Chapter 2
Water Resources

Chester Morse Reservoir

SPU's Water Resources business area focuses on the programs and projects that ensure SPU's customers and instream resources will have sufficient water to meet their needs, both in the present and for the foreseeable future. One important function of the business area is the real-time management and operation of mountain reservoir and river facilities for municipal use while meeting instream flow requirements supporting hydropower production, and managing floods. Water resource concerns also include forecasting future water demands, and evaluating current supply capacity and the need for future additional supply sources and new water rights. The business area also addresses issues related to dam safety and infrastructure maintenance and improvements.

SPU has the water supply necessary to meet needs now and well into the future.

Chapter 2 describes how SPU is prepared to meet water demands in the foreseeable future even with the uncertainties surrounding the potential impacts of future climate change and population growth.

2.1 Accomplishments Since 2007 WSP

Since completion of the *2007 Water System Plan*, SPU has accomplished the following activities in the water resources business area:

- Water Conservation: Completed the 2000-2010 Regional 1% Conservation Program, Seattle's additional conservation requirements of the Initiative 63 Settlement Ordinance, and the first 6-Year Water Use Efficiency Goal. More information on past conservation program savings is provided in Section 2.3.3 below.
- North Bend Mitigation Water: Per an agreement signed in 2008, began delivering untreated water from Hobo Springs via Boxley Creek to the city of North Bend to mitigate the use of their municipal water wells on the Snoqualmie River (2009).
- New Wholesale Contracts: Signed new wholesale contracts with the six remaining 1982 wholesale contract holders, the city of Renton, and Cascade Water Alliance. More information is provided in Section 2.3.1 below.

- Cedar Moraine Improvements: Installed a horizontal drainage system in the West Boxley area of Cedar Moraine to partially dewater the moraine embankment, reducing the risk of a groundwater-blowout event flooding downstream properties along Boxley Creek. Completion of the project was a key factor in gaining approval to refill Chester Morse Lake to elevation 1563 feet (2008).
- Tolt Reservoir Temperature Management: Completed an interactive reservoir water quality computer model that enhances water managers' ability to manage the South Fork Tolt Reservoir and installed equipment throughout the entire vertical water column for real-time temperature monitoring and management (2009).

2.2 SERVICE LEVEL PERFORMANCE

In managing its water resources, SPU has established service levels that are consistent with its regulatory requirements and environmental commitments. In particular, SPU's water resources service levels give emphasis to instream flows and conservation. By meeting these service levels, SPU has high confidence in having adequate water supply to meet all customer demands. Table 2-1 summarizes these service levels.

Table 2-1. SPU's Service Levels for Managing Water Resources

Service Level Objective	Service Level Target
Meet the environmental requirements of our water rights and water supply operations.	Meet instream flow requirements and performance commitments in tribal, regional, state, and federal agreements and permits.
Meet water use efficiency goals to ensure wise use and demonstrate good stewardship of limited resource.	Achieve water conservation goals: - Save 14.5 mgd peak season (11 mgd annual average) from 2000 to 2010. - Save additional 15 mgd (average annual) from 2011 to 2030. - Meet the Initiative 63 Settlement Ordinance requirements.

Since 2006, SPU has been in compliance with all minimum flow specifications and supplemental flow targets for its Cedar and South Fork Tolt River water supplies. Since 2006, there have been a few downramping events on the Cedar River, in which water levels fell more quickly than prescribed by the Cedar River Watershed Habitat Conservation Plan (HCP). All events have been reported to the Instream Flow Commission and corrective action described and taken. To date, SPU has also met other performance commitments of the Cedar River Watershed HCP and

Muckleshoot Indian Tribe (MIT) Settlement Agreement that do not involve instream flows, including limits on diversions from the Cedar River.

In addition, SPU has achieved its water conservation goals through 2010. Additional information on these achievements is provided in Section 2.3.3. The service level targets for water use efficiency will be updated with the Water Use Efficiency Goal described in Section 2.4.1.1 of this plan.

2.3 Existing System and Practices

The total population currently served by SPU and its wholesale customers in King and south Snohomish County is about 1.3 million.

