL - 2,000 CY      	EXCAVATED MATERIAL - 14,000 CY      

B - SHARED STORAGE OPTION

1 - North Delridge	2 - South Delridge	3 - Duwamish	4 - East Waterway
TRUCK TRIPS - 800      	TRUCK TRIPS - 2,300      	TRUCK TRIPS - 500      	TRUCK TRIPS - 1,100      
EXCAVATED MATERIAL - 6,000 CY      	EXCAVATED MATERIAL - 12,000 CY      	EXCAVATED MATERIAL - 2,000 CY      	EXCAVATED MATERIAL - 5,000 CY      

C - SHARED WEST SHIP CANAL TUNNEL OPTION

1 - North Delridge	2 - South Delridge	3 - Duwamish	4 - East Waterway
TRUCK TRIPS - 800      	TRUCK TRIPS - 2,300      	TRUCK TRIPS - 500      	TRUCK TRIPS - 2,600      
EXCAVATED MATERIAL - 6,000 CY      	EXCAVATED MATERIAL - 12,000 CY      	EXCAVATED MATERIAL - 2,000 CY      	EXCAVATED MATERIAL - 14,000 CY      

D - SHARED SHIP CANAL TUNNEL OPTION

1 - North Delridge	2 - South Delridge	3 - Duwamish	4 - East Waterway
TRUCK TRIPS - 1,200      	TRUCK TRIPS - 2,300      	TRUCK TRIPS - 3,000      	TRUCK TRIPS - 2,600      
EXCAVATED MATERIAL - 5,400 CY      	EXCAVATED MATERIAL - 12,000 CY      	EXCAVATED MATERIAL - 14,000 CY      	EXCAVATED MATERIAL - 14,000 CY      

¹All details are approximate, based on plan-level information only; reflects construction for the City and shared facilities only.

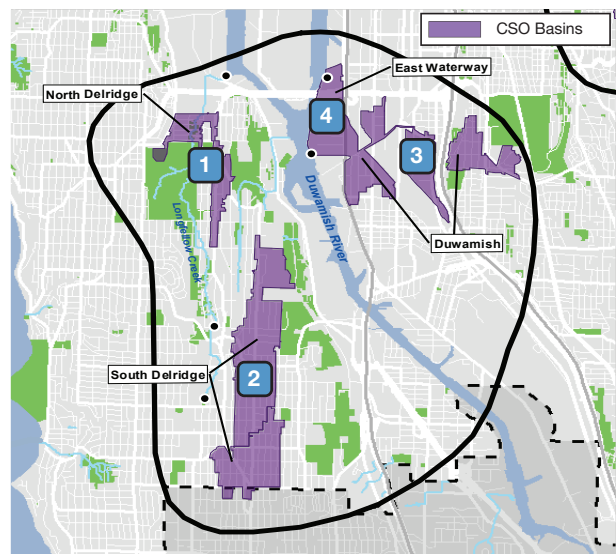
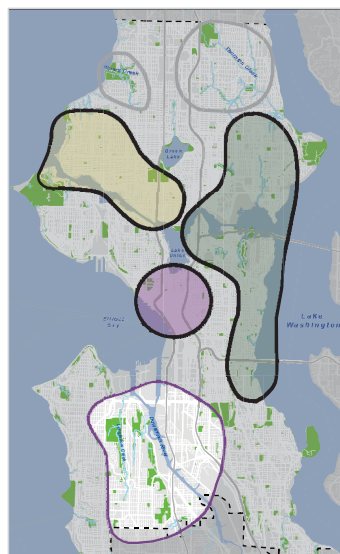
LEGEND



1 = 1,000 Truck Trips



1 = 5,000 cy Excavated Material



SOURCE: SPU, 2013; CH2M Hill, 2013.

Figure 5-8. LTCP Options Potential Construction Details - Longfellow Creek/Duwamish Neighborhoods.

LTCP Options Potential Construction Details¹

ELLIOTT BAY/LAKE UNION NEIGHBORHOODS

A - NEIGHBORHOOD STORAGE OPTION

1 - Downtown

TRUCK TRIPS - 900



EXCAVATED MATERIAL - 5,000 CY



B - SHARED STORAGE OPTION

1 - Downtown

TRUCK TRIPS - 900



EXCAVATED MATERIAL - 5,000 CY



C - SHARED WEST SHIP CANAL TUNNEL OPTION

1 - Downtown

TRUCK TRIPS - 900



EXCAVATED MATERIAL - 5,000 CY



D - SHARED SHIP CANAL TUNNEL OPTION

1 - Downtown

TRUCK TRIPS - 900



EXCAVATED MATERIAL - 5,000 CY



¹All details are approximate, based on plan-level information only; reflects construction for the City and shared facilities only.

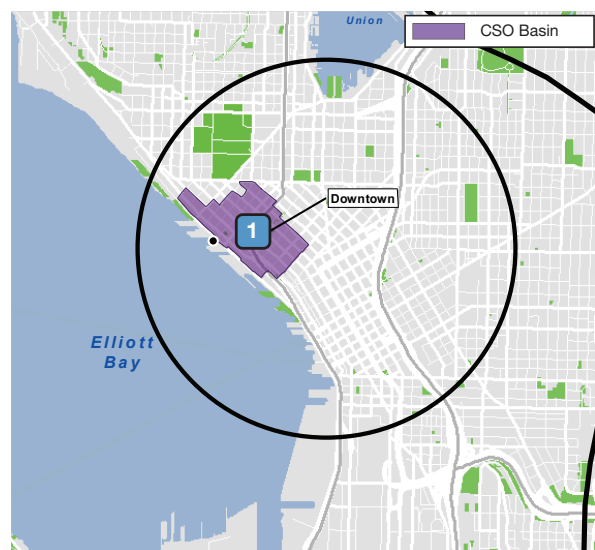
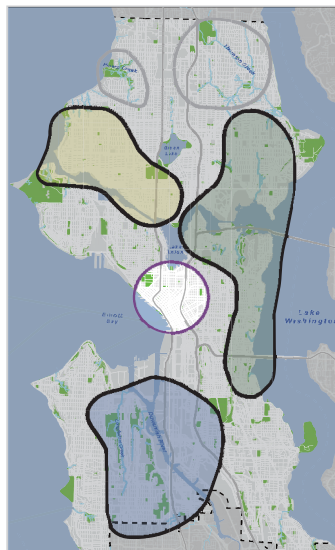
LEGEND



1 = 1,000 Truck Trips



1 = 5,000 cy Excavated Material



SOURCE: SPU, 2013; CH2M Hill, 2013.

Figure 5-9. LTCP Options Potential Construction Details - Elliott Bay/Lake Union Neighborhoods.

5.2 Earth and Groundwater

This section describes the types of impacts that could occur to the geological setting, soils, and groundwater within the Plan area during implementation of Plan alternatives.

5.2.1 What potential earth-related construction impacts are common to all of the alternatives?

Construction activities and equipment have the potential to cause short-term impacts to earth and groundwater during construction. CSO control projects included in the LTCP – and common to both the LTCP Alternative and the Integrated Plan Alternative – range from those that would cause minimal displacement of soil, to major projects involving substantial excavation, trenching, or tunneling and removal of large soil quantities. These common impacts are described below.

Erosion

Erosion by rain, runoff, or wind may occur as a result of clearing vegetation, placing fill, and removing, grading, or stockpiling uncovered spoils during construction. The potential for erosion depends on the area, slope, and characteristics of exposed soils; the volume and configuration of spoils piles; and the intensity and duration of rain, runoff, or wind.

Slope Failure

Depending on individual project designs, construction has the potential to cause hillside slumping or sliding due to changes in grade, removal of vegetation, and introduction of new loads to the hillside. Construction on steep slopes or areas with inappropriate geological conditions would be especially susceptible to slope instability. Excavations and trenching for structure foundations and pipe installation in any location, if not shored correctly, could fail and result in damage to adjacent utilities, roadways, and structures.

Unsuitable or Excess Soils

Existing soils that cannot be reused as structural fill or landscape material would require removal and disposal. Liquefiable soils, particularly peat and other organic-rich soils, may be especially unsuitable for use as structural fill. Offsite disposal would result in temporary truck traffic, dust, road runoff, and other construction-related impacts.

Key Findings

Earth and Groundwater

Construction activities under the *LTCP Alternative* have the potential to cause short-term impacts to earth and groundwater during construction of major projects involving substantial excavation, trenching or tunneling, and removal of large quantities of soil. Any areas that are disturbed during construction would be subject to increased erosion, and control measures would be required. Dewatering could cause ground settlement of nearby structures, roadways and utilities.

The primary differences in potential effects of the LTCP options are related to amount of surface disturbance and excavation potentially required. Overall, there would be the greatest number of projects with associated impacts under the Neighborhood Storage Option, and least under the Shared West Ship Canal and Ship Canal Tunnel Options. Impacts would be concentrated and of longer duration at fewer locations under the shared options.

The *Integrated Plan Alternative* would have minor, additional short-term impacts.

Dewatering Impacts

Dewatering of excavations below the groundwater table could result in settlement of nearby structures, roadways, and utilities. Potential for impact is considered low if proper measures to minimize and avoid dewatering are used. Dewatering also has the potential to encounter contaminated groundwater requiring special disposal. Refer to Section 5.4, Surface Water, for additional discussion.

Vibration

Use of construction equipment can cause ground vibration. The magnitude of vibration depends on type of equipment, distance to source, and soil conditions. Tunneling and pile driving (if required) are two of the major activities that can cause vibration impacts. Apart from discomfort to people living and working within the area of vibration, the main concern is potential damage to structures arising from excessive levels of vibration.

Spoils Disposal

Spoils that are unsuitable for project reuse would require disposal at an appropriate facility. Fill material with appropriate engineering properties may be required for most projects.

5.2.2 What are the potential earth and groundwater impacts of the LTCP options?

Table 5-2 summarizes the types of earth impacts that could occur under the four options of the LTCP Alternative. Many of the impacts are associated with earthwork quantities, which are summarized for the options in Figures 5-6 through 5-9.

Table 5-2. Summary of Potential Earth and Groundwater Impacts for LTCP Options

Neighborhood Storage Option*

This option has the greatest number of City and King County independently constructed CSO storage facilities. Construction of distributed tanks and pipes throughout the Plan area would have substantial impacts to earth due to the magnitude of excavation, dewatering, and special construction requirements, such as installation of shoring (sheet piles).

Storage tank and storage pipe construction would result in approximately 7.5 acres of surface disturbance (the second highest of all the LTCP options) and total excavation volume of 185,000 cubic yards (the lowest of all the LTCP options). Most projects would require substantial dewatering, which could result in settling of nearby structures.

The neighborhoods that would be most affected are as follows:

- Ship Canal Neighborhoods. Large storage tanks would be built in both the Ballard and Fremont/Wallingford neighborhoods, resulting in approximately 2 acres of surface disturbance at each site. Extensive areas of artificial fill exist along the Ship Canal waterfront. Construction has the potential to result in vibration damage to nearby structures within this highly urbanized area. Dewatering has the potential to encounter contaminated groundwater or result in settlement of nearby structures.
- Lake Washington Neighborhoods. Three pipes, one storage tank, and associated pump stations would be constructed in Leschi, which contains steep slopes and known or potential landslide zones. Projects near these zones would be at heightened risk for erosion and slope instability. The proximity to Lake Washington could increase potential for erosion and sedimentation in site runoff.
- Longfellow Creek/Duwamish Neighborhoods. Three pipes and associated pump stations would be constructed in North and South Delridge. These neighborhoods contain steep slopes and known or potential landslide zones. Projects near these zones could be at heightened risk for erosion and slope instability.

East Waterway. One tank would be constructed in East Waterway, resulting in approximately 1 acre of surface disturbance. The neighborhood contains extensive areas of organic and liquefiable soils that may require additional excavation and imported fill.

Table 5-2. Summary of Potential Earth and Groundwater Impacts for LTCP Options**Shared Storage Option**

Construction of storage tanks and storage pipes under this option would result in approximately 12 acres of surface disturbance (the highest of all the LTCP options) and 408,000 CY of excavation (the second highest of all the LTCP options). Additional construction would be required for associated conveyance (pipelines, pump stations). Overall impacts would be reduced compared to the Neighborhood Storage Option because the shared tanks would eliminate the need for several City and King County independently constructed CSO storage facilities.

The neighborhoods that would be most affected are as follows:

- Ship Canal Neighborhoods. Impacts of shared storage tanks would be similar to but greater than the Neighborhood Storage Option because the Fremont/Wallingford tank would be larger, resulting in more excavation and soil disposal. Depending on siting, increased dewatering could be required, increasing the risk for encountering contaminated groundwater.
- North Union Bay. Construction of a shared storage tank near Union Bay has increased potential to encounter organic or liquefiable soils. Dewatering has the potential to encounter contaminated groundwater or result in settlement of nearby structures due to the presence of historic landfill deposits, as well as natural organic deposits.
- Montlake/ Leschi. A shared storage tank would be constructed in these neighborhoods, which contain steep slopes and known or potential landslide zones. Projects near these zones could be at heightened risk for erosion and slope instability.
- Other neighborhoods would experience similar level of impacts as under the Neighborhood Storage Option except the East Waterway neighborhood, where a flow transfer with limited conveyance construction would replace the storage tank and cause potentially fewer earth impacts.

Shared West Ship Canal Tunnel Option

The Shared West Ship Canal Tunnel Option would result in total surface disturbance of 7 acres and 276,000 CY of excavation for construction of the tunnel and tunnel launch and retrieval portals. Additional construction would be required for associated conveyance (pipelines, pump stations). Overall impacts would be reduced compared to the Neighborhood Storage Option as this option eliminates City and King County independently constructed CSO storage facilities that would otherwise be constructed in the same neighborhoods.

The neighborhoods that would be most affected are as follows:

- Ballard and Fremont/ Wallingford. Tunneling would displace more soil than storage tanks under the Neighborhood Storage Option, but less than shared storage tanks under the Shared Storage Option. Installation of sheet piles for the portals could result in vibration. Movement of the tunnel boring machine could result in vibration and settling if project controls are not implemented according to plan, or unforeseen conditions are encountered. Location of the portals and tunnel near extensive areas of liquefiable soils in Fremont could result in soil settling.
- Leschi. Impacts of constructing three pipes, one tank, and associated pump stations in the confined neighborhood would have the same earth impacts as the Neighborhood Storage Option.
- Other neighborhoods would have similar impacts as the Neighborhood Storage Option except in Magnolia and East Waterway. In Magnolia, a flow diversion to King County facilities would replace the storage pipe, but would have similar potential earth impacts. The East Waterway area would have the same flow diversion as under the Shared Storage Option.

Table 5-2. Summary of Potential Earth and Groundwater Impacts for LTCP Options**Shared Ship Canal Tunnel Option**

Compared to all other LTCP options, the Shared Ship Canal Tunnel Option would have the fewest City and King County independently constructed CSO storage facilities, and therefore the lowest level of surface disturbance. While construction of the tunnel and tunnel launch and retrieval portals under this option would result in approximately 7.5 acres of surface disturbance and total excavation of 507,000 CY (the highest of all the LTCP options), overall impacts would be reduced because the shared tanks would eliminate the greatest number of City and King County independently constructed CSO storage facilities.

The neighborhoods that would be most affected are as follows:

- Ship Canal and Lake Washington Neighborhoods. Major construction impacts would occur at the portal locations (up to 4 acres of disturbance). Small areas of organic soils exist, but soils are otherwise generally suitable for construction. Installation of pilings could result in vibration. Movement of the tunnel boring machine could result in vibration and settling. Compared with the West Ship Canal Tunnel, the longer Ship Canal Tunnel has greater potential to encounter earth hazards.
- Other neighborhoods would have similar impacts or reduced impacts as compared to the Neighborhood Storage Option.

*The Neighborhood West Ship Canal Tunnel would have similar impacts in Ballard and Fremont/Wallingford as described for the Shared West Ship Canal Tunnel Option.

5.2.3 What are the potential earth and groundwater impacts of the Integrated Plan Alternative?

Construction of storage pipes, tanks, and tunnels under the Integrated Plan Alternative would have the same potential earth and groundwater impacts as under the LTCP Alternative, but construction would be delayed in some neighborhoods. In addition to construction of CSO control projects under the selected LTCP option, additional construction would occur to construct NDS Partnering projects and the South Park Water Quality Facility project. The street sweeping expansion program does not involve construction; therefore, no earth or groundwater impacts would occur.

NDS Partnering projects would be constructed in public road rights-of-way of the Piper's, Thornton, and Longfellow Creek neighborhoods and cause minimal earth impacts. Natural drainage system projects are constructed in relatively flat public rights-of-way within developed areas. These areas are typically characterized by previous grading, filling, paving, landscaping, or utility installation. Individual NDS Partnering projects would be evaluated with respect to geological hazards, would be relatively small in size, and would be conducted with appropriate erosion control measures in place.

Construction of the South Park Water Quality Facility would involve approximately one acre of surface disturbance. The facility is expected to be located in an industrial area near the Duwamish River. Depending on specific site location, the soils may be susceptible to liquefaction and compaction. The City would take appropriate engineering measures to account for these hazards.

5.2.4 What are the potential earth and groundwater impacts of the No Action Alternative?

Under the No Action Alternative, the CSO control projects included in the LTCP would not be built. However, the City would continue with two of its ongoing programs to reduce CSOs—sewer system improvements and natural drainage systems.

RainWise and roadside rain garden projects are constructed in relatively flat public rights-of-way or private property within developed areas. These areas are typically characterized by previous grading, filling, paving, landscaping, or utility installation. Individual projects constructed under these programs generally have a limited footprint and depth, and they are unlikely to result in substantial erosion or dewatering.

During scoping, several comments were received regarding the history of unsuccessful roadside rain gardens in the Ballard neighborhood due to unsuitable soils, and the potential for continued impacts associated with rain gardens. The City has incorporated the lessons learned from the previous projects into its voluntary RainWise program, including detailed evaluation of subsurface conditions prior to implementation of rain gardens.

5.2.5 What measures are proposed to reduce or minimize earth and groundwater impacts?

Potential construction impacts include erosion, failure, excess/unsuitable soils, settling or encountering contaminated groundwater during dewatering, and vibration damage. The City would undertake the following measures to reduce or minimize these impacts for all four proposed options:

- Avoid construction on steep slopes, known and potential landslide zones, and areas with organic or liquefiable soils, where feasible.
- Use appropriate shoring during construction.
- Use erosion and runoff control measures, including retention of vegetation, replanting, ground cover, etc.
- Comply with relevant federal, state, and local critical areas and groundwater requirements.
- Dispose of soils at approved disposal sites.

If site-specific earth or groundwater impacts are identified during future review of individual projects, additional measures to reduce or minimize those impacts may be identified.

5.3 Air Quality and Odors

This section describes the types of air quality and odor impacts that could occur within the Plan area during implementation of the Plan alternatives.

5.3.1 What construction impacts are common to all of the alternatives?

Air emissions during construction are influenced by construction techniques, types of equipment used, truck trips, worker commute trips, and construction duration. Reduced air quality from construction emissions has a greater impact in residential areas than in commercial and industrial areas. In addition, sensitive receptors – those structures and uses that are most sensitive to reduced air quality, such as hospitals, nursing homes, daycare centers, and schools – are located throughout the Plan area (see Figure 5-10).

Many of the potential construction-related air quality and odor impacts would be common to all of the alternatives and options. These common impacts are described below.

Dust

Air quality impacts resulting from construction-related dust would vary during the stage of construction. Impacts would likely be greatest at the beginning of a project as a result of earth moving, land clearing, and excavation. Sources of construction-related dust would include disturbed soils at the construction sites and trucks carrying loads of soils. If not properly controlled, vehicles leaving the site could deposit mud on local streets, which could be an additional source of airborne dust after it dries.

Odors and Emissions

Some projects would require a substantial amount of construction equipment operation and truck trips which would result in increased emissions. Emissions from gasoline and diesel-powered construction equipment and trucks would include carbon monoxide, particulate matter, sulfur dioxide, nitrogen oxides, and volatile organic compounds. Particularly in low-traffic residential areas, increases in truck trips would substantially increase odors and emissions over background conditions. If construction traffic were to reduce the speed of hauling trucks and other vehicles in the area, carbon monoxide emissions from traffic would increase slightly while those vehicles are delayed. These emissions would be limited to peak construction periods and to the immediate area surrounding the construction site. In general, emissions would vary depending on the project and construction phase. The longer project construction lasts, the longer nearby land uses would be impacted by construction emissions.

Sulfur dioxide is an odorous compound generated during combustion of diesel fuel. Some phases of construction, particularly asphalt paving, would result in short-term odors in the immediate area of paving sites. Such odors would be quickly dispersed below detectable thresholds as distance from the site increases.

Key Findings

Air Quality and Odors

Construction of the *LTCP Alternative* or *Integrated Plan Alternative* would not have a significant effect on air quality in the Seattle area, but may result in moderate localized impacts during the construction periods largely related to vehicle emissions and dust.

The primary differences in potential air quality and odor effects of the LTCP options are related to the length of construction period and estimated number of truck trips. More dispersed impacts would occur under the *Neighborhood Storage Option*. Impacts would be concentrated at fewer locations under the shared options.

5.3.2 What are the potential air quality and odor impacts of the LTCP options?

Short-term, minimal to moderate localized effects on air quality would be expected from construction activities under any of the LTCP options. Use of heavy equipment and trucks would end once construction is completed and would not be concentrated in any one area over the duration of construction. However, construction would take place over several years in many locations and affect a wide variety of both residential and commercial properties.

Each of the four LTCP options would cause different levels of air quality and odor impacts to different neighborhoods. Table 5-3 summarizes the air quality and odor impacts for each option.

Table 5-3. Comparison of Potential Air Quality and Odor Impacts among LTCP Options
Neighborhood Storage Option* The Neighborhood Storage Option has the most individual project locations compared to the other options. Consequently, this option would have dispersed short-term air and odor impacts throughout the city. The neighborhoods that would be most affected are as follows: • <u>Ballard, Fremont/Wallingford, Magnolia</u>. Storage tank and pipe construction would result in intermittent increases in dust, emissions, and odors in these largely residential neighborhoods over the 5-year (Ballard), 3.5-year (Fremont/Wallingford), and 1.5-year (Magnolia) construction periods. Multi-family residential units and a number of sensitive receptors, including Swedish Ballard Hospital, could be affected. • <u>Leschi</u>. Storage pipes and associated pump stations would be constructed in Leschi near residential areas. Intermittent dust, emissions, and odors would temporarily impact air quality over the 2-year construction period.
Shared Storage Option Generally, air quality impacts from approximately 10 smaller projects in the Ship Canal and Lake Washington Neighborhoods (under the Neighborhood Storage Option) would be consolidated into three larger projects producing air quality impacts in more concentrated locations. Overall impacts would be reduced compared to the Neighborhood Storage Option because the shared tanks would eliminate the need for several City and King County independently constructed CSO storage facilities. The neighborhoods that would be most affected are as follows: • <u>Ballard and Fremont/Wallingford</u>. Impacts of storage tanks would be the same as for the Neighborhood Storage Option. Potentially impacted receptors include high-density residential areas. • <u>North Union Bay</u>. A shared storage tank would take 3 years to construct and require approximately 11,000 truck trips, resulting in longer duration of construction-related air quality and emissions impacts compared to the Neighborhood Storage Option. High-density residential areas and a number of sensitive receptors including the University of Washington and Children's Hospital could be affected. • <u>Montlake</u>. A shared storage tank would take 4.5 years to construct and require approximately 15,600 truck trips, resulting in longer term air quality and emissions impacts to residential areas. • Other neighborhoods would experience the same level of impacts as the Neighborhood Storage Option. Exceptions include the East Waterway neighborhood (where a flow diversion would replace the storage tank and cause fewer impacts due to reduced construction areas and timeframes); and the Leschi neighborhood (where conveyance construction would replace three storage pipes and a tank resulting in less construction emissions).

Table 5-3. Comparison of Potential Air Quality and Odor Impacts among LTCP Options

Shared West Ship Canal Tunnel Option
Overall impacts would be reduced compared to the Neighborhood Storage Option as this option eliminates several City and King County independently constructed CSO control facilities in the same neighborhoods. However, impacts would be concentrated in fewer areas (Ship Canal Neighborhood). The neighborhoods that would be most affected are as follows: • <u>Ballard and Fremont/Wallingford</u>. Construction for the storage tunnel would last 3.5 years and require approximately 60,000 or more truck trips, a substantially higher number than for storage tanks under the Neighborhood Storage Option or Shared Storage Option. Construction would be concentrated at the portal areas located in Ballard along the Ship Canal commercial area and in Fremont/Wallingford. • Other neighborhoods would experience similar level of impacts as the Neighborhood Storage Option.
Shared Ship Canal Tunnel Option
Compared to all other options, the Shared Ship Canal Tunnel Option would have the fewest City and King County independently constructed CSO storage facilities, and therefore the fewest areas that would experience air quality and odor impacts. In the Ship Canal and Lake Washington Neighborhoods, air quality and odor impacts would be consolidated to two portal sites instead of spread across numerous sites for storage tanks and pipes. In the Longfellow Creek/Duwamish Neighborhoods, several storage pipes and a storage tank proposed under the Neighborhood Storage Option would be replaced with conveyance construction, which would have similar construction-related air quality and emission impacts. The neighborhoods that would be most affected are as follows: • <u>Ship Canal and Lake Washington Neighborhoods</u>. Air quality and odor impacts would occur at the portal locations. An estimated 106,000 or more truck trips occurring over 7 years would result in increased exhaust emissions. Construction activities would be concentrated at the portal areas located along the south side of the Ship Canal and in the North Union Bay neighborhood. • Other neighborhoods would experience similar or reduced level of impacts as compared to the Neighborhood Storage Option.

*The Neighborhood West Ship Canal Tunnel would have similar impacts in Ballard and Fremont/Wallingford as described for the Shared West Ship Canal Tunnel Option.

5.3.3 What are the potential air quality and odor impacts of the Integrated Plan Alternative?

Construction of storage pipes, tanks, and tunnels under the Integrated Plan Alternative would have the same air quality impacts as under the LTCP Alternative, but construction would be delayed in some neighborhoods. Construction-related dust and emissions associated with the Integrated Plan would be minimal, as construction activities would be minimal. Construction for NDS projects would be of short duration and would have minimal air quality impacts. The South Park Water Quality Facility would involve a small construction footprint, which would result in short-term, localized emissions. The facility would be located in an industrial area and emissions would not impact residential properties or other sensitive receptors.

5.3.4 What are the potential air quality and odor impacts of the No Action Alternative?

Ongoing sewer system improvements and RainWise program projects have minimal air quality impacts because they are small and located within public rights-of-way or private property that is typically already developed or landscaped. Emissions during construction would include dust from grading, sod-cutting, and rototilling activities and exhaust from vehicles and construction equipment. These emissions are minimal, localized, and temporary.

5.3.5 What measures are proposed to reduce or minimize air quality and odor impacts?

Construction-related dust and emissions would be minimized by implementation of construction best management practices. The City would comply with all applicable regulations for air quality and would use the mitigation techniques listed below. Additional site-specific mitigation measures may be developed when project locations are determined.

- Use measures to control dust, such as watering construction surfaces, using temporary ground covers, sprinkling the site with approved dust palliatives, or using other temporary stabilization practices upon completion of grading.
- Incorporate specifications into construction contracts that encourage use of well maintained construction vehicles to reduce vehicle emissions.
- Encourage contractors to offer carpooling options for employees.
- When possible, use local building materials to reduce transport distances.

5.4 Surface Water

This section describes the types of surface water impacts that could occur within the Plan area during construction of the Plan alternatives.

5.4.1 What potential construction impacts are common to all of the alternatives?

Many of the construction impacts to surface water would be common to all of the projects included in the options and alternatives, as described below. No in-water construction is anticipated for any of the alternatives or options.

Construction Site Runoff

Construction and excavation at project sites would expose bare soils, making the sites more susceptible to erosion during rain events. In general, larger sites have a greater potential for releases of turbid site runoff due to the larger area of exposed soils. Surface water runoff could increase sedimentation and turbidity if the runoff is allowed to discharge untreated or uncontrolled to surface waters. Runoff may also carry other contaminants, such as fuels, oil, metals, and organic compounds from construction operations. Both sediment and contaminants can increase turbidity and affect other water quality parameters such as the amount of available oxygen in the water.

Stormwater runoff from construction sites would drain to either sewers or surface waters depending on the specific location. In general, most construction sites for the LTCP options would drain to combined or partially combined sewer systems. However, some construction sites could drain to surface waters or into isolated storm drains. In addition, stormwater discharged to the combined sewer system could enter surface waters during CSOs caused by large storm events.

Because the City would comply with state and City stormwater permit requirements and would employ best management practices to control surface water runoff from project sites, no major surface water impacts are expected. Uncontrolled runoff could occur during heavy rainstorms, but best management practices to contain sediment are expected to minimize impacts.

Dewatering Discharge

Dewatering would be required to remove water that seeps into soil excavation areas during construction of storage pipes, tanks, pump stations, and tunnels. Water present in the excavation areas would be pumped to sedimentation tanks to settle soil particles and could be treated further depending on the water quality and discharge location. Dewatering could also use temporary, shallow wells to lower the groundwater elevation and reduce seepage into excavation areas. Direct rainfall or local drainage into excavation areas could also be removed by dewatering.

Key Findings

Surface Water

Construction effects on surface water from the *LTCP Alternative* or *Integrated Plan Alternative* could include increased pollutants and sediments from site runoff, requiring control measures. Discharges of dewatering water could introduce contaminants and sediments into local water bodies if not properly managed.

The primary differences in potential effects of the LTCP options are related to amount of surface disturbance and excavation potentially required. Overall impacts would potentially be greatest under the Neighborhood Storage Option, and least under the Shared West Ship Canal and Ship Canal Tunnel Options. Impacts would be concentrated at fewer locations under the shared options.

The amount of dewatering would vary depending on the excavation duration, area, and quantity, and on the groundwater elevation and amount of rainfall. Dewatering waters would be either discharged to adjacent surface waters or the sewer system depending on the water quality and quantity and site constraints. Dewatering waters discharged to the combined sewer system could enter surface waters during CSOs caused by large storm events.

Where feasible, uncontaminated dewatering water would be discharged to surface waters in accordance with the Construction Stormwater General Permit issued by Ecology, employing best management practices and meeting water quality standards established for stormwater. Highly turbid or contaminated dewatering water would be discharged to the sewer system in accordance with the Wastewater Discharge Permit issued by King County. Discharges to the sewer system must meet requirements for quality (less than 7 milliliters of settleable solids per liter of water) and quantity (less than 25,000 gallons per day during the wet months from November through April and an unlimited quantity during dry months). Alternatively, highly turbid or contaminated dewatering water could be treated to meet water quality criteria and discharged to adjacent surface waters, or it could be trucked offsite for appropriate disposal. Potential impacts to groundwater are discussed in Section 5.2, Earth and Groundwater.

Inadvertent Discharges of Toxic Materials

Oils, fuels, solvents, and other chemicals could spill or leak from construction equipment, inadvertently contaminating stormwater or dewatering water that discharges to surface waters. If the spills are large and uncontrolled, the spills could flow to adjacent storm drainage systems or surface water bodies or seep into groundwater. The highest probability for spills is at staging areas. Because the City would follow the requirements of all applicable permits and would implement Spill Prevention and Control Plans for each project, the potential for uncontrolled spills is minimal.

5.4.2 What are the potential surface water impacts of the LTCP options?

Table 5-4 summarizes the types of surface water impacts that could occur under the LTCP options. Substantial construction would occur in areas draining to the combined sewer system for each of the LTCP options. Surface water resources could be impacted if construction activities result in uncontrolled spills or releases of turbid and contaminated stormwater to adjacent water bodies. While unlikely, uncontrolled releases could occur due to unanticipated conditions such as failure of best management practices or treatment systems that discharge directly to surface waters, particularly during large winter storm events. Uncontrolled releases could also occur from discharges to the combined sewer system during large storm events. Surface waters with the greatest potential to be affected by uncontrolled releases of turbid or contaminated water include the Ship Canal and Portage Bay/Union Bay area of Lake Washington where large storage tanks and major tunnels would be constructed adjacent to these water bodies. The City would comply with all applicable requirements for control of stormwater, dewatering, and spills, resulting in minimal potential for these releases.

Table 5-4. Comparison of Potential Surface Water Impacts among LTCP Options

Neighborhood Storage Option*

This option would have a higher potential for construction site runoff impacts relative to the other options because of the greater number of storage facilities potentially constructed near surface water bodies, and related surface disturbance and excavation. Storage tank and pipe construction under this option would result in approximately 7.5 acres of surface disturbance and a total excavation volume of approximately 185,000 cubic yards.

The neighborhoods that would be most affected are as follows:

- Ship Canal Neighborhoods. Construction in Ballard and Fremont/Wallingford would involve open excavations over extended periods to construct storage tanks and pipes. Substantial dewatering and

Table 5-4. Comparison of Potential Surface Water Impacts among LTCP Options

stormwater control would be needed. Potential temporary surface water quality impacts to the Ship Canal, Salmon Bay, or Puget Sound could occur as a result of increased turbidity in runoff to nearby streams, ditches, and stormwater collection systems, if not properly controlled.

- Lake Washington Neighborhoods. Construction of three storage pipes and one tank would require open excavations over extended periods, and substantial dewatering and stormwater control would be required. There is a potential for construction-related sediment to enter Portage Bay, the Montlake Cut, or Lake Washington, potentially increasing turbidity, if not controlled.
- Longfellow Creek/ Duwamish Neighborhoods. Construction of several storage pipes/tanks would require open excavations over extended periods, and substantial dewatering and stormwater control would be required. Excavation in contaminated areas could result in contaminated sediments entering Longfellow Creek or the Duwamish River.
- Other neighborhoods would have a minor potential for construction site runoff impacts.

Shared Storage Option

The Shared Storage Option would have a similar potential for surface water impacts as the Neighborhood Storage Option, but it includes larger construction areas and excavation quantities concentrated at shared storage tank locations. While construction of storage tanks under this option would result in approximately 12 acres of surface disturbance (the highest of all the LTCP options) and 408,000 CY of excavation, overall impacts would be reduced compared to the Neighborhood Storage Option because the shared tanks would eliminate the need for several City and King County independently constructed CSO storage facilities.

The neighborhoods that would be most affected are as follows:

- Ship Canal Neighborhoods. The potential for impacts would be slightly greater than the Neighborhood Storage Option because the shared storage tank in Fremont/ Wallingford would have a greater disturbance area and excavation quantities.
- Lake Washington Neighborhoods. The potential for impacts would be greater than the Neighborhood Storage Option because the shared storage tanks in North Union Bay and Montlake would result in a greater disturbance area with an extended period of open excavation, increasing the potential for turbid discharges to Lake Washington.
- East Waterway Neighborhood. The potential for impacts would be less than the Neighborhood Storage Option because flow diversion in the East Waterway neighborhood would reduce the amount of disturbance and excavation required.

Shared West Ship Canal Tunnel Option

The Shared West Ship Canal Tunnel Option would require a similar amount of surface disturbance as the Neighborhood Storage Option, and therefore a similar potential for surface water impacts during construction. The Shared West Ship Canal Tunnel Option would result in total surface disturbance of approximately 7 acres and an excavation volume of 276,000 CY. Overall impacts would be reduced compared to the Neighborhood Storage Option as this option eliminates City and King County independently constructed CSO storage facilities that would otherwise be constructed in the same neighborhoods.

The neighborhoods that would be most affected are as follows:

- Ship Canal Neighborhoods. The potential for temporary surface water quality impacts to the Ship Canal would be less than the Neighborhood Storage and Shared Storage Options because the tunnel would eliminate the need for construction of several large storage tanks involving large areas of exposed earth. Site runoff or dewatering associated with construction of a tunnel portal could result in discharges to the Ship Canal if not properly controlled.
- Lake Washington Neighborhoods. Potential impacts would be the same as the Neighborhood Storage Option.
- Longfellow Creek/Duwamish Neighborhoods. Potential impacts would be the same as the Shared Storage Option.

Table 5-4. Comparison of Potential Surface Water Impacts among LTCP Options**Shared Ship Canal Tunnel Option**

The Shared Ship Canal Tunnel Option would have a similar overall amount of surface disturbance as the Neighborhood Storage Option, and therefore a similar potential for surface water impacts during construction. While construction under this option would result in approximately 7.5 acres of surface disturbance and total excavation of 507,000 CY (the highest of all the LTCP options), overall impacts would be reduced because the shared tanks would eliminate the greatest number of City and King County independently constructed CSO storage facilities.

The neighborhoods that would be most affected are as follows:

- Ship Canal Neighborhoods As described for the Shared West Ship Canal Tunnel, the potential for temporary surface water quality impacts to the Ship Canal would be less than the Neighborhood Storage and Shared Storage Options because the tunnel would eliminate the need for construction of several large storage tanks involving large areas of exposed earth. Site runoff or dewatering associated with construction of a tunnel portal could result in discharges to the Ship Canal if not properly controlled.
- Lake Washington Neighborhoods Flow transfers in these neighborhoods to the tunnel would have a potential for increased sedimentation and turbidity in Lake Washington due to construction runoff. Tunnel portal construction could generate surface water runoff or construction dewatering, which could affect water quality in Portage Bay and Lake Washington if not properly controlled.
- Longfellow Creek/Duwamish Neighborhoods The potential for impacts would be similar to the Neighborhood Storage Option. Flow diversions under this option would disturb slightly less area than the tanks under the Neighborhood Storage Option.

*The Neighborhood West Ship Canal Tunnel would have similar impacts in Ballard and Fremont/Wallingford as described for the Shared West Ship Canal Tunnel Option.

5.4.3 What are the potential surface water impacts of the Integrated Plan Alternative?

Construction-related impacts associated with the Integrated Plan Alternative would largely depend on the LTCP option implemented. Construction of storage pipes, tanks, and tunnels under the Integrated Plan Alternative would have the same potential impacts to surface water as under the LTCP Alternative, with some impacts delayed until after 2028. In addition to construction of CSO control projects under the selected LTCP option, additional work would occur to construct NDS Partnering projects and the South Park Water Quality Facility project.

NDS Partnering projects would be constructed in public road rights-of-way of the Piper's, Thornton, and Longfellow Creek neighborhoods and cause minimal surface water impacts. Natural drainage system projects are constructed in relatively flat public rights-of-way within developed areas, with low potential to generate runoff. Individual NDS Partnering projects would be relatively small in size with appropriate erosion control measures in place.

Construction of the South Park Water Quality Facility would involve approximately one acre of surface disturbance. The facility is expected to be located in an industrial area near the Duwamish River. Considering historic land uses in the area, the soils at the site may include contaminated materials. The City would conduct appropriate studies during predesign and design to determine this potential and develop appropriate measures to ensure that contaminated runoff or groundwater does not leave the site.

5.4.4 What are the potential surface water impacts of the No Action Alternative?

Construction activity associated with ongoing sewer system improvements and natural drainage solution program projects is not expected to result in surface water impacts due to the limited construction areas. Sewer system

improvements are not likely to result in vegetation removal or grading that would have potential for impacts from runoff because work would occur within underground vaults/chambers at existing CSO or stormwater facilities, and within street rights-of-way. RainWise program projects and roadside rain gardens would have minimal potential for surface water impacts due to their small footprint. Refer to the SEPA Checklist completed for the RainWise program for an evaluation of program impacts (SPU, 2013a).

5.4.5 What measures are proposed to reduce or minimize surface water impacts?

Compliance with the requirements of the Construction Stormwater General Permit issued by Ecology and the City of Seattle's stormwater code and manual would minimize potential surface water runoff and sedimentation.

Dewatering impacts would be minimized by compliance with the King County Wastewater Discharge Permit requirements. Additional measures to minimize surface water runoff, dewatering, and spills include the following:

- Limit the area of construction disturbances.
- Implement stormwater best management practices identified in the City of Seattle's Stormwater Code (SMC 22.800 – 22.808), Director's Rule: 2009-004 SPU/16-2009 DPD, and Volume 2 Construction Stormwater Control Technical Requirements Manual to control erosion and sediment transport from the project sites. Typical measures include silt fencing, plastic sheeting, and straw wattles to prevent sediment discharge, and wheel washing stations to prevent sediment from entering nearby roadways.
- Provide water quality treatment as necessary to improve the quality of intercepted stormwater flows from adjacent impervious surfaces.
- Develop and implement a Construction Stormwater and Erosion Control Plan, including a Stormwater Pollution Prevention Plan and Spill Prevention and Countermeasures Plan, to reduce the potential for sediment, waste materials, construction-related leaks, and spills to contaminate surface water, groundwater, and stormwater runoff.
- Adhere to the requirements of Seattle Director's Rule DWW-201.1 / 15-2012 and DWW-201.2 / 16-2012, requiring all projects to implement green stormwater infrastructure (GSI) to the maximum extent feasible.

5.5 Biological Resources

This section describes the types of impacts that could occur to biological resources within the Plan area during implementation of Plan alternatives.

5.5.1 What potential construction impacts are common to all of the alternatives?

The majority of impacts to fish and wildlife and their habitats during construction would be common to all of the alternatives and options as described below. No in-water construction would occur for any of the alternatives or storage options.

Direct Loss of Terrestrial Habitat

The majority of the CSO control projects would be located within paved rights-of-way or on previously developed parcels. However, some projects could require grading or removal of vegetation that currently provides wildlife habitat. It is anticipated that direct losses of terrestrial habitat would be minimal because most of the remaining patches of wildlife habitat in the city are within undeveloped areas of public parks, riparian corridors, and steep slope areas, which would not be targeted for CSO control projects. Storage pipes and flow diversions would likely be located in paved or developed rights-of-way and would not affect wildlife habitat.

Because specific sites have not been chosen for CSO control projects, this EIS does not evaluate habitat impacts for specific properties. An evaluation of wildlife habitat would be conducted as part of project-level SEPA analyses performed for each project, as appropriate. To evaluate programmatic impacts, the overall size of the construction footprint (amount of surface disturbance) associated with each project was used to compare the potential for impacts associated with the options.

Disturbance to Wildlife from Noise and Human Activity

Indirect impacts to wildlife would be associated with increased noise and human activity during construction. Wildlife in the vicinity (e.g., terrestrial birds and mammals, waterfowl, seabirds) could be displaced and move to adjacent suitable habitats if available. Many wildlife species in the urbanized areas of the city are generally tolerant of high noise levels and would not be disturbed. Some of the projects, such as sewer system improvements, would cause only short-term increases in noise and activity, while other projects, such as storage tanks and tunnels, could require multiple years to construct and some wildlife could be permanently displaced as a result of sustained periods of disturbance. Projects that require pile driving and other high-impact activity would have a higher potential to disturb wildlife in the vicinity. In addition, those projects located closest to mapped priority habitats or documented species locations have the highest potential to disturb wildlife in the vicinity during construction.

Key Findings

Biological Resources

No direct impacts to aquatic habitats, plants, and invertebrates would occur, and only minor indirect impacts from construction noise are anticipated. The potential for direct losses of terrestrial habitat associated with facility construction would be minimal under both the *LTCP Alternative* and *Integrated Plan Alternative* because the facilities are likely to be located in developed areas with low habitat value.

The primary differences in potential effects of the LTCP options are related to amount of construction activity (surface disturbance) and proximity to mapped priority habitats or species. Overall disturbance would potentially be greatest under the Neighborhood Storage Option, and least under the Shared West Ship Canal and Ship Canal Tunnel Options. However, impacts to priority species would potentially be higher under the Shared Storage and Shared Ship Canal Tunnel Options due to construction activity in proximity to priority habitats along the Lake Washington shoreline and Union Bay Natural Area.

Sedimentation of Aquatic Habitats from Construction Site Runoff

As described previously in Section 5.4, Surface Water, surface water runoff from construction and excavation at project sites could increase sedimentation and turbidity if allowed to discharge untreated or uncontrolled. Uncontrolled runoff could result in sedimentation of aquatic habitats near project sites, which would impact aquatic species including threatened and endangered salmonids. However, best management practices to control surface water runoff would be employed at all construction sites to comply with state and City stormwater permit requirements. With implementation of the required best management practices, the potential for uncontrolled runoff is minimal.

Contamination of Aquatic Habitats from Construction Equipment Spills

As described previously in Section 5.4, Surface Water, there is a potential for accidental spills of oils, solvents, and other chemicals from equipment during construction. If the spills are large and uncontrolled, the spills could flow to adjacent surface water and impact aquatic habitats and species. However, the City would follow the requirements of all applicable permits and would implement Spill Prevention and Control Plans for each project. Thus, the potential for uncontrolled spills is minimal.

5.5.2 What are the potential biological resource impacts of the LTCP options?

Table 5-5 summarizes the general types of impacts to biological resources that could occur under the type of CSO control projects proposed under the LTCP Alternative. Each of the four LTCP options would cause different levels of impacts to different neighborhoods. Indirect impacts to wildlife would be highest for those alternatives and storage options that have multiple project locations, require high-impact activities, have mapped priority habitats or species use nearby, and require multiple years to construct. Neighborhoods where wildlife and habitat would be especially affected by construction include the Ship Canal and Lake Washington Neighborhoods because the proposed storage tanks and major tunnels are adjacent to mapped priority habitats and species.

Table 5-5. Summary of Potential Biological Resource Impacts for LTCP Options
Neighborhood Storage Option*
The total amount of surface disturbance and potential for direct impacts to habitat is approximately 7.5 acres, which is second highest of all the storage options. This storage option has the most individual project locations compared to the other options. The neighborhoods that would be most affected are as follows: • <u>Ballard and Fremont/Wallingford</u>. A storage tank would be built in each neighborhood. Ballard would have the most construction disturbance for the longest duration (up to 5 years) with the potential to disrupt wildlife in the vicinity. However, impacts are anticipated to be minimal as there is no mapped priority habitat near the west segment of the Lake Washington Ship Canal. Habitat potentially affected is largely landscaped vegetation consisting of native and nonnative species. • <u>Magnolia</u>. A storage pipe would be built adjacent to mapped priority habitats (natural areas and riparian corridors in Discovery Park) and species (great blue heron in Kiwanis Ravine, bald eagle); therefore, there is some potential for disturbance to wildlife. • <u>Leschi</u>. Storage pipes and associated pump stations would be constructed in areas adjacent to mapped priority habitats (natural areas and riparian corridors of Madrona, Frink, and Mount Baker Creeks) and species (peregrine falcon). Construction could disrupt wildlife in the vicinity for up to 1.5 years. • <u>Delridge</u>. Storage pipes and associated pump stations would be constructed in areas adjacent to mapped priority habitats (natural areas and riparian corridors of Longfellow Creek). Construction could disrupt wildlife in the vicinity for 1 year.

Table 5-5. Summary of Potential Biological Resource Impacts for LTCP Options**Shared Storage Option**

Shared storage tanks would reduce the total number of new storage tanks required in the city (by both the City and King County) as compared to the Neighborhood Storage Option. The total amount of surface disturbance (12.0 acres) is the highest of all options, which suggests a higher potential for habitat impacts. However, this option has the second to least number of individual project locations, and therefore a lower potential to cause indirect impacts to wildlife through construction-related noise and activity. The shared storage projects would occur along the shoreline of the Lake Washington Ship Canal near high-value habitat and could disturb priority wildlife species such as bald eagle and great blue heron.

The neighborhoods that would be most affected are as follows:

- Ballard and Fremont/Wallingford. Impacts of storage tanks would be the same as for the Neighborhood Storage Option except the Fremont/ Wallingford tank site would require slightly more surface disturbance and potentially more vegetation removal.
- North Union Bay. A shared storage tank in this neighborhood would involve high levels of noise and human activity for up to 3.5 years. The location is largely high-density residential with pockets of forested habitat and in the vicinity of mapped priority habitats (wetlands associated with Lake Washington shoreline and Yesler Creek).
- Montlake. A shared storage tank would involve high levels of noise and human activity for up to 4.5 years. The location is largely high-density residential with pockets of forested habitat and in the vicinity of mapped priority habitats (wetlands associated with Lake Washington shoreline) and mapped bald eagle nest sites. The Union Bay Natural Area is proximate to both sites. No direct impacts to wildlife habitat within the Union Bay Natural Area are anticipated, but indirect impacts to wildlife could occur due to elevated noise and human activity during construction. Some individual animals could be permanently displaced as a result of the sustained period of disturbance.
- Other neighborhoods would experience the same or similar level of impacts for constructing storage pipes and tanks as under the Neighborhood Storage Option.

Shared West Ship Canal Tunnel Option

The Shared West Ship Canal Tunnel Option would require a similar amount of surface disturbance as the Neighborhood Storage Option, and therefore a similar potential for direct and indirect impacts to wildlife and habitat during construction. Overall impacts would be reduced compared to the Neighborhood Storage Option as this option eliminates City and King County independently constructed CSO storage facilities that would otherwise be constructed in the same neighborhoods.

The neighborhoods that would be most affected are as follows:

- Ballard and Fremont/Wallingford. Construction of the storage tunnel would require less surface disturbance than tanks, and therefore less potential for direct impacts to wildlife habitat because construction disturbance would largely be limited to tunnel portals. Also, tunnel construction requires less surface activity than with tank construction, resulting in potentially shorter duration of disturbance to wildlife in the vicinity. Both portal locations would be in areas that are generally developed as commercial or industrial and not near mapped priority habitats or species.
- Other neighborhoods would experience the same or similar level of impacts associated with storage pipes as the Neighborhood Storage Option.

Table 5-5. Summary of Potential Biological Resource Impacts for LTCP Options**Shared Ship Canal Tunnel Option**

There is a potential for wildlife disturbance during the 7-year construction duration based on mapped priority habitats and species near potential tunnel portal areas. While the total amount of surface disturbance and potential for direct impacts to habitat is similar to the Neighborhood Storage Option, the overall impact is lower (and lowest for all options) because the Shared Ship Canal Tunnel Option would eliminate the greatest number of the City and King County independently constructed CSO storage facilities.

The neighborhoods that would be most affected are as follows:

- Ship Canal and Lake Washington Neighborhoods. Construction of the storage tunnel would require less surface disturbance than tanks, and therefore less potential for direct impacts to wildlife habitat because construction disturbance would largely be limited to tunnel portals. Also, tunnel construction requires less surface activity than with tank construction, resulting in potentially shorter duration of disturbance to wildlife in the vicinity. Tunnel portals potentially could be located near priority habitat (wetlands associated with Lake Washington shoreline and Union Bay Natural Area). Other neighborhoods would experience the same or reduced level of impacts as compared to the Neighborhood Storage Option.

*The Neighborhood West Ship Canal Tunnel would have similar impacts in Ballard and Fremont/Wallingford as described for the Shared West Ship Canal Tunnel Option.

5.5.3 What are the potential biological resource impacts of the Integrated Plan Alternative?

In addition to construction of CSO control projects under the selected LTCP option, additional construction would occur to construct NDS Partnering projects and the South Park Water Quality Facility project. The street sweeping expansion program does not involve construction.

NDS Partnering projects would be constructed in public road rights-of-way of the Piper's, Thornton, and Longfellow Creek neighborhoods, causing minimal to no impacts to terrestrial habitat and wildlife. It is not possible to identify all potential project locations at this time, but most projects will likely occur in paved or developed rights-of-way in residential areas and would not affect wildlife habitat. Construction of NDS projects would cause minimal indirect impacts to wildlife in the vicinity as increases in noise and activity would be short-term. Projects located closest to mapped priority habitats or documented species locations have a higher potential to disturb wildlife in the vicinity during construction because these areas have higher concentrations of wildlife. Prior to installation of NDS projects, a site-specific evaluation of impacts to biological resources would be completed as part of the City's acquisition of applicable land use permits and approvals.

Construction of the South Park Water Quality Facility would involve approximately one acre of surface disturbance and high levels of noise and human activity for approximately two years. The facility is expected to be located on previously developed City-owned property in an industrial area and not near mapped priority habitats or species. Therefore, no direct loss of habitat is expected to occur and indirect impacts to wildlife associated with the increased level of noise and human activity during construction would be minimal.

5.5.4 What are the potential biological resource impacts of the No Action Alternative?

Sewer system improvements are not likely to result in vegetation removal or grading that would affect wildlife habitat because work would occur within underground vaults/chambers at existing CSO or stormwater facilities, and within street rights-of-way. Construction activities would temporarily cause elevated levels of noise and

human activity that could disturb wildlife, if present, near the project. However, system improvements are not anticipated to require pile driving, the construction technique that would cause the most noise and the greatest potential to disturb wildlife in the vicinity.

RainWise program projects and roadside rain gardens would have minimal direct impact on wildlife and habitat due to their small footprint and location within public rights-of-way or private property, both of which are typically developed or landscaped. (Refer to the SEPA Checklist completed for the RainWise program for an evaluation of program impacts (SPU, 2013c).)

5.5.5 What measures are proposed to reduce or minimize impacts to biological resources?

Construction effects on fish, wildlife, and habitat adjacent to future projects would primarily relate to elevated levels of noise and human activity during construction. Measures that minimize these effects are described in Section 5.8.5, Noise and Vibration.

In addition, the City would undertake the following measures to mitigate impacts to biological resources for all four options.

- Site projects away from mapped priority habitats and species locations where possible.
- Follow federal, state, and local permit conditions for managing construction site runoff and protecting habitats for federally listed species.
- Retain site vegetation as much as possible.
- Provide prompt revegetation with native species after construction is complete.
- Adhere to development conditions within City of Seattle's Director Rule 5-2007 for construction within Great Blue Heron Management Areas and Colony Nesting Areas.

Additional measures would be identified during future review of individual projects to mitigate biological resource impacts on specific properties. The City would coordinate with regulatory agencies on mitigation efforts as appropriate.

5.6 Energy and Climate Change

This section describes the types of energy and greenhouse gas impacts that could occur within the Plan area during construction of the Plan alternatives. Because specific projects have not been identified, estimates of energy consumption are generalized based on plan-level information.

5.6.1 What potential construction impacts are common to all of the alternatives?

Energy and greenhouse gas impacts that would be common to all of the alternatives and options are described below.

Energy Consumption during Construction

Project construction would consume energy during the initial mining and production of construction materials, during transportation of materials to the project sites, and during operation of construction equipment and worker vehicles.

Diesel and gasoline would be consumed to fuel construction equipment and worker vehicles. Energy consumption is expressed in gallons of diesel consumed. Quantities of fuel consumed would be considerably greater for storage facilities than for sewer system improvements or natural drainage systems. Compared to storage tanks and pipes, diesel fuel consumption would likely be somewhat lower and electricity consumption would likely be measurably higher for construction of storage tunnels due to use of electric tunnel boring machines.

Estimated numbers of truck trips, hours of pile driving, hours of earthwork, and hours of dewatering associated with construction were used to provide an estimate of fuel consumption. Electricity, either produced by diesel generators or from the grid, would be used to power machinery such as tunnel boring machines. Electricity consumption is typically expressed as millions of British Thermal Units (MBtu).

Key Findings

Energy and Climate Change

Neither the *LTCP Alternative* nor the *Integrated Plan Alternative* would have a significant impact on energy resources in the Seattle area.

The primary difference in energy consumption and greenhouse gas (GHG) emissions between the LTCP options relates to the type of storage facility (e.g., tank or tunnel) and whether it is part of the Neighborhood Storage Option or one of the shared options. While the shared options would have higher energy consumption and GHG emissions per facility, there would be fewer new storage facilities built by the City and King County. Therefore, overall emissions would likely be lower.

Fuel Consumption Calculation Assumptions

1 truck trip = 50 miles

Truck fuel efficiency = 5 miles per gallon

Pile driver fuel efficiency = 30 gallons per hour

Excavator fuel efficiency = 17 gallons per hour

Dewatering pump fuel efficiency = 24 gallons per hour

Greenhouse Gas Emissions

During construction, the primary source of greenhouse gas emissions would be fuel combustion, with the greenhouse gas emissions being proportional to the amount of energy used. Following is a list of terms used to discuss greenhouse gas emissions.

Greenhouse Gas Terms

Greenhouse gas emission estimates are expressed in metric tons of **carbon dioxide equivalents** (MT CO₂e).

Global Warming Potential (GWP): A measure of the total energy that a gas absorbs over a particular period of time (usually 100 years), compared to carbon dioxide.

CO₂ equivalents (CO₂e) provide a universal standard of measurement against which the impacts of releasing different greenhouse gases can be evaluated. Every greenhouse gas has a global warming potential (GWP), a measure of the impact that particular gas has on the additional heat/energy that is retained in the Earth's ecosystem through the addition of this gas to the atmosphere.

Diesel Emission Factor: Emission factors assume a linear relationship between the intensity of the activity and the emission resulting from this activity. Carbon dioxide emissions from the combustion of diesel fuel can be estimated with a high degree of certainty, as these emissions depend almost exclusively on the carbon content of the fuel. Multiplying the gallons of diesel by the emissions factor provides an estimate of the CO₂ produced during combustion.

Diesel Emission Factor = 0.01 MT CO₂e per unit volume (from U.S. Energy Information Administration)

Emissions from combustion of diesel fuel during construction were estimated and compared between the Plan alternatives. Numbers of truck trips, hours of heavy equipment use, hours of earthwork, and hours of dewatering associated with construction of each project alternative were used to provide an estimate of gallons of diesel fuel consumed. An emission factor was applied to the gallons of diesel consumed to provide an estimate of MT CO₂e produced under each alternative.

5.6.2 What are the potential energy and greenhouse gas impacts of the LTCP options?

Table 5-6 summarizes the types of energy and greenhouse gas impacts that could occur under the four LTCP options.

Table 5-6. Summary of Potential Energy and Greenhouse Gas Impacts for LTCP Options

Neighborhood Storage Option
Construction of distributed storage pipes or tanks would consume roughly 2,000,000 gallons of diesel. Greenhouse gas emissions would be proportional to petroleum-based fuel consumption and are estimated to be 30,000 MT CO₂e. Under this option King County would independently construct CSO storage tanks. Construction of the King County facilities would consume additional energy and emit greenhouse gases. Construction of a Neighborhood West Ship Canal Tunnel would consume roughly 2,000,000 gallons of diesel and would produce roughly 40,000 MT CO₂e. Construction of the West Ship Canal Tunnel would require use of roughly 6 megavolt amperes (MVA) of electricity in addition to diesel fuel. The tunnel boring machine used to construct the deep tunnel would be powered by electricity “from the grid”. Greenhouse gas emissions associated with the tunnel boring machine are expected to be small because electricity supplied to the greater Seattle area is typically generated by low-emission hydroelectric facilities.
Shared Storage Option
Shared storage tanks would reduce the total number of new storage tanks required in the city and would reduce the number of City and King County storage facilities that would be constructed as compared to the Neighborhood Storage Option. Construction of fewer storage tanks and pipes would reduce construction-related energy consumption and greenhouse gas emissions as compared with the Neighborhood Storage Option. Construction of the Shared Storage Option would consume roughly 4,000,000 gallons of diesel and emit roughly 60,000 MT CO₂e.
Shared West Ship Canal Tunnel Option
The Shared West Ship Canal Tunnel would reduce the total number of City and King County storage projects in the Ship Canal Neighborhoods, reducing construction-related fuel consumption and resulting greenhouse gas emissions. Construction of pipes, tanks, and a tunnel under this option is estimated to consume roughly 2,000,000 gallons of diesel and emit roughly 30,000 MT CO₂e. Construction of the Shared West Ship Canal Tunnel would require use of roughly 6 MVA of electricity, in addition to diesel fuel. See the Neighborhood West Ship Canal Tunnel Option (under Neighborhood Storage Option) for impacts associated with use of the tunnel boring machine.
Shared Ship Canal Tunnel Option
The Shared Ship Canal Tunnel Option would further reduce the total number of City and King County independently constructed CSO storage facilities. Construction of this option would consume approximately 4,000,000 gallons of diesel and emit 70,000 MT CO₂e, roughly the same as the Shared Storage Option. Construction of the Ship Canal Tunnel would require use of roughly 8 MVA of electricity, in addition to diesel fuel. See the Neighborhood West Ship Canal Tunnel Option (under Neighborhood Storage Option) for impacts associated with use of the tunnel boring machine.

5.6.3 What are the potential energy and greenhouse gas impacts of the Integrated Plan Alternative?

The greenhouse gas emissions and energy consumption associated with construction of the Integrated Plan Alternatives are very low. On-road vehicle operation is the primary contributor to greenhouse gas emissions (compared with materials and off-road vehicle operation) for NDS Partnering projects and for the South Park Water Quality Facility.

Street sweeping would not result in any construction emissions. Greenhouse gas emissions associated with construction of the NDS Partnering projects range from 200 MT CO₂e to almost 1,000 MT CO₂e. Emissions of greenhouse gas associated with constructing the South Park Water Quality Facility would be approximately 300 MT CO₂e.

5.6.4 What are the potential energy and greenhouse gas impacts of the No Action Alternative?

Under the No Action Alternative, the Plan would not be implemented. No additional construction-related energy consumption and emissions would occur related to CSO control other than those from existing plans and programs. Project construction under ongoing programs to implement sewer system improvements and natural drainage systems would have minor energy consumption and greenhouse gas emissions.

5.6.5 What measures are proposed to reduce or minimize energy and greenhouse gas impacts?

Measures to minimize air quality impacts may also contribute to reduced energy consumption and greenhouse gas emissions (see Section 5.3.5). In addition, the City would undertake the following measures to mitigate energy and greenhouse gas impacts for all four proposed options.

- Incorporate specifications into construction contracts that encourage the use of fuel-efficient construction equipment.
- Minimize engine idling during construction.

5.7 Environmental Health and Public Safety

This section describes the types of environmental health and public safety impacts that could occur during implementation of the Plan alternatives.

5.7.1 What potential construction impacts are common to all of the alternatives?

Many of the construction-related environmental health and public safety impacts would be common to all of the alternatives and options, as described below.

Contaminated Sites

Projects under each alternative have the potential to be constructed in or near sites contaminated with hazardous materials. The types of hazardous materials that could be encountered during excavation or dewatering would depend on previous uses of the sites. Disturbance of these materials during construction could release hazardous materials to the air or water, or could expose construction workers to hazardous substances unless proper handling methods are used. This analysis considers quantities of excavation and whether or not dewatering would be necessary for each project type in order to estimate the likelihood of encountering hazardous materials. Since project sites have not been determined, this analysis does not include detailed information.

Equipment Leaks and Spills

Accidental spills of hazardous materials from equipment and vehicles could occur during construction. Spilled materials could include fuels, lubricants, solvents, antifreeze, and similar materials. If not contained, these contaminants could enter groundwater or surface water and pose a health risk.

5.7.2 What are the potential environmental health and public safety impacts of the LTCP options?

Construction activities under any of the LTCP options have the potential to release hazardous materials into the environment. Larger projects, such as storage tanks and tunnels, have a greater potential for environmental health and public safety impacts than smaller projects such as storage pipes and flow diversions. Table 5-7 summarizes the environmental health and public safety impacts for projects that could occur under each option.

Key Findings

Environmental Health and Public Safety

Ground excavations and dewatering have the potential to encounter contaminated materials and may require special handling methods depending on the site and type of materials encountered. In general, environmental health risks associated with construction under both the *LTCP Alternative* and *Integrated Plan Alternative* are low, and the potential for the public to encounter contaminated soils or groundwater is low.

The primary differences in potential effects of the LTCP options are related to the potential for large excavations and dewatering outside of the right-of-way in potentially contaminated areas (typically industrial lands). Potential impacts would be similar among all options. Overall, the greatest number of projects with associated impacts would occur under the Neighborhood Storage Option, and the least under the Shared West Ship Canal and Ship Canal Tunnel Options. Impacts would be concentrated and of longer duration at fewer locations under the shared options.

Table 5-7. Comparison of Potential Environmental Health and Public Safety Impacts among LTCP Options**Neighborhood Storage Option***

Construction of distributed storage facilities disperses the potential for environmental health and public safety impacts to numerous locations throughout the city. For storage pipes, the potential to encounter unknown contaminated sites is relatively low because pipes would be built in previously disturbed areas in the right-of-way. The highest potential for impacts would occur at the site of storage tanks due to the large volumes of excavation required and, for some tanks, the need for substantial dewatering.

The neighborhoods that would be most affected are as follows:

- Ship Canal Neighborhoods. Storage tank construction would require substantial excavation and in some cases substantial dewatering. Storage tanks would likely be built in commercial/industrial areas near the Ship Canal, which have a high concentration of known contaminated sites.
- Lake Washington Neighborhoods. Storage pipes with relatively low potential for environmental health impacts would be built in these neighborhoods. These neighborhoods have the lowest concentration of known contaminated sites of any LTCP neighborhoods so the potential to encounter contaminated sites is lower than for other neighborhoods.
- Longfellow Creek/Duwamish Neighborhoods. Storage pipes would be built in the Delridge and Duwamish neighborhoods. The Duwamish and East Waterway neighborhoods consist mostly of industrial areas and have a particularly high concentration of known contaminated sites where the potential to encounter hazardous materials is higher.
- Elliott Bay/Lake Union Neighborhoods. A storage pipe with relatively low potential for environmental health impacts would be built in this neighborhood. However, the neighborhood has a particularly high concentration of known contaminated sites.

Shared Storage Option

The larger, shared storage tanks under this option have a higher potential to cause environmental health and public safety impacts due to substantially greater volumes of excavation increasing the risk of encountering contaminated materials. However, overall impacts would be reduced because the shared tanks would eliminate the need for 10 City and 3 King County independently constructed CSO control facilities. Construction required to implement flow diversions under this option would have a very low potential to cause environmental health and public safety impacts because excavation volumes would be minimal and dewatering would not be significant.

The neighborhoods that would be most affected are as follows:

- Ship Canal Neighborhoods. Impacts of storage tanks would be similar to the Neighborhood Storage Option. The shared Fremont/Wallingford tank would require substantially more excavation and would therefore have a higher potential to encounter hazardous materials.
- Lake Washington Neighborhoods. Shared storage tanks constructed in the North Union Bay and Montlake neighborhoods would have a greater potential to encounter hazardous materials than storage pipes due to the increased need for excavation. Storage pipes and a tank would not be built in the Leschi neighborhood, thereby reducing the number of construction sites with the potential for environmental health impacts.
- Longfellow Creek/Duwamish Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.
- Elliott Bay/ Lake Union Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.

Shared West Ship Canal Tunnel Option

The Shared West Ship Canal Tunnel Option would replace four City and one King County CSO independently constructed CSO control facilities with a large storage tunnel. Consequently, overall impacts would be reduced compared to the Neighborhood Storage Option.

The neighborhoods that would be most affected are as follows:

- Ship Canal Neighborhoods. Tunnel and portal sites and associated construction in these neighborhoods would require substantial excavation, so the potential to encounter contaminated materials is high.
- Lake Washington Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.

Table 5-7. Comparison of Potential Environmental Health and Public Safety Impacts among LTCP Options

- Longfellow Creek/Duwamish Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.
- Elliott Bay/Lake Union Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.

Shared Ship Canal Tunnel Option

The Shared Ship Canal Tunnel Option would replace numerous construction sites, each with the potential to encounter contaminated materials, with one larger project. This tunnel would have the most excavation of any of the CSO control projects, increasing the risk of encountering contaminated materials. However, for the option as a whole, the potential impacts would be concentrated in fewer locations throughout the city as a result of eliminating 15 City and 3 King County independently constructed CSO control facilities, the most of all the options.

The neighborhoods that would be most affected are as follows:

- Ship Canal and Lake Washington Neighborhoods. Tunnel portal sites and associated construction in these neighborhoods would require substantial excavation. Industrial areas along the Ship Canal in these neighborhoods have a high concentration of known contaminated sites.
- Longfellow Creek/Duwamish Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.
- Elliott Bay/Lake Union Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.

*The Neighborhood West Ship Canal Tunnel would have similar impacts in Ballard and Fremont/Wallingford as described for the Shared West Ship Canal Tunnel Option.

5.7.3 What are the potential environmental health and public safety impacts of the Integrated Plan Alternative?

Construction of storage pipes, tanks, and tunnels under the Integrated Plan Alternative would have the same potential environmental health impacts as under the LTCP Alternative, but construction would be delayed in some neighborhoods. The potential for environmental health and public safety impacts from the projects specific to the Integrated Plan Alternative would be low. Excavation for natural drainage systems is limited to the top few feet of soil, reducing the chances of encountering contaminated material. It is unlikely that contaminated sites would be located in the rights-of-way where the natural drainages systems are implemented. Construction of the South Park Water Quality Treatment Facility has the potential to encounter contaminated materials as the facility is located in an industrial area in the South Park neighborhood.

5.7.4 What are the potential environmental health and public safety impacts of the No Action Alternative?

The potential for environmental health and public safety impacts from the No Action Alternative would be low. Sewer system improvements occur at existing CSO or stormwater drainage locations. These locations have previously been excavated; therefore, the risk of encountering contaminated soil is minimal.

Excavation for rain gardens is limited to the top few feet of soil, reducing the chances of encountering contaminated material. It is unlikely that contaminated sites would be located on the residential properties where the RainWise Program is implemented. It is possible that contamination could have occurred in commercial or business properties, in public rights-of-way, and on public parcels selected for rain gardens. Equipment used for the projects in public rights-of-way could cause spills of contaminants such as petroleum products, but equipment would be limited to small trucks and backhoes, which would be well-maintained and would remain onsite for a limited time.

5.7.5 What measures are proposed to reduce or minimize environmental health and public safety impacts?

Measures to minimize impacts from hazardous materials would include site-specific investigations to determine the potential for hazardous materials and to develop site-specific cleanup or pollution prevention plans. For all sites, City would develop plans for sediment and groundwater handling, testing, and disposal. Spill prevention and control plans would be developed to prevent the accidental release of contaminants into the environment.

5.8 Noise and Vibration

This section describes the types of noise and vibration impacts that could occur within the Plan area during implementation of the Plan alternatives.

5.8.1 What potential construction impacts are common to all of the alternatives?

Many of the construction noise and vibration impacts would be common to all of the alternatives and options. These common impacts are described below.

Noise Generated by Construction Equipment and Activities

Construction noise levels vary depending upon the type and intensity of activity, with the highest levels of intensity typically occurring during earthwork. The most common noise source in construction areas would be engine-powered machinery such as earthmoving equipment

Sound Levels Produced by Construction Equipment

Equipment	Maximum Sound Level at 50 Feet (dB)
Backhoe	85
Compressor	80
Concrete pump	82
Concrete saw	90
Cement mixer	80
Crane	85
Drill rig	84
Dump or boom truck	84
Excavator	85
Fork lift	65
Generator	82
Jet grouter	70
Light plant	70
Front-end loader	80
Pickup truck	55
Pile driver (Impact)	101
Pump	81
Street sweeper	80
Vibratory hammer	95
Water truck	84
Welder	74

Source: FHWA, 2006

(bulldozers and excavators), material-handling equipment (cranes), and stationary equipment (compressors, generators, and pumps). The loudest and most disruptive construction activities would be from driving sheet piles (if required). Installation of shoring for storage tanks, pipes, and tunnels would also be a source of construction noise. Other noise sources include tools such as jackhammers. Noise generated by mobile equipment would occur intermittently, while stationary equipment would generate sound fairly constantly. Backup alarms from onsite construction vehicles would add to the overall increased noise levels.

Key Points

Noise and Vibration

Construction of projects under the *LTCP Alternative* would result in short-term moderate to substantial increases in noise, lasting from one to as much as seven years, depending upon the LTCP option selected.

The primary differences in potential effects of the LTCP options are related to the amount of noise-generating earthwork and the length of construction period. The primary differences in potential effects of the LTCP options are related to the amount of noise-generating earthwork and the length of construction period. In general, storage pipes/tanks would result in shorter duration but more geographically distributed impacts, while the tunnels would result in longer duration impacts in relatively smaller areas.

The Neighborhood Storage Option would have the most dispersed noise and vibration impacts throughout the Plan area. Impacts would be of potentially higher intensity but concentrated at fewer locations under the shared options. Vibration impacts along the tunnel routes are likely to be a concern to property owners.

Noise and vibration impacts from the projects specific to the *Integrated Plan*

Increased Noise Levels in Residential Areas and near Sensitive Receptors

Sensitive receptors are those building occupants and uses that are most susceptible to noise, such as hospitals and schools. Noise from construction could interfere with activities that require a quiet atmosphere, including sleep if construction occurs at night. Construction noise could also cause impacts to wildlife (see Section 5.5, Biological Resources). Figure 5-10 shows sensitive receptors in the project area.

Residential areas are more sensitive to noise impacts than commercial and industrial areas because they tend to have lower baseline noise levels. Residential neighborhoods typically have baseline noise levels of around 50 dBA. Construction-related noise levels can range from 70 to over 100 dB during peak activity. The top end of this range (100 dB) is the same sound level as a lawn mower 3 feet away.

Vibration

Construction techniques have the potential to cause ground vibration. The closer a person or building is to the source of vibration, the more likely the vibration would be perceptible to humans and to cause structural damage to buildings. Ground vibration associated with general construction equipment (i.e., nonimpact equipment) would dissipate more quickly (over a shorter distance) than vibration from pile driving. Tunneling could cause vibration along the route, which could impact structures sensitive to vibration or cause unconsolidated soils to settle. Generally, however, vibration from tunneling would not be noticeable.

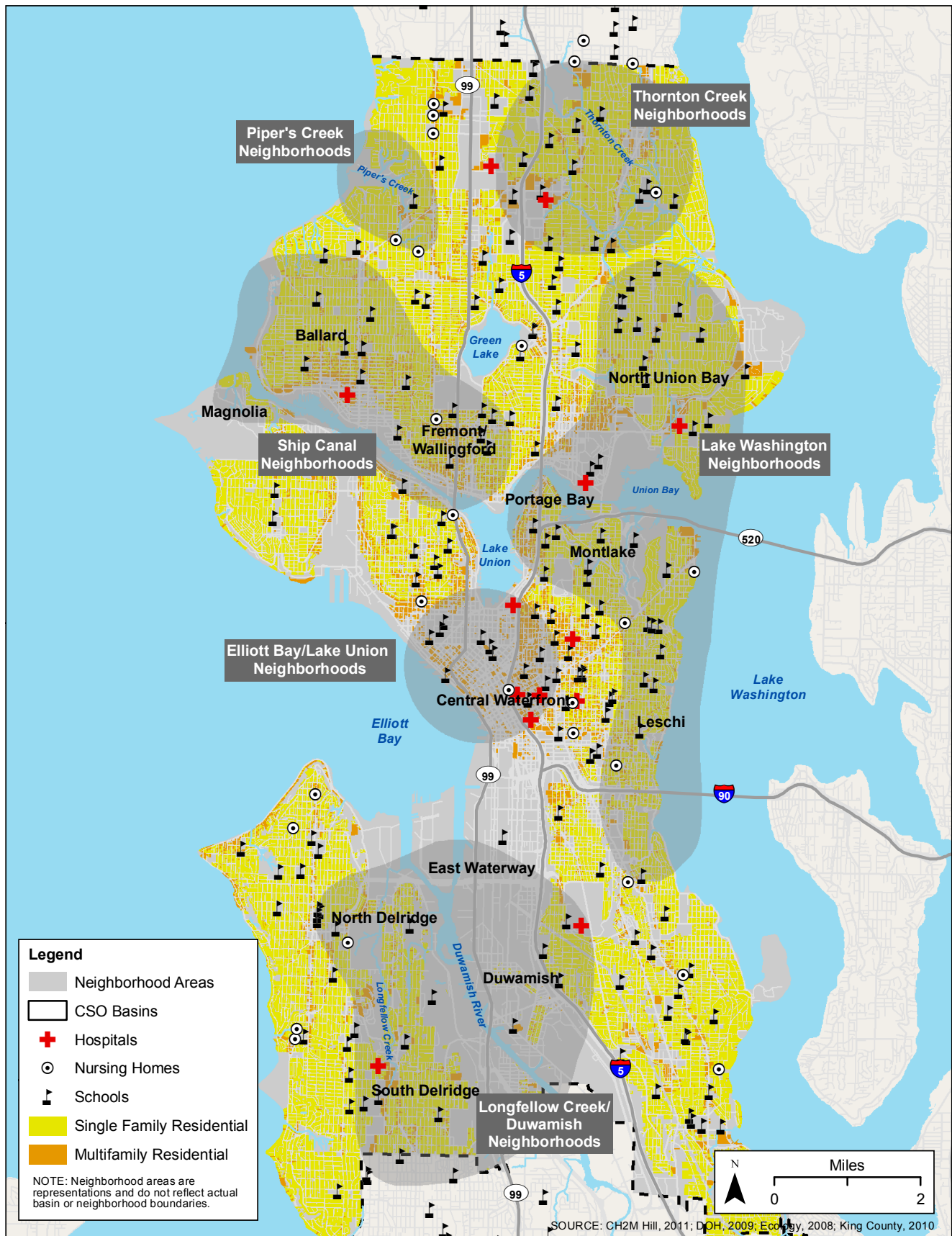


Figure 5-10 Sensitive Receptors.

5.8.2 What are the potential noise and vibration impacts of the LTCP options?

Construction-related noise impacts would occur under all of the LTCP options. Heavy equipment operation, earthwork, and other construction-related activities would result in short-term increases in noise by as much as 30 to 40 dB compared to baseline conditions. Construction would take place over several years in many locations and affect a wide variety of both residential and commercial properties. Table 5-8 summarizes the noise and vibration impacts for projects that would occur for each option.

Table 5-8. Comparison of Potential Noise and Vibration Impacts among LTCP Options

Neighborhood Storage Option*

The Neighborhood Storage Option would have the most dispersed noise impacts throughout the Plan area.

The neighborhoods that would be most affected are as follows:

- Ship Canal Neighborhoods. Storage tanks would be constructed in Ballard and Fremont/Wallingford, with construction noise lasting up to 5 years. Tanks would likely be built in industrial and commercial areas near the Ship Canal, but adjacent to residential areas which could be affected. Both neighborhoods include sensitive receptors, including a hospital in Ballard. Construction of a storage pipe in Magnolia would require less time and fewer truck trips, but the project would likely be in a residential area and single-family homes would be subject to construction noise for up to 1 year.
- Lake Washington Neighborhoods. Construction noise from storage pipe construction could be disruptive to residential properties and other sensitive receptors such as schools, daycare centers, and nursing homes, though they tend to be concentrated away from shorelines. In Leschi, steep slopes could create a canyon effect, concentrating noise from construction of three storage pipes and one storage tank. Noise impacts in this neighborhood in particular could be substantial during peak construction periods.
- Longfellow Creek/Duwamish Neighborhoods. Storage pipes in the Delridge neighborhoods could have greater noise impacts due to the presence of sensitive receptors and the proximity to residential areas. If trucks are required to use residential streets, they could add to the impacts from construction noise.
- Elliott Bay/Lake Union Neighborhoods. A storage pipe would be built in the Central Waterfront area. The neighborhood is primarily commercial and industrial, and very few sensitive receptors are located near the shoreline. Therefore, construction noise is not expected to impact sensitive receptors.