The total population currently served by SPU and its wholesale customers in King and south Snohomish County is about 1.3 million. To provide water to the people and businesses in its service area, SPU operates and maintains supply facilities associated with its surface water sources and well fields. This section provides an overview of the area to which SPU provides water service. The section also summarizes the City's water rights and the quantity of water that can be reliably provided to the service area, or the firm yield of its supply sources. SPU's water demands, including the non-revenue component of demand, are then summarized. The City's water conservation programs are described, and the section concludes by describing the operations activities employed to manage instream flows and the maintenance activities for the water supply facilities.

2.3.1 Service Area Characteristics

SPU's retail service area includes the City of Seattle and portions of the cities of Shoreline, Lake Forest Park and Burien, as well as portions of unincorporated King County south of the City of Seattle. SPU also provides retail water service to Shorewood Apartments on Mercer Island and SeaTac Airport. The SPU retail service area reflects the proposed annexation of the area known as the Greenbridge Notch (Wind Rose) by Water District 45. Also, the area served in the City of Shoreline may become a wholesale area in 2020 if current efforts by the City of Shoreline are successful in creating a new utility.

Besides serving retail customers, SPU provides wholesale water to area cities and water districts, who in turn deliver water to their customers' taps. Figure 2-1 shows these different customer types and service area boundaries, which, in general, includes the City of Seattle, the suburban areas immediately to the north and south, and similar areas extending east of Lake Washington to slightly beyond North Bend.