Shared Storage Option

Generally, noise impacts from 10 smaller storage projects would be consolidated into 3 larger storage projects, producing noise impacts in fewer but more concentrated locations. The shared storage tanks would eliminate the need for several City and King County storage facility construction sites in the Ship Canal and Lake Washington Neighborhoods. In other neighborhoods, storage pipes or tanks would be replaced by flow diversions, which would cause less noise but could still be disruptive if located next to sensitive receptors.

The neighborhoods that would be most affected are as follows:

- Ship Canal Neighborhoods. Impacts would be similar to the Neighborhood Storage Option, except a shared storage tank in the Fremont/Wallingford area would concentrate impacts in one area.
- Lake Washington Neighborhoods. Shared storage tanks would be built in North Union Bay and Montlake. The storage tank in North Union Bay could be located in proximity to the University of Washington, which features sensitive receptors such as educational facilities and the University of Washington Medical Center. The storage tank in Montlake would likely be located near residential areas. Construction noise from storage tanks would last for approximately 4.5 years, and in Montlake in particular, truck trips on residential roads could add additional noise. Storage pipes in the Leschi neighborhood would be replaced with flow transfer to the new shared storage tank. Flow transfer would likely still be built in residential areas, but construction duration would be shorter and construction noise would not be as substantial.
- Longfellow Creek/Duwamish Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.
- Elliott Bay/Lake Union Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.

Table 5-8. Comparison of Potential Noise and Vibration Impacts among LTCP Options**Shared West Ship Canal Tunnel Option**

The Shared West Ship Canal Tunnel would reduce the number of City and King County independently constructed storage facilities compared to the Neighborhood Storage Option. Fewer areas in the Ship Canal and Lake Washington Neighborhoods would experience construction noise, but noise would be concentrated at tunnel portal locations. Following initial tunnel portal site construction, most work would occur underground, which would not produce noticeable street-level noise or vibration.

The neighborhoods that would be most affected are as follows:

- Ship Canal Neighborhoods. The tunnel portal sites would likely be located in commercial and industrial areas, but near residential areas that could be affected. Tunnel boring would occur underneath Ship Canal Neighborhoods, but ground-borne noise and vibration would not be noticeable at street level. Additional evaluation of vibration potential may be needed during project-level evaluations, as vibration-related impact to structures is likely to be a concern to area property owners. Unlike the Neighborhood Storage Option, King County would not need to build its own new storage tank, which would reduce the overall number of construction sites in the neighborhood. Once initial construction is complete at storage tunnels, the majority of work would occur underground so there would be less construction noise than for storage tanks with open construction areas.
- Lake Washington Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.
- Longfellow Creek/Duwamish Neighborhoods. Impacts would be similar to the Shared Storage Option.
- Elliott Bay/Lake Union Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.

Shared Ship Canal Tunnel Option

Compared to all other options, construction noise from the Shared Ship Canal Tunnel Option would affect the fewest areas, but similar to the Shared West Ship Canal Tunnel Option, it would result in concentrated impacts in the Ship Canal and Lake Washington Neighborhoods. Following initial tunnel portal site construction, most work would occur underground, which would not produce noticeable street-level noise or vibration.

The neighborhoods that would be most affected are as follows:

- Ship Canal and Lake Washington Neighborhoods. Tunnel portal sites would be built along the Ship Canal, potentially on the south side of the Ship Canal and in North Union Bay. Haul trucks may be required to use roads adjacent to residential areas or sensitive receptors. Construction noise impacts would be focused at the portal sites. If a portal site is near sensitive receptors associated with the University of Washington, impacts could be substantial during peak construction periods. Construction noise would occur over the 7-year duration of the project. Tunnel boring would occur underneath the Ship Canal and Lake Washington Neighborhoods, but ground-borne noise and vibration would not be noticeable at building level. As noted for the Shared West Ship Canal Tunnel Option, potential vibration impacts to structures may require additional evaluation. Storage tanks and pipes would not need to be built in these neighborhoods, but flow diversions to the tunnel would be required. Construction of conveyance lines would still cause construction noise in residential areas in the Lake Washington Neighborhoods, but the construction techniques are likely to be less noisy and would occur over a shorter duration (two months).
- Longfellow Creek/Duwamish Neighborhoods. Impacts would be similar to the Shared Storage Option.
- Elliott Bay/Lake Union Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.

*The Neighborhood West Ship Canal Tunnel would have similar impacts in Ballard and Fremont/Wallingford as described for the Shared West Ship Canal Tunnel Option.

5.8.3 What are the potential noise and vibration impacts of the Integrated Plan Alternative?

Construction of storage pipes, tanks, and tunnels under the Integrated Plan Alternative would have the same noise impacts as under the LTCP Alternative, but construction would be delayed in some neighborhoods. Noise and vibration impacts from the projects specific to the Integrated Plan Alternative would be minor. Construction for natural drainage system projects is not likely to require high-impact noise equipment and construction noise would be of short duration. The South Park Water Quality Facility would generate typical construction noise similar to projects implemented under the LTCP Alternative and is anticipated to last two years.

5.8.4 What are the potential noise and vibration impacts of the No Action Alternative?

Noise and vibration impacts from the No Action Alternative would be minor. Sewer system improvements and projects implemented under natural drainage systems programs (RainWise and roadside rain gardens) are not likely to require high-impact noise equipment, and construction noise would be of short duration.

5.8.5 What measures are proposed to reduce or minimize noise and vibration impacts?

When project sites are selected, City would identify potentially impacted receptors and buildings and determine whether noise would exceed permitted levels or vibration would exceed applicable structural damage thresholds. If necessary, the City could perform baseline noise and vibration surveys at selected locations.

If construction activities exceeded permitted noise levels established in Seattle Noise Control Ordinance (SMC 25.08.425), the City would instruct the contractor to implement measures to reduce noise impacts to comply with the Noise Ordinance. Onsite noise monitoring could be used to ensure compliance with City code if necessary.

Construction noise could be minimized by implementation of construction best management practices, including the following:

- Identify potentially impacted receptors and buildings and determine whether noise and vibration levels at those sites would exceed permitted levels.
- Encourage noise-reducing measures, such as using sound-control devices on equipment, prohibiting equipment with unmuffled exhaust, minimizing idling time of equipment and vehicles, and installing acoustic barriers around stationary sources of construction noise.
- Conduct onsite noise monitoring to ensure compliance with SMC provisions, if necessary.
- Coordinate with Seattle City Light to ensure electrical power is available to construction sites during construction dewatering (to avoid using diesel powered generators).

Mitigation for vibration impacts would be determined on a site-by-site basis depending on impacts. Mitigation measures could include shoring of impacted buildings, coordination of vibration-causing construction with sensitive activities in impacted buildings, or onsite vibration-minimizing practices.

5.9 Land Use and Visual Quality

This section describes the types of land use and visual impacts that could occur within the Plan area during implementation of the Plan alternatives.

5.9.1 What potential construction impacts are common to all of the alternatives?

Many of the potential construction-related impacts to land use and visual resources would be common to all of the alternatives and options. These common impacts are described below.

Acquisition of Property and Easements

As with other large public infrastructure projects, CSO control projects can require the acquisition of easements or property for construction access, facilities, and staging areas.

Property acquisition could be required for storage tank locations, although public property would be preferred when available. For storage pipes and flow diversions, construction would occur primarily in street rights-of-way. For storage tunnels, potential property acquisition could be required for tunnel portals in industrial or residential areas. Acquisition could also be required for temporary and permanent easements for access or staging areas and for pump stations, conveyance lines, and other facilities.

To the extent possible, the City would avoid private property acquisition and displacement of residents or businesses. For each project, the City would conduct a siting process as described in Section 3.2.2.2 of this EIS. A top priority is to locate facilities on public property if possible. If acquisition of private property or displacement of residents or businesses is necessary, the City would attempt to find willing property sellers, and would follow federal, state, and local requirements for property acquisition, compensation, and relocation (Seattle Municipal Code Title 20).

Incompatibility with Surrounding Land Uses

The availability of sites suitable for CSO control facilities is limited, particularly for larger facilities such as storage tanks. This could result in the City needing to locate facilities in areas surrounded by residential or other types of land uses that could be affected during the construction period. These impacts would be noticeable throughout the construction period, but they would not likely continue following construction because most of the facilities would be underground.

Key Findings

Land Use and Visual Quality

CSO control projects included under the *LTCP Alternative* range from those that would be located in the public right-of-way or streets and cause little or no land use or visual impact, to major infrastructure projects that could require acquisition of property or easements. The acquisitions /easements could be temporary to accommodate access to a site or a location for project staging, or they could be permanent for locating storage tanks or tunnels. Impacts to visual quality during construction would be minor under all LTCP options.

The primary differences in potential effects of the LTCP options are related to the types of projects and their potential location and length of construction. Overall impacts would potentially be greatest under the Neighborhood Storage Option, and least under the Shared West Ship Canal and Ship Canal Tunnel Options. Impacts from storage facility construction would be concentrated at fewer locations under the shared options.

Only minor land use and visual quality impacts would occur as a result of stormwater projects implemented under the *Integrated Plan Alternative*.

Conflicts with Existing Plans and Policies

As described in Section 4.8, the City has established land use plans and regulations that determine what types of facilities are permitted in neighborhoods. The City's land use regulations acknowledge that public facilities may need to be located in areas where the facility would not be compatible. The City has included specific permit requirements for locating public facilities. When individual projects are carried forward under the Plan, the City would apply for land use permits as appropriate using the Master Use Permit process and would comply with the requirements of those permits. Proposed CSO projects are expected to require compliance with the Shoreline Master Program, environmentally critical areas reports, SEPA, and other land use and zoning regulations.

Changes to Views

Construction activities, equipment, and stockpiled materials would change the appearance of work sites and could temporarily modify the views from surrounding neighborhoods. Construction activities would be visible from nearby residences, commercial areas, and surrounding streets. None of the projects are anticipated to interfere with public views protected under the City Public View Protection Policy, such as views of the Space Needle and Mount Rainier. View impacts would be limited because many of the projects would be constructed underground with a limited aboveground footprint, and most construction equipment would be small and not obstruct views. Larger scale construction projects would require larger construction equipment, such as cranes and pile drivers, but even that equipment would have relatively small visual impacts.

Light and Glare

Most construction is expected to occur between 7 a.m. and 7 p.m. on weekdays and 9 a.m. and 7 p.m. on weekends and legal holidays. Consequently, light and glare impacts associated with construction site lighting would be limited to early morning and evenings during winter months. The tunnel projects could include nighttime construction and require round-the-clock lighting. This would introduce new sources of light and glare into the portal neighborhoods. In addition, safety lighting may be required at some construction sites during nighttime hours.

5.9.2 What are the potential land use and visual resources impacts of the LTCP options?

Table 5-9 summarizes the types of impacts to land use and visual resources that could occur under the four options of the LTCP. Proposed projects range from those that would be located in the public right-of-way or streets and cause little or no land use or visual impact, to major infrastructure projects that could require acquisition of property or easements. The acquisitions/easements could be temporary to accommodate access to a site or a location for project staging, or they could be permanent for locating storage tanks or tunnels.

Table 5-9. Summary of Potential Land Use and Visual Resource Impacts for LTCP Options

Neighborhood Storage Option*

This option has the largest number of City and King County independently constructed CSO storage facilities and the most areas that would experience temporary land use and visual resource impacts from storage facility construction. If public property is not available, acquisition of private property would be required. Because this option has the highest number of tanks, it may be difficult to site all facilities on public property. Property acquisition in most neighborhoods would be limited to construction easements or access. Storage pipe construction in streets could intermittently block or modify access to businesses and residences for a year or more.

Table 5-9. Summary of Potential Land Use and Visual Resource Impacts for LTCP Options

The neighborhoods that have the highest potential to be affected are as follows:

- Ballard and Fremont/Wallingford. A storage tank would be built in each neighborhood. While public property or right-of-way may be available for tank locations, the tanks could require property or easement acquisition in industrial or residential neighborhoods.
 - In the Ballard neighborhood, construction could disrupt adjacent property and business access for up to five years. The storage tank would require as much as 2 acres, likely on private property because of the limited availability of public property. The storage tank would likely be located in an industrial area.
 - In the Fremont/Wallingford neighborhood, a storage tank would be constructed on an approximately 2-acre site. Construction duration would be up to 3.5 years. It is possible that City-owned property would be available for this tank. Three pump stations would be constructed in support of the storage tank.
- Leschi. Storage pipes and associated pump stations would be constructed in a neighborhood with steep topography, a limited road network, and dense development. Construction would take place primarily in the right-of-way along Lake Washington Boulevard and would likely intermittently disrupt access to residences and businesses, potentially requiring detours around the construction sites. Construction could occur in the designated shoreline zone and would require compliance with the Shoreline Master Program. Views of Lake Washington could be temporarily disrupted by construction activities.
- Longfellow Creek/Duwamish. Storage pipes constructed in the Delridge and Duwamish neighborhoods could largely be constructed in the rights-of-way, causing localized intermittent disruptions to access for up to 1.5 years.
- East Waterway. Construction could require property and easement acquisition for a storage tank requiring up to an acre of surface disturbance. Access to adjacent residences and businesses could be intermittently disrupted for up to 2 years.
- Central Waterfront. A storage pipe would be located within the public right-of-way and would not require property acquisition. Access to businesses could be disrupted for up to 1 year, compounding access problems associated with the Viaduct replacement and waterfront projects. Construction could temporarily disrupt views of the Elliott Bay waterfront.

Shared Storage Option

Impacts would be similar to the Neighborhood Storage Option, but construction-related land use and visual quality impacts would be concentrated at fewer, larger project sites in the Ship Canal and Lake Washington Neighborhoods of Fremont/Wallingford, North Union Bay, and Montlake. This option would eliminate 10 smaller storage projects in the Lake Washington Neighborhoods. The neighborhoods that have the highest potential to be affected are as follows:

- Ballard and Fremont/Wallingford. Impacts of storage tanks would be the same as for the Neighborhood Storage Option, except the Fremont/Wallingford tank would require up to 3 acres of property acquisition in a primarily residential area and construction would last approximately 3 years.
- North Union Bay. A shared storage tank with up to 3 acres of surface disturbance could require property and easement acquisition in a predominantly residential area that includes portions of the University of Washington. Construction duration of up to 4 years could intermittently disrupt access to residences, businesses, and the University.
- Montlake. A shared storage tank covering up to 2 acres could require property and easement acquisition in a primarily residential neighborhood. Construction duration of up to 4.5 years could intermittently disrupt access to residences, businesses, and portions of the University of Washington campus.
- Other neighborhoods would experience similar level of impacts as under the Neighborhood Storage Option except the East Waterway neighborhood, where a flow diversion would replace the need for a storage tank and cause fewer impacts.

Table 5-9. Summary of Potential Land Use and Visual Resource Impacts for LTCP Options**Shared West Ship Canal Tunnel Option**

The Shared West Ship Canal Tunnel would reduce the number of City and King County independently constructed storage facilities compared to the Neighborhood Storage Option. This would reduce the number of areas affected by storage facility construction compared to the Neighborhood Storage Option, but would concentrate land use impacts in fewer areas of the city (Ballard and Fremont/Wallingford).

The neighborhoods that would be most affected are as follows:

- Ballard and Fremont/Wallingford. The storage tunnel would require a similar amount of property acquisition and easement acquisition as the Neighborhood Storage Option. Construction duration (3.5 years) would also be slightly shorter than for the storage tanks under the Neighborhood Storage Option, potentially resulting in fewer disturbances to property access. Nighttime construction would be required, causing light and glare impacts to adjacent neighborhoods.
- Leschi. Impacts of constructing three pipes and a storage tank and associated pump stations in the Leschi neighborhood would cause the same impacts to traffic, property access, and views of Lake Washington as described above for the Neighborhood Storage Option.
- Other neighborhoods would experience similar level of impacts as under the Neighborhood Storage Option.

Shared Ship Canal Tunnel Option

The Shared Ship Canal Tunnel Option would eliminate storage tank/pipe construction in several neighborhoods, but it would result in concentrated, potentially higher intensity impacts in the Ship Canal and certain Lake Washington Neighborhoods. Overall, the need for property acquisition and the amount of interference with access to residences and businesses would be reduced since most areas in the Lake Washington and Longfellow Creek/ Duwamish Neighborhoods would be controlled by flow diversions to the shared tunnel or King County facilities. Most of the construction associated with those projects would take place in paved rights-of-way and at existing facilities, reducing the need for property acquisition. The smaller flow diversion projects would also reduce construction duration and the potential for access impacts.

The neighborhoods that would be most affected are as follows:

- Ship Canal and Lake Washington Neighborhoods. Major construction impacts would occur at the portal locations including property acquisition of up to 4 acres in residential or industrial areas for tunnel portals, staging areas, and related facilities. Private property acquisition is likely. Intermittent access disruption would last for up to 7 years. Nighttime construction would be required, causing potential light and glare impacts to adjacent properties.
- Other neighborhoods would experience similar or reduced level of impacts as compared to the Neighborhood Storage Option.

*The Neighborhood West Ship Canal Tunnel would have similar impacts in Ballard and Fremont/Wallingford as described for the Shared West Ship Canal Tunnel Option.

5.9.3 What are the potential land use and visual resource impacts of the Integrated Plan Alternative?

Under the Integrated Plan Alternative, completion of selected CSO control projects described under the LTCP Alternative would be deferred so that the City can focus on implementing the proposed stormwater projects. As a result, construction impacts associated with certain CSO control facilities in the Delridge, East Waterway, Duwamish, Portage Bay, and Montlake neighborhoods would occur later (after 2028) under the Integrated Plan Alternative. Consequently, these neighborhoods would experience fewer near-term land use and visual quality-related construction impacts.

In addition to construction of CSO control projects, additional construction would be needed to complete NDS Partnering projects and the South Park Water Quality Facility project. The street sweeping expansion program does not involve construction and no land use or visual quality impacts are anticipated.

NDS Partnering projects would be constructed in public road rights-of-way of the Piper's, Thornton, and Longfellow Creek areas and cause little or no land use or visual impact. It is not possible to identify all potential project locations at this time, so site-specific zoning classifications cannot be determined. Most projects are expected to occur within the Single Family (SF) zone but could occur in other zones. Prior to installation of rain gardens, the City would need to apply for and obtain applicable land use permits and approvals. Depending on the site, temporary easements could be required to accommodate access to a site or a location for project staging.

During scoping, several comments were received regarding the history of unsuccessful roadside rain gardens in the Ballard neighborhood, citing that the rain gardens did not function properly, altered the character of the neighborhood, and created a safety hazard. The City has incorporated the lessons learned from the previous project into the agency's rain garden programs. Rain gardens constructed under NDS Partnering would include detailed evaluation of subsurface conditions prior to implementation. Construction impacts to land use and visual resources are not anticipated.

The South Park Water Quality Facility would involve a small construction footprint, and suitable City-owned property is available in the drainage basin for this purpose. It is unlikely that property acquisition or easements would be required. Available City-owned property is located in an industrial-zoned area with surrounding industrial land use. Therefore, it is anticipated that a suitable site is available that would result in minimal land use and visual quality impacts during construction. If this project is carried forward under the Integrated Plan, the City would apply for land use permits as appropriate using the Master Use Permit process and would comply with the requirements of those permits. The project would be expected to require compliance with the Shoreline Master Program, environmentally critical areas reports, SEPA, and other land use and zoning regulations.

5.9.4 What are the potential impacts to land use and visual resources of the No Action Alternative?

Under the No Action Alternative, the CSO control projects included in the LTCP would not be built. However, the City would continue with two of its ongoing programs to reduce CSOs—sewer system improvements and natural drainage systems. Property acquisitions would not likely be required for sewer system improvements because work would occur at existing CSO or stormwater drainage locations. Construction activities are not expected to interfere with access to properties or businesses. See the previous section on the Integrated Plan Alternative for discussion of rain garden projects.

5.9.5 What measures are proposed to reduce or minimize impacts to land use and visual resources?

Construction impacts to land use and visual resources include dust, noise, and increased traffic. Measures to minimize these effects are described in Sections 5.3, 5.8, and 5.12. In addition, the City would undertake the following measures to mitigate construction-related impacts to land use and visual resources for all construction projects:

- Prioritize project locations on public property and in public rights-of-way.

- Comply with federal, state, and local regulations regarding property acquisition and relocation assistance.
- Follow conditions of the Master Use Permit as described in Section 4.8.
- Provide access to property and businesses during construction.

Additional mitigation measures for specific land use and visual resource impacts may be identified during future review of individual projects. The City would coordinate with property owners on mitigation efforts as appropriate. The City would also coordinate with property owners to identify any relocation or other mitigation options for properties that would be directly affected during the construction period.

Projects proposed under the LTCP options would require more extensive construction disturbance and, therefore, would potentially cause more land use and visual impacts. Neighborhoods that would be most affected by property acquisition include the Ship Canal and Lake Washington Neighborhoods where storage tanks and major tunnels would likely require more property acquisition and potentially relocations. The City would comply with all applicable requirements for property acquisition and relocation.

5.10 Recreation

This section describes the types of recreation impacts that could occur within the Plan area during implementation of the Plan alternatives.

5.10.1 What potential construction impacts are common to all of the alternatives?

Many of the construction-related recreation impacts would be common to all of the alternatives and options. Because specific sites have not been chosen, these are described as potential impacts. Additional site-specific impacts would be evaluated as appropriate during project-level evaluations. The potential impacts common to all alternatives are described below.

Construction within a Park

Impacts to recreation could occur if a facility is sited within a park. Of the types of projects included in the LTCP options, storage tanks and tunnel portals could potentially be located on private or public property, including parks, although the City would attempt to avoid park locations. If located in a park, construction could limit or preclude use of as much as two to three acres of the park for multiple years. Recreation would be impacted by high levels of noise, and truck trips to the park could make access or parking difficult for recreational users, particularly during peak construction periods. Portions of the park could be closed or inaccessible during construction. Any construction in a park would comply with the requirements of Initiative 42 (Ordinance No. 118477) related to siting public facilities in parks. If a CSO facility was built in or adjacent to a park with a National Park Service grant, the City would need to coordinate with Seattle Parks and Recreation to ensure that the project did not interfere with grant compliance.

Construction adjacent to a Park

Because specific sites have not been chosen, it is unclear which projects (if any) would be located adjacent or nearby to a park. If construction or staging areas are located adjacent to or nearby to a park, recreational use of the park could be disrupted by restricted access, noise, dust, and truck trips during peak construction periods.

Construction in a Right-of-Way

Construction of storage pipes and flow diversions would generally be located in road rights-of-way, and it could temporarily interfere with informal recreation opportunities such as biking and walking.

Key Findings

Recreation

For all options under the *LTCP Alternative*, impacts to recreation could occur if a facility is sited within a park. Of the types of projects included in the LTCP options, storage tanks and tunnel portals could potentially be located on private or public property, including parks, although SPU would attempt to avoid park locations. If construction or staging areas are located adjacent or nearby to a park, recreational use of the park could be disrupted by restricted access, noise, dust, and truck trips during peak construction periods.

The potential for recreation impacts is highly variable and site dependent. The potential for impacts would be greatest under the Neighborhood Storage Option due to the higher number of tanks, but the larger tanks under the Shared Storage Option would have greater impacts if located in or adjacent to a park. Potential for impacts would be lower under the Shared West Ship Canal and Ship Canal Tunnel Options due to fewer tank sites.

Construction impacts to recreation specific to stormwater projects under the *Integrated Plan Alternative* are expected to be minimal.

5.10.2 What are the potential recreation impacts of the LTCP options?

Each of the four LTCP options has different potential to result in recreation impacts. Table 5-10 summarizes the recreation impacts for projects that would occur for each option.

Table 5-10. Comparison of Potential Recreation Impacts among LTCP Options

Neighborhood Storage Option*

Because this option has the highest number of projects located throughout the city, it has a greater likelihood of having projects located adjacent to a park or recreational facility. There are approximately 150 parks within the potentially affected neighborhoods (see Section 4.9, Recreation). Storage pipes located in the right-of-way, often in or near residential areas, could affect access to parks and impact informal recreation opportunities such as walking and biking.

The neighborhoods that would be most affected are as follows:

- **Ship Canal Neighborhoods.** Storage tanks would be built in the Ballard and Fremont/Wallingford neighborhoods. Due to the availability of underdeveloped or undeveloped commercial and industrial properties in these neighborhoods, storage tanks are less likely to be built in a park. The Burke Gilman Trail runs through the Fremont/Wallingford neighborhood near the Ship Canal and CSO outfalls. It is possible that the storage tank or a new conveyance line could be built near the trail. Other parks in Ballard and Fremont/Wallingford near where storage tanks could be constructed are generally small neighborhood parks. The storage pipe built in the Magnolia neighborhood would be constructed in the right-of-way, but if built near Discovery Park or a small neighborhood park, noise from construction could intermittently disrupt recreation in the park.
- **Lake Washington Neighborhoods.** Storage pipes would be constructed in road rights-of-way in these neighborhoods. Lake Washington Neighborhoods have a high concentration of parks, including both small neighborhood parks and major parks such as the Washington Park Arboretum and numerous parks designed by the Olmsted Brothers. Storage pipes would not be built in these parks, but there is a high likelihood that they would be constructed in roadways adjacent to parks, resulting in high levels of noise, disruption of access, and potential placement of construction staging areas in parks (likely in parking lots).

One of the major roads in the area is Lake Washington Boulevard, which was designed by the Olmsted Brothers and is a city park. It is likely that a storage pipe would be built in the right-of-way of Lake Washington Boulevard because few other options are available. Construction would take place in the paved area of the boulevard, but construction staging could potentially disturb vegetation designed by the Olmsted Brothers. Construction would disrupt use of the boulevard for pedestrians and bicyclists.

The Leschi neighborhood would require three storage pipes and a tank. This neighborhood has a particularly high concentration of parks, particularly Olmsted parks, and fewer roads suitable for construction in the right-of-way. Therefore, it is likely that storage pipes could be built directly adjacent to parks in this neighborhood.

- **Longfellow Creek/Duwamish Neighborhoods.** Storage pipes and a storage tank would be constructed in these neighborhoods. These neighborhoods have a lower density of parks than other neighborhoods and many undeveloped or underdeveloped commercial and industrial sites available. Therefore, it is less likely that CSO control projects would be constructed in or directly adjacent to a park. Storage pipes in the Delridge neighborhoods could be constructed near enough to parks (such as the Longfellow Creek Green Space or smaller neighborhood parks) that noise from construction could intermittently disrupt recreation.
- **Elliott Bay/Lake Union Neighborhoods.** The Central Waterfront neighborhood includes many significant parks and recreational facilities, such as the Sculpture Park and the Aquarium, as well as smaller neighborhood parks such as the Belltown Cottage Park and Victor Steinbrueck Park. The storage pipe constructed in this neighborhood is unlikely to be located directly adjacent to a park, but it could be near enough to a park that construction noise and truck traffic could disrupt use of or access to the park.

Table 5-10. Comparison of Potential Recreation Impacts among LTCP Options**Shared Storage Option**

The Shared Storage Option would have recreation impacts similar to the Neighborhood Storage Option. Due to their size and surface area required, shared storage tanks have a greater potential to impact recreation if located within or near parks. However, the use of shared storage tanks would reduce the number of storage tanks and pipes required in the Ship Canal and Lake Washington Neighborhoods. In other neighborhoods, storage pipes or tanks would be replaced by flow diversions, which would have less potential to impact parks but could still impact informal recreation such as walking and biking.

The neighborhoods that would be most affected are as follows:

- Ship Canal Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.
- Lake Washington Neighborhoods. Shared storage tanks would be built in North Union Bay and Montlake. The storage tank in North Union Bay could be located in proximity to the University of Washington Athletic Complex (including fields, a golf course, a ballpark, and an outdoor track) and the Union Bay Natural Area. Construction could limit use of or access to these areas for several years. Because the area is dominated by these recreational areas, impacts to recreation are likely. The storage tank in Montlake could impact recreation if located in or near East Montlake Park or West Montlake Park, or if construction traffic used Montlake Boulevard, an Olmsted Park.

Storage pipes in the Leschi neighborhood would be replaced with flow transfer to the new shared storage tank. Flow transfer would likely still be built in the right-of-way next to parks, but there would be less construction disturbance.

Compared to the Neighborhood Storage Option, impacts to the Lake Washington Neighborhoods would be lower because this option eliminates King County-only storage tanks in the North Union Bay and Montlake neighborhoods.

- Longfellow Creek/Duwamish Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.
- Elliott Bay/Lake Union Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.

Shared West Ship Canal Tunnel Option

Impacts to recreation from construction would be similar to the Neighborhood Storage Option, but impacts in the Ballard and Fremont/Wallingford neighborhoods would be concentrated at portal locations. If located in or adjacent to a park or recreational facility, portal construction could have a substantial impact on recreation.

The neighborhoods that would be most affected are as follows:

- Ballard and Fremont/Wallingford. A tunnel portal site would be built in each of these neighborhoods and could be located in or adjacent to existing or planned parks or greenways. A substantially higher number of truck trips would be required as compared to storage tanks, which would have a greater likelihood of disrupting access to nearby parks and informal recreation on city streets (such as biking and walking). Unlike the Neighborhood Storage Option, King County would not need to build its own storage tank in the neighborhood, which would decrease the overall number of construction sites.
- Lake Washington Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.
- Longfellow Creek/Duwamish Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.
- Elliott Bay/Lake Union Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.

Shared Ship Canal Tunnel Option

Under the Shared Ship Canal Tunnel Option, storage pipes and tanks throughout the Ship Canal and Lake Washington Neighborhoods would be replaced by a tunnel. Impacts would be similar to those described above for the Shared West Ship Canal Tunnel. The overall potential for this option to impact parks is lower than under other options because there are fewer project sites, particularly in Lake Washington Neighborhoods where storage pipes and tanks would likely be located adjacent to parks.

The neighborhoods that would be most affected are as follows:

- Ship Canal and Lake Washington Neighborhoods. If located in or adjacent to a park or recreational facility, noise impacts from tunnel portal construction would be substantial and truck trips could disrupt access to the park. If located in the park, multiple acres of the park could be closed to recreation for up to several years. A substantially higher number of truck trips would be required as compared to storage tanks, which would have a greater likelihood of disrupting access to nearby parks and informal recreation opportunities. The launch portal site would be located in

Table 5-10. Comparison of Potential Recreation Impacts among LTCP Options

the Ship Canal Neighborhoods and could be located in a recreational facility, such as an athletic field. The recovery portal site, which would have less construction activity than the launch portal site, would likely be located in the North Union Bay neighborhood. This neighborhood has many recreational facilities, including the University of Washington Athletic Complex (including Husky Stadium and its parking lots) and Montlake Park. If the tunnel portal site was located in or adjacent to these areas, access to and recreation at these facilities would be disrupted during the 6-year construction period.

- Longfellow Creek/Duwamish Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.
- Elliott Bay/Lake Union Neighborhoods. Impacts would be similar to the Neighborhood Storage Option.

*The Neighborhood West Ship Canal Tunnel would have similar impacts in Ballard and Fremont/Wallingford as described for the Shared West Ship Canal Tunnel Option.

5.10.3 What are the potential recreation impacts of the Integrated Plan Alternative?

Construction of storage pipes, tanks, and tunnels under the Integrated Plan Alternative would have the same potential recreation impacts as under the LTCP Alternative, but construction would be delayed in some neighborhoods. Recreation impacts from construction of the elements specific to the Integrated Plan Alternative would be minor. Construction in the right-of-way for natural drainage system projects could temporarily interfere with informal recreation such as walking and biking due to restricted access. Construction would be of short duration and would not require noisy equipment. The South Park Water Quality Facility would be constructed in an industrial area and would not be located near parks or informal recreation.

5.10.4 What are the potential recreation impacts of the No Action Alternative?

Recreation impacts from construction of the No Action Alternative would be minor. Sewer system improvements would occur at existing CSO or stormwater drainage locations and are therefore not likely to be located in parks or designated recreational trails. Construction in the right-of-way for both sewer system improvements and for right-of-way rain garden projects could temporarily interfere with informal recreation due to restricted access. Construction would be of short duration and would not require noisy equipment.

5.10.5 What measures are proposed to reduce or minimize recreation impacts?

If a project component is located in a park, impacts to recreation would be unavoidable. The City would attempt to avoid siting projects in parks. See Section 3.2.2.2 for more information about how locations will be prioritized. Impacts to recreational facilities could be further minimized through coordination with Seattle Parks, including coordinating construction timing with special events at the park; construction staging methods and siting; scheduling to avoid overlap with the construction of other projects in the vicinity; and advance public notice and signage. Parks and recreational features would be restored to the extent possible.

Noise from construction would be mitigated using the methods discussed in Section 5.8. Increased truck traffic could make it more difficult to access parks, but access would be maintained and transportation impacts would be minimized as discussed in Section 5.12. Noise and access impacts to recreation for projects located adjacent to parks and to informal recreation areas would be mitigated using the same methods.

5.11 Historic, Cultural, and Archaeological Resources

This section describes the types of impacts that could occur to historic and cultural resources within the Plan area during implementation of Plan alternatives.

5.11.1 What potential construction impacts are common to all of the alternatives?

The majority of impacts to historic and cultural resources during construction would be common to all of the alternatives and options. These common impacts are described below.

Belowground Historic and Cultural Resources

Shoring, excavation, and dewatering for storage pipes, storage tanks, tunnel portals, and flow diversions have the potential to cause construction impacts to belowground cultural resources. In most neighborhoods, construction of pipes, tanks, and flow diversions is likely to require disturbance that would extend from ground surface, down through geological layers with potential to contain cultural resources, and all the way into layers that would be considered too old to contain cultural remains. Exceptions to this general pattern may exist in the Central Waterfront, Duwamish, and North Union Bay, where the thickness of historic fill may exceed the depth of construction excavation. Due to their smaller construction footprints, storage pipes would be expected to have less potential impact than storage tanks.

Based on the Washington State Department of Archaeology and Historic Preservation (DAHP) Statewide Predictive Model, within individual neighborhoods, areas in proximity to permanent sources of water (shorelines) would be more likely to contain archaeological sites than areas not in proximity to water (uplands).

Aboveground Historic and Cultural Resources

Depending on project site locations, construction of storage pipes, storage tanks, new conveyance for flow diversions, and tunnel portal sites has the potential for impacts to aboveground historic properties. Temporary construction impacts to aboveground resources typically include vibration, dust, noise, and can sometimes include impacts to the visual integrity of a historic property. All of the neighborhoods identified for these types of projects contain designated Seattle Landmarks. Similarly, there are properties listed on the National Register of Historic Places in all neighborhoods except for Delridge South. Depending on the sites selected for storage tanks or storage pipes, existing recorded or unrecorded historic-aged properties may be present.

Under all LTCP options, work is being proposed in neighborhoods that contain aboveground properties that are historic in age, but which have not yet been evaluated for their eligibility to the National Register or as a designated Seattle Landmark.

Key Findings

Historic, Cultural, and Archaeological Resources

Construction under the *LTCP Alternative* or *Integrated Plan Alternative* could have a potential adverse effect on historic, cultural, or archaeological resources in the Plan area. For aboveground resources, all Plan alternatives include similar, minimal potential for impacts.

The primary difference in impacts for the LTCP options relates to the amount of excavation in geological layers and their potential to encounter cultural resources. The Shared Storage Option – and to a lesser extent the Neighborhood Storage Option – would have greater amounts of excavation in geological layers with greater potential to encounter cultural resources than the tunnel options.

Because specific sites have not been chosen for the CSO control projects, this EIS does not evaluate historic and cultural resources impacts for specific projects. An evaluation of historic and cultural resources will be conducted as part of project-level SEPA analyses performed for each project, as appropriate.

5.11.2 What are the potential historic and cultural resources impacts of the LTCP options?

Table 5-11 summarizes the types of historic and cultural resource impacts that could occur under all four LTCP options. Each option would cause different levels of historic and cultural resources impacts to different neighborhoods. Impacts to belowground resources would be highest for options that propose the most ground disturbance, depending on selected project locations. For aboveground resources, the options with the highest potential impacts are those that propose the greatest amount of work in older, developed neighborhoods such as the Central Waterfront and Duwamish or neighborhoods with historic districts.

Table 5-11. Summary of Potential Historic and Cultural Resources Impacts for LTCP Options

Neighborhood Storage Option*

For aboveground historic and cultural resources, the neighborhoods that would be most affected are as follows:

- Ballard, Fremont/Wallingford, and East Waterway. A storage tank would be built in each of these neighborhoods. Tanks would be located on private or City property and may require demolition of existing structures, including potentially historic structures, if present.
- Leschi. Three pipes and a tank are proposed within this neighborhood, including along Lake Washington Boulevard East which was designed by the Olmsted Brothers. Depending on the proposed location and depth of the storage pipes, these have a greater potential to impact historic and cultural resources.
- Central Waterfront. Established in 1851, this neighborhood contains the oldest aboveground historic resources. Construction of the proposed storage pipe through this area has a higher potential for impacting aboveground historic resources due to the greater number of historic properties in the neighborhood.

For belowground historic and cultural resources, the neighborhoods that would be most affected are as follows:

- Ballard and Fremont/Wallingford. The historic Ballard and Fremont/Wallingford neighborhoods have a high probability to contain historic-period belowground cultural resources that could be impacted by construction of large tanks.
- Montlake. The Montlake neighborhood has recorded, belowground precontact and historic cultural resources, and it has a high probability to contain additional belowground resources. Construction of three storage pipes beneath the right-of-way has the potential to impact belowground resources.
- Duwamish. The Duwamish neighborhood contains several important precontact archaeological sites. Depending on project location, installation of storage pipes has a potential to affect additional belowground cultural resources, if present.
- Central Waterfront. Due to multiple, historic-period regrades, the potential for belowground precontact and historic cultural resources can vary significantly from block to block. Depending on project location, the potential for encountering precontact or historic cultural resources may range from very low to very high.

Table 5-11. Summary of Potential Historic and Cultural Resources Impacts for LTCP Options**Shared Storage Option**

For aboveground historic and cultural resources, the neighborhoods that would be most affected are as follows:

- Ballard, Fremont/Wallingford, North Union Bay, Montlake, and East Waterway neighborhoods. A storage tank would be built in each of these neighborhoods. Tanks would be located on private or City property and may require demolition of existing structures, including historic structures, if present.
- Central Waterfront. Same as the Neighborhood Storage Option.

For belowground historic and cultural resources, the neighborhoods that would be most affected are as follows:

- North Union Bay. The North Union Bay neighborhood contains both precontact and historic belowground cultural resources. A storage tank built in this neighborhood has the potential to affect additional belowground resources, if present.
- Montlake and Leschi neighborhoods. A shared storage tank would be built in these neighborhoods, with a greater potential to affect any belowground cultural resources than the Neighborhood Storage Option. The Montlake neighborhood contains precontact and historic archaeological sites in proximity to the waterfront. Unknown belowground resources may also exist, and impacts resulting from tank construction would be permanent and irreversible if resources are encountered during construction.
- Other neighborhoods. Same as the Neighborhood Storage Option.

Shared West Ship Canal Tunnel Option

This option has the potential for temporary impacts to numerous historic properties along the proposed tunnel alignment (vibration, dust, noise, and visual integrity). Historic structures may be more susceptible to damage from vibration. However, no permanent impacts to aboveground resources within the proposed tunnel alignment are anticipated.

For aboveground historic and cultural resources, the neighborhoods that would be most affected are as follows:

- Ballard and Fremont/Wallingford. The deep storage tunnel has the greatest potential impact to aboveground historic and cultural resources in the Ballard and Fremont/Wallingford neighborhoods. The tunnel would pass through or next to designated Seattle Landmarks and National Register-listed properties.

Historic properties that may be impacted by the proposed tunnel alignment include but are not limited to structures, parks, and districts listed on the National Register. National Register-listed properties within the proposed tunnel alignment include Gas Works Park, Chittenden Locks, and numerous buildings, bridges, and libraries. In addition, the tunnel may impact designated Seattle Landmarks and Seattle Historic Districts such as Gas Works Park, buildings, bridges, schools, and multiple residences.

- Leschi. Same as the Neighborhood Storage Option.
- Central Waterfront. Same as the Neighborhood Storage Option.

For belowground historic and cultural resources, the neighborhoods that would be most affected are as follows:

- Ballard and Fremont/Wallingford. The greatest potential to affect belowground precontact or historic cultural resources is associated with portal construction. The neighborhoods of Fremont/Wallingford and Ballard, where portals would be built, do not contain previously recorded archaeological sites. Compared with Neighborhood Storage and Shared Storage Options, the Shared West Ship Canal Tunnel Option would involve less disturbance of geologic layers that have the potential to contain cultural resources.

Shared Ship Canal Tunnel Option

This option has a similar potential for construction impacts on historic properties as the Shared West Ship Canal Tunnel Option.

For aboveground historic and cultural resources, the neighborhoods that would be most affected are as follows:

- Montlake, Portage Bay, Fremont/Wallingford, and Ballard. The storage tunnel has the greatest potential impact to aboveground historic and cultural resources in these neighborhoods. This tunnel would be longer than the West Ship Canal Tunnel and would pass through or next to designated Seattle Landmarks and National Register-listed properties. Historic properties that may be impacted by the proposed tunnel alignment include but are not limited to structures, parks, and districts listed on the National Register. In addition, the tunnel may impact designated Seattle Landmarks and Seattle Historic Districts such as Gas Works Park, Fremont Hotel, and Ballard Avenue Historic

Table 5-11. Summary of Potential Historic and Cultural Resources Impacts for LTCP Options

District.

For belowground historic and cultural resources, the neighborhoods that would be most affected are as follows:

- North Union Bay, Montlake, and Fremont/Wallingford. The storage tunnel proposed between these two neighborhoods would be constructed through glacial deposits too old to contain belowground cultural resources. The greatest potential to affect any belowground precontact or historic cultural resources is associated with portal construction. Compared with the Neighborhood Storage and Shared Storage Options, which call for storage tank construction, the Ship Canal Tunnel Option would involve less disturbance of geologic layers that have the potential to contain cultural resources. Compared with the West Ship Canal Tunnel, portal construction (depending on location) in the North Union Bay neighborhood has a greater risk to affect any existing belowground precontact or historic cultural resources.

*The Neighborhood West Ship Canal Tunnel would have similar impacts in Ballard and Fremont/Wallingford as described for the Shared West Ship Canal Tunnel Option.

5.11.3 What are the potential historic and cultural resources impacts of the Integrated Plan Alternative?

In addition to construction of CSO control projects under the selected LTCP option, additional construction would occur for NDS Partnering projects and the South Park Water Quality Facility project. The street sweeping expansion program does not involve construction; therefore, no historic and cultural resources impacts are anticipated.

NDS Partnering projects constructed in public road rights-of-way of the Piper's, Thornton, and Longfellow Creek neighborhoods have the potential to encounter buried cultural resources. NDS Partnering projects have the potential to impact the setting of adjacent historic properties by changing the amount and character of vegetation.

Construction of the South Park Water Quality Facility would involve approximately one acre of surface disturbance. The facility is expected to be located in an industrial area near the Duwamish River. Depending on specific site location, construction has the potential to permanently impact any buried cultural resources which may be in the area. Depending on specific site location, construction of aboveground buildings or structures also has the potential to impact existing historic properties adjacent to the project.

5.11.4 What are the potential historic and cultural resources impacts of the No Action Alternative?

Sewer system improvements have the potential for construction impacts to historic properties depending on the locations of the improvements. Temporary construction impacts to aboveground resources typically include vibration, dust, noise, and can sometimes affect the visual integrity of a historic property. Depending on specific project location, these projects have the potential to impact belowground cultural resources. However, compared with the LTCP CSO control projects, sewer system improvements and natural drainage systems would have very low potential to impact belowground resources because they would generally be constructed in previously disturbed areas.

5.11.5 What measures are proposed to reduce or minimize impacts to historic and cultural resources?

To minimize impacts to historic and cultural resources, the City would conduct project-level cultural resource surveys prior to construction. These surveys would identify any belowground and aboveground historic and

cultural resources that may be impacted by the proposed project. The City would consult with stakeholders as required by the regulatory trigger (i.e., Section 106, Washington State Governor's Executive Order 05-05, or SEPA) to avoid, minimize, and mitigate potential impacts to identified resources.

If historic properties are identified during project-level cultural resource surveys, the City would follow the applicable regulatory process to evaluate those resources for their eligibility to relevant historic registers (i.e., National Register, Washington Heritage Register, or Seattle Landmarks) and consult with stakeholders regarding resource-specific mitigation measures.

For work within City of Seattle historic districts, review by the Seattle Landmarks Preservation Board or district-specific review boards would be required. Proposed changes to a designated Seattle Landmark, or proposed work adjacent to a designated Seattle Landmark, requires review by the Seattle Landmarks Preservation Board which manages proposed changes through the Certificate of Approval process.

Under Section 106 of the National Historic Preservation Act, proposed impacts to a National Register-listed property or district would require review by DAHP (acting as Washington's State Historic Preservation Office, or "SHPO") to determine if there would be any adverse effects on listed properties.

The City would follow best management practices to reduce potential impacts to historic properties from vibration, dust, noise, and visual alterations. Practices to minimize potential vibration and dust impacts include property-specific vibration monitoring; regular washing of construction equipment, vehicles, and tires before exiting the project locations; and controlling stormwater runoff from distributing sediments onto surrounding properties. For potential visual and audible impacts that would diminish the integrity of a property's significant historic features, mitigation measures may include screening off the project location or reducing construction activity during the property's peak usage time, such as open hours for a park or church.

5.12 Transportation

The description of potential transportation impacts provided in this Draft EIS is programmatic. The types of impacts that could be expected from implementation of the Plan alternatives are generally discussed, but site-specific impacts are not evaluated. Site-specific, project-level transportation analysis would be conducted prior to implementation of each project.

5.12.1 What potential construction impacts are common to all of the alternatives?

The following sections describe the general types of transportation impacts that could occur with the range of CSO control projects proposed as part of all four LTCP options.

5.12.1.1 Construction Truck Trips

Construction activities that generate truck trips include mobilization of construction equipment and materials to the site, transport of excavated material away from the site, and demobilization of construction equipment away from the site when construction is complete. The expected number of truck trips generated by construction activities varies greatly among the options. For example, 300 total truck round trips may be generated for minor conveyance construction, while over 106,000 total truck round trips may be generated to construct the Shared Ship Canal Tunnel.

Construction truck routes typically follow the most direct paths to and from the regional highway system using arterial streets. Construction transportation is often limited during commuter peak periods (typically the most congested hours of the day) to reduce construction truck delays due to commuter congestion and in some cases to minimize their impact on roadway operations.

The duration over which construction-generated traffic would occur also would vary. Some storage projects may require one year or less to construct, while the Shared Ship Canal Tunnel may require up to seven years. Construction of sewer system improvements would result in minor transportation impacts, similar to those described with the No Action Alternative. Figure 5-11 shows total estimated truck trips by Plan neighborhood area under each LTCP option. The differences in the number of truck trips expected among the options are further described in the following sections.

Key Findings

Transportation

Construction of CSO control projects under the *LTCP Alternative* or *Integrated Plan Alternative* would result in moderate to substantial, adverse transportation impacts for temporary periods ranging from one to seven years. Potential construction-related transportation impacts would be highly visible and are of concern to local residents, business owners, and commuters. Transportation impacts would include increases in traffic volumes due to construction-generated truck trips and commute trips of construction workers, and roadway lane and sidewalk closures where construction activities take place.

The primary differences in potential transportation impacts of the LTCP options are related to the length of construction period, the estimated number of truck trips, and the road network in the affected neighborhood. More dispersed impacts would occur under the Neighborhood Storage Option. Impacts would be higher but concentrated at fewer locations under the shared options.

For the tunnel options, if the tunnel portals are located near Lake Washington, Elliott Bay, or the waterway that connects them, it could be possible to transport excavated material by barge rather than by truck. This would reduce truck trips on the surrounding roadway system related to tunnel excavation.

LTCP Options

ESTIMATED TRUCK TRIPS¹ BY NEIGHBORHOOD

A - NEIGHBORHOOD STORAGE OPTION²

1 SHIP CANAL NEIGHBORHOODS	51,500
2 LAKE WASHINGTON NEIGHBORHOODS	4,500
3 ELLIOTT BAY/LAKE UNION NEIGHBORHOODS	900
4 LONGFELLOW CREEK/DUWAMISH NEIGHBORHOODS	6,200

B - SHARED WEST SHIP CANAL TUNNEL OPTION³

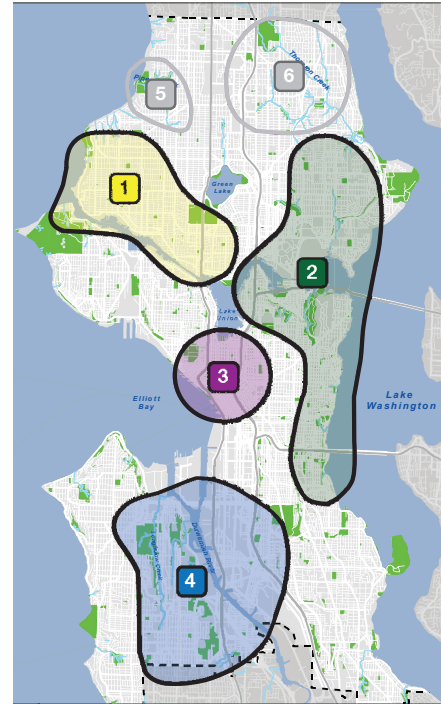
1 SHIP CANAL NEIGHBORHOODS	51,900
2 LAKE WASHINGTON NEIGHBORHOODS	4,300
3 ELLIOTT BAY/LAKE UNION NEIGHBORHOODS	900
4 LONGFELLOW CREEK/DUWAMISH NEIGHBORHOODS	3,700

C - SHARED SHIP CANAL TUNNEL OPTION⁴

1 WEST SHIP CANAL TUNNEL OPTION	100,000
2 LAKE WASHINGTON NEIGHBORHOODS	6,000
3 ELLIOTT BAY/LAKE UNION NEIGHBORHOODS	500
4 LONGFELLOW CREEK/DUWAMISH NEIGHBORHOODS	7,000

D - SHARED STORAGE OPTION⁵

1 SHIP CANAL NEIGHBORHOODS	24,000
2 LAKE WASHINGTON NEIGHBORHOODS	33,000
3 ELLIOTT BAY/LAKE UNION NEIGHBORHOODS	900
4 LONGFELLOW CREEK/DUWAMISH NEIGHBORHOODS	4,700



- 1 SHIP CANAL**
- 2 LAKE WASHINGTON**
- 3 ELLIOTT BAY/LAKE UNION**
- 4 LONGFELLOW CREEK/DUWAMISH**

LEGEND

Approximate Number of Truck Trips

¹ City-only and shared facilities only; all details approximate.
² 9 King County-only CSO facilities would also be constructed.
³ 8 King County-only CSO facilities would also be constructed.
⁴ 6 King County-only CSO facilities would also be constructed.
⁵ 6 King County-only CSO facilities would also be constructed.

SOURCE: SPU, 2013; CH2M Hill, 2013.

Figure 5-11. LTCP Options Estimated Truck Trips by Neighborhood Area.

Storage Pipes

Total construction truck trips are expected to range from 500 to 2,600 at each storage pipe construction location, depending on the diameter and length of the pipe. With storage pipe construction lasting generally between 1.5 to two years at each location, an average of approximately 1 to 6 truck round trips per day would occur at each location. However, during peak construction activities, up to 24 truck round trips per day could occur. This range of volumes is low compared to typical background traffic on city arterials. Average increases of 1 to 3 round trips per hour are not expected to adversely affect roadway operations and would not likely be noticeable to other drivers.

Storage Tanks

Total construction truck round trips are expected to range from 2,000 to 16,200 at each location, depending on the size of the tank. With expected construction duration of two to five years at each location, this averages to about 4 to 16 truck round trips per day per neighborhood location. However, during peak construction activities, 20 to 80 truck round trips per day could occur. The truck volumes generated by storage tank construction would be relatively low compared to typical background traffic on city arterials. Average increases of 1 or 2 round trips per hour are not expected to adversely affect roadway operations and would not likely be noticeable to other drivers. Increases of up to 10 round trips per hour during peak activity are also not expected to affect roadway operations, but they could be noticeable to other drivers.

Storage Tunnels

Total construction trips are expected to be over 60,000 truck round trips for the Shared West Ship Canal Tunnel Option and over 106,000 truck round trips for the Shared Ship Canal Tunnel Option. In addition to truck trips generated by excavation that would primarily be generated at the tunnel entrances, these options include pipeline, pump station, and micro-tunnel elements that would generate trips in several neighborhoods. With expected construction duration of about 3.5 years, truck trips generated by the Shared West Ship Canal Tunnel excavation are expected to average approximately 40 truck round trips per day, with about 60 round trips per day occurring during times of peak activity. With expected construction duration of about six to seven years, truck trips generated by the Shared Ship Canal Tunnel excavation are expected to average approximately 50 truck round trips per day, with about 100 round trips per day occurring during times of peak activity. (Truck trip impacts were calculated using a six-year construction period, to be conservative.) Increases of 5 to 13 round trips per hour are relatively low compared to typical background traffic on city arterials and are not expected to adversely affect roadway operations. However, at the upper end of the range, the truck trips could be noticeable to other drivers. Depending on the access location, the potential hourly volume of trucks could require supplemental traffic control (such as flaggers, signage, or temporary signals).

The pipeline, pump station, and micro-tunnel elements associated with the tunnel options are expected to generate truck trips in the neighborhoods where they would be constructed. Construction duration of these elements is expected to range from six months to two years. Pipeline construction is expected to generate an average of 6 to 10 round truck trips per day, with up to 18 round trips per day occurring during peak construction activity. Pump station construction is expected to generate an average of 1 to 5 round truck trips per day, with up to 10 round trips per day occurring during peak construction activity. Micro-tunnel construction is expected to generate an average of 3 to 7 round truck trips per day, with 18 to 60 round trips occurring during peak construction activity. The truck volumes generated by construction of these elements would be relatively low compared to typical background traffic on city arterials. Average increases of 1 or 2 round trips per hour are not expected to adversely affect roadway operations and would not likely be noticeable to other drivers. Increases of

up to 8 round trips per hour during peak activity are also not expected to affect roadway operations, but they could be noticeable to other drivers.

Flow Transfers and Flow Diversions

Total construction truck trips are expected to range from 300 to 1,100 at each flow transfer or flow diversion construction location. With construction lasting one year or less at each location, this averages to about 3 to 4 truck round trips per day per neighborhood location. However, during peak construction activities, 12 to 16 truck round trips per day could occur. This range of volumes is low compared to typical background traffic on city arterials. Average increases of 1 to 2 round trips per hour are not expected to adversely affect roadway operations and would not likely be noticeable to other drivers.

5.12.1.2 Construction Employee Commute Trips

Construction activities generate commute trips for construction workers who travel to and from the sites. Because the neighborhood areas are located in urban settings where parking may be limited or priced, it is expected that construction employee vehicle trips would be limited only to the number that can park within the construction staging area, and that workers may either travel via transit or be shuttled from an offsite location such as a park-and-ride lot.

5.12.1.3 Road Closures and Associated Traffic, Transit, Non-Motorized Impacts, and Parking Impacts

Storage Pipes

Storage pipes would be located within roadway rights-of-way, requiring excavation beneath roadway lanes on existing city streets. Installation of pipes ranging from 4 to 5 feet in diameter may require closure of only one traffic lane, but installation of larger diameter pipes (10 to 12 feet) could require two lanes to be closed. In addition, construction could temporarily reduce on-street parking, require transit route detours, and require closure of sidewalks and bicycle lanes located within or adjacent to the project footprint. The potential for impact varies depending on the street type. For example, many local access streets are narrow (often 25 feet wide), so lane closures may also affect on-street parking in the vicinity of construction activities. In addition, local access streets typically have a higher density of driveways, so maintaining access to homes and businesses during construction would typically be more challenging on local access streets than on arterial streets. Pavement on local access streets is typically designed to carry lower traffic volumes and lighter vehicles, so it would be expected to deteriorate more quickly with construction truck traffic.

For arterials that have more than one lane in each direction (including both travel and parking lanes), it may be feasible to close one or more lanes and still maintain traffic flow on the roadway without requiring a detour. However, arterial streets also carry higher traffic volumes and provide the primary means for vehicle traffic traveling through a neighborhood. Transit routes and stops are typically located on arterial streets. Lane closures on high-volume arterials can result in congested conditions and traffic delays. Arterials also provide local access (via driveways) to homes and businesses located along them; lane closures and street excavation must be implemented in a way that maintains local access to adjacent properties. Pavement on arterial streets is typically designed to carry higher traffic volumes and heavier vehicles, so it would better accommodate construction truck traffic.

Neighborhoods with a limited number of route alternatives, such as those that do not have a grid network of arterials or local access streets, would likely be more severely impacted by lane or road closures. Lane closures or full closures of streets in these areas could result in adverse impacts to residents and businesses.

Depending on the characteristics of a road, construction within a traffic lane could require that the sidewalk and/or bicycle facilities adjacent to the segment under construction be narrowed or closed. If sidewalks are present on both sides of a street, pedestrians could be detoured to the sidewalk across the street. If not, it would be necessary to delineate a pedestrian pathway that separates them from construction activities. Special accommodations would be needed to retain pedestrian access to homes and businesses along the construction route if a sidewalk is closed. If a street has a separate bicycle lane or marked sharrows, it may experience a higher level of bicycle traffic. However, regardless of whether marked bicycle facilities exist, lane closures and detours would also need to be designed in a way to safely accommodate bicycle traffic.

If a lane closure occurs on a street with transit service, transit routes may need to be detoured. Transit stops may need to be temporarily closed or relocated. In addition, special accommodations would be needed if construction occurs within streets with transit infrastructure such as overhead trolley lines or raised transit stop islands.

It is likely that on-street parking would need to be prohibited along a roadway segment under construction. This would reduce the publicly available parking supply in the area during the construction period. The level of impact resulting from a reduction of on-street parking supply would vary depending on the neighborhood. For neighborhoods where on-street parking is the primary source of supply and parking utilization is high, the impact would be greater. In neighborhoods with excess available on-street parking supply, the impact would be minimal.

Storage Tanks

Storage tanks would be located on city or private property outside of the roadway right-of-way and generally would not require extensive excavation in city streets. It is possible that street lanes and sidewalks located adjacent to the tank sites would need to be closed or narrowed during construction of connections. This would result the same types of potential impacts as those described for the storage pipes, but to a less extensive degree.

Storage Tunnels

The storage tunnels would be excavated with a tunnel boring machine. Excavation would not be necessary in city streets except possibly at the tunnel entrance portals. It is possible that street lanes and sidewalks located adjacent to the tunnel endpoints would need to be closed or narrowed during construction. This would result in the same types of potential impacts as those described for the storage pipes, but to a less extensive degree.

The pipeline and micro-tunnel elements associated with the storage tunnel options would require in-street construction, similar to that described above for storage pipes. Pump stations would be located outside of roadway right-of-way, with potential impacts similar to those described for storage tanks.

Flow Transfers and Flow Diversions

Flow transfers and flow diversions would require minor construction. It is possible that minor in-street construction would occur, requiring street lanes and sidewalks to be closed or narrowed during construction. This would result in the same types of potential impacts as those described for the storage pipes, but with less extensive construction duration and intensity.

5.12.2 What are the potential transportation impacts of the LTCP options?

Table 5-12 summarizes the general types of transportation impacts that could occur with the type of CSO control projects proposed under all four LTCP options. Each of the four LTCP options would cause different levels of impacts to different neighborhoods. Figures 5-6 through 5-9 summarize the total construction truck round trips estimated to be generated by the LTCP options within the potentially affected neighborhoods.

Table 5-12. Summary of Potential Transportation Impacts for LTCP Options

Neighborhood Storage Option*

The Neighborhood Storage Option would have a high level of overall transportation impact. It would require extensive roadway lane and sidewalk closures throughout the city to accommodate storage pipe and tank construction from the City and King County independently constructed CSO storage facilities.

The neighborhoods that would be most affected are as follows:

- **Ship Canal Neighborhoods.** Construction of storage tanks in the Ballard and Fremont/Wallingford neighborhoods would result in an estimated 12,000 truck round trips (average 9 truck round trips per weekday over a 5-year duration) in Ballard, and an estimated 7,000 total truck round trips (average 13 truck round trips per weekday over a 3.5-year duration in Fremont/Wallingford). However, during periods of peak activity, up to 45 truck round trips per day could occur. The majority of the truck travel to and from these neighborhoods could be made using arterials. In addition, these neighborhoods have a grid of arterial and local access streets that could provide detour opportunities where lane closures are necessary. Trucks traveling to and from Ballard would have the farthest to travel of the three neighborhood areas to access the regional highway system, and their routes could potentially include arterials through the Fremont, Wallingford, or Green Lake neighborhoods. In Magnolia, installation of storage pipe within the right-of-way would require approximately 530 linear feet of roadway lane closure and potentially adjacent sidewalk closures, lasting about 1.5 years. The total 600 truck round trips generated would average to about 2 truck round trips per weekday, occurring at points along the length of the pipeline. However, during periods of peak activity, up to 8 truck round trips per day could occur. Topographical constraints limit access to and through the neighborhood, and there would be a limited number of route alternatives if detours due to lane closures were needed.
- **Lake Washington Neighborhoods.** Work to construct storage pipes in Leschi, Portage Bay and Montlake, and an additional storage tank in Leschi, would require work in road right-of-way and potential lane and sidewalk closures, lasting about 1.5 to 2 years. The length of storage pipe is anticipated to be up to 210 feet in each neighborhood. The total 900 to 2,000 truck round trips generated in each neighborhood would average 2 to 4 truck round trips per weekday, occurring at points along the length of the pipelines. However, during periods of peak activity, up to 8 truck round trips per day could occur in Portage Bay, 16 round trips in Montlake, and up to 20 round trips in Leschi. Topographical constraints limit access to and through these neighborhoods, and there would be a limited number of route alternatives if detours due to lane closures were needed. In the North Union Bay area, this option would require minor improvements to the existing sewer system, which would generate minimal transportation impacts.
- **Longfellow Creek/Duwamish Neighborhoods.** Work to construct storage pipes in North Delridge, South Delridge and Duwamish, and a storage tank in East Waterway would require work in road right-of-way and potential lane and sidewalk closures, lasting about 1.5 to 2 years. The total 500 to 2,600 truck round trips generated in each neighborhood would average 1 to 6 truck round trips per weekday, occurring at points along the length of the pipelines. However, during periods of peak activity, 4 to 8 truck round trips per day could occur in North Delridge and Duwamish, and up to 25 truck round trips per day could occur in South Delridge and East Waterway. The majority of the truck travel to and from these neighborhoods could be made using arterials. In addition, these neighborhoods have a grid of arterial and local access streets that could provide detour opportunities where lane closures are necessary.
- **Central Waterfront.** Installation of storage pipe within the right-of-way would require approximately 600 linear feet of roadway lane closure and potentially adjacent sidewalk closures, lasting about 2 years. The total 900 truck round trips generated would average to about 2 truck round trips per weekday, occurring at points along the length of the pipeline. However, during periods of peak activity, up to 8 truck round trips per day could occur. The majority of the truck travel to and from these neighborhoods could be made using arterials. In addition, this neighborhood has a grid of arterial streets that could provide detour opportunities where lane closures are necessary.

Table 5-12. Summary of Potential Transportation Impacts for LTCP Options**Shared Storage Option**

The shared tanks constructed with the Shared Storage Option would eliminate or reduce the facilities needed in the Leschi and Montlake areas, compared to the Neighborhood Storage Option, but would increase transportation impacts in the Fremont/Wallingford and North Union Bay areas. In East Waterway, this option would require in-street construction, compared to construction of a storage tank with the Neighborhood Storage Option.

Total construction truck round trips are estimated to range from 11,000 to 16,200 at each neighborhood tank location, depending on the size of the tank. With expected construction duration of 3 to 4.5 years at each location, this averages to about 13 to 18 truck round trips per day per neighborhood location. However, during periods of peak construction activity, 65 to 80 truck round trips per day could be generated at the storage tank sites, which is higher than the expected peak activity at the tank sites with the Neighborhood Storage Option.

The neighborhoods that would be most affected are as follows:

- Fremont/ Wallingford. Storage tank construction would generate more truck trips than the Neighborhood Storage Option – 11,000 total truck round trips over 3 years averages to 14 round trips per day.
- North Union Bay. Construction of a shared storage tank would generate 16,200 truck trips over 4 years – an average of 16 truck trips per weekday generated at the tank site.
- Montlake. Construction of a shared storage tank would result in increased truck trips at the tank site (15,600 total truck round trips over 4.5 years, average 13 per day), compared to the storage pipes that would be constructed with the Neighborhood Storage Option. However, less in-street work and fewer lane closures would be needed. Due to limited arterials in this area combined with topographical constraints, this option would have less impact on Montlake than the Neighborhood Storage Option because it would not require major lane closures or detours.
- East Waterway. Minor in-street construction would potentially occur, requiring street lanes and sidewalks to be closed or narrowed during construction. About 1,100 total construction truck round trips are expected over a 1-year period, averaging about 4 truck round trips per day. However during periods of peak construction activity, up to 16 truck round trips per day could occur. This is lower than the 5 to 25 truck trips per day expected to result from storage tank construction under the Neighborhood Storage Option.
- Other neighborhoods. In Leschi, the shared storage tank would eliminate the need for storage pipe; therefore, transportation impacts would be reduced relative to the Neighborhood Storage Option. Transportation impacts in the Ballard, Magnolia, Portage Bay, North and South Delridge, Duwamish, and Central Waterfront areas would be similar to the Neighborhood Storage Option.

Shared West Ship Canal Tunnel Option

Elements of the Shared West Ship Canal Tunnel Option that would generate truck trips include tunnel excavation and construction of supporting pipeline, pump station and micro-tunnels. An estimated 60,000 truck round trips are anticipated for the Shared West Ship Canal Tunnel Option, generated primarily in Ballard. Overall, this option would result in substantially more truck trips over a longer period in Ballard compared to the Neighborhood Storage and Shared Storage Options.

The neighborhoods that would be most affected are as follows:

- Ballard. Truck trips resulting from tunnel excavation would primarily be generated at the launch portal location, which would likely be located in Ballard. With expected construction duration of 3.5 years, truck trips generated by the tunneling are expected to average 40 per day, with up to 60 round trips per day occurring during periods of peak construction activity. Supporting pipeline construction is expected to generate an average of 6 truck round trips per day, and up to 18 round trips per day during peak construction activity. Pump station construction is expected to generate an average of 1 truck round trip per day, and up to 2 truck round trips per day during peak construction activity. Micro-tunnel construction would generate an average of 5 truck round trips per day, and up to 54 round trips during peak construction activity, spread out among four locations in Ballard. The majority of the truck travel to and from Ballard could be made using arterials.
- Fremont/Wallingford and Magnolia. The majority of truck trips in the Ship Canal Neighborhoods are expected to be generated in Ballard. Transportation impacts in Fremont/Wallingford and Magnolia with this option would be lower than impacts with the Neighborhood Storage Option or Shared Storage Option.
- Other neighborhoods. The transportation impacts in all other neighborhoods would be the same as the Neighborhood Storage Option.

Table 5-12. Summary of Potential Transportation Impacts for LTCP Options**Shared Ship Canal Tunnel Option**

The Shared Ship Canal Tunnel Option would replace the storage tanks and pipes in the Ship Canal and Lake Washington Neighborhoods (under the Neighborhood Storage Option) with a large tunnel across the length of the Ship Canal. Elements of the Shared Ship Canal Tunnel Option that would generate truck trips include tunnel excavation and construction of supporting pipeline, pump stations, and micro-tunnels in the Ship Canal and Lake Washington Neighborhoods. An estimated 106,000 truck round trips are anticipated for the Shared Ship Canal Tunnel Option. Overall, this option would result in substantially more truck trips over a longer period south of the Lake Washington Ship Canal, where the launch portal would likely be located, compared to the other options.

The neighborhoods that would be most affected are as follows:

- Ship Canal Neighborhoods. Truck trips resulting from tunnel excavation would primarily be generated at the launch portal location, which would likely be located on the south side of the Lake Washington Ship Canal. With estimated construction duration of 7 years, truck trips generated by the tunneling are expected to average up to 50 per day. Up to 100 round trips per day would occur during periods of peak construction activity. The majority of the truck travel to and from the area could be made using arterials. Supporting pipeline, pump station, and micro-tunnel construction would generate additional truck trips. Supporting pipeline construction is expected to generate an average of 10 truck round trips per day in Ballard and Fremont, and up to 18 round trips per day during peak construction activity. Pump station construction is expected to generate an average of 1 to 2 truck round trips per day, and up to 10 truck round trips per day during peak construction activity, at two locations in Ballard. Micro-tunnel construction would generate an average of 6 truck round trips per day, and up to 59 round trips during peak construction activity, spread out among 13 locations in Ballard.
- Lake Washington Neighborhoods. Supporting pipeline construction is expected to generate an average of 10 truck round trips per day, and up to 18 round trips per day during peak construction activity, in North Union Bay, Montlake, and Leschi. Pump station construction is expected to generate an average of 1 to 5 truck trips per day, and up to 10 truck trips per day during peak construction activity, at one location in Montlake and one location in Leschi. Micro-tunnel construction would generate an average of 3 to 7 truck round trips per day, and 18 to 37 round trips during peak construction activity, spread out among two locations in Montlake, two locations in Portage Bay, and five locations in North Union Bay.
- North Delridge. About 1,200 total construction truck round trips are expected to be generated over a 1-year period, averaging about 5 truck round trips per day. However, during periods of peak construction activity, up to 20 truck round trips per day could occur. This is higher than the 2 to 8 truck trips per day expected to result from storage pipe construction under the other options.
- Duwamish. About 3,000 total construction truck round trips are expected to be generated over a 1-year period, averaging about 12 truck round trips per day. However, during periods of peak construction activity, up to 48 truck round trips per day could occur. This is higher than the 1 to 4 truck trips per day expected to result from storage pipe construction under the other options.
- Other neighborhoods. Transportation impacts in the Magnolia neighborhood would be the same as for the Shared West Ship Canal Tunnel Option. In the South Delridge, East Waterway, and Central Waterfront areas, the transportation impact would be the same as for the Neighborhood Storage Option.

*The Neighborhood West Ship Canal Tunnel would have similar impacts in Ballard and Fremont/Wallingford as described for the Shared West Ship Canal Tunnel Option.

Notes:

Average and peak truck trip estimates are round trips – each round trip reflects one inbound and one outbound trip. While average trips per day are presented, it is likely that the number of daily truck trips would fluctuate according to the construction activities that occur from day to day, with the estimated peak numbers reflecting the highest volumes expected. Average and peak trips per day assume that construction would occur on weekdays (260 days per year).

5.12.3 What are the potential transportation impacts of the Integrated Plan Alternative?

Under the Integrated Plan Alternative, completion of selected CSO control projects under the LTCP would be deferred so that the City can focus on implementing stormwater projects. As a result, construction impacts associated with certain CSO control projects in Delridge, East Waterway, Duwamish, Portage Bay, and Montlake neighborhoods would occur later (after 2028) under the Integrated Plan Alternative. Consequently, those neighborhoods would experience fewer near-term construction-related transportation impacts.

NDS Partnering would occur in neighborhoods in the Piper's Creek, Thornton Creek, and Longfellow Creek areas. Neighborhoods would voluntarily sign up for the project, and areas would be identified for construction of bioretention facilities that may also include traffic calming and other local street improvements. Potential impacts related to construction would be short-term and localized, including a small number of construction vehicle trips, and lane or sidewalk narrowings or closures adjacent to construction activities.

The South Park Water Quality Facility is expected to be constructed on City-owned property, in an industrially zoned neighborhood with adequate access. Construction impacts would primarily consist of a small number of construction vehicle trips and are expected to be minimal.

Arterial street sweeping expansion does not involve construction and consists of expanding the extent of a program that is already in place. No construction impacts are expected.

5.12.4 What are the potential transportation impacts of the No Action Alternative?

Construction of sewer system improvements would generally occur within underground vaults/chambers at existing CSO or stormwater facilities, and to a lesser extent within street rights-of-way. Temporary lane closures could be required at these access locations, but they would be expected to be localized and of short duration. These projects could also generate a small number of construction truck trips.

A small number of truck trips could be generated during installation of natural drainage systems completed as part of ongoing programs. Construction of rain gardens within the public right-of-way could require short-term lane closures. Each roadside rain garden would be expected to generate up to 10 truck trips over a construction period that could last up to five days. Short-term lane closures, if required, would be limited to a day or two.

A very small number of truck trips (less than 10) would be generated under the RainWise program. These projects are typically constructed at the parcel scale rather than at a block-level scale as with roadside rain gardens. No disturbance of roadways or sidewalks would occur with construction of RainWise projects and transportation impacts are expected to be negligible.

5.12.5 What measures are proposed to reduce or minimize transportation impacts?

As described earlier, site-specific transportation analysis would be conducted prior to implementation of projects. If potential operational or safety impacts are identified through project-level analysis, mitigation measures would be identified to minimize or avoid those impacts. Transportation-related mitigation measures would depend on the exact type and size of the proposed improvement but could include the following.

- Develop a Traffic Control Plan for any work within the public right-of-way that affects vehicular, transit, bicycle, or pedestrian traffic.

- Avoid creating additional delay at congested intersections either by choosing construction truck routes that avoid these locations, or constructing during nonpeak times of day.
- Maintain access for driveways and private roads.
- Provide adequate off-street parking areas at designated staging areas for construction-related vehicles.
- Provide onsite loading areas for removal and delivery of material.
- Provide a plan for construction workers to commute via alternative modes or ridesharing, to minimize added vehicle trips and parking demand at the site.
- Maintain pedestrian and bicycle access and circulation during project construction. If construction encroaches on a sidewalk, a safe detour should be provided for pedestrians at the nearest crosswalk. If construction encroaches on a bike lane, post warning signs that indicate bicycles and vehicles are sharing the roadway.
- Provide traffic controls such as flaggers and traffic control officers as appropriate.
- Maintain access to transit services and coordinate with transit agencies (King County Metro, Sound Transit, Community Transit) if transit stop closures or route detours are needed.
- Coordinate with the Seattle School District to ensure that access to school buses is maintained.
- Post standard construction warning signs in advance of the construction area and at any intersection that provides access to the construction area.
- Provide access for emergency vehicles at all times.
- Provide written notification to contractors regarding appropriate routes to and from construction sites, and weight and speed limits for local roads used to access construction sites.
- Coordinate with the local neighborhoods to ensure that access to residences and businesses is adequately maintained, and that any additional potential issues unique to the neighborhood are identified and addressed.
- Repair or restore the roadway right-of-way to its original condition or better upon completion of the work.
- Comply with Seattle Department of Transportation (SDOT) requirements to schedule work on arterial streets and sidewalks outside of peak traffic hours unless otherwise authorized by the City Traffic Engineer.
- Follow the Holiday Moratorium for construction, which indicates that no work shall be scheduled on streets or sidewalks within the Central Retail District and Pioneer Square from Thanksgiving Day through New Year's Day.

Transportation-related mitigation measures specific to the Shared West Ship Canal Tunnel and Shared Ship Canal Tunnel Options could include the following:

Barge Transport of Excavated Materials for Shared West Ship Canal Tunnel Option and Shared Ship Canal Tunnel Option. If the tunnel portals are located near Lake Washington, Elliott Bay, or the waterway that connects them, it could be possible to transport excavated material by barge rather than by truck. This could eliminate an estimated 16,000 truck round trips (average 40 and peak 60 truck round trips per day, for a 1,200-weekday duration) for the Shared West Ship Canal Tunnel Option, and an estimated 32,000 truck round trips (average 50 and peak 100 truck round trips per day, for a 1,810-weekday duration) for the Shared Ship Canal Tunnel Option. When the eliminated truck trips are divided by day and by hour, barging would cause a moderate reduction in impacts on roadway traffic operations. The number of trucks removed from roadways would be high enough to be noticeable to drivers, as well as to residents and businesses located along truck haul routes. Using barging as mitigation would require additional evaluations at the project level to determine feasibility of constructing ancillary facilities, including a conveyor system and a dock to support the barge, and to assess agency permit/approval feasibility. Based on preliminary Plan-level information, barge transport would involve an estimated 3 barge trips per week during active tunneling. The barges would act as normal marine traffic through the Ship Canal, Ballard Locks, and Puget Sound.

5.13 Utilities

This section describes the types of impacts that could occur to utilities (largely wastewater and water utilities) within the Plan area during construction of projects included under the Plan alternatives. Potential impacts to other utilities including water, electrical, natural gas, and communications are highly project-specific and would be evaluated at the future project implementation stage.

5.13.1 What potential construction impacts are common to all of the alternatives?

Construction of storage tanks, pipes, tunnels, pump stations, and appurtenant facilities will require extensive coordination with existing utilities. The LTCP is proposed to be constructed in an area that is heavily developed, with a full range of underlying utilities, including electrical power, cable, natural gas, storm and sanitary sewer, water, and others. During project design, City engineers will identify all existing utilities and attempt to avoid impacts to utilities to the extent possible. However it is not likely that the projects will be able to be constructed without encountering utility conflicts. The City will work with affected utilities to coordinate construction. Construction of combined sewer system improvements would involve building new portions of the system (e.g., new sewer pipes to convey flows to CSO storage facilities). This construction would not interrupt sewer service to existing customers.

In general, the potential to affect existing utility corridors is lower for construction of tunnels because they are constructed deeper underground, below most utilities. Local connections to the tunnel and pump stations would have the potential to encounter utilities at shallow depths. Conveyance connections to the tunnels and portal construction have the potential for surface disturbance and accompanying impacts to utilities.

Because the City's wastewater collection system sends wastewater flows to King County for treatment, it will be important for any construction-related flow modifications to be coordinated closely with King County. Ongoing discussions with King County will continue, and agreements will be negotiated prior to implementing the LTCP, as described in Section 5.13.5.

5.13.2 What are the potential utilities impacts of the LTCP options?

All of the LTCP options have the potential to result in utilities conflicts during construction, as described in Table 5-13.

Key Findings

Utilities

Construction of CSO control facilities under the *LTCP Alternative* would occur in areas highly constrained by existing underground and overhead utilities, requiring extensive coordination with existing utilities to avoid conflicts. The primary difference in impacts among the options relates to the number of new storage facilities constructed and the amount of new conveyance (pipelines) required to transport flows to the new storage facilities. Several of the options include flow diversions to King County facilities. Coordination with King County would be needed to ensure minimal impacts to King County facilities during construction. It would also be important to coordinate with SPU to ensure that construction impacts to major water mains are avoided.

Under the *Integrated Plan Alternative*, localized belowground utilities could be affected by conveyance line construction for the South Park Water Quality Facility. There may be minor utility conflicts associated with NDS Partnering projects.