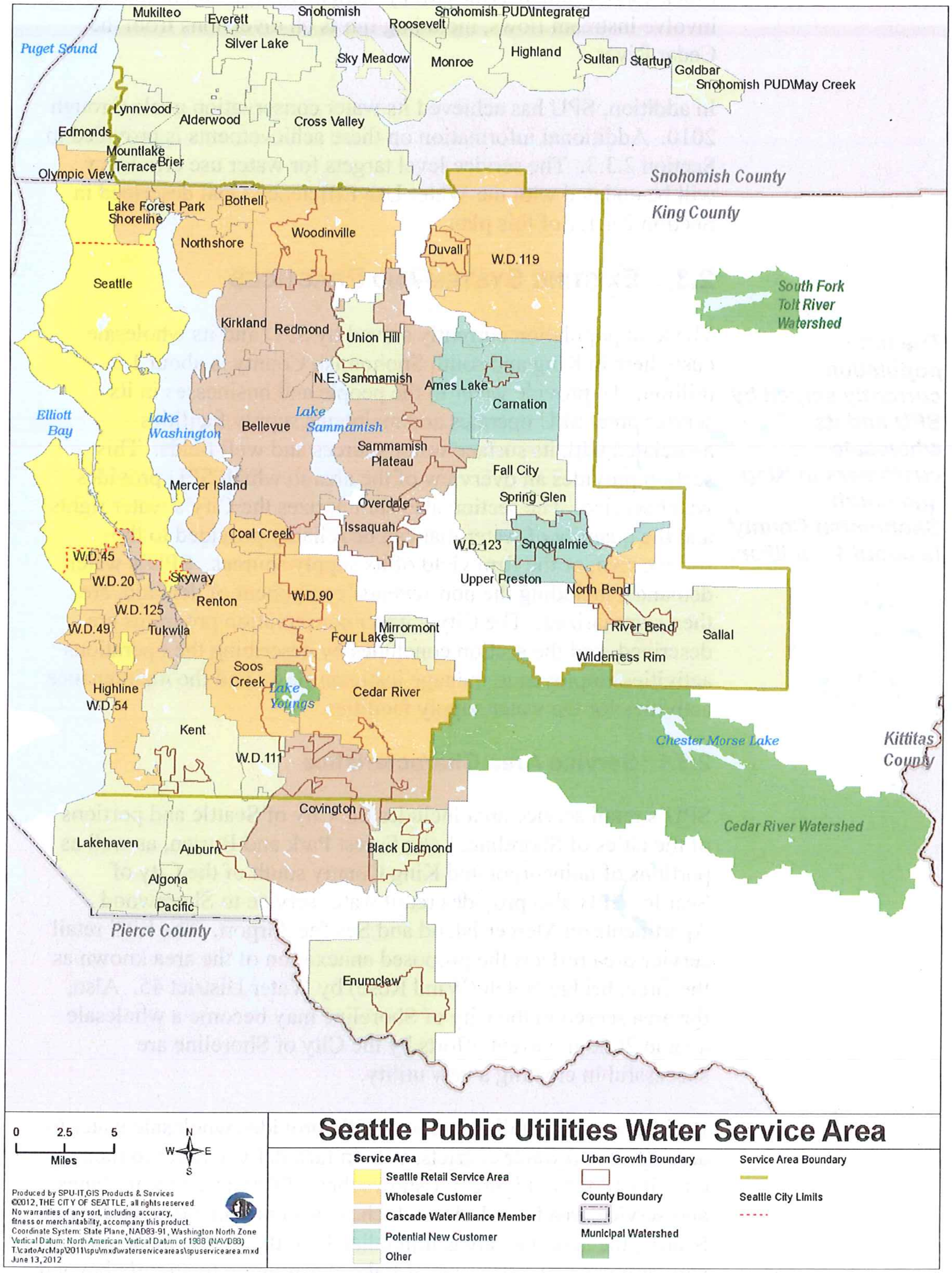


Figure 2-1. SPU's Water Service Area

2.3.1.1 Changes in Demographics

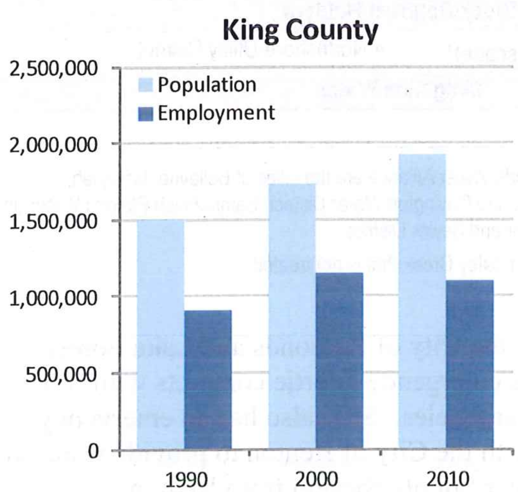
Since 2000, there have been significant changes in demographics that were influenced by the economy. Following the 1990 recession, King County employment grew much faster than population, 27 percent compared to 15 percent, from 1990 to 2000. In the last decade, population grew a little slower at 11 percent, but employment shrank so that 4 percent fewer people were employed in 2010 than in 2000. Table 2-2 and the figures below show the changes in population, households and employment in King County and Seattle.

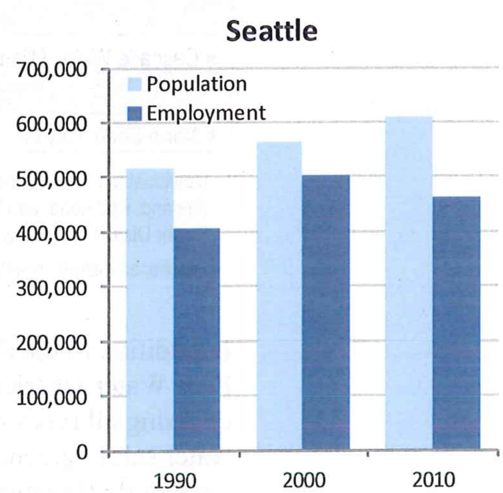
Table 2-2. Demographic Changes

	Population[1]		Households[1]		Employment[2]	
	King County	Seattle	King County	Seattle	King County	Seattle
1990	1,507,319	516,290	615,792	236,715	907,753	407,862
2000	1,737,034	563,374	710,916	258,510	1,149,642	502,835
2010	1,931,249	608,660	789,232	283,510	1,099,639	462,180
Change						
1990-2000	229,715	47,084	95,124	21,795	241,889	94,973
2000-2010	194,215	45,286	78,316	25,000	-50,003	-40,655
% Change						
1990-2000	15.2%	9.1%	15.4%	9.2%	26.6%	23.3%
2000-2010	11.2%	8.0%	11.0%	9.7%	-4.3%	-8.1%
Annual %						
1990-2000	1.4%	0.9%	1.4%	0.9%	2.4%	2.1%
2000-2010	1.1%	0.8%	1.1%	0.9%	-0.4%	-0.8%