Table 5-13. Summary of Potential Utilities Impacts for LTCP Options**Neighborhood Storage Option***

This option has the greatest number of City and King County independently constructed CSO storage facilities. Construction of tanks and pipes distributed throughout the Plan area would have substantial potential for impacts to utilities due to the magnitude of excavation, dewatering, and special construction requirements, such as installation of shoring (sheet piles).

Storage tank and storage pipe construction would result in an approximate 7.5 acres of surface disturbance. The neighborhoods that would be most affected are as follows:

- Ship Canal Neighborhoods. Large storage tanks and accompanying pipeline conveyance would be built in both the Ballard and Fremont/Wallingford neighborhoods, resulting in approximately 2 acres of surface disturbance at each site. The construction would occur in highly urbanized areas, resulting in potential for utility conflicts. Extensive coordination with existing utility providers would be required.
- Lake Washington Neighborhoods. Three pipes, one storage tank, and associated pump stations would be constructed in Leschi. This neighborhood includes steep slope areas, which will limit construction options. Building in existing roadways and rights-of-way will have high potential for utility conflicts.
- Longfellow Creek/Duwamish Neighborhoods. Three pipes and associated pump stations would be constructed in North and South Delridge neighborhoods, with accompanying utility conflicts.
- East Waterway. One tank would be constructed in East Waterway, resulting in approximately 1 acre of surface disturbance.

Shared Storage Option

While construction of storage tanks and storage pipes under this option would result in approximately 12 acres of surface disturbance (the highest of all the LTCP options), overall impacts would be reduced compared to the Neighborhood Storage Option because the shared tanks would eliminate the need for several City and King County independently constructed CSO storage facilities. As noted for the Neighborhood Storage Option, all potentially affected neighborhoods are highly developed, and utility conflicts will be difficult to avoid.

The neighborhoods that would be most affected are as follows:

- Ship Canal Neighborhoods. Impacts of shared storage tanks would be similar to but greater than the Neighborhood Storage Option because the Fremont/Wallingford tank would be larger.
- Montlake. A shared storage tank with up to 2 acres of surface disturbance would be constructed. These neighborhoods contain steep slopes, which will constrain the location of tanks and pipes and could create potential for utility conflicts.
- Other neighborhoods would experience similar level of impacts as under the Neighborhood Storage Option except the East Waterway neighborhood, where a flow transfer with limited conveyance construction would replace the storage tank and cause potentially fewer utility impacts.

Shared West Ship Canal Tunnel Option

The Shared West Ship Canal Tunnel Option would result in total surface disturbance of 7 acres. Overall potential impacts to utilities would be reduced compared to the Neighborhood Storage Option as this option eliminates City and King County independently constructed CSO storage facilities that would otherwise be constructed in the same neighborhoods.

The neighborhoods that would be most affected are as follows:

- Ballard and Fremont/Wallingford. The storage tunnel would cause less surface disturbance than storage tanks, with disturbance limited to 4 acres split between the entry and exit portals. Potential impacts to utilities would be concentrated at the portals.
- Leschi. Impacts of constructing three pipes, one tank, and associated pump stations in the confined neighborhood would have generally the same potential impacts to utilities as the Neighborhood Storage Option.
- Other neighborhoods would have similar impacts as the Neighborhood Storage Option except in Magnolia and East Waterway. In Magnolia, a flow diversion to King County facilities would replace the storage pipe but would result in similar potential impacts to utilities. The East Waterway area would have the same flow diversion as under the Shared Storage Option.

Table 5-13. Summary of Potential Utilities Impacts for LTCP Options**Shared Ship Canal Tunnel Option**

Compared to all other LTCP options, the Shared Ship Canal Tunnel Option would have the fewest City and King County independently constructed CSO storage facilities, and therefore the lowest level of surface disturbance and accompanying impacts to utilities.

The neighborhoods that would be most affected are as follows:

- Ship Canal and Lake Washington Neighborhoods. Major construction impacts and potential utility conflicts would occur at the portal locations (up to 4 acres of disturbance).
- Other neighborhoods would have similar impacts or reduced impacts as compared to the Neighborhood Storage Option.

*The Neighborhood West Ship Canal Tunnel would have similar impacts in Ballard and Fremont/Wallingford as described for the Shared West Ship Canal Tunnel Option.

5.13.3 What are the potential utilities impacts of the Integrated Plan Alternative?

Impacts to public utilities under the Integrated Plan Alternative would be associated with localized belowground utilities potentially affected by conveyance line construction for the South Park Water Quality Facility. There may be minor utility conflicts associated with NDS Partnering projects.

5.13.4 What are the potential utilities impacts of the No Action Alternative?

Under the No Action Alternative, construction-related impacts to public utilities would occur under ongoing programs. However, impacts would be lower than those expected to occur under the LTCP or Integrated Plan Alternatives.

5.13.5 What measures are proposed to reduce or minimize impacts to utilities?

For both the LTCP Alternative and the Integrated Plan Alternative, the City would take measures to help reduce or eliminate potential impacts to utilities. The measures would include, but are not limited to, those listed below:

- Coordinate with other utilities and transportation departments to plan for shared construction and to avoid consecutive construction projects (CSO control projects, road construction, other underground utilities).
- Provide advance notice and coordinate with affected utilities to minimize disruption of services.
- Adhere to the City's design criteria for the clearance of water mains and other utilities as outlined in Section 1-07.17 of the City of Seattle's Standard Specifications for Road, Bridge and Municipal Construction.
- For all LTCP options, the City would work together with King County to analyze and mitigate downstream operational and capital impacts to the King County System. If downstream impacts cannot be successfully mitigated, then there is the potential that the County will be required to build new or larger downstream capital facilities to accommodate the LTCP options. Even with adequate mitigation though, there would likely be an increase in the County's operations & maintenance (O&M) costs to account for the additional flows from the City's system.

5.14 Socioeconomics and Environmental Justice

This section describes the types of socioeconomic impacts that could occur within the Plan area during implementation of the alternatives. Potential effects on historically underserved communities and low-income populations (environmental justice populations) are also discussed.

Much of the basis for the evaluation of impacts in this section comes from analyses for other sections of this EIS (particularly Section 5.12, Transportation; Section 5.9, Land Use and Visual Quality; and Section 5.8, Noise and Vibration). The intent of this section is to synthesize the results of those analyses to provide a qualitative assessment of the potential socioeconomic and environmental justice impacts that could occur under the alternatives.

5.14.1 What potential construction impacts are common to all of the alternatives?

Construction of CSO storage facilities such as storage tanks and tunnels can have a short-term impact on socioeconomic conditions and environmental justice populations. These impacts would generally be common to all of the alternatives and options and are discussed below.

Neighborhood Disruption

Although the intensity of construction activity would vary depending on the project and the phase of construction, construction activities would be noticeable in adjacent neighborhoods for periods lasting from months to several years. These construction activities include increases in noise, ground-borne vibration, and dust, and the presence of construction workers and temporary use of properties for project construction. Neighborhoods adjacent and nearby to construction could experience impacts from detour routes, haul truck traffic, and relocated bus stops. Modified access from partial closures/detours of streets, sidewalks, bicycle paths/routes, and trails, and increased noise and construction activity in these areas, could discourage neighborhood activity and use of community resources. Although access would be modified during construction, it would not be eliminated.

These effects could reduce residents' perceived quality of life and limit connections to community resources, patronage at neighborhood businesses, or use of recreational amenities, especially those with access from affected roadways. While these impacts would not be permanent, a multi-year project could result in shifts of neighborhood patterns, such as access to businesses, parks, and other community resources and activities.

The availability of sites ranging from 0.5 acre to 2 acres that are suitable for large storage tanks is limited. This could result in the location of facilities in proximity to residential areas, or within community resources, such as parks. Economic and business impacts could result if economically important industrial or commercial lands are purchased or leased for this purpose.

Key Findings

Socioeconomics and Environmental Justice

Construction under the *LTCP Alternative* could cause a hardship for some residents due to disruptions to access and public transportation in project areas. There could be short-term impacts on existing economic conditions due to construction disturbance and temporary changes in the use of the land during construction. Construction associated with stormwater projects of the *Integrated Plan Alternative* would cause minor and temporary impacts to local communities and could alter access to community resources. Although construction effects may be substantial, none of the Plan alternatives would cause disproportionately high and adverse effects on minority and low-income populations.

Storage pipes would likely be located in paved or developed rights-of-way and could result in neighborhood disruption and business impacts from temporary changes in access. In general, noise impacts would be less than for storage pipes or tanks, as tunneling construction would occur underground, and the tunnel portals would likely be located in industrial or commercial areas that have high levels of existing noise.

Business Impacts / Economic Activity

The types of projects included under the LTCP options would have short-term impacts on existing economic conditions due to construction disturbance and temporary changes in the use of the land during construction. In some cases, these changes would be permanent, while in other cases, economic activity would largely be restored following construction. These impacts could include loss of direct access to existing uses or the need for substantial detours to reach properties. Business operators would be concerned about the potential for lost patronage during construction, which could occur in some locations. There would be a higher potential for long-term effects on businesses that experience impacts from multi-year construction projects than from shorter duration projects. There would also be moderate, short-term economic benefits to local businesses from construction contracts and spending by construction workers.

Some storage projects may take place near shorelines in industrial and commercial areas. Adverse economic impacts can occur if economically important land is purchased or leased for construction of tunnels or tanks, taking the land out of income-generating industrial or commercial uses during construction. While some, or all, of this land may be reclaimed or repurposed for industrial or commercial use after construction, reduced local economic activity could result during the construction period. If acquisition of private property or displacement of residents or businesses is necessary, the City would attempt to find willing property sellers and would follow federal, state, and local requirements for property acquisition, compensation, and relocation (Seattle Municipal Code Title 20). Because specific sites have not been chosen for the CSO control projects, this EIS does not evaluate impacts for specific locations.

Construction jobs and indirect jobs generated by construction of projects under the LTCP options would vary depending on the project and over the course of the LTCP implementation period. Construction would not be expected to result in a substantial change in the overall local labor force and employment characteristics for the City, but it would provide some benefit to the local economy and neighborhood businesses.

5.14.2 What are the potential socioeconomic impacts of the LTCP options?

Table 5-14 summarizes the types of socioeconomic and environmental justice impacts that could occur under the four options of the LTCP. Each of the four LTCP options would cause different levels of impacts to different neighborhoods. Impacts would be highest for those alternatives and storage options that have long construction periods, affect residential areas or community resources, or could require large areas of property acquisition or use of industrial or commercial lands. In general, impacts are similar to those described in Section 5.9, Land Use and Visual Quality, because socioeconomic impacts are strongly related to land use impacts.

Table 5-14. Summary of Potential Socioeconomic Impacts for LTCP Options**Neighborhood Storage Option***

This storage option has the greatest number of City and King County independently constructed CSO storage facilities, and therefore, the greatest number of areas that would experience construction disturbance and modified access to community resources and businesses during the construction period.

The neighborhoods that would be most affected include the Ballard, Fremont/Wallingford, Leschi, and Longfellow Creek/Duwamish neighborhoods, relating to impacts outlined in Sections 5.9 and 5.12.

Shared Storage Option

Shared storage tanks would reduce the total number of new storage tanks required in the city (by both the City and King County) and would reduce the number of storage pipes that would be constructed as compared to the Neighborhood Storage Option. This would reduce the number of areas where property acquisition is required, as well as the number of areas that would experience construction disturbance and modified access to community resources and businesses.

The neighborhoods that have the highest potential to be affected include Ballard, Fremont/Wallingford, North Union Bay, and Montlake, relating to construction-related impacts outlined in Section 5.9, Land Use, and Section 5.12, Transportation.

Shared West Ship Canal Tunnel Option

The Shared West Ship Canal Tunnel would eliminate the need for the City (and King County) independently constructed storage facilities in the Ship Canal and Lake Washington Neighborhoods. Therefore, fewer areas would experience construction disturbance and modified access to community resources or businesses. However, this option would concentrate impacts in the Ship Canal Neighborhoods.

In Ballard and Fremont/Wallingford, the storage tunnel would potentially result in less overall business or economic disruption because less property or easement acquisition would be needed to accommodate the tunnel portals. However, portal locations could require property acquisition of industrial or commercial lands along the Ship Canal in the vicinity of Ballard and Fremont/Wallingford neighborhoods during the 3.5-year construction duration. Economic and business impacts could result if economically important industrial or commercial lands are directly or indirectly affected. Truck trips for hauling tunnel spoils would be substantial in the vicinity of the Ballard and Fremont/Wallingford neighborhoods, and could reduce residents' quality of life and limit connections to community resources, patronage at neighborhood businesses, or use of recreational amenities, especially those with access from affected roadways.

If barges are used to haul tunnel spoils (to mitigate transportation impacts), there would be a potential for disruption to fishing areas in the Ship Canal. The Muckleshoot Indian Tribe's usual and accustomed fishing areas within the Plan area include all of Lake Washington and the Ship Canal, where barges would be loaded and transported. Usual and accustomed fishing areas are crucially important to the livelihood, lifestyle, and identity of Muckleshoot Indian Tribe members. Barging tunnel spoils could prevent or limit access to usual and accustomed fishing areas under one or both of the following conditions: (1) existing areas used by the Muckleshoot Indian Tribe for fishing would be partially obstructed; and (2) barge movements in the Ship Canal would interfere with tribal fishing. In-water construction (to construct or retrofit a pier to support the barge operation) could harm fish and adversely affect treaty fisheries resources by limiting the availability of fish for subsistence, ceremonial, and commercial purposes. If barging is advanced as a mitigation measure, the City would work with the Muckleshoot Indian Tribe to resolve fully and fairly issues associated with the impacts on treaty rights. Given the low numbers of estimated barge trips required to haul the tunnel spoils, adverse impacts from barge movements are not anticipated.

Table 5-14. Summary of Potential Socioeconomic Impacts for LTCP Options**Shared Ship Canal Tunnel Option**

The Shared Ship Canal Tunnel Option would affect the fewest neighborhoods throughout the city of all of the options, but it would also concentrate impacts in the Ship Canal and Lake Washington Neighborhoods. Overall, the potential to impact businesses and local economic activity would be reduced city-wide. Impacts would be similar to the West Ship Canal Tunnel but would occur over a longer duration (up to 7 years).

Economic and business impacts could result if economically important industrial or commercial lands are directly or indirectly affected. Truck trips for hauling tunnel spoils would be substantial in the vicinity of the south side of the Ship Canal and could reduce residents' quality of life and limit connections to community resources, patronage at neighborhood businesses, or use of recreational amenities, especially those with access from affected roadways. Potential impacts from barging are the same as discussed for the Shared West Ship Canal Tunnel Option, but they would occur over a longer construction timeframe.

*The Neighborhood West Ship Canal Tunnel would have similar impacts in Ballard and Fremont/Wallingford as described for the Shared West Ship Canal Tunnel Option.

5.14.3 What are the potential environmental justice impacts of the LTCP options?

Construction impacts on environmental justice populations would generally be the same as those previously described in the discussion of socioeconomics. In particular, environmental justice populations would experience increased traffic congestion, reduced mobility, reduced transit service, air emissions, and increased noise. Temporary congestion during construction may also have an impact on organizations that serve environmental justice populations. These construction impacts would affect all populations including historically underserved and low-income residents of neighborhoods in the Plan area.

As discussed in Section 4.13, demographic analysis shows that neighborhoods in the Plan area have generally the same or lower proportions of low-income and minority populations compared to the rest of the city. Based on a review of the population and income characteristics of the Plan neighborhood areas, the Longfellow Creek/Duwamish Neighborhoods have the highest presence of minority populations. In terms of income, the per capita income of the study area is lower than that of the city as a whole, and the proportion of population below poverty thresholds in the Plan area is slightly higher in comparison to the whole city.

While the Longfellow Creek/Duwamish Neighborhoods have a greater presence of minority and low-income populations in comparison to other neighborhoods in the Plan area, none of the options include projects that would have greater construction disturbance in this area than in the other Plan neighborhoods. In fact, the largest, most disruptive projects included in the options would be located in the Ship Canal and Lake Washington Neighborhoods where the populations are predominantly not historically underserved or low-income. Even though the amount of construction disturbance would be less in the Longfellow Creek/Duwamish Neighborhoods than other neighborhoods, environmental justice populations in this area could be more sensitive to construction impacts as they are generally more reliant on public transit, which could be affected by traffic congestion and road closures/detours.

Given the distribution of the CSO control projects throughout the city, and the fact that the largest, longest duration construction projects under any of the LTCP options would not be located in neighborhoods with a greater presence of minority and low-income populations, construction-related effects on neighborhoods would not fall disproportionately on environmental justice populations.

5.14.4 What are the potential socioeconomic and environmental justice impacts of the Integrated Plan Alternative?

Construction of storage pipes, tanks, and tunnels under the Integrated Plan Alternative would have the same potential socioeconomic impacts as under the LTCP Alternative, but certain CSO control projects would be delayed in Delridge, East Waterway, Duwamish, Portage Bay, and Montlake neighborhoods. Consequently, these neighborhoods would experience fewer near-term construction-related socioeconomic impacts.

Installation of natural drainage systems through NDS Partnering would cause minor and temporary impacts. Specific installations may require temporary closures of sidewalks and street lanes, and brief detours of traffic and pedestrians around the work area. Construction could result in temporary community impacts from relocated bus stops, and modified access to community resources from partial closures of streets, sidewalks, or bicycle paths/routes. Such detours would comply with relevant policies administered by the Seattle Department of Transportation as part of its Street Use permitting process, as applicable. Project construction associated with the South Park Water Quality Facility could alter access to community resources and result in short-term noise and other impacts in affected neighborhoods. However, the potential for impacts is minimal as the project is anticipated to be located in an industrial area.

5.14.5 What are the potential socioeconomic and environmental justice impacts of the No Action Alternative?

Project construction under ongoing programs to implement sewer system improvements and natural drainage systems could alter access to community resources and result in short-term noise and other impacts in affected neighborhoods. However, these impacts would be temporary and would not affect the integrity of the neighborhoods. The No Action Alternative would require fewer disruptions in industrial and commercial areas, and fewer property acquisitions and displacements than would the LTCP or Integrated Plan Alternatives.

Sewer system improvements would occur at existing CSO or stormwater drainage locations. Construction activities would be minor and generally less than four months in duration, with only minor neighborhood disruption and economic impacts. In some neighborhoods, the City is able to substantially reduce CSO volumes using sewer system improvements, reducing the need to construct storage projects as part of the LTCP. This is particularly true in the Longfellow Creek/Duwamish Neighborhoods where sewer system improvements would substantially reduce the size of needed storage projects and related construction activity under the LTCP.

Installation of natural drainage systems through the City's Right-of-Way program would cause minor and temporary impacts similar to those described above for NDS Partnering under the Integrated Plan Alternative. Specific installations may require temporary closures of sidewalks and street lanes, and brief detours of traffic and pedestrians around the work area. Construction of roadside rain gardens could result in temporary community impacts from relocated bus stops, and modified access to community resources from partial closures of streets, sidewalks, or bicycle paths/routes. Such detours would comply with relevant policies administered by the Seattle Department of Transportation as part of its Street Use permitting process, as applicable.

5.14.6 What measures are proposed to reduce or minimize socioeconomic and environmental justice impacts?

Measures to minimize noise and ground-borne vibration, dust, and truck trips are described in Sections 5.3, 5.8, and 5.12.

In addition, the City would undertake the following measures to mitigate socioeconomic impacts for all four proposed options:

- Prioritize project locations on public property and in public rights-of-way.
- Comply with federal, state, and local regulations regarding property acquisition and relocation assistance.
- Provide advance notification to nearby residents of construction activities including any sidewalk and street lane closures.
- Prepare a traffic control plan including measures to address residential access, emergency vehicle access, road closures and detours, and temporary bus route changes.

Additional measures to minimize impacts to environmental justice populations and organizations and businesses that serve them would include communicating information and obtaining feedback about construction activities, impacts, and mitigation at low-income housing sites and through social service providers. The project would also focus outreach to populations with limited English proficiency and to other populations susceptible to construction-related impacts.

Additional mitigation measures for specific socioeconomic and environmental justice impacts may be identified during future review of individual projects. The City would coordinate with property owners on mitigation efforts as appropriate. The City would also coordinate with property owners to identify any relocation or other mitigation options for properties that would be directly affected during the construction period.

CHAPTER 6

OPERATION IMPACTS AND MITIGATION

6.1 Introduction

6.1.1 What is included in this chapter?

This chapter describes the potential effects of the Plan after construction has been completed and the Plan projects are in operation. Both the LTCP Alternative and the Integrated Plan Alternative would implement one of the four LTCP options, although some of these CSO control projects would be deferred under the Integrated Plan Alternative. Because CSO control facilities under the LTCP options would largely be underground, few operational effects to the environment would result from Plan implementation.

The same elements of the environment discussed in Chapters 4 and 5 are discussed in this chapter, following the same general organization. The potential direct and indirect effects of project operation were analyzed for the Plan alternatives and the No Action Alternative. Because the Plan would be implemented as a coordinated package phased over time, the effects of the combination of all elements functioning together as an overall plan are presented. Long-term cumulative impacts are presented in Chapter 7.

Under the No Action Alternative, the Plan would not be implemented. The main long-term implications of not implementing the Plan relate to surface water quality and include indirect effects on biological resources, environmental health, and recreation. The only other operational effects would be those caused by the operation and future maintenance and repairs of existing CSO facilities, planned CSO control projects, ongoing programs (roadside rain gardens, RainWise), and existing and planned stormwater facilities.

6.2 Earth and Groundwater

This section describes the types of impacts that could occur to the geological setting, soils, and groundwater within the Plan area resulting from operation of the Plan alternatives.

6.2.1 What are the potential operational effects of the LTCP Alternative on earth and groundwater?

Generally, none of the projects proposed for any of the LTCP Alternative options would cause erosion impacts because there would be no exposed soils following construction and site restoration. Because underground storage facilities (pipes, tanks, tunnels) would not be constructed on steep slopes or landslide-prone areas, and would not require new slopes or major earth fills, operational impacts

Key Findings

Earth and Groundwater

Overall, the operational effects from the *LTCP Alternative* and the *Integrated Plan Alternative* are expected to be minor. With the implementation of site-appropriate design, potential adverse impacts would be avoided and minimized.

would generally be limited to geologic hazards that already exist. For example, there would be a risk of seismic events during the period of operation, and this risk could result in other related geologic hazards, such as liquefaction and seismic-induced slope failures.

6.2.1.1 Seismic Hazards

The CSO control projects, including storage tanks and tunnels, would be designed for the seismic hazards that are known to exist. As part of project-specific site analysis and facility design, technical engineering analysis would be conducted to confirm that the facility meets appropriate seismic design criteria, including the design of shoring, storage structures, and related facilities. Storage tanks, pipes, and tunnels included in the LTCP options would be designed in accordance with seismic design standards, which are intended to minimize the long-term risks to the system.

6.2.1.2 Changes to Groundwater Flow

Groundwater flow paths could be altered by tanks, pipes, and tunnels, or ground improvements included in project designs. The potential impact to groundwater flow is considered low for all types of projects included under the LTCP options. However, the potential effects of barriers to groundwater flow, such as sheet pile walls or subsurface tunnels, would be considered during siting and final design to confirm that effects to any nearby soils or structures supported on or within the soils would be negligible.

6.2.1.3 Comparison of Earth and Groundwater Impacts among the LTCP Options

The degree of the impacts described above would depend on the specific site conditions and project-specific design. The most important geologic hazard for operations would result from seismic ground shaking, which would affect all facilities, although the hazard could be slightly higher in the Longfellow Creek / Duwamish Neighborhoods because of their proximity to the Seattle Fault Zone where the risks from fault movement and ground shaking are higher. In other areas, the primary seismic hazard would be associated with ground shaking and secondary effects of ground shaking, such as liquefaction. With the implementation of appropriate design, potential adverse impacts would be avoided and minimized.

All of the CSO facilities included in the options would be designed to meet all applicable standards to minimize seismic risk. While impacts are generally similar among the LTCP options, the following differences exist.

Neighborhood Storage Option

This option would have the most tanks and pipes located throughout the Plan area potentially at risk during a seismic event. However, storage facilities would be designed in accordance with seismic design standards, which are intended to minimize the long-term risks to the system. Tanks and pipes located in the Longfellow Creek / Duwamish Neighborhoods (in proximity to the Seattle Fault Zone) could potentially be at a greater risk during a seismic event than other areas, and they would be at a potentially higher risk for liquefaction in saturated soils than the other options. In most other Plan neighborhoods, the general project areas offer overall stable geology and soil conditions during operation.

The Neighborhood West Ship Canal Tunnel would have similar impacts in Ballard and Fremont/Wallingford as described below for the Shared West Ship Canal Tunnel Option.

Shared Storage Option

This option would have similar potential for impacts as the Neighborhood Storage Option, although fewer storage tanks and pipes in the Ship Canal and Lake Washington Neighborhoods would be at potential risk.

Shared West Ship Canal Tunnel Option

This option replaces storage tanks in Ballard and Fremont/Wallingford with a tunnel. Impacts would be similar to the Neighborhood Storage Option but there would be fewer storage tanks and pipes potentially at risk during a seismic event. Tunnels are generally designed to avoid other underground developments and take advantage of stable glacial till layers. Operational effects are anticipated to be minor. In East Waterway and Magnolia, flow diversions would replace storage tanks/pipes, which present lower potential risk during seismic events.

Shared Ship Canal Tunnel Option

This option would have similar potential for impacts as the Shared West Ship Canal Tunnel Option. Additional flow diversions in Duwamish and Delridge (and flow transfers to the Shared Ship Canal Tunnel from Leschi, Montlake, and Portage Bay) would further reduce the number of storage facilities at potential risk.

6.2.2 What are the potential operational effects of the Integrated Plan Alternative on earth and groundwater?

In addition to the operational impacts of the selected LTCP option, the operational impacts of the stormwater projects specific to the Integrated Plan Alternative are anticipated to be minor. Depending on location selected, the South Park Water Quality Facility could be at risk for liquefaction in saturated soils; however, the facility would meet seismic design standards. NDS Partnering projects could cause erosion if not properly maintained. Street sweeping would not be expected to have operational effects on earth or groundwater.

6.2.3 What are the potential operational effects of the No Action Alternative on earth and groundwater?

Under the No Action Alternative, the existing earth and groundwater environment in the Plan area would essentially remain unchanged. Projects completed as part of the ongoing RainWise and roadside rain garden programs could cause erosion if they are not properly maintained. City projects included in the 2010 Plan Amendment will meet seismic design standards.

6.2.4 What measures are proposed to reduce or minimize potential impacts to earth?

The City would undertake the following measures to mitigate operational impacts to earth for all proposed projects under the Plan:

- All sites would be maintained to prevent erosion.
- Projects would be sited and designed to minimize seismic risk and potential for earth subsidence.

As part of ongoing programs, the City undertakes the following measures to minimize impacts of natural drainage systems:

- The City maintains all roadside rain gardens to prevent erosion.

- The City provides education and incentives for homeowners to maintain rain gardens on their properties.

6.3 Air Quality and Odors

This section describes the air quality impacts and odors that could result from operating the facilities constructed for the Plan alternatives.

6.3.1 What are the potential operational effects of the LTCP Alternative on air quality and odor?

6.3.1.1 Emissions

Operational emissions would be limited to vehicle and equipment emissions associated with periodic maintenance activities and infrequent use of emergency generators. These emissions would be minimal and would not produce localized air quality impacts. Diesel engine emissions would be emitted through exhaust stacks at the site of the ancillary equipment facility during maintenance and operation of standby generators. All emergency generators would be required to incorporate Best Available Control Technology to minimize emissions of pollutants. Since the generators would operate only during power outages and testing, emissions would be infrequent and of short duration.

6.3.1.2 Odors

Several of the CSO control facilities have the potential to generate odors during operation because they detain or hold a mixture of wastewater and stormwater during and following storms. These flows include potentially odor-generating compounds that can be released to the air under some conditions. These facilities include pump stations, diversion weir structures (due to turbulence), storage facilities (due to the increased detention time), and any permanent access or ventilation facilities (including tunnel portals). The potential for odors would depend on the wastewater characteristics (dissolved sulfide, dissolved oxygen, pH, temperature, etc.), wastewater hydraulics, and facility operation (cleaning, etc.).

The level of odor would likely be less than with a facility handling only sewage because stormwater inputs to the combined sewer system dilute the concentration of odor-causing compounds. Also, most combined sewage flows are generated during the rainy season when both the ambient air and water temperatures are relatively cool, which reduces the potential for odor-generating compounds such as hydrogen sulfide. In addition, CSO storage facilities would have automated cleaning systems and would be maintained at slightly negative pressure to minimize odors. Finally, all CSO control facilities installed for the Plan would include the appropriate level of state-of-the-art technology for odor control (Figure 6-1) and would be maintained to minimize emissions of odorous compounds to the atmosphere.

Key Findings

Air Quality

The net operational effects of the *LTCP Alternative* on air quality and odors would be minor in the Plan area. The Neighborhood Storage Option would have the highest number of potential odor-producing tanks and pipes located throughout the Plan area. All facilities would be designed and maintained to minimize emissions of odorous compounds.

In addition to the operational impacts of the selected LTCP option, the air quality impacts of the stormwater projects specific to the *Integrated Plan Alternative* are anticipated to be minor.



Figure 6-1. Typical odor control equipment for a CSO storage facility

Odor control systems would be operated at access shaft points for storage facilities and at the pump stations. Odor release at storage tunnels is primarily limited to the launch and recovery portals. During normal operation of the tunnel, the ventilation system at the pump station would pull outside air into the tunnel. This results in continuous movement of all air within the tunnel to the pump station for odor treatment and exhaust. When the tunnel fills with combined sewage during a storm event, the air (and odor) from the tunnel will be displaced. Although air may be vented from the tunnel at the tunnel shafts when the tunnel fills, odor problems are not expected. All air from the tunnel would be vented to an odor control system, where it would be treated prior to release to the atmosphere. The largest potential source of odor would be at the effluent pump stations. However, these structures would also have the highest level of mechanical odor control equipment.

Emissions would be minimal from operation of all CSO control facilities included in the LTCP options. All CSO facilities installed for the Plan would include state-of-the-art technology for odor control and would be maintained to minimize emissions of odorous compounds to the atmosphere. Odors would not likely be noticeable outside of the proposed facility under normal operating conditions.

6.3.1.3 Comparison of air quality and odor impacts among the LTCP options

All of the CSO control facilities included in the options have potential for odor impacts, but they would be designed to minimize odors by incorporating odor control and automated flushing systems. CSO control projects that store flows (e.g., tanks and tunnels) have a higher potential for odor impacts than flow transfers. Also, larger storage facilities have the potential to produce larger volumes of odorous emissions. However, concentrations of odorous compounds would be the same regardless of size, and control facilities would be sized accordingly to treat the higher volumes of air. While impacts are generally similar among the LTCP options, the following differences exist, based upon the location of facilities and potential receptors.

Neighborhood Storage Option

This option would have the greatest number of potential odor-producing tanks and pipes located throughout the Plan area, including several that could be located in or near residential areas of the Ship Canal, Lake Washington, Longfellow Creek /Duwamish, and Central Waterfront Neighborhoods. Odors are more likely to be noticed in residential or commercial areas. This option includes an estimated 13 pump stations, which could result in occasional odors.

The Neighborhood West Ship Canal Tunnel would have similar impacts in Ballard and Fremont/Wallingford as described below for the Shared West Ship Canal Tunnel Option.

Shared Storage Option

This option includes several storage tanks that could be located in or near residential areas of the Ship Canal, Lake Washington, Longfellow Creek / Duwamish, and Central Waterfront Neighborhoods. This option would have similar potential for impacts as the Neighborhood Storage Option, with fewer potential odor-producing storage tanks and pipes in the Ship Canal Neighborhoods. This option replaces a storage tank with a flow diversion in the East Waterway neighborhood, which has less potential to produce odors. Of all the options, this option potentially has the greatest number of pump stations (15), which could result in occasional odors.

Shared West Ship Canal Tunnel Option

The large tunnel would reduce the number of potential odor-producing storage facilities in the Ballard and Fremont/Wallingford neighborhoods. The large tunnel would have the greatest potential for odors at the downstream tunnel portal (likely located along the Ship Canal in the vicinity of Ballard) but these would be minimized by an odor control facility. In neighborhoods where flow diversions would replace storage tanks/pipes (East Waterway and Magnolia), there would be less potential for odor impacts. This option includes an estimated 10 pump stations, which could result in occasional odors.

Shared Ship Canal Tunnel Option

This option would have similar potential for impacts to the Shared West Ship Canal Tunnel Option, except that storage facilities with odor-producing potential would largely be eliminated in the Lake Washington Neighborhoods of Montlake, Portage Bay, and Leschi. The large tunnel would have the greatest potential for odors at the downstream tunnel portal (likely located along the south side of the Ship Canal) but these would be minimized by an odor control facility. Additional flow diversions in Duwamish and Delridge would further reduce the number of potentially odor-producing storage facilities in those neighborhoods. This option includes an estimated 10 pump stations, which could result in occasional odors.

6.3.2 What are the potential operational effects of the Integrated Plan Alternative on air quality and odors?

In addition to the operational impacts of the selected LTCP option, the air quality impacts of the stormwater projects specific to the Integrated Plan Alternative are anticipated to be minor. Similar to CSO storage facilities, the South Park Water Quality Facility has the potential to generate odors. However, this impact is expected to be minimal because stormwater has fewer odor-generating compounds than wastewater or combined sewer overflows. Street sweeping has the potential to temporarily increase localized dust and emissions, but this would be minimal and street sweeping occurs at night on most arterials. There are no operational air-related impacts associated with NDS Partnering.

6.3.3 What are the potential operational effects of the No Action Alternative on air quality and odors?

No air quality impacts or increased odors are anticipated from the ongoing sewer system improvements and natural drainage systems. Air quality impacts and odors associated with the projects in the 2010 Plan Amendment would be similar to those described above. The projects either have completed, or will undergo, separate SEPA analysis as appropriate and are not included in this EIS.

If projects included in the No Action Alternative are not adequate to reduce CSO events, odors associated with the CSO releases would continue and could increase if the number of CSO events increases.

6.3.4 What measures are proposed to reduce or minimize potential impacts to air quality and odors?

The City would undertake the following measures to mitigate air quality and odor impacts for the operation of all proposed projects. Mitigation measures would be the same for all the Plan alternatives.

- All storage facilities would be designed with state-of-the-art odor control systems.
- The City would operate storage facilities to minimize the potential for odors by limiting the length of time combined sewage is stored in the facilities, maintaining air space at slightly negative pressures, and scheduling maintenance of odor control systems during cold temperatures and periods of low flow.

6.4 Surface Water

This section describes the types of impacts that could occur to surface water within the Plan area from operation of the Plan alternatives.

Implementation of either the LTCP or the Integrated Plan Alternative would result in substantially reduced pollutant loadings to receiving water bodies. The LTCP is being implemented to improve receiving water quality, meet CSO standards administered by EPA and Ecology, and comply with the Consent Decree. The alternatives have been developed to be consistent with those requirements; however, the timing of water quality benefits and the reduction in pollutants vary depending on which alternative is implemented, as described below.

6.4.1 What are the surface water impacts of the LTCP Alternative?

Operational impacts to surface water quality would be the same for all of the LTCP options, because all options would meet the Consent Decree requirement for control of CSOs, in compliance with the Clean Water Act, EPA's CSO Control Policy, and the objectives of the Washington Water Pollution Control Act. All options are required to meet the regulatory requirements of the City's National Pollutant Discharge Elimination System permit,

Key Findings

Surface Water

The *LTCP Alternative* would result in substantial reduction of pollutant loading from existing uncontrolled CSO outfalls compared with the No Action Alternative. The LTCP Alternative would comply with Clean Water Act requirements and the Consent Decree. The Ship Canal/Lake Union, Lake Washington, Duwamish River, Longfellow Creek, Elliott Bay, and Puget Sound would receive reduced discharges from CSOs. The *Integrated Plan Alternative* would result in greater pollutant loading reductions than the LTCP Alternative.

The *No Action Alternative* would not comply with the Consent Decree and would not achieve the City's Plan for Protecting Seattle's Waterways.

which limits overflows from controlled outfalls. Therefore, long-term operational impacts to surface water are discussed for the LTCP Alternative as a whole.

The City of Seattle has been working to control CSOs since the 1960s. The LTCP is the final component to complete CSO control efforts and comply with federal and state requirements. The 2013 Consent Decree, an agreement between the City of Seattle, Washington Department of Ecology, EPA, and U.S. Department of Justice, specifies the actions that the City must take to address CSOs that violate the Clean Water Act. Regulations require that CSO outfalls must meet a performance standard to achieve the “greatest reasonable reduction” to be considered “controlled” in accordance with WAC 173-245-020(22), which outlines the requirements for CSO control facilities. According to these regulations, a CSO is considered “controlled” when no more than one untreated discharge occurs per year, determined annually and based on a 20-year moving average period.

As noted in Chapter 1, the Consent Decree has established a deadline of December 2025 to complete construction of all CSO control measures. One year following completion of construction of each CSO control measure, the City is required to document that the CSO outfall has been controlled, through post-construction monitoring. Additional detail on the Consent Decree requirements is included in the Summary section of *Volume 2, LTCP*.

In 2012, there were 355 overflow events and 154 million gallons of untreated CSOs discharged from the City’s 87 managed outfalls, 35 of which are uncontrolled. Eight of these CSOs will be controlled through the implementation of the 2010-2015 CSO Plan, described in more detail in Chapter 1 of *Volume 2, LTCP*. Early Action CSO Programs and Measures will result in an additional five outfalls being controlled by 2019, including two in the North Henderson basin and three in the South Henderson basin. The remaining 22 uncontrolled outfalls will be controlled through implementation of the approved LTCP. Figure 2-3 illustrates the outfalls to be controlled.

Under the LTCP, uncontrolled outfalls discharging into Lake Washington, the Ship Canal, Union Bay, Portage Bay, Longfellow Creek, the Duwamish River, and Elliott Bay would be controlled to one untreated discharge per year on a 20-year rolling average in order to comply with EPA and Ecology requirements. The LTCP would reduce the frequency of CSO discharge events by more than 50 percent and the average annual CSO discharge volume by more than 55 percent.

Controlling these outfalls to meet EPA and Ecology requirements would result in substantial reductions of fecal coliform bacteria, toxics, metals, and nutrients entering local receiving water bodies from CSOs.

The LTCP would reduce fecal coliform discharges from CSO outfalls by nearly 70 percent, with reductions of bacterial and other pathogen loading between 65 and 75 percent in Lake Washington and the Ship Canal/Lake Union receiving waters, where high levels of water contact recreation occur. While CSO discharges can include viruses and other pathogens as well as toxic organic constituents, not all of these constituents are measured. Fecal coliform bacteria is an indicator for pathogenic constituents.

Suspended solids from CSOs deposited near CSO outfalls would be substantially reduced, thereby reducing the potential for wildlife and humans to come into contact with potentially contaminated sediments. Total suspended solids discharged from CSO outfalls would be reduced by nearly 65 percent, with reductions of 75 percent in the Ship Canal/Lake Union receiving waters.

Total copper, a constituent that is toxic to salmonids and other aquatic organisms, would be reduced by nearly 65 percent from CSO outfalls when compared to the No Action Alternative. Reductions of nearly 75 percent would occur in the Ship Canal/Lake Union, and nearly 67 percent in Lake Washington. Total phosphorus, an important constituent in algae production, would be reduced by 65 percent over the No Action Alternative, with highest reductions from outfalls in the Ship Canal/Lake Union and Lake Washington basins. Fecal coliform bacteria discharged from CSO outfalls would be reduced by roughly 69 percent. Reductions of other toxic contaminants, nutrients, and metals would also be substantial.

There are no adverse operational impacts on surface waters associated with the LTCP Alternative.

6.4.2 What are the potential operational effects of the Integrated Plan Alternative on surface water?

The Consent Decree allows the City to propose an Integrated Plan as an alternative to the LTCP. This would allow deferral of some LTCP projects if evaluations indicate that stormwater projects could achieve significantly better water quality benefits than would be achieved by implementing LTCP CSO control projects only. The stormwater projects would need to be implemented by December 31, 2025, while the deferred LTCP projects would be completed between 2028 and 2030, as approved by Ecology. Implementing the Integrated Plan Alternative would not replace or eliminate any CSO control projects in the LTCP Alternative, but it would allow the City to devote more resources in the near term to addressing stormwater pollutant loads, resulting in greater water quality benefits.

The Consent Decree listed a number of specific constituents that the Integrated Plan must address. These are constituents that represent both environmental and human health concerns and are contained in both stormwater and CSOs. These include fecal coliform bacteria, total suspended solids, biochemical oxygen demand (BOD), ammonia, phosphorus, oil and grease, and pH. The Consent Decree also includes several general categories of constituents (e.g., metals, pesticides, and semi-volatile organic compounds).

Because of the limited timeframe for developing the Integrated Plan, it was not possible to collect new water quality data. Therefore the City compiled and reviewed existing stormwater, CSO, and receiving water data to develop a list of "Representative Constituents of Concern" (RCOCs). In some cases, the City used surrogates to represent categories of constituents, such as dissolved copper and dissolved zinc for metals, and PCBs and polybrominated diphenyl ethers (PBDEs) for toxic organic compounds. Additional detail on the development of RCOCs can be found in Chapter 6 of *Volume 3, Integrated Plan, as well as the methods used* to estimate the pollutant load reductions for the LTCP projects to be deferred, and for the stormwater projects considered for inclusion in the Integrated Plan.

In development of the Integrated Plan, the City also ranked local receiving water bodies based on requirements outlined in the Consent Decree, as described in Chapter 1 of *Volume 3, Integrated Plan*.

The City identified potential stormwater projects for implementation, and potential LTCP CSO control projects for deferral, based on the water body and drainage basin rankings and EPA guidance. An initial list of more than 14 projects or programs was narrowed to 10 stormwater projects that were evaluated in detail. The stormwater projects/programs were selected based on their ability to provide benefits in key drainage basins and receiving water bodies, as described in Chapter 5 of *Volume 3, Integrated Plan*. In contrast, the LTCP projects identified for deferral were relatively small. The intent was to identify stormwater projects that could provide significant water quality benefits compared to the CSO control projects proposed for deferral.

The Integrated Plan team then evaluated data relating to potential impacts on pollutant loading and exposures for RCOCs for human and ecological receptors, and then estimated pollutant load and exposure reductions for the stormwater projects relative to the CSO control projects. The team used a Multi-Objective Decision Analysis (MODA) to score the candidate stormwater projects and compare the benefits of each project with its costs. They selected a combination of projects that would provide significantly more water quality benefits than the LTCP CSO control projects.

As summarized in Chapter 1 of this document, the Integrated Plan evaluation identified three stormwater projects that would result in deferral of six CSO control projects included in the LTCP. The stormwater projects would be implemented by 2025, and completion of the deferred CSO control projects would be delayed until 2030. The three stormwater projects are described in more detail in Chapter 3, Plan Alternatives, and in Chapter 8 of *Volume 3, Integrated Plan*. The Integrated Plan projects include the following:

- Natural Drainage System (NDS) Partnering
- South Park Water Quality Facility
- Expanded Street Sweeping (Arterials)

Six LTCP CSO control projects were identified for deferral in the Delridge, East Waterway, Duwamish, Portage Bay, and Montlake basins. Table IPS-1 in *Volume 3, Integrated Plan* summarizes the Integrated Plan projects and the LTCP projects identified for deferral. Under the Integrated Plan, approximately 1,600 MG/year of stormwater would be treated or removed from the Longfellow, Piper's, and Thornton Creek basins, through the implementation of NDS Partnering, the South Park Water Quality Facility, and the expansion of street sweeping on arterials (based on the volume of stormwater on streets to be swept). The LTCP projects proposed to be deferred would treat or remove approximately 1.4 MG/year in the Delridge, East Waterway, Duwamish, Portage Bay, and Montlake basins. Additional discussion of these findings is included in Chapter 8 of *Volume 3, Integrated Plan*.

Based on detailed evaluations conducted by the City's Integrated Plan team, the Integrated Plan would result in a greater reduction of pollutant loading than would occur for the LTCP Alternative. Implementation of the Integrated Plan projects would result in substantially greater reductions of total suspended solids, oil and grease, total and dissolved copper and zinc, phosphorus, PCBs, and PBDEs, among other constituents.

The Integrated Plan stormwater projects provide greater reductions for all RCOCs except for ammonia-N. The primary reason for the substantial increase in pollutant load reduction for the Integrated Plan projects is that the stormwater projects treat or remove much larger volumes of water than the comparable CSO control projects within their respective basins. In addition, the Integrated Plan stormwater projects treat larger volumes of water than the comparable CSO control projects during February through September, when human exposure with receiving waters is more likely.

CSO pollutant loads deferred from 2025 until after 2028 for the Integrated Plan would amount to between 2 and 7 percent of the existing uncontrolled CSO loads, and between 7 and 16 percent of the projected CSO loads in 2025 to all water bodies. These ranges of deferred CSO pollutant loads depend on the specific constituent, with the greatest reductions associated with total suspended solids, metals, oil and grease, and other constituents associated with street runoff. After the deferred LTCP CSO control projects are completed, their water quality benefits will add to the water quality benefits of the stormwater projects, resulting in further water quality improvements.

Figure 3-8 shows the location of the stormwater projects/programs that would be implemented and the LTCP CSO control projects that would be deferred under the Integrated Plan Alternative. The City selected the South Park Water Quality Facility, the arterial street sweeping expansion program, and the NDS Partnering project for the Integrated Plan because they provide the most pollutant reduction and other benefits as determined during the MODA evaluation. The six LTCP CSO control projects were identified for deferral because they are located in CSO basins determined by the LTCP team to be lower priority based on EPA guidelines and consideration of potential partnering opportunities with King County. The deferred LTCP CSO control projects would provide considerably smaller reductions in pollutant loads and exposures than the Integrated Plan stormwater projects.

The deferral of CSO pollutant load reductions for the Integrated Plan would primarily delay reductions to the Duwamish Waterway and the Ship Canal/Lake Union. The deferred CSO pollutant loads would amount to approximately 30 percent of existing uncontrolled CSO loads to the Duwamish Waterway, and less than 1 percent of existing uncontrolled CSO loads to the Ship Canal and Lake Union. However, stormwater pollutant load reductions by 2025 for the Integrated Plan would far exceed the deferred CSO pollutant loadings to each of these water bodies.

6.4.3 What are the potential operational effects of the No Action Alternative on surface water?

Under the No Action Alternative, pollutant loadings to receiving water bodies would not be reduced beyond levels provided from construction of projects included in the 2010 CSO Control Plan and currently planned NDS and RainWise projects. This alternative does not comply with the Consent Decree, and it would result in significant fines for the City. This alternative is not consistent with the City's Plan to Protect Seattle's Waterways.

CSO pollutant loadings would continue, with potential impacts highest for the Ship Canal and Lake Union because they currently receive the highest CSO pollutant loads of all water bodies in Seattle. Potential impacts would also be high for Longfellow Creek because it currently receives moderate CSO pollutant loads and is a relatively small receiving water body. Impacts would be moderate for Lake Washington and Duwamish Waterway, and lowest for Puget Sound and Elliott Bay, based on their relatively low existing CSO pollutant loads.

6.4.4 What measures are proposed to reduce or minimize impacts to surface water?

The LTCP and the Integrated Plan are intended to reduce impacts to surface water bodies in Seattle's waterways, and as such, they will lessen water quality impacts that are currently occurring. Implementation of either of these alternatives would result in anticipated benefits to receiving water bodies. Post-construction monitoring required in the Consent Decree will ensure that facilities are operating as intended, and it will include adjustments to improve facility performance if necessary.

6.5 Biological Resources

This section describes the types of impacts that could occur to biological resources within the Plan area resulting from operation of the Plan alternatives. In general, implementation of either alternative would reduce the volume of untreated sewage and stormwater runoff being discharged to surface waters, thereby reducing the potential for related adverse effects on biological resources and aquatic life in particular. Implementation of either the LTCP or Integrated Plan Alternative would comply with the Consent Decree, as well as other federal and state requirements.

6.5.1 What are the potential operational effects of the LTCP Alternative on biological resources?

The LTCP Alternative would not cause ongoing impacts to terrestrial wildlife and would benefit aquatic species and habitats. Direct impacts to terrestrial habitats associated with constructing facilities and permanent aboveground access areas are discussed as construction impacts in Chapter 5 (see Section 5.5). Some of the projects, such as storage tanks, may include habitat enhancements, such as replanting with native plants. This would create new areas of habitat for species tolerant of urban conditions.

Pump stations and other surface facilities could generate noise depending on the specific design. Occasional noise associated with maintenance vehicles would also occur. Noise levels from operation of the facilities are not expected to result in impacts to wildlife because species in urban areas are more or less tolerant of some level of human activity.

All options would reduce the number of CSO events and lead to improved water quality, as described in Section 6.4, Surface Water. Consequently, all options would result in long-term, beneficial impacts for fish and other aquatic species. The total volume of the City's current CSO discharge would be decreased by nearly 60 percent with the implementation of all CSO control projects included in the LTCP options. No in-water construction would occur for any of the options, and therefore no permanent impacts to aquatic habitats would occur.

There are no adverse operational impacts on biological resources associated with the LTCP Alternative.

6.5.2 What are the potential operational effects of the Integrated Plan Alternative on biological resources?

In addition to the beneficial impacts described above for the LTCP Alternative, the Integrated Plan Alternative would result in additional pollutant reductions, particularly in the Duwamish Waterway. Reductions in metals loading, particularly copper, would benefit aquatic resources in these waterways. Thornton Creek, Piper's Creek, and Longfellow Creek would experience reduced pollutant loadings from NDS Partnering projects. Multiple drainages throughout the Plan area would benefit from the expanded street sweeping program as summarized in Section 6.4.

Key Findings

Biological Resources

The *LTCP Alternative* would have negligible to minor operational effects in the Plan area. There would be long-term beneficial effects on fish and aquatic life from reducing CSOs. The *Integrated Plan Alternative* would provide additional water quality reductions, providing greater potential benefits to biota in the affected receiving water bodies.

The *No Action Alternative* would result in no additional improvements to CSO reductions in the Plan area, which could have long-term adverse effects on fish and aquatic life including listed species.

6.5.3 What are the potential operational effects of the No Action Alternative on biological resources?

None of the projects proposed under the No Action Alternative are expected to cause impacts to biological resources. Rain gardens could provide small areas of habitat in neighborhoods. However, the No Action Alternative would not result in any of the long-term, beneficial impacts as described for the LTCP and Integrated Plan Alternatives because no additional CSO or stormwater control projects would be implemented beyond those projects and programs currently funded or slated for implementation. Water quality in water bodies throughout the Plan area would continue to be negatively impacted by CSO and stormwater releases. Fish and other aquatic species, including threatened or endangered salmonids and marine mammals, and their habitats would continue to be exposed to CSO discharges at the current levels.

Impacts would be greater during the wet weather season (approximately October through May) when CSOs and stormwater discharges are more likely. CSO and stormwater discharges in Elliott Bay would continue to cause potentially adverse effects to listed species present during the wet weather season, including Pacific salmon, steelhead, bull trout, rockfish, killer whale, Steller sea lion, and humpback whale. Adult Chinook, steelhead, coho, and sockeye salmon are present in the Duwamish, Ship Canal, Lake Union, Union Bay, and Lake Washington during this time, and sockeye salmon are present in Thornton, Piper's, and Longfellow Creeks. Thornton and Longfellow Creeks also support adult Chinook salmon, and Piper's Creek contains adult chum during the winter months. Juvenile salmonids, which are dependent on shoreline and nearshore habitats near outfalls, are present during the winter months in many of the same water bodies, particularly the Duwamish and Lake Washington, and would be exposed to CSO releases. Thornton, Piper's, and Longfellow Creeks support juvenile steelhead and coho salmon, and Piper's Creek also contains cutthroat and chum.

6.5.4 What measures are proposed to reduce or minimize impacts to biological resources?

Because none of the Plan alternatives are expected to cause adverse impacts to biological resources, no mitigation measures are proposed. Mitigation measures for reducing noise associated with facility operations are discussed in Section 6.8, Noise and Vibration.

6.6 Energy and Climate Change

This section describes the types of impacts that could occur to energy use and the risks associated with climate change within the Plan area resulting from operation of the Plan alternatives.

6.6.1 What are the potential operational effects of the LTCP Alternative on energy and climate change?

6.6.1.1 Energy Use

Storage facilities that are drained and flushed by gravity are anticipated to have the lowest energy requirements. Conversely, underground tanks or tunnels that rely on pump stations for dewatering, and mechanical flushing systems to scour accumulated sediments, are anticipated to have higher operation and maintenance needs. Electric pumps and ventilation equipment would be required at facilities such as pump stations, storage tanks, flow transfers, and tunnel facilities. The pumps and equipment would be operated by electricity. Although operating the CSO facilities can be energy intensive, most of the equipment operates infrequently, only during

storm events. Therefore, the CSO facilities are expected to have a minor impact on energy use or demand in the Plan area.

6.6.1.2 Greenhouse Gas Emissions

Operation of the CSO facilities would generate greenhouse gases. Although most electricity used in the city is generated by hydropower, which does not produce greenhouse gases, small amounts of electricity are generated by natural gas and coal which do produce greenhouse gases.

6.6.1.3 Risks from Climate Change

As described in Chapter 4, the major risks associated with climate change in Seattle are increased precipitation and sea level rise. Climate change and some aspects of climate variability are expected to increase rainfall in the winter. Increased rainfall likely means an increase in stormwater runoff from impervious surfaces in the basin. Increased precipitation could increase the number of CSO events if new facilities are not designed to include climate change projections. However, CSO storage tanks have been designed to address the changes expected from climate change and climate variability. The City has incorporated climate change modeling in its development of Plan alternatives and would incorporate additional modeling in the design of individual CSO facilities as projects move forward. The control volumes required for compliance with the once-per-year overflow requirement for the LTCP have been determined based on a 6 percent increase in precipitation and associated stormwater over the current levels. Six percent is within the range of precipitation increase predicted by climate change modeling for the future planning period. Refer to *Volume 2, LTCP* for further information on climate change modeling.

Sea level rise is not anticipated to impact the proposed projects in the Ship Canal and Lake Washington Neighborhoods because the U.S. Army Corps of Engineers maintains Lake Washington at levels that are lower than the elevation of the project sites. The City would avoid locating CSO facilities in other areas of the city that are vulnerable based on sea level rise projections.

6.6.1.4 Comparison of Energy and Climate Change Impacts among the LTCP Options

All of the LTCP options include proposed facilities that would require electrical power and increase energy use in the city. As described above, the increased use is expected to be minor. Climate change and climate variability have the potential to impact the proposed project due to increases in sea level and rainfall. All of the LTCP options would be designed to handle increased precipitation predicted by climate change modeling, and the projects would not be located in areas vulnerable to projected sea level changes. Therefore, all of the projects are expected to minimize risk from climate change. Differences among the LTCP options are described below.

Neighborhood Storage Option

CSO control facilities (tanks, pipes, sewer system improvements) would have minor operational effects on energy use as a result of pumping and electrical equipment requirements. The Neighborhood West Ship Canal Tunnel would have slightly higher energy requirements as described below for the Shared West Ship Canal Tunnel Option. Overall, energy use would be higher under the Neighborhood Storage Option compared to the other

Key Findings

Energy and Climate Change

Both the *LTCP Alternative* and *Integrated Plan Alternative* would have minor operational effects on energy use. The greenhouse gas emissions produced by operating and maintaining CSO facilities are not expected to cause appreciable climate change impacts. SPU has incorporated climate change modeling in its development of Plan alternatives and would incorporate additional modeling in the design of individual CSO facilities to minimize risks from anticipated changes in precipitation and sea level rise.

options because this option has the highest number of City and King County independently constructed CSO facilities.

Shared Storage Option

The larger shared storage tanks under the Shared Storage Option have slightly higher energy requirements than smaller tanks under the Neighborhood Storage Option. However, overall energy use would be expected to be lower because the shared tanks eliminate 10 City and 3 King County independently constructed CSO facilities.

Shared West Ship Canal Tunnel Option

The Shared West Ship Canal Tunnel Option would potentially have a slightly higher electrical requirement than tanks under both the Neighborhood Storage and Shared Storage Options because of the electricity needed to pump the deeply stored water. However, overall energy use would be expected to be lower than the Neighborhood Storage Option because 4 City and 1 King County independently constructed CSO facilities would be eliminated.

Shared Ship Canal Tunnel Option

The Shared Ship Canal Tunnel Option would have slightly higher energy use than the Shared West Ship Canal Tunnel because of the electrical energy requirements of the larger tunnel. However, overall energy use would be the most reduced under this option compared to the Neighborhood Storage Option because it eliminates 15 City and 3 King County independently constructed CSO facilities, the most of all the options.

6.6.2 What are the potential operational effects of the Integrated Plan Alternative on energy and climate change?

In addition to the CSO control facilities under the LTCP, the South Park Water Quality Facility would use energy on an intermittent basis. In general, impacts from the Integrated Plan Alternative would be very similar to the LTCP Alternative.

6.6.3 What are the potential operational effects of the No Action Alternative on energy and climate change?

Energy requirements from operation of projects implemented under ongoing programs are minimal.

Natural drainage systems do not require energy and would be located away from areas prone to sea level rise. Sewer system improvements and the planned storage projects included in the 2010 Plan Amendment would require electrical power, but the small increase in electrical demand is not expected have a major effect on electrical use in the city.

Any existing CSO facilities located in areas prone to sea level rise could be flooded, reducing their ability to effectively handle CSO events.

6.6.4 What measures are proposed to reduce or minimize energy and climate change impacts?

The City would undertake the following measures to reduce the impacts of CSO facilities on energy and to protect the facilities from the risks of climate change:

- Comply with state and City requirements related to energy efficiency of the new CSO facilities.
- Include evaluations of greenhouse gas emissions as required by the City in project-level SEPA analyses.
- Incorporate climate change modeling into design of CSO facilities.
- Utilize the adaptation planning pathways incorporated in the City's *Sea Level Rise Planning Guidance for Capital Projects* (City of Seattle, 2011d) to design and locate CSO facilities.

6.7 Environmental Health and Public Safety

This section describes the types of impacts that could occur to environmental health and public safety within the Plan area from operation of the Plan alternatives.

6.7.1 What are the potential operational effects of the LTCP Alternative on environmental health?

Operation of the CSO facilities is expected to reduce the risk to human health by reducing CSO events that release untreated wastewater to surface water bodies. Reduced CSO discharges would reduce potential contamination that could reach Plan area beaches, thereby lowering the potential for human contact with contaminated waters. Water quality improvements from reduced CSO events may also help reduce contamination of fish and shellfish that are caught in the area and consumed.

As described in Chapter 5, contaminated materials could be encountered during construction, and some facilities, such as storage tanks and tunnels, could be constructed on contaminated sites. In both cases, the contaminated materials would be removed, resulting in improved conditions and reducing the potential for long-term environmental health impacts.

All options would reduce the number of CSO events and lead to improved water quality, as described above. None of the LTCP Alternative options are expected to cause adverse impacts to environmental health.

6.7.2 What are the potential operational effects of the Integrated Plan Alternative on environmental health and public safety?

As described in Section 6.4.2, a number of contaminants conveyed in CSOs and stormwater pose potential environmental health concerns. While both the LTCP Alternative and the Integrated Plan Alternative would substantially reduce pollutant loading, the Integrated Plan provides a higher level of pollutant reduction.

Pollutant load and human exposure evaluations conducted as part of the Integrated Plan indicated fecal coliform bacteria (an indicator for pathogens) would be reduced to a greater level under the Integrated Plan Alternative

Key Findings

Environmental Health and Public Safety

Overall, the *LTCP Alternative* is expected to reduce environmental health risks associated with CSOs by reducing untreated discharges. Pathogens and toxic organic and inorganic constituents would be reduced to a greater level under the *Integrated Plan Alternative* than the *LTCP Alternative*. Once the deferred CSO control projects are implemented, they will add to the long-term loading reduction achieved by the Integrated Plan stormwater projects.

Under the *No Action Alternative*, water quality in surface waters throughout the Plan area would continue to be negatively impacted by CSO releases from uncontrolled outfalls and by stormwater discharges. The *No Action Alternative* is not compliant with the Consent Decree and is not consistent with the City's Plan for Protecting Seattle's Waterways.

than the LTCP Alternative. As described above in Section 6.4, this is largely due to the greater volume reduced by the Integrated Plan Alternative, and because reductions from Integrated Plan projects would be greater during the months when potential for human contact is highest, between February and September. Refer to Chapters 6 and 8 of *Volume 3, Integrated Plan* for a more detailed discussion of the evaluation methodology and results for human exposure. In general, reduction in environmental health risks would be greatest under the Integrated Plan Alternative.

Under the Integrated Plan Alternative, both the stormwater projects and the deferred LTCP projects would reduce pollutant loads to water bodies. However, the stormwater projects would benefit water bodies throughout the city, while deferred LTCP projects would largely benefit the Duwamish Waterway and the Ship Canal. The Integrated Plan Alternative would result in substantially larger reductions in pollutant loads than the LTCP projects alone. These large reductions should bring accompanying reductions in environmental health risks.

NDS Partnering would construct bioretention facilities (i.e., engineered rain gardens) in the storm sewer system basis that drain to Piper's, Thornton, and Longfellow Creeks. Concerns have been raised by citizens regarding the potential safety risks and mosquito breeding potential associated with ponded water within bioretention facilities. However, proper siting and design of these facilities will minimize health and safety risks.

The South Park Water Quality Facility would treat runoff from approximately 250 acres in the 7th Avenue S drainage system, prior to discharge to the Lower Duwamish Waterway. The primary objectives are to reduce flows and loads of total PCBs, metals, bacteria, and other pollutants, which would be anticipated to reduce environmental health risks in these water bodies.

Expanded street sweeping would focus on the storm sewer system basins. Increased sweeping of arterials would remove potential stormwater pollutants from a drainage area of approximately 1,736 acres. The primary objective of expanded street sweeping would be to reduce loads of total PCBs, metals, bacteria, and other particulate-bound pollutants and prevent these pollutants from entering receiving waters, where environmental and public health risks could occur. Expanded street sweeping, in particular, is shown to provide substantial fecal coliform load reduction, resulting in lower levels of pathogens in receiving waters.

The stormwater projects provide larger load reductions for the key drivers for human exposure (PCBs and fecal coliform) than the LTCP projects that would be deferred. The primary reason is that the stormwater projects would treat larger volumes than the LTCP projects. Because the stormwater discharges are much more frequent than CSO discharges, they are more likely to present an exposure and environmental health risk.

Refer to *Volume 3, Integrated Plan*, for more information on pollutant reductions anticipated under the Integrated Plan Alternative.

6.7.3 What are the potential operational effects of the No Action Alternative on environmental health and public safety?

The No Action Alternative would not implement any additional CSO or stormwater control projects beyond those projects and programs currently funded or slated for implementation. Water quality in surface waters throughout the Plan area would continue to be negatively impacted by CSO releases from uncontrolled outfalls and by stormwater discharges. Contaminated discharges could continue to affect swimming beaches and fishing areas, causing potential environmental health impacts. People could be exposed to pathogens or other pollutants through direct contact with contaminated water or sediments (e.g., swimming or wading), ingestion of pathogen-

containing water, or eating contaminated fish or shellfish. The No Action Alternative does not comply with the Consent Decree and is not consistent with the City's Plan for Protecting Seattle's Waterways.

The risk of CSOs having a harmful effect on humans from pathogens or other contaminant exposure ultimately depends on the extent of human activity in water bodies near CSOs during and immediately after a discharge event. Because CSO events largely occur during heavy rainfall in the cooler months, the potential number of individuals swimming or wading is likely fairly low, but activities on and near the water occur year-round. These risks could continue or potentially worsen under the No Action Alternative.

Natural drainage systems that are not maintained or properly sited could create breeding areas for mosquitoes. Mosquitoes breed in standing water and require at least a week to complete their life cycles. Generally rain gardens are designed to drain quickly, usually within several hours or a day. Thus, rain gardens that are properly sited and have quickly draining soils are unlikely to provide good breeding conditions for mosquitoes (Rector et al., 2012). Rain gardens require maintenance to keep vegetation healthy and to prevent standing water.

6.7.4 What measures are proposed to reduce or minimize impacts to environmental health and public safety?

The proposed projects and programs associated with the LTCP and Integrated Plan Alternatives would help to reduce environmental health risks and do not require further mitigation. As part of ongoing programs, the City undertakes the following measures to minimize impacts of natural drainage systems:

- The City maintains roadside rain gardens to prevent standing water and reduce the potential for mosquito breeding.
- The City provides education and incentives to encourage property owners to maintain rain gardens.

6.8 Noise and Vibration

This section describes the types of noise and vibration impacts that could occur from operation of the Plan alternatives.

6.8.1 What are the potential operational effects of the LTCP Alternative on noise?

Some facilities associated with storage tanks, pipes, and tunnels could generate noise during operation, including the following:

- Odor control facilities. Where passive odor control systems (without ventilation fans) are used, no noise control is required. Otherwise, odor control facilities, and any ventilation facilities, would be provided with noise reduction and attenuation measures as required to conform to permissible noise levels.
- Fans. Fans associated with heating, ventilating, and air conditioning would be contained within a facility vault. Fans would generate a steady, continuous sound and would operate 24 hours a day, 7 days a week.

Key Findings

Noise and Vibration

The net operational effects of the *LTCP Alternative* would be minor in the Plan area. Noise would be generated under all options by pump stations and odor control facilities. All facilities would be designed and maintained to reduce noise to permissible levels. Because the Neighborhood Storage and Shared Storage Options have the most project sites needing pump stations and other facilities, potential noise impacts are greatest for these options. Overall potential for noise impacts would be reduced under the Shared Storage and shared tunnel options because of fewer City and King County-only CSO facilities. No additional noise impacts are expected from the *Integrated Plan Alternative*.

- Tipping buckets, which flush a storage tank with clean water after a CSO event. Noise from tipping buckets is only generated after CSO events and would largely be contained within the tank itself.
- Pump stations. Pumps generate sound on an intermittent basis and most of the noise would be contained within the facility vault.
- Maintenance activities. Maintenance of the facilities would be infrequent and occur only during daytime hours, resulting in a minor source of noise.

Most noise-generating equipment associated with storage tanks and tunnels would be located below ground. All facilities would be designed to comply with the City's maximum allowable noise limits and, in all but the quietest of locations, to not exceed existing background noise levels at facility sites.

There would be no long-term sources of vibration at storage tank, pipe, or tunnel sites.

6.8.1.1 Comparison of Noise Impacts among the LTCP Options

Specific evaluation of noise levels and impacts is addressed at the project level when facility sites are known and site-specific background noise levels can be investigated. However, a general comparison of the potential noise impacts among the LTCP options is provided. Noise would occur from: (1) operation of pump stations and mechanical and electrical facilities, and (2) maintenance activities associated with projects included under the LTCP. Noise-related impacts would be minor under all options.

Because the Neighborhood Storage and Shared Storage Options would potentially have the most pump stations and other facilities, they would have a higher potential for noise impacts. Some pump stations and mechanical facilities could be located in residential areas, particularly in the Lake Washington, Longfellow Creek / Duwamish, and Ship Canal Neighborhoods.

The Shared West Ship Canal and Shared Ship Canal Tunnel Options would potentially have fewer pump stations and mechanical facilities than the other options, so operational noise impacts would potentially be the least under these options.

6.8.2 What are the potential operational effects of the Integrated Plan Alternative on noise?

Storage pipes, tanks, and tunnels constructed under the Integrated Plan Alternative would have the same operational noise impacts as under the LTCP Alternative, but construction of these facilities would be delayed in some neighborhoods. Operation of the projects specific to the Integrated Plan Alternative would have minimal noise impacts. Natural drainage systems would not generate noise. Street sweeping would only occur on arterial streets and would not generate noise in excess of typical vehicle noise. The South Park Water Quality Facility could generate some operational noise from ventilation fans and maintenance activities. However, the facility would be located in an industrial area and operational noise would not impact residences or other sensitive receptors.

6.8.3 What are the potential operational effects of the No Action Alternative on noise?

Operation of sewer system improvements and natural drainage systems would not generate noise.

6.8.4 What measures are proposed to reduce or minimize noise impacts?

A noise analysis for each project would be performed during final design. Once project sites are selected and receiving properties are identified, noise regulations (see Table 4-8) can be used to determine the level at which project-generated noise would be considered significant. Project- and location-specific mitigation measures would be determined at that time. Potential mitigation measures could include the following:

- Pump station and odor control facility designs would include attenuation measures for fan noise and pump and motor noise as needed to comply with noise levels specified by the City of Seattle and to address location-specific factors as determined during project design.
- Facility vault access hatches would be designed to be relatively thick and to have seals at the perimeters to contain noise within the vault.
- Noise-producing ventilation air intakes and exhausts would be placed in a direction facing away from sensitive receptors whenever possible.

6.9 Land Use and Visual Quality

This section describes the types of impacts that could occur to land use and visual quality within the Plan area from operation of the Plan alternatives.

6.9.1 What are the potential operational effects of the LTCP Alternative on land use and visual quality?

6.9.1.1 Consistency with Seattle Comprehensive Plan Policies

The Plan is consistent with the overall goals and policies of the Comprehensive Plan, and individual goals and policies related to utilities and environment that call for improving water quality and minimizing CSO events. Consistency with individual Comprehensive Plan goals and policies related to land use, transportation, and other resources would depend on the details of the future projects.

6.9.1.2 Land Conversion or Easement Restrictions

Potential land use impacts associated with the proposed CSO facilities include conversion of land in residential, commercial, or industrial areas to public utility uses. Residents of residential areas in which CSO facilities are located could perceive the facilities as being inconsistent with local land use policies. As described in Section 4.8.1.2, locating such facilities in residential zones requires a Council Conditional Use Permit which requires public notification and input.

Storage pipes included in the LTCP Alternative would be located within the public right-of-way and would not cause land use changes. Storage pipes and other CSO control projects constructed within existing rights-of-way or City property would generally be most compatible with existing zoning and planning policies. Storage tanks and tunnels would require permanent access hatches or shafts for maintenance, but those access sites would require less property for permanent easements than the areas used for construction. To the extent possible, the City

Key Findings

Land Use and Visual Quality

Potential land use impacts associated with CSO control projects under the *LTCP Alternative* include conversion of land in residential, commercial, or industrial areas to public utility uses. These impacts differ between the options because of different property requirements of tanks vs. tunnels. The completed facilities would largely be constructed below ground; aboveground facilities would have minimal visual impacts with the use of site appropriate design and screening. Stormwater projects constructed under the *Integrated Plan Alternative* are not expected to cause major long term impacts to land use.

would attempt to avoid locating storage facilities such as storage tanks and tunnel portals in parks, and no facilities would be built on beaches. However, limitations in available sites for facilities may necessitate locating storage facilities in or adjacent to a park in some cases, potentially affecting current and future recreational uses. See Section 6.10, Recreation.

The presence of underground storage tanks would restrict certain future uses at the site of the facility. Typical uses for the tops of storage tanks include athletic fields and parking facilities. The City would retain more area in ownership or by permanent easement for a storage tank than for a tunnel.

In contrast to storage tanks, the City would be able to sell or lease approximately 75 percent of the tunnel launch portal lands required for construction back to private ownership where it could be developed for zoned uses (e.g., industrial, commercial). Approximately 0.5 acre would be retained by the City to house the pump station, odor control, and permanent shaft (approximately 30-foot-diameter caisson) for access and maintenance. All of the area used for the smaller, recovery end of the tunnel would be retained by the City. Additionally, tunnel shafts would be required to accept flows from each contributing City and King County CSO basin (depending on the LTCP option).

6.9.1.3 Redevelopment Potential

Construction of tunnel portals could occur in contaminated soils, given the probable location of the tunnel portal along the Lake Washington Ship Canal within historically industrial areas. Remediation of these sites would be required prior to tunnel construction. Once the tunnel has been constructed, much of the tunnel launch portal land could be sold back to private ownership. Remediation would make these areas more attractive for private developers.

6.9.1.4 Visual Impacts

The completed facilities would largely be constructed below ground (Figure 6-2). Aboveground facilities would have minimal visual impacts with the use of appropriate design and screening. Visible facilities would include pump stations and other facilities (if located above ground) to support storage tanks, pipes, and tunnels. Typically the size of these facilities ranges from a small shed to as large as a small residential house; they are designed to blend in with the neighborhood. Some storage facilities would require air ventilation stacks and access panels set into concrete slabs, which would be visible from the immediate site but would not have substantial visual impacts offsite. Apart from the potential removal of vegetation and structures at these sites, visual impacts would be minimal.



Figure 6-2. Typical Underground Storage Tank (Genesee CSO Storage Tank Rendering)

6.9.1.5 Comparison of Land Use and Visual Quality Impacts among the LTCP Options

As described above, storage tanks, and to a lesser extent storage tunnels, could potentially cause minor long-term land use impacts depending on the sites selected. Visual impacts for all options would be minor because aboveground facilities would be relatively small and designed to blend with the surrounding neighborhood. While impacts would generally be similar among the LTCP options, the following differences exist.

Neighborhood Storage Option

This option would have the most storage tanks located throughout the Plan area with the potential to cause permanent land use changes. Private property or permanent easements could be acquired for any of the LTCP options, but they would likely be greatest under the Neighborhood Storage and Shared Storage Options. Current land uses would be permanently changed to become storage facilities, but the tanks and associated equipment would largely be underground. The presence of underground storage tanks would restrict certain future uses at the site of the facility. While there is the potential to redevelop the surface area into certain beneficial uses, the previous land use at the site could be permanently altered. Typical uses for the tops of storage tanks include passive recreation, athletic fields, and parking facilities. The City would retain more area in ownership or by permanent easement for a storage tank than for a tunnel.

Ballard would have the largest storage tank (occupying an estimated 60,000 square feet). The completed facilities would be designed to visually blend with the surroundings, but it is likely that they will have a different appearance than preconstruction conditions. Storage pipes would be constructed in street rights-of-way and would have less potential for land use changes.

Storage pipes located in the Lake Washington Neighborhoods, Longfellow Creek /Duwamish Neighborhoods, and in Magnolia would be constructed in street rights-of-way and would not have a long-term impact on local residential and commercial land uses. Tanks located in the Ship Canal Neighborhoods and the East Waterway area could result in long-term, localized land use impacts given the number of tanks that would potentially need to be sited on industrial lands. The City has heard public concerns about converting the city's limited industrial lands to other uses.

The Neighborhood West Ship Canal Tunnel would have similar impacts in Ballard and Fremont/Wallingford as described below for the Shared West Ship Canal Tunnel Option.

Shared Storage Option

The impacts would be similar to the Neighborhood Storage Option. While fewer sites in the Ship Canal Neighborhoods would be used for storage tanks, and no tank would be sited in the East Waterway area, potential land use impacts from siting larger shared tanks could occur in the Lake Washington Neighborhoods. These tanks would occupy an estimated 35,000 square feet (North Union Bay) and 40,000 square feet (Montlake). There is a greater potential for conversion of residential lands for storage tanks in the Lake Washington Neighborhoods under this option, with perceived inconsistency with adjacent residential land use. As noted above, the City would retain more area in ownership or by permanent easement for a storage tank than for a tunnel, and the presence of an underground tank restricts certain future uses of the site.

Shared West Ship Canal Tunnel Option

This option would have less potential for long-term land use impacts than both the Neighborhood Storage and Shared Storage Options since the tunnel would replace the need to site several storage tanks in the Ship Canal Neighborhoods (Ballard and Fremont/ Wallingford), and less property would need to be retained by the City following construction. In contrast to storage tanks, the City would be able to sell or lease approximately 75 percent of the tunnel launch portal lands in Ballard required for construction back to private ownership where it could be developed for zoned uses (e.g., industrial, commercial). Approximately 0.5 acre of the launch portal would be retained by the City to house the pump station, odor control, and permanent shaft for access and maintenance. All of the area used for the smaller, recovery end of the tunnel in Fremont/Wallingford would be retained by the City. Some additional areas would be retained for permanent shafts as required to accept flows from each contributing City and King County CSO area.

Shared Ship Canal Tunnel Option

Similar to the Shared West Ship Canal Tunnel Option, less property would need to be retained following construction of the tunnel compared to the Neighborhood and Shared Storage Options. The City would be able to sell or lease approximately 75 percent of the tunnel launch portal lands on the south side of the Ship Canal required for construction back to private ownership where it could be developed for zoned uses (e.g., industrial, commercial). Approximately 0.5 acre would be retained by the City to house the pump station, odor control, and permanent shaft for access and maintenance. All of the area used for the smaller, recovery end of the tunnel in North Union Bay would be retained by the City. Compared to the Shared West Ship Canal Tunnel Option, the Ship Canal Tunnel would result in less potential for land use impacts in Ballard and more potential for land use impacts on the south side of the Ship Canal and in North Union Bay.

6.9.2 What are the potential operational effects of the Integrated Plan Alternative on land use and visual quality?

Stormwater projects constructed under the Integrated Plan are not expected to cause major long-term impacts to land use or visual quality. The South Park Water Quality Facility is expected to have a footprint of less than 1 acre and there is likely available City property within the basin that is suitable for the facility. The facility would likely be sited in an industrial-zoned area, surrounded by industrial land uses. The visual impact of the facility is expected to be minimal, because the aboveground structure would be less than two stories high, resembling a pump station building.

Long-term land use impacts from NDS Partnering projects would be minimal because the projects would be implemented in neighborhoods on a voluntary basis, and they would be installed to blend with neighborhood character. Projects such as rain gardens constructed within public rights-of-way would add vegetated elements and streetscaping to existing neighborhoods. The projects would result in narrower roads that can provide a traffic calming effect, which could be a beneficial impact in some neighborhoods. Some neighborhoods would experience increased community interaction, as residents collaborate to develop landscaping plans and implement stewardship programs. Because ongoing maintenance would be an important component in the long-term effectiveness of these facilities, the City would implement a maintenance and monitoring program. The City's early experiences with rain gardens would be used to implement projects that function according to design, are safe, and are sustainable. The facilities would be sited in areas with appropriate soils, and they would only be implemented in areas where the neighborhood has volunteered to be a part of the program.

Land use impacts associated with expanded street sweeping are not expected to occur. Residential parking would not be affected by the expanded program, and because only minimal parking occurs on arterials at night, indirect land use impacts are not expected.

6.9.3 What are the potential operational effects of the No Action Alternative on land use and visual quality?

Operation of sewer system improvements and NDS projects implemented under ongoing programs is not expected to result in land use or visual quality impacts. The planned CSO control projects included in the 2010 Plan Amendment would have minor land use impacts. Visual quality impacts would be limited to the aboveground support facilities needed for the CSO control projects and are also expected to be minor.

6.9.4 What measures are proposed to reduce or minimize impacts to land use and visual quality?

The City would undertake the following measures to mitigate land use and visual quality impacts for all proposed projects:

- Minimize the size of permanent aboveground facilities and design them to blend with the surroundings.
- Locate and aim any artificial lighting away from adjacent roadways, residential areas, and water bodies. Use the minimum wattage necessary to provide the necessary illumination.
- Sell or lease portal land in excess of what is needed back to private ownership.

Additional site-specific measures would be identified during project design.

6.10 Recreation

This section describes the types of impacts that could occur to recreational activities, parks, and beaches within the Plan area resulting from operation of the Plan alternatives.

6.10.1 What are the potential operational impacts of the LTCP Alternative on recreation, parks, and beaches?

The operation of CSO facilities such as sewer system improvements, storage pipes, and flow transfers would cause few impacts to recreation, parks, and beaches because the facilities would be located in public rights-of-way. To the extent possible, the City would attempt to avoid locating CSO facilities such as storage tanks and tunnel portals in parks, and no facilities would be built on beaches.

However, because of limitations in available sites for facilities, it may be necessary to locate storage tanks or tunnel portals in or adjacent to a park or athletic field, or in parking areas or other associated park land. Locating CSO facilities in parks could constrain the use of that portion of a park for certain future park uses. Any underlying utility facility could preclude future development on the site for some uses. Close coordination with Seattle Parks and Recreation would occur to avoid and minimize impacts. Siting a CSO facility in a park would require compliance with Initiative 42 (Ordinance No. 118477) which requires a public hearing and an ordinance finding that any change of a park use to another usage is necessary (see Section 4.9.1.4).

In contrast to storage tanks, which require only small access hatches as permanent surface features, the City would need to retain a portion of the surface area above the tunnel shafts (approximately 30-foot-diameter caisson) for permanent access and maintenance. This permanent area could occupy as much as 0.5 acre.

If the City locates a storage tank in a park, the area over the tank would be restored and opportunities would be explored to provide park amenities on the surface. Associated CSO facilities could take up a small area of the park and would be designed to blend in with the park surroundings. The CSO facility would be designed and constructed to ensure that recreational activities (such as walking, biking, sports, etc.) at parks would not be impacted by the operation of CSO facilities, and that planned or programmed future recreational uses would be maintained to the extent possible. If the City locates a storage tank or tunnel portal on athletic fields, the fields would be restored following construction and no long-term changes in use of the fields would occur. If a CSO facility is built in or adjacent to a park with a National Park Service grant, close coordination with Seattle Parks and Recreation would occur to ensure that the project does not interfere with grant compliance.

In general, the LTCP Alternative would reduce pollutant loading to the area's water bodies, with potential long-term benefits to water-based recreation. In particular, parks within the Ship Canal and Lake Union would experience the highest level of pollutant reduction, followed by Lake Washington, Longfellow Creek, and Puget Sound.

Key Findings

Recreation

Overall, the operational effects from the *LTCP Alternative* on recreational activities are expected to be minor. Reductions in pollutant loading would benefit long-term water quality and help maintain beneficial uses at area beaches. Water contact recreation would be enhanced by improved water quality in Lake Washington, Portage Bay, and Lake Union, in particular. If located in a park, storage facilities would constrain certain future uses of that area for park purposes. However, recreational amenities could be provided on top of storage tanks following construction. The *Integrated Plan Alternative* would not result in additional impacts to recreation. The *No Action Alternative* would result in no additional improvements to water quality in the Plan area water bodies, with ongoing adverse effects on swimming beaches.

6.10.1.1 Comparison of Recreation Impacts among the LTCP Options

Differences among the options within each neighborhood are as follows.

Neighborhood Storage Option

This option would have the most tanks located throughout the Plan area, thereby resulting in the greatest potential to result in long term effects to an existing park or recreational facility. Parks in the Ship Canal Neighborhoods would have the greatest potential to be affected, given the number of tanks located in those neighborhoods. Once construction is complete, recreational activities at parks would be returned to preconstruction uses to the greatest extent possible. Potential future changes in park use could be constrained if permanent CSO facilities are located within the park area.

Parks in the Ship Canal Neighborhoods that could be near CSO facilities include the Burke Gilman Trail in the Fremont/Wallingford neighborhood, Discovery Park, and small neighborhood parks. Lake Washington Neighborhoods have a high concentration of parks, including both small neighborhood parks and major parks such as the Washington Park Arboretum, Madison Park, and numerous parks designed by the Olmsted Brothers. One of the major roads in the area is Lake Washington Boulevard, which was designed by the Olmsted Brothers and is a city park. It is likely that a storage pipe would be built in the right-of-way of Lake Washington Boulevard under this option because few other areas are available. The Leschi neighborhood has a particularly high concentration of parks and few roads suitable for construction in the right-of-way, so it is likely that storage pipes would be built directly adjacent to parks in this neighborhood. CSO facilities in the Longfellow Creek/Duwamish Neighborhoods are less likely to be constructed near parks, though smaller neighborhood parks and the Longfellow Creek Green Space are located in the Delridge neighborhood. CSO facilities in the Central Waterfront neighborhood are unlikely to be directly adjacent to a park, but the neighborhood does include many significant recreational facilities such as the Sculpture Park, the Aquarium, and small neighborhood parks.

The Neighborhood West Ship Canal Tunnel would have similar impacts in Ballard and Fremont/Wallingford as described below for the Shared West Ship Canal Tunnel Option.

Shared Storage Option

This option would have similar potential impacts as the Neighborhood Storage Option. While fewer sites in the Ship Canal Neighborhoods would be used for storage tanks, potential park and recreation impacts from siting larger shared tanks could occur in Fremont/Wallingford (Burke Gilman Trail and Fremont Canal Park) and in the Lake Washington Neighborhoods. The Montlake neighborhood is more likely to be affected under this option because of the relatively larger amount of parkland, including Montlake Boulevard (an Olmsted Park). The storage tank in North Union Bay would be located in proximity to the University of Washington Athletic Complex (including fields, a golf course, a ballpark, and an outdoor track) and the Union Bay Natural Area. Potentially impacted parks in other neighborhoods would be the same as under the Neighborhood Storage Option.

Shared West Ship Canal Tunnel Option

The tunnel would replace the need to site several storage tanks in the Ship Canal Neighborhoods (Ballard and Fremont/Wallingford), reducing the potential for long-term impacts to parks and recreational facilities. However, the tunnel portal site could be located in or adjacent to existing or planned parks and greenways. Potentially impacted parks in other neighborhoods would be the same as under the Neighborhood Storage Option.

Shared Ship Canal Tunnel Option

Tunnel portals would be located along the south side of the Ship Canal and North Union Bay where there are many park and recreation areas, including sports fields owned and operated by Seattle Pacific University and the University of Washington, as well as the Burke Gilman Trail and numerous neighborhood parks. Fields and parking lots associated with the University of Washington Athletic Complex could be impacted. However, no storage tanks would be built in the Ship Canal or Lake Washington Neighborhoods, reducing the potential to affect parks and recreational opportunities in these neighborhoods. Potentially impacted parks in the Longfellow Creek/Duwamish and Elliott Bay/Lake Union Neighborhoods would be the same as under the Neighborhood Storage Option.

6.10.2 What are the potential operational effects of the Integrated Plan Alternative on recreation, parks, and beaches?

Storage pipes, tanks, and tunnels constructed under the Integrated Plan Alternative would have the same recreational impacts as under the LTCP Alternative. The elements specific to the Integrated Plan Alternative are not expected to result in recreation impacts. Natural drainage systems would be constructed largely in residential areas and the completed projects would not impact passive recreation such as walking and biking. Expanded street sweeping would use main arterial roads and would occur at night, so it would be unlikely to impact recreational use of streets. The South Park Water Quality Facility would be located in an industrial area and would not be near any recreational uses.

In general, the Integrated Plan Alternative would result in greater reduction of pollutant loading to the area's water bodies than the LTCP Alternative, although both alternatives would provide overall benefits to water-based recreation. Water-based recreation in the Duwamish River would receive the highest level of initial benefit because of proposed projects within that basin.

6.10.3 What are the potential operational effects of the No Action Alternative on recreation?

Sewer system improvements would cause no direct impacts to recreation, parks, and beaches. Natural drainage solution projects such as rain gardens could be constructed adjacent to or in parks. These facilities are not expected to affect recreation or use of the parks. Rain garden plantings would blend with park landscaping. The CSO control projects included in 2010 Plan Amendment could be located in or near parks and beaches. Those projects either have been completed or will undergo separate SEPA analysis, as appropriate.

The No Action Alternative would result in no additional improvements to water quality in the Plan area. Indirect effects on water-based recreational activities at swimming beaches and in Plan area water bodies associated with continued CSO discharges would continue and potentially worsen.

6.10.4 What potential measures are proposed to reduce or minimize impacts to recreation?

The City would undertake the following measures to mitigate park and recreational impacts for all proposed projects:

- Comply with the conditions of Initiative 42 (Ordinance No. 118477) related to siting public facilities in parks.

- Coordinate closely with Seattle Parks and Recreation Department to minimize potential operational impacts for current and future recreational activities.

Additional site-specific measures, including mitigation for project-related impacts, would be identified during project design.

6.11 Historic, Cultural, and Archaeological

Operation of projects implemented under the Plan alternatives is anticipated to have no effect on historic, cultural, and archaeological resources within the Plan area.

6.12 Transportation

This section describes the types of impacts that could occur to transportation within the Plan area from operation of the Plan alternatives.

6.12.1 What are the potential operational effects of the LTCP Alternative on transportation?

When constructed, the CSO facilities would be located mostly underground and physically separated from transportation infrastructure and services. Transportation infrastructure disrupted during construction would be restored, and streets disturbed during construction would be repaved.

The most common visits to storage facilities by City maintenance staff would occur quarterly and after a CSO event, typically requiring only one vehicle. In the first year or so of use, City staff may elect to visit the site periodically during or after a CSO event, which would also typically require only one vehicle. The frequency and number of vehicles represent a very small portion of the overall traffic in the project vicinity. Occasional maintenance may be required at these locations, which could generate a small number of localized vehicle trips. This is expected to occur infrequently and would not affect roadway operations. Therefore, no long-term impacts on transportation are expected to result from the LTCP Alternative.

6.12.2 What are the potential operational effects of the Integrated Plan Alternative on transportation?

Operation of the additional projects implemented under the Integrated Plan Alternative would have minimal transportation impacts. Projects implemented under NDS Partnering may generate occasional maintenance trips that would have negligible effects on traffic operations. The South Park Water Quality Facility could also generate occasional vehicle trips with minimal effect on roadway operations. Expanded street sweeping would consist of expanding the extent of a program that is already in place. Street sweeping would only occur on arterial streets at night when traffic is low and would not affect roadway operations.

Key Findings

Transportation

Overall, the operational effects from vehicle trips generated by facility maintenance under all Plan alternatives are expected to be minor.

6.12.3 What are the potential operational effects of the No Action Alternative on transportation?

Completed projects under the No Action Alternative are not expected to cause transportation impacts.

Occasional maintenance may be required at locations of sewer system improvements, natural drainage projects, and CSO control projects completed under the 2010 Plan Amendment, which could generate a small number of localized vehicle trips. These trips would be expected to occur infrequently and would not affect roadway operations.

6.12.4 What measures are proposed to reduce or minimize impacts to transportation?

Because there would be no impacts to transportation, no mitigation measures are proposed.

6.13 Utilities

This section describes the types of impacts that could occur to utilities (largely wastewater utilities) within the Plan area from operation of the Plan alternatives. Potential impacts to other utilities including water, electrical, natural gas, and communications are highly project-specific and will be evaluated at the future project implementation stage.

6.13.1 What are the potential operational effects of the LTCP Alternative on utilities?

Implementation of the LTCP will require close coordination with numerous utilities, in particular, wastewater and stormwater utilities within the service area. Because the City's collection system network sends wastewater to King County for treatment, coordination with King County will be particularly important. King County's West Point Treatment Plant would receive additional sewage flows as a result of Plan implementation. The high variability in flow rates within the sewer system associated with heavy storms could be challenging to manage at the King County West Point Treatment Plant.

Based on City modeling, these additional flows will have little effect on the peak loading to King County's West Point Treatment Plant and may potentially reduce peak loading. However, annual average flows will increase, resulting in greater operational and maintenance costs. Seattle and King County will address the incremental cost of these flows in their sewage disposal agreement. The potential implications to King County's combined sewer system vary depending upon the option implemented, as described below. In general the operational implications associated with shared options will require greater coordination with King County than the Neighborhood Storage Option.

Key Findings

Utilities

Implementation of the *LTCP Alternative* would require close coordination with numerous utilities within the service area. King County's West Point Treatment Plant would receive additional sewage flows, but these additional flows would have little effect on the peak loading to West Point. However, annual average flows would increase, resulting in greater operational and maintenance costs to King County. The potential implications to King County's combined sewer system vary depending upon the option implemented. For all LTCP options, the City would work together with King County to analyze and mitigate downstream operational and capital impacts to the King County System.

Impacts to public utilities would be largely related to selection of an LTCP option. No additional impacts are expected to occur related to the implementation of *Integrated Plan* stormwater projects.

Neighborhood Storage Option

This option would generally have minimal operational impacts to utilities within the service area once construction is complete. Sewer system improvements in North Union Bay and a flow diversion in Portage Bay, as well as flow diversions in the South Delridge and East Waterway neighborhoods, would modify the flow volumes diverted to the King County system. This could result in operational impacts if not adequately coordinated with the County. However, all flow diversions would be undertaken in accordance with signed agreements with King County to ensure that impacts do not occur or are mitigated.

This option would result in the largest number of independent storage and conveyance (pipeline and pump station) facilities constructed and operated by both the City and the County, resulting in accompanying operation and maintenance requirements for each facility. Implementing the Neighborhood West Ship Canal Tunnel option would reduce the total number of facilities constructed, which could reduce the operational impacts associated with the individual storage facilities, but would result in operational considerations for the tunnel.

Shared Storage Option

The Shared Storage Option would result in three shared storage projects, including a shared tunnel in the Fremont/Wallingford neighborhood, a storage tank in the North Union Bay neighborhood, and a storage tank and flow diversion structures in the Montlake/Leschi neighborhoods. Shared projects would require close coordination regarding operation and maintenance considerations, cost sharing, and other factors. Close coordination of these projects between utilities can avoid any decrease in the operational efficiency of shared facilities. Long-term agreements will be made prior to the decision to implement the shared projects; therefore, significant long-term impacts are not anticipated. Implementation of this option would eliminate the need for several City and King County independent storage facilities, which would reduce the overall operational and maintenance requirements.

Shared West Ship Canal Tunnel Option

The Shared West Ship Canal Tunnel Option would require substantial coordination with King County during project planning, design, and construction. The Shared West Ship Canal Tunnel Option may reduce the operational complexity of controlling neighborhood storage tanks or even shared storage tanks, as it provides one large storage facility for all flows to be managed through a single point of discharge to the West Point Treatment Plant. Substantial coordination with King County would be needed during the planning, design, construction, and operation of the shared tunnel to capture all potential benefits.

Shared Ship Canal Tunnel Option

The Shared Ship Canal Tunnel Option would require substantial coordination with King County during project planning, design, and construction. As with the Shared West Ship Canal Tunnel Option, this option may reduce the operational complexity of controlling neighborhood storage tanks or even shared storage tanks, as it provides one large storage facility for all flows to be managed through a single point of discharge to the West Point Treatment Plant. Additional City and King County flows would be handled by the larger, Shared Ship Canal Tunnel, further reducing operational complexity. Substantial coordination with King County would be needed during the planning, design, construction, and operation of the shared tunnel to capture all potential benefits.

6.13.2 What are the potential operational effects of the Integrated Plan Alternative on utilities?

Operation of the additional projects implemented under the Integrated Plan Alternative would not have any anticipated adverse impacts on utilities.

6.13.3 What are the potential operational effects of the No Action Alternative on utilities?

Operation of projects completed as part of ongoing programs under the No Action Alternative is not expected to cause utility impacts. Under the No Action Alternative, no additional CSO control measures would be completed. Therefore, no additional storage would be constructed within the City's combined sewer system, resulting in continued and likely more frequent and/or higher volume overflows occurring into the future. Implementation of the No Action Alternative would not comply with the Consent Decree, and it could potentially result in significant fines for the City, with potential impacts to City ratepayers.

6.13.4 What measures are proposed to reduce or minimize impacts to utilities?

For all LTCP options, the City would work together with King County to analyze and mitigate downstream operational and capital impacts to the King County System. If downstream impacts cannot be successfully mitigated, then there is the potential that the County will be required to build new or larger downstream capital facilities to accommodate the LTCP options. Even with adequate mitigation though, there would likely be an increase in the County's operations & maintenance (O&M) costs to account for the additional flows from the City's system.

6.14 Socioeconomics and Environmental Justice

This section describes the types of socioeconomic and environmental justice impacts that could occur within the Plan area from operation of the Plan alternatives.

6.14.1 What are the potential operational effects of the LTCP Alternative on socioeconomic conditions and environmental justice populations?

6.14.1.1 Neighborhood Cohesion

The greatest impact of storage facilities on socioeconomic conditions, including neighborhood cohesion, would occur during construction. Once the facilities are completed, the disruptions would be minor and infrequent. Sewer system improvements and storage pipes, tanks, and tunnels would be located underground and would not cause impacts. Some associated facilities would generate noise, but noise levels are not expected to exceed the City's maximum noise levels. Some facilities also have the potential to produce odor, but that potential is minimal because the facilities would include state-of-the-art odor reduction equipment. None of the completed facilities

Key Findings

Socioeconomics and Environmental Justice

The operational effects of both the *LTCP Alternative* and *Integrated Plan Alternative* would be minor to moderately beneficial, and there would be no adverse operational effects that would be predominantly borne by minority or low-income populations and underserved communities. The *No Action Alternative* could result in minimal to substantial adverse impacts on environmental justice populations in the Plan area.

would have long-term effects on community facilities (churches, schools, community centers, or libraries). There would be no changes to travel routes and durations, transit service, pedestrian access, or the character of land uses in neighborhoods. Therefore, none of the options would have long-term operational effects on neighborhood cohesion.

6.14.1.2 Environmental Justice

Because the LTCP options would result in very limited and minor operational effects, there would be no adverse operational effects that would be predominantly borne by minority or low-income populations. These minor impacts would affect all populations including historically underserved and low-income residents of neighborhoods in the Plan area. While the Longfellow Creek/Duwamish Neighborhoods have a greater presence of minority and low-income populations in comparison to other neighborhoods in the Plan area, none of the options include projects that would have greater operational disturbance in this area than in the other Plan neighborhoods. Given the distribution of the LTCP projects throughout the city, these minor operational effects on neighborhoods would not fall disproportionately on environmental justice populations. Implementation of the LTCP Alternative would not result in any identifiable effects that would be specific to any minority, low-income, or underserved community.

Under the LTCP Alternative, CSO discharges would be reduced, which would indirectly result in a long-term, beneficial impact on human health and safety. There would be beneficial effects on those who fish along the piers or waterfront as a result of improved water quality. These effects would be the same regardless of option. The improved water quality that would be achieved could increase the number of salmon and other fish species over time and could indirectly benefit Native American fishing in the area.

6.14.1.3 Comparison of Socioeconomic and Environmental Justice Impacts among the LTCP Options

Generally, none of the projects proposed for any of the LTCP Alternative options would have environmental justice impacts. While socioeconomic impacts would be minor and are generally similar among the LTCP options, the following differences exist.

Neighborhood Storage Option

The availability of sites ranging from 0.5 acre to 2 acres that are suitable for storage tanks is limited in the Plan neighborhoods. Economic and business impacts could result if economically important industrial or commercial lands are purchased or leased for this purpose.

The Neighborhood West Ship Canal Tunnel would have similar impacts in the Ship Canal Neighborhoods as described below for the Shared West Ship Canal Tunnel Option.

Shared Storage Option

Shared storage tanks (and a flow transfer in the East Waterway area) would reduce the total number of new storage tanks required in the city (by both the City and King County). This would reduce the amount of property acquisition or permanent easements required.

Shared West Ship Canal Tunnel Option

Under the Shared West Ship Canal Tunnel Option, beneficial effects on local economic activity in the Ship Canal Neighborhoods could occur over time once construction is completed and previous vacant industrial or commercial lands (if used for tunnel portals) become more attractive for investment. Lands reclaimed or

repurposed for industrial or commercial use after construction of tunnels could stimulate economic activity, provide opportunities for new or expanded business and employment, and generate more tax revenues.

Shared Ship Canal Tunnel Option

Impacts would generally be the same as the West Ship Canal Tunnel Option and could potentially be beneficial.

6.14.2 What are the potential operational effects of the Integrated Plan Alternative on socioeconomic conditions and environmental justice populations?

The effects of the additional Integrated Plan stormwater projects would be minor to moderately beneficial. There would be no adverse operational effects that would be predominantly borne by minority or low-income populations and underserved communities. Under the Integrated Plan Alternative, both the stormwater projects and the deferred LTCP projects would reduce pollutant loads to water bodies. However, the deferred LTCP projects would benefit the Duwamish Waterway and the Ship Canal while the stormwater projects would benefit water bodies throughout the city. The Integrated Plan Alternative would result in substantially larger reductions in pollutant loads than the LTCP projects alone. This should bring large reductions in environmental health risks, which are often predominantly borne by minority or low-income populations.

6.14.3 What are the potential operational effects of the No Action Alternative on socioeconomic conditions and environmental justice populations?

Under the No Action Alternative, CSO discharges would not be reduced beyond what is planned as part of the 2010 Plan Amendment. No further improvements in current environmental health risks associated with pollution of the Plan area water bodies would occur. These current health risks are predominantly borne by low-income, tribal, and subsistence fishing communities, and immigrant families for whom fishing the Duwamish River, the Lake Washington system, and Puget Sound is rooted in cultural traditions.

Sewer system improvements and natural drainage systems included in the No Action Alternative are not expected to cause socioeconomic or environmental justice impacts.

6.14.4 What measures are proposed to reduce or minimize socioeconomic and environmental justice impacts?

The City actively solicited public participation as part of the planning process for the Plan and gave equal consideration to all input from persons regardless of age, race, income status, or other socioeconomic or demographic factors. The City will continue public participation efforts as projects are advanced consistent with the City's social and racial justice initiative.

CHAPTER 7

Cumulative Impacts

7.1 What are cumulative impacts and why do we study them?

Cumulative impacts are the effects that may result from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions, regardless of who undertakes them. Generally, an action can be considered cumulative if: (a) effects of several actions occur in the same locale; (b) effects on a particular resource are similar in nature; and (c) effects are long-term in nature. It is appropriate to evaluate the cumulative effects of a comprehensive program such as the **Plan to Protect Seattle's Waterways** (the Plan) in this programmatic EIS, to get a full understanding of the tradeoffs, impacts and benefits associated with the Plan alternatives and options.

7.2 How were cumulative impacts identified and evaluated?

Cumulative impacts were analyzed by identifying projects within the same geographic area (city of Seattle) and time period (2015 - 2030). First, similar CSO reduction projects being pursued by the City and King County during the same timeframe were identified and analyzed to determine whether cumulative impacts could occur from the combined projects (Section 7.3.1 below). Then other major capital projects were identified using plans, agency web sites, and other available information (Section 7.3.2). Due to the extended timeframe of Plan implementation, many major ongoing projects in Seattle are expected to be completed by the time the LTCP CSO control and Integrated Plan stormwater projects would be built. Therefore, the types of projects that could be under construction at the same time as the Plan projects are discussed.

7.3 What are the reasonably foreseeable projects and actions that could affect or be affected by the Plan alternatives?

7.3.1 Combined Sewer Overflow Control Projects

Other projects that could occur in the same neighborhoods or coincide with implementation of the LTCP include CSO control projects being constructed by the City and King County. Table 7.1 lists CSO reduction projects being constructed under the City's 2010 CSO Plan Amendment. These projects are part of the No Action Alternative, and would be constructed regardless of the implementation of the Plan. Together, these projects are expected to store approximately 5 million total gallons of combined sewage. Only one of these projects would occur in the same neighborhood as LTCP projects (Central Waterfront). A more complete description of these projects, can be found at www.seattle.gov/CSO.

Table 7-1. Storage Projects (2010 Plan Amendment)		
CSO Basin / Basin #	Project Description	Completion Date
Windermere		
13	Storage tank in Magnusson Park	2014
Genesee		
40/41	Storage tank at 49th Avenue South and Lake Washington Boulevard	2015
43	Storage tank at 53rd Avenue South and Lake Washington Boulevard	2015
Central Waterfront		
70, 71, and 72	Increased conveyance to King County Elliott Bay Interceptor and storage	2018
Henderson North		
44	Storage tank in Seward Park	2018
45	Storage tank in ROW	

Table 7-2 lists CSO control projects included in King County's Long-Term CSO Control Plan Amendment (King County, 2012a). Several of the King County CSO control projects would be located within Plan neighborhoods, including one each in the North Union Bay, Montlake, and Fremont/Wallingford neighborhoods, and five in the Longfellow Creek/Duwamish Neighborhoods. Under three of the four LTCP options, projects would be shared between the City and King County.

Table 7-2. King County CSO Control Projects				
King County CSO Project	Independent Project	Shared Project	Project Planning and Implementation	Proximity to LTCP Projects
University	2.9 MG storage tank	Shared Storage Option: Joint 5.2 MG storage tank Ship Canal Tunnel: Conveyance to tunnel	2022-2028	In North Union Bay neighborhood
Montlake	6.6 MG storage tank	Shared Storage Option: Joint 7.9 MG storage tank Ship Canal Tunnel: Conveyance to tunnel	2022-2028	In Montlake neighborhood
3rd Ave West	4.2 MG storage tank	Shared Storage Option: Joint 7.2 MG storage tank Ship Canal Tunnel: Conveyance to tunnel	2017-2026	In Fremont/ Wallingford neighborhood
11th Ave West	Conveyance to Ballard Siphon	Ship Canal Tunnel: Conveyance to tunnel	2025-2031	Between Fremont/ Wallingford and Ballard neighborhoods

Table 7-2. King County CSO Control Projects				
King County CSO Project	Independent Project	Shared Project	Project Planning and Implementation	Proximity to LTCP Projects
Chelan Ave	3.9 MG storage tank	No shared project	2017-2025	In Longfellow Creek/ Duwamish neighborhoods
W. Michigan-Terminal 115	0.3 MG storage pipe	No shared project	2019-2025	In Longfellow Creek/ Duwamish neighborhoods
Hanford #1	Conveyance to Bayview Tunnel	No shared project	2011-2019	In Longfellow Creek/ Duwamish neighborhoods
Hanford #2 - Lander St - King St - Kingdome (HLKK)	151 MGD wet weather treatment facility	Shared Storage Option, West Ship Canal Tunnel Option, and Ship Canal Tunnel Option: HLKK treatment facility would receive flows from East Waterway	2021-2031	In Longfellow Creek/ Duwamish and Elliott Bay neighborhoods
Brandon St – S. Michigan (Georgetown)	66 MGD wet weather treatment facility	No shared project	2012-2022	In Longfellow Creek/ Duwamish neighborhoods

7.3.2 Other Major Construction Projects

Several major construction projects in Seattle will be complete by the time LTCP projects begin construction, including the SR-520 Bridge Replacement. Major transportation projects that could be under construction simultaneously with LTCP CSO control projects include the Sound Transit U-Link Extension (to be completed in 2016), Lynnwood Link Extension (construction in 2018 - 2023), East Link Extension (construction in 2015 - 2021), Waterfront Project (Elliott Bay Seawall and Waterfront Seattle Core projects), the Alaskan Way Viaduct Replacement Project, WSDOT's SR-509 and SR-167 project, Colman Ferry Dock Replacement, and other roadway and transit improvements. Transportation projects throughout the city are discussed in Section 4.11.

Over the next 15 years, Seattle City Light will be building new substations in Interbay, SODO, South Lake Union (Denny Way Substation), and the northeast and northwest parts of the city, as well as expanding capacity at the North, Duwamish, Shoreline, University, and Creston substations (Seattle, 2005). The City of Seattle has adopted a Capital Improvement Program for 2013-2018 which lists 622 individual capital projects to be constructed over the five-year period (Seattle, 2013). The Capital Improvement Program is updated yearly.

Given the extended timeframe of the Plan projects, other major projects that are not yet anticipated would likely have construction periods that overlap with Plan projects. Minor construction (such as single- and multi-family residential or commercial construction, road resurfacing, bridge repair, and general maintenance projects) could also cause localized cumulative construction impacts if located in close proximity to Plan projects.

Major capital transportation projects that are planned within the Plan area include both roadway and transit improvements. Construction schedules span several years. Figure 7-1 illustrates major planned transportation projects and other major infrastructure projects planned for the area.

7.4 What are the potential construction-related cumulative impacts of the LTCP Alternative?

Major construction projects have been underway in the greater Seattle area for the past decade. The long term effects of dealing with construction-related impacts can negatively affect residents, businesses, and those who travel through the area, resulting in impacts that range from temporary inconvenience to loss of residences, businesses, and quality of life. The primary construction impacts related to LTCP projects include traffic and slowdowns, increased dust and emissions, and construction noise. In addition, in many neighborhoods, residents and workers have experienced ongoing construction noise and traffic delays for years from unrelated construction efforts. “Construction fatigue” could be worse in neighborhoods that have seen a high level of construction for major projects in recent years, such as Montlake and the University District. Neighborhoods such as Ballard that have experienced high levels of construction for new residential and commercial structures are also at high risk for construction fatigue.

Other major construction projects (either King County CSO control projects or other projects) could contribute to cumulative impacts on transportation or air quality even if located farther away from LTCP or Integrated Plan projects. Other construction projects in the same neighborhood or affecting another portion of the same arterial as LTCP or Integrated Plan projects could also contribute to traffic congestion.

Simultaneous construction of t Plan projects and other CSO control projects is unlikely to cause cumulative noise impacts, because projects would not be close enough together that noise from two CSO control projects would be audible at any one receptor. However, cumulative impacts from other projects, even minor construction projects, could add to the noise levels near the Plan projects.

7.4.1 Comparison of Cumulative Impacts among the LTCP Options

All of the CSO facilities would include long-term construction projects that would overlap with other, unrelated construction projects throughout the city. While impacts are generally similar between the LTCP options, the following differences exist.

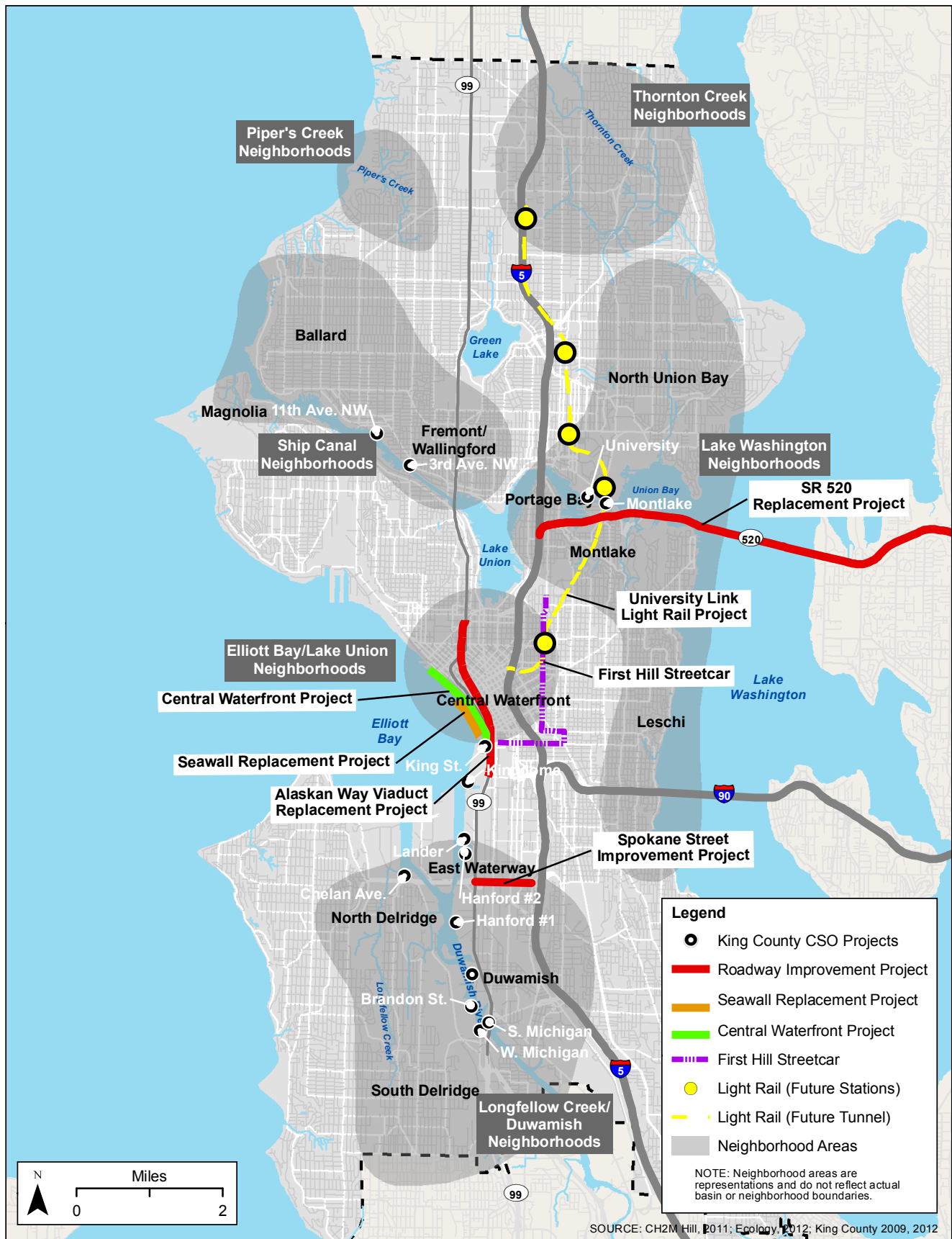


Figure 7-1 Major Planned Transportation Projects and King County CSO Locations.

7.4.1.1 Neighborhood Storage Option

Cumulative impacts would affect the greatest number of neighborhoods under the Neighborhood Storage Option, where a combined total of 27 storage tanks or pipes (18 by the City, and nine by King County) would be built by both the City and King County throughout the city over a multi-year period from approximately 2018 to 2025 or beyond. Neighborhoods most directly affected include the University, Montlake, Ballard, and Longfellow/Duwamish neighborhoods. Construction-related impacts from City and County projects would be greatest in these neighborhoods, with a duration ranging from one to five years, with the longest duration in the Ballard neighborhood for construction of a large storage tank. Under other LTCP options, these projects would be combined into a single shared project in each neighborhood. If a tunnel is used for the Neighborhood Storage Option, there would be two fewer tanks constructed. The construction of 27 storage tanks in the Seattle area represents a significant level of construction throughout the city.

7.4.1.2 Shared Storage Option

This option would have a lower potential for construction-related cumulative impacts than the Neighborhood Storage Option because some CSO control projects would be shared by the City and King County, but still represents a substantial level of construction throughout the city. This option would result in nine facilities constructed by the City, six by King County, and three shared facilities, for a total of 18 tanks. Construction durations at some locations could be as long as 4.5 years, with the longest durations in the Leschi and Montlake neighborhoods. Fewer storage tanks and pipes would be constructed in the Ship Canal and Lake Washington Neighborhoods, reducing the potential for cumulative impacts in these neighborhoods. This option also includes several storage tanks with the potential to be located in or near residential areas of the Ship Canal, Lake Washington, Longfellow Creek / Duwamish, and Central Waterfront neighborhoods, and replaces a storage tank with a flow transfer in the East Waterway neighborhood, which would reduce construction-related impacts in these neighborhoods.

7.4.1.3 Shared West Ship Canal Tunnel Option

This option would have a potential for cumulative impacts similar to the Neighborhood Storage Option, with 14 storage facilities constructed by SPU, eight by King County, and one shared facility for a total of 23 facilities constructed. The Shared West Ship Canal Tunnel would replace City and King County storage tanks in Ballard and Fremont/Wallingford, which would reduce construction-related impacts at the site of those tanks; however, the large tunnel would concentrate construction-related impacts at the launch portal (likely located along the Lake Washington Ship Canal in Ballard) for as long as 3.5 years. In East Waterway and Magnolia, flow transfers would replace storage tanks/pipes, which would reduce cumulative impacts in these neighborhoods.

7.4.1.4 Shared Ship Canal Tunnel Option

This option would affect the fewest number of neighborhoods throughout the city. This option would include three storage facilities constructed by the City, six by King County, and one shared facility for a total of 10 facilities constructed. Storage facilities would largely be eliminated in the Lake Washington Neighborhoods of Montlake, Madison Park, Portage Bay, and Leschi, thereby reducing the construction-related impacts in these neighborhoods. This option would also reduce the number of storage tanks in Ballard and Fremont/Wallingford. The large tunnel would be the largest single project associated with any of the LTCP options, and has the greatest potential to contribute to construction fatigue in the areas where the six- year construction project would be located. The launch portal would likely be located on the south side of the Ship Canal on the north slope of Queen Anne, and would be subject to the highest intensity of impacts over the approximate six-year construction

duration. This option would reduce the number of King County projects being constructed, including projects slated for the University, Montlake, and Queen Anne (north slope) neighborhoods.

7.4.2 What are the potential construction-related cumulative impacts of the Integrated Plan Alternative?

The cumulative impacts associated with the Integrated Plan relate largely to construction of the LTCP storage facilities, as described above. Impacts resulting from the construction of the South Park Water Quality Facility would be offset by deferred construction of six CSO facilities, but overall impacts are not expected to be appreciably different from the LTCP. Impacts to the Duwamish River neighborhoods would be delayed associated with the deferral of three CSO projects, but the South Park Water Quality Facility would occur within that neighborhood. Cumulative impacts associated with expanded street sweeping and NDS Partnering are not expected.

7.5 What are the potential long-term cumulative operational impacts of multiple CSO reduction and/or stormwater treatment projects?

The LTCP projects would have long-term benefits to water quality in Plan area water bodies. After construction, the City's projects along with King County's projects would benefit water quality by reducing the frequency and volume of CSO events. This would reduce the potential for human health risks associated with CSO and stormwater discharges, and provide benefits to fish and aquatic habitat. As noted in Section 6.4 and 6.7, the Integrated Plan Alternative results in greater benefits to water quality, and accompanying reduction of potential risk to human and environmental health, than the LTCP Alternative.

Potential cumulative impacts to park properties could occur if the City and King County CSO (and/or stormwater) facilities are built in parks. As discussed in Section 6.10, constructing CSO storage facilities in parks could constrain future use of the park and preclude certain development in the park at a later date. There is a limited amount of park land in the city, and the cumulative impact of this project combined with other past and future projects could put constraints on the park system for future development.

Potential cumulative impacts to industrial-zoned properties could occur if the City and King County CSO facilities are located on industrial parcels. As discussed in Section 6.9, constructing CSO storage or stormwater facilities on industrial-zoned parcels could constrain future use of the parcel for other industrial uses and preclude future industrial development, if the areas are permanently retained by the City and King County. There is a limited amount of industrial land in the city, and the cumulative impact of this project combined with other past and future citywide infrastructure projects could limit the potential for future industrial development within selected areas of the city.

Potential operational issues associated with shared City facilities with King County could increase or change operational considerations for both King County and the City. For all LTCP options, the City would work together with King County to analyze and mitigate downstream operational and capital impacts to the King County System. If downstream impacts cannot be successfully mitigated, then there is the potential that the County will be required to build new or larger downstream capital facilities to accommodate the LTCP options. Even with adequate mitigation there would likely be an increase in the County's operations & maintenance (O&M) costs to account for the additional flows from the City's system.

To the greatest extent practicable, the City would try to time construction projects to minimize neighborhood impacts and reduce overall construction-related impacts in affected communities. The City will coordinate closely with the proponents of major projects throughout the city to minimize the potential for cumulative impacts; however, it is likely that some level of cumulative impact is unavoidable. As appropriate, the City will develop site-specific mitigation during project level review.

CHAPTER 8

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Appendix A: Scoping Summary Report

Plan to Protect Seattle's Waterways Scoping Summary Report

Report Purpose

Seattle Public Utilities is preparing an Environmental Impact Statement (EIS) under the State Environmental Policy Act (SEPA) to identify how the Plan to Protect Seattle's Waterways (Plan) could impact people and the environment. Per the City of Seattle's SEPA Policy and Procedures (SMC 25.05), Seattle Public Utilities issued a Determination of Significance (DS) and scoping notice on May 20, 2013 to initiate scoping, the first step in the environmental review process.

Scoping was conducted from May 20 - June 20, 2013, and this report summarizes the process. The first section of the report explains the need for the Plan, provides an overview of the environmental review process, and introduces the Plan alternatives. The second section describes the opportunities Seattle Public Utilities provided the public, agencies, and tribes to learn about and comment on the Plan alternatives. The third section summarizes the comments Seattle Public Utilities received during scoping and describes how Seattle Public Utilities will address these comments.

Plan Overview

About two-thirds of Seattle is served by a combined sewer system, which was designed to carry sewage from inside homes and stormwater runoff from streets, rooftops, and parking lots in a single pipe—a “combined sewer.” During dry weather, all raw sewage flows to the treatment plant. When it rains, the pipes can become overloaded with polluted stormwater. This mixture of stormwater (about 90%) and raw sewage may overflow into lakes, creeks, and Puget Sound.

The Plan to Protect Seattle’s Waterways will outline Seattle Public Utilities’ strategy to control sewage overflows and meet state and federal regulations.

Specifically, the Plan will:

- Identify areas of Seattle where projects are needed to reduce sewage overflows.
- Evaluate alternatives for reducing sewage overflows in these areas.
- Identify areas where additional projects to control and treat polluted stormwater runoff will improve water quality.
- Recommend a schedule for designing and constructing projects.
- Estimate program costs and associated impacts on Seattle Public Utilities' customer bills.
- Consider input from the public, stakeholders, agencies, and tribes.

Why does Seattle Need the Plan?

Thirty-five of the 87 outfalls Seattle Public Utilities manages are uncontrolled, meaning that sewage overflows occur more than once per year on average. Seattle’s combined sewers overflowed into local waterways 355 times in 2012 releasing 154 million gallons of untreated raw sewage and stormwater into local waterways.

The mixture of stormwater and sewage can affect fish, wildlife, and water quality in the areas where overflows occur. Consequently, the federal Clean Water Act and state regulations require that we take action and reduce overflows to an average of no more than one overflow per outfall per year. The Plan to Protect Seattle’s Waterways will outline Seattle Public Utilities’ strategy for complying with these requirements.

Location of Sewage Overflow Outfalls Managed by Seattle Public Utilities



35 of the 87 outfalls Seattle Public Utilities Manages are uncontrolled, meaning that overflows occur more than once per year on average.

Environmental Review Process

The Plan to Protect Seattle's Waterways will be a planning level document that identifies the general location, type, size, and number of projects Seattle Public Utilities proposes to build throughout the city to reduce sewage overflows. Seattle Public Utilities is preparing an EIS under the State Environmental Policy Act (SEPA) to analyze the environmental impacts of the Plan.

Because the Plan describes an entire program, rather than individual projects, Seattle Public Utilities is preparing a programmatic EIS to analyze the potential effects of the Plan on people and the environment. The EIS will examine how combinations of projects may collectively impact the environment. It differs from a project-specific EIS, which focuses on the site-specific impacts of individual projects. The programmatic EIS will not include site-specific evaluations or select project sites. It will describe the alternatives' impacts comparatively, within potentially affected neighborhoods and within the entire City service area.

Scoping is the first step in the environmental review process. The purpose of scoping is to determine the range, or "scope" of issues to study in the environmental review document, as required by SEPA.

Seattle Public Utilities will conduct a project-specific environmental review process for each project during Plan implementation.

Plan Alternatives

Seattle Public Utilities is evaluating two alternatives in the EIS. The Sewage Overflow Reduction Alternative (also referred to as the Long-Term Control Plan or LTCP Alternative) focuses solely on the combined sewer system and reducing sewage overflows to an average of no more than one overflow per outfall per year. Seattle Public Utilities is evaluating four options within the Sewage Overflow Reduction Alternative: the Neighborhood Storage Option, Shared Storage Option, West Ship Canal Tunnel Option, and Ship Canal Tunnel Option. The Sewage and Stormwater Pollution Reduction Alternative (also referred to as the Integrated Plan Alternative) uses an integrated approach to reduce both sewage overflows and polluted stormwater runoff. Both alternatives would allow Seattle Public Utilities to meet its obligation to prepare a Long-Term Control Plan, a required element of the U.S. Environmental Protection Agency's Combined Sewer Overflow Control Policy. Consistent with SEPA, Seattle Public Utilities is also evaluating a "no action" alternative.

A complete description of the Plan alternatives is available in the *Protecting Seattle's Waterways: Community Guide to the Plan (Issue 2 Spring 2013)*, available [online](#) and in Appendix A.

Early Stakeholder Outreach

Seattle Public Utilities conducted outreach prior to the start of the public comment period to introduce the Plan to community organizations, businesses, and agencies and encourage participation in the scoping process. Seattle Public Utilities conducted briefings with 13 community organizations and environmental groups. A list of organizations that received a briefing is provided in Appendix B.

Seattle Public Utilities prepared a *Community Guide to the Plan to Protect Seattle's Waterways* and a six-minute video to provide details about the Plan purpose and alternatives, environmental review process, and ways to provide comment. The video and Community Guide are available at www.seattle.gov/CSO.

Agency and Tribal Coordination and Outreach

Seattle Public Utilities is working cooperatively with the following agencies in developing the Plan and EIS:

- King County
- U.S. Environmental Protection Agency
- U.S. Department of Justice
- Washington Department of Ecology

Seattle Public Utilities is committed to government-to-government consultation with Native American tribes on projects that may affect tribal rights and resources. Federally-recognized tribal governments invited to participate in the development of the EIS include:

- Muckleshoot Indian Tribe
- Snoqualmie Tribe
- Suquamish Tribe

Seattle Public Utilities is coordinating with the non-federally recognized Duwamish tribe as an interested party. Seattle Public Utilities will continue to engage with affected tribes throughout the development of the Plan.

Public Scoping Meeting Overview

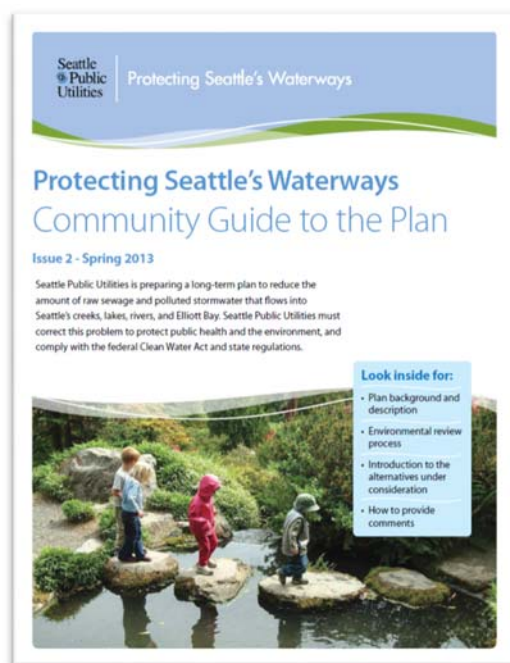
Seattle Public Utilities hosted a public scoping meeting on June 3, 2013 to provide an opportunity for the public to learn about the Plan and environmental review process and to invite comment on the scope of the EIS relating to the plan alternatives and issues to be evaluated. Five people attended the meeting which was held from 4:30 p.m. to 6:30 p.m. in Seattle City Hall's Bertha Knight Landes Room at 600 4th Avenue, Seattle.

Meeting Format

Participants signed in as they arrived and Seattle Public Utilities staff informed them of the meeting format. Each participant received a copy of the *Community Guide to the Plan to Protect Seattle's Waterways* and a comment form.

The meeting was conducted as an open house where participants could review information and displays and discuss the material with Seattle Public Utilities staff and members of the consultant team. Display boards contained information describing a sewer overflow, how Seattle Public Utilities is addressing sewage overflows throughout Seattle, the purpose of the Plan, information about the environmental review process and the plan alternatives, and a project timeline defining the decision process and upcoming public involvement opportunities.

Participants were encouraged to provide comments via comment forms. Following the public scoping meeting and at any time during the scoping comment period from May 20 – June 20, 2013, the public also could provide written comments by mail or email. Seattle Public Utilities also accepted public comment via an online survey, which was available at www.seattle.gov/CSO. Display boards are available online at www.seattle.gov/CSO.



Community Guide to the Plan

Public Notification

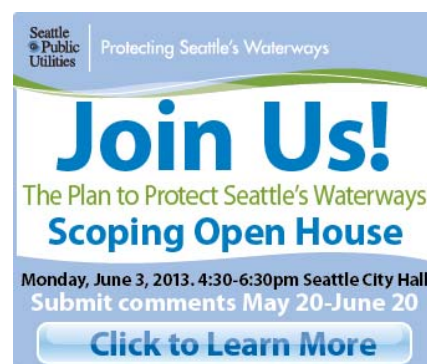
Seattle Public Utilities advertised the public scoping meeting through a variety of methods including:

- The SEPA Determination of Significance (DS) and Scoping Notice was published in the *Daily Journal of Commerce* on May 20, 2013. The notice included statements in Chinese, Spanish, Tagalog, and Vietnamese with a phone number for non-English speaking community members to call for interpretation services and to obtain information about the scoping meeting.
- The SEPA DS and Scoping Notice was sent to the Washington Department of Ecology SEPA Public Information Center on May 20, 2013 and entered in the SEPA Register.
- The SEPA DS and Scoping Notice was included in the May 20, 2013 Seattle Department of Planning and Development (DPD) Land Use Information Bulletin.
- The SEPA DS and Scoping Notice was mailed to agencies with jurisdiction and expertise, tribes, and the public.

Display Ad Placements

Publications	Circulation	Placement Date
Ballard News Tribune	6,000	5/24/13 5/31/13
City Living	24,000	5/17/13
Queen Anne News & Magnolia News	12,000	5/22/13 5/29/13
West Seattle Herald	8,000	5/24/13 5/31/13

Website	Estimated Impressions	Placement Date
CityLivingSeattle.com	3,000	5/20/13 – 6/20/13
EastlakeAve.com	5,000	
FremontUniverse.com	5,000	
MadisonParkTimes.com	3,000	
MagnoliaVoice.com	25,000	
MyBallard.com	250,000	
MyWallingford.com	3,000	
Wallyhood.org	11,000	
WestSeattleBlog.com	600,000	
WestSeattleHerald.com	55,000	



Blog Ad

- The SEPA DS and Scoping Notice and Community Guide to the Plan were e-mailed to organizations that received early outreach briefings.
- Meeting advertisements were placed in five print publications and nine community blogs and online newspapers editions. The print advertisements included statements in Chinese, Korean, Somali, Spanish, Tagalog, and Vietnamese with a phone number for non-English speaking community members to call for interpretation services and information about the scoping meetings.
- The SEPA DS and Scoping Notice was linked to Seattle Public Utilities' Protecting Seattle's Waterways and Long-Term Control Plan websites starting May 20, 2013.
- An article about the Plan was placed in the Seattle Public Utilities' summer 2013 *Curb Waste* newsletter, which is mailed to approximately 330,000 Seattle residents.
- A meeting announcement was posted to the City's online public outreach and engagement calendar.

Samples of meeting notifications are provided in Appendix C.

Comment Summary

Comment Sources

Seattle Public Utilities received comments from the following sources:

- 26 completed online surveys
- 4 comment letters and emails

The following agencies, tribes, organizations, and individuals provided written comments by e-mail and letter:

- Ballard Stormwater Consortium
- Muckleshoot Indian Tribe
- Pacific Fishermen Shipyard and Electric Facilities Manager
- Seattle Parks and Recreation

Copies of the comment emails and letters are provided in Appendix D.

Comment Highlights

Following are highlights of comments submitted during the scoping comment period.

Environmental Elements

The online survey asked respondents to list the three environmental, community, or neighborhood issues that are most important to them. Water quality, protecting existing parks and open spaces or creating new parks and open spaces, and social justice, equity, and fairness were the most commonly cited issues. Responses included:

Issue	# of Responses
Water quality	15
Protecting existing parks and open spaces/ creating new parks and open spaces	9
Social justice, equity, and fairness	7
Pedestrian and bicycle safety	6
Transportation and traffic impacts	6
Long-term sustainability/reducing waste	4
Public safety	4
Air quality	3
Parking impacts	3
Schools	2
Local food production/access to fresh food	2
Economic development	1
Operational impacts	1
Climate change	1
Community cohesion	1
Improved quality of life	1
Construction impacts	1

Following is a summary of additional comments submitted via the online survey and in comment letters that relate to the environmental elements Seattle Public Utilities will address in the EIS. Comments are organized by environmental element.

Recreation – Park Use and Access

Seattle Parks and Recreation submitted a comment letter outlining specific concerns relating to the impacts of the Plan to Protect Seattle’s Waterways on parkland. Comments included:

- *“Parks understands SPU’s challenges in finding appropriate site(s) for large utility infrastructure projects which benefit the long term health of the City. That said, parks and public open space should be considered as a site for a CSO facility after all other alternatives have been exhausted.”*
- *“Shoreline parks are not ‘free’ land within which to site utilities. Shoreline parks are a precious commodity; a finite resource. Free and open access to the shores of Lake Washington and Puget Sound is a necessary component of sustainable urban living in*

Seattle. The ability of a shoreline Park to provide a variety of active and passive recreational opportunities is paramount. Siting a utility in a park limits the park's adaptability for future needs, both of people and the environment."

- *"Parks' central concern is that the placement of a CSO facility within Parks' property forever constrains the use of this area, regardless of whether or not it is under paved and/or un-programmed areas. Parks will be forever precluded from changing the use of the site to provide a different park amenity and/or recreational opportunity due to the underlying utility facility. Should stormwater regulations become more stringent in the future and SPU need to expand these facilities, even more Park property could be needed."*
- *"Note that Initiative 42 (Ordinance No. 118477) discourages the conversion of park lands within the City of Seattle to non-park usage."*

Water Quality

The Ballard Stormwater Consortium requested that Seattle Public Utilities describe the policies and plans the City of Seattle is implementing to minimize stormwater and drainage problems in Department of Planning and Development decisions and approvals, transit decisions, and neighborhood planning and projects.

Geology and Soils

The Ballard Stormwater Consortium expressed concerns about potential soil and groundwater contamination from roadside rain garden projects, citing a study of a roadside rain garden project in Redmond, Washington. The Consortium requested that Seattle Public Utilities fully evaluate infiltration-based low impact development facilities in the Draft EIS.

The Ballard Stormwater Consortium also requested that Seattle Public Utilities discuss the potential for settling and soil compression and how it would affect various facilities over time. This comment applies to all alternatives.

Climate Change

The Ballard Stormwater Consortium requested that Seattle Public Utilities analyze the effect of climate change on sewage overflow control volumes and the performance of sewage overflow reduction strategies, including:

- Describe the impact of projections of warmer and wetter winters with more frequent, stronger winter storm events.
- Discuss potential changes in vegetation.

- Describe the potential impact of drier, hotter summers on soils and how this climate change affects the performance of natural drainage projects and sewage overflow control volumes.
- Clearly describe how sewage overflow control models account for the projected increase in storm events. Describe the assumptions used in modeling and that are incorporated into the analysis documented in the programmatic EIS.

Comments Related to a Specific Sewage Overflow Control Strategy

Storage

The Ballard Stormwater Consortium commented that storage should be the primary tool for controlling sewage overflows. The Consortium is especially interested in the West Ship Canal and Ship Canal tunnel options, but also supports careful analysis of all storage options to determine which option would provide the lowest cost per gallon of storage. They also encourage coordination between King County and Seattle Public Utilities.

Other comments relating to storage included:

- *“Honestly, I wonder about the effectiveness of additional storage. However, the stormwater reduction methods sound creative and will hopefully help the problem.” – Wallingford resident*
- *“Concern regarding all storage tanks: would these cause odor issues?” – Downtown resident*

Natural Drainage Systems

Comments in support of natural drainage projects included:

- *“Natural drainage gets the most bang for the public buck - reduces runoff before it's a problem, increases beauty, wildlife habitat, and calms traffic. Bring it to everyone, not just the well-off in north Seattle.” – Delridge resident*
- *“Please consider adding non-residential properties to those eligible for rain garden, cistern, etc. rebates.” – Whittier Heights resident*
- *“I'd like to see more natural drainage plans implemented along the Alki shoreline.” Alki/Admiral resident*

Comments expressing concern about natural drainage projects included:

- *Please do not ram this down our throats, requiring us to seek legal representation in order to remain whole. If a mid-block curb bulb removes our street parking, and only our parking, we lose home value.” – Roxhill/Westwood/White Center resident*

The Ballard Stormwater Consortium commented that it does not support large-scale implementation of roadside rain gardens in Ballard, citing geology, the perceived higher cost of installation and maintenance compared to storage, and concerns about soil toxicity and groundwater contamination. The Consortium expressed concern that Seattle Public Utilities is relying too much on natural drainage strategies.

The Consortium requested that Seattle Public Utilities discuss the following issues in the Plan and Draft EIS:

- Provide a full analysis of how soil and groundwater conditions affect performance of natural drainage projects prior to the installation of new projects.
- Describe how Seattle Public Utilities will consider community preferences when implementing natural drainage projects.
- Describe how natural drainage projects will be designed to ensure drainage within 24-hours of a storm event.
- Discuss the potential impacts of standing water on children's safety and public health and how Seattle Public Utilities will respond in the event standing water becomes an issue in a project.
- Describe tests Seattle Public Utilities has conducted to determine how porous pavement compacts underlying native soils.
- Describe commitments to maintain porous pavement per manufacturer's specifications.

Comments Related to a Specific Alternative

The online survey asked respondents to comment on the individual alternatives and options and to describe changes Seattle Public Utilities should consider making to the alternatives.

Sewage Overflow Reduction Alternative: Neighborhood Storage Option

Comments relating to the Neighborhood Storage Option focused primarily on questions about where tanks would be built, impacts during construction, and opportunities for neighborhood improvements associated with the projects. Others called for more natural drainage projects to be included in the Neighborhood Storage Option.

Neighborhood Impacts, Cost

Several comments expressed concerns about the cost and neighborhood impacts associated with building ten individual storage tanks, both during and after construction:

- *"Disruption due to noise and construction, damaging wildlife habitat, interfering with marine traffic." – Ballard resident*

- *“Costs, disruption of neighborhoods due to large construction projects.” – West Seattle Junction/Genesee Hill resident*
- *“Location of the storage tanks, access for cleaning and maintenance.” – Fauntleroy/Seaview resident*
- *“How expensive is it? How disruptive to the neighborhood? Is it unsightly?”—Capitol Hill resident*
- *“Lots of construction, most of the money gets buried instead of being used for multifunctional green infrastructure.” – Delridge resident*
- *“Building storage infrastructure seems expensive and invasive.” – Fauntleroy/Seaview resident*
- *“Location of storage tanks. Installation could be very disruptive. Appearance of tanks at end of project.” – Beacon Hill resident*
- *“Construction of large storage tanks could disrupt the neighborhood.” – Greenwood/Phinney Ridge resident*

Support for Natural Drainage Projects

Several respondents asked Seattle Public Utilities to include more natural drainage projects in the Neighborhood Storage Option:

- *“Too many disruptive tanks in our neighborhoods and parks. Not nearly enough natural drainage projects being applied. Even if a tank is still needed, natural option components could improve operation and reduce variability.” – Pioneer Square/International District resident*
- *“Only one neighborhood is slated for natural drainage. Amend the plan to include natural drainage for all neighborhoods, especially those with salmon-bearing creeks.” – Delridge resident*
- *“Could we have more natural drainage projects – would these reduce the need for storage? Why so few natural drainage projects? Why not more projects around multifamily housing instead of the current push to have everything concrete.” – Capitol Hill resident*
- *“More green, less gray infrastructure.” –Delridge resident*
- *“Adding natural drainage considerations to more of the projects, particularly the smaller capacity need ones - adjacent to natural areas, Delridge, Duwamish, Leschi, Montlake - where there might be possibilities for large gains.”—Pioneer Square/International District resident*

One comment expressed a preference for storage over natural drainage projects:

- *“Prefer this option to GSI ditches.” – Roxhill/Westwood/White Center*

Neighborhood Improvements

Respondents would like Seattle Public Utilities to look for opportunities to include neighborhood improvements in underground storage projects:

- *“Are there opportunities to make other improvements associated with the storage, like street or park improvements on top? Can the natural drainage improvements also make our public spaces (streets and parks) more inviting for walking, biking and meeting neighbors?” – Sunset Hills/Loyal Heights resident*
- *“Is SPU working with Seattle Parks to create rain gardens/cisterns at the community centers in that area?” – Ballard resident*
- *“More trees. Especially in areas where we don't have enough Parks. I like rain gardens, and I think we need to consider all options, but it seems like trees, parks and wetlands are our best natural resources for the job.” – Capitol Hill resident*
- *“Make them attractive sites, pocket parks.” – Roxhill/Westwood/White Center resident*
- *“If storage tanks are selected, please make the site a neighborhood amenity – parks, playground, plaza, etc.” – Broadview/Bitter Lake resident*

Agency Coordination

Respondents encouraged coordination between Seattle Public Utilities and King County:

- *“I would rather see SPU and the County work together. Having each entity create their own solutions is likely to cause confusion, conflict, and high costs.” – Ballard resident*
- *“Options seem limited. Are the city and county coordinating on their respective storage plans?” – Ballard resident*

Adaptability to Projected Population Growth

A few comments raised questions about how Seattle Public Utilities is factoring in projected population growth as it determines storage volume needs.

- *“Will the proposed storage tanks be able to scale up in storage capacity along with inevitable population growth?” – Downtown Seattle resident*
- *“Does the storage put us into a corner in the future – no room to expand as Seattle/region grows?” – Broadview/Bitter Lake resident*
- *“Is that enough? It seems like there are lots of neighborhoods that don't have storage – like south and west Seattle.” – Capitol Hill resident*

Equity

Respondents also raised concerns about social equity:

- *“Poorer neighborhoods get facilities. More affluent get underground storage. Consider social justice issues and historical injustices and disproportional impacts.” – Georgetown resident*
- *“No dumping in these critical areas of recreation. Service equity in heavily used south end.” – Alki/Admiral resident*

Sewage Overflow Reduction Alternative: Shared Storage Option

Several comments were positive about the potential cost savings and efficiency of collaboration between King County and Seattle Public Utilities which is a feature of the Shared Storage Option. Other key themes were similar to the Neighborhood Storage Option, including a desire from some respondents for more natural drainage projects and concerns about cost and equity considerations. In addition, one commenter expressed concerns about impacts on parking. One person commented against this option.

King County/Seattle Public Utilities Coordination

Comments in favor of King County/Seattle Public Utilities collaboration included:

- *“I like the idea of coordinating with King County.” – Sunset Hill/Loyal Heights resident*
- *“I’m glad Seattle and King County are partnering – it should be a joint venture.” – Broadview/Bitter Lake resident*
- *“I like having SPU and the County work together.” – Ballard resident*
- *“This seems, at first glance, more efficient.” – Beacon Hill resident*

Equity

A few comments expressed concerns relating to cost and equity considerations of the proposed King County treatment plant in SODO.

- *“I’m concerned that Georgetown will get the CSO treatment plant, and add another apparent ‘blight’ to the already-impacted neighborhood. Why can’t the treatment plant be a large pipe to convey to the already-existing treatment facilities we have?” – Broadview/Bitter Lake resident*
- *“Duwamish area seems unfairly impacted.” – Georgetown resident*

Support for Natural Drainage Projects

As with the Neighborhood Storage Option, several comments called on Seattle Public Utilities to incorporate more natural drainage projects into this option.

- *“Still mostly burying the problem (and our investment) in single purpose solutions.” – Delridge resident*
- *“Add more natural drainage projects.” Capitol Hill resident*
- *“Similarly, it seems that there are a lot of CSO outfalls in west and south Seattle, and not many storage facilities for those areas. It would also be good to see King County contribute to natural drainage solutions.” – Capitol Hill resident*

Neighborhood Impacts, Cost

Comments relating to cost and neighborhood impacts included:

- *“Are the bigger ones [tanks] more expensive?” – Capitol Hill resident*
- *“Requires building new treatment plant. Sounds costly. Why not just reduce the need for more treatment by reducing runoff to begin with?” – Delridge resident*
- *“SODO seems kind of congested now.” – Fauntleroy/Seaview resident*
- *“More green infrastructure instead of gray.” – Delridge resident*

Sewage Overflow Reduction Alternative: West Ship Canal Tunnel Option

Most of the comments about the West Ship Canal Tunnel Option related to cost, potential impacts on fish habitat, and neighborhood impacts during construction. As with the Neighborhood Storage and Shared Storage options, commenters questioned why Ballard is the only neighborhood slated for natural drainage projects. One person commented against this option.

Cost

Several respondents perceived tunnel construction as a more expensive and potentially risky strategy than underground storage tanks:

- *“I worry about the cost of this project and the disruptions of construction and the possible loss of usable land or habitat. This appears likely to be the most expensive option.” – Ballard resident*
- *“How do the costs of these projects compare? That is a big factor.” – Wallingford resident*
- *“Tunnels are very expensive, and might cause sinkholes.” – Fauntleroy/Seaview resident*
- *“Cost of drilling a tunnel...Brightwater anyone?” – Beacon Hill resident*

- *“Requires building new treatment plant and a REALLY big tunnel in a dense neighborhood. Sounds even more costly. Why not just reduce the need for more treatment by reducing runoff to begin with?” – Delridge resident*
- *“The pipe seems expensive, but does have a lot of capacity and could be constructed in conjunction with shoreline/park improvements along the Ship Canal, so that would be an added benefit.” – Broadview/Bitter Lake resident*

Natural Resources and Neighborhood Impacts

Respondents are interested in how tunnel construction compares with storage tank construction in terms of neighborhood impacts, both during and after construction. Respondents also requested additional information about the impact of tunnel construction and operation on fish and aquatic habitat.

- *“What are the impacts to salmon habitat, both for juveniles and adults?” – Sunset Hill/Loyal Heights resident*
- *“Tunnel concentrates impact in one area – does this mean that management of impacts could be more comprehensive? Would this lead to less impacts overall?” – Pioneer Square/International District resident*
- *“Will this be ugly?” – Capitol Hill resident*
- *“What if it was on the other side of the canal?” – Fauntleroy/Seaview resident*

Support for Natural Drainage Projects

Similar to the Neighborhood Storage and Shared Storage options, some respondents would like Seattle Public Utilities to incorporate more natural drainage projects into the West Ship Canal Tunnel option.

- *“Ack, an even bigger waste of resources on a gray infrastructure mega project. Are there going to be any green options in this bunch?” – Delridge resident*
- *“Requires building new treatment plant and a big tunnel in a dense neighborhood. Sounds even more costly. Why not just reduce the need for more treatment by reducing runoff to begin with?” – Delridge resident*
- *“Green infrastructure, not last century solutions. No more gray infrastructure mega projects. Green please.” – Delridge resident*
- *“Why only one Natural Drainage Solution?” – Downtown resident*

Sewage Overflow Reduction Alternative: Ship Canal Tunnel Option

Comments about the Ship Canal Tunnel Option were similar to the West Ship Canal Tunnel option and discussed cost, neighborhood impacts, and interest in more natural drainage projects. Two commenters indicated a preference for this option over the West Ship Canal Tunnel Option. One person commented against this option.

Cost

Several comments expressed concern about the potential costs associated with tunnel construction:

- *“I worry about the cost of this project and the disruptions of construction and the possible loss of usable land or habitat. This appears likely to be the most expensive option.” – Ballard resident*
- *“Is this too expensive?” – Capitol Hill resident*
- *“Looks very expensive.” – Fauntleroy/Seaview resident*
- *“Cost again. Of the two tunnel options so far, this one seems more logical to me.” – Beacon Hill resident*

Neighborhood Impacts and Benefits

Respondents expressed concerns about potential for leaks and asked questions about how flows would be transferred to the tunnel:

- *“This option seems like it would benefit more neighborhoods with the single tunnel than the other tunnel option.” – Downtown resident*
- *“What safeguards exist to ensure no leaks from a very large storage tunnel?” – Wallingford resident*
- *“If the Ship Canal Tunnel does the whole job how are you going to get water from Ballard to the tunnel or is the one new siphon currently under construction sufficient to get the water to the other side or would another have to be built.” – Larry Ward, Pacific Fisherman Shipyard and Electric*
- *“Is the King County system robust enough to handle these flow transfers?” – Alki/Admiral resident*

Equity

One comment raised concerns about the fairness of the strategies Seattle Public Utilities is proposing for different neighborhoods:

- *“Again, I think it's inequitable that the north end neighborhoods would get a pipe, and mostly will have zero impact in their neighborhoods on their overflows/stormwater runoff, while the Duwamish neighborhoods will have a CSO treatment plant built near where people live and work. What would it take to build more capacity at West Point and add pipes and storage along the way so that all neighborhoods could use this as a resource, rather than putting more impacts on Georgetown?” – Broadview/Bitter Lake resident*

Sewage and Stormwater Pollution Reduction Alternative

Several respondents supported the Sewage and Stormwater Pollution Reduction Alternative because of its focus on reducing stormwater runoff and improving water quality.

Comments in Support of the Sewage and Stormwater Pollution Reduction Alternative

Comments in support of the Sewage and Stormwater Pollution Reduction Alternative included:

- *“Addressing stormwater runoff is critical.” – Sunset Hills/Loyal Heights resident*
- *“I like this option, as it uses a variety of strategies to reduce stormwater runoff. I worry that it won't reduce runoff sufficiently and that it may be hard to get residents and business to buy in to the changes. It may also be very expensive as the solutions are very distributed, lowering the possibility of cost savings from a smaller number of constructions sites. It is appealing, in that it reduces stormwater flow to the sewage treatment plants.” – Ballard resident*
- *“Strong support for efforts that will help clean up the Thornton Creek Watershed area.” – Lake City/Olympic Hills/Victory Heights resident*
- *“This integration of efforts should have been the case long ago.” – Wallingford resident*
- *“This option, if it can meet the requirements, seems like the lowest impact. Lowest cost. Higher personal responsibility (to homeowners) – would require some serious public outreach. Also, include all Beacon Hill that's West of Beacon Avenue in Duwamish (definitely our watershed).” – Beacon Hill resident*
- *“Well, this is a start. I like the sound of reducing stormwater pollution at the source, but I'd like to see more explicit commitment to green infrastructure, not just doing a little and then falling back on traditional measures.” – Delridge resident*

- *“Much less concerns here. Integrated approach appears more productive and likely to reduce impacts. Also appears that there may be more options for natural integration.” Pioneer Square/International District resident*
- *“I think it is great that stormwater is being included in this integrated plan, and that the plans would be localized to neighborhoods.” – Broadview/Bitter Lake resident*
- *“This seems like by far the best option, fixing the larger problem all at once. Maximizes natural drainage solutions and recognizes public health.” – Delridge resident*

Requests for Additional Information

While many people commented in support of the Sewage and Stormwater Pollution Reduction alternative, respondents also requested more detailed information about the specific projects that would be included in the alternative.

- *“What happens with areas not highlighted?” – Capitol Hill resident*
- *“What is the integrated approach? The above alternative option seems a little vague. Simply outlining a few types of projects that would fit into this integrated approach/alternative options. More greenspace? More trees? More drains? How would you lessen pollution?” – Capitol Hill resident*
- *“More commitment. Don't let this be a greenwash solution where we see photo ops at rain gardens, but still most of the money goes to the same old same old.” – Delridge resident*
- *“Would this approach be considering the massive forests in these neighborhoods in the outflow and runoff reductions. Seems that at this scale the forests have a large opportunity to provide major benefits.” – Pioneer Square/International District resident*

Need for Public Education

Respondents also identified a need for public education to encourage involvement of private property owners.

- *“I hope the neighborhoods could be mobilized to join in with these projects.” – Capitol Hill resident*
- *“Educate the public about ways to reduce pollution. Verify that your data accurately measures pollution sources in the south end and give the south end service equity.” – Alki/Admiral resident*
- *“Develop a jobs program out of this initiative to train people (veterans, young adults, etc.) to build and care for rain gardens and other green infrastructure.” – Broadview/Bitter Lake resident*

- *“How can we direct home and business owners to avoid impermeable surfaces, and running gutters down the sewer drains? Do we need a legal statute?” – Beacon Hill resident*

Neighborhood Impacts

The following comments related to neighborhood impacts:

- *“Please preserve neighborhood character and parking as well as access for all ages and abilities. Raingarden ditches need to be beautiful, not eyesores and should not negatively impact street parking.” – Roxhill/Westwood/White Center resident*
- *“Adding more water to the hills could increase landslides. Increasing groundwater makes the sand/clay areas more slippery.” – Fauntleroy/Seaview resident*
- *“Be sure property owners are fully compensated for costs of GSI [green stormwater infrastructure].” – Fauntleroy/Seaview resident*

Comments Common to All Alternatives

The following comments related to all alternatives:

- *“Discuss the potential impacts of an earthquake on the alternative strategies. Does the ability to withstand an earthquake differ significantly by alternative? Does one type of strategy appear more robust than another?” – Ballard Stormwater Consortium*
- *“Describe the effect of these CSO control projects on the West Point sewage treatment plant. How much volume is West Point projected to handle? Does it have the capacity to do so? Will it need to be expanded?” – Ballard Stormwater Consortium*
- *“I hope this alternative (and all alternatives) work with DPD to implement mandatory stormwater reduction in all new construction.” – Ballard resident*

Construction Impacts

As noted in the previous sections, several comments addressed concerns about construction-period impacts. One commenter was specifically concerned about construction-period impacts of all alternatives in the Ballard industrial area. The commenter was especially concerned about impacts to Shilshole Avenue which is the primary truck route in the area. The commenter also expressed concern about the combined effects of the Plan and other large projects on freight mobility, such as the Mercer Corridor and Alaskan Way Viaduct Replacement projects. The commenter requested more detail on the type of construction activities that would be associated with the Plan.

Cost and Funding for Operation and Maintenance

A few comments raised questions about the cost of the Plan and how it will be financed. One commenter suggested that Plan implementation should be financed through bonds rather than utility rate increases. Other comments raised concerns about impacts of utility rate increases on low-income residents, noting that rate increases would have a disproportionate impact on low-income rate payers.

- *“Regardless of the alternatives you choose, you should use a bond measure to fund it. This is a capital project creating a long-term capital investment. There is no excuse on the City’s part to increase the Utility rate to pay for this. This should be a property tax funded over 30 years. Increasing utility rates would hit poor folks disproportionately.” – Larry Ward, Pacific Fisherman Shipyard and Electric*
- *“Describe how these projects will be funded and the assumptions that have been used in modeling expenses over time.” – Ballard Stormwater Consortium*

Comments also raised questions about how Seattle Public Utilities will finance long-term operations and maintenance. One commenter suggested that bond financing would provide a dedicated funding source for maintenance, and that it would be more a stable source of funding than utility rates. Another commenter specifically requested that the Draft EIS and Plan include a discussion about how Seattle Public Utilities will plan for and fund on-going maintenance of natural drainage projects.

Decision Process and Community Involvement

The following comments address the decision-process for the development of the Plan and how public comment will be considered:

- *“We would like to know what those are [SPU’s preferred alternative] so that we can make reasonable comments on the EIS at least when it is time for the public comment on EIS. That means know what alternatives were considered and the pros and cons of each. What are the physical limitations you have to design around and any alternatives to alter those limitations that were considered.” – Larry Ward, Pacific Fisherman Shipyard and Electric*
- *“Describe SPU’s guiding principles and the criteria that will be used in deciding among the alternatives.” – Ballard Stormwater Consortium*
- *“Describe methods for incorporating public input in the selection of the alternative for our neighborhoods.” – Ballard Stormwater Consortium*

- *“What is the sense of timing for when these projects would be designed and built? In what order would they be phased? Does SPU have enough money to do all these projects?” – Downtown resident*

Other

Additional comments included:

- *“Discuss demographic projections and the impact of growing population and housing density on sewage loadings, the CSO problem and stormwater management. Discuss how projected increases in population and population density will affect sewage and stormwater flows. Clearly describe whether and how these projections have been incorporated into the CSO models that generate the CSO control volumes.” – Ballard Stormwater Consortium*
- *“Discuss factors that may result in an increase in impervious surfaces including transit, high density housing and other factors. Describe how the increase in impervious pavement will affect stormwater flows. Clearly describe whether and how these projections have been incorporated into the CSO models that generate the CSO control volumes.” – Ballard Stormwater Consortium*

Summary of Tribal Input

The Muckleshoot Indian Tribe Fisheries Division noted that many sewage overflow outfalls are located in areas where Muckleshoot Tribal members fish or otherwise affect the Tribe’s treaty-protected fisheries resources. They expressed interest in working closely with Seattle Public Utilities and King County. The Tribe is especially interested in working with Seattle Public Utilities as it develops the pollutant load analysis for the Plan and individual projects to understand impacts on salmon and human health and issues related to fish consumption.

In addition, the Tribe requested that Seattle Public Utilities discuss the following issues in the Plan and Draft EIS:

- Explain why the No Action Alternative is out of compliance with the Clean Water Act and state regulations.
- Discuss previous sewage overflow control efforts and why they did meet Clean Water Act and state regulations for sewage overflow control.
- Explain the two action alternatives in sufficient detail to distinguish one another and facilitate environmental review. Provide more information about how storage needs will be met.

- Identify stormwater pollution reduction projects so reviewers understand where Seattle Public Utilities proposes to build projects.
- Explain why Pipers Creek is being considered as part of the long term plan if there is only one controlled outfall in this area.
- Identify the projects that Seattle Public Utilities proposes to delay past 2025 and the potential environmental impacts to water quality, sediment quality, fisheries resources, and Tribal fishing activities caused by the delay.
- Consider impacts to all salmon species in the study area, not just threatened or endangered species, as these resources are protected under the Tribe's treaties.
- For each alternative, discuss opportunities to remove sewage overflow outfalls and restore habitat.

Next Steps

The scoping comments will be used as appropriate to shape the environmental analyses included in the Draft EIS and the development of the Draft Plan. Following is a summary of the anticipated approach to incorporating the scoping comments received, organized according to the topics outlined above. Comments relating to environmental issues will be considered as part of the EIS process; comments relating to specific components of the Plan, costs, and other engineering factors will be considered in those respective processes.

Environmental Elements

Recreation – Park Use and Access

The EIS will include a discussion of impacts to Seattle's parks and recreational facilities in the Recreation sections of Chapter 5, Construction Impacts and Mitigation, and Chapter 6, Operation Impacts and Mitigation. The EIS will outline the process to be used for site selection of projects in Chapter 3, Plan Alternatives.

Water Quality

Impacts to surface water quality during construction and operation will be considered in the Surface Water sections of Chapter 5, Construction Impacts, and Chapter 6, Operational Impacts. Impacts to groundwater quality and quantity will be discussed in the Earth and Groundwater sections of Chapters 5 and 6. Short term and long term effects to surface water resources will be described in the Surface Water section of Chapters 5 and 6. Criteria used to site facilities, including the considerations for installation of natural drainage systems, will be described in the Draft Plan and will be summarized in Chapter 3, Plan Alternatives. Relevant City plans and policies relating to stormwater and sewage overflows will be described in Chapter 1, Introduction and Background.

Geology and Soils

Soils and geological conditions relating to the siting of facilities, including natural drainage systems, will be discussed in the Earth and Groundwater section of Chapter 4, Plan Area Environment. Potential impacts to geology and soils during construction and operation will be discussed in the Earth and Groundwater sections of Chapters 5 and 6.

Climate Change

Factors affecting climate change in the Pacific Northwest will be discussed in Chapter 4, Plan Area Environment under Energy and Climate Change. The Draft Plan will describe how these factors were incorporated into the development of the alternatives, and the EIS will include a summary of this information in Chapter 3, Plan Alternatives. A discussion of how the alternatives will affect adaptation to climate changes will be included in Chapter 6, Operation Impacts and Mitigation.

Comments Related to a Specific Sewage Overflow Control Strategy

Seattle Public Utilities will consider public, agency, Tribal, and stakeholder preferences during evaluation of the alternatives, but this issue will not be specifically addressed within the EIS.

Comments Related to a Specific Alternative

No Action Alternative

The EIS will clearly describe the No Action Alternative and the SEPA requirements for this alternative. Previous sewage overflow reduction planning efforts will be discussed in Chapter 1, Introduction and Background.

Sewage Overflow Reduction Alternative: Neighborhood Storage Option

The EIS will discuss construction impacts associated with the Neighborhood Storage Option in Chapter 5, Construction Impacts and Mitigation. Impacts discussed will include transportation, noise, air quality, and land use, and other elements required for consideration by SEPA. A discussion of the overall cost of this option will be included in the Plan, but is not an element required by SEPA and as such will not be discussed in the EIS.

Seattle Public Utilities will consider public, agency, Tribal, and stakeholder preferences during evaluation of the alternatives, but this issue will not be included in the EIS.

Discussion of joint cooperative efforts between Seattle Public Utilities and King County will be included in Chapter 1, Introduction and Background, and Chapter 3, Plan Alternatives.

Joint use opportunities, including the potential for co-location of sewage overflow facilities with other types of public amenities, will be discussed in Chapter 3, Plan Alternatives and in the respective Mitigation sections of Chapters 5 and 6.

The ability of the storage facilities to adapt to climate change will be included in Chapter 3, Plan Alternatives as well as in Chapter 6, Operational Impacts and Mitigation, in the Climate Change section.

Potential impacts to neighborhoods, quality of life and aesthetics, will be discussed in Chapters 5 and 6 in the Land Use and Visual Quality section.

Issues of equity and socioeconomics/environmental justice will be discussed in Chapter 4, Affected Environment, Chapter 5, Construction Impacts and Mitigation, and Chapter 6, Operational Impacts and Mitigation, in the Socioeconomics and Environmental Justice section.

Sewage Overflow Reduction Alternative: Shared Storage Option

Discussion of joint cooperative efforts between Seattle Public Utilities and King County will be included in Chapter 1, Introduction and Background, and Chapter 3, Plan Alternatives.

As noted for the Neighborhood Option, issues relating to equity and socioeconomics/environmental justice will be discussed in Chapter 4, Plan Environment, Chapter 5, Construction Impacts and Mitigation, and Chapter 6, Operational Impacts and Mitigation, in the Socioeconomics and Environmental Justice section.

Seattle Public Utilities will consider public, agency, Tribal, and stakeholder preferences during evaluation of the alternatives, but this issue will not be included in the EIS.

The EIS will discuss construction impacts associated with the Shared Storage Option in Chapter 5, Construction Impacts. Impacts discussed will include transportation, noise, air quality, and land use, among other elements required for consideration by SEPA. A discussion of the overall cost of this option will be included in the Plan, but is not an element required by SEPA and as such will not be discussed in the EIS.

Sewage Overflow Reduction Alternative: West Ship Canal Tunnel Option

As noted above, Seattle Public Utilities will evaluate the cost of each alternative as part of the Plan. Cost information will be included in the Plan, but will not be discussed in the EIS.

Impacts to natural resources, including numerous species of salmon throughout their life cycle, will be discussed in Chapters 5 and 6 of the EIS, in the Biological Resources section.

Potential impacts to neighborhoods, quality of life and aesthetics, will be discussed in Chapters 5 and 6 in the Land Use and Visual Quality section.

Impacts to neighborhoods associated with all of the options will be comparatively assessed in the EIS in Chapters 5 and 6. A cumulative impact discussion will summarize the range of tradeoffs associated with the options and the alternatives.

Sewage Overflow Reduction Alternative: Ship Canal Tunnel Option

As previously described, cost will not be included in the EIS, but will be addressed in the Plan.

Long-term operational considerations, including safety and reliability, will be discussed in Chapter 6, Operational Impacts and Mitigation, in the Environmental Health section.

Equity and environmental justice considerations will be evaluated in the Socioeconomics and Environmental Justice sections of Chapters 5 and 6. The factors contributing to the development of the alternatives and the options within those alternatives, including selection of the neighborhoods and basins for facilities, will be discussed in Chapter 3, Plan Alternatives.

Sewage and Stormwater Pollution Reduction Alternative

The Sewage and Stormwater Pollution Reduction Alternative will include a general description of proposed projects by type and area in Chapter 3, Plan Alternatives. Detailed project descriptions will not be available for the EIS, but will be provided when project-level environmental evaluations are conducted. Additional information about tiered EIS evaluations, and a discussion of programmatic EISs under SEPA, will be included in Chapter 1, Introduction and Background.

The public outreach process conducted to date, and efforts planned for the future, will be described in Chapter 1

Impacts to parking will be described in Chapters 5 and 6 in the Transportation section.

The potential for landslides and other earth-related impacts will be described in Chapters 5 and 6 in the Earth and Groundwater section.

Comments Common to All Alternatives

The EIS will include program-level descriptions of the alternatives, at a level appropriate to evaluate comprehensive impacts, including cumulative impacts. Potential for habitat restoration will be discussed in the Mitigation section in Chapters 5 and 6 in the Biological Resources section.

The potential for landslides, seismic issues, and other earth-related impacts will be described in Chapters 5 and 6 in the Earth and Groundwater section.

The EIS will include a comparative summary of construction impacts within the potentially affected neighborhoods, to help identify the neighborhoods most impacted by the various options and alternatives.

The potential for low-income ratepayers to be affected by the Plan will be discussed in Chapter 6, Operational Impacts and Mitigation, in the Socioeconomics and Environmental Justice section. Long term funding and other financial considerations will be described in the Plan.

The decision process for the Plan will be described in Chapter 3, Plan Alternatives. Criteria used to evaluate the alternatives will be summarized, and the methods for incorporating public input into the process will be described. Chapter 3 will include a schedule for implementation of the Plan. Additional detail will be available in the Plan.

Factors used in developing the alternatives, including assumptions used for modeling climate change, population projections, and future land use, will be summarized in Chapter 3, Plan Alternatives. Additional detail will be available in the Plan.

Tribal Input

The EIS will discuss impacts to all species of locally present salmon at various life stages in Chapters 5 and 6, in the Biological Resources section. Potential impacts to treaty-protected fisheries resources will be discussed in this section. The EIS will also summarize historic, ongoing and anticipated future coordination with the Muckleshoot Indian Tribe and other Tribal governments as the Plan moves forward.

The EIS will include a more detailed discussion of the No Action Alternative, which will be included in Chapter 3. Chapter 1 will summarize sewage overflow control efforts to date. Chapter 3 will include a summary level discussion of the alternatives, at a level appropriate for programmatic review, including general types of stormwater projects to be included in the Integrated Plan. Additional project level evaluations will be conducted when sites have been selected. More detailed descriptions of stormwater pollution reduction projects will be included in the Plan. Generalized criteria for prioritizing the neighborhoods for inclusion in the Sewage and Stormwater Pollution Reduction Alternative will be included in Chapter 3.

Impacts to the receiving water environment and natural resources associated with implementation of the Sewage and Stormwater Pollution Reduction Alternative, including impacts associated with deferral of projects, will be discussed in Chapter 5, within the respective elements of the environment.

Future Evaluations

Seattle Public Utilities will develop, evaluate, and analyze the Plan alternatives from now through early 2014. The Draft EIS, which will provide a detailed analysis of the plan alternatives, potential impacts and mitigation measures to reduce impacts, and the Draft Plan are scheduled to be issued for public review in mid-2014. Seattle Public Utilities will offer a public comment period and a public hearing upon release of the Draft EIS, in accordance with SEPA regulations. The Final EIS will be released in late 2014. The Mayor and Seattle City Council are scheduled to consider the Draft Plan in early 2015. Following Council adoption, Seattle Public Utilities will submit the Plan for approval by the Washington Department of Ecology and U.S. Environmental Protection Agency in mid-2015.

The final, approved Plan will include a capital improvement program with a schedule for implementation of all sewage overflow reduction projects to meet Washington Department of Ecology requirements. If the Sewage and Stormwater Pollution Reduction Alternative is selected by the City Council, the implementation schedule also will include stormwater projects. After completion of the Plan and EIS, Seattle Public Utilities will proceed with implementation of the capital improvement program.

Seattle Public Utilities will work with all affected neighborhoods to select specific sites where facilities will be built starting in 2016. As part of each project siting process, Seattle Public Utilities will perform a project-specific environmental review as appropriate. The project level environmental review will identify project-specific impacts and mitigation measures and will help inform decisions regarding site and project-level details.

Appendix B: Distribution List

Protecting Seattle's Waterways Plan
Draft Environmental Impact Statement Distribution List

Notice of DEIS	Notice of DEIS + Compact Disc	Notice + DEIS + Compact Disc	Agency or Name	Name or Address1	Name or Address2	Address3	City	State	Zip
		✓	Washington State Dept of Ecology	SEPA Unit	P.O. Box 47703		Olympia	WA	98504-7703
	✓		Allyson Brooks, PhD		WA State Dept of Archaeology and Historic Preservation	P.O. Box 48343	Olympia	WA	98504-8343
	✓		Larry Fisher	WDFW Area Habitat Biologist	1775 12th Ave NW	Suite 201	Issaquah	WA	98027
	✓		SEPA Coordinator	Habitat Management Division	WA State Dept of Fish.	P.O. Box 43155	Olympia	WA	98504
	✓			SEPA Center	WA State Dept of Natural Res.	P.O. Box 47015	Olympia	WA	98504-7015
	✓			SEPA Review	WA State Dept of Public Health	P.O. Box 47820	Olympia	WA	98504-7820
	✓		Kelly Cooper	Environmental Health Div.	WA State Dept of Health	P.O. Box 47820	Olympia	WA	98504-7820
	✓		Ramin Pazooki	WSDOT NW Region	15700 Dayton Avenue N		Seattle	WA	98133
	✓			Planning Division	WA State Dept of Transportation	P.O. Box 330310	Seattle	WA	98133-9710
	✓				US Ad Council Historic Preservation	Old Post Office Bldg - 1100 Pennsylvania Ave NW	Washington	DC	20004
	✓			WA Division Area Engineer	Federal Highway Administration	711 Capitol Way, Suite 501	Olympia	WA	98501-0943
	✓			Transportation Program Specialist	Federal Transit Administration	915 2nd Ave. Suite 3142	Seattle	WA	98174-1002
	✓			SEPA Review	National Marine Fisheries Services	510 Desmond Drive SE	Lacey	WA	98503
	✓			Regulatory	US Army Corps of Engineers	P.O. Box C-3755	Seattle	WA	98124-3755
	✓		Alisa Ralph	Seattle District	US Army Corps of Engineers	4735 E. Marginal Way S.	Seattle	WA	98134-2384
	✓		NEPA Review Unit	US Environmental Protection Agency	1200 Sixth Avenue	ETPA 088	Seattle	WA	98101
	✓			Washington Fish & Wildlife Office	US Fish & Wildlife Service	510 Desmond Dr. SE Suite 102	Lacey	WA	98503-1263
	✓		Jim Muck	USFWS & NOAA	US Fish & Wildlife Service	7600 Sandpoint Way	Seattle	WA	98115
✓				Cascade Water Alliance	520 112th Ave NE	Suite 400	Bellevue	WA	98004
✓			Paul Meyer	Manager, Environmental Permitting	Port of Seattle	P.O. Box 1209	Seattle	WA	98111
✓				SEPA Review	Puget Sound Clean Air Agency	1904 Third Ave Suite 105	Seattle	WA	98101-3417
✓			Rhonda Kaetzel	Environmental Health Svcs	Public Health - Seattle KC	401 5th Avenue, 11th Floor	Seattle	WA	98104-1818
✓				Roads & Engineering	KC Dept of Transportation	201 S Jackson St - MS KCS 0313	Seattle	WA	98104
✓			Environmental Planning-OAP	Wastewater Treatment Div.	KC Dept of Natural Resources	201 S Jackson St - MS KCS NR 0505	Seattle	WA	98104
✓				Parks Environmental Review	KC Dept of Natural Resources	201 S. Jackson St	Seattle	WA	98104-3856
✓				Land Use Services Division	KC Department of Permitting and Environmental Review	35030 SE Douglas St. Ste 210	Snoqualmie	WA	98065-9266
✓			Gary Kriedt	Environmental Planning	KC Dept of Transportation	201 S. Jackson St - MS KSC TR 0431	Seattle	WA	98104-3856
✓			Charlie Sundberg	Preservation Planner	KC Historic Preservation	201 S. Jackson St. KSC-NR-0700	Seattle	WA	98104
✓					KC Regional Water Quality Committee	201 S Jackson St	Seattle	WA	98104
	✓				Suquamish Tribe	P.O. Box 498	Suquamish	WA	98392
	✓			SEPA Review	Tulalip Tribes of WA	6406 Marine Drive	Tulalip	WA	98271

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	✓				United Indians of All Tribes	P.O. Box 99100	Seattle	WA	98199
	✓		The Honorable Cecile Hansen	Chair	Duwamish Tribe	4705 W. Marginal Way SW	Seattle	WA	98106
	✓		Karen Walter	Fisheries Division Habitat Program	Muckleshoot Tribe	39015 172nd Ave SE	Auburn	WA	98092
	✓		Laura Murphy	Tribe Preservation Program	Muckleshoot Tribe	39015 172nd Ave SE	Auburn	WA	98092
	✓		The Honorable Virginia Cross	Chair, Muckleshoot Tribal Council	Muckleshoot Tribe	39015 172nd Ave SE	Auburn	WA	98092
	✓		The Honorable Mike Evans	Chair, Snohomish Tribe	11014 19th Ave SE	Suite #8 PMB #101	Edmonds	WA	98208
	✓		Steven Mullen-Moses	Director of Archaeology & Historic Preservation	Snoqualmie Tribe	P.O. Box 969	Snoqualmie	WA	98065
	✓			SEPA Review	Snoqualmie Tribe	P.O. Box 969	Snoqualmie	WA	98065
	✓			Chair, Snoqualmie Tribe of Indians	Snoqualmie Tribe	P.O. Box 969	Snoqualmie	WA	98065
	✓		Earngy Sandstrom	Chair	Snoqualmoo Tribe	2613 Pacific St	Bellingham	WA	98226
	✓			SEPA Review	Suquamish Tribe	18490 Suquamish Way	Suquamish	WA	98392
	✓		The Honorable Leonard Forsman	Chair, Suquamish Tribal Council	Suquamish Tribe	P.O. Box 498	Suquamish	WA	98392
	✓		The Honorable Melvin Sheldon	Chair, Tulalip Board of Directors	Tulalip Tribes of WA	6406 Marine Drive	Tulalip	WA	98271
	✓			Governmental Publications	UW Library	P.O. Box 353900	Seattle	WA	98195-2900
✓			Cass Mabbott	Ballard Branch	Seattle Public Library	5614 22nd Ave NW	Seattle	WA	98107-3119
✓			Wei Cai	Beacon Hill Branch	Seattle Public Library	2821 Beacon Ave S	Seattle	WA	98144-5813
✓			Rekha Kuver	Broadview Branch	Seattle Public Library	12755 Greenwood Ave N	Seattle	WA	98133-7901
✓			Dave Valencia	Capitol Hill Branch	Seattle Public Library	425 Harvard East	Seattle	WA	98102-4908
✓			Steve Del Vecchio	Columbia Branch	Seattle Public Library	4721 Rainier Ave S	Seattle	WA	98118-1657
✓			Steve Del Vecchio	Delridge Branch	Seattle Public Library	5423 Delridge Way S	Seattle	WA	98106-1479
✓			Valerie Garrett-Turner	Douglass-Truth Branch	Seattle Public Library	2300 E Yesler Way	Seattle	WA	98122-6061
✓			Cass Mabbott	Fremont Branch	Seattle Public Library	731 N 35th St	Seattle	WA	98103-8802
✓			Francesca Wainwright	Green Lake Branch	Seattle Public Library	7364 E Green Lake Drive N	Seattle	WA	98115-5352
✓			Francesca Wainwright	Greenwood Branch	Seattle Public Library	8016 Greenwood Av N	Seattle	WA	98103-4229
✓			Sibyl de Haan	High Point Branch	Seattle Public Library	3411 SW Raymond St	Seattle	WA	98126-2953
✓			Wei Cai	International District/Chinatown Branch	Seattle Public Library	713 Eighth Avenue S	Seattle	WA	98104-3060
✓			Andy Bates	Lake City Branch	Seattle Public Library	12501 28th Ave NE	Seattle	WA	98125-4319
✓			Dave Valencia	Madrona-Sally Goodmark Branch	Seattle Public Library	1134 33rd Avenue	Seattle	WA	98122-5120
✓			Lisa Scharnhorst	Magnolia Branch	Seattle Public Library	2801 34th Ave W	Seattle	WA	98199-2602
✓			Valerie Garrett-Turner	Montlake Branch	Seattle Public Library	2401 24th Ave E	Seattle	WA	98112-2642
✓			Daria Cal	New Holly Branch	Seattle Public Library	7058 32nd Ave S	Seattle	WA	98118-6401

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✓			Marion Scichilone	Northeast Branch	Seattle Public Library	6801 35th Ave NE	Seattle	WA	98115-7333
✓			Rekha Kuver	Northgate Branch Library	Seattle Public Library	10548 Fifth Avenue NE	Seattle	WA	98125
✓			Lisa Scharnhorst	Queen Anne Branch	Seattle Public Library	400 W. Garfield	Seattle	WA	98119-3038
✓			Daria Cal	Rainier Beach Branch	Seattle Public Library	9125 Rainier Ave S	Seattle	WA	98118-5026
✓			Jane Appling	South Park Branch	Seattle Public Library	8604 Eighth Ave S	Seattle	WA	98108-4713
✓			Jane Appling	Southwest Branch	Seattle Public Library	9010 35th Ave SW	Seattle	WA	98126-3821
✓			Andy Bates	University Branch	Seattle Public Library	5009 Roosevelt Way NE	Seattle	WA	98105-3610
✓			Marion Scichilone	Wallingford Branch	Seattle Public Library	1501 North 45th Street	Seattle	WA	98103-6708
✓			Sibyl de Haan	West Seattle Branch	Seattle Public Library	2306 42nd Ave. S.W.	Seattle	WA	98116-2535
	✓		Steve Cohn		Ballard Dist Council	5604 22nd Ave NW	Seattle	WA	98107
✓			David Folweiler	President	Groundswell Northwest	1725 NW 64th St	Seattle	WA	98107
	✓			Annie Davis	Ballard Chamber of Commerce	2208 NW Market St. Suite 100	Seattle	WA	98107
	✓			Caryle Teel, President	Ballard Rotary	P.O. Box 70472	Seattle	WA	98107
	✓		Jenny Heins	Sustainable Ballard	2442 NW Market St.	PMB 286	Seattle	WA	98107
	✓		Lois Spiegel	President	Sunset Hill Community Association	3003 NW 66th St.	Seattle	WA	98117
✓					Central District Council	2301 S. Jackson St #208	Seattle	WA	98144
✓					Central Neighborhood Council	1170 Harrison St N #201	Seattle	WA	98109
✓			Rob Martin		Columbia City Business Assoc	3827A So Edmunds St.	Seattle	WA	98118
✓			Pablo Laminicio		DNDA, Westwood Neighborhood	8820 31st Ave SW	Seattle	WA	98126
✓			Catherine Stanford		Downtown Dist Council	1904 3rd Ave Suite 828	Seattle	WA	98101
	✓		Paul Storms		East District Council	1834 Parkside Drive E	Seattle	WA	98112
	✓		Suzie Burke		Lk Union Dist Council	3401 Evanston Ave N. Suite A	Seattle	WA	98103
	✓				Leschi Community Council	3450 E. Alder St	Seattle	WA	98122
	✓		Janis Traven		Magnolia/Queen Ann Dist Council	3247 Magnolia Blvd	Seattle	WA	98199
✓			Phil Shack		North Dist Council	12509 42nd Ave NE	Seattle	WA	98125
✓			Irene Wall		North Dist Council	207 N. 60th St	Seattle	WA	98103
✓			Jerry Owens		Northwest Dist Council	8546 Burke Ave N	Seattle	WA	98103
✓			Jill Arnow	Executive Director	Queen Anne Chamber	2212 Queen Anne Ave N.	Seattle	WA	98109
✓			Erica Karlovits		SW Dist Council	4538-C 41st SW	Seattle	WA	98116
✓			Charles Redmond		SW District Council	3903 SW Monroe St	Seattle	WA	98136
✓			Nancy Bolin		View Ridge Community Council	4241 NE 75th St	Seattle	WA	98115
✓			Lynn Ferguson		Windemere N. Community Council	6422 NE 60th Street	Seattle	WA	98115
	✓			Thornton Creek Alliance	P.O. Box 25690		Seattle	WA	98165-1190
	✓		Thornton Creek Watershed	Oversight Council	ATT: Cheryl Klinker	12036 35th Ave NE	Seattle	WA	98125
	✓		Jennifer Ott	Friends of Seattle's Olmsted Parks	P.O. Box 9884		Seattle	WA	98109-0884
	✓		Thatcher Bailey	Seattle Parks Foundation	105 S. Main St. #235		Seattle	WA	98104
	✓		John Barber, Chairman	Friends of Street Ends	3421 E. Superior St.		Seattle	WA	98122-6557

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Notice of DEIS	Notice of DEIS + Compact Disc	Notice + DEIS + Compact Disc	Agency or Name	Name or Address1	Name or Address2	Address3	City	State	Zip
✓			Christa Dumpys	Coordinator, Central	Department of Neighborhoods	PO Box 94645	Seattle	WA	98124
✓			Laurie Ames	Coordinator, Central	Department of Neighborhoods	PO Box 94646	Seattle	WA	98124
✓			Tim Durkan	Coordinator, Central	Department of Neighborhoods	PO Box 94647	Seattle	WA	98124
✓			Stan Lock	Coordinator, Central	Department of Neighborhoods	PO Box 94648	Seattle	WA	98124
✓			Jenny Frankl	Coordinator, Delridge	Department of Neighborhoods	PO Box 94649	Seattle	WA	98124
✓			Yun Pitre	Coordinator, Delridge	Department of Neighborhoods	PO Box 94646	Seattle	WA	98124
✓			Ed Pottharst		Department of Neighborhoods	PO Box 94647	Seattle	WA	98124
✓			Thomas Whittemore	Coordinator, Ballard	Department of Neighborhoods	PO Box 94648	Seattle	WA	98124
✓			Karen Ko	Coordinator, Ballard	Department of Neighborhoods	PO Box 94649	Seattle	WA	98124
✓			Bill Pelosa	Councilmember	City of Auburn	25 West Main St.	Auburn	WA	98001
✓			Claudia Balducci	Mayor	City of Bellevue	450 110th Ave NE, PO Box 90012	Bellevue	WA	98009
✓			Paul Bucich	Assistant Director of Engineering	City of Bellevue	450 110th Ave NE, PO Box 90012	Bellevue	WA	98009
✓			Nav Otal	Utilities Director	City of Bellevue	450 110th Ave NE, PO Box 90012	Bellevue	WA	98009
✓			Douglas Jacobsen		Dawson Building	9654 NE 182nd St	Bothell	WA	98011
✓			Erin J. Leonhart	Public Works Director	Dawson Building	9654 NE 182nd St	Bothell	WA	98011
✓			Christopher Hagedorn	Public Works Director	City of Carnation	4621 Tolt Avenue, PO Box 1238	Carnation	WA	98014
✓			Walt Canter	Commissioner	Cedar River Water and Sewer District	18421 SE Petrovitsky Road	Renton	WA	98058
✓			Richard Anderson	Commissioner	Coal Creek Utility District	6801 132nd Place SE	Newcastle	WA	98059
✓			Mark Cassell	Commissioner	Cross Valley Water District	8802 180th St SE	Snohomish	WA	98296
✓			Sheldon Lynne	Deputy Director of Public Works	City Shop	670 1st Avenue NE, PO Box 1307	Issaquah	WA	98027
✓			Greg Reed	Utilities Superintendent	City of Kent	5821 S 240th St	Kent	WA	98032
✓			Bobbi Wallace	Surface and Wastewater Manager	City of Kirkland	123 Fifth Avenue	Kirkland	WA	98033
✓			Neil Jensen	City Engineer	City of Lake Forest Park	17425 Ballinger Way NE	Lake Forest Park	WA	98155
✓			Ron Nowicki	Commissioner	Lakehaven Utility District	31627 1st Avenue S, PO Box 4249	Federal Way	Wa	98063
✓			Patrick Yamashita	City Engineer	City of Mercer Island	9611 SE 36th St	Mercer Island	WA	98040
✓			Vince Koester	Commissioner	Midway Sewer District	PO Box 3487	Kent	WA	98089
✓			Paul Sentena	Commissioner	Northeast Sammamish Sewer and Water District	3600 Sahalee Way NE	Sammamish	WA	98074
✓			Margaret Wiggins	Commissioner	Northshore Utility District	6830 NE 185th St	Kenmore	WA	98028
✓			Lora Petso, Commissioner	Olympic View Water & Sewer	8128 228 th Street SW		Edmonds	WA	98026
✓			Scott Thomasson	Utility Engineering Manager	City of Redmond	PO Box 97010	Redmond	WA	98073
✓			Linda De Boldt	Public Works Director	City of Redmond	PO Box 97010	Redmond	WA	98073
✓			Dave Christensen	Utility Engineering Supervisor	City of Renton	1055 S. Grady Way	Renton	WA	98057
✓			Art Wadekamper	Commissioner	Ronald Wastewater District	17505 Linden Ave N	Shoreline	WA	98113
✓			Mary Shustov	Commissioner	Sammamish Plateau Water and Sewer District	1510 228th Avenue SE	Sammamish	WA	98075
✓			Don Henry	Commissioner	Skyway Water and Sewer District	6723 S 124th St.	Seattle	WA	98178

Protecting Seattle's Waterways Plan
Draft Environmental Impact Statement Distribution List

✓	✓	✓	Agency or Name	Name or Address1	Name or Address2	Address3	City	State	Zip
✓			Gary O. Cline	Commissioner	Soos Creek Water and Sewer District	PO Box 58039	Renton	WA	98058
✓			Bill Tracy	Commissioner	Southwest Suburban Sewer District	431 Ambaum Blvd	Burien	WA	98166
✓			Pat Brodin	Operations Manager	City of Tukwila	6200 Southcenter Blvd	Tukwila	WA	98188
✓			Pam Carter	Commissioner	Valley View Sewer District	3460 S 148th, Suite 100	Seattle	WA	98168
✓			Karen Steeb	Commissioner	Woodinville Water District	17238 NE Woodinville-Duvall Road	Woodinville	WA	98072
✓			Ed Cebon	Rates & Finance Subcommittee Chair	Woodinville Water District	17238 NE Woodinville-Duvall Road	Woodinville	WA	98072
✓			Ron Speer	Sewage Disposal Advisory Agreement Sub-Committee Chair	Soos Creek Water and Sewer District	PO Box 58039	Renton	WA	98058
✓			Anindita Mitra		7813 8 th Ave. NW		Seattle	WA	98117
✓			Dusty Hoerler		8929 5th Ave NE		Seattle	WA	98115
✓			Bruno Lambert		801 Pine St #24D		Seattle	WA	98101
✓			Julio Moran, Jr.		4401 S. Dawson St.		Seattle	WA	98118
✓			Mary Junttila		6021 S. Ryan St.		Seattle	WA	98178
✓			Robin McKennon Thaler		5042 49 th Ave. SW		Seattle	WA	98136
✓			Joan Rosenstock	Floating Home Association	1822 4th Ave N.		Seattle	WA	98109
✓			Rachel Ben-Shmuel	Vulcan			Seattle	WA	98104
✓			Henry McGee	Seattle University School of Law, Futurewise	Seattle University School of Law, Sullivan Hall, Room 437	901 12 th Ave., P.O Box 222000	Seattle	WA	98122-1090
✓			Taylor Washburn	Greater Seattle Chamber of Commerce	Foster Pepper PLLC 1111 3rd Ave, Ste 3400		Seattle	WA	98101-3299
✓			Kathy Fletcher		911 Western Ave., Ste 580,		Seattle	WA	98104
✓			Tom von Schrader	SvR Design Company	1205 Second Avenue, Suite 200 Seattle, WA		Seattle	WA	98101
		✓	Mark Henley	Permit Manager	Department of Ecology, Northwest Regional Office	3190 160th Ave. SE	Bellevue	WA	98008
		✓	Robert Grandinetti	USEPA Region 10	309 Bradley Blvd, Suite 115	Mail Code HPO	Richland	WA	99352
		✓	Edward J. Kowalski	Office of Compliance and Enforcement	US Environmental Protection Agency	1200 Sixth Avenue, Suite 900	Seattle	WA	98101
		✓	Alison Evans	Permit Manager	Department of Ecology, Northwest Regional Office	3190 160th Ave. SE	Bellevue	WA	98008
		✓	Rachel McCrea	Municipal Stormwater Specialist	Department of Ecology, Northwest Regional Office	3190 160th Ave. SE	Bellevue	WA	98008
		✓	Dino Marchalonis	Stormwater Technical Coordinator	US Environmental Protection Agency	1200 Sixth Avenue, Suite 900	Seattle	WA	98101
	✓		Chief, Environmental Enforcement Section	Environmental and Natural Resources Division, Environmental and Natural Resources Division	US Department of Justice	PO Box 7611	Washington	DC	20044-7611

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	✓		Director, Water Enforcement Division	Office of Civil Enforcement	US Environmental Protection Agency	1200 Pennsylvania Ave., NW, Mail Code: 2243-A	Washington	DC	20460
	✓		Director, Office of Compliance and Enforcement	US Environmental Protection Agency, Region 10	1200 6th Ave, Suite 900		Seattle	WA	98101
	✓		Attorney General of Washington	Ecology Division	P.O. Box 40117		Olympia	WA	98504
		2	Laura Wharton	Project Resource Unit Manager	Department of Natural Resources and Parks/Wastewater Treatment Division	201 Jackson St, Rm 512	Seattle	WA	98104
✓			Dave Boyd		6105 36th Ave NW		Seattle	WA	98107
✓			Margaret Kitchell		1410 E Pine St Unit 312		Seattle	WA	98122-8500
✓			John Peterson	Victory Heights Community Council	1914 NE 100th St		Seattle	WA	98125
✓			Jonathan Whiting		9242 Ashworth Ave N. #A202		Seattle	WA	98103
✓			Nate Cormier		4135 21st Ave SW		Seattle	WA	98106
✓			Jamie Rowe		111 1st Ave S		Seattle	WA	98104
✓			V. Ikehara		3200 California ave SE		Seattle	WA	98116
✓			Scott Coomes		7932 31st Ave SW		Seattle	WA	98126
✓			David Wiktorski		11226 Phinney Avenue North		Seattle	WA	98133
✓			Kathleen Dellplain	FCA	10273 Maplewood PL SW		Seattle	WA	98146
✓			Amber Knox		6951 23rd Ave SW		Seattle	WA	98106
✓			Marie McKinsey		2434 55th Ave. SW #2		Seattle	WA	98116
✓			Robert Hinrix	Beacon Hill Merchants Assoc	2821 Beacon Av S		Seattle	WA	98144
	✓		Robert Drucker		3226 NW 69 th St		Seattle	WA	98117
	✓		Catherine Weatbrook		8926 23 rd Ave NW		Seattle	WA	98117
	✓		Larry Ward		7703 19 th Ave NW		Seattle	WA	98117
	✓		Kim McDonald		7716 32 nd Ave NW		Seattle	WA	98117
	✓		Jessica Vets	Fremont Chamber	PO Box 31139		Seattle	WA	98103
	✓		Rachel Koller		7355 23 rd Ave NW		Seattle	WA	98117
	✓		Stephen Fickenscher		4515 Meridian Ave, Suite B		Seattle	WA	98117
	✓		Barry Hawley	Hawley Realty	5600 14 th Ave NW, Suite 3		Seattle	WA	98107
	✓		Elizabeth Dunigan		6508 32 nd Ave NW		Seattle	WA	98117
		✓	Betty Galarosa	SEPA PIC	City of Seattle	Dept of Planning & Development	SMT-18-62		
		✓	Public Review Documents	Quick Information Center	Seattle Public Library		LB-03-01		

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✓			Cliff Portman		City of Seattle	Planning & Development	SMT-18-00		
✓			Sue Putnam		City of Seattle	Planning & Development	SMT-18-00		
	✓		Andy Lunde		City of Seattle	Planning & Development	SMT-18-00		
	✓		Jerry Suder		City of Seattle	Planning & Development	SMT-18-00		
	✓		Laurie Olson		City of Seattle	Office of Housing	SMT-57-00		
✓			Kyle Joyce		City of Seattle	Finance & Admin Svcs	SMT-52-01		
✓			Mark Jaeger		City of Seattle	Seattle Public Utilities	SMT-49-00		
✓			Paul Fleming		City of Seattle	Seattle Public Utilities	SMT-49-00		
✓			Miles Mayhew		City of Seattle	Seattle Public Utilities	SMT-49-00		
✓			Laurie Geissinger	Environmental Compliance	City of Seattle	City Light	SMT 00-28-22		
✓			Jen Trout		City of Seattle	City Light	SMT 00-28-22		
✓			Bill Davis		City of Seattle	City Light	SMT 00-28-22		
✓			Margaret Duncan		City of Seattle	City Light	SMT 00-28-22		
	✓		Michael Shiosaki	Planning & Development Division	City of Seattle	Dept of Parks and Recreation	PK-01-01		
	✓		David Graves	Planning & Development Division	City of Seattle	Dept of Parks and Recreation	PK-01-01		
	✓		Maureen Meehan	Street Use Division	City of Seattle	Dept of Transportation	SMT 00-39-00		
	✓		Luke Korpi	Street Use Division	City of Seattle	Dept of Transportation	SMT 00-30-00		
✓			Ron Borowski	Policy and Planning	City of Seattle	Dept of Transportation	SMT-00-39-00		

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✓			Jill Macik	Capital Projects & Roadway Str.	City of Seattle	Dept of Transportation	SMT-00-39-00		
✓			Dongho Chang	Traffic Operation	City of Seattle	Dept of Transportation	SMT-00-39-00		
✓			Cristina VanValkenburgh	Mobility Programs	City of Seattle	Dept of Transportation	SMT-00-39-00		
✓			Sarah Sodt	Landmarks Preservation Board	City of Seattle	DON/HISTORICAL PROG.	SMT 00-17-00		
✓			Tina Vlasaty		City of Seattle	Economic Development	SMT-57-52		
✓			Gregory Dean, Fire Chief	Office of the Chief	City of Seattle	Fire Department	FD-44-04		
✓			Russ Byrd	Sr Fire Protection Engineer	City of Seattle	Fire Marshall's Office	TM-02-04		
✓			Nikki Douce		City of Seattle	Fire Department	FD-44-04		
	✓			City Council	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Sally Bagshaw	Councilmember	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Tim Burgess	Councilmember	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Sally Clark	Councilmember	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Kshama Sawant	Councilmember	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Jean Godden	Councilmember	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Bruce Harrell	Councilmember	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Nick Licata	Councilmember	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Mike O'Brien	Councilmember	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Tom Rasmussen	Councilmember	City of Seattle	Legislative Dept	CH 02-10-00		

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	✓		The Honorable Ed Murray	Mayor	City of Seattle	Office of the Mayor	CH-00-07-01		
	✓		Bob Tobin	Assistant City Attorney	City of Seattle	Office of the City Attorney	CH 00-04-01		
	✓		Jeff Weber	Senior Assistant City Attorney	City of Seattle	Office of the City Attorney	CH 00-04-01		



City of Seattle
Seattle Public Utilities

The Plan to Protect Seattle's Waterways
Notice of Availability of Final Environmental Impact Statement (FEIS)

Proponent

City of Seattle; Seattle Public Utilities (SPU)

Location

Projects included in the Plan to Protect Seattle's Waterways (the Plan) would be located throughout the City of Seattle in the following areas:

- Ship Canal Neighborhoods
- Lake Washington Neighborhoods
- Longfellow Creek/ Duwamish Neighborhoods
- Elliott Bay/ Lake Union Neighborhoods
- Piper's Creek Neighborhoods
- Thornton Creek Neighborhoods

Purpose

The objective of this proposal is to adopt a Plan to reduce overflows and the discharge of pollutants from combined sewers and stormwater runoff, in order to protect public health and the environment and to comply with federal and state regulations. When implemented, the Plan would bring Seattle into compliance with state and federal combined sewer overflow (CSO) regulations and a Consent Decree with the Washington State Department of Ecology, the U.S. Environmental Protection Agency, and the U.S. Department of Justice. Specifically, the Plan would:

- Identify areas of Seattle where projects are needed to reduce combined sewer overflows.
- Evaluate alternatives for reducing combined sewer overflows in these areas.
- Identify additional areas where projects to reduce stormwater pollution would improve water quality.
- Recommend a schedule for designing and constructing projects.
- Estimate program costs and associated impacts on SPU customer bills.
- Consider regulatory, public and stakeholder input.

Proposed Alternatives

SPU identified the following alternatives for evaluation in this EIS:

- No Action Alternative
- Long-Term Control Plan Alternative
- Integrated Plan Alternative

No Action Alternative: Under the No Action Alternative, the City would not implement the Plan. Progress would be made in reducing the number and volume of CSOs through implementation of previously planned CSO control projects identified in the City's National Pollutant Discharge Elimination System (NPDES) Waste Discharge Permit and in the 2010-2015 Implementation Plan for the *2010 CSO Reduction Plan Amendment* (2010 Plan Amendment). These projects are currently scheduled for implementation, and they will be completed regardless of whether the Plan is implemented. The City would also continue to implement a portion of two of its CSO reduction strategies: combined sewer system improvements and Natural Drainage Systems. However, the City would not implement any additional projects to further reduce CSOs or reduce stormwater pollution. Under the No Action Alternative, the City would not be in compliance with the Consent Decree. The No Action Alternative is required by SEPA, and serves as a baseline for comparison with the action alternatives.

Long-Term Control Plan Alternative: The Long-term Control Plan (LTCP) Alternative is focused solely on controlling all remaining uncontrolled CSO outfalls. The LTCP presents a comprehensive strategy for reducing the remaining uncontrolled CSO discharges in the city. The City must address these CSOs to protect public health and the environment, and comply with the Clean Water Act and state regulations. The City would implement the projects identified in the LTCP Alternative from 2016 through 2025.

There are four potential combinations of storage facilities, referred to as “options” in the LTCP, that are evaluated in this EIS. Any of these four options would meet the Plan objectives. The options were developed under one of two basic concepts: the City meets its Consent Decree-mandated CSO control requirements through implementation of independent (City only) control projects, or the City participates in one or more shared projects with King County to take advantage of potential cost / impact reduction opportunities. The options vary in terms of the number, size, and potential location of storage facilities considered. The four LTCP options are:

- Neighborhood Storage Option (independent, City only implementation)
 - Neighborhood Tanks/Pipes, or
 - Neighborhood West Ship Canal Tunnel plus Tanks/Pipes
- Shared West Ship Canal Tunnel Option (Shared King County / City implementation)
- Shared Ship Canal Tunnel Option (Shared King County /City implementation)
- Shared Storage Option (Shared King County / City implementation)

Integrated Plan Alternative: The Integrated Plan Alternative includes control of all remaining uncontrolled CSO outfalls and reduction of stormwater pollution. Stormwater runoff is a major contributor to surface water quality issues. The objective of the Integrated Plan is to implement stormwater pollution management projects that would provide greater benefits to surface water quality than those provided by the LTCP CSO reduction strategies alone. The Integrated Plan represents a more comprehensive approach to water quality management by integrating stormwater pollution management with CSO reduction strategies.

Under the Integrated Plan Alternative, the City would still build the CSO reduction projects included in one of the four LTCP options outlined above. However, the City would delay the completion of some of the CSO control projects, to allow earlier completion of high-benefit stormwater treatment technology projects. Six projects to control CSO discharges into the lower Duwamish, Portage Bay and Ship Canal waterways would be delayed until after 2025.

Under the Integrated Plan Alternative, the City would implement three programs/ projects in Seattle neighborhoods to reduce pollution from stormwater runoff in areas that are not part of the combined sewer system, using a combination of stormwater treatment technologies. These programs/projects include:

- Natural Drainage System (NDS) Partnering
- Arterial Street Sweeping Expansion
- South Park Water Quality Facility

Timing of Preferred Alternative Selection and Implementation

Following the release of the Final EIS, the City will identify a recommended LTCP option and recommended Plan Alternative. The City also will continue to implement a public process and outreach to solicit input from the public and other stakeholders during the Plan adoption process. Throughout the spring of 2015, the City Council will review and hold Council hearings and meetings (open to the public) to discuss the Plan. After Plan adoption in May 2015, the Final Plan will be submitted to EPA and Ecology for approval. The Final Plan is anticipated to be approved by EPA and Ecology in late summer 2015, and Plan implementation would commence in late 2015 or early 2016.

Timing of Additional Environmental Review

This EIS is programmatic in nature and has been prepared to disclose probable significant adverse impacts associated with the Plan to Protect Seattle's Waterways. As individual projects are identified, site-specific environmental review will be conducted prior to implementation. Depending on the preferred alternative and the amount of time needed to obtain regulatory approval of the Plan, some projects and actions would be ready for site-specific environmental review starting in 2016.

Project Proponent and Lead Agency

City of Seattle, Seattle Public Utilities (SPU)
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P.O. Box 34018
Seattle, WA 98124-4018

Project Information / Background Data Contact Person

Ed Mirabella
Long Term Control Plan Manager
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Date of Issuance of this Final EIS

December 4, 2014

Availability of the Final EIS and Background Materials

The Final EIS is available for viewing at the following locations:

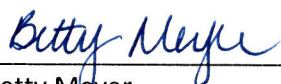
- Seattle Public Utilities, Director's Office Main Reception Area, Seattle Municipal Tower, Suite 4900, 700 Fifth Avenue, Seattle, Washington
- Seattle Central Library, General Reference Section
- Online at www.seattle.gov/CSO

The Final EIS can be downloaded for free from the City's website www.seattle.gov/CSO or purchased on CD for \$10 or in paper form for \$170. Purchased copies will be mailed upon receipt of a check made payable to Seattle Public Utilities.

Additional background materials can be viewed on the City's website: www.seattle.gov/CSO. They may also be viewed in paper form by arranging a time with Ed Mirabella at the number or email listed above.

The Final EIS and the background materials will be available until the close of the appeal period, which is December 4, 2014 through December 19, 2014.

Signature:


Betty Meyer

Issue Date: December 4, 2014

For interpretation services please call **206-684-5959**

如需要口譯服務，請撥電話號碼 **206-684-5959**

Para servicios de interpretación por favor llame al **206-684-5959**

Para sa serbisyo ng tagapagpaliwanag, tumawag sa **206-684-5959**

Về dịch vụ phiên dịch xin gọi **206-684-5959**



Protecting Seattle's Waterways

Volume 4 Addendum Final Programmatic Environmental Impact Statement

December 4, 2014





City of Seattle
Seattle Public Utilities

December 4, 2014

Dear Affected Agencies, Tribes, Organizations and Interested Parties:

Enclosed is the Final Environmental Impact Statement (Final EIS) for the proposed Plan to Protect Seattle's Waterways.

The City of Seattle (City) is preparing a comprehensive strategy, called the Plan to Protect Seattle's Waterways (Plan), to reduce overflows and the discharge of pollutants from combined sewers and stormwater runoff. The City must correct this problem to protect public health and the environment, and comply with the federal Clean Water Act, state regulations, and a Consent Decree with the Washington State Department of Ecology, the U.S. Environmental Protection Agency, and the U.S. Department of Justice. This Final EIS is one of four volumes included in the Plan. The Executive Summary is Volume 1, the Long Term Control Plan (LTCP) is Volume 2, the Integrated Plan is Volume 3, and the Final EIS is Volume 4.

This programmatic Final EIS discloses the potential construction and operational impacts associated with implementation of each Plan alternative:

- The No Action Alternative – completes only the combined sewer overflow (CSO) reduction projects currently planned or underway by the City, leaving 22 CSO outfalls uncontrolled;
- The Long Term Control Plan Alternative – completes CSO reduction projects needed to control the remaining 22 CSO outfalls,
- The Integrated Plan Alternative – completes CSO reduction projects needed to control the remaining 22 CSO outfalls and also implements additional projects to reduce stormwater pollution.

The Long Term Control Plan Alternative includes four options, any of which would control the remaining 22 CSO outfalls and meet regulatory requirements:

- Neighborhood Storage Option – All storage projects would be completed independently by the City, with one variation providing storage in tanks/pipes, and the other a combination of a tunnel and tanks/pipes.
- Shared West Ship Canal Tunnel Option – Where feasible, storage projects would be completed jointly by the City and King County. This option includes storage tanks/pipes and a shared City/King County tunnel for storage of flows from four of the largest CSO areas.
- Shared Ship Canal Tunnel Option – This option includes a large shared City/King County tunnel for storage from seven of the largest CSO areas, as well as storage tanks and pipes.
- Shared Storage Option – the City and King County would complete shared storage projects in the Ship Canal, Portage Bay and Lake Washington areas.

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Any shared projects between the City and King County would be implemented in accordance with joint project agreements between the two agencies.

Impacts are evaluated at a programmatic level, to provide a comprehensive evaluation of potential impacts and mitigation associated with implementation of the Plan. Site-specific project evaluations will be conducted at a later date, when additional information is available.

Environmental elements covered in the EIS include Earth and Groundwater, Air Quality and Odors, Surface Water, Biological Resources, Energy and Climate Change, and Environmental Health. Noise and Vibration, Land Use and Visual Quality, Recreation, Historic and Cultural Resources, Transportation, Utilities, and Socioeconomics and Environmental Justice are also evaluated.

Key issues associated with the alternatives and options include potential construction-related impacts, particularly traffic, noise, and other community impacts during construction periods that could range from roughly one year to as much as seven years, depending upon the size of the project. Possible long term impacts include a potential for odor and noise at storage facilities, and potential operational implications for the region's wastewater system. Appropriate design and mitigation, along with coordination with potentially affected agencies and organizations, will reduce the potential for significant impacts.

The Final EIS responds to comments received on the Draft EIS, describes changes to the alternatives that have occurred since the issuance of the Draft EIS, and includes modification and revisions to the analysis provided in the Draft EIS as appropriate. Changes to the Draft EIS in response to the comments received are minor. Consistent with WAC 197-11-560(5) and SMC 25.05.560.E, the City has prepared an addendum to the Draft EIS that includes the comments, responses, changes to the document since release of the Draft EIS, and an updated fact sheet. This Final EIS is intended to be used as a companion document to the Draft EIS and avoids repetition of the detailed material provided in the Draft EIS.

The appeal period associated with this Final EIS is December 4, 2014 through December 19, 2014.

Thank you for your interest in the Plan to Protect Seattle's Waterways.

Sincerely,



Betty Meyer
SEPA Responsible Official

Fact Sheet

Name of Proposal

Plan to Protect Seattle's Waterways (the Plan)

Proponent

City of Seattle (City): Seattle Public Utilities (SPU)

Location

Projects included in the Plan would be located throughout the City of Seattle in the following areas:

- Ship Canal Neighborhoods
- Lake Washington Neighborhoods
- Longfellow Creek/ Duwamish Neighborhoods
- Elliott Bay/ Lake Union Neighborhoods
- Piper's Creek Neighborhoods
- Thornton Creek Neighborhoods

Purpose

The objective of this proposal is to adopt a Plan to reduce overflows and the discharge of pollutants from combined sewers and stormwater runoff, in order to protect public health and the environment and to comply with federal and state regulations. When implemented, the Plan would bring Seattle into compliance with state and federal combined sewer overflow (CSO) regulations and a Consent Decree with the Washington State Department of Ecology, the U.S. Environmental Protection Agency, and the U.S. Department of Justice. The Plan would define projects to control this significant source of contamination and when implemented, the Plan would bring the City into compliance with the State and Federal requirements for CSO discharges. Specifically, the Plan would:

- Identify areas of Seattle where projects are needed to reduce combined sewer overflows.
- Evaluate alternatives for reducing combined sewer overflows in these areas.
- Identify additional areas where projects to reduce stormwater pollution would improve water quality.
- Recommend a schedule for designing and constructing projects.
- Estimate program costs and associated impacts on SPU customer bills.
- Consider regulatory, public and stakeholder input.

Proposed Alternatives

SPU identified the following alternatives for evaluation in this EIS:

- Long Term Control Plan Alternative
- Integrated Plan Alternative
- No Action Alternative

Long Term Control Plan Alternative: The Long Term Control Plan (LTCP) Alternative is focused solely on controlling all remaining uncontrolled CSO outfalls. As a planning-level document, the LTCP presents a comprehensive strategy to reduce the remaining uncontrolled CSO discharges in the city. The City must address these CSOs to protect public health and the environment, and comply with the Clean Water Act and state regulations. The City would implement the projects identified in the LTCP Alternative from 2016 through 2025.

There are four potential combinations of storage facilities, referred to as “options” under the LTCP that are evaluated in this EIS. Any of these four options would meet the Plan objectives. The options were developed under one of two basic concepts: the City meets its Consent Decree-mandated CSO control requirements through implementation of independent (City only) control projects, or the City participates in one or more shared projects with King County to take advantage of potential cost /impact reduction opportunities. The options vary in terms of the number, size, and potential location of storage facilities considered. The four LTCP options are:

- Neighborhood Storage Option (independent, City only implementation)
 - Neighborhood Tanks/Pipes, or
 - Neighborhood West Ship Canal Tunnel plus Tanks/Pipes
- Shared West Ship Canal Tunnel Option (Shared King County / City implementation)
- Shared Ship Canal Tunnel Option (Shared King County /City implementation)
- Shared Storage Option (Shared King County / City implementation)

Integrated Plan Alternative: The Integrated Plan Alternative includes control of all remaining uncontrolled CSO outfalls and reduction of stormwater pollution. Stormwater that enters the City's separate stormwater system is a major contributor to surface water quality issues. The objective of the Integrated Plan is to implement stormwater pollution management projects that would provide greater benefits to surface water quality than those provided by the LTCP CSO reduction strategies alone. The Integrated Plan represents a more comprehensive approach to water quality management by integrating stormwater pollution management with CSO reduction strategies.

Under the Integrated Plan Alternative, the City would still build the CSO reduction projects included in one of the four LTCP options outlined above. However, the City would delay the completion of some of the CSO control projects until after 2025, to allow earlier completion of high-benefit stormwater treatment technology projects. Six projects to control CSO discharges into the lower Duwamish, Portage Bay and Ship Canal waterways would be delayed until after 2025.

Under the Integrated Plan Alternative, the City would implement three programs/projects in Seattle neighborhoods to reduce pollution from stormwater runoff in areas that are not part of the combined sewer system, using a combination of stormwater treatment technologies. These programs/projects include:

- Natural Drainage System (NDS) Partnering
- Arterial Street Sweeping Expansion
- South Park Water Quality Facility

No Action Alternative: Under the No Action Alternative, the City would not implement the Plan. Progress would be made in reducing the number and volume of CSOs through implementation of previously planned CSO control projects, some of which are identified in the City's National Pollutant Discharge Elimination System (NPDES) Waste Discharge Permit and others of which are identified in the 2010-2015 Implementation Plan for the *2010 CSO Reduction Plan Amendment* (2010 Plan Amendment). These projects are currently scheduled for implementation, and they will occur regardless of whether the Plan is implemented. The City would also continue to implement a portion of two of its CSO reduction strategies: combined sewer system improvements and Natural Drainage Systems (called 'Green Infrastructure' in the LTCP). However, the City would not implement any additional projects to further reduce CSOs or reduce stormwater pollution. Under the No Action Alternative, the City would not be in compliance with the Consent Decree. SEPA requires that the No Action Alternative be included, and it serves as a baseline for comparison with the action alternatives.

Implementation and Next Steps

Foremost in the development of the Plan is the need to comply with the Consent Decree and meet federal and state regulatory requirements. In order to comply with the Consent Decree, the City must select and implement an LTCP option. All City LTCP options have elements that may impact King County's wastewater system. Interagency coordination will be conducted in accordance with the SPU and King County Wastewater Division Coordination Plan, in which the two entities agreed upon specific factors to be considered in evaluating and recommending which CSO projects would be undertaken jointly or independently by either SPU or King County. It is possible that the selected LTCP option may include a combination of options or facilities presented in the EIS. An Integrated Plan is an optional approach that is not required by EPA or Ecology, but can be used to satisfy the Consent Decree.

The Draft Plan for Protecting Seattle's Waterways, which consists of the following four volumes, was submitted to EPA and Ecology for review and comment on May 29, 2014:

- Volume 1: Executive Summary
- Volume 2: CSO Long Term Control Plan
- Volume 3: Integrated Plan
- Volume 4: Programmatic EIS

Ecology submitted comments on the draft LTCP and Integrated Plan on August 21, 2014, and EPA submitted comments on the draft Plan on October 31, 2014. The City will work with EPA and Ecology to ensure their comments are addressed in the Final Plan.

Following the release of the Final EIS, the City will identify a recommended LTCP option and recommended Plan Alternative. The City also will continue to implement a public process and outreach to solicit input from the public and other stakeholders during the Plan adoption process. Throughout the spring of 2015, the City Council will

review and hold Council hearings and meetings (open to the public) to discuss the Plan. After Plan adoption in May 2015, the Final Plan will be submitted to EPA and Ecology for approval. The Final Plan is anticipated to be approved by EPA and Ecology in late summer 2015, and Plan implementation would commence in late 2015 or early 2016.

Timing of Additional Environmental Review

The analysis presented in this EIS is programmatic in nature. The EIS has been prepared to disclose probable significant adverse impacts associated with the Plan to Protect Seattle's Waterways. As individual projects are identified and designed, project-specific environmental review will be conducted prior to implementation. Depending on the selected alternative and the amount of time needed to obtain regulatory approval of the Plan, some projects and actions would be ready for project-specific environmental review starting in 2016.

Required Approvals or Permits

Because a preferred alternative has not been selected, it is not possible to present a complete list of approvals and permits that would be required for future projects. It is possible to identify the most common types of approvals and permits that would generally be required for the types of projects presented in this document. These approvals and permits are listed below by jurisdictional agency.

- Federal
 - Section 10/404 permit--U.S. Army Corps of Engineers
 - Endangered Species Act consultation--National Marine Fisheries Service and/or U.S. Fish and Wildlife Service
- State
 - National Pollutant Discharge Elimination System (NPDES) construction stormwater general permit--Ecology
 - Section 401 water quality certification--Ecology
 - Shoreline conditional use permit, or variance--Ecology
 - Hydraulic project approval--Washington Department of Fish and Wildlife (WDFW)
 - Section 106 National Historic Preservation Act or Executive Order 05-05 consultation--Department of Archaeology and Historic Preservation
- County
 - Applicable project approval under King County Code (KCC) 28.84.050
 - Shared Project Agreement
 - Operational Agreement
- City
 - Environmentally critical areas approval--Department of Planning and Development (DPD) or Seattle Public Utilities
 - Master Use Permit--DPD, Seattle City Council, as appropriate

- Floodplain development permit---DPD
- Shoreline Management Program permit--DPD
- Building and related permits--DPD
- Clearing and grading permit--DPD
- State Environmental Policy Act (SEPA) compliance--Seattle Public Utilities
- Initiative 42 approval (park lands conversion)--Seattle City Council
- Street use permit--Seattle Department of Transportation

Authors and Principal Contributors to this EIS

This Final EIS has been prepared under the direction of Seattle Public Utilities. The following consulting firms provided research and analysis associated with this EIS:

- **ESA** - lead EIS consultant, document preparing; writing of all EIS sections
- **CH2M Hill** - engineering support
- **Brown and Caldwell** - engineering support
- **Herrera Environmental Consultants** – analysis of water resources
- **Heffron Transportation, Inc.** – transportation analysis
- **PRR** – public outreach

Project Proponent and Lead Agency

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Date of Issuance of this Final EIS

December 4, 2014

SPU SEPA Responsible Official

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Availability of the Final EIS and Background Materials

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Additional background materials can be viewed on the City's website: www.seattle.gov/CSO.

They may also be viewed in paper form by arranging a time with Ed Mirabella at the number or email listed above.

Appeal of the Final EIS

Appeals of the Final EIS must be accompanied by a \$85.00 filing fee and must be filed by 5:00 p.m. on December 19, 2014. Delivery of appeals filed by any form of USPS mail service may be delayed by several days. Allow extra time if mailing an appeal.

Written appeals must be sent to:

City of Seattle Hearing Examiner
700 5th Avenue Suite 4000
P.O. Box 94729
Seattle, WA 98124-4729

Appeals can be filed electronically. Details on electronic filing procedures are available under "e-File" at the Office of the Hearing Examiner's web site: <http://www.seattle.gov/examiner/>

Filing fees must be paid by the appeal deadline and can be paid via check (made payable to the City of Seattle) or credit/debit card (Visa and MasterCard only). Credit/debit card payments can be made in-person or over-the-phone.

You should be prepared to make specific factual objections. Please refer to the Hearing Examiner Rules of Practice and Procedure for rules that govern appeals, which are available on the Hearing Examiner's website at www.seattle.gov/examiner/rules-toc.htm or by calling 206-684-0521.

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List of Abbreviations

Term	Definition
BMP	best management practice
BTRC	Ballard Terminal Railroad Company
CESF	chitosan-enhanced sand filtration
CFR	Code of Federal Regulations
City	City of Seattle
CSO	Combined Sewer Overflow
CSS	Combined Sewer System
CWA	Clean Water Act
CY	cubic yards
DAHP	Washington Department of Archaeology and Historic Preservation
DNRP	King County Department of Natural Resources and Parks
DPD	Seattle Department of Planning and Development
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
GHG	greenhouse gas
I-5	Interstate 5
I-90	Interstate 90
LTCP	Long Term Control Plan
MG	million gallons
MS4	municipal separate storm sewer system
NDS	Natural Drainage System
NPDES	National Pollutant Discharge Elimination System
O&M	Operations and Maintenance
PBDE	polybrominated diphenyl ether
PCB	polychlorinated biphenyl
PHS	Priority Habitat and Species
The Plan	The Plan to Protect Seattle's Waterways
RCW	Revised Code of Washington
ROW	right-of-way
SDOT	Seattle Department of Transportation
SEPA	State Environmental Policy Act
SF	square feet
SMC	Seattle Municipal Code
SODO	South of Downtown neighborhood
SPU	Seattle Public Utilities
SR	State Route
TBM	tunnel boring machine
TMDL	Total Maximum Daily Load
WAC	Washington Administrative Code
WDNR	Washington Department of Natural Resources
WSDOT	Washington State Department of Transportation Glossary

Glossary

Term	Definition
Alternative	There are 3 alternatives for the Plan to Protect Seattle's Waterways: 1. The LTCP Alternative is focused solely on reducing CSOs under an approved Long-term Control Plan (LTCP), 2. The Integrated Plan Alternative includes reduction of both CSOs and stormwater pollution, 3. The No Action Alternative, which provides a baseline for comparison of potential effects of the Plan alternatives, as required by the State Environmental Policy Act (SEPA).
Anadromous Fish	Fish species, such as salmon, which are born in fresh water, spend most of their lives in salt water, and return to fresh water to spawn.
Best Management Practice (BMP)	A method, activity, or procedure for reducing the amount of pollution entering a water body.
Carbon Monoxide	A colorless and odorless toxic gas.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act.
CFS	Flow rate in Cubic Feet per Second.
Code of Federal Regulations (CFR)	A compilation of federal laws.
Combined Sewers	Conveyance systems designed to carry both wastewater and stormwater.
Combined Sewer Overflow(CSO)	During rainfall events, the volume of the stormwater entering a combined sewer system often is far greater than the capacity of the conveyance system and, as a result, the untreated sewage and stormwater mixture empties directly into receiving waters through designated overflow points.
Combined Sewer System (CSS)	The wastewater collection and conveyance system owned or operated by the City, including all pipes, force mains, gravity sewer segments, pump stations, lift stations, interceptors, diversion structures, maintenance holes, and appurtenances thereto, designated to collect and convey municipal sewage, including residential, commercial, and industrial wastewaters, and stormwater, through a single-pipe system to King County's wastewater treatment plants, King County's CSO treatment plants, or to permitted CSO outfalls.
Consent Decree	A written agreement entered in United States District Court for Western District of Washington on July 3, 2013, between the City of Seattle, Washington State Department of Ecology, the EPA, and the United States Department of Justice that describes the actions that The City must take to address violations of the Clean Water Act caused by Combined Sewer Overflows.
Control Measure	A project, action, or other activity set forth in the City's Long-Term Control Plan or any

	Supplemental Compliance Plan, provided for in Section V.B. of the Consent Decree that controls CSO outfall.
Control Status	Whether an outfall meets the Consent Decree's definition of "greatest reasonable reduction" of CSOs; an average of no more than one overflow occurrence per outfall per year determined on a 20 year moving average.
Control Volume	The amount of combined sewage that would need to be stored in order for a basin to achieve control status
Controlled	The control of a CSO outfall in accordance with WAC 173-245-020(22).
Critical Habitat	Habitat which is essential for the conservation of a threatened or endangered species.
CSO area	A logical grouping of one or more outfalls based on hydraulic relationships, receiving waters, neighborhoods, or other readily recognizable features.
CSO outfall	The outfall structure from which a CSO is discharged.
CWA	Clean Water Act; passed by Congress in 1972, meant to restore and maintain the integrity of the nation's waters.
Designated Receiving Water	Waters determined by SPU as having sufficient capacity to receive discharges of drainage water such that a site discharging to the designated receiving water is not required to implement flow control. Includes the Duwamish River, Puget Sound, Lake Washington, Lake Union, Elliott Bay, Portage Bay, Union Bay, and the Lake Washington Ship Canal.
Drop shaft	The vertical excavation used to get from the ground surface down to tunnel grade.
Early Action Projects	The Consent Decree mandates that the City shall implement all CSO control measures necessary to reduce discharges from CSO outfalls in North and South Henderson CSO Areas in accordance with Section V.A. of the Consent Decree.
Ecology	The State of Washington Department of Ecology.
Environmental Impact Statement (EIS)	A document that discloses the probable significant adverse environmental impacts of a proposed project or planning, discusses reasonable mitigation of identified impacts, and evaluates alternatives to the project and/or proposal. EISs are required under certain circumstances by the Washington State Environmental Policy Act (SEPA).
Environmental Justice	The fair treatment of people of all races and incomes with respect to actions affecting the environment. Fair treatment implies that there is equity of the distribution of benefits and risks associated with a proposed project and that one group does not suffer disproportionate adverse effects.
Erosion	The wearing away of land surfaces by wind or water. Erosion can be intensified by land clearing processes. Sediment is a product of stream erosion.
Fecal Coliform	A group of bacteria that are passed through the fecal excrement of humans, livestock, and wildlife.
Green (Stormwater)	Systems and practices that use or mimic natural processes to infiltrate, evapotranspire,

Infrastructure	and/or harvest stormwater on or near the site where it is generated. Green infrastructure may include, but is not limited to, green roofs, downspout disconnection, trees and tree boxes, rain gardens, vegetated swales, pocket wetlands, infiltration planters, vegetated median strips, permeable pavements, reforestation, and protection and enhancement of riparian buffers and floodplains.
Groundwater	Water that infiltrates into the earth and is stored in the soil and rock within the zone of saturation below the earth's surface. Groundwater is created by rain, which soaks into the ground and flows down until it is collected at a point where the ground is not permeable. Groundwater then usually flows laterally toward a river, lake, or ocean. It is often used for supplying wells and springs.
Independent CSO Control Measure	A CSO control measure that is implemented by the City only or King County only. When implemented by the City only, also referred to as a Neighborhood Solution.
Launching Portal	A primary portal used to insert a tunnel boring machine for excavation of tunnels. Lining and ventilation operations would also occur at these portals.
Long Term Control Plan (LTCP)	The Long Term Control Plan under development by the City in accordance with Section V.B. of the CD, as well as any additional remedial measures for eliminating or reducing the City's CSOs included in any Supplemental Compliance Plan developed and implemented in accordance with Section V.B. of the CD.
LTCP Option	An overall CSO Control Strategy which ultimately will resolve all SPU uncontrolled outfalls; the four possible Options are: Neighborhood Storage, Shared Storage, Shared West Ship Canal Tunnel, Shared Ship Canal Tunnel.
Natural Drainage System	A method that uses soil to absorb stormwater and slow the rate that it enters the sewer system. Examples include rain gardens, porous pavement, and cisterns.
Neighborhood	A term used in this EIS to characterize the potential affected areas. (Note: this term is not used in Volume 2, LTCP.)
Nitrogen Dioxide	A highly reactive gas formed from the emissions of motor vehicles, power plants, and off-road equipment. Nitrogen dioxide contributes to ground-level ozone and fine particle pollution and has adverse effects on the respiratory system.
Open Cut	See "trenching".
Ozone	An atmospheric pollutant created by chemical reactions of other pollutants in the air when exposed to sunlight.
Partially Separated Stormwater System	Street drainage system that routes runoff to separate storm sewers and conveys the remaining drainage in a combined sewer.
The Plan	The Plan to Protect Seattle's Waterways, includes 4 Volumes: Executive Summary, Long Term Control Plan, Integrated Plan, and Environmental Impact Statement.

Priority Habitats and Species	The Priority Habitats and Species list is a catalog of habitats and species considered to be priorities for conservation and management. The list is published by the Washington Department of Fish and Wildlife.
Pump Station	A structure that houses pumps and other equipment for lifting stormwater or wastewater in pipes to higher elevations so that it can continue to flow by gravity
Rain Garden	Small vegetated depressions with designed soil mixes that retain runoff for subsequent infiltration or delayed release to the combined sewer system.
Receiving Water	Any body of water which receives CSO and stormwater discharges.
Recovery Portal	A primary portal used to remove tunnel boring machines during construction of tunnels.
Regulator	A structure that controls the flow of wastewater from two or more input pipes to a single output. Regulators can be used to restrict or halt flow, thus causing wastewater to be stored in the conveyance system until it can be handled by the treatment plant (as in King County 3rd Avenue West 11th Avenue West, Montlake, and University Regulators)
Salmonids	The common name for several species of fish of the family Salmonidae. The family includes salmon, trout, and char.
Sanitary Sewer System	The portion of the wastewater collection system designed to convey only sewage, and not stormwater, from residences, commercial buildings, industrial plants, and institutions for treatment at a wastewater treatment plant.
Sensitive Receptors	Noise-sensitive locations including residences, schools, hospitals, and nursing homes.
Shared	A CSO reduction strategy that is implemented by the City and King County Department of Natural Resources and Parks (DNRP).
Source control	An action to prevent pollution where it originates.
State Environmental Policy Act (SEPA)	A Washington State law (Chapter 43.21C RCW) that requires state agencies and local governments to consider environmental impacts when making decisions regarding certain activities, such as development proposals over a certain size, and comprehensive plans. As part of this process, environmental impacts are documented and opportunities for public comment are provided.
Storm Drain	A system of gutters, pipes, or ditches used to carry stormwater from surrounding lands to streams, lakes, or other receiving water. Also refers to the end of the pipe where the stormwater is discharged.
Storm Sewer	A pipe (separated from sanitary sewers) that carries only stormwater runoff from buildings and land surfaces.

Stormwater Runoff	Stormwater is rain and melting snow that runs off surfaces that cannot readily absorb water, such as streets, rooftops, and parking lots. As stormwater runs across these hard surfaces, it picks up pollutants such as oil, grease, and metals, carrying them through the City's storm drain system to our lakes, streams, rivers, and Puget Sound. It also flows into the combined sewer system and causes overflows of raw sewage and polluted stormwater into Seattle waterways.
Sulfur Dioxide	A highly reactive gas emitted by fossil fuel combustion at power plants and industrial facilities. Sulfur dioxide has adverse effects on the respiratory system.
Surface Water	Any water, including fresh water and salt water, on the surface of the earth.
Trenching	A method for installing pipe near the surface, also called "open cut." The trenching method consists of three stages: digging a trench and stockpiling excavated materials; installing pipe in the trench; and backfilling the trench and restoring the surface.
Truck Trip	A trip made by a truck hauling materials or workers for construction projects.
Tunneling	Method used for excavating a tunnel within the earth and installing pipes. A tunnel boring machine (TBM) is inserted through a launching portal and retrieved from a recovery portal.
Uncontrolled outfall	A CSO outfall which experiences more than an average of one untreated CSO discharge event annually on a twenty year moving average.

CHAPTER 1

Plan Description and Final EIS Addendum

1.1 Introduction

The City is preparing a comprehensive strategy, called the **Plan to Protect Seattle's Waterways** (the Plan), to reduce overflows and the discharge of pollutants from combined sewers and stormwater runoff. The City must correct this problem to protect public health and the environment, and comply with the federal Clean Water Act, state regulations and a Consent Decree with the Washington Department of Ecology, the U.S. Environmental Protection Agency, and the U.S. Department of Justice.

On May 29, 2014, the City of Seattle issued a Draft Environmental Impact Statement (EIS) for the Plan. The issuance of the Draft EIS was followed by a 30 day public review period which ended on June 30, 2014. During the review period, the City conducted one public hearing on June 24, 2014. Comments were received from 12 different parties, including four agencies, two organizations and six individuals.

Changes to the Draft EIS in response to the comments received are minor. Consistent with WAC 197-11-560(5) and SMC 25.05.560.E, the City has prepared an addendum to the Draft EIS that includes the comments, responses, changes to the document since release of the Draft EIS, and an updated fact sheet. This Final EIS is intended to be used as a companion document to the Draft EIS and avoids repetition of the detailed material provided in the Draft EIS.

Since the release of the Draft EIS, the City has made changes to one option under the LTCP (Long Term Control Plan) Alternative and has updated the project description for one project included under the No Action Alternative. These changes are described below under "*Plan Alternatives and Updates*", and the impacts associated with these changes are discussed in "*Impacts and Mitigation*."

This Final EIS contains:

Section 1.1 *Introduction* introduces the approach and contents of the Final EIS.

Section 1.2 *Background* summarizes key background information from the Draft EIS, including an introduction to the Plan, its objectives, and an introduction to the Plan alternatives.

Section 1.3 *Plan Alternatives and Updates* describes the Plan alternatives, including changes and updates to the Plan alternatives since the issuance of the Draft EIS.

Section 1.4 *Impacts and Mitigation* summarizes the potential construction and operational impacts, as well as measures that the City would take to help reduce or minimize potential impacts associated with the Plan alternatives.

Section 1.5 *Public and Agency Review* describes the public and agency review process for the Draft EIS and summarizes comments received and City responses. A summary of public involvement activities is included in Appendix A, and a complete list of Draft EIS comments and City responses is included in Appendix B.

1.2 Background

1.2.1 What is the Plan to Protect Seattle's Waterways and why is it needed?

Sewers in the City of Seattle carry raw sewage and other wastewater away from neighborhoods for treatment at King County's West Point Treatment Plant before discharge to Puget Sound. When it rains, some of these same sewers also carry untreated stormwater from neighborhood roofs, foundation drains, and some streets. During heavy rains, if the amount of raw sewage and untreated stormwater exceeds the sewer system capacity, the excess flow discharges into local waterways. These "combined sewer overflows," or CSOs, are a public health and environmental concern. In addition, stormwater runoff from streets, parking lots, and buildings contributes a wide range of pollutants to the city's waters.

The objective of this proposal is to adopt a Plan to reduce overflows and the discharge of pollutants from combined sewers and stormwater runoff, in order to protect public health and the environment and to comply with federal and state regulations.

1.2.2 What Alternatives does this EIS Consider?

The EIS is a programmatic or plan-level evaluation, assessing the broad, comprehensive implications and impacts associated with adoption and implementation of the Plan. Additional project-level evaluations will be conducted in accordance with the City's Environmental Policies and Procedures (SMC 25.05) when additional project details are available, and as such this EIS is part of a phased SEPA review process.

The EIS evaluates two Plan alternatives and a No Action Alternative. The two Plan alternatives represent different ways of achieving the objectives of the Plan. The Plan Alternatives are described in detail in Chapter 3 of the Draft EIS. A preferred alternative has not been identified at this time.

The **LTCP Alternative** is focused solely on reducing CSOs under an approved Long Term Control Plan (LTCP). As a planning-level document, the LTCP presents a comprehensive strategy to reduce the remaining uncontrolled CSO discharges in the city. The City must address these CSOs to protect public health and the environment, and comply with the Clean Water Act and state regulations. The City would implement the projects identified in the LTCP Alternative from 2016 through 2025, to comply with federal requirements, including a federal Consent Decree.

The **Integrated Plan Alternative** includes reduction of CSOs and stormwater pollution. Stormwater that enters the City's separate stormwater system is a major contributor to surface water quality issues. The objective of the Integrated Plan is to implement stormwater pollution management projects that would provide greater benefits to surface water quality than those provided by the LTCP CSO reduction strategies alone. The Integrated Plan represents a more comprehensive approach to water quality management by integrating stormwater pollution management with CSO reduction strategies.

What is the Consent Decree?

The Consent Decree is a written agreement between the City of Seattle, Washington State Department of Ecology, U.S. Environmental Protection Agency, and the U.S. Department of Justice that describes the actions that the City of Seattle must take to address violations of the Clean Water Act.

Previously, the City implemented CSO control measures and stormwater management as separate and distinct programs. Recognizing that polluted runoff has a big impact on surface water quality, the Consent Decree allows the City to prepare a plan that integrates CSO control projects with stormwater control projects. Under the Consent Decree, the City may submit an Integrated Plan that proposes stormwater control projects and defers certain CSO control projects, provided that the stormwater projects will result in significant benefits to surface water quality beyond those that would be achieved by implementation of CSO controls alone. The CSO control projects deferred would be delayed until after 2025.

The **No Action Alternative** provides a baseline for comparison of potential effects of the Plan alternatives, as required by SEPA. Under the No Action Alternative, progress will be made in controlling CSOs through implementation of previously planned CSO control projects identified in the City's National Pollutant Discharge Elimination System (NPDES) Waste Discharge Permit (WA0031682) and projects included in the 2010-2015 Implementation Plan for the *2010 CSO Reduction Plan Amendment* (2010 Plan Amendment). These projects are scheduled for implementation, and they will occur regardless of whether the Plan is implemented.

The City would also continue to implement a portion of two of its CSO reduction strategies, combined sewer system improvements and Natural Drainage Systems (called 'Green Infrastructure' in the LTCP). However, the City would not implement any additional CSO reduction or stormwater control projects beyond those that are currently slated for implementation. Under the No Action Alternative, untreated sewage and stormwater in excess of current regulations would continue to discharge into Lake Washington, the Lake Washington Ship Canal (Ship Canal), the Duwamish River, and Puget Sound when the capacity of the existing systems is exceeded. Under the No Action Alternative, the City would not be in compliance with the Consent Decree.

1.2.3 Implementation and Next Steps

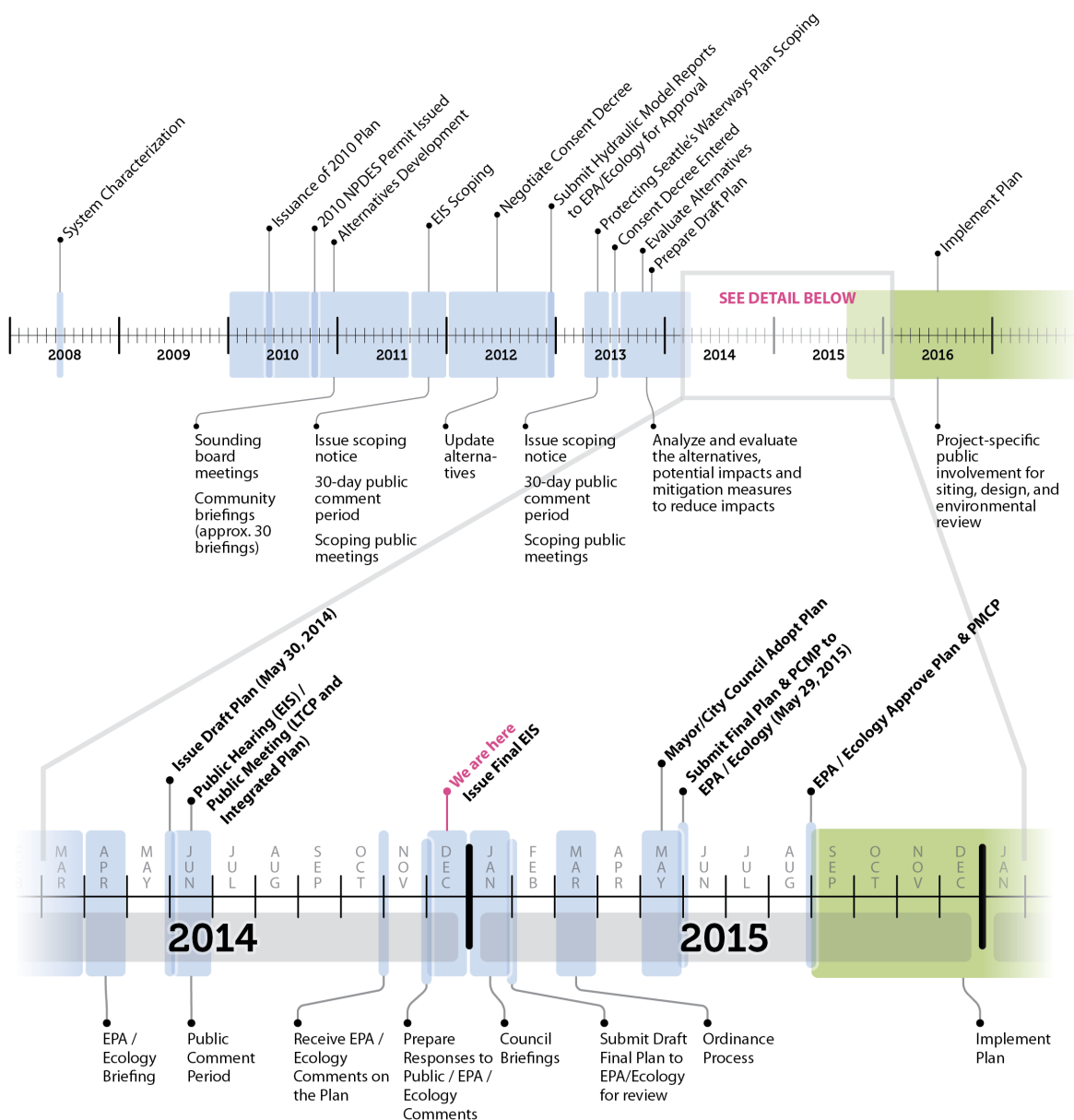
Foremost in the development of the Plan is the need to comply with the Consent Decree and meet federal and state regulatory requirements. In order to comply with the Consent Decree, the City must select and implement an LTCP option. All City LTCP options have elements that may impact King County's wastewater system. Interagency coordination will be conducted in accordance with the SPU and King County Wastewater Division Coordination Plan, in which the two entities agreed upon specific factors to be considered in evaluating and recommending which CSO projects would be undertaken jointly or independently by either SPU or King County. It is possible that the selected LTCP option may include a combination of options or facilities presented in the EIS. An Integrated Plan is an optional approach that is not required by EPA or Ecology, but can be used to satisfy the Consent Decree.

The Draft Plan for Protecting Seattle's Waterways, which consists of the following four volumes, was submitted to EPA and Ecology for review and comment on May 29, 2014:

- Volume 1: Executive Summary (SPU, 2014a)
- Volume 2: CSO Long Term Control Plan (SPU, 2014b)
- Volume 3: Integrated Plan (SPU, 2014c)
- Volume 4: Draft Programmatic EIS (SPU, 2014d)

Ecology submitted comments on the draft LTCP and Integrated Plan on August 21, 2014, and EPA submitted comments on the draft Plan on October 31, 2014. The City will work with EPA and Ecology to ensure their comments are addressed in the Final Plan.

Following the release of the Final EIS, the City will identify a recommended LTCP option and recommended Plan Alternative. The City also will continue to implement a public process and outreach to solicit input from the public and other stakeholders during the Plan adoption process. Throughout the spring of 2015, the City Council will review and hold Council hearings and meetings (open to the public) to discuss the Plan. After Plan adoption in May 2015, the Final Plan will be submitted to EPA and Ecology for approval. The Final Plan is anticipated to be approved by EPA and Ecology in late summer 2015, and Plan implementation would commence in late 2015 or early 2016.



1.3 Plan Alternatives and Updates

1.3.1 What changes have occurred since release of the Draft EIS?

Since the release of the Draft EIS, the City has been actively engaged in developing refinements to the planning, early design, and scheduling of the LTCP, and has continued to collaborate with King County on shared LTCP options under the LTCP Alternative. As a result of continued collaboration, one of the options under the LTCP Alternative – the Shared West Ship Canal Tunnel Option – has been modified to include flows from an additional King County CSO area (11th Avenue Northwest). In order to accommodate these additional flows, the diameter of the potential Shared West Ship Canal Tunnel has increased from 13 feet to 14 feet, but could increase to a range of 15 to 18 feet depending on future project design. A diameter of 14 feet was used as the basis for analysis in the Draft and Final EIS, however, a larger diameter tunnel (15 to 18 feet) would have the same type and similar magnitude of impacts as described in the Final EIS.

These changes would allow both the City and King County to be more cost-effective, produce better community outcomes, and minimize disruption to communities from implementing each agency's CSO control projects. Other changes since the Draft EIS are a result of continued modeling. These include a potential new flow diversion line from King County's 3rd Avenue West CSO area on the south side of the Ship Canal to the tunnel on the north side of the Ship Canal (under the Shared West Ship Canal Tunnel Option) and updates to a project included under the No Action Alternative (Henderson 49). These changes are further described in Section 1.1.6, and potential impacts of these changes are incorporated in the impacts summary discussions in Section 1.4 and Tables 1-3 and 1-4. These changes to the projects result in changes to impacts in transportation and land use.

As part of continued planning and feasibility studies, measures for reducing construction truck trips have been further defined in Ship Canal Neighborhoods, including options for barge and/or rail transport of equipment and materials. Information on these potential measures is included in Table 1-3, under Transportation.

Otherwise, all other aspects of the affected environment and potential impacts associated with implementing the Plan are as addressed in the Draft EIS. Some sections of the Draft EIS are included in this chapter, to provide context for the changes that have been made.

1.3.2 What is included in the LTCP Alternative?

Section 3.2 of the Draft EIS includes a detailed description of the LTCP Alternative, which is summarized below. The LTCP Alternative uses a combination of traditional storage facilities and sewer system improvements to reduce CSOs in 11 CSO areas throughout Seattle. For the purpose of this EIS, CSO areas within the City's service area have been grouped into what are referred to as "neighborhoods". In *Volume 2, LTCP* these are referred to as CSO areas only. Figure 1-1 illustrates the neighborhoods relative to designated CSO areas and outfalls. The LTCP also explores opportunities to partner with King County on collaborative projects to control both agencies' CSOs. These Plan area neighborhoods include:

- **Ship Canal Neighborhoods**—Ballard, Fremont/Wallingford, Magnolia;
- **Lake Washington Neighborhoods**—North Union Bay, Portage Bay, Montlake, and Leschi
- **Longfellow Creek/Duwamish Neighborhoods**—Delridge, Duwamish, and East Waterway; and
- **Elliott Bay/Lake Union Neighborhoods**—Central Waterfront.

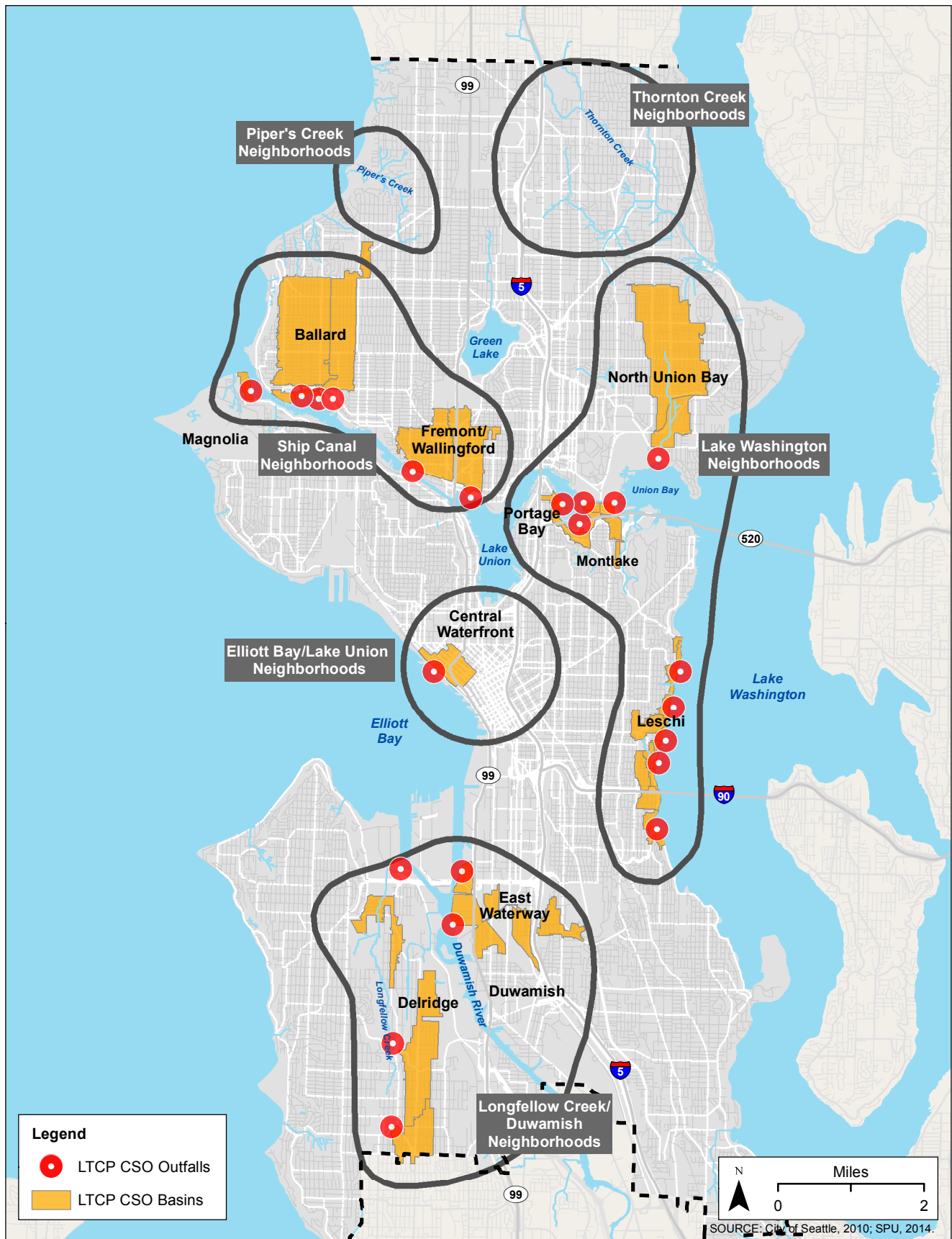


Figure 1-1 Plan Area Neighborhoods

1.3.3 What are the options for implementing the LTCP Alternative?

As described in Chapter 3 of the Draft EIS, there are four potential combinations of storage facilities, referred to as “options,” that could meet U.S. Environmental Protection Agency (EPA) requirements for an LTCP that are evaluated in this EIS. These options were developed under one of two basic concepts: the City meets its Consent Decree-mandated control requirements through implementation of independent (City only) control projects, or the City participates in one or more shared projects with King County to take advantage of potential cost/impact reduction opportunities. These options vary in terms of the number, size, and potential location of storage facilities considered. The four LTCP options are:

- Neighborhood Storage Option (City only implementation)
 - Neighborhood Tanks/Pipes
 - Neighborhood West Ship Canal Tunnel
- Shared Storage Option (Shared City/King County implementation)
- Shared West Ship Canal Tunnel Option (Shared City/King County implementation)
- Shared Ship Canal Tunnel Option (Shared City/King County implementation)

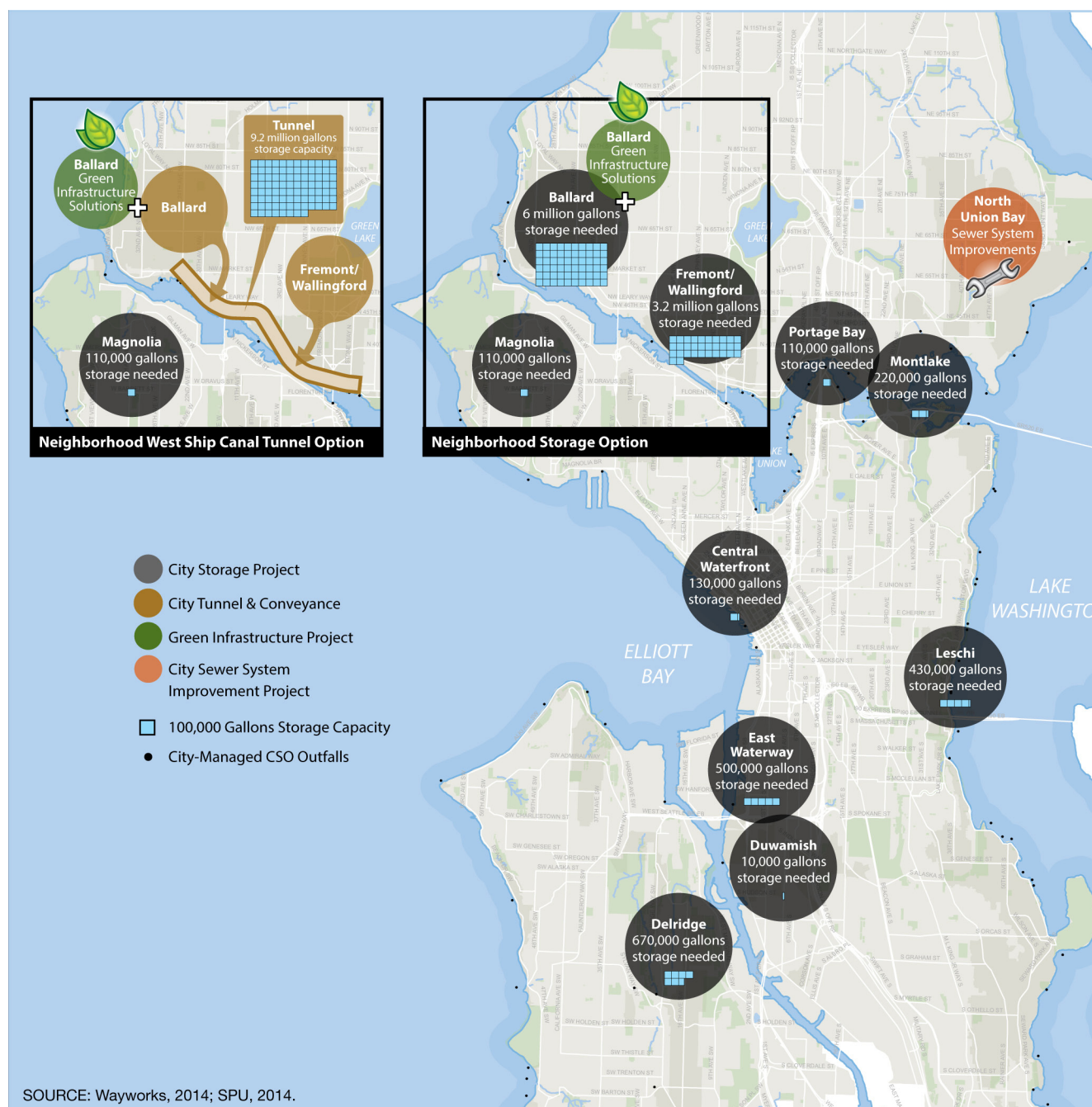


Figure 1-2. Neighborhood Storage Option

Under the **Neighborhood Storage Option**, the City would build underground storage facilities in Ballard, Fremont/Wallingford, Magnolia, Portage Bay, Montlake, Leschi, Central Waterfront, Duwamish, Delridge, and East Waterway CSO areas, and sewer system improvements in the North Union Bay CSO area. This option involves building the largest number of storage facilities throughout the city.

There are two variations in the Neighborhood Storage Option: one would provide storage in tanks/pipes only, and the other would include a tunnel (Neighborhood West Ship Canal Tunnel) in combination with tanks and pipes. The storage tank/pipe option involves the greatest number of affected locations. The Neighborhood West Ship Canal

Tunnel Option was developed because the two CSO areas with the largest storage volumes (Ballard and Fremont/Wallingford) are relatively close to one another. The Neighborhood West Ship Canal Tunnel Option likely reduces the number of facilities and neighborhood impacts.

Implementation of the North Union Bay sewer system improvements will require City coordination with King County because additional flows will be transferred to the King County system. Specifically, the City and King County will need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.

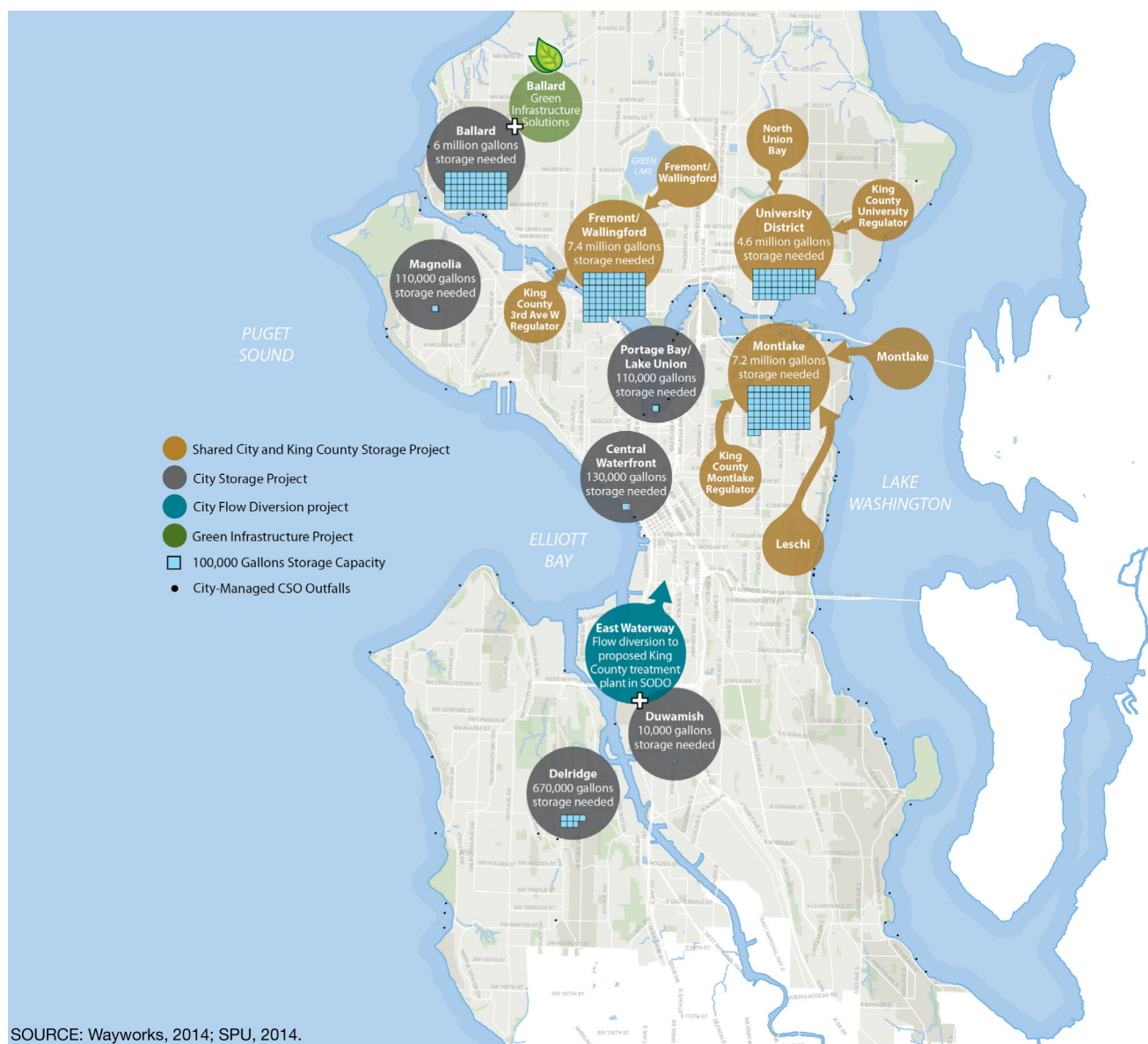


Figure 1-3. Shared Storage Option

Under the **Shared Storage Option**, the City and King County would jointly build larger but fewer storage tanks in three CSO areas: Fremont/Wallingford/King County 3rd Avenue West; North Union Bay/King County University Regulator; and Montlake/Leschi/King County Montlake Regulator. These three shared storage projects were recommended in the approved 2012 King County CSO plan. In the Duwamish CSO area, the City would divert flows to a treatment facility proposed by King County. All other CSO areas would have the same storage facilities as proposed under the Neighborhood Storage Option.

Prior to implementing any shared projects between the City and King County, a shared project agreement would need to be signed between the two agencies. Specifically, the City and King County would need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.

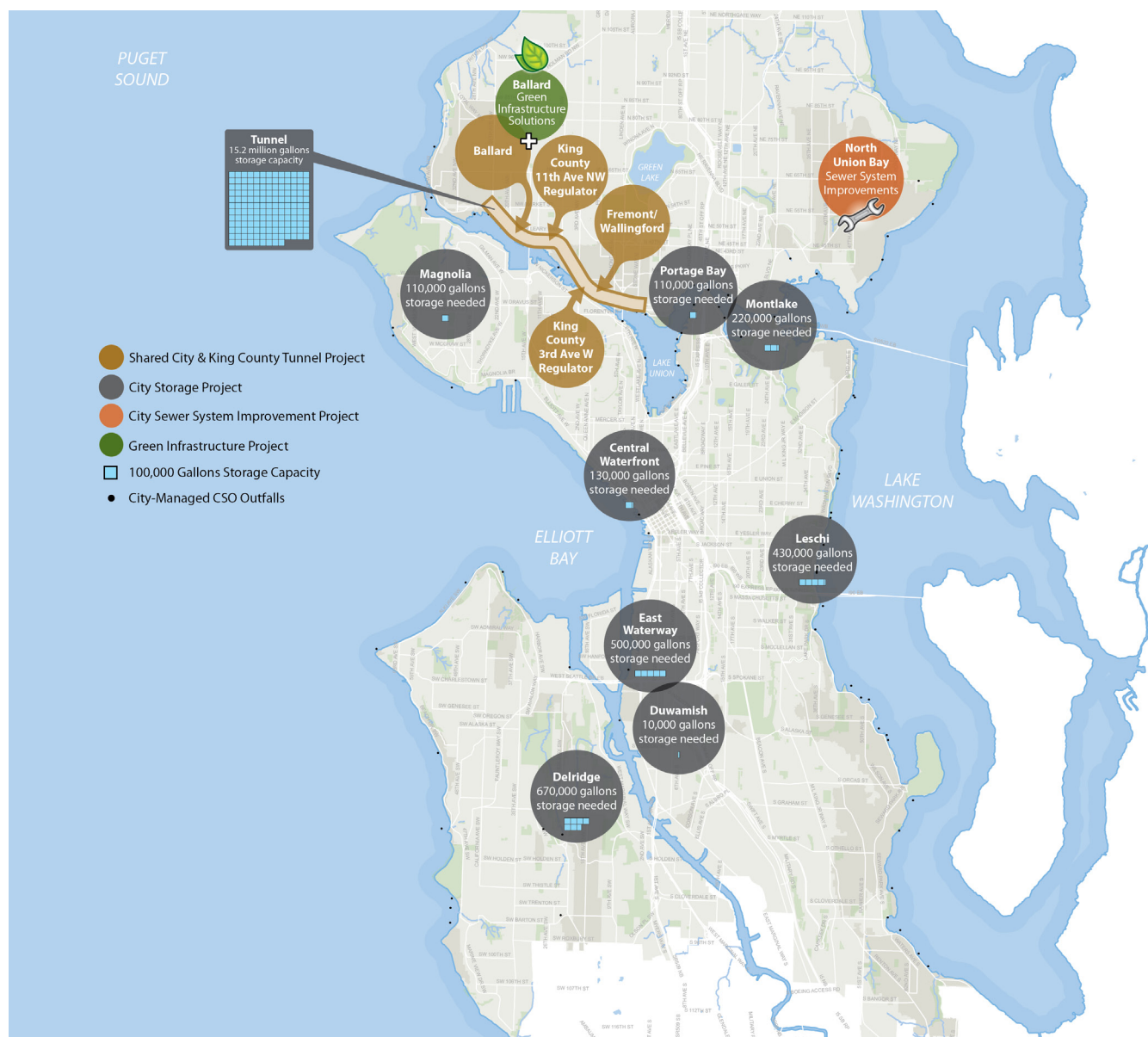
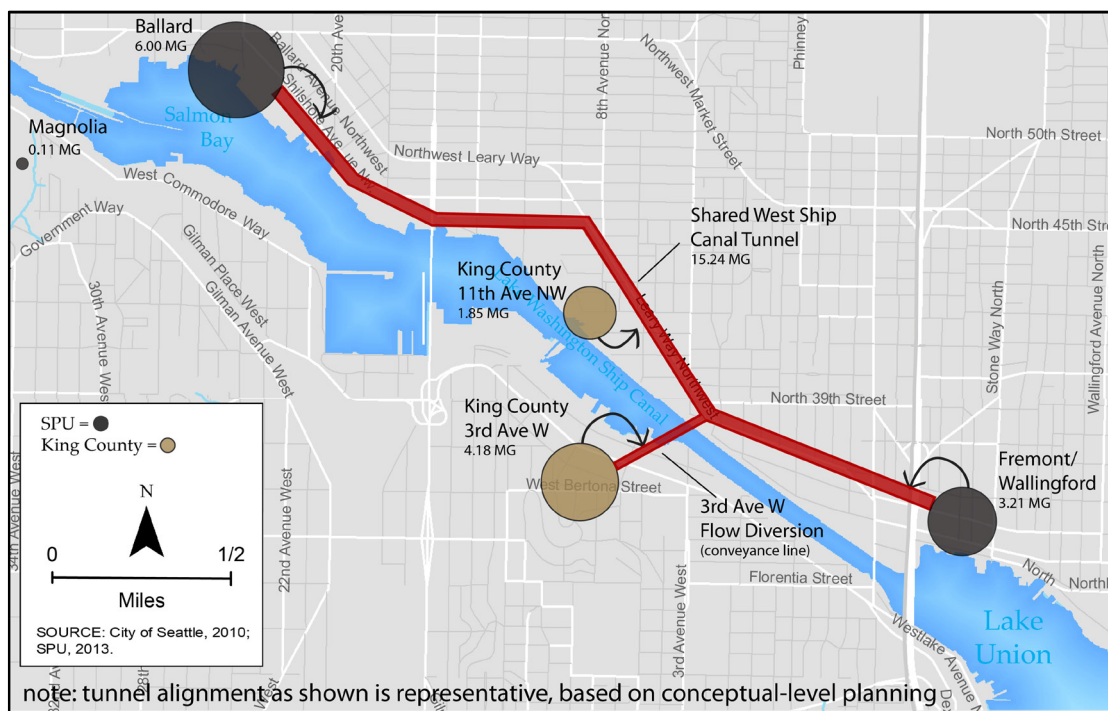


Figure 1-4. Shared West Ship Canal Tunnel Option

The **Shared West Ship Canal Tunnel Option** combines four of the largest CSO areas into a single deep tunnel. The West Ship Canal Tunnel is proposed as a shared option because the four CSO areas (two from the City and two from King County) with the largest control volumes are relatively close to one another. The tunnel would extend from Fremont/Wallingford to Ballard and would provide the storage needed to address sewage overflows in Ballard, Fremont/Wallingford, and King County's 3rd Avenue West and 11th Avenue Northwest CSO areas. The tunnel would replace the need for separate King County CSO projects at outfalls near 3rd Avenue West and 11th Avenue Northwest. Prior to implementing any shared projects between the City and King County, a shared project agreement would need to be signed between the two agencies as noted above. Within this option, the remaining CSO areas would be controlled by their respective neighborhood control measures.

What has changed since the Draft EIS?

Since the Draft EIS, the **Shared West Ship Canal Tunnel Option** has been modified to include flows from King County's 11th Avenue Northwest CSO area. These flows would be in addition to flows from King County's 3rd Avenue West CSO area, described in the Draft EIS. While the conceptual tunnel alignment described in the Draft EIS does not change with the addition of the 11th Avenue Northwest CSO area, a slightly larger diameter tunnel would be required to accommodate the additional flows (14 feet instead of 13 feet). The diameter could increase to a range of 15 to 18 feet, depending on final project design. Additional conveyance and connection components also would be required to accommodate the flows from both King County's 3rd Avenue West and 11th Avenue Northwest CSO areas. Conveyance to divert flow from near the 3rd Avenue West CSO site to the Shared West Ship Canal Tunnel would include a trenchless installation of a flow diversion line (conveyance line) from the south side of the Ship Canal to the tunnel on the north side of the Ship Canal. In addition, drop shafts would be needed to transfer flow from the 3rd Avenue West and 11th Avenue Northwest CSO areas to the tunnel. These two drop shafts would be in addition to the two drop shafts described in the Draft EIS for transferring Ballard and Fremont/Wallingford flows to the tunnel (to be located at the west and east tunnel portals). The 3rd Avenue West and 11th Avenue Northwest drop shafts would likely be offset from the tunnel to enable the structures to be constructed out of the road right-of-way to minimize impacts.



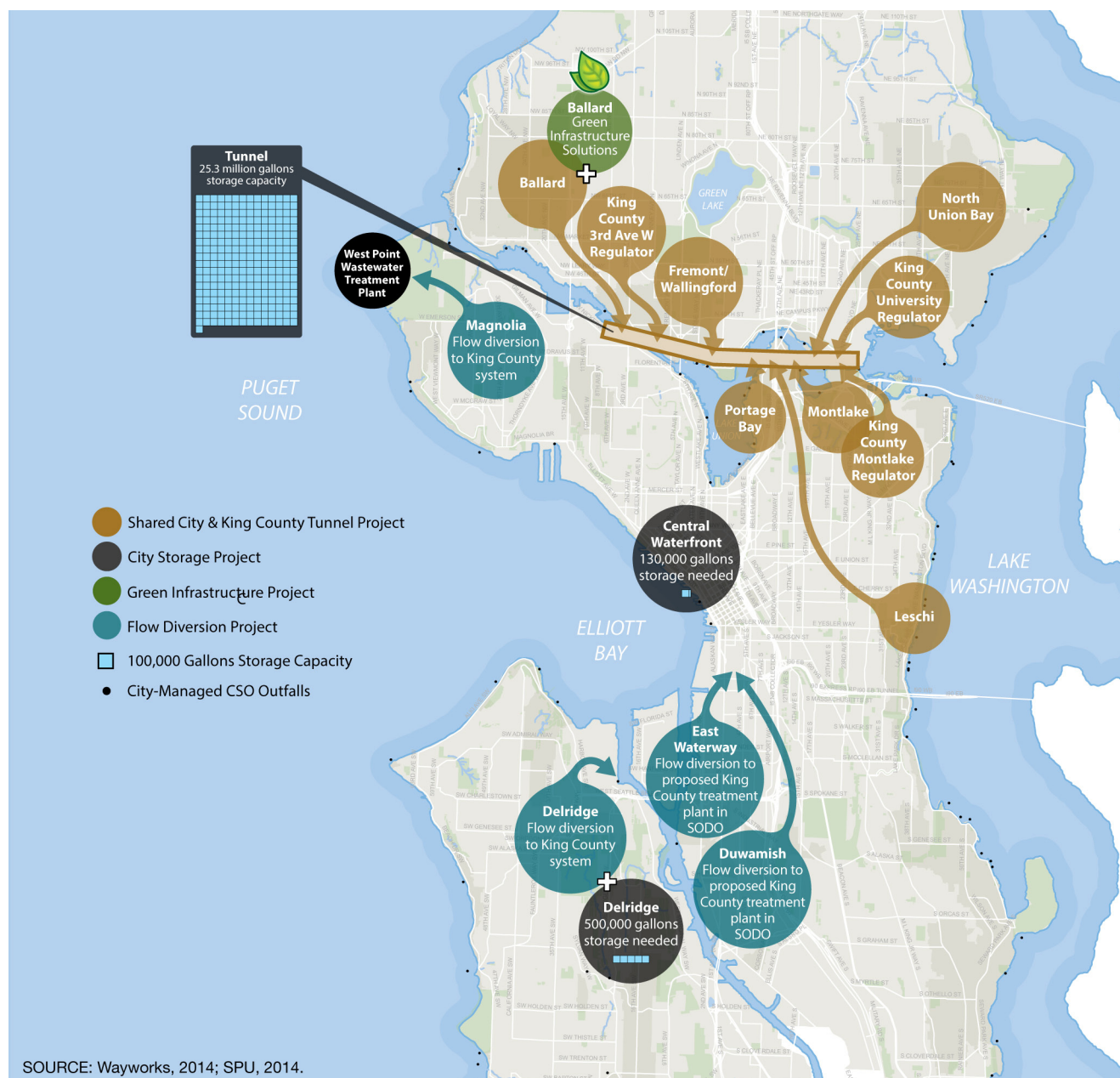


Figure 1-5. Shared Ship Canal Tunnel Option

The **Shared Ship Canal Tunnel Option** combines the control volumes from six City CSO areas along the Ship Canal and Lake Washington, and three of the largest King County CSO areas along the Ship Canal in a deep tunnel extending from the University District to Fremont/Wallingford. The tunnel would provide the storage needed to address sewage overflows in the City's CSO areas of Ballard, Fremont/Wallingford, Portage Bay, Montlake, North Union Bay, and Leschi. The tunnel would also replace the need for three separate King County CSO projects at outfalls near Pacific Street (University Regulator), Montlake Avenue (Montlake Regulator), and 3rd Avenue West.

The remaining City CSO areas (Magnolia, Duwamish, East Waterway, and the northernmost Delridge CSO basin) would be diverted to King County under the assumption that flow diversions could be incorporated into mutual

interagency agreements. Prior to implementing any shared projects between the City and King County, a shared project agreement would need to be signed between the two agencies as noted above. The Central Waterfront and the southern Delridge CSO neighborhoods would continue to be served by their respective neighborhood control measures.

Table 1-1 illustrates the total number of CSO storage facilities that would be constructed under the four LTCP options, either by City-only, King County-only, or as shared facilities. As shown in the table, the opportunity to construct shared facilities reduces the total number of facilities constructed by both the City and King County and reduces impacts to the neighborhoods slated for several major storage facilities. More detailed information can be found in *Volume 2, LTCP*.

Table 1-1. CSO Storage Facilities Constructed under LTCP Options					
	Neighborhood Storage		Shared West Ship Canal Tunnel	Shared Ship Canal Tunnel	Shared Storage
	Neighborhood Tanks/Pipes	Neighborhood West Ship Canal Tunnel			
City-only CSO Facilities	18	16	14	3	9
King County-only CSO Facilities ¹	9	9	7	6	6
Shared Facilities			1	1	3
TOTAL	27	25	22	10	18

¹King County-only CSO facilities are part of King County's LTCP, and not the City's LTCP

1.3.4 How will the City and King County coordinate on CSO projects?

The City recognizes the importance of strong coordination with King County in controlling CSOs in the City. All of the proposed LTCP options have elements which may have an impact on King County's downstream wastewater system. Three of the proposed LTCP options include shared City/King County projects along the Ship Canal. Several of the proposed LTCP options include sewer system improvements which will convey additional wastewater volume to the downstream King County system. Regardless of which LTCP option is selected, coordination between the City and King County is critical to successfully designing, constructing, and eventually operating the proposed CSO control projects in the City.

The City and King County are continuing to work together closely to analyze and recommend LTCP options that are more cost-effective, produce better community outcomes, and minimize disruptions. King County must also reach its own independent conclusions about the benefits of a shared project to the regional system, and the implications of such as project to its own Long Term Control Plan and Consent Decree. Selection of a shared City/King County project will be dependent on the City's and County's analytical results as well as a number of joint factors mutually agreed upon in a City/County Coordination Plan. These factors include such things as which agency will be responsible for the design/construction/operations of the shared facility, each agency's project cost-share, operational and implementation roles and responsibilities, the process for dispute resolution, and the ability to fulfil regulatory and contractual obligations. If the City and King County choose to implement a shared

City/King County project, then a shared project agreement between the two agencies will be necessary prior to designing and constructing the project. In addition, the City and King County will analyze the impacts of any recommended project on the downstream King County system and agree on an approach to addressing those impacts prior to constructing the project.

1.3.5 What is included in the Integrated Plan Alternative?

Under the Integrated Plan Alternative, the City would implement three stormwater control programs/projects in Seattle neighborhoods to address stormwater runoff in areas that are not part of the combined sewer system, using a combination of stormwater treatment technologies. These programs/projects include:

- Natural Drainage System (NDS) Partnering
- Arterial Street Sweeping Expansion
- South Park Water Quality Facility

These three programs/projects would collectively reduce stormwater pollutant loads discharging into the following waterways: Duwamish Waterway, Lake Washington, Piper's Creek, Thornton Creek, Longfellow Creek, and Lake Union/Ship Canal. The City is focusing stormwater control projects in these areas to meet the Integrated Plan objectives established by the Consent Decree.

Under the Integrated Plan Alternative, the City would still build CSO reduction projects using one of the four LTCP options outlined above. However, the City would delay the completion of some of the CSO control projects until after 2025, to allow earlier completion of high-benefit stormwater treatment technology projects. Six CSO projects to control discharges into the lower Duwamish, Portage Bay and Ship Canal waterways would be delayed until after 2025. In keeping with the Consent Decree, the three stormwater control programs/projects would provide significant benefits to water quality beyond those that would be achieved by implementing the CSO control projects alone. Figure 1-6 shows the proposed stormwater control programs/project locations and the CSO control projects that would be deferred under this alternative.

The stormwater control programs/projects are summarized below. Comments from EPA and Ecology will be addressed in the final Integrated Plan, which will be submitted to EPA and Ecology following adoption by the City Council.

1.3.5.1 NDS Partnering

Natural Drainage System (NDS) Partnering, a flow control and stormwater treatment best management practice (BMP), involves using natural drainage systems, such as engineered rain gardens within various basins that drain to Piper's, Thornton, and Longfellow Creeks. Piper's Creek ultimately discharges to Puget Sound; Thornton Creek discharges to Lake Washington; and Longfellow Creek discharges to the Duwamish River and then into Puget Sound.

Projects implemented under this program would involve reconstructing City rights-of-way to manage flow and provide water quality treatment for polluted urban runoff, primarily using bioretention facilities such as engineered rain gardens. Project locations would be identified by site factors and a community-nomination process. Projects would be designed to infiltrate into native soil where appropriate. Where complete reliance on infiltration is not technically feasible, systems would be augmented with underdrains.

Project locations would be prioritized based on stormwater management goals; however, community partnering goals (mobility, traffic calming, and beautification) would also be accomplished as a secondary benefit. As a first step to NDS Partnering, the City would develop a program for encouraging residents or community groups to nominate their block(s) as a candidate for NDS. Candidate blocks must be among the blocks identified by the City as potentially feasible for bioretention; the majority of these blocks are part of informal drainage systems (i.e., lacking curbs and gutters). If the Integrated Plan Alternative is selected, NDS Partnering would be implemented in multiple phases.

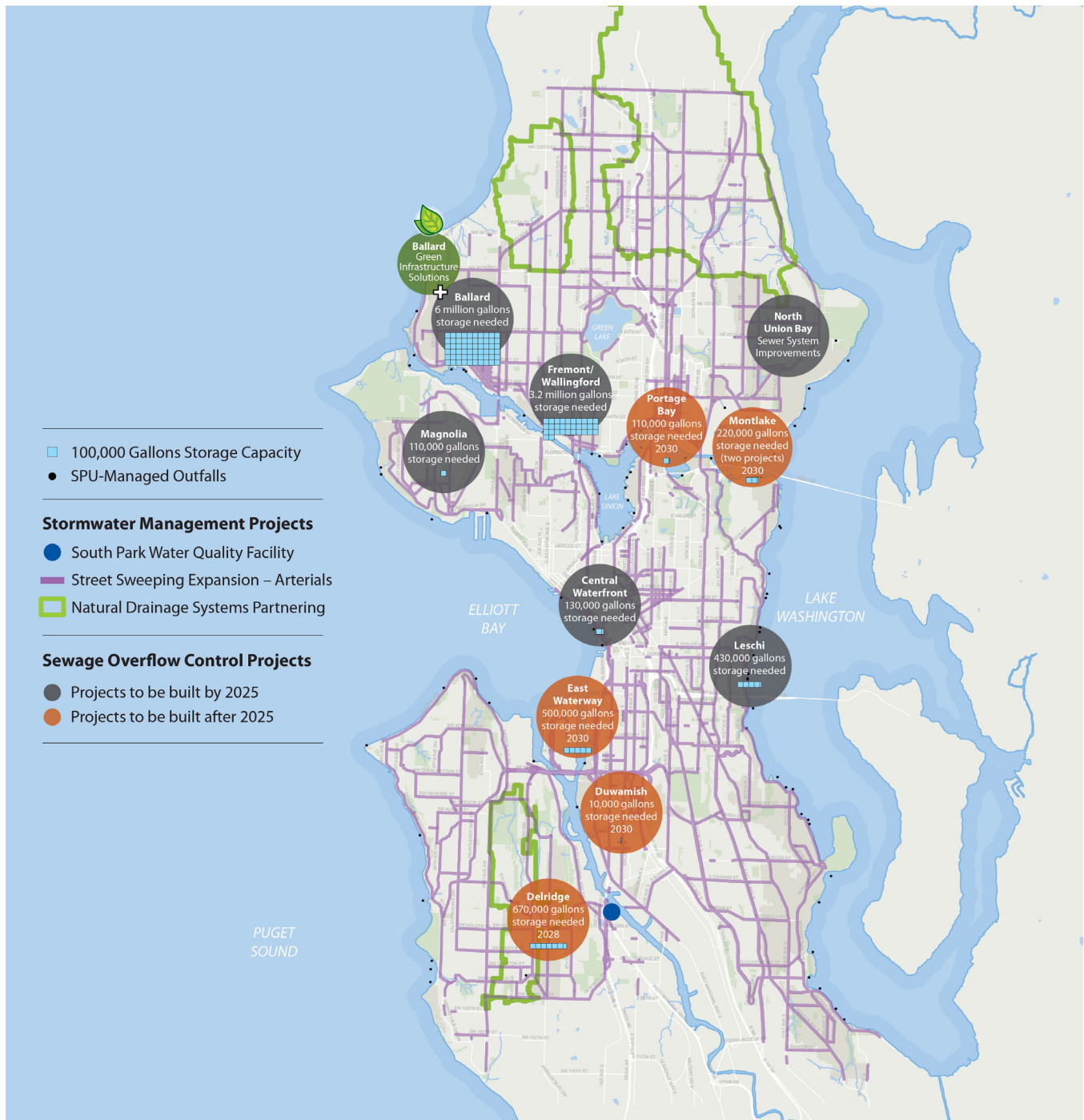


Figure 1-6. Integrated Plan Alternative

1.3.5.2 Arterial Street Sweeping Expansion (Weekly Arterial Sweeping)

Street sweeping, a source control BMP, removes pollutants from roadways before they wash off into sewers and local waterways.

The City would expand its existing arterial street sweeping programs by adding new routes, increasing the frequency of sweeps, and employing new technologies. The arterial sweeping project would be expandable and adaptable to meet future needs.

The proposed program expansion would:

- Increase the route coverage from 83 to approximately 85 percent of curbed arterials (for a total 10,600 annual curb-miles), by adding one route, for a total of 25 routes.
- Increase the sweeping season from 40 to 48 weeks per year.
- Increase the sweeping frequency from biweekly to weekly for some routes: 21 routes will be swept on a weekly basis and four routes will be swept on a biweekly basis.

Because most existing development and roadways in the city were constructed before stormwater controls were required, runoff from many areas discharges directly to receiving waters without treatment. Retrofitting these existing systems to improve stormwater quality is often difficult and in many cases, retrofitting is not feasible due to physical site constraints (e.g., utility conflicts, grade restrictions, and tidal influence). Street sweeping can provide effective pollutant load reductions in areas where retrofitting is impractical.

1.3.5.3 South Park Water Quality Facility

The South Park Water Quality Facility would treat stormwater prior to discharge into the Duwamish Waterway. The end-of-pipe facility would treat approximately 89 million gallons (MG) of stormwater runoff from the 7th Avenue South drainage system, which encompasses approximately 250 acres. The City identified the South Park location as a high priority for stormwater pollutant reduction because of the sensitivity of the Duwamish Waterway. The facility would be built in the same location as a new stormwater pump station the City plans to build to reduce flooding in this same area, creating an opportunity to leverage water quality and flood control projects.

Stormwater would be routed through a basic, active treatment system, such as chitosan-enhanced sand filtration (CESF), prior to discharge to the Lower Duwamish Waterway through an existing outfall.

1.3.6 What is included in the No Action Alternative?

Under the No Action Alternative, substantial progress will be made in controlling CSOs through implementation of previously planned CSO control projects. These projects include those identified in the City's wastewater NPDES Permit (WA0031682), those identified in the 2010-2015 Implementation Plan for the *2010 CSO Reduction Plan Amendment* (2010 Plan Amendment), and 'Early Action' projects identified by Consent Decree in the Henderson CSO basin. These projects are scheduled for implementation, and they will occur regardless of whether the Plan is implemented. Many of these projects have already undergone project-level evaluations in accordance with the City's Environmental Policies and Procedures (SMC 25.05). Others will undergo project-level evaluations as planning progresses.

The City would also continue to implement a portion of two of its CSO reduction strategies, combined sewer system improvements and natural drainage systems (referred to as green infrastructure in the LTCP). However,

the City would not implement any additional CSO reduction or stormwater control projects beyond those that are currently slated for implementation.

Combined sewer system improvements and natural drainage systems alone will not be sufficient to reduce the volume and frequency of CSOs to meet federal and state regulations. If the City does not make additional improvements in the remaining uncontrolled basins addressed by the Plan, untreated sewage and stormwater in excess of current regulations would continue to be illegally discharged into Lake Washington, the Lake Washington Ship Canal, the Duwamish River, and Puget Sound when the capacity of the existing combined sewer systems is exceeded. Under the No Action Alternative, the City would not be in compliance with the Consent Decree.

Previously, a flow diversion project was planned for Henderson South CSO Basin 49 (Henderson 49). Based upon the results of additional modeling, the estimated total control volume to control Henderson 49 is significantly higher than modeling previously estimated. As a result, a storage project has now been identified for Henderson 49. The project includes a storage facility with a volume of up to 0.83 million gallons, which is planned for a City-owned property on Rainier Avenue at the site of an abandoned City wastewater facility. CSO flow stored in the storage facility will be conveyed to an adjacent King County interceptor after a CSO event. This project is now considered as part of the 2010 Plan Amendment Projects and not an 'Early Action' project as described in the Draft EIS. The schedule for completion has also changed from what was described in the Draft EIS. Construction of the storage project is now anticipated to be complete in 2023 instead of 2018 as described in the Draft EIS.

The current and ongoing combined sewer system improvements, natural drainage, and storage projects included in the No Action Alternative are described in more detail in Section 3.1 of the Draft EIS. Locations of No Action projects are shown on Figure 1-7.

FILE NAME: Fig03-01_NoActionAlternative_SharedStorageOption.ai / CREATED BY: JAC / DATE LAST UPDATED: 04/23/14

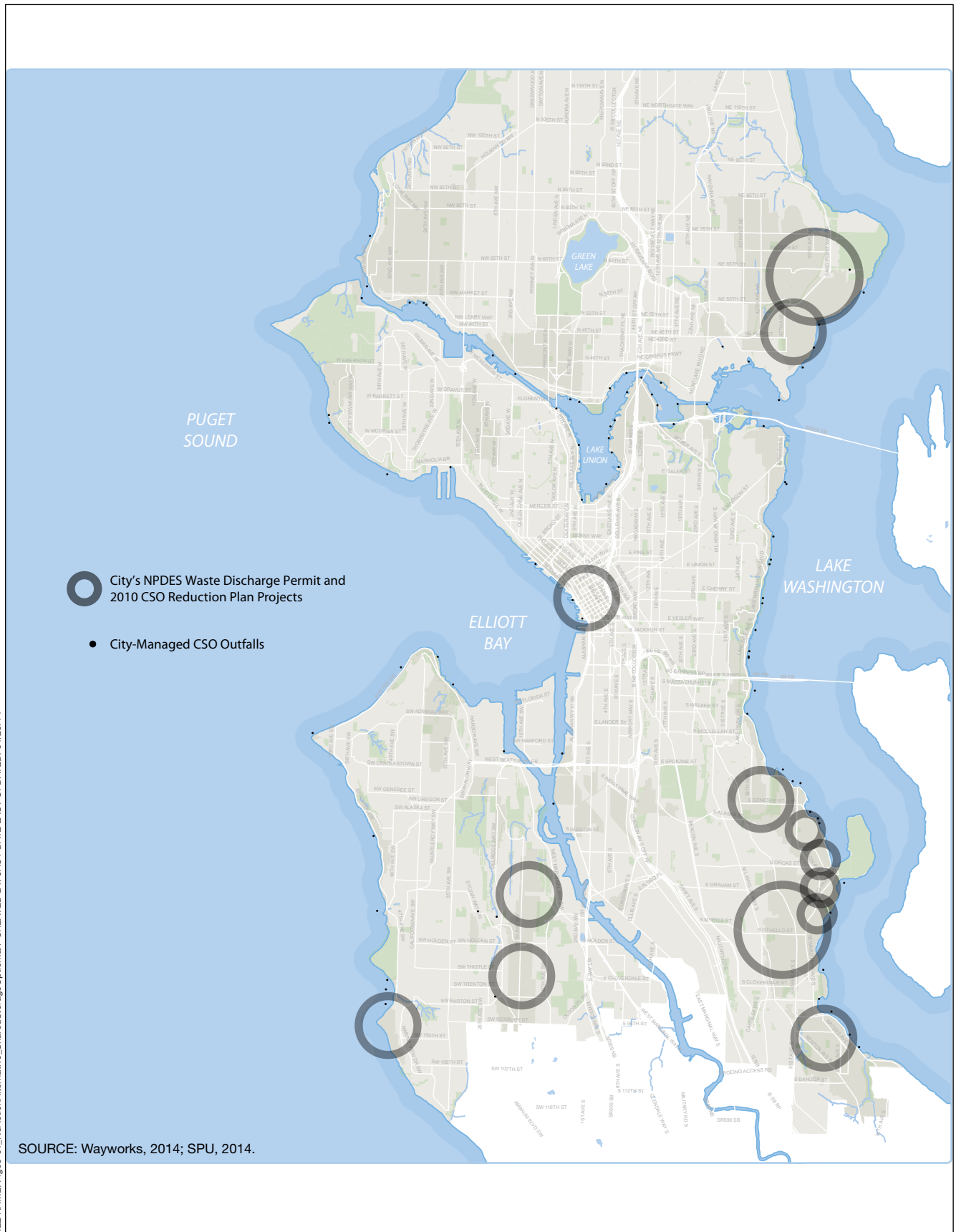


Figure 1-7. No Action Alternative Project Locations.

Table 1-2. No Action Alternative Storage Projects		
CSO Basin/ Basin #	Project Description	Estimated Completion Date
Windermere		
13	Storage tank in Magnusson Park	2015
Genesee		
40/41	Storage tank at 49th Avenue South and Lake Washington Boulevard	2015
43	Storage tank at 53rd Avenue South and Lake Washington Boulevard	2015
Central Waterfront		
70, 71, 72	Increased conveyance to King County Elliott Bay Interceptor and storage	2018-2020
Henderson North		
44, 45	Storage tank in Seward Park	2018
Henderson South		
46, 47, 171	Flow diversion project	2015
49		2025

1.4 Impacts and Mitigation

This section provides a summary of impacts and the measures the City would take to help reduce or minimize potential impacts associated with the LTCP, Integrated Plan, and No Action Alternatives. These impacts and measures are described in detail in the Draft EIS, which also describes the basis for analysis of impacts. Additional discussion of impacts is provided in the Final EIS for changes that have occurred since the Draft EIS issuance (see Section 1.3.1, “*What changes have occurred since release of the Draft EIS?*”).

The LTCP options include projects that would be implemented by the City independently, as well as projects that would be implemented jointly with King County. In addition to these options, King County is considering projects that would be implemented independently from the City. This EIS identifies those independent King County projects, but does not analyze them. As described below under “*How do cumulative impacts compare among alternatives?*”, constructing independent King County projects would add to overall cumulative impacts associated with the LTCP and Integrated Plan Alternatives.

This EIS programmatically addresses the impacts from independent City and shared City/King County projects. King County will address its independent projects separately, in accordance with its SEPA requirements. All projects implemented by both the City and King County will receive the appropriate project-level evaluation under SEPA.

1.4.1 What are the potential construction impacts?

Table 1-3 summarizes the identified potential construction impacts, as well as measures that the City would take to help reduce or minimize potential impacts associated with the LTCP, Integrated Plan, and No Action Alternatives. Those components that do not involve construction, such as street sweeping, are not included in the discussion.

The identified potential construction impacts remain largely unchanged from what was described in the Draft EIS. The changes described for the Shared West Ship Canal Tunnel Option and the updates to the No Action Alternative do not modify the primary characteristics of the Plan alternatives evaluated in the Draft EIS. Impacts of the revised Shared West Ship Canal Tunnel Option are of similar magnitude to the impacts identified in the Draft EIS and are within the range of impacts of other alternatives evaluated in the Draft EIS; none result in different conclusions with regard to significance of the impacts. The updates to the No Action Alternative modify the characteristics of one CSO control project, but do not modify the primary characteristics and impacts of this alternative. The changes would not change the analysis of impacts presented in the Draft EIS.

1.4.2 What are the potential long term effects?

Table 1-4 summarizes the identified potential long term, operational impacts associated with the LTCP, Integrated Plan, and No Action Alternatives, as well as measures that the City would take to help reduce or minimize potential impacts.

As described above, this EIS addresses the impacts from City projects constructed independently or jointly with King County. Independent King County projects will be addressed by the County, in accordance with their SEPA requirements.

The identified potential operational impacts remain largely unchanged from what was described in the Draft EIS. Impacts resulting from the revised Shared West Ship Canal Tunnel Option and the updated No Action Alternative are of the same or similar magnitude to the impacts identified in the Draft EIS; none result in different conclusions with regard to significance of the impacts. The changes would not change the analysis of impacts presented in the Draft EIS.

1.4.3 Are there significant impacts that cannot be mitigated?

Implementation of the Plan would involve a wide range of short term impacts associated with the construction of numerous large infrastructure projects. Depending upon the size, location, and type of project, these impacts would include potentially substantial traffic impacts, including temporary road closures and traffic detours. Other construction-related impacts of potential significance include increases in noise and dust that could last from approximately one to seven years and potential disruptions of access to business, residential, or recreational facilities. These impacts, however, are expected to be reduced by compliance with all applicable regulations and permit requirements and as such would not be considered significant impacts under SEPA.

There are no significant long term or operational impacts associated with implementation of the Plan alternatives that cannot be mitigated. Implementation of the No Action Alternative would result in potentially significant long term adverse impacts to water quality and aquatic habitat in the Plan area, as well as non-compliance with the Consent Decree.

1.4.4 Are there areas of controversy?

As with all major infrastructure projects, there are difficult decisions associated with implementation of the Plan. Compliance with the federal Consent Decree (between the City, U.S. Department of Justice, EPA, and Ecology) will require a significant commitment of funding to construct major water quality control projects and programs. There may be concern that the commitment of funding for these projects would limit the City's ability to fund other water and non-water quality projects. The Consent Decree includes a date of 2025 for completion of the LTCP, which limits the City's flexibility in compliance with this legal requirement. However, there are likely to be questions from stakeholders about the LTCP and the Integrated Plan regarding prioritization of projects, tradeoffs, and coordination with other CSO and/or water quality managers in the region, particularly King County. The timing of project implementation is a potential concern, and a wide range of viewpoints can be expected. Deferral of six CSO control projects in the Duwamish, Portage Bay, and Ship Canal waterways may be controversial with some stakeholders.

Construction of storage projects in a highly developed city where limited undeveloped land is available will result in difficult siting decisions that could require short term or permanent impacts to existing land uses, including the potential for impacts to parks or recreational facilities, private properties, or community facilities. Construction-related traffic impacts will be of considerable concern to affected residents, business owners, travelers, and commuters. Depending upon the alternative implemented, some neighborhoods that have been the locations for previous major construction projects would experience construction-related impacts. The City will follow its policies regarding the siting of underground storage facilities, which gives preference for City-owned or other public property and rights of way, but there will likely be controversy as individual sites are identified.

1.4.5 How do cumulative impacts compare among the alternatives?

Cumulative impacts are those that could result from the combination of individual effects of multiple actions (projects) over time. Plan elements could be constructed in areas that may have recently been subject to large-scale construction projects or will be subject to construction of future planned projects. In addition, there is a potential for construction resulting from Plan implementation to coincide with the construction of other projects.

Other projects that could occur in the same neighborhoods or coincide with implementation of the LTCP include CSO control projects being constructed by the City and King County. King County's 2012 CSO Control Plan identifies several CSO control projects that would be located within LTCP neighborhoods, including one each in the North Union Bay, Montlake, and Fremont/Wallingford neighborhoods and five in the Longfellow Creek/Duwamish Neighborhoods. Other major construction projects that could be under construction simultaneously with LTCP CSO control projects include the Sound Transit U-Link Extension (to be completed in 2016), Lynnwood Link Extension (construction in 2018-2023), East Link Extension (construction in 2015-2021), Waterfront Project (Elliott Bay Seawall and Waterfront Seattle Core projects), the Alaskan Way Viaduct Replacement Project, WSDOT's SR-509 and SR-167 project, Colman Ferry Dock Replacement, Denny Way Substation and other new or expanded Seattle City Light substations throughout the City, City of Seattle capital projects, and roadway and transit improvements. These projects, in addition to numerous large-scale private developments located throughout the Plan area, will likely result in cumulative impacts to traffic, noise and dust that will present inconveniences and varying levels of annoyance to the local population.

In terms of the LTCP options, the **Neighborhood Storage Option** has the potential for construction-related cumulative impacts that would affect the broadest area, because it involves construction of the largest number of storage tanks and storage pipes in neighborhoods throughout the city. While many of these projects would be

constructed within public rights-of-way, there would be construction-related traffic, road closures and/or traffic constraints, dust, odor, and other short term impacts that would last between one and five years. Many of these neighborhoods have been the location of major construction projects such as the SR 520 bridge, major roadway renovations, and large scale residential/commercial building, creating a high level of “construction fatigue”. In addition to the projects constructed by the City, King County would construct additional storage tanks and storage pipes in the Fremont/Wallingford, Montlake, and North Union Bay neighborhoods, adding to the construction-related impacts in those neighborhoods, including potential impacts to earth, air, noise, surface water, biological resources, land use, and transportation. This option would result in the highest potential for cumulative impacts resulting from construction of City and King County CSO projects.

The **Shared Storage Option** would affect fewer neighborhoods than the Neighborhood Storage Option because certain CSO control projects would be shared by the City and King County. The potential for cumulative impacts would be the same as under the Neighborhood Storage Option for the Longfellow Creek/Duwamish and Elliott Bay/Lake Union neighborhoods, but would be lower for the Fremont/Wallingford and Lake Washington neighborhoods because of the overall lower number of projects between the City and King County in those neighborhoods.

The **Shared West Ship Canal Tunnel Option** would have a lower potential for construction-related cumulative impacts than both the Neighborhood Storage Option and the Shared Storage Option in terms of neighborhoods affected by storage facility construction. This option would replace two independent City CSO control projects in the Ballard and Fremont/Wallingford areas, and two independent King County CSO control projects at 3rd Avenue West in the Queen Anne area and 11th Avenue Northwest in Fremont with a single, large tunnel. It would reduce impacts to these neighborhoods associated with construction of separate CSO storage facilities, but it would require a longer duration construction period (3.5 years or more) and would create potentially more intense impacts at the tunnel launch portal, likely located along the Ship Canal in Ballard. Impacts would be experienced to a lesser extent at the recovery portal and drop shafts for King County 3rd Avenue West and 11th Avenue Northwest CSO areas, which would likely be located in or near the Fremont neighborhood. In addition, a new flow diversion (conveyance line) would introduce construction impacts near the 3rd Avenue West CSO area on the south side of the Ship Canal. As under the Neighborhood Storage Option, both the City and King County would be pursuing multiple storage projects in the Longfellow Creek/Duwamish neighborhoods.

The **Shared Ship Canal Tunnel Option** would have the lowest potential for construction-related cumulative impacts in terms of neighborhoods affected, because it would substantially reduce the number of storage facilities located throughout the city constructed by the City and King County. However, impacts would be concentrated for up to seven years at the portals. The tunnel launch portal would likely be located on the south side of the Ship Canal and the recovery portal would likely be located in the North Union Bay neighborhood. These neighborhoods have had, or will have, several large-scale projects constructed in recent years, including the renovation of Husky Stadium, Sound Transit U-Link Extension, and the SR 520 project, and have expressed concerns about additional large scale construction in their neighborhoods.

Implementing the **Integrated Plan Alternative** would not represent a substantive increase in cumulative impacts. The expansion of street sweeping on City arterials would not affect overnight parking and NDS Partnering would have minimal short-term construction-related and long-term impacts. Construction of the South Park Water Quality Facility would not result in extensive construction-related impacts. The facility is expected to be sited in an area with compatible land use, with a low potential to cause long term changes in use. Under the Integrated Plan Alternative, construction of LTCP projects would be delayed in some neighborhoods, potentially resulting in reduced or increased cumulative impacts depending on the neighborhood and project schedules.

The City would coordinate construction sequencing with other major planned projects to minimize the potential for cumulative impacts, but it is likely that some level of cumulative impact is unavoidable. Given the number of proposed projects throughout the City, it will be difficult to avoid overlapping with other construction projects in some areas. Close coordination with King County will be particularly key for all options to coordinate construction schedules. In addition, it will be important to coordinate with Seattle Department of Transportation (SDOT), Washington Department of Transportation (WSDOT), and other major utilities in the area.

Impacts of independent King County CSO control projects will be evaluated separately by King County in accordance with their SEPA requirements.

Tables 1-3 and 1-4 respectively summarize the construction and operation impacts associated with the LTCP, Integrated Plan, and No Action Alternatives. Impacts are summarized for City projects or projects shared by the City and King County; King County will evaluate impacts associated with their proposed facility in accordance with SEPA, as appropriate. These impacts and the basis for conclusions are described in detail in the Draft EIS.

Table 1-3. Summary of Construction Impacts

Earth and Groundwater		
Long Term Control Plan Alternative	Key Findings	Construction activities and equipment have the potential to cause temporary impacts to earth and groundwater during construction of major projects involving substantial excavation, trenching, or tunneling and removal of large quantities of soil. Any areas that are disturbed during construction would be subject to increased erosion, and control measures would be required. Ground settlement from dewatering could cause settlement of nearby structures, roadways, and utilities. Vibration associated with tunneling operations could result in soil settlement along tunneling alignments. The primary differences in potential effects of the LTCP options are related to the amount of surface disturbance and excavation potentially required.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> Overall, this option has the second highest amount of surface disturbance for construction. Any areas that are disturbed during construction would be subject to increased erosion, and control measures would be required. Storage tanks constructed in the Ballard, Fremont/Wallingford, and East Waterway neighborhoods would require the most surface disturbance. Storage pipes in the Leschi and Delridge neighborhoods might be constructed near steep slopes and known or potential landslide-prone areas. Projects near these zones would be at heightened risk for erosion and slope instability Ground settlement from dewatering could cause settlement of nearby structures, roadways, and utilities. Most projects would require significant dewatering. Impacts would be most dispersed under this option, which would result in the highest number of storage facilities constructed independently by the City. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)
	Shared Storage Option	This option would have the highest amount of surface disturbance for construction and second highest amount of excavation. However, the shared tanks would reduce the number of City and King County independently constructed CSO control facilities. Impacts would be similar to the Neighborhood Storage Option but would be concentrated in fewer locations. Larger shared storage facilities in Fremont/Wallingford, North Union Bay, and Montlake would require greater amounts of excavation and soil disposal. Construction of the shared storage tank in North Union Bay has increased potential to encounter organic or liquefiable soils, and dewatering has the potential to encounter contaminated groundwater or result in settlement of nearby structures due to the presence of historic landfill deposits and natural organic deposits.
	Shared West Ship Canal Tunnel Option	Construction of tunnel portals and movement of the tunnel boring machine could result in vibration and settling. The location of the portals, drop shafts, conveyance lines, and tunnel near liquefiable soils in Fremont, Ballard, and the south side of the Ship Canal could result in soil settling. Geotechnical exploration and testing would be conducted during future project design to identify potential hazards along the tunnel alignment. Impacts from projects in the Lake Washington, Longfellow Creek/Duwamish, and Elliott Bay Neighborhoods would be similar to the Neighborhood Storage Option. Overall impacts would be reduced under this option compared to the Neighborhood Storage Option because the shared tunnel would reduce the number of City and King County independently constructed CSO control facilities.

Table 1-3. Summary of Construction Impacts

	Shared Ship Canal Tunnel Option	This option would have the highest amount of excavation and earthwork. The longer tunnel would require additional geotechnical exploration and testing during future project design, and has a greater potential to encounter earth hazards and to result in vibration and settling than the Shared West Ship Canal Tunnel because of its greater length. Impacts from projects in the Longfellow Creek/Duwamish and Elliott Bay Neighborhoods would be similar to the Neighborhood Storage Option. The geographic extent of impacts would be reduced the most under this option because the shared tunnel would result in the fewest number of City and King County independently constructed CSO control facilities.
Integrated Plan Alternative		Construction of storage pipes, tanks, and tunnels under the Integrated Plan Alternative would have the same impacts as under the LTCP Alternative, but construction would be delayed in some neighborhoods. In addition, minor construction-related impacts associated with construction of the South Park Water Quality Facility and its proximity to the Duwamish River would be a potential concern during construction. Depending on the specific site location, the soils at the site location may be susceptible to liquefaction and compaction. The City would take appropriate engineering measures to account for these hazards. Street sweeping does not involve construction, and would therefore not result in any short-term impacts. Impacts associated with NDS Partnering would be localized and of short duration, with limited footprint and depth. Individual NDS Partnering projects would be evaluated with respect to geological hazards, would be relatively small in size, and would be conducted with appropriate erosion control measures in place.
No Action Alternative		Projects constructed under ongoing sewer system improvement and NDS programs would generally have a limited footprint and depth, and are unlikely to result in substantial erosion or dewatering. Impacts associated with storage facilities associated with currently planned projects are evaluated in their respective site-specific SEPA evaluations.
Measures to reduce or minimize potential impacts		The City would: • Avoid construction on steep slopes, known and potential landslide zones, and areas with organic or liquefiable soils, where feasible. • Use appropriate shoring during construction. • Use erosion and runoff control measures, including retention of vegetation, replanting, ground cover, etc. • Comply with relevant federal, state, and local critical areas and groundwater requirements. • Dispose of soils at approved disposal sites. • Monitor settlement during dewatering and tunnel construction as appropriate.

Table 1-3. Summary of Construction Impacts

Air Quality		
Long Term Control Plan Alternative	Key Findings	Construction would not have a significant effect on air quality in the Seattle area, but may result in moderate localized impacts during the construction periods, largely related to vehicle emissions and dust. The primary differences in potential air quality and odor effects of the LTCP options are related to the length of construction period and estimated number of truck trips.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> This option has the most individual project locations. As a result, this option would have dispersed short term construction-related air and odor impacts in numerous neighborhoods throughout the city, with impacts likely to be most noticeable in residential areas. Storage tank construction in the largely residential Ballard and Fremont/Wallingford neighborhoods could last up to five years (Ballard) and 3.5 years (Fremont/Wallingford). Multiple storage pipes/tanks would be constructed in residential areas of Leschi. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)
	Shared Storage Option	Air quality impacts would occur at fewer sites than under the Neighborhood Storage Option. However, construction-related air quality impacts (largely vehicle emissions and dust) would occur for longer construction durations at the shared storage facility locations in Fremont/Wallingford, North Union Bay, and Montlake. Overall impacts would be reduced under this option because the shared tanks reduce the number of City and King County independently constructed CSO control facilities.
	Shared West Ship Canal Tunnel Option	Construction-related air quality impacts would occur at fewer sites than under the Neighborhood Storage and Shared Storage Options. However, impacts would be concentrated in fewer areas (Ship Canal Neighborhoods). Construction of the tunnel would require a substantially higher number of truck trips and associated emissions than smaller, independently constructed CSO control facilities in Ballard and Fremont/Wallingford, resulting in more concentrated and longer duration impacts at the tunnel portal sites in these neighborhoods. Overall impacts would be reduced under this option because the shared tunnel would replace a number of City and King County independently constructed CSO control facilities with a single, large tunnel.
	Shared Ship Canal Tunnel Option	Compared to all other options, the Ship Canal Tunnel Option would have the fewest City and King County independently constructed CSO storage facilities, and therefore the fewest areas that would experience air quality and odor impacts. Construction of the tunnel would require a substantially higher number of truck trips and associated emissions in Ballard, Fremont/Wallingford, and the Lake Washington neighborhoods than would occur for storage facilities, resulting in the potential for noticeable impacts in these areas for several years.

Table 1-3. Summary of Construction Impacts

Integrated Plan Alternative	Construction of CSO storage pipes, tanks, and tunnels under the Integrated Plan Alternative would have the same air emissions as under the LTCP Alternative, but construction would be delayed in some neighborhoods. The South Park Water Quality Facility would involve a small construction footprint, which would result in short-term, localized emissions. The facility would be located in an industrial area and any air emissions would not impact residential properties or other sensitive receptors. Temporary air quality and odor emissions associated with NDS Partnering projects would also be minor.
No Action Alternative	Construction activity associated with ongoing sewer system improvements and NDS projects would produce dust and exhaust emissions that would be minimal, localized, and temporary.
Measures to reduce or minimize potential impacts	Measures would include: • Using measures to control dust, such as watering of construction surfaces, using temporary ground covers, sprinkling the site with approved dust palliatives, or using other temporary stabilization practices upon completion of grading. • Incorporating specifications into construction contracts that encourage use of well maintained construction vehicles to reduce vehicle emissions. • Encouraging contractors to offer carpooling options for employees. • When possible, using local building materials to reduce transport distances.
Surface Water	
Long Term Control Plan Alternative	Key Findings Construction effects on surface water could include increased pollutants and sediments from site runoff and would require control measures. Construction of pipes, tanks, and portals could occur in proximity of sensitive receiving water bodies, including Lake Washington, the Ship Canal, and the Duwamish River. Discharges of dewatering water could introduce contaminants and sediments into local water bodies if not properly managed. The primary differences in potential effects of the LTCP options are related to the amount of surface disturbance and the amount of excavation potentially required.
	Neighborhood Storage Option <i>Neighborhood (Tanks/Pipes):</i> Construction effects on surface water could include increased pollutants and sediments from site runoff and would require control measures. Short term construction-related impacts to Salmon Bay, the Ship Canal, Portage Bay, North Union Bay, Lake Union, Lake Washington, the Duwamish River/East Waterway, and Elliott Bay could occur if site runoff controls do not function effectively. Overall, construction related impacts are expected to be minor because all construction would be required to comply with applicable regulations and permit conditions. Discharges of dewatering water could introduce contaminants and sediments into local water bodies if not properly managed. The highest risk from dewatering is likely to be associated with the Ballard and Fremont/Wallingford storage tanks, because the larger facilities require deeper excavations, which could be more likely to encounter groundwater. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)

Table 1-3. Summary of Construction Impacts

	Shared Storage Option	Impacts would be similar to the Neighborhood Storage Option but would occur in fewer locations in the Ship Canal and Lake Washington neighborhoods. This option reduces the overall number of facilities, but results in larger facilities with a greater potential for site runoff and dewatering impacts because of longer duration of construction and larger construction sites.
	Shared West Ship Canal Tunnel Option	This option involves construction of a deep tunnel shared with King County. Deep tunnels have less surface disruption than storage tanks and pipes, but would likely have dewatering impacts. The shared tunnel would have reduced potential for impacts associated with increased pollutants in site runoff compared to independently constructed City (Ballard and Fremont/Wallingford) and King County CSO control facilities (3rd Ave W and 11th Ave NW regulators). Construction of tunnel drop shafts and the conveyance line from King County's 3rd Avenue West CSO area would introduce potential surface water quality impacts in these areas. Portal locations, due to their larger construction footprint, would be the focal point for potential surface water runoff impacts. Tunnel portal locations are not yet known but could include areas near Portage Bay and Salmon Bay.
	Shared Ship Canal Tunnel Option	The shared tunnel would have reduced impacts to surface waters compared to construction of independently constructed City (Ballard, Fremont/Wallingford, Portage Bay, Montlake, and Leschi), and King County CSO storage facilities (3rd Ave W, Montlake, and University Regulators) because fewer, large construction sites would be required. Portal locations would be the focal point for potential surface water runoff impacts because of the duration of construction and larger construction area. While portal locations have not been determined, areas near the shorelines of Portage Bay, Union Bay, and Salmon Bay could be affected.
Integrated Plan Alternative		In addition to the impacts described for the LTCP Alternative, construction of the South Park Water Quality Facility could include increased potential for runoff into the Duwamish River and would require construction control measures. As noted above, the potential for impacts is low because the projects would be required to comply with applicable regulations and permit conditions.
No Action Alternative		Construction activity associated with ongoing sewer system improvements and NDS projects is not expected to result in surface water impacts due to the limited construction areas.
Measures to reduce or minimize potential impacts		Compliance with the requirements of the Construction Stormwater General Permit issued by Ecology and the City of Seattle's stormwater code and manual would minimize potential surface water runoff and sedimentation. Dewatering impacts would be minimized by compliance with King County Wastewater Discharge Permit requirements. Additional measures to minimize surface water runoff, dewatering, and spills include the following: • Limiting the area of construction disturbances. • Implementing stormwater best management practices identified in the City of Seattle's Stormwater Code (SMC 22.800 – 22.808), Director's Rule: 2009-004 SPU/16-2009 DPD, and Volume 2 Construction Stormwater Control Technical Requirements Manual to control erosion and sediment transport from the project sites. Typical measures include silt fencing, plastic sheeting, and straw wattles to prevent sediment discharge and wheel washing stations to prevent sediment from entering nearby roadways. • Providing water quality treatment as necessary to improve the quality of intercepted stormwater flows from adjacent impervious surfaces. • Developing and implementing a Construction Stormwater and Erosion Control Plan, including a Stormwater Pollution Prevention Plan and Spill Prevention and

Table 1-3. Summary of Construction Impacts

		Countermeasures Plan, to reduce the potential for sediment, waste materials, construction-related leaks, and spills to contaminate surface water, groundwater, and stormwater runoff.
Biological Resources		
Long Term Control Plan Alternative	Key Findings	No direct impacts to aquatic habitats, plants, and invertebrates would occur, and no indirect impacts to fish, including federally listed salmonids, are anticipated because none of the alternatives would involve in-water construction or work within sensitive areas. The potential for direct losses of terrestrial habitat associated with facility construction would be minimal under both Plan alternatives, because the facilities are likely to be located in developed areas with low habitat value. Indirect impacts to wildlife would be associated with increased level of noise and human activity during construction. The primary differences in potential effects of the LTCP options are related to amount of construction activity (surface disturbance) and proximity to mapped priority habitats or species.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> CSO control projects would be constructed in urbanized areas. The potential for direct losses of terrestrial habitat associated with facility construction would be minimal. Indirect impacts to wildlife would be associated with increased level of noise and human activity during construction. Construction would occur in areas adjacent to mapped priority habitats in the Magnolia, Leschi, and Delridge neighborhoods. The total amount of surface disturbance and potential for direct impacts to habitat is second highest of all the storage options. This storage option has the most individual project locations compared to the other options, dispersed through a number of neighborhoods. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)
	Shared Storage Option	The total amount of surface disturbance that would occur is the highest of all options, which suggests a higher potential for habitat impacts. However, this option has the second to least number of individual project locations, and therefore, a lower potential to cause indirect impacts to wildlife through construction-related noise and activity. Impacts to priority species would potentially be higher under this option due to construction activity in proximity to priority habitats along the Lake Washington shoreline and Union Bay Natural Areas; however, impacts are not expected because all construction would be required to comply with applicable permit requirements to protect habitat.
	Shared West Ship Canal Tunnel Option	In general, impacts would potentially be lower under this option due to the concentration of construction in the Ship Canal Neighborhoods at fewer locations and the lower amount of surface disturbance than other options. Construction associated with the new flow diversion (conveyance line) near the 3rd Avenue West CSO area (on the south side of the Ship Canal) would introduce minor and temporary disturbance impacts in this area.

Table 1-3. Summary of Construction Impacts

	Shared Ship Canal Tunnel Option	Overall disturbance would potentially be lower compared to all other options because this option replaces the greatest number of City and King County independently constructed CSO storage facilities with a single, large tunnel. However, impacts to priority species could potentially be higher due to construction activity lasting up to seven years in proximity to priority habitats along the Lake Washington shoreline and Union Bay Natural Area. It may be difficult to avoid siting portals in areas with high habitat value.
Integrated Plan Alternative		Impacts would primarily be related to the LTCP option selected for implementation. Additional impacts associated with the Integrated Plan Alternative would be minimal. Most NDS partnering projects would likely occur in paved or developed rights-of-way in residential areas and would not affect wildlife habitat. The potential for direct losses of terrestrial habitat associated with NDS Partnering projects and South Park Water Quality Facility construction would be minimal. Indirect impacts to wildlife would be associated with short-term increased level of noise and human activity during construction, and are not expected to be significant.
No Action Alternative		Construction activities associated with ongoing sewer system improvements would temporarily cause elevated levels of noise and human activity that could disturb wildlife, if present, near the project. Natural Drainage System program projects and roadside rain gardens have minimal direct impact on wildlife and habitat due to their small footprint and location within public rights-of-way or private property, both of which are typically developed or landscaped.
Measures to reduce or minimize potential impacts		The City would undertake the following measures: • Site projects away from mapped priority habitats and species locations where possible. • Follow federal, state, and local permit conditions for managing construction site runoff and protecting habitats for federally listed species. • Retain site vegetation as much as possible. • Provide prompt revegetation with native species after construction is complete. • Adhere to development conditions within City of Seattle's Director Rule 5-2007 for construction within Great Blue Heron Management Areas and Colony Nesting Areas.
Energy and Climate Change		
Long Term Control Plan Alternative	Key Findings	None of the LTCP options would have a significant impact on energy resources in the Seattle area. The primary difference in energy consumption and greenhouse gas (GHG) emissions between the options relates to the type of storage facility (e.g., tank or tunnel) and whether it is part of the Neighborhood Storage Option or one of the shared options. While the shared options would have higher energy consumption and GHG emissions per facility, there would be fewer new storage facilities built by the City and King County. Therefore, overall emissions would likely be lower.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> Construction-related energy consumption and GHG emissions would be lower than those estimated for the Shared Storage or Shared Ship Canal Tunnel Options.

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		<i>Neighborhood West Ship Canal Tunnel:</i> Energy consumption would be similar, but GHG emissions would be slightly higher than those estimated for the Shared West Ship Canal Tunnel Option.
	Shared Storage Option	Construction-related energy consumption and GHG emissions would be higher than those estimated for the Neighborhood Storage Option. However, overall impacts would be reduced under this option because the shared tanks replace a number of City and King County independently constructed CSO control facilities.
	Shared West Ship Canal Tunnel Option	Construction-related energy consumption and GHG emissions would be lower than those estimated for the Shared Storage or Shared Ship Canal Tunnel Options. Overall impacts would be reduced under this option because the shared tunnel replaces a number of City and King County independently constructed CSO control facilities.
	Shared Ship Canal Tunnel Option	Construction-related energy consumption and GHG emissions associated with this option would be higher than those estimated for the Neighborhood Storage and Shared West Ship Canal Tunnel Options. However, overall impacts from both the City and King County projects would be the most reduced under this option because the shared tunnel replaces the greatest number of City and King County independently constructed CSO control facilities.
Integrated Plan Alternative		Construction of CSO storage pipes, tanks, and tunnels under the Integrated Plan Alternative would have the same energy use and GHG emissions as under the LTCP Alternative, but construction would be delayed in some neighborhoods. Construction of NDS Partnering projects and the South Park Water Quality Facility would add incrementally to the overall energy required for construction of the Plan.
No Action Alternative		Project construction under ongoing programs to implement sewer system improvements and NDS projects would have minor energy consumption and GHG emissions.
Measures to reduce or minimize potential impacts		The City would undertake the following measures to minimize energy and GHG impacts: • Incorporating specifications into construction contracts that encourage the use of fuel-efficient construction equipment. • Minimizing engine idling during construction.
Environmental Health and Public Safety		
Long Term Control Plan Alternative	Key Findings	Ground excavations and dewatering have the potential to encounter contaminated materials, and may require special handling methods depending on the site and type of materials encountered. Discharges of dewatering water could introduce contaminants and sediments into local waterways if not properly managed. In general, environmental health risks associated with construction under the LTCP options are low, and the potential for the public to encounter contaminated soils or groundwater is also low. Larger projects, such as storage tanks and tunnels, have a greater potential for environmental health and public safety impacts than smaller projects constructed in the right-of-way, such as storage pipes and flow diversions.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> Under this option, there is a higher potential for impacts in Ballard, Fremont/Wallingford, and the Duwamish/East Waterway neighborhoods from large excavations and dewatering outside of the right-of-way in potentially contaminated areas (typically industrial lands). Risks would be greatest for construction workers, and would

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		generally be low for the public. Pre-design studies would be conducted to determine the extent of contamination and appropriate measures to minimize health risks. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)
	Shared Storage Option	The larger, shared storage facilities under this option in Fremont/Wallingford, North Union Bay, and Montlake would require higher volumes of excavation compared to the Neighborhood Storage Option. However, the geographic extent of the impact is limited because fewer facilities would be constructed. Construction required to implement flow diversion projects under this option would have a very low potential to cause environmental health and public safety impacts because excavation volumes would be minimal and dewatering would not be significant.
	Shared West Ship Canal Tunnel Option	Potential construction-related impacts in the Ship Canal Neighborhoods would be concentrated at the tunnel portals in the Fremont/Wallingford and Ballard neighborhoods. Potential impacts in other neighborhoods would be similar to those described for the Neighborhood Storage Option.
	Shared Ship Canal Tunnel Option	Potential impacts would be concentrated at the tunnel portals potentially located on the south side of the Ship Canal and in the North Union Bay neighborhood, areas that do not have known high levels of contamination. Potential impacts in other neighborhoods would be similar to those described for the Neighborhood Storage Option.
Integrated Plan Alternative		Construction of CSO storage pipes, tanks, and tunnels under the Integrated Plan Alternative would have the same potential for environmental health impacts as under the LTCP Alternative. In addition to the impacts outlined for the LTCP Alternatives, ground excavation and dewatering for the South Park Water Quality Facility would have the potential to encounter contaminated materials, with accompanying environmental health considerations, based on the history of industrial land uses in the Duwamish basin. Pre-design investigations would determine the potential for contamination at the construction site. Overall, potential public health impacts are expected to be low.
No Action Alternative		Construction activity associated with ongoing sewer system improvements and NDS programs is not expected to result in environmental health or safety impacts. The locations of sewer system improvement projects have largely been previously excavated; therefore, the risk of encountering contaminated soil is minimal. Excavation for rain gardens is unlikely to encounter contaminated material, but spills from construction equipment are possible. Overall, potential public health impacts are low.
Measures to reduce or minimize potential impacts		Measures would include: • Site-specific investigations and clean-up or pollution prevention plans. • Plans for sediment and groundwater handling, testing, and disposal. • Spill prevention and control plans.

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Noise and Vibration		
Long Term Control Plan Alternative	Key Findings	Construction of projects under the Plan alternatives would result in short-term moderate to substantial increases in noise, lasting from one to as much as seven years, depending upon the option selected. The primary differences in potential noise and vibration effects of the LTCP options are related to the amount of noise-generating earthwork and the length of construction period. In general, storage pipes/tanks would result in shorter duration, but more geographically distributed impacts, while the tunnels would result in longer duration impacts in relatively smaller areas.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> Construction of projects would result in short-term moderate to substantial increases in noise. This option would have the most dispersed noise and vibration impacts throughout the Plan area. Construction would occur in every CSO neighborhood, but would last longest in Ballard, Fremont/Wallingford, and East Waterway, where construction durations would range from one to five years. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)
	Shared Storage Option	Impacts would be similar to the Neighborhood Storage Option, but potentially higher intensity noise would be concentrated at fewer locations in Fremont/Wallingford, North Union Bay, and Montlake, for construction durations from three to 4.5 years.
	Shared West Ship Canal Tunnel Option	Potential construction-related impacts in the Ship Canal Neighborhoods would largely be concentrated at the tunnel portals in the Ballard and Fremont/Wallingford neighborhoods. After initial tunnel portal site construction, most work would occur underground, which would not produce noticeable street-level noise or vibration other than from trucks hauling tunnel spoils on roadways. The duration of these impacts would be 3.5 years. Potential for vibration impacts along the tunnel routes is likely to be a concern to property owners. Potential impacts in other neighborhoods, including those associated with construction of the new flow diversion (conveyance line) near the 3rd Avenue West CSO area on the south side of the Ship Canal, would be similar to those described for the Neighborhood Storage Option.
	Shared Ship Canal Tunnel Option	Noise-generating construction sites in the Ship Canal and Lake Washington neighborhoods would largely be consolidated at the two tunnel portals, and would last for as long as seven years. Most activities would occur at the launch portal along the south side of the Ship Canal (near the Fremont Cut). Noise impacts could be experienced in the vicinity of the portal locations, particularly during night time construction. Potential for vibration impacts along the tunnel routes would likely be a concern to property owners.
Integrated Plan Alternative		Construction of CSO storage pipes, tanks, and tunnels under the Integrated Plan Alternative would have the same noise impacts as under the LTCP Alternative, but construction would be delayed in some neighborhoods. Noise and vibration impacts from the stormwater projects specific to the Integrated Plan Alternative would be minor. Construction of NDS Partnering projects is not likely to require high-impact noise equipment and construction noise would be of short duration. The South Park Water Quality Facility would generate typical construction noise similar to projects implemented under the LTCP Alternative.

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No Action Alternative	Construction activity associated with ongoing sewer system improvements and NDS programs is not likely to require high-impact noise equipment, and construction noise would be of short duration.
Measures to reduce or minimize potential impacts	Measures would include: • Identify potentially impacted receptors and buildings and determine whether noise and vibration levels at those sites would exceed permitted levels. • Encourage noise-reducing measures, such as using sound-control devices on equipment, prohibiting equipment with unmuffled exhaust, minimizing idling time of equipment and vehicles, and installing acoustic barriers around stationary sources of construction noise. • Conduct on-site noise monitoring to ensure compliance with SMC provisions, if necessary. • Coordinate with Seattle City Light to ensure electrical power is available to construction sites during construction dewatering (to avoid using diesel powered generators). Measures to reduce vibration impacts would be determined on a site-by-site basis depending on impacts. Measures could include shoring of impacted buildings, coordination of vibration-causing construction with sensitive activities in impacted buildings, or onsite vibration-minimizing practices.
Land Use and Visual Quality	
Long Term Control Plan Alternative	Key Findings CSO control projects included under the LTCP range from those that would be located in the public right-of-way or streets and cause little or no land use or visual impact to major infrastructure projects that could require acquisition of property or easements over the course of construction, which would range from approximately one to seven years, depending upon the project. The acquisitions/easements could be temporary to accommodate access to a site or a location for project staging, or they could be permanent for locating storage tanks or tunnels. Impacts to visual quality during construction would be minor under all LTCP options. The primary differences in potential effects of the LTCP options are related to the types of projects and their potential location and the length of construction.
	Neighborhood Storage Option <i>Neighborhood (Tanks/Pipes):</i> Due to the largest number of distributed CSO storage facilities, this option has the greatest number of areas that would experience temporary land use impacts. Construction could intermittently disrupt access to residences, businesses, and institutions, including (potentially) the University of Washington during the multi-year construction duration. Access disruption could affect businesses. Staging areas would prevent other uses during construction; however, uses could be restored following construction completion. Temporary easements would be needed from some private landowners, depending on the project. Acquisition-related impacts would potentially be greatest under this option because it would require the greatest number of project locations. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)

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	Shared Storage Option	Impacts would be similar to the Neighborhood Storage Option, but construction-related land use and visual quality impacts would be concentrated at fewer, larger project sites in the Ship Canal and Lake Washington neighborhoods of Fremont/Wallingford, North Union Bay, and Montlake. Construction could intermittently disrupt access to residences, businesses, and institutions, including (potentially) the University of Washington during the up to four years or longer construction duration.
	Shared West Ship Canal Tunnel Option	This option would reduce the number of areas affected by construction, but would concentrate construction-related land use impacts at fewer, larger project sites in Ballard and Fremont/Wallingford. The tunnel is estimated to require 3.5 years to construct and up to four acres for construction staging. Much of this area could be sold back to private ownership following construction. In addition to land use and visual quality impacts from tunnel portal activity, dispersed impacts and disrupted access from construction of drop shafts and microtunnels, and from open-cut construction in roadways throughout the Ship Canal Neighborhoods would occur. In addition, the new flow diversion (conveyance line) would introduce minor and temporary land use and visual quality impacts to the 3rd Avenue West area on the south side of the Ship Canal.
	Shared Ship Canal Tunnel Option	Compared to the other options, the number of large storage facility construction sites would be reduced because this option would replace the greatest number of City and King County independently constructed CSO storage facilities with a single, large tunnel. Overall, the need for property acquisition and the amount of interference with access to residences and businesses would be reduced. However, construction-related land use impacts would potentially be higher in the Ship Canal and Lake Washington Neighborhoods under this option because most of the construction activity during the up to seven-year construction period would be consolidated to the two tunnel portal sites located on the south side of the Ship Canal and in the North Union Bay neighborhood. As much as 6 acres could be required for construction staging, which would preclude other uses during the construction period. Much of this area could be sold back to private ownership following construction. In addition to land use and visual quality impacts from tunnel portal activity, dispersed impacts and disrupted access from construction of drop shafts and microtunnels, and from open-cut construction in roadways throughout the Lake Washington and Ship Canal Neighborhoods would occur.
Integrated Plan Alternative		Construction impacts associated with certain CSO control facilities in the Delridge, East Waterway, Duwamish, Portage Bay, and Montlake neighborhoods would occur later under the Integrated Plan Alternative. As a result, these neighborhoods would experience fewer near-term land use and visual quality-related construction impacts. Additional impacts specific to stormwater projects associated with the Integrated Plan Alternative are not expected. Most NDS Partnering projects are expected to occur within the Single Family zone, but could occur in other zones. Prior to installation of rain gardens, the City would need to apply for and obtain applicable land use permits and approvals. Depending on the site, easements could be required on a temporary basis to accommodate access to a site or a location for project staging. The South Park Water Quality Facility is expected to be located on City-owned property in an industrial-zoned area. Therefore, it is anticipated that a suitable site is available that would result in minimal land use and visual quality impacts during construction.

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No Action Alternative	Construction activity would be limited to ongoing sewer system improvements and NDS programs. Construction related impacts to land use and visual resources are not anticipated from these ongoing programs.
Measures to reduce or minimize potential impacts	Measures would include: • Prioritizing project locations on public property and in public rights-of-way; • Complying with federal, state, and local regulations regarding property acquisition and relocation assistance; • Following conditions of the Master Use Permit; and • Providing access to property and businesses during construction.
Recreation	
Long Term Control Plan Alternative	Key Findings For all LTCP options, temporary impacts to recreation could occur if a facility is sited within a park, although the City would attempt to avoid siting facilities in parks. If construction or staging areas are located adjacent or nearby to a park, recreational use of the park could be disrupted by restricted access, noise, dust, and truck trips during peak construction periods. The primary differences in potential effects of the LTCP options are related to the types of projects and their potential location, amount of construction disturbance, and the length of construction.
	Neighborhood Storage Option <i>Neighborhood (Tanks/Pipes):</i> Temporary loss of recreational opportunities could occur if the CSO facility is located within the park. If construction or staging areas are located adjacent or nearby to a park, recreational use of the park could be disrupted by restricted access, noise, dust, and truck trips during peak construction periods. Because this option has the highest number of projects located throughout the city, it has a higher likelihood of having projects located adjacent to a park or recreational facility. This option would include construction of multiple storage pipes/tanks in the Lake Washington Neighborhoods, which have a higher concentration of parks than other neighborhoods. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)
	Shared Storage Option Potential construction-related impacts to recreation would be lower than the Neighborhood Storage Option because fewer project sites would be required. Due to the larger area required for larger tanks, however, shared storage tanks could have a greater potential to impact recreation if located within or near parks. However, the use of shared storage tanks would reduce the overall number of parks that could potentially be affected by construction in the Ship Canal and Lake Washington Neighborhoods. In other neighborhoods, storage would be provided by flow diversion projects, which would have less potential to impact parks but could still impact informal recreation such as walking and biking.
	Shared West Ship Canal Tunnel Option Impacts to recreation from construction would be similar to the Neighborhood Storage Option for most neighborhoods, but impacts in the Ballard and Fremont/Wallingford neighborhoods would be concentrated at portal locations, and construction durations would be up to 3.5 years. If located in or adjacent to a park or recreational facility, impacts from tunnel portal construction on recreation would be substantial and truck trips could disrupt access to the park. If located in a park, multiple acres of the park could be closed to recreation for several years. A substantially higher number of truck trips would be required

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		as compared to storage tanks, which would have a greater likelihood of disrupting access to nearby parks and informal recreation opportunities. In addition, the new flow diversion (conveyance line) would introduce impacts to the 3rd Avenue West area on the south side of the Ship Canal, which could temporarily affect recreation areas if located in or adjacent to a park or recreational facility.
	Shared Ship Canal Tunnel Option	This option requires the fewest number of large construction sites, but the sites would be impacted during a relatively longer construction period, estimated at seven years. Tunnel portals have the potential to affect parks or athletic fields, particularly on the south side of the Ship Canal and in North Union Bay (University District). Potential impacts to parks or recreation facilities would be as described above for the Shared West Ship Canal Tunnel.
Integrated Plan Alternative		Construction impacts associated with certain CSO control facilities in the Delridge, East Waterway, Duwamish, Portage Bay, and Montlake neighborhoods would occur later under the Integrated Plan Alternative. As a result, these neighborhoods would potentially experience fewer near-term recreation impacts. Construction related impacts to recreation specific to stormwater projects under the Integrated Plan are expected to be minimal. NDS Partnering projects would be constructed within public rights-of-way, primarily along or in roadways, and could temporarily interfere with informal recreation such as walking and biking due to restricted access. The South Park Water Quality Facility is expected to be located in an industrial area on City-owned property, with no public access or recreational opportunities.
No Action Alternative		Recreation impacts from construction of ongoing programs under the No Action Alternative would be minor. Construction in the right-of-way for both sewer system improvements and for right-of-way rain garden projects could temporarily interfere with informal recreation due to restricted access.
Measures to reduce or minimize potential impacts		If a CSO facility were located in a park, impacts to recreation would be unavoidable. The City would attempt to avoid siting projects in parks. If locating outside of a park is not possible, impacts to recreational facilities could be minimized through coordination with Seattle Parks, including coordinating construction timing with special events at the park; construction staging methods and siting; scheduling to avoid overlap with the construction of other projects in the vicinity; and advance public notice and signage. Parks and recreation features would be restored to the extent possible.
Historic, Cultural, and Archaeological Resources		
Long Term Control Plan Alternative	Key Findings	Construction under any of the LTCP options could have a potential adverse effect on historic, cultural, or archaeological resources in the Plan area. The primary difference in impacts relates to the amount of excavation in geological layers and their potential to encounter cultural resources. All options include similar, minimal potential for impacts on aboveground historic resources.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> Construction could have a potential adverse effect on historic, cultural or archaeological resources in the Plan area. This option would have a greater amount of excavation in geological layers with greater potential to encounter cultural resources than the tunnel options. Only a minimal potential for impacts to aboveground resources is anticipated. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)

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	Shared Storage Option	Potential for construction impacts to belowground historic and cultural resources would be similar to those described for the Neighborhood Storage Option. The Montlake neighborhood (where a shared storage tank would be constructed) contains known precontact and historic archaeological sites in proximity to the waterfront. Unknown belowground resources may also exist, and impacts resulting from tank construction would be permanent and irreversible if resources are encountered during construction. Impacts to aboveground resources would be the same as for the Neighborhood Storage Option.
	Shared West Ship Canal Tunnel Option	Because excavation for the tunnel portals would be deeper and therefore in geological layers with lower potential for encountering cultural resources, the tunnel options would have less potential to encounter cultural resources than the Neighborhood Storage Option or the Shared Storage Option. This option has the potential for temporary impacts to historic properties along the proposed tunnel alignment (vibration, dust, noise, and visual integrity). Historic structures may be more susceptible to damage from vibration.
	Shared Ship Canal Tunnel Option	This option has a similar potential for construction impacts on historic properties as the Shared West Ship Canal Tunnel Option.
Integrated Plan Alternative		Impacts are primarily associated with the LTCP option selected for implementation as described above. Additional impacts associated with the Integrated Plan alternative are minimal. Construction of the NDS Partnering projects would occur within previously disturbed public rights of way, and would not be likely to impact cultural or historic resources. For construction of the South Park Water Quality Facility, there is a potential to affect cultural resources. Site specific studies would be conducted as necessary to determine the potential for this impact.
No Action Alternative		Ongoing programs for sewer system improvements have the potential for construction impacts to historic properties depending on the locations of the improvements. Sewer system improvements and NDS projects generally would be anticipated to have very low potential to impact belowground resources because they would generally be constructed in previously disturbed areas.
Measures to reduce or minimize potential impacts		The City would conduct project-level cultural resource surveys prior to construction and consult with stakeholders to avoid, minimize, and mitigate potential impacts to identified resources.

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Transportation		
Long Term Control Plan Alternative	Key Findings	Construction of projects under the LTCP options would result in moderate to substantial adverse transportation impacts for temporary periods ranging from one to seven years. Potential construction-related transportation impacts would be highly visible and are of concern to local residents, business owners, and commuters. Transportation impacts would include increases in traffic volumes due to construction-generated truck trips and commute trips of construction workers, and roadway lane and sidewalk closures where construction activities take place. The primary differences in potential transportation impacts of the LTCP options are related to the length of construction period, estimated number of truck trips, and the road network in the affected neighborhood.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> Potential construction-related transportation impacts would be highly visible and would be of concern to local residents, business owners, and commuters in affected neighborhoods. Transportation impacts would include increases in traffic volumes due to construction-generated truck trips and commute trips of construction workers, and roadway lane and sidewalk closures where construction activities take place. Neighborhoods with limited number of route alternatives could experience adverse impacts from lane or road closures. The Neighborhood Storage Option would have the most dispersed transportation impacts because it would require roadway lane and sidewalk closures at a number of locations throughout the city to accommodate storage pipe and tank construction from City (and King County) independently constructed CSO storage facilities. Localized impacts would occur in certain areas (including Leschi, Montlake, and Magnolia) where the ability to accommodate lane closures for storage pipe construction is highly constrained due to a limited number of route alternatives. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar)
	Shared Storage Option	Impacts would be similar to the Neighborhood Storage Option but concentrated at fewer locations. This option would eliminate or reduce transportation impacts in the Leschi neighborhood but would have increased transportation impacts in Fremont/Wallingford, North Union Bay, and Montlake. Arterials in the Montlake area are limited, so existing congestion levels would be exacerbated by lane closures and truck trips.
	Shared West Ship Canal Tunnel Option	Impacts in the Ship Canal Neighborhoods would be concentrated at two tunnel portal locations in Ballard and Fremont/Wallingford. Elements of the West Ship Canal Tunnel construction that would generate truck trips include tunnel excavation as well as construction of supporting pipelines, pump stations, micro-tunnels, drop shafts, and flow diversions. Total truck trips for tunnel construction are expected to be over 34,000 truck round trips for the West Ship Canal Tunnel Option, generated primarily in Ballard. Additional truck trips would be generated by construction of conveyance and connection elements (e.g., drops shafts, conveyance lines). Overall, this option would result in substantially more truck trips over a longer period in Ballard compared to the Neighborhood Storage and Shared Storage Options. With expected construction duration of 3.5 years, trucks generated by the tunneling are expected to average 33 per day. This option would eliminate construction truck trips associated with a separate King County 3rd Avenue West CSO control project in the Queen

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		Anne area (average of 14 trips per day), and a separate, independent King County 11th Avenue Northwest CSO control project between Ballard and Fremont/Wallingford areas (average 4 to 8 round trips per day). These truck trips are estimated based upon the relative capacities and construction duration of other similar-sized storage facilities presented in the Draft EIS. In addition, this option would avoid the need for substantial in-road construction of a potential King County 11th Avenue Northwest storage pipe project, which could result in traffic disruptions in this area. While construction truck trips and traffic disruptions from separate, independent CSO control projects would be avoided under this option, conveyance and connection elements needed to deliver 3rd Avenue West and 11th Avenue Northwest flows to the tunnel (drop shafts and a conveyance line) would bring some additional construction truck trips and traffic disruptions to these areas during construction of the tunnel. However, these truck trips and traffic disruptions would be less than what would likely be experienced under independent CSO control projects. Anticipated increase in truck traffic during tunnel construction is relatively low compared to typical background traffic on city arterials and is not expected to adversely affect roadway operations. However, at peak construction times, the truck trips could be noticeable to drivers. Localized impacts in other neighborhoods would be the same or similar to those described for the Neighborhood Storage Option.
	Shared Ship Canal Tunnel Option	Total construction trips are expected to be over 100,000* truck round trips for the Shared Ship Canal Tunnel Option, generated primarily on the south side of the Ship Canal at the launch portal. With estimated construction duration of seven years, truck trips generated by the tunneling are expected to average 70 per day. Anticipated increase in truck traffic is relatively low compared to typical background traffic on city arterials and is not expected to adversely affect roadway operations. However, at peak construction times, the truck trips could be noticeable to drivers. Overall, this option would result in substantially more truck trips over a longer period south of the Ship Canal, where the launch portal would likely be located, compared to the other options. Impacts would be similar to the Neighborhood Storage Option for the Longfellow Creek/Duwamish and Elliott Bay Neighborhoods. * Truck trip estimates provided at the programmatic level are high-level planning estimates that are intended to be conservative; more detailed project-level estimates could result in lower trip projections.
Integrated Plan Alternative		Construction impacts associated with certain CSO control facilities in the Delridge, East Waterway, Duwamish, Portage Bay, and Montlake neighborhoods would occur later under the Integrated Plan Alternative. As a result, these neighborhoods would experience fewer near-term transportation impacts. There would be localized impacts to the neighborhoods implementing NDS Partnering. These would include neighborhoods in the Piper's Creek, Thornton Creek, and Longfellow Creek areas. Neighborhoods would voluntarily sign up for the project, and impacts would be short-lived and localized, including generation of a small number of construction vehicle trips, and lane or sidewalk narrowings or closures adjacent to construction activities. The South Park Water Quality Facility is expected to be constructed on City-owned property in an industrially zoned neighborhood with adequate access. Construction related impacts should be minimal.

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No Action Alternative	Project construction under ongoing programs to implement sewer system improvements and NDS projects requires only a small number of truck trips for each project. No impacts to transportation are anticipated under the No Action Alternative.
Measures to reduce or minimize potential impacts	Measures would depend on the exact type and size of the proposed improvement, but could include the following. • Develop a Traffic Control Plan for any work within the public right-of-way that affects vehicular, transit, bicycle, or pedestrian traffic. • Avoid creating additional delay at congested intersections either by choosing construction truck routes that avoid these locations, or constructing during nonpeak times of day. • Maintain access for driveways and private roads. • Provide adequate off-street parking areas at designated staging areas for construction-related vehicles. • Provide onsite loading areas for removal and delivery of material. • Provide plan for construction workers to commute via alternative modes or ridesharing, to minimize added vehicle trips and parking demand at the site. • Maintain pedestrian and bicycle access and circulation during project construction. If construction encroaches on a sidewalk, provide a safe detour for pedestrians at the nearest crosswalk. If construction encroaches on a bike lane, post warning signs that indicate bicycles and vehicles are sharing the roadway. • Provide traffic controls such as flaggers as appropriate. • Maintain access to transit services and coordinate with transit agencies (King County Metro, Sound Transit, Community Transit) if transit stop closures or route detours are needed. • Coordinate with the Seattle School District to ensure that access to school buses is maintained. • Post standard construction warning signs in advance of the construction area and at any intersection that provides access to the construction area. • Provide access for emergency vehicles at all times. • Provide written notification to contractors regarding appropriate routes to and from construction sites and weight and speed limits for local roads used to access construction sites. • Coordinate with the local neighborhoods to ensure that access to residences and businesses is adequately maintained, and that any additional potential issues unique to the neighborhood are identified and addressed. • Repair or restore the roadway right-of-way to its original condition or better upon completion of the work. • Comply with Seattle Department of Transportation requirements to schedule work on arterial streets and sidewalks outside of peak traffic hours unless otherwise authorized by the City Traffic Engineer. • Follow the Holiday Moratorium for construction, which indicates that no work shall

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		be scheduled on streets or sidewalks within the Central Retail District and Pioneer Square from Thanksgiving Day through New Year's Day. <u>Barge or Rail Transport of Materials for Tunnel Options (and for Ballard Storage Tank under Neighborhood Storage Option):</u> For the Shared West Ship Canal Tunnel Option and the Shared Ship Canal Tunnel Option, if the tunnel portals are located near Lake Washington, Elliott Bay, or the waterway that connects them, it could be possible to transport some equipment and materials by barge rather than by truck. If the tunnel portals are located near the Ballard Terminal Rail Company (BTRC) rail line (located along the north side of the waterway between Ballard and Fremont), it could be possible to transport some materials and equipment by rail instead of truck. Feasibility analysis completed for the Shared West Ship Canal found that the use of barge transport could eliminate up to 29% of the total estimated 34,000 construction truck round trips; the use of rail transport could eliminate up to 90% of truck round trips (SPU, 2014e). Although detailed analysis was not completed for the Shared Ship Canal Tunnel Option, it is expected that similar proportions of truck trip reductions could be achieved by use of barge or rail transport. Detailed analysis of the Ballard Storage Tank element of the Neighborhood Storage Option found that use of barge transport could potentially eliminate up to 44% of the total estimated 12,000 construction truck trips; use of rail transport could eliminate up to 78% of truck round trips. Using barge or rail transport would require additional evaluations at the project level to determine feasibility of constructing ancillary facilities, including a conveyor system and a dock to support the barge, or equipment to facilitate rail loading/unloading and increased train trips at crossings, and to assess agency permit/approval feasibility. Additional evaluation would also be needed to determine if barge transport could present potential impacts to surface water quality and biological resources, and to identify measures to avoid or minimize potential impacts to these resources.
Utilities		
Long Term Control Plan Alternative	Key Findings	Construction of storage tanks, pipes, tunnels, pump stations, and appurtenant facilities would occur in areas highly constrained by existing underground and overhead utilities and would require extensive coordination with existing utilities to avoid conflicts. The primary difference in impacts between the options relates to the number of new storage facilities constructed and the amount of new conveyance (pipelines) required to transport flows to the new storage facilities. Several of the options include flow diversions to King County facilities, which would necessitate coordination with King County to ensure that there are minimal impacts to King County facilities during construction. It would also be important to coordinate with the City's drinking water line of business to ensure that construction impacts to major water mains are avoided.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> This option has the greatest potential for construction-related impacts to utilities due to the number of new storage tanks to be constructed and the amount of conveyance required to transport flows to storage facilities. The storage facilities and associated conveyance lines would be located in areas and at underground elevations with existing utilities. The Ballard, Fremont, East Waterway, and Delridge neighborhoods have the largest number of proposed facilities, but all proposed facilities are located in areas with existing underground utilities. Coordination with all potentially affected facilities would be required. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar).

Table 1-3. Summary of Construction Impacts

	Shared Storage Option	Large storage facilities would be constructed in neighborhoods with existing utilities, resulting in potential conflicts during construction. This option would include three shared storage facilities with King County as well as a proposed flow diversion to a King County facility, which would require close coordination to ensure that there are minimal impacts to King County facilities during construction.
	Shared West Ship Canal Tunnel Option	This option involves the City and King County sharing a deep tunnel. This option requires a high level of coordination with King County to avoid potential construction-related impacts. Deep tunnels tend to be constructed below many underground utilities, reducing the potential for utility conflicts. However, temporary electrical substations to power the tunnel boring machine and construction of tunnel portals and other associated facilities would require utility coordination and reconfiguration. This option would also include two flow diversions to King County facilities, necessitating close coordination with King County to ensure that there are minimal impacts to King County facilities during construction.
	Shared Ship Canal Tunnel Option	This option involves the City and King County sharing a deep tunnel, and includes four flow diversions to King County facilities. This option requires the highest level of coordination with King County, to avoid potential construction-related impacts.
Integrated Plan Alternative		Impacts to public utilities would be associated with localized below ground utilities potentially affected by conveyance line construction for the South Park Water Quality Alternative. There may be minor utility conflicts associated with NDS Partnering projects.
No Action Alternative		Construction-related impacts to utilities would occur under ongoing programs; however, impacts are expected to be lower than those expected to occur under the LTCP or Integrated Plan Alternatives.
Measures to reduce or minimize potential impacts		Impacts to utilities would be reduced by early and ongoing coordination with all potentially affected utilities. The measures would include, but are not limited to, those listed below: • Coordinate with other utilities and transportation departments to plan for shared construction to avoid consecutive construction projects (CSO control projects, road construction, other underground utilities). • Provide advance notice and coordinate with affected utilities to minimize disruption of services. • Adhere to the City's design criteria for the clearance of water mains and other utilities as outlined in Section 1-07.17 of the City of Seattle's Standard Specifications for Road, Bridge and Municipal Construction. • For all LTCP options, the City would work together with King County to analyze and address downstream operational and capital impacts to the King County System. If downstream impacts cannot be successfully reduced, then there is the potential that the County will be required to build new or larger downstream capital facilities to accommodate the LTCP options. Even with measures to reduce impacts, there would likely be an increase in the County's operations and maintenance (O&M) costs to account for the additional flows from the City's system.

Table 1-3. Summary of Construction Impacts

Socioeconomics and Environmental Justice		
Long Term Control Plan Alternative	Key Findings	Construction of the LTCP options could cause construction disturbance and modified access to community resources and businesses, resulting in temporary reduction in neighborhood cohesion. Temporary disruptions may be a particular hardship for some residents – particularly transit-dependent persons – due to disruptions to access and public transportation in project areas. There could be short-term impacts on existing economic conditions in the construction areas due to construction disturbance and temporary changes in the use of the land during construction. In some cases, these changes would be permanent, while in other cases, economic activity would largely be restored following construction. Although construction effects may be substantial, none of the LTCP options would cause disproportionately high and adverse effects on minority and low-income populations.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> Construction may cause construction disturbance and modified access to community resources and businesses, resulting in temporary reduction in neighborhood cohesion. The Neighborhood Storage Option has the greatest number of City and King County independently constructed CSO storage facilities, and therefore the greatest number of areas that would experience construction disturbance and modified access to community resources and businesses during the construction period. The neighborhoods that would be most affected include the Ballard, Fremont/Wallingford, Leschi, and Longfellow Creek/Duwamish neighborhoods. Although construction activity may be substantial, no potential disproportionately high and adverse effects on minority and low-income populations have been identified. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar).
	Shared Storage Option	The Shared Storage Option would reduce the total number of new storage facilities required in the city (by both the City and King County) and would reduce the number of storage facilities that would be constructed as compared to the Neighborhood Storage Option. Fewer areas would experience construction disturbance and modified access to community resources or businesses, and there would be fewer areas where property acquisition is required. However, it would concentrate impacts at shared tank locations. The neighborhoods that have the highest potential to be affected include Fremont/Wallingford, North Union Bay, and Montlake. Disproportionate impacts to minority or low income populations are not expected.
	Shared West Ship Canal Tunnel Option	The Shared West Ship Canal Tunnel would replace City (and King County) independently constructed storage facilities in the Ship Canal Neighborhoods with a single, large tunnel, and therefore fewer areas would experience construction disturbance and modified access to community resources or businesses. However, it would concentrate impacts at fewer locations in the Ship Canal Neighborhoods. The neighborhoods that have the highest potential to be affected include Ballard and Fremont/Wallingford. Disproportionate impacts to minority or low income populations are not expected.

Table 1-3. Summary of Construction Impacts

	Shared Ship Canal Tunnel Option	The Ship Canal Tunnel Option would affect the fewest neighborhoods throughout the city, but it would also concentrate impacts in the Ship Canal and Lake Washington Neighborhoods. Overall, the potential to impact businesses and local economic activity would be reduced city-wide. Disproportionate impacts to minority or low income populations are not expected.
Integrated Plan Alternative		Construction impacts associated with certain CSO control facilities in the Delridge, East Waterway, Duwamish, Portage Bay, and Montlake neighborhoods would occur later under the Integrated Plan Alternative. As a result, these neighborhoods would experience fewer near-term socioeconomic impacts. Construction associated with NDS Partnering would cause minor and temporary impacts to the communities in which they're located, and could alter access to community resources. Project construction associated with the South Park Water Quality Facility could also alter access to community resources and result in short-term noise and other impacts in affected neighborhoods. However, the potential for impacts is minimal as the project is anticipated to be located in an industrial area.
No Action Alternative		Project construction under ongoing programs to implement sewer system improvements and NDS projects could alter access to community resources and result in short-term noise and other impacts in affected neighborhoods. However, these impacts would be very short term and would not affect the integrity of the neighborhoods. The No Action Alternative would require fewer disruptions in industrial and commercial areas, and fewer property acquisitions and displacements than would the LTCP or Integrated Plan Alternatives.
Measures to reduce or minimize potential impacts		The City would undertake the following measures to reduce socioeconomic impacts: • Prioritizing project locations on public property and in public rights-of-way, • Complying with federal, state, and local regulations regarding property acquisition and relocation assistance, • Providing advance notification of construction activities, including any sidewalk and street lane closures, to nearby residents, and • Preparing a traffic control plan including measures to address residential access, emergency vehicle access, road closures and detours, and temporary bus route changes. Additional measures to minimize impacts to environmental justice populations and organizations and businesses that serve them would include communicating information and obtaining feedback about construction activities, impacts, and measures to reduce or minimize potential impacts at low-income housing sites and through social service providers. The project would also focus outreach to populations with limited English proficiency and to other populations susceptible to construction-related impacts.

Table 1-4 summarizes operational impacts associated with the LTCP, Integrated Plan, and No Action Alternatives. As previously described, impacts are described for those projects and programs proposed by the City independently or working jointly with King County. Independent King County projects are identified but not discussed in this document. Impacts will be assessed by King County in accordance with their SEPA requirements.

Table 1-4. Summary of Operational Impacts

Earth and Groundwater		
Long Term Control Plan Alternative	Key Findings	Overall, the operational effects from the LTCP Alternative are expected to be minor. With the implementation of site-appropriate design, potential adverse impacts would be avoided and minimized.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> This option would have the most tanks and pipes located throughout the Plan area potentially at risk during a seismic event. However, storage facilities would be designed in accordance with seismic design standards, which are intended to minimize the long-term risks to the system. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar).
	Shared Storage Option	Impacts would be similar to the Neighborhood Storage Option but there would be fewer storage tanks and pipes potentially at risk during a seismic event.
	Shared West Ship Canal Tunnel Option	Impacts would be similar to the Neighborhood Storage Option but there would be fewer storage tanks and pipes potentially at risk during a seismic event. Tunnels are generally designed to avoid other underground developments and take advantage of stable glacial till layers. Operational effects are anticipated to be minor.
	Shared Ship Canal Tunnel Option	This option would have similar potential for impacts as the Shared West Ship Canal Tunnel Option. Additional flow diversions under this option would further reduce the number of storage facilities at potential risk.
Integrated Plan Alternative		In addition to the operational impacts of the selected LTCP option, the operational impacts of the stormwater projects specific to the Integrated Plan Alternative are anticipated to be minor. Depending on location selected, the South Park Water Quality Facility could be at risk for liquefaction in saturated soils; however, the facility would be constructed to meet seismic design standards. NDS Partnering projects could cause slope instability or groundwater contamination if not properly sited and designed, and erosion if not properly maintained. Street sweeping operations would not be expected to affect earth or groundwater.
No Action Alternative		Projects completed as part of the ongoing Natural Drainage System program and roadside rain garden programs could cause erosion if they are not properly maintained. Projects included in the City's NPDES Waste Discharge Permit and the 2010 Plan Amendment will meet seismic design standards.
Measures to reduce or minimize potential impacts		The City would undertake the following measures: • All sites would be maintained to prevent erosion. • Projects would be sited and designed to minimize seismic risk and potential for earth subsidence. • NDS Partnering projects (under the Integrated Plan Alternative) would be sited and designed to avoid potential impacts on slope stability and/or groundwater quality.

Table 1-4. Summary of Operational Impacts

Air Quality		
Long Term Control Plan Alternative	Key Findings	The net operational effects of the LTCP Alternative on air quality and odors would be minor in the Plan area. All facilities would be designed and maintained to minimize emissions of odorous compounds and would include odor control components as necessary.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> This option would have the highest number of potential odor-producing tanks and pipes located throughout the Plan area, including in or near residential areas in the Ship Canal, Lake Washington, and Longfellow Creek/Duwamish Neighborhoods. All facilities would be designed and maintained to minimize emissions of odorous compounds. Therefore, operational effects of the CSO control facilities on air quality and odors would be minor in the Plan area. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar).
	Shared Storage Option	Impacts would be similar to the Neighborhood Storage Option but there would be fewer potential odor-producing tanks and pipes in the Ship Canal Neighborhoods.
	Shared West Ship Canal Tunnel Option	The large tunnel would replace the need for a number of potential odor-producing storage facilities in the Ballard and Fremont/Wallingford neighborhoods. The large tunnel would have the greatest potential for odors at the downstream tunnel portal (likely located along the Ship Canal in the vicinity of Ballard), which would be controlled by an odor control facility. In neighborhoods where flow diversions would replace storage tanks/pipes, there would be less potential for odor impacts.
	Shared Ship Canal Tunnel Option	This option would have similar potential for impacts to the Shared West Ship Canal Tunnel Option, except that the shared tunnel would replace the need for additional independently constructed storage facilities with odor-producing potential in the Lake Washington Neighborhoods of Montlake, Portage Bay, and Leschi. The large tunnel would have the greatest potential for odors at the downstream tunnel portal (likely located along the south side of the Ship Canal), which would be controlled by an odor control facility. Additional flow diversions in Duwamish and Delridge would further reduce the number of potentially odor-producing storage facilities in those neighborhoods.
Integrated Plan Alternative		In addition to the operational impacts of the selected LTCP option, the air quality impacts of the stormwater projects specific to the Integrated Plan Alternative are anticipated to be minor. Similar to CSO storage facilities, the South Park Water Quality Facility has the potential to generate odors. However, this impact is expected to be minimal because stormwater has fewer odor generating compounds than wastewater or combined sewer overflows. Street sweeping has the potential to temporarily increase localized dust and emissions, but increases would be minimal and occurring at night. There are no operational air-related impacts associated with NDS Partnering.
No Action Alternative		No air quality impacts or increased odors are anticipated from the ongoing sewer system improvements and NDS programs.

Table 1-4. Summary of Operational Impacts

Measures to reduce or minimize potential impacts	The City would undertake the following measures: • All storage facilities and downshafts (for tunnels) would be designed with state-of-the-art odor control systems. • The City would operate storage facilities to minimize the potential for odors by limiting how long combined sewage is stored in the facilities, maintaining air space at slightly negative pressures, and scheduling maintenance of odor control systems during cold temperatures and periods of low flow.
Surface Water	
Long Term Control Plan Alternative	The LTCP Alternative would result in substantial pollutant loading reduction from existing uncontrolled CSO outfalls when compared with the No Action Alternative. Pollutant loadings from control of 22 currently uncontrolled CSOs would be substantively reduced and would come into compliance with the Clean Water Act and the requirements of the Consent Decree. The Ship Canal/Lake Union, Lake Washington, Duwamish River, Longfellow Creek, Elliott Bay and Puget Sound would receive reduced discharges from CSOs. The Integrated Plan Alternative would result in greater pollutant loading reductions than the LTCP Alternative.
Integrated Plan Alternative	Reduced pollutant loadings would be greater than those achieved by the LTCP alone because of the additional reductions achieved by stormwater projects. The Integrated Plan would provide greater reductions in a number of pollutants, including total suspended solids, PCBs, PBDEs, total copper, total zinc, total phosphorus, fecal coliform, and oil and grease. Relative reductions would be highest for the Duwamish Waterway, which was identified as the highest priority water body by the Integrated Plan team based on the criteria described in the Consent Decree within those water bodies. Deferral of six CSO projects would result in delayed reduction of pollutant loads that constitute less than 10 percent of the total CSO volume currently being discharged. These CSOs were identified for deferral primarily because they are already close to being controlled and have relatively low average annual discharge volumes. Discharges from the deferred CSOs into Portage Bay and the Duwamish Waterway would continue until the projects are constructed (after 2025).
No Action Alternative	Under the No Action Alternative, pollutant loadings to receiving water bodies would not be reduced beyond levels provided from construction of projects included in the 2010 CSO Control Plan and currently planned NDS projects. This alternative does not comply with the Consent Decree, and it would result in significant fines for the City. This alternative is not consistent with the City's Plan to Protect Seattle's Waterways.
Measures to reduce or minimize potential impacts	The Plan Alternatives are intended to reduce surface water impacts and comply with the Clean Water Act and the Consent Decree. Additional water quality benefits will be achieved through ongoing watershed management efforts, stormwater management programs, and other cooperative efforts with watershed managers throughout the region.

Table 1-4. Summary of Operational Impacts

Biological Resources		
Long Term Control Plan Alternative		The LTCP Alternative would result in negligible to minor impacts from operation of the storage facilities in the Plan area. There would be long-term beneficial effects on fish and aquatic life from reducing CSOs. Implementation of the LTCP would reduce the volume of untreated sewage and stormwater runoff, thereby reducing the potential for related impacts on aquatic life. Implementation of the LTCP would comply with the Consent Decree as well as other federal and state requirements.
Integrated Plan Alternative		In addition to the benefits associated with the LTCP CSO control facilities, there would be additional pollutant reductions to the Duwamish waterway, Thornton Creek, Piper's Creek, and Longfellow Creek. The expanded Street Sweeping program would also benefit Lake Union/Ship Canal, Elliott Bay and Puget Sound. Reductions in pollutant loading would benefit aquatic resources in these waterways. NDS Partnering would help reduce high flow pulses that can adversely affect aquatic life in the creeks.
No Action Alternative		The No Action Alternative would result in no additional improvements to CSO reductions in the Plan area, which could have long term adverse effects on fish and aquatic life including listed species.
Measures to reduce or minimize potential impacts		Because none of the Plan alternatives are expected to cause adverse impacts to biological resources, no measures are proposed.
Energy and Climate Change		
Long Term Control Plan Alternative	Key Findings	The LTCP would have minor operational effects on energy use in the city. The greenhouse gas (GHG) emissions produced by operating and maintaining CSO facilities are not expected to cause appreciable climate change impacts. The City has incorporated climate change modeling in its development of Plan alternatives and would incorporate additional modeling in the design of individual CSO facilities to minimize risks from anticipated changes in precipitation and sea level rise.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> The CSO control facilities would have minor operational effects on energy use as a result of pumping and electrical equipment requirements. Although operating the CSO equipment can be energy intensive, most of the equipment operates infrequently, only during storm events. Therefore, the CSO equipment is expected to have a minor impact on energy use or demand in the Plan area. The GHG emissions produced by operating and maintaining CSO control facilities are expected to be minor. The City has incorporated climate change modeling in its development of Plan alternatives and would incorporate additional modeling in the design of individual CSO control facilities to minimize risks from anticipated changes in precipitation and sea level rise. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar).

Table 1-4. Summary of Operational Impacts

	Shared Storage Option	The CSO facilities included in the Shared Storage Option would have somewhat higher electrical requirements than the City independent CSO facilities included in the Neighborhood Storage Option because of the greater energy requirements of the larger shared storage tanks. However, overall energy use would be expected to be lower because the shared tanks replace the need for 10 City and 3 King County independently constructed CSO facilities.
	Shared West Ship Canal Tunnel Option	The Shared West Ship Canal Tunnel Option would potentially have a higher electrical requirement than the City neighborhood CSO facilities included in the Neighborhood Storage Option and the shared storage tanks included in the Shared Storage Option because of the electricity needed to pump the deeply stored water. However, overall energy use would still be minor and would be expected to be further reduced as this option replaces the need for 4 City and 2 King County independently constructed CSO facilities.
	Shared Ship Canal Tunnel Option	The Shared Ship Canal Tunnel Option would have slightly higher than the West Ship Canal Tunnel because of the electrical energy requirements of the larger tunnel. However, overall energy use would be expected to be the most reduced under this option compared to the Neighborhood Storage Option because it replaces the need for 15 City and 3 King County independently constructed CSO facilities, the most of all the options.
Integrated Plan Alternative		In addition to the CSO control facilities under the LTCP, the South Park Water Quality Facility would use energy on an intermittent basis.
No Action Alternative		Energy requirements from operation of projects implemented under ongoing programs are minimal.
Measures to reduce or minimize potential impacts		The City would undertake the following measures to reduce the impacts of CSO control facilities on energy and to protect the new facilities from the risks of climate change: • Comply with state and city requirements related to energy efficiency of the new CSO control facilities. • Include evaluations of GHG emissions as required by the City in project-level SEPA analyses. • Incorporate climate change modeling into design of CSO control facilities. • Utilize the adaptation planning pathways incorporated in the City's <i>Sea Level Rise Planning Guidance for Capital Projects</i> (City of Seattle, 2011d) to design and locate CSO control facilities.

Table 1-4. Summary of Operational Impacts

Environmental Health and Public Safety		
Long Term Control Plan Alternative		Overall, the LTCP Alternative is expected to reduce environmental health risks associated with CSOs by reducing untreated discharges. Reductions of CSO discharges to water bodies where water contact recreation occurs, including Lake Union, the Ship Canal, Lake Washington, and the Duwamish Waterway, would reduce the potential for CSO-related environmental health risks in those water bodies.
Integrated Plan Alternative		In general, reduction in environmental health risks would be greatest under the Integrated Plan Alternative. Pollutant load and human exposure evaluations conducted as part of the Integrated Plan indicated that pathogens and toxic organic and inorganic constituents would be reduced to a greater level under the Integrated Plan Alternative than the LTCP Alternative. Once the deferred CSO projects are implemented, they will add to the long term loading reduction achieved by the Integrated Plan Alternative. Residents have expressed concerns about health risks associated with rain gardens, including safety risks associated with ponded water, and potential for mosquito breeding. With proper siting, design and maintenance, these issues are not expected to occur.
No Action Alternative		Under the No Action Alternative, water quality in surface waters throughout the Plan area would continue to be negatively impacted by CSO releases from uncontrolled outfalls. Contaminated water could continue to affect swimming beaches and fishing areas, causing environmental health impacts. The No Action Alternative is not compliant with the Consent Decree, and is not consistent with the City's Plan for Protecting Seattle's Waterways.
Measures to reduce or minimize potential impacts		As part of ongoing programs, the City undertakes the following measures to minimize impacts of NDS projects: • The City maintains roadside rain gardens to prevent standing water and reduce the potential for mosquito breeding. • The City provides education and incentives to encourage property owners to maintain rain gardens.
Noise and Vibration		
Long Term Control Plan Alternative	Key Findings	The net operational effects of the LTCP Alternative would be minor in the Plan area. Noise would be intermittently generated under all options by pump stations and odor control facilities. All facilities would be designed and maintained to reduce noise to permissible levels.
	Neighborhood Storage Option	<i>Neighborhoods (Tanks/Pipes):</i> Because the Neighborhood Storage and Shared Storage Options would have the most pump stations and other facilities, they would have a higher potential for noise impacts. Some pump stations and mechanical facilities could be located in residential areas, particularly in the Lake Washington, Longfellow Creek/Duwamish, and Ship Canal Neighborhoods. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar).
	Shared Storage Option	Impacts would be similar to the Neighborhood Storage Option but there would be additional noise-generating pump stations and mechanical facilities.

Table 1-4. Summary of Operational Impacts

	Shared West Ship Canal Tunnel Option	Because the Shared West Ship Canal Tunnel Option and the Shared Ship Canal Tunnel Option would have fewer pump stations and mechanical facilities than the Neighborhood and Shared Storage Options, they would have a lower potential for noise impacts.
	Shared Ship Canal Tunnel Option	Because the Shared West Ship Canal Tunnel Option and the Shared Ship Canal Tunnel Option would have fewer pump stations and mechanical facilities than the Neighborhood and Shared Storage Options, they would have a lower potential for noise impacts.
Integrated Plan Alternative		CSO storage pipes, tanks, and tunnels constructed under the Integrated Plan Alternative would have the same operational noise impacts as under the LTCP Alternative, but implementation would be delayed in some neighborhoods. Operation of the elements specific to the Integrated Plan Alternative would have minimal noise impacts. Natural drainage systems would not generate noise. Street sweeping, which would occur at night, would only occur on arterial streets and would not generate noise in excess of typical vehicle noise. The South Park Water Quality Facility could generate some operational noise from ventilation fans and maintenance activities. However, the facility would be located in an industrial area and operational noise would not impact residences or other sensitive receptors.
No Action Alternative		Operation of sewer system improvements and NDS projects implemented under ongoing programs would not generate noise.
Measures to reduce or minimize potential impacts		A noise analysis for each project would be performed during final design. Information on sensitive noise receiving properties and site-specific characteristics will be used to determine location-specific measures. Potential measures could include: • Pump station and odor control facility designs would include attenuation measures for fan noise and pump and motor noise as needed to comply with noise levels specified by the City of Seattle and to address location-specific factors as determined during project design. • Facility vault access hatches would be designed to be relatively thick and to have seals at the perimeters to contain noise within the vault. • Pumps, standby generators, and odor control equipment would be located in below ground structures.
Land Use and Visual Quality		
Long Term Control Plan Alternative	Key Findings	Potential land use impacts associated with CSO control projects include conversion of land in residential, commercial, or industrial areas to public utility uses. These impacts differ between the options because of different property requirements of tanks as compared to tunnels. The completed facilities would primarily be constructed below ground; aboveground facilities would have minimal visual impacts with the use of site appropriate design and screening.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> This option would have the most storage tanks located throughout the Plan area with the potential to cause permanent land use changes. Private property or permanent easements could be acquired for any of the LTCP options, but would likely be greatest under the Neighborhood Storage (and Shared Storage Options). Current land uses would be permanently changed to become storage facilities, however, the tanks and associated equipment would primarily be underground. The presence of underground

Table 1-4. Summary of Operational Impacts

		storage tanks would restrict certain future uses on top of the facility. While there is the potential to redevelop the surface area into certain beneficial uses, the previous land use at the site could be permanently altered. Typical uses for the tops of storage tanks include passive recreation, athletic fields and parking facilities. More area would be retained in ownership or by permanent easement by the City for a storage tank than for a tunnel. Ballard would have the largest storage tank (occupying an estimated 60,000 square feet (SF)). The completed facilities would be designed to visually blend with the surroundings, but it is likely that they would have a different appearance from pre-construction conditions. Storage pipes would be constructed in street rights-of-way, and would have less potential for land use changes. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar).
	Shared Storage Option	The impacts would be similar to the Neighborhood Storage Option. While fewer sites in the Ship Canal Neighborhoods would be used for storage tanks, and no tank would be sited in the East Waterway area, potential land use impacts from siting larger shared tanks could occur in the Lake Washington Neighborhoods. These tanks would occupy an estimated 35,000 SF (North Union Bay) and 40,000 SF (Montlake). There is a greater potential for conversion of residential lands for storage tanks in the Lake Washington Neighborhoods under this option. As noted above, more area would be retained in ownership or by permanent easement by the City for a storage tank than for a tunnel, and the presence of an underground tank restricts certain future uses of the site.
	Shared West Ship Canal Tunnel Option	This option would have less potential for long-term land use impacts than both the Neighborhood Storage and Shared Storage Options since the tunnel would replace the need to site several storage tanks in the Ship Canal Neighborhoods (Ballard and Fremont/Wallingford), and less property would need to be retained following construction. In contrast to storage tanks, the City would be able to sell or lease approximately 75 percent of the tunnel launch portal lands in Ballard required for construction back to private ownership where it could be developed for zoned uses (e.g., industrial, commercial). Approximately 0.5 acre of the launch portal would be retained by the City to house the pump station, odor control, and permanent shaft for access and maintenance. All of the area used for the smaller, recovery end of the tunnel in Fremont/Wallingford would be retained by the City. Some additional areas would be retained for permanent drop shafts as required to accept flows from each contributing City and King County CSO area.
	Shared Ship Canal Tunnel Option	Similar to the Shared West Ship Canal Tunnel, less property would need to be retained following construction of the tunnel compared to the Neighborhood and Shared Storage Options. The City would be able to sell or lease approximately 75 percent of the tunnel launch portal lands on the south side of the Ship Canal required for construction back to private ownership where it could be developed for zoned uses (e.g., industrial, commercial). Approximately 0.5 acre would be retained by the City to house the pump station, odor control, and permanent drop shaft for access and maintenance. All of the area used for the smaller, recovery end of the tunnel in North Union Bay would be retained by the City. Additional areas would be retained for permanent drop shafts as required to accept flows from each contributing City and King County CSO area. Compared to the Shared West Ship Canal Tunnel Option, the Ship Canal Tunnel would result in less potential for land use impacts in Ballard and more potential for land use impacts on the south side of the Ship Canal and in North Union Bay.

Table 1-4. Summary of Operational Impacts

Integrated Plan Alternative	Stormwater projects constructed under the Integrated Plan are not expected to cause major long term impacts to land use. Long term land use impacts from NDS Partnering would be minimal, because the projects would be implemented in neighborhoods on a voluntary basis, and would be installed to blend with neighborhood character. The South Park Water Quality Facility would likely be sited in an industrial-zoned area, surrounded by industrial and commercial land uses. The visual impact of the facility is expected to be minimal.	
No Action Alternative	Operation of sewer system improvements and NDS projects implemented under ongoing programs is not expected to result in land use or visual quality impacts. The planned CSO projects included in the City's NPDES Waste Discharge Permit and the 2010 Plan Amendment would have minor land use impacts. Visual quality impacts would be limited to the aboveground support facilities needed for the CSO projects and are also expected to be minor.	
Measures to reduce or minimize potential impacts	The City would undertake the following measures to minimize land use and visual quality impacts for all proposed projects: • Minimize the size of permanent aboveground facilities and design them to blend with the surroundings. • Locate and aim any artificial lighting away from adjacent roadways, residential areas, and water bodies. Use the minimum wattage necessary to provide the necessary illumination. • Sell or lease portal land in excess of what is needed back to private ownership.	
Recreation		
Long Term Control Plan Alternative	Key Findings	Overall, the operational effects from the LTCP Alternative on recreational activities are expected to be minor. Reductions in pollutant loading would benefit long term water quality and help maintain beneficial uses at area beaches. Water contact recreation in area water bodies would be enhanced by improved water quality in Lake Washington, Portage Bay, the Duwamish River, and Lake Union, in particular. Locating storage facilities in a park would constrain certain future uses of that area for park purposes. However, there is a potential to provide recreational facilities on top of storage tanks following construction.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> The Neighborhood Storage and Shared Storage Options would have the highest potential to cause park and recreation impacts because these options have the most tank facilities. Locating storage facilities in a park or its associated uses (such as parking) would constrain certain future uses of that area for park purposes. However, there is a potential to provide recreational facilities on top of storage tanks following construction. <i>Neighborhood West Ship Canal Tunnel:</i> (See Shared West Ship Canal Tunnel Option below – impacts would be similar).

Table 1-4. Summary of Operational Impacts

	Shared Storage Option	The impacts would be similar to the Neighborhood Storage Option. While fewer sites in the Ship Canal Neighborhoods would be used for storage tanks, potential recreation impacts from siting larger shared tanks could occur in the North Union Bay and Montlake neighborhoods if a tank is located in a park. The Montlake neighborhood, because of the relatively higher amount of parkland, including Montlake Boulevard (an Olmsted Park), has a greater potential to be affected under this option. The storage tank in North Union Bay would be located in proximity to the University of Washington Athletic Complex (including fields, a golf course, a ballpark, and an outdoor track) and the Union Bay Natural Area.
	Shared West Ship Canal Tunnel Option	This option would have less potential for long-term impacts to recreation than both the Neighborhood Storage and Shared Storage Options since the tunnel would replace the need to site several storage tanks in the Ship Canal Neighborhoods (Ballard and Fremont/Wallingford), with less potential for recreation impacts.
	Shared Ship Canal Tunnel Option	Compared to the Shared West Ship Canal Tunnel Option, the Ship Canal Tunnel would result in less potential for recreation impacts in Ballard and more potential for impacts on the south side of the Ship Canal and in North Union Bay if the tunnel portals are sited in a park or recreation area. Parks and recreation areas in these areas include athletic fields owned and operated by Seattle Pacific University and the University of Washington, as well as the Burke Gilman Trail, and numerous neighborhood parks.
Integrated Plan Alternative		Storage pipes, tanks, and tunnels constructed under the Integrated Plan Alternative would have the same recreation impacts as under the LTCP Alternative, but implementation would be delayed in some neighborhoods. Operation of the stormwater projects specific to the Integrated Plan Alternative is not expected to result in any additional adverse recreation impacts. The additional pollutant load reductions would indirectly benefit water-based recreation activities in the Plan area.
No Action Alternative		The No Action Alternative would result in no additional improvements to water quality in the Plan area water bodies, with ongoing potential for adverse indirect effects on recreation at swimming beaches.
Measures to reduce or minimize potential impacts		The City would comply with the conditions of Initiative 42 (Ordinance No. 118477) related to siting public facilities in parks. Additional site-specific measures, including measures for project-related impacts, would be identified during project design.
Historic, Cultural, and Archaeological Resources		
Long Term Control Plan Alternative		Operation of projects implemented under the LTCP Alternative is anticipated to have no effect on historic, cultural, and archaeological resources within the Plan area.
Integrated Plan Alternative		No additional effects on historic, cultural, and archaeological resources within the Plan area are anticipated under the Integrated Plan Alternative.
No Action Alternative		Operation of projects implemented under ongoing programs is anticipated to have no effect on historic, cultural, and archaeological resources within the Plan area.
Measures to reduce or minimize potential impacts		No measures would be required.

Table 1-4. Summary of Operational Impacts

Transportation		
Long Term Control Plan Alternative		Overall, the operational effects from vehicle trips generated by facility maintenance under the LTCP Alternative are expected to be minor.
Integrated Plan Alternative		Operation of the additional projects implemented under the Integrated Plan Alternative would have minimal transportation impacts. The South Park Water Quality Facility could generate occasional vehicle trips with minimal effect on roadway operations. Street sweeping would primarily occur at night when traffic volumes are low, and would not affect roadway operations or parking.
No Action Alternative		Completed projects under the No Action Alternative are not expected to cause transportation impacts.
Measures to reduce or minimize potential impacts		Because there would be no impacts to transportation, no measures are proposed.
Utilities		
Long Term Control Plan Alternative	Key Findings	Implementation of the LTCP will require close coordination with numerous utilities, in particular, wastewater and stormwater utilities within the service area. Because the City's collection system network sends wastewater to King County for treatment, coordination with King County will be particularly important. King County's West Point Treatment Plant would receive additional sewage flows as a result of Plan implementation. The high variability in flow rates within the sewer system associated with heavy storms could be challenging to manage at the King County West Point Treatment Plant. Based on City modeling, these additional flows will have little effect on the peak loading to King County's West Point Treatment Plant and may potentially reduce peak loading. However, annual average flows will increase, resulting in greater operational and maintenance costs. Seattle and King County will address the incremental cost of these flows in their sewage disposal agreement. The potential implications to King County's combined sewer system vary depending upon the option implemented, as described below. In general the operational implications associated with shared options will require greater coordination with King County than the Neighborhood Storage Option.
	Neighborhood Storage Option	<i>Neighborhood (Tanks/Pipes):</i> This option would generally have minimal operational impacts to utilities once construction is complete. However, this option would require the greatest length of sewer pipe construction, with accompanying maintenance requirements. Sewer system improvements in North Union Bay could have operational implications to King County, which would be resolved according to agreements negotiated with King County. Selection of this option would necessitate the need for King County to construct the largest number of independent storage facilities to meet regulatory requirements. <i>Neighborhood West Ship Canal Tunnel:</i> Impacts would be the same as described above.
	Shared Storage Option	Impacts would be similar to those described for the Neighborhood Storage Option. However, flow diversion projects in cooperation with King County would result in potential operational considerations for both King County and the City. Potential operational implications would be coordinated with King County to ensure that detrimental impacts do not occur.

Table 1-4. Summary of Operational Impacts

	Shared West Ship Canal Tunnel Option	As described above, shared storage projects have operational implications to King County and the City. A large shared tunnel would be implemented in accordance with operational agreements between the City and King County. The Shared West Ship Canal Tunnel Option may reduce the operational complexity of controlling neighborhood storage tanks or shared storage tanks, as it provides one large storage facility for all flows to be managed through a single pump station discharging to King County's West Point Treatment Plant. Close coordination with King County would be needed to optimize operational benefits.
	Shared Ship Canal Tunnel Option	This option involves the City and King County sharing a deep tunnel, and includes four flow diversions to King County facilities. This option requires the highest level of coordination with King County, to reduce the potential for impacts. Extensive coordination between the City and King County would be conducted to develop operational agreements that are workable and efficient for both entities.
Integrated Plan Alternative		Impacts to public utilities would primarily be related to implementation of CSO control measures under the selected LTCP option. No additional impacts are expected to occur related to the implementation of Integrated Plan stormwater projects.
No Action Alternative		Implementation of the No Action Alternative would not comply with the Consent Decree, and could potentially result in significant fines for the City, with potential impacts to City ratepayers.
Measures to reduce or minimize potential impacts		For all LTCP options, the City would work together with King County to analyze and address downstream operational and capital impacts to the King County System. If downstream impacts cannot be successfully minimized, then there is the potential that the County will be required to build new or larger downstream capital facilities to accommodate the LTCP options. Even with measures to reduce impacts, there would likely be an increase in the County's operations & maintenance (O&M) costs to account for the additional flows from the City's system.
Socioeconomics and Environmental Justice		
Long Term Control Plan Alternative		The operational effects of the LTCP Alternative would be minor to moderately beneficial associated with improved water quality in area receiving waters, and there would be no adverse operational effects that would be predominantly borne by minority or low-income populations and underserved communities.
Integrated Plan Alternative		The operational effects of the additional Integrated Plan stormwater projects would be minor to moderately beneficial, and there would be no adverse operational effects that would be predominantly borne by minority or low-income populations and underserved communities.
No Action Alternative		CSO discharges would not be reduced beyond levels outlined in the City's NPDES Waste Discharge Permit and 2010 CSO Control Plan, so no further improvements in current environmental health risks would occur. These health risks are predominantly borne by low-income, tribal, and subsistence fishing communities. Sewer system improvements and NDS programs included in the No Action Alternative are not expected to cause socioeconomic or environmental justice impacts.
Measures to reduce or minimize potential impacts		The City would continue public participation efforts as projects are advanced consistent with the City's social and racial justice initiative.

1.5 Public and Agency Review

This section provides an overview of the public and agency review of the Draft EIS, the issues identified during the public comment period, and the City's responses to those comments. Appendix B of this Final EIS includes all comments received during the public review period and the City's response to each.

1.5.1 How were the public and agencies involved in the process?

SPU issued a Notice of Availability of the Draft EIS on May 29, 2014 (SPU, 2014f). The Notice of Availability described the purpose of the Plan and the three alternatives that were considered in the Draft EIS (LTCP Alternative, Integrated Plan Alternative, and No Action Alternative). The Notice of Availability invited agencies, affected tribes, and members of the public to comment on the Draft EIS; provided the date, time, and location of the Draft EIS public hearing; provided the name, address, email address, and phone number of the project manager and the SEPA Responsible Official; and directed people to respond with their comments via email or in writing by June 30, 2014 to the SEPA Responsible Official. Additional SEPA required public notification included the following:

1. The Notice of Availability was posted on the Seattle Department of Planning and Development's Land Use Bulletin on May 29, 2014.
2. The Notice of Availability was posted on the Washington Department of Ecology's SEPA Register on May 29, 2014.
3. The Notice of Availability was published in the Daily Journal of Commerce on May 29, 2014
4. The Notice of Availability was published in the Seattle Times on May 29, 2014.
5. The Notice and Draft EIS were mailed to agencies with jurisdiction, organizations and individuals who requested copies, and organizations and individuals who commented during the scoping process.
6. The Draft EIS was available for public review at SPU's main office on the 49th floor of the Seattle Municipal Tower, the Seattle Central Library, and online at www.seattle.gov/cso.

SPU conducted an extensive public involvement program throughout the development of the LTCP and Integrated Plan, as summarized in Appendix A, Public Involvement Summary Report. This outreach began with EIS scoping in 2011, when SPU conducted 30 briefings of stakeholder groups throughout the city, as well as holding four in-person scoping and one online scoping meeting. The City continued outreach through 2013 and 2014, include briefings and meetings to discuss the Integrated Plan and the LTCP throughout the City, including the South Park and Georgetown communities. Briefings in May and June, 2014 included Sustainable West Seattle, Lake City Neighborhood Alliance, Friends of Gasworks Park, Ballard District Council, Fremont Neighborhood Council, Groundswell NW, Puget Soundkeeper Alliance, NW District County, North Seattle Industrial Association, Leschi Community Council, South Park Neighborhood Association, Delridge Neighborhoods Council, and Thornton Creek Alliance. Briefings were offered to an additional 13 organizations, but were not scheduled, including the Duwamish River Cleanup Coalition, the Georgetown Community Council, and the Greater Duwamish District Council. In addition to the public meeting/hearing, comments could be provided through email or letter. SPU conducted a comprehensive effort to obtain input from all potentially affected neighborhoods and incorporate that input into the development of the LTCP and Integrated Plan Alternatives.

1.5.2 What comments were received on the Draft EIS?

During the Draft EIS comment period, a total of 37 comments were received from the public and agencies. Comments were received from 12 different parties, including four agencies, two organizations, and six individuals. The public hearing was attended by 12 individuals. Comments received were varied, and addressed the following issues or concerns:

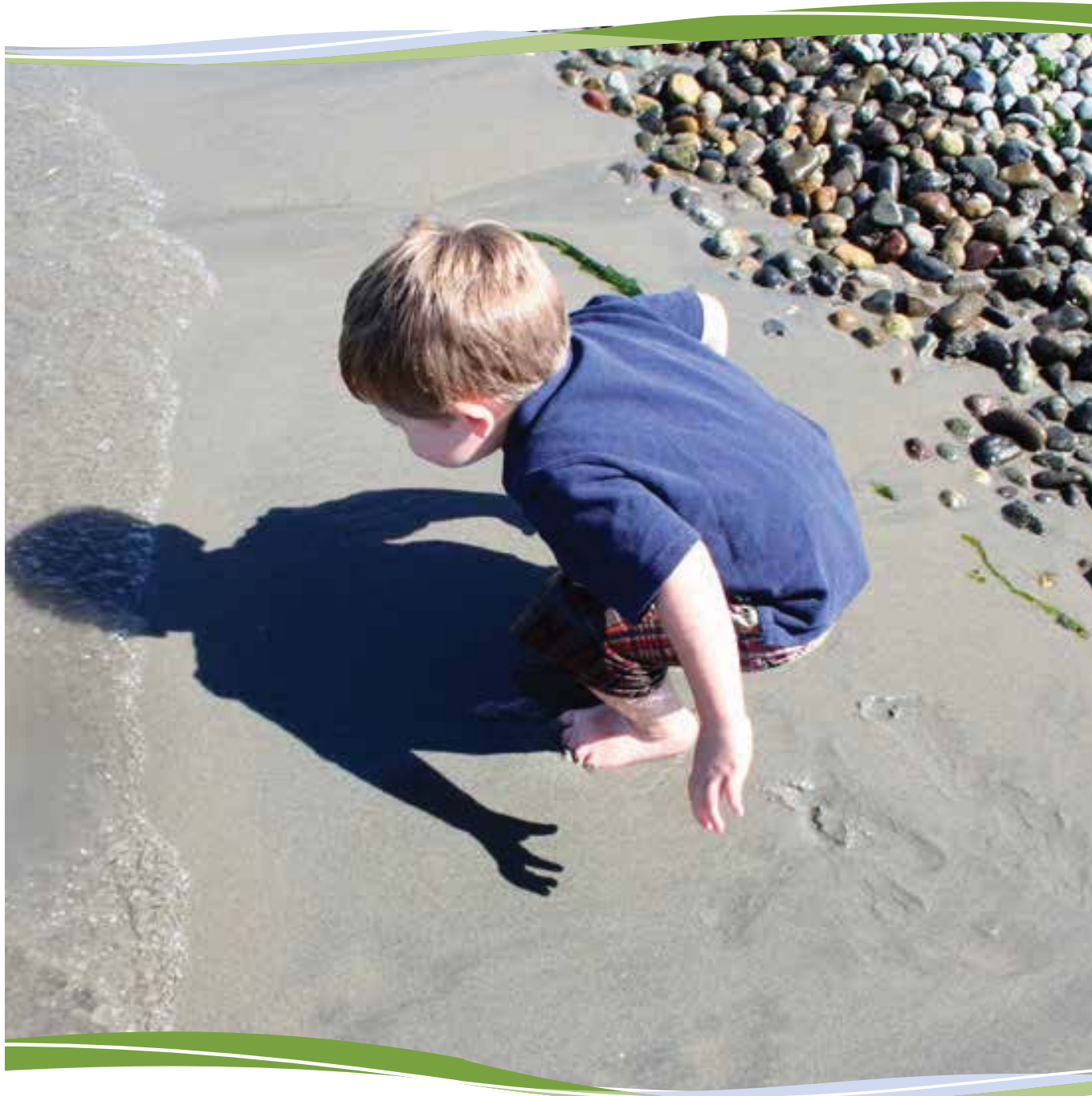
- Water quality: protection of natural resources; protection of public health; maximizing water quality benefits
- Implications of the Plan on the regional wastewater system;
- Concerns of siting facilities in parks;
- Concerns about feasibility of GSI in the Ballard neighborhood;
- Relationship of the Plan to source control efforts in the Duwamish River; outreach and coordination with the South Park and Georgetown neighborhoods;
- Specific concerns related to Thornton Creek and Piper's Creek;
- Support for the Integrated Plan Alternative.

A complete list of the comments and the City's responses is included in Appendix B.

References

- King County. 2012. *2012 King County Long-term Combined Sewer Overflow Control Plan*. Wastewater Treatment Division. October 2012.
- SPU (Seattle Public Utilities). 2010. *Combined Sewer Overflow Program 2010 CSO Reduction Plan Amendment*, May 2010.
- SPU (Seattle Public Utilities). 2013. *2012 Annual Report Combined Sewer Overflow (CSO) Reduction Program*. March 30, 2013.
- SPU (Seattle Public Utilities). 2014a. *The Plan to Protect Seattle's Waterways Volume 1: Executive Summary*. 2014. Available online at www.seattle.gov/cso.
- SPU (Seattle Public Utilities). 2014b. *The Plan to Protect Seattle's Waterways Volume 2: Long-Term Control Plan*. 2014. Available online at www.seattle.gov/cso.
- SPU (Seattle Public Utilities). 2014c. *The Plan to Protect Seattle's Waterways Volume 3: Integrated Plan*. 2014. Available online at www.seattle.gov/cso.
- SPU (Seattle Public Utilities). 2014d. *The Plan to Protect Seattle's Waterways Volume 4: Draft Programmatic Environmental Impact Statement*. May 29, 2014. Available online at www.seattle.gov/cso.
- SPU (Seattle Public Utilities). 2014e. *Long-Term Control Plan: Final – Transportation Alternatives Analysis for Ballard Construction Operations*. October 2014.
- SPU (Seattle Public Utilities). 2014f. *The Plan to Protect Seattle's Waterways – Notice of Availability of Draft Environmental Impact Statement*. 2014. Available online at www.seattle.gov/cso.

Appendix A: Public Involvement Summary Report



Plan to Protect Seattle's Waterways Public Involvement Summary 2010-2014

Since 2010, Seattle Public Utilities has provided multiple opportunities for community members to get information, talk with staff, and provide input as it develops the Plan to Protect Seattle's Waterways, its long-range strategy to keep raw sewage and polluted runoff out of Seattle's lakes, creeks, and Puget Sound. Community input will help Seattle Public Utilities and City Council as it makes decisions that will protect Seattle's waterways. This report summarizes these public involvement activities.

Public Involvement Objectives

Inform

Seattle Public Utilities shared information with the city neighborhoods about the following topics:

- The nature, seriousness, and scale of the combined sewer overflow (CSO) and stormwater runoff problems
- Strategies for controlling and treating sewage overflows and stormwater runoff
- Process and schedule for public participation
- Public meetings and public comment periods
- Availability of project documents
- Project information and updates at key milestones

Involve

Seattle Public Utilities engaged community members by:

- Maintaining consistent communications contact and easy access to Seattle Public Utilities' staff
- Providing opportunities to weigh in at key milestones before decisions are finalized
- Working with community leaders to identify outreach strategies to engage low-income, minority, and limited-English proficient populations in neighborhoods affected by the Plan
- Holding meetings in accessible facilities and making materials available in multiple formats

Consider

After gathering public input, Seattle Public Utilities has:

- Taken community feedback into consideration at all stages of planning, environmental review, and decision-making
- Considered, answered, and accounted for public questions and ideas in the decision-making process



Public Involvement History

2010 – 2011



Signs posted near CSO outfalls notify the public about possible sewage overflows during and following heavy rain

Early Planning

Outreach Purpose: Understand Settle Public Utilities residential customers' awareness, understanding, and attitudes about combined sewer overflows (CSOs). Solicit input to guide early planning decisions for the Long-Term Control Plan (LTCP).

Activities:

- Conducted statistically valid telephone survey of Seattle Public Utilities residential customers. The survey was offered in English, Chinese, and Spanish.
- Conducted four focus groups
- Formed the Sounding Board, comprised of residents, environmental advocates, and representatives of the business and development communities and convened eight meetings
- Conducted interviews with leaders from five community organizations serving low-income, minority, and limited-English proficient community members to develop culturally appropriate public involvement strategies
- Established a real-time reporting website to alert the public when CSOs occur

Outcomes:

- Identified key messages and appropriate outreach strategies
- Sounding Board members:
 - Developed an understanding of the data and rationale for Long-Term Control Plan projects
 - Assisted in developing and applying criteria to make decisions about Plan alternatives
 - Provided guidance on public involvement activities and communications

Plan to Protect Seattle's Waterways Scoping

Outreach Purpose:

Inform Seattle residents about Seattle Public Utilities intent to prepare a Programmatic EIS for the Plan to Protect Seattle's Waterways and provide opportunities to share preferences about the scope of issues to study in the EIS.

Activities:

- Conducted briefings with 13 community organizations and stakeholder groups
- Prepared the Community Guide to the Plan to Protect Seattle's Waterways to provide an overview of the Plan purpose and alternatives and how to comment during scoping
- Developed a six-minute video about the Plan and environmental review process
- Published Determination of Significance (DS) and SEPA Scoping Notice and advertised scoping meetings through mail to approximately 330,000 Seattle residents, email, posters, and advertisements in local newspapers and community blogs
- Hosted one public scoping meeting and one agency scoping meeting and received 30 comment forms, letters, and emails during the 30-day comment period

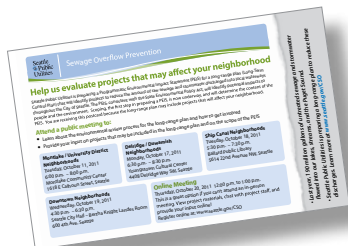
Outcomes:

- Reviewed comments and determined the range of alternatives, identified potentially significant issues and refined the public involvement program
- Summarized and shared the EIS Scoping Summary Report, available on the Seattle Public Utilities CSO website



Approximately 120 people viewed the Plan to Protect Seattle's Waterways information video and 26 people completed the online survey imbedded in the video

Fall 2011



Seattle Public Utilities mailed postcards to over 63,000 residences and businesses and published a Determination of Significance to inform the community it was preparing an EIS.

Long-Term Control Plan Scoping

Outreach Purpose: Inform Seattle residents about Seattle Public Utilities plans to prepare a programmatic Environmental Impact Statement (EIS) for the Long-Term Control Plan and provide opportunities to share preferences about the scope of issues to study in the EIS.

Activities:

- Conducted briefings with 30 community organizations and stakeholder groups
- Prepared the Community Guide to the Long-Term Control Plan to describe the Plan purpose, alternatives, and environmental review process
- Hosted four public scoping meetings, one online scoping meeting, and one agency scoping meeting and received 34 comments during the 30-day public comment period

Outcomes:

- Reviewed comments and identified potentially significant issues and refined the public involvement program
- Summarized and shared the EIS Scoping Summary Report, available on the Seattle Public Utilities CSO website

2012

Reevaluate Alternatives

Outreach Purpose: Inform the community about the purpose and benefits of the Consent Decree the City of Seattle negotiated with the Washington Department of Ecology (Ecology), the U.S. Environmental Protection Agency (EPA), and the U.S. Department of Justice.

Activities:

- Updated website with information about the Consent Decree and why Seattle Public Utilities negotiated it
- Conducted media outreach to announce the Consent Decree and provide information about its purpose and benefits
- Refined the public involvement process to support the development and environmental review of the Plan to Protect Seattle's Waterways

Outcomes:

- Identified new stakeholders interested in and potentially affected by the new Integrated Plan alternative
- Community members who participated in past public outreach activities for the Long-Term Control Plan learned about the new opportunities Seattle Public Utilities is exploring to control and treat both CSOs and polluted stormwater runoff

Evaluate Alternatives

Outreach Purpose: Provide the public and stakeholders with more detailed information about Plan alternatives, with an emphasis on the Integrated Plan alternative.

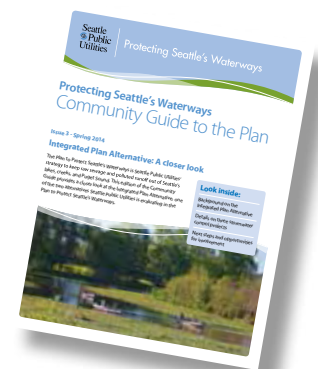
Activities:

- Prepared the Community Guide to the Integrated Plan to provide an overview of the three stormwater control projects Seattle Public Utilities is evaluating for the Integrated Plan Alternative
- Established the West Ship Canal Stakeholder Advisory Group to obtain focused input from stakeholders in Ballard, Fremont, and Wallingford and convened six meetings

Outcomes:

- Identified the West Ship Canal Advisory Groups' seven priorities for Seattle Public Utilities to consider as it evaluates the Plan to Protect Seattle's Waterways:
 - Protect waterfront/industrial businesses
 - Minimize impacts to freight mobility
 - Protect habitat
 - Avoid impacts to private property
 - Minimize economic impacts
 - Maintain flow of traffic
 - Benefit the community

Fall 2013 – Winter 2014



The Community Guide to the Integrated Plan introduces three projects to address stormwater runoff in areas that are not part of the combined sewer system

Issue Draft Environmental Impact Statement

Outreach Purpose: Provide information to and collect comments from the public and agencies about the environmental impacts associated with adopting and implementing either of the two Plan alternatives.

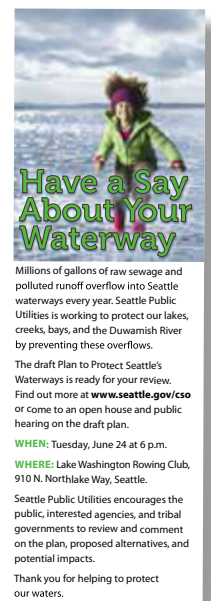
Activities:

- Published legal notice of the Draft EIS release and received 37 comments during the 30-day comment period
- Advertised the availability of the Draft EIS and public hearing through mail to approximately 330,000 Seattle residents and website notices
- Hosted the Draft EIS public hearing and Long-Term Control Plan public meeting on June 24, 2014
- Conducted briefings with 13 community organizations and stakeholder groups

Outcomes:

- Considered the Draft EIS findings and public comments to identify a preferred alternative
- Summarized public comments and published the Draft EIS Public and Agency Comment Summary, available on the project website

Spring 2014



Seattle Public Utilities advertised the Draft EIS public hearing in its Curb Waste newsletter, which is mailed to approximately 330,000 Seattle residents

Next Steps

Late 2014

- Publish the Final EIS
- Announce the Preferred Alternative

Spring 2015

- Mayor and Seattle City Council Adopt Plan
- Submit for approval by the Washington Department of Ecology and U.S. Environmental Protection Agency by May 30, 2015

2016

- Project-specific public involvement for siting, design and environmental review for individual combined sewer overflow reduction projects and stormwater control projects

Sounding Board Members

City Residents

Anindita Mitra, *Greenwood resident*
Dusty Hoerler, *Maple Leaf resident*
Bruno Lambert, *Pike/Pine resident*
Julio Moran, Jr., *Columbia City resident*
Mary Junttila, *Rainier Beach resident*
Robin McKennon Thaler, *West Seattle resident*

Stakeholders

Rachel Ben-Shmuel, *Vulcan*
Kathy Fletcher, *People for Puget Sound*
Henry McGee Jr., *Professor of Law, Seattle University*
Joan Rosenstock, *Floating Home Owners/Floating Homes Association*
Tom von Schrader, *SvR Design Company*
J. Tayloe Washburn, *Greater Seattle Chamber of Commerce*

West Ship Canal Stakeholder Advisory Group

Barry Hawley, *Ballard real estate/business communities*
Catherine Weatbrook, *Chair, Ballard District Council, Crown Hill Business Association*
Elizabeth Dunigan, *Threading the Needle Park*
Jessica Vets, *Fremont Chamber of Commerce*
Kim McDonald, *Ballard Stormwater Consortium*
Larry Ward, *Waterfront/industrial businesses*
Rachel Koller, *Ballard District Council*
Robert Drucker, *Ballard District Council*
Stephen Fickenscher, *Wallingford Chamber of Commerce*

For more information:

Call: **206-733-9195**

E-mail: **CSO_LTCP@seattle.gov**

Visit our website: **www.seattle.gov/CSO**

Appendix B: Draft EIS Comments and Responses



Allyson Brooks Ph.D., Director
State Historic Preservation Officer

June 30, 2014

Mr. Betty Meyer
SEPA Responsible Official
Seattle Public Utilities
Seattle Municipal Tower
PO Box 34018
Seattle, WA 34018

In future correspondence please refer to:
Log: 063014-32-ECY
Property: Plan to Protect Seattle's Waterways
Re: Archaeology-Review Comments

Dear Mr. Meyer:

1-1 [Thank you for contacting the Washington State Department of Archaeology and Historic Preservation (DAHP). The above referenced project has been reviewed on behalf of the State Historic Preservation Officer. DAHP will need to review all cultural resources reports for any ground disturbing activities at least 60 days in advance. As you are aware, Seattle contains many archaeological sites which are protected under state laws. Archaeological resources do not seem to have been addressed as part of the current EIS but will need to be identified and addressed prior to project implementation.

Thank you for the opportunity to review and comment.

Sincerely,

Gretchen Kaehler
Local Governments Archaeologist
(360) 586-3088
gretchen.kaehler@dahp.wa.gov

cc. Richard Young, Cultural Resources, Tulalip Tribe
Laura Murphy, Archaeologist, Muckleshoot Tribe
Dennis Lewarch, THPO, Suquamish Tribe
Steve Moses-Mullen, THPO, Snoqualmie Tribe
Tara Duff, Cultural Resources Directory, Stillaguamish Tribe
Kerry Lyste, Cultural Resources, Stillaguamish Tribe



Response to Comment 1-1

The Draft EIS acknowledges that additional project-specific SEPA evaluations will be required once project sites are identified and prior to project implementation. As described in Section 5.11.5, the City would also consult with agencies and other stakeholders, including DAHP, in accordance with SEPA or other regulatory triggers (i.e., Section 106).



June 30, 2014

Electronic submittal: betty.meyer@seattle.gov

Ms. Betty Meyer
SPU SEPA Responsible Official
Seattle Public Utilities
Seattle Municipal Tower, Suite 4900
PO Box 34018
Seattle, WA 98124-4018

Subject: Response to public comment period on the Plan to Protect Seattle's Waterways

2-1

Please accept these comments from the Washington State Department of Natural Resources (DNR) regarding the Plan to Protect Seattle's Waterways (Plan). DNR understands that the Plan includes Volume 1 Executive Summary, Volume 2 Long Term Control Plan (LTCP), Volume 3 Integrated Plan, and Volume 4 Environmental Impact Statement (EIS). Seattle Public Utilities (SPU) prepared an Environmental Impact Statement (EIS) under the State Environmental Policy Act (SEPA) to identify how the Plan could impact people and the environment. DNR has the constitutional responsibility to manage state-owned aquatic lands as a public trust. We strive to provide a balance of benefits to people and the environment including: ensuring environmental protection, providing opportunities for using renewable resources such as shellfish, fostering water dependent uses and facilitating public access. DNR is committed to sustainably managing the state's resources, relying on sound science, and making transparent decisions in the public's interest throughout the environmental review process.

Please accept the following comments on Volume 4 Draft Programmatic Environmental Impact Statement.

2-2

DNR appreciates the actions that the City has taken over the years to reduce the number and frequency of sewerage overflows from the City's combined sewer overflow (CSO) system. In 2013, 38 million gallons of untreated sewage and stormwater discharged at CSOs managed by the City. CSOs from the City's combined sewer system currently discharge into Puget Sound, Elliott Bay, Lake Washington, Longfellow Creek, Lower Duwamish Waterway, East Waterway, and Lake Union/Ship Canal. Although state citizens appreciate the steps that the City is taking to reduce the CSO events and volume, these discharges are impacting state-owned aquatic lands and natural resources.

2-3

Due the length of the document and short-time frame that was given for review, DNR will not be providing specific comments on the document. Instead, DNR would like SPU and the City to know that we look forward to working with both entities on upcoming projects and work that will be on, or affecting, state-owned aquatic lands. We encourage the City and SPU to work with DNR early to ensure that changes to outfalls, permits, and upland activities affecting state-owned aquatic lands will meet DNR's goals with regard to protecting habitats and species in the aquatic environment. Working with DNR early can help ensure that time, money, and effort is not wasted. Underlying our habitat goals is our foundational goal: to provide sustainable stewardship of the lands in our care; DNR is required by statute (RCW 79.105.030) to ensure environmental protection when managing state-owned aquatic lands.

2-4

DNR is concerned with the range of public health and environmental concerns that pollutants conveyed in CSOs can create, such as human health risks from contact with water, consumption of fish/shellfish from areas of recent CSO discharge, and impacts to aquatic life. DNR is anticipating the final result of this Plan will eliminate these discharges and substantially reduce releases of microbial pathogens, suspended solids, toxics, and nutrients. We believe it is important for the City to implement the Consent Decree to provide increased protection for several impaired water bodies, including Puget Sound, Lake Washington, and the Duwamish River. Due to magnitude and complexity of the CSO problem it would be ideal for the City and King County to work together to find solutions to the problems with CSOs.

Thank you for the opportunity to comment and we look forward to working with SPU and the City of Seattle on this important issue.



Michal Rechner
Washington Department of Natural Resources
Aquatic Resources Assistant Division Manager

Response to Comment 2-1

Comment noted.

Response to Comment 2-2

Comment noted. The Draft EIS acknowledges the importance of reducing CSO discharges in order to protect public health and the environment.

Response to Comment 2-3

Comment noted. As described in the Draft EIS, additional project- and site-specific SEPA evaluations will be required once project sites are identified and prior to project implementation. The City is committed to working with DNR early in this process to address the impacts of any proposed work on DNR lands.

Response to Comment 2-4

The Draft EIS acknowledges the importance of reducing CSO discharges in order to protect public health and the environment. These public health and environmental concerns are discussed in EIS Sections 2.2, 2.3, and 4.6, and in Chapter 2 of the Long Term Control Plan. The City is committed to complying with federal and state regulations, and meeting its Consent Decree requirements. As described in Section 2.4.4, CSOs will not be completely eliminated, but will be controlled in accordance with Consent Decree requirements. Section 6.4 discusses the reductions of pathogens and loading reductions, which are further described in the Long Term Control Plan and in Section 8 of the Integrated Plan. The response to Comment Letter No. 3 (King County WTD) describes the City's commitment to working with King County on meeting CSO reduction goals.



King County

Wastewater Treatment Division

Department of Natural Resources and Parks

King Street Center
201 South Jackson Street
Seattle, WA 98104-3855

June 30, 2014

Nancy Ahern, Deputy Director
Utility Systems Management Branch
Seattle Public Utilities
700 5th Avenue, Suite 4900
Seattle, WA 98124-4018

Dear Ms. Ahern,

Thank you for the opportunity to review and comment on Seattle Public Utilities' (SPU) Draft Plan to Protect Seattle's Waterways. Staff at the King County Wastewater Treatment Division (WTD) reviewed all four volumes; the Executive Summary, Long-Term Control Plan (LTCP), Integrated Plan, and Draft Environmental Impact Statement (DEIS). WTD's comments are as follows.

3-1 [The LTCP (Volume 2) recognizes that all of the proposed options have elements that may have an impact on King County's downstream wastewater system, and that strong coordination between the City and County is needed. We look forward to continuing to coordinate with the City as it designs and constructs its CSO control facilities.

3-2 [The LTCP includes three shared options for controlling CSOs that would involve both SPU and WTD working together to control our respective CSOs along the Lake Washington Ship Canal. WTD concurs with statements made throughout the LTCP regarding City/County coordination. We are committed to working with SPU to analyze and recommend LTCP options that are more cost effective, produce better environmental outcomes, and minimize disruption to communities. As described in the LTCP, King County will need to reach its own independent conclusions about the benefits of any shared project to our regional wastewater system as well as the implications of a shared project to the County's LTCP and Consent Decree. In addition, as described in the LTCP, prior to implementing any shared projects between the County and the City, joint project agreements will need to be signed between the two agencies.

3-3 [WTD has reviewed the Integrated Plan (Volume 3). We recognize that the Integrated Plan is additive to the LTCP and is intended to provide the City with additional tools for addressing water quality concerns. We have no additional comments.

3-4

The Draft EIS (Volume 4) acknowledges the importance of strong coordination with King County as part of controlling the City's CSOs for both shared and City-only projects. Section 1.5 addresses how the City and King County will coordinate and the need for shared project agreements prior to implementing any shared projects between the City and King County. Both parties would need to be involved analyzing the impacts of the proposed projects on the downstream system and agree on an approach to address those impacts. The shared project agreements would need to be negotiated and signed between the two agencies. Coordination is also necessary on City projects that are not shared, such as retrofits, where increased flow will be transferred to King County and have the potential to cause downstream impacts. The nature of those impacts will need to be analyzed and appropriate compensation to the County to negotiated, where applicable.

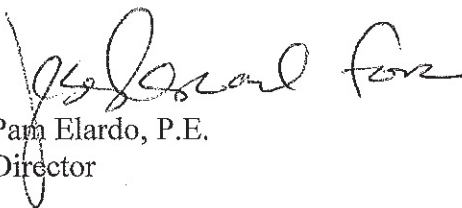
The Draft EIS describes the commitment the City has to work with King County to analyze and recommended LTCP options that produce better environmental outcomes and minimize disruption to communities. The construction and operational elements also recognize the important need for close coordination and shared agreements.

3-5

Please note that Table 1-1 of the Draft EIS illustrates the total number of CSO storage facilities that would be constructed under the four SPU LTCP options, either by the City-only, King County-only or as shared City/County facilities. It is not clear that the King County-only facilities are elements in King County's own LTCP and not part of the City's LTCP. Please clarify this detail.

Thank you again for the opportunity to review and comment on Seattle Public Utilities' (SPU) Draft plan to Protect Seattle's Waterways. We look forward to continuing to work with SPU as our two agencies work to implement our respective CSO Long-Term Control Plans. If you have questions or require additional information regarding our review of SPU's Draft Plan, please contact Mark Buscher, Comprehensive Planning Supervisor at (206) 477-5553.

Sincerely,



Pam Elardo, P.E.
Director

Response to Comment 3-1

SPU will continue to coordinate with King County regarding the optimal shared approach to CSO control.

Response to Comment 3-2

SPU is committed to continued coordination with King County. The need to develop a joint project agreement prior to implementing any project in association with King County is acknowledged in Sections 1.4, 1.5, 2.7.1, 3.2.2, and 6.13.1 of the Draft EIS.

Response to Comment 3-3

Comment noted.

Response to Comment 3-4

As noted in the Draft EIS and in the response to Comment 3-2, SPU is committed to continued coordination with King County. All interagency coordination will be conducted in accordance with commitments included in the SPU and King County Wastewater Treatment Division Coordination Plan, signed by SPU and King County on April 4, 2014. Agreements between the City and King County will be made in accordance with the Guiding Principles and final Term Sheet agreed upon by the City and King County in November, 2013. As noted in that memorandum, the City and the County have agreed to move together on two fronts: 1) coordination on implementation of the agencies' respective CSO reduction projects and Long Term Control Plans; and 2) negotiations toward a new sewage disposal agreement.

Response to Comment 3-5

Additional text has been added to Table 1-1 to clarify that King County-only facilities are part of King County's LTCP, and not SPU's LTCP.



City of Seattle
Seattle Parks and Recreation

June 24, 2014

Betty Meyer, SEPA Responsible Official
Seattle Public Utilities
Seattle Municipal Tower, Suite 4900
Seattle, WA 98124-4018

Sent via e-mail: betty.meyer@seattle.gov

Re: Draft Environmental Impact Statement for the Plan to Protect Seattle's Waterways

4-1

Seattle Parks and Recreation (Parks) appreciates the opportunity to provide comments on the Seattle Public Utilities' Draft Environmental Impact Statement for the Plan to Protect Seattle's Waterways issued on May 29, 2014. Parks also appreciates SPU's stated commitment that they will "[a]ttempt to avoid siting projects in parks." Parks' concerns are the potential impacts associated with the construction and long term operation of CSO facilities within and/or adjacent to parks within the City of Seattle.

4-2

Parks' concern is that the placement of a CSO facility within a park forever constrains the use of this area, regardless of whether or not it is under paved and/or un-programmed areas. Parks will be forever precluded from changing the use of the site to provide a different park amenity and/or recreational opportunity due to the underlying utility facility. Should stormwater regulations become more stringent in the future and SPU needs to expand a facility within a park, even more property could be needed. Parks looks forward to a full and complete analysis of all alternatives and their potential impacts on the public's opportunities for recreation within the city, including both the short term construction and long term operational impacts of siting a utility facility within a recreational and/or natural resource area. Note also that Initiative 42 (Ordinance No. 118477) discourages the conversion of park lands within the City of Seattle to non-park usage.

4-3

Parks also looks forward to working cooperatively with Seattle Public Utilities throughout the process to ensure that CSOs can be addressed and that impacts on parks and park visitors are minimized. Thank you for your consideration of these comments as you begin the process of selecting sites and designing facilities. If you have any questions regarding these comments, please contact me at 206.684.7048 or david.graves@seattle.gov.

Regards,

David Graves, AICP
Senior Planner
Planning & Development Division
Seattle Parks & Recreation

Cc: Michael Shiosaki, Planning & Development Division Director

❖Planning and Development Division ❖

800 Maynard Avenue South, 3rd Floor, Seattle, Washington 98134-1336
Tel: (206) 233-3872, Fax: (206) 233-3949

Response to Comment 4-1

Comment noted. SPU acknowledges that if a facility is located in a park, impacts to recreation would occur. Construction-related and long-term impacts to recreation, and measures to reduce short- and long-term impacts, are described in Sections 5.10 and 6.10, respectively.

As described in Section 5.10.5 of the Draft EIS, SPU would attempt to avoid siting facilities in parks. If a facility were to be located in a park, SPU would coordinate closely with Parks during the facility siting process to incorporate Parks' considerations. SPU is committed to working with Parks to develop facilities that fulfill the City's legal obligations for the reduction of sewage discharges while addressing short- and long-term recreational impacts. If a facility were to be located in a park, mitigation would be identified at the project level, either as part of the City Council process to address Initiative 42 and the City's land use codes or during the process to obtain a Revocable Use Permit.

Response to Comment 4-2

Parks' concerns and priorities are a significant consideration during the project-level siting process of CSO reduction facilities. It is acknowledged that the presence of an underground storage facility in a park limits some types of potential park uses. If a CSO reduction facility were to be located in a park, SPU would work closely with Parks to design and install a facility that provides long-term flexibility for Parks while meeting SPU's mandated water quality requirements.

Response to Comment 4-3

SPU is committed to working with Parks throughout the process. The Draft EIS describes this commitment in Sections 5.10.5 and 6.10.4, respectively.



SHELTERWOOD CONSULTING

7716 -32nd Ave NW, Seattle, Washington 98117

206.571-4249

Ms. Betty Meyer
SPU SEPA Responsible Official
Seattle Public Utilities
Seattle Municipal Tower, Suite 4900
PO Box 34018
Seattle, Washington 98124-4018

Re: DEIS on Plan to Protect Seattle's Waterways

Dear Ms. Meyer:

Thank you for the opportunity to comment on the DEIS referenced above.

I represent the Ballard Stormwater Consortium and a variety of Ballard residents located in the Combined Sewer Overflow areas. As stakeholders in the discussions over solutions and compliance with the Consent Decree, my clients wish to comment on the DEIS as it impacts the Ballard combined sewer overflows.

5-1

Ballard residents are uniquely located. Many residents have views of Puget Sound, boats moored in the Shilshole Marina, take family outings through "the Locks," and bicycle along Salmon Bay. Ballard residents are very aware of the consequences of storm water runoff and the potential for combined sewer overflows at the outtake pipes located in Salmon Bay. Water quality is a vital issue to Ballard residents.

5-2

Because of their concerns, many Ballard residents believe that the solutions to the CSO issues in the Ballard and Fremont neighborhoods should focus on maximizing detention and "pulsing" of storm water at the greatest volumes (including those volumes projected to increase because of climate change). Additionally, Ballard residents believe that delaying any CSO projects in order to attempt to facilitate so-called green storm water infrastructure (GSI), simply increases the amounts of untreated sewage into Salmon Bay and Puget Sound.

5-3

Ballard, like much of Seattle, has a native soil composition found throughout the Puget Sound region. The soils are not conducive to infiltration. The first phase of the Ballard Rain Garden project, completed in 2009, was a failure because of the soils. The reliance, in both the Long Term Control Plan Alternative and the Integrated Plan Alternative, of rain gardens to capture a

5-3

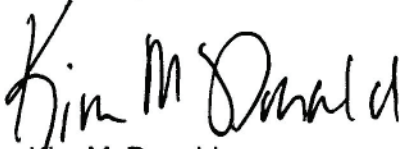
small amount of storm water (compared to the ability to capture greater volumes in the proposed tanks underneath the Ship Canal) is not cost effective per gallon of stormwater contained. Plus, there remains a likelihood the rain gardens will, again, not be successful.
Page Two

5-4

Ballard Stormwater Consortium strongly endorses the Long-Term Control Plan Alternative, with a strong emphasis on storage for storm water. We believe that any use of GSI should be minimal because of lack of effectiveness. If the goal is to prevent combined sewer overflows into Seattle's waterways, finding the most cost effective and efficient system is vital.

Thank you for your consideration.

Sincerely,

A handwritten signature in black ink that reads "Kim McDonald". The signature is written in a cursive, flowing style.

Kim McDonald
Principal
Shelterwood Consulting
kim@shelterwoodconsulting.com

Response to Comment 5-1

Comment noted.

Response to Comment 5-2

Comment noted. The City's Consent Decree requires that the Long Term Control Plan provide 100% of the necessary control volume using "gray infrastructure" solutions. However, the Consent Decree allows the City to use Green Infrastructure as appropriate to reduce or replace certain CSO control measures included in the LTCP once the City has demonstrated those facilities' effectiveness, as long as the combined "green" and "gray" measures provide substantially the same or greater levels of control than the traditional "gray" CSO control measures alone. SPU will continue to evaluate the potential applicability of Green Infrastructure, which could reduce the volume requirements for the storage facilities. In the Integrated Plan Alternative, the proposed deferred CSO reduction facilities are in relatively small volume CSO basins that do not discharge directly to Salmon Bay or Puget Sound. Refer to the Summary included in the Integrated Plan for a figure illustrating deferred CSO reduction facilities, and the overall pollutant reduction associated with implementation of the Integrated Plan.

Response to Comment 5-3

Comment noted. Refer to Section 4.1.5 for a discussion of soils and surface geology and the potential to affect infiltration potential; Figure 4-2 illustrates infiltration potential in Seattle Plan Area neighborhoods, including Ballard. Additional site specific evaluations will be conducted for all proposed rain garden facilities, to ensure that conditions are appropriate for their long term feasibility. The City will monitor the effectiveness of facilities as part of post-construction monitoring required under the Consent Decree.

Response to Comment 5-4

Comment noted. The City has evaluated the potential cost-effectiveness for all LTCP options, and has factored this information into the evaluation of alternatives. The City is committed to providing a cost-effective approach to CSO control, and as part of this commitment, developed the Integrated Plan Alternative that extends beyond the Consent Decree compliance date, but can be potentially more cost effective and lower impact to communities.



Technical Advisory Group

Community Advisory Board:

Community Coalition for
Environmental Justice

The Duwamish Tribe

Environmental Coalition
Of South Seattle

Georgetown Community
Council

IM-A-PAL Foundation

People For Puget Sound

Puget Soundkeeper
Alliance

South Park Neighborhood
Association

Washington Toxics
Coalition

Waste Action Project

*Working to ensure a
Duwamish River cleanup
that is accepted by and
benefits the community
and protects fish, wildlife
and human health.*

210 S. Hudson, Suite #332

Seattle, WA 98134

206.954.0218

www.duwamishcleanup.org
contact@duwamishcleanup.org

TO

Betty Meyer

SEPA Responsible Official

Seattle Public Utilities 700 5th Ave, Suite 4900 PO Box

34018 Seattle, WA 98124-4018

(206) 386-1999

Betty.Meyer@Seattle.Gov

Ms. Meyer

The Duwamish River Cleanup Coalition/Technical Advisory Group (DRCC/TAG) was founded in 2005 by the member organizations of the Duwamish River Cleanup Coalition (DRCC), the Environmental Protection Agency's (EPA) Community Advisory Group (CAG) for the Lower Duwamish Waterway Superfund Site (the Site). DRCC/TAG provides technical support and public education, outreach and involvement services to the DRCC member organizations, the communities affected by the Superfund site, other Duwamish River stakeholders, and the general public.

DRCC/TAG has reviewed the Draft Environmental Impact Statement for the Plan to Protect Seattle's Waterways and has the following comments.

- 6-1

6-2

Most of our comments will be on SPU outreach that was done for the draft EIS. Even though it is stated in the plan that public comment is valued the plan fails to directly approach the source control plan for the Duwamish River Superfund Site. There has been no outreach done on the Plan to Protect Seattle's Waterways to the effected communities of South Park or Georgetown that have been designated as Environmental Justice Communities by USEPA. With only one public meeting that was also combined with a public hearing plus only designated outreach done in Ballard, Wallingford and Fremont it seems that SPU has made the decision those are the only communities that have a stake in your

plan.

6-3

I would refer you to the City of Seattle's Race and Social Justice Initiative that clearly states that "city departments work together on common areas like: Inclusive outreach and public engagement" Goal 2 of the "Moving Forward" section of the RSJ plan "Strengthen the way the city engages the community and provides services" No matter how good you think your plan is if you do not engage communities that are directly affected you really don't have an effective plan.

6-4

The communities of South Park and Georgetown have been very actively engaged in the Superfund process and the fact that your plan does not even attempt to directly address it should suggest there is a big problem. Several of our stake holders have expressed concern that this plan fails to address impacts to the Duwamish River. DRCC/TAG is the Community Advisory Group to EPA on the Duwamish River Superfund Site and it is our job to point out these inequities.

6-5

The consent decree with Ecology and EPA is not the only pressing issue SPU has. Source control in the Duwamish River should be elevated to at least a section of focus in your EIS.

James Rasmussen



Coordinator DRCC/TAG

Response to Comment 6-1

Comment noted. In conducting public outreach for the development of the LTCP and the Integrated Plan, SPU did not explicitly ask for input on the Duwamish source control plan because (a) it was not the focus of the LTCP or the Integrated Plan and (b) it was being developed as part of an inter-agency effort to clean up the Duwamish River.

Response to Comment 6-2

SPU conducted an extensive public outreach program throughout the development of the LTCP and Integrated Plan, as summarized in Appendix A, DEIS Public Hearing and LTCP Public Meeting Summary Report. SPU sought input throughout the Draft EIS process, including during Draft EIS scoping as well as during the Draft EIS comment period.

From April through October 2011, SPU conducted 30 briefings associated with the Draft EIS Scoping, including briefings with the Environmental Coalition of South Seattle (ECOSS), Greater Duwamish District Council, Southeast District Council, and the SPU Creeks Drainage and Wastewater Advisory Committee. Additional briefings were conducted from April to June of 2013 that included the Georgetown Community Council, Delridge District Council, and the Greater Duwamish District Council, among others. SPU hosted four in-person EIS scoping meetings, and one on-line scoping meeting in 2011, which were sparsely attended. As a result, when the Draft EIS “re-scoping” process was conducted in 2013 to include the Integrated Plan Alternative, one centrally-located scoping meeting was held.

Following scoping and during the Draft EIS comment period, SPU conducted additional briefings and meetings throughout the City, including in the South Park and Georgetown communities. Briefings in May and June, 2014 included Sustainable West Seattle, Lake City Neighborhood Alliance, Friends of Gasworks Park, Ballard District Council, Fremont Neighborhood Council, Groundswell NW, Puget Soundkeeper Alliance, NW District Council, North Seattle Industrial Association, Leschi Community Council, South Park Neighborhood Association, Delridge Neighborhoods Council, and Thornton Creek Alliance. Comments received are included in Appendix A, Briefing Summary. Briefings were offered to an additional 13 organizations, but were not accepted, including the Duwamish River Cleanup Coalition, the Georgetown Community Council, and the Greater Duwamish District Council. SPU conducted a comprehensive effort to obtain input from all potentially affected neighborhoods, and incorporate that input into the development of the LTCP and Integrated Plan Alternatives.

Response to Comment 6-3

SPU has incorporated the goals of the City’s Race and Social Justice Initiative into its public outreach plan, working actively toward inclusive outreach and public engagement since the early stages of the planning process. The project team conducted interviews with leaders from community organizations that serve low-income, minority, and limited-English proficient community members, to develop outreach strategies for the program. The following organizations participated in interviews: El Centro de la Raza, Neighborhood House, Southwest Youth and Family Services, Vietnamese Friendship Association, and Solid Ground. Given feedback, SPU conducted outreach through briefings with organizations/dovetailing on existing meetings, as the CSO long-range plan was not a very compelling topic for a standalone meeting. In addition, SPU conducted a citywide survey in 2011 to gauge awareness and to determine effective outreach strategies. The survey was offered in English, Chinese, and Spanish.

At the project level, SPU is working closely with communities using many of the strategies discussed in the interviews, such as hiring community members to conduct project outreach. These efforts would likely be employed during implementation of the Plan/project development phase as appropriate.

SPU is committed to continuing to work closely with all potentially affected communities, including the South Park and Georgetown communities.

Response to Comment 6-4

SPU is aware of the active engagement of the South Park and Georgetown neighborhoods in the Superfund process. The Duwamish River is summarized as a Superfund site in Section 4.3.3.4 of the Draft EIS, and in Section 2.1 of the Integrated Plan. The DEIS notes that stormwater runoff is the leading pollution threat to surface waters within the Plan area, along with CSOs. The sensitivity of the Lower Duwamish Waterway led to its prioritization for a stormwater project as part of the Integrated Plan Alternative. Implementation of the South Park Water Quality Facility would result in significant pollutant load reductions to the Lower Duwamish River, which support water quality improvement objectives for the Lower Duwamish. As described in Section 8.4.1.2 of the Integrated Plan, the South Park Water Quality Facility would treat runoff from approximately 254 acres in the 7th Ave. South drainage system, and would reduce loads of total PCBs, metals, bacteria, and other pollutants to the Duwamish Waterway.

SPU will continue to support Superfund cleanup efforts through the LTCP and/or Integrated Plan Alternative, and will coordinate as appropriate with lead agencies responsible for implementing the cleanup plan, as well as the potentially affected communities.

Response to Comment 6-5

SPU acknowledges that there are many pressing issues to be considered, including source control in the Duwamish River. As part of its efforts to comply with the Consent Decree, SPU is taking a significant step toward reducing pollutant loading to the Duwamish River.

From: Frank I Backus [<mailto:frankbackus1@gmail.com>]
Sent: Monday, June 30, 2014 11:09 PM
To: Meyer, Betty
Subject: Integrated Stormwater Plan

7-1

I have lived on Thornton Creek for 44 years. I would like to thank SPU for its efforts over the years to improve the Thornton Creek Watershed. I know that it has done a lot. But we are still the most polluted of the streams in the city.

7-2

I have seen severe problems with pollution including seeing the result of the North Fork actually having been on fire. I have seen severe flooding that in previous decades did not occur. I have seen dead fish from pollution. I have called uncounted times to report pollution in the stream. I have seen the results of coliform testing that show that Thornton Creek is the most polluted stream in the City of Seattle. I have partnered with SPU to put large woody debris in the creek on my property at great expense to me (Salmon Grant). I have volunteered many hundreds of hours in stewarding parks and private property; and I have invested thousands of dollars in plantings, formation of rain gardens, stream rehabilitation, weeding, and working with King County weed specialists. I have counted fish for the Salmon in the Streams research program. I have helped look for and document presence of salamanders. I have walked to help count "pre-spawn mortality" (though in Piper's Creek). I have spent countless hours with the Thornton Creek Alliance and have been on the Thornton Creek Watershed Oversight Council.

I support the Integrated Stormwater Plan, but have some added comments:

The Integrated Stormwater Plan is a more comprehensive and effective way to address water pollution in the city; and it addresses the most significant Combined Sewer Overflow locations in the city.

Please include more than the current very meager 4% of the Natural Drainage System appropriate sites in the efforts to improve the watershed.

7-3

SPU should increase its efforts to partner with private land owners.

7-4

VACUUM sweeping of the streets is much more effective in removing pollution and fine particles (which in turn often hold additional pollutants) than simply sweeping. In addition, the fine particles are pollutants in themselves, as they are bad for fish spawning.

Thank you for considering my comments.

Frank I. Backus, MD
 450 NE 100th Street
 Seattle, WA 98125-4028

Response to Comment 7-1

Comment noted. SPU acknowledges that Thornton Creek has a number of persistent water quality challenges. This is why Thornton Creek is one of three drainage basins targeted in the Integrated Plan for candidate stormwater projects, including Natural Drainage Systems (NDS) Partnering as described in the EIS.

Response to Comment 7-2

Potential blocks for NDS Partnering were identified by the City based on their potential feasibility for bioretention. The initial estimate of 4 percent was identified as areas that were determined to be feasible for implementation within the time frame of the Integrated Plan. This percentage is approximate; SPU will continue to look for expanded opportunities for partnership on NDS projects.

The site selection approach will involve information exchange with neighborhood groups and other public agencies about the program, and selection of project sites based on input from these groups. The project locations would be prioritized based primarily on stormwater management goals, but factors such as community support and overlapping City priorities would be considered.

Response to Comment 7-3

SPU has found that the most successful NDS projects are those that have neighborhood support. SPU will continue to conduct outreach with neighborhood groups in the potentially feasible residential areas. SPU is currently developing the framework for enhanced partnering efforts as part of NDS projects, and will continue to coordinate with potential partners.

Response to Comment 7-4

Comment noted. All City street sweepers used for this program are regenerative air vacuum sweepers.

-----Original Message-----

From: Estell Berteig [mailto:estell.berteig@gmail.com]

Sent: Monday, June 30, 2014 10:44 PM

To: Meyer, Betty

Cc: Estell Berteig; Chuck Dolan

Subject: The Integrated Stormwater Plan

8-1

I do strongly support the integrated watershed plan and urge the City to include more of the NDS appropriate sites of the Thornton Creek Watershed. We have lived on a tributary (in 2 different houses) since 1970 and treasure our little wooded neighborhood. We would consider partnering with SPU but would insist on no entry to our private property without proper notice.

8-2

Here is an example that I know about that illustrates why partnering with property owners is important. They know what happening around them. Our neighborhood was aware that sometimes a lot of "suds " came down the creek. In about 1994 a drain from a laundry room was found hidden in a stump. That water is now pumped into the the house drain. While this may not be a common source of pollution, soap would surely be harmful to fish. We think that there should be an increased effort in partnering with private owners.

Estell and Irv Berteig

9025 42nd Ave NE

Seattle Wa. 98115

Response to Comment 8-1

Comment noted. The Thornton Creek basin is included in the proposed NDS Partnering projects associated with the Integrated Plan Alternative. As noted in the response to Comment 7-3, SPU is developing a framework for enhanced partnering, which will include protocols for homeowner notification and property access.

Response to Comment 8-2

See response to Comment 7-3.

From: Selena Carsiotis [<mailto:scarsiotis@gmail.com>]

Sent: Saturday, June 21, 2014 10:40 PM

To: Meyer, Betty

Subject: Comment on DEIS

9-1

The Draft Environmental Impact Statement omits the Piper's Creek Flow Control Study and the "References" section. There should be equal numbers of data-based studies for each of the three options. The Piper's Creek Flow Control Study includes hydrologic modeling data that is pertinent to the Draft EIS. For example,

Plan 1: Flow and Rainfall Monitoring
Quality Assurance Project Plan
Laura Reed, Seattle Public Utilities

9-2

This draft EIS twice cites a public comment from someone who was upset about the potential for mosquitoes breeding in standing water but makes no mention of the body of academic research that exists in response to the public's growing concern for the pollution in urban creeks. For example,

Master's Thesis @ University of Washington
Characterizing Water Quality of Urban Stormwater Runoff: Interactions of Heavy Metals and Solids in Seattle Residential Catchments.

9-3

The Integrated Plan is the only realistic solution. The Plan should include natural "spot drainage" solutions throughout Upper Piper Creek and incorporate green stormwater traffic calming infrastructure along residential streets in Crown Hill to absorb water surface water.

Thank you,
Selena Carsiotis
Crown Hill Neighborhood Association, Ballard District Council

Response to Comment 9-1

Chapter 3, Affected Environment, is focused on characterizing existing conditions as they relate to impacts from the Plan. As such, it does not include a comprehensive literature review of scientific studies that have been conducted on Plan area waterbodies. The Integrated Plan includes more detailed information on Plan area waterbodies, including Piper's Creek.

Response to Comment 9-2

Both the Draft EIS and Integrated Plan acknowledge that water quality in urban creeks and streams is a concern. The objective of Plan is to reduce overflows and the discharge of pollutants from combined sewers and stormwater runoff. The focus of the EIS is on addressing impacts of the Plan – including potential concerns received as part of scoping and outreach that relate to alternatives. It is not the purpose of the EIS to provide an exhaustive study of water pollution in urban creeks; however this issue is acknowledged in the EIS and in the Integrated Plan. The purpose of an EIS is to describe the potential impact of the future actions resulting from implementing the Plan. In that regard, the focus is on the impacts of the Plan.

Response to Comment 9-3

Comment noted.

From: Gordon Dass Adams [<mailto:gordondass@yahoo.com>]
Sent: Sunday, June 29, 2014 7:24 AM
To: Meyer, Betty
Subject: Comment on Integrated Plan for Stormwater

• .

As a resident of the Thornton Creek watershed since 2009 I have been involved with citizen efforts to improve the water quality of the creek.

Currently I am first vice-president of Thornton Creek Alliance, and chair of the Friends of Licorice Fern Natural Area. In these roles I both learn about government involvement with the watershed, and have direct experience with the creek and its riparian areas by directing volunteer workparties, planting native plants, clearing invasive plants, and enjoying the creek environment.

10-1

I'm aware that bacterial pollution of the creek may be reduced by technical changes to the piping systems for sewage and stormwater. But the general situation with runoff from contaminated impervious surfaced (road, etc) cannot be improved with pipe changes. And so I strongly support the Integrated Plan and its inclusion of Natural Drainage Systems and direct cleaning of streets.

Thank you for your efforts to improve water quality in Thornton Creek and Seattle.

Gordon Dass Adams
 Box 15268
 Seattle WA 98115

Gordon Dass Adams gordondass@yahoo.com
 Seattle 206-227-3864

Response to Comment 10-1

Comment noted.

From: Chuck Dolan

Regarding the Integrated Stormwater Plan (ISP)

11-1

As a resident in the Thornton Creek Watershed, the city's largest and home to over 70,000 residents and several species of salmon including the protected chinook, I am strongly supportive the holistic approach that is represent by the Integrated Stormwater Plan.

Specifically, the ISP is:

11-2

- A more comprehensive and effective way to address water pollution in more of the city and addresses the most signification Combined Sewer Overflow locations in the city.
- Woefully inadequate in only seeking to apply Natural Drainage System to 4% of appropriate sites! How can this be effective or equatable?

11-3

- The ISP misses a vital opportunity engage with private property owners to reduce stormwater runoff BEFORE it reaches public right-of-ways

11-4

- The street sweeping is the excellent step to capturing fine sediments that carry much of the most damaging toxics to the creek. But it MUST employ vacuum sweepers or in will be ineffective and a waste of money and time.

Response to Comment 11-1

Comment noted.

Response to Comment 11-2

See response to Comment 7-2.

Response to Comment 11-3

See response to Comment 7-3.

Response to Comment 11-4

See response to Comment 7-4.



Plan to Protect Seattle's Waterways Draft EIS Comment Form

Please return comments by June 30, 2014

Your comments on the Draft EIS will help Seattle Public Utilities identify a preferred alternative later this year. Seattle Public Utilities will respond to all comments in the Final EIS, which is scheduled to be released in late 2014. The comment deadline is June 30, 2014.

In what neighborhood do you live? Please specify North Greenwood. What organization do you represent? Please specify (if applicable) citizen.

Please share your comments in the space provided.

12-1

I support The integrated plan (I think) and any movements to address improving overall water quality in Puget Sound. Population growth only makes This more difficult to address the longer we delay.

Seattle Public Utilities is required to mail a notice to each person that submits a comment on the Draft EIS to announce when the Final EIS is available. Please help us meet this requirement by providing your name and mailing address:

Name Heather Grube
Mailing Address 9559 Palatine Ave N
City, State, Zip Seattle WA 98103

Response to Comment 12-1

Comment noted.

Appendix C: Distribution List

The Plan to Protect Seattle's Waterways
Final Environmental Impact Statement Distribution List

Notice of FEIS	Notice of FEIS + Compact Disc	Notice of FEIS + Compact Disc	Agency or Name	Name or Address1	Name or Address2	Address3	City	State	Zip
		✓	Washington State Dept of Ecology	SEPA Unit	P.O. Box 47703		Olympia	WA	98504-7703
	✓		Allyson Brooks, PhD		WA State Dept of Archaeology and Historic Preservation	P.O. Box 48343	Olympia	WA	98504-8343
	✓		Larry Fisher	WDFW Area Habitat Biologist	1775 12th Ave NW	Suite 201	Issaquah	WA	98027
	✓		SEPA Coordinator	Habitat Management Division	WA State Dept of Fish.	P.O. Box 43155	Olympia	WA	98504
	✓			SEPA Center	WA State Dept of Natural Res.	P.O. Box 47015	Olympia	WA	98504-7015
	✓			SEPA Review	WA State Dept of Public Health	P.O. Box 47820	Olympia	WA	98504-7820
	✓		Kelly Cooper	Environmental Health Div.	WA State Dept of Health	P.O. Box 47820	Olympia	WA	98504-7820
	✓		Ramin Pazooki	WSDOT NW Region	15700 Dayton Avenue N		Seattle	WA	98133
	✓			Planning Division	WA State Dept of Transportation	P.O. Box 330310	Seattle	WA	98133-9710
	✓		Advisory Council on Historic Preservation	401 F St NW Ste 308			Washington	DC	20001-2637
	✓			WA Division Area Engineer	Federal Highway Administration	711 Capitol Way, Suite 501	Olympia	WA	98501-0943
	✓			Transportation Program Specialist	Federal Transit Administration	915 2nd Ave. Suite 3142	Seattle	WA	98174-1002
	✓			SEPA Review	National Marine Fisheries Services	510 Desmond Drive SE	Lacey	WA	98503
	✓			Regulatory	US Army Corps of Engineers	P.O. Box C-3755	Seattle	WA	98124-3755
	✓		Alisa Ralph	Seattle District	US Army Corps of Engineers	4735 E. Marginal Way S.	Seattle	WA	98134-2384
	✓		NEPA Review Unit	US Environmental Protection Agency	1200 Sixth Avenue	ETPA 088	Seattle	WA	98101
	✓			Washington Fish & Wildlife Office	US Fish & Wildlife Service	510 Desmond Dr. SE Suite 102	Lacey	WA	98503-1263
	✓		Jim Muck	USFWS & NOAA	US Fish & Wildlife Service	7600 Sandpoint Way	Seattle	WA	98115
✓				Cascade Water Alliance	520 112th Ave NE	Suite 400	Bellevue	WA	98004
✓			Paul Meyer	Manager, Environmental Permitting	Port of Seattle	P.O. Box 1209	Seattle	WA	98111
✓				SEPA Review	Puget Sound Clean Air Agency	1904 Third Ave Suite 105	Seattle	WA	98101-3417
✓			Rhonda Kaetzel	Environmental Health Svcs	Public Health - Seattle KC	401 5th Avenue, 11th Floor	Seattle	WA	98104-1818
✓				Roads & Engineering	KC Dept of Transportation	201 S Jackson St - MS KCS 0313	Seattle	WA	98104
✓			Environmental Planning-OAP	Wastewater Treatment Div.	KC Dept of Natural Resources	201 S Jackson St - MS KCS NR 0505	Seattle	WA	98104
✓				Parks Environmental Review	KC Dept of Natural Resources	201 S. Jackson St	Seattle	WA	98104-3856
✓				Land Use Services Division	KC Department of Permitting and Environmental Review	35030 SE Douglas St. Ste 210	Snoqualmie	WA	98065-9266
✓			Gary Kriedt	Environmental Planning	KC Dept of Transportation	201 S. Jackson St - MS KSC TR 0431	Seattle	WA	98104-3856
✓			Charlie Sundberg	Preservation Planner	KC Historic Preservation	201 S. Jackson St. KSC-NR-0700	Seattle	WA	98104
✓					KC Regional Water Quality Committee	201 S Jackson St	Seattle	WA	98104
	✓				Suquamish Tribe	P.O. Box 498	Suquamish	WA	98392
	✓			SEPA Review	Tulalip Tribes of WA	6406 Marine Drive	Tulalip	WA	98271
	✓				United Indians of All Tribes	P.O. Box 99100	Seattle	WA	98199
	✓		The Honorable Cecile Hansen	Chair	Duwamish Tribe	4705 W. Marginal Way SW	Seattle	WA	98106
	✓		Karen Walter	Fisheries Division Habitat Program	Muckleshoot Tribe	39015 172nd Ave SE	Auburn	WA	98092
	✓		Laura Murphy	Tribe Preservation Program	Muckleshoot Tribe	39015 172nd Ave SE	Auburn	WA	98092
	✓		The Honorable Virginia Cross	Chair, Muckleshoot Tribal Council	Muckleshoot Tribe	39015 172nd Ave SE	Auburn	WA	98092
	✓		The Honorable Mike Evans	Chair, Snohomish Tribe	9792 Edmonds Way SW #267		Edmonds	WA	98020
	✓		Steven Mullen-Moses	Director of Archaeology & Historic Preservation	Snoqualmie Tribe	P.O. Box 969	Snoqualmie	WA	98065

The Plan to Protect Seattle's Waterways
Final Environmental Impact Statement Distribution List

Notice of FEIS	Notice of FEIS + Compact Disc	Notice + FEIS + Compact Disc	Agency or Name	Name or Address1	Name or Address2	Address3	City	State	Zip
✓				SEPA Review	Snoqualmie Tribe	P.O. Box 969	Snoqualmie	WA	98065
✓				Chair, Snoqualmie Tribe of Indians	Snoqualmie Tribe	P.O. Box 969	Snoqualmie	WA	98065
✓			Earngy Sandstrom	Chair	Snoqualmoo Tribe	2613 Pacific St	Bellingham	WA	98226
✓			Shawn Yanity	Chair	Stillaguamish Tribe	4126 172nd St	Arlington	WA	98223
✓				SEPA Review	Suquamish Tribe	18490 Suquamish Way	Suquamish	WA	98392
✓			The Honorable Leonard Forsman	Chair, Suquamish Tribal Council	Suquamish Tribe	P.O. Box 498	Suquamish	WA	98392
✓			The Honorable Herman Williams	Chair, Tulalip Board of Directors	Tulalip Tribes of WA	6406 Marine Drive	Tulalip	WA	98271
✓				Governmental Publications	UW Library	P.O. Box 353900	Seattle	WA	98195-2900
✓			Cass Mabbott	Ballard Branch	Seattle Public Library	5614 22nd Ave NW	Seattle	WA	98107-3119
✓			Wei Cai	Beacon Hill Branch	Seattle Public Library	2821 Beacon Ave S	Seattle	WA	98144-5813
✓			Rekha Kuver	Broadview Branch	Seattle Public Library	12755 Greenwood Ave N	Seattle	WA	98133-7901
✓			Dave Valencia	Capitol Hill Branch	Seattle Public Library	425 Harvard East	Seattle	WA	98102-4908
✓			Steve Del Vecchio	Columbia Branch	Seattle Public Library	4721 Rainier Ave S	Seattle	WA	98118-1657
✓			Steve Del Vecchio	Delridge Branch	Seattle Public Library	5423 Delridge Way S	Seattle	WA	98106-1479
✓			Valerie Garrett-Turner	Douglass-Truth Branch	Seattle Public Library	2300 E Yesler Way	Seattle	WA	98122-6061
✓			Cass Mabbott	Fremont Branch	Seattle Public Library	731 N 35th St	Seattle	WA	98103-8802
✓			Francesca Wainwright	Green Lake Branch	Seattle Public Library	7364 E Green Lake Drive N	Seattle	WA	98115-5352
✓			Francesca Wainwright	Greenwood Branch	Seattle Public Library	8016 Greenwood Av N	Seattle	WA	98103-4229
✓			Sibyl de Haan	High Point Branch	Seattle Public Library	3411 SW Raymond St	Seattle	WA	98126-2953
✓			Wei Cai	Int. District/Chinatown Branch	Seattle Public Library	713 Eighth Avenue S	Seattle	WA	98104-3060
✓			Andy Bates	Lake City Branch	Seattle Public Library	12501 28th Ave NE	Seattle	WA	98125-4319
✓			Dave Valencia	Madrona-Sally Goodmark Branch	Seattle Public Library	1134 33rd Avenue	Seattle	WA	98122-5120
✓			Lisa Scharnhorst	Magnolia Branch	Seattle Public Library	2801 34th Ave W	Seattle	WA	98199-2602
✓			Valerie Garrett-Turner	Montlake Branch	Seattle Public Library	2401 24th Ave E	Seattle	WA	98112-2642
✓			Daria Cal	New Holly Branch	Seattle Public Library	7058 32nd Ave S	Seattle	WA	98118-6401
✓			Marion Scichilone	Northeast Branch	Seattle Public Library	6801 35th Ave NE	Seattle	WA	98115-7333
✓			Rekha Kuver	Northgate Branch Library	Seattle Public Library	10548 Fifth Avenue NE	Seattle	WA	98125
✓			Lisa Scharnhorst	Queen Anne Branch	Seattle Public Library	400 W. Garfield	Seattle	WA	98119-3038
✓			Daria Cal	Rainier Beach Branch	Seattle Public Library	9125 Rainier Ave S	Seattle	WA	98118-5026
✓			Jane Appling	South Park Branch	Seattle Public Library	8604 Eighth Ave S	Seattle	WA	98108-4713
✓			Jane Appling	Southwest Branch	Seattle Public Library	9010 35th Ave SW	Seattle	WA	98126-3821
✓			Andy Bates	University Branch	Seattle Public Library	5009 Roosevelt Way NE	Seattle	WA	98105-3610
✓			Marion Scichilone	Wallingford Branch	Seattle Public Library	1501 North 45th Street	Seattle	WA	98103-6708
✓			Sibyl de Haan	West Seattle Branch	Seattle Public Library	2306 42nd Ave. S.W.	Seattle	WA	98116-2535
✓	✓		Steve Cohn		Ballard Dist Council	5604 22nd Ave NW	Seattle	WA	98107
✓			David Folweiler	President	Groundswell Northwest	1725 NW 64th St	Seattle	WA	98107
✓				Annie Davis	Ballard Chamber of Commerce	2208 NW Market St. Suite 100	Seattle	WA	98107
✓				Caryle Teel, President	Ballard Rotary	P.O. Box 70472	Seattle	WA	98107
✓			Jenny Heins	Sustainable Ballard	2442 NW Market St.	PMB 286	Seattle	WA	98107
✓			Lois Spiegel	President	Sunset Hill Community Association	3003 NW 66th St.	Seattle	WA	98117
✓					Central District Council	2301 S. Jackson St #208	Seattle	WA	98144
✓			Rob Martin		Columbia City Business Assoc	3827A So Edmunds St.	Seattle	WA	98118
✓			Pablo Lambinico		DNDA, Westwood Neighborhood	8820 31st Ave SW	Seattle	WA	98126
✓			Catherine Stanford		Downtown Dist Council	1904 3rd Ave Suite 828	Seattle	WA	98101
✓	✓		Paul Storms		East District Council	1834 Parkside Drive E	Seattle	WA	98112

The Plan to Protect Seattle's Waterways
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Notice of FEIS	Notice of FEIS + Compact Disc	Notice of FEIS + Compact Disc	Agency or Name	Name or Address1	Name or Address2	Address3	City	State	Zip
✓			Suzie Burke		Lk Union Dist Council	3401 Evanston Ave N. Suite A	Seattle	WA	98103
✓					Leschi Community Council	3450 E. Alder St	Seattle	WA	98122
✓			Janis Traven		Magnolia/Queen Ann Dist Council	3247 Magnolia Blvd	Seattle	WA	98199
✓			Phil Shack		North Dist Council	12509 42nd Ave NE	Seattle	WA	98125
✓			Irene Wall		North Dist Council	207 N. 60th St	Seattle	WA	98103
✓			Jerry Owens		Northwest Dist Council	8546 Burke Ave N	Seattle	WA	98103
✓			Jill Arnow	Executive Director	Queen Anne Chamber	2212 Queen Anne Ave N.	Seattle	WA	98109
✓			Erica Karlovits		SW Dist Council	4538-C 41st SW	Seattle	WA	98116
✓			Charles Redmond		SW District Council	3903 SW Monroe St	Seattle	WA	98136
✓			Nancy Bolin		View Ridge Community Council	4241 NE 75th St	Seattle	WA	98115
✓			Lynn Ferguson		Windemere N. Community Council	6422 NE 60th Street	Seattle	WA	98115
	✓			Thornton Creek Alliance	P.O. Box 25690		Seattle	WA	98165-1190
	✓		Thornton Creek Watershed	Oversight Council	ATT: Cheryl Klinker	12036 35th Ave NE	Seattle	WA	98125
	✓		Jennifer Ott	Friends of Seattle's Olmsted Parks	P.O. Box 9884		Seattle	WA	98109-0884
	✓		Thatcher Bailey	Seattle Parks Foundation	105 S. Main St. #235		Seattle	WA	98104
	✓		John Barber, Chairman	Friends of Street Ends	3421 E. Superior St.		Seattle	WA	98122-6557
✓			Bill Pelosa	Councilmember	City of Auburn	25 West Main St.	Auburn	WA	98001
✓			Claudia Balducci	Mayor	City of Bellevue	450 110th Ave NE, PO Box 90012	Bellevue	WA	98009
✓			Paul Bucich	Assistant Director of Engineering	City of Bellevue	450 110th Ave NE, PO Box 90012	Bellevue	WA	98009
✓			Nav Ota	Utilities Director	City of Bellevue	450 110th Ave NE, PO Box 90012	Bellevue	WA	98009
✓			Douglas Jacobsen		Dawson Building	9654 NE 182nd St	Bothell	WA	98011
✓			Erin J. Leonhart	Public Works Director	Dawson Building	9654 NE 182nd St	Bothell	WA	98011
✓			Christopher Hagedorn	Public Works Director	City of Carnation	4621 Tolt Avenue, PO Box 1238	Carnation	WA	98014
✓			Walt Canter	Commissioner	Cedar River Water and Sewer District	18421 SE Petrovitsky Road	Renton	WA	98058
✓			Richard Anderson	Commissioner	Coal Creek Utility District	6801 132nd Place SE	Newcastle	WA	98059
✓			Mark Cassell	Commissioner	Cross Valley Water District	8802 180th St SE	Snohomish	WA	98296
✓			Sheldon Lynne	Deputy Director of Public Works	City Shop	670 1st Avenue NE, PO Box 1307	Issaquah	WA	98027
✓			Greg Reed	Utilities Superintendent	City of Kent	5821 S 240th St	Kent	WA	98032
✓			Bobbi Wallace	Surface and Wastewater Manager	City of Kirkland	123 Fifth Avenue	Kirkland	WA	98033
✓			Neil Jensen	City Engineer	City of Lake Forest Park	17425 Ballinger Way NE	Lake Forest Park	WA	98155
✓			Ron Nowicki	Commissioner	Lakehaven Utility District	31627 1st Avenue S, PO Box 4249	Federal Way	Wa	98063
✓			Patrick Yamashita	City Engineer	City of Mercer Island	9611 SE 36th St	Mercer Island	WA	98040
✓			Vince Koester	Commissioner	Midway Sewer District	PO Box 3487	Kent	WA	98089
✓			Paul Sentena, Commissioner	NE Sammamish Sewer & Water District	3600 Sahalee Way NE		Sammamish	WA	98074
✓			Margaret Wiggins	Commissioner	Northshore Utility District	6830 NE 185th St	Kenmore	WA	98028
✓			Lora Petso, Commissioner	Olympic View Water & Sewer	8128 228 th Street SW		Edmonds	WA	98026
✓			Scott Thomasson	Utility Engineering Manager	City of Redmond	PO Box 97010	Redmond	WA	98073
✓			Linda De Boldt	Public Works Director	City of Redmond	PO Box 97010	Redmond	WA	98073
✓			Dave Christensen	Utility Engineering Supervisor	City of Renton	1055 S. Grady Way	Renton	WA	98057
✓			Art Wadekamper	Commissioner	Ronald Wastewater District	17505 Linden Ave N	Shoreline	WA	98113
✓			Mary Shustov, Commissioner	Sammamish Plateau Water & Sewer	1510 228th Avenue SE		Sammamish	WA	98075
✓			Don Henry	Commissioner	Skyway Water and Sewer District	6723 S 124th St.	Seattle	WA	98178
✓			Gary O. Cline	Commissioner	Soos Creek Water and Sewer District	PO Box 58039	Renton	WA	98058
✓			Bill Tracy	Commissioner	Southwest Suburban Sewer District	431 Ambaum Blvd	Burien	WA	98166

The Plan to Protect Seattle's Waterways
Final Environmental Impact Statement Distribution List

✓	✓	✓	Agency or Name	Name or Address1	Name or Address2	Address3	City	State	Zip
✓			Pat Brodin	Operations Manager	City of Tukwila	6200 Southcenter Blvd	Tukwila	WA	98188
✓			Pam Carter	Commissioner	Valley View Sewer District	3460 S 148th, Suite 100	Seattle	WA	98168
✓			Karen Steeb	Commissioner	Woodinville Water District	17238 NE Woodinville-Duvall Road	Woodinville	WA	98072
✓			Ed Cebron	Rates & Finance Subcommittee Chair	Woodinville Water District	17238 NE Woodinville-Duvall Road	Woodinville	WA	98072
✓			Ron Speer, Sewage Disposal Advisory	Agreement Sub-Committee Chair	Soos Creek Water and Sewer District	PO Box 58039	Renton	WA	98058
✓			Anindita Mitra		7813 8 th Ave. NW		Seattle	WA	98117
✓			Dusty Hoerler		8929 5th Ave NE		Seattle	WA	98115
✓			Bruno Lambert	1510 Melrose Ave			Seattle	WA	98122-3608
✓			Julio Moran, Jr.		4401 S. Dawson St.		Seattle	WA	98118
✓			Mary Junttila		6021 S. Ryan St.		Seattle	WA	98178
✓			Robin McKennon Thaler		5042 49 th Ave. SW		Seattle	WA	98136
✓			Joan Rosenstock	Floating Home Association	1822 4th Ave N.		Seattle	WA	98109
✓			Henry McGee, SU School of Law	Sullivan Hall, Room 437	901 12 th Ave., P.O Box 222000		Seattle	WA	98122-1090
✓			Tayloe Washburn	Greater Seattle Chamber of Commerce	Foster Pepper PLLC 1111 3rd Ave, Ste 3400		Seattle	WA	98101-3299
✓			Tom von Schrader	SvR Design Company	1205 Second Avenue, Suite 200 Seattle, WA		Seattle	WA	98101
		✓	Mark Henley	Permit Manager	Department of Ecology, Northwest Regional Office	3190 160th Ave. SE	Bellevue	WA	98008
		✓	Robert Grandinetti	USEPA Region 10	309 Bradley Blvd, Suite 115	Mail Code HPO	Richland	WA	99352
		✓	Edward J. Kowalski	Office of Compliance and Enforcement	US Environmental Protection Agency	1200 Sixth Avenue, Suite 900	Seattle	WA	98101
		✓	Alison Evans	Permit Manager	Department of Ecology, Northwest Regional Office	3190 160th Ave. SE	Bellevue	WA	98008
		✓	Rachel McCrea	Municipal Stormwater Specialist	Department of Ecology, Northwest Regional Office	3190 160th Ave. SE	Bellevue	WA	98008
		✓	Dino Marchalonis	Stormwater Technical Coordinator	US Environmental Protection Agency	1200 Sixth Avenue, Suite 900	Seattle	WA	98101
	✓		Chief, Environmental Enforcement Section	Environmental and Natural Resources Division, Environmental and Natural Resources Division	US Department of Justice	PO Box 7611	Washington	DC	20044-7611
	✓		Director, Water Enforcement Division	Office of Civil Enforcement	US Environmental Protection Agency	1200 Pennsylvania Ave., NW, Mail Code: 2243-A	Washington	DC	20460
	✓		Director, Office of Compliance and Enforcement	US Environmental Protection Agency, Region 10	1200 6th Ave, Suite 900		Seattle	WA	98101
	✓		Attorney General of Washington	Ecology Division	P.O. Box 40117		Olympia	WA	98504
		2	Laura Wharton	Project Resource Unit Manager	Department of Natural Resources and Parks/Wastewater Treatment Division	201 Jackson St, Rm 512	Seattle	WA	98104
✓			Dave Boyd		6105 36th Ave NW		Seattle	WA	98107
✓			Margaret Kitchell		1410 E Pine St Unit 312		Seattle	WA	98122-8500
✓			John Peterson	Victory Heights Community Council	1914 NE 100th St		Seattle	WA	98125
✓			Jonathan Whiting		9242 Ashworth Ave N. #A202		Seattle	WA	98103
✓			Nate Cormier		4135 21st Ave SW		Seattle	WA	98106

The Plan to Protect Seattle's Waterways
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✓	✓	✓	Agency or Name	Name or Address1	Name or Address2	Address3	City	State	Zip
✓			Jamie Rowe	Enviroissues	101 Stewart St Suite 1200		Seattle	WA	98101
✓			Scott Coomes		7932 31st Ave SW		Seattle	WA	98126
✓			David Wiktorski		11226 Phinney Avenue North		Seattle	WA	98133
✓			Kathleen Dellplain	FCA	10273 Maplewood PL SW		Seattle	WA	98146
✓			Amber Knox		6951 23rd Ave SW		Seattle	WA	98106
✓			Marie McKinsey		2434 55th Ave. SW #2		Seattle	WA	98116
✓			Robert Hinrix	Beacon Hill Merchants Assoc	2821 Beacon Av S		Seattle	WA	98144
	✓		Robert Drucker		3226 NW 69 th St		Seattle	WA	98117
	✓		Catherine Weatbrook		8926 23 rd Ave NW		Seattle	WA	98117
	✓		Larry Ward		7703 19 th Ave NW		Seattle	WA	98117
	✓		Kim McDonald		7716 32 nd Ave NW		Seattle	WA	98117
	✓		Jessica Vets	Fremont Chamber	PO Box 31139		Seattle	WA	98103
	✓		Rachel Koller		7355 23 rd Ave NW		Seattle	WA	98117
	✓		Stephen Fickenscher		4515 Meridian Ave, Suite B		Seattle	WA	98117
	✓		Barry Hawley	Hawley Realty	5600 14 th Ave NW, Suite 3		Seattle	WA	98107
	✓		Elizabeth Dunigan		6508 32 nd Ave NW		Seattle	WA	98117
	✓		Gretchen Kaehler	Department of Archaeology & Historic Preservation	P.O. Box 48343		Olympia	WA	98504
	✓		Michal Rechner	Washington Department of Natural Resources	1111 Washington St SE	MSS 47000	Olympia	WA	98504
	✓		Pam Elardo	Department of Natural Resources and Parks	King Street Center	201 South Jackson Street	Seattle	WA	98104
	✓		Kim McDonald	Shelterwood Consulting	7716 32nd Ave NW		Seattle	WA	98117
	✓		James Rasmussen	Duwamish River Cleanup Coalition	210 S. Hudson, Suite 332		Seattle	WA	98134
	✓		Frank I Backus	450 NE 100th Street			Seattle	WA	98125
	✓		Estell and Irv Berteig	9025 42nd Ave NE			Seattle	WA	98115
	✓		Selena Carsiotis	Ballard District Council	5604 22nd Ave NW		Seattle	WA	98107
	✓		Gordon Dass Adams		P.O. Box 15268		Seattle	WA	98115
	✓		Chuck Dolan	Thornton Creek Alliance	mailto:chucklesd2@hotmail.com				
		✓	Betty Galarosa	SEPA PIC	City of Seattle	Dept of Planning & Development	SMT-18-62		
		✓	Public Review Documents	Quick Information Center	Seattle Public Library		LB-03-01		
✓			Cliff Portman		City of Seattle	Planning & Development	SMT-18-00		
✓			Sue Putnam		City of Seattle	Planning & Development	SMT-18-00		
	✓		Andy Lunde		City of Seattle	Planning & Development	SMT-18-00		
	✓		Jerry Suder		City of Seattle	Planning & Development	SMT-18-00		
	✓		Laurie Olson		City of Seattle	Office of Housing	SMT-57-00		
✓			Kyle Joyce		City of Seattle	Finance & Admin Svcs	SMT-52-01		
✓			Mark Jaeger		City of Seattle	Seattle Public Utilities	SMT-49-00		
✓			Tim Ramsaur		City of Seattle	Seattle Public Utilities	SMT-49-00		
✓			Paul Fleming		City of Seattle	Seattle Public Utilities	SMT-49-00		
✓			Miles Mayhew		City of Seattle	Seattle Public Utilities	SMT-49-00		
✓			Jen Trout		City of Seattle	City Light	SMT 00-28-22		
✓			Bill Davis		City of Seattle	City Light	SMT 00-28-22		
✓			Margaret Duncan		City of Seattle	City Light	SMT 00-28-22		
	✓		Michael Shiosaki	Planning & Development Division	City of Seattle	Dept of Parks and Recreation	PK-01-01		
	✓		David Graves	Planning & Development Division	City of Seattle	Dept of Parks and Recreation	PK-01-01		

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Notice of FEIS	Notice of FEIS + Compact Disc	Notice + FEIS + Compact Disc	Agency or Name	Name or Address1	Name or Address2	Address3	City	State	Zip
✓			Maureen Meehan	Street Use Division	City of Seattle	Dept of Transportation	SMT 00-39-00		
✓			Luke Korpi	Street Use Division	City of Seattle	Dept of Transportation	SMT 00-30-00		
✓			Ron Borowski	Policy and Planning	City of Seattle	Dept of Transportation	SMT-00-39-00		
✓			Jill Macik	Capital Projects & Roadway Str.	City of Seattle	Dept of Transportation	SMT-00-39-00		
✓			Dongho Chang	Traffic Operation	City of Seattle	Dept of Transportation	SMT-00-39-00		
✓			Cristina VanValkenburgh	Mobility Programs	City of Seattle	Dept of Transportation	SMT-00-39-00		
✓			Sarah Sodt	Landmarks Preservation Board	City of Seattle	DON/HISTORICAL PROG.	SMT 00-17-00		
✓			Tina Vlasaty		City of Seattle	Economic Development	SMT-57-52		
✓			Gregory Dean, Fire Chief	Office of the Chief	City of Seattle	Fire Department	FD-44-04		
	✓			City Council	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Sally Bagshaw	Councilmember	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Tim Burgess	Councilmember	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Sally Clark	Councilmember	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Kshama Sawant	Councilmember	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Jean Godden	Councilmember	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Bruce Harrell	Councilmember	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Nick Licata	Councilmember	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Mike O'Brien	Councilmember	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Tom Rasmussen	Councilmember	City of Seattle	Legislative Dept	CH 02-10-00		
	✓		The Honorable Ed Murray	Mayor	City of Seattle	Office of the Mayor	CH-00-07-01		
	✓		Bob Tobin	Assistant City Attorney	City of Seattle	Office of the City Attorney	CH 00-04-01		
	✓		Jeff Weber	Senior Assistant City Attorney	City of Seattle	Office of the City Attorney	CH 00-04-01		
			Inhouse/Consultant						
		1	Nancy Ahern						
		1	Rick Scott						
		1	Betty Meyer						
		1	Susan Stoltzfus						
		1	Ben Marre						
		1	Tracy Tackett						
		1	Kevin Buckley						
		1	Ed Mirabella						
		2	Archive						
		10	Extra						
		2	BFW Team						
		2	CH2M Hill						
		2	B&C						
		2	ESA						

Form revised: December 5, 2014

BILL SUMMARY & FISCAL NOTE

Department:	Contact Person/Phone:	Executive Contact/Phone:
Seattle Public Utilities	Ed Mirabella/4-5959	Aaron Blumenthal/3-2656

1. BILL SUMMARY

Legislation Title: AN ORDINANCE relating to Seattle Public Utilities; authorizing the Director of Seattle Public Utilities to submit the “Plan to Protect Seattle’s Waterways” and to fulfill the obligations set forth therein, to fulfill obligations under a Consent Decree required by the United States Environmental Protection Agency and the State of Washington Department of Ecology.

Summary and background of the Legislation:

The proposed ordinance would authorize the director of Seattle Public Utilities to sign and carry out the Plan to Protect Seattle’s Waterways. The Plan would implement projects to control Combined Sewer Overflows (CSOs) and stormwater discharges to comply with a Consent Decree with the Environmental Protection Agency (EPA) and the Washington Department of Ecology (Ecology).

Seattle Public Utilities owns, maintains and operates a system of sanitary sewers and storm and surface water drainage as part of the City’s drainage and wastewater system. The EPA determined sewage discharges from Seattle’s combined sewers violate the federal Clean Water Act and the conditions and limitations of a permit from Ecology. They issued a Consent Decree requiring the City develop and implement a CSO long-term control plan by 2025. The Consent Decree includes a special provision allowing the City to defer certain CSO projects if alternative stormwater projects yielding greater environmental benefits could be identified.

SPU therefore developed two alternatives to comply with the Consent Decree. The Long Term Control Plan Alternative focuses on reducing uncontrolled CSO overflows by 2025 by constructing CSO control projects. The second alternative, the Integrated Plan Alternative, would implement the Long Term Control Plan as described above, modified to construct some CSO projects by 2030, in exchange for constructing three stormwater projects by 2025. SPU determined greater environmental benefits would be achieved by implementing the Integrated Plan Alternative, albeit at a greater financial cost, and recommends the Integrated Plan Alternative be submitted to EPA and Ecology for Compliance with the Consent Decree.

2. CAPITAL IMPROVEMENT PROGRAM

_____ This legislation creates, funds, or amends a CIP Project.

Project Name:	Project I.D.:	Project Location:	Start Date:	End Date:	Total Cost:

3. SUMMARY OF FINANCIAL IMPLICATIONS

Please check one:

☐ This legislation has direct financial implications.

☒ This legislation does not have direct financial implications.

The Consent Decree which this legislation is intended to satisfy requires the City implement its CSO reduction program by 2025. The budget estimate for completing SPU's Plan to Protect Seattle's Waterways by 2030 is estimated to be \$600 million. Supporting appropriations will be proposed to Council for consideration and approval during the development of future CIPs. More information about estimated costs by fiscal year and rate impacts on drainage and wastewater rates are provided in the attachment to this fiscal note.

3.a. Appropriations

☐ This legislation adds, changes, or deletes appropriations.

Fund Name and number	Dept	Budget Control Level Name/##	2015 Appropriation Change	2016 Estimated Appropriation Change
TOTAL				

**See budget book to obtain the appropriate Budget Control Level for your department.*

Appropriations Notes:

No 2015 appropriation actions are required by this proposed Council Bill. Appropriations for the Plan to Protect Seattle's Waterways are included in the City of Seattle's 2015/16 budget and the six- year CIP. SPU has included the costs of compliance with the Consent Decree in the SPU Strategic Business Plan, approved by Council in 2014, and associated 2015-2020 rate package.

3.b. Revenues/Reimbursements

☐ This legislation adds, changes, or deletes revenues or reimbursements.

Anticipated Revenue/Reimbursement Resulting from this Legislation:

Fund Name and Number	Dept	Revenue Source	2015 Revenue	2016 Estimated Revenue
TOTAL				

Revenue/Reimbursement Notes:

4. OTHER IMPLICATIONS

- a) **Does the legislation have indirect or long-term financial impacts to the City of Seattle that are not reflected in the above?**

Yes, the legislation has long-term financial implications which are described in Exhibit A.

- b) **Is there financial cost or other impacts of not implementing the legislation?**

The Consent Decree contains penalties ranging from \$3,000 to \$5,000 per day per violation depending on the period of Non-compliance. The City could also be sued by a third-party for instances of non-compliance, which could result in the City paying fines up to \$25,000 per day per violation and associated legal fees. Non-compliance could result in criminal prosecution is possible against the City and against individuals.

- c) **Does this legislation affect any departments besides the originating department?**

This legislation primarily impacts SPU. However, the types of projects implemented to comply with the Consent Decree (e.g., pipelines, pump stations, small retrofits, green stormwater infrastructure, and underground storage structures) may have impacts on the Department of Planning and Development, the Department of Parks and Recreation, the Seattle Department of Transportation, and other City departments.

- d) **Is a public hearing required for this legislation?**

No

- e) **Is publication of notice with *The Daily Journal of Commerce* and/or *The Seattle Times* required for this legislation?**

No

- f) **Does this legislation affect a piece of property?**

This legislation does not have a direct on a particular piece of property. However, the types of projects that will be implemented to comply with the Consent Decree (e.g., pipelines, pump stations, small retrofits, green stormwater infrastructure (GSI), and underground storage structures) will have impacts on both private and public property. These projects will be constructed in the public right-of-way, in City-owned lands, and/or on private property.

- g) **Please describe any perceived implication for the principles of the Race and Social Justice Initiative. Does this legislation impact vulnerable or historically disadvantaged communities?**

This legislation does not unfairly impact any particular population or community.

h) If this legislation includes a new initiative or a major programmatic expansion:

What are the long-term and measurable goals of the program? Please describe how this legislation would help achieve the program's desired goals.

The plan which is the subject of this legislation would significantly improve water quality by reducing overflows from Seattle's 90 CSO outfalls and implementing stormwater pollution control projects and enable the City to comply with a Consent Decree with the Federal and State governments.

i) Other Issues:

List attachments below:

Exhibit A: Financial Impacts Summary

2015 Plan to Protect Seattle's Waterways

Financial Impacts Summary

1/15/2015

Background

The City of Seattle created two alternatives for complying with the Consent Decree requirement to implement its Combined Sewer Overflow (CSO) reduction program. The first is the Long Term Control Plan Alternative, which would implement a comprehensive program by 2025 to control overflows at all of the City's 86 CSO outfalls. The Long Term Control Plan (LTCP) would construct the Shared West Ship Canal Tunnel in partnership with King County and CSO control using tanks and pipes associated with specific CSO outfalls by 2025. The Integrated Plan Alternative would implement the CSO control measures contained in the LTCP and three stormwater treatment projects. Six relatively small CSO control projects would be delayed up to five years while the stormwater projects are implemented. The Integrated Plan alternative leads to great improvement in water quality, and represents a more comprehensive approach to water quality management.

Financial Impact of Implementing the Consent Decree Requirements

The budget estimate for completing SPU's CSO Reduction Program by 2030 ranges from \$182 million to \$627 million (*2010 CSO Reduction Plan Amendment, p. 5-18*). For purposes of estimating the financial impact of the Consent Decree, SPU has conservatively assumed remaining Long Term Control Plan program expenditures will be approximately \$500 million.

Rate Impact of Implementing the Consent Decree Requirements

Based on the planning level cost estimates prepared and the implementation schedule for the projects, Long Term Control Plan and Integrated Plan, the City analyzed how the recommended alternative may affect monthly City wastewater and drainage rates between 2015 and 2045. The table below shows the total monthly estimated rates (baseline and recommended alternative) between 2015 and 2045.

Monthly Wastewater and Drainage Rate Estimate for the Integrated Plan							
LTCP Option	2015	2020	2025	2030	2035	2040	2045
Total Baseline Rate	\$80.31	\$110.64	\$127.80	\$140.46	\$156.68	\$174.44	\$193.88
Integrated Plan (West Ship Canal Tunnel With Integrated Plan)	\$81.49	\$115.48	\$135.43	\$147.04	\$163.35	\$181.31	\$200.99

STATE OF WASHINGTON -- KING COUNTY

--SS.

324546

No. 124764,765,766

DPD-ACCOUNTS PAYABLE

Affidavit of Publication

The undersigned, on oath states that he is an authorized representative of The Daily Journal of Commerce, a daily newspaper, which newspaper is a legal newspaper of general circulation and it is now and has been for more than six months prior to the date of publication hereinafter referred to, published in the English language continuously as a daily newspaper in Seattle, King County, Washington, and it is now and during all of said time was printed in an office maintained at the aforesaid place of publication of this newspaper. The Daily Journal of Commerce was on the 12th day of June, 1941, approved as a legal newspaper by the Superior Court of King County.

The notice in the exact form annexed, was published in regular issues of The Daily Journal of Commerce, which was regularly distributed to its subscribers during the below stated period. The annexed notice, a

CT:TITLE ONLY ORDINANCES

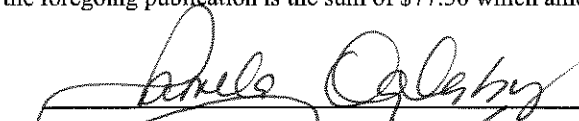
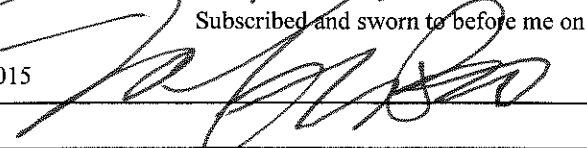
was published on

05/27/15

The amount of the fee charged for the foregoing publication is the sum of \$77.50 which amount has been paid in full.



Affidavit of Publication


Subscribed and sworn to before me on
05/27/2015

Notary public for the State of Washington,
residing in Seattle

State of Washington, King County

City of Seattle Title Only Ordinances

The full text of the following legislation, passed by the City Council on May 4, 2015, and published below by title only, will be mailed upon request, or can be accessed at <http://clerk.seattle.gov>. For information on upcoming meetings of the Seattle City Council, please visit <http://www.seattle.gov/council/calendar>.

Contact: Office of the City Clerk at (206) 684-8344.

ORDINANCE NO. 124763

AN ORDINANCE appropriating money to pay certain audited claims and ordering the payment thereof.

ORDINANCE NO. 124764

AN ORDINANCE relating to the Department of Finance and Administrative Services, declaring the vacant property located at 8030 Fauntleroy Way SW as surplus to the City's needs; authorizing the sale of said property; authorizing the Director of Finance and Administrative Services to execute all documents for the sale and transfer of the property to Gary Moore; and directing how proceeds from the sale shall be distributed.

ORDINANCE NO. 124765

AN ORDINANCE relating to rates and charges for water services of Seattle Public Utilities; authorizing withdrawals from the Water Fund Revenue Stabilization Subfund; revising water rates and charges, and credits to low income customers; and amending the Seattle Municipal Code Sections 21.04.430, 21.04.440, and 21.76.040.

ORDINANCE NO. 124766

AN ORDINANCE relating to Seattle Public Utilities; authorizing the Director of Seattle Public Utilities to submit the "Plan to Protect Seattle's Waterways" and to fulfill the obligations set forth therein, to fulfill obligations under a Consent Decree required by the United States Environmental Protection Agency and the State of Washington Department of Ecology.

Date of publication in the Seattle Daily Journal of Commerce, May 27, 2015.

5/27(324546)