1 U.S. Census: 1990, 2000 and 2010

2 Puget Sound Regional Council covered employment estimates





2.3.1.2 Retail Customers

SPU delivers water directly to a population in its retail service area of more than 664,000 through more than 188,000 service connections, approximately 36,000 more people than indicated in the *2007 Water System Plan*. This increase has resulted from increased population density from development of vacant property and redevelopment of property to higher densities.

2.3.1.3 Wholesale Customers

SPU's wholesale customers, excluding North Bend, provide SPU water to a resident population of about 629,000. Current Seattle wholesale customers, listed in Table 2-3, include 19 municipalities and special purpose districts, plus Cascade Water Alliance.

Table 2-3. SPU Wholesale Water Customers

Full Requirements Contract Holders	
• Bothell, City of	• Water District No. 20
• Cedar River Water and Sewer District	• Water District No. 45
• Coal Creek Utility District	• Water District No. 49
• Duvall, City of	• Water District No.119
• Mercer Island, City of	• Water District No.125
• Shoreline Water District	• Woodinville Water District
• Soos Creek Water and Sewer District	
Partial Requirements Contract Holders	
• Highline Water District	• Renton, City of
• Olympic View Water and Sewer District	• Water District No. 90
Block Contract Holders	
• Cascade Water Alliance (Cascade)[1]	• Northshore Utility District
Mitigation Water	
• North Bend, City of[2]	

1 Individual members of the Cascade Water Alliance are the cities of Bellevue, Issaquah, Kirkland, Redmond, and Tukwila, and Covington Water District, Sammamish Plateau Water and Sewer District, and Skyway Water and Sewer District.

2 Purchases mitigation water from Boxley Creek that is not treated.

In addition to the above, the City of Edmonds and Lake Forest Park Water District have emergency intertie contracts with SPU covering all types of emergencies. SPU also has an emergency water sales agreement with the City of Renton to provide water to the Seattle Regional Water Supply System from Renton.

Since the last of the 1982 contract holders signed new contracts in 2011, SPU now provides regular municipal water service to its wholesale customers under three contract types:

- Full Requirements Contracts. Thirteen of SPU's wholesale customers, as shown in Table 2-3, now receive all of their water supply under full-requirements contracts. These contracts extend to 2060, establish wholesale water rates, and include a provision for an operating board to address issues related to the Seattle water supply system.

- Partial Requirements Contracts. As shown in Table 2-3, four of SPU's wholesale customers purchase water from SPU under a partial requirements contract. These utilities have their own sources of supply with which they meet a portion of their demand and depend on Seattle for the rest. Contract provisions pertaining to expiration dates, wholesale rates, Operating Board membership, etc., are identical to the full requirements contracts.

- Block Contracts. In 2003, SPU signed long-term contracts for specified amounts of water ("block contracts") with the Cascade Water Alliance (Cascade), whose members are listed above in a footnote to Table 2-3, and Northshore Utility District (Northshore).

  - SPU's contract with Cascade is a declining block contract that limits annual Cascade purchases from SPU to an average 30.3 million gallons per day (mgd) through 2023, after which the block volume begins to decline. The block will be reduced by 5 mgd in 2024 and by another 5 mgd in 2030. Additional 5-mgd reductions will occur every 5 years thereafter through 2045, leaving a final block of 5.3 mgd. A contract amendment in 2008 provides for supplemental blocks of water of 3 mgd from 2009 through 2017 and 5 mgd from 2018 through 2023 that are in addition to the blocks specified in the first contract. Cascade chose to not participate on the Operating Board and the regional conservation program.

  - Northshore's block contract is for 8.55 mgd on an average annual basis for the duration of the contract, which is expected to meet all the district's water supply needs into the future. Northshore provides water directly to its retail customers and participates on the Operating Board and in the regional conservation program.

2.3.2 Water Demand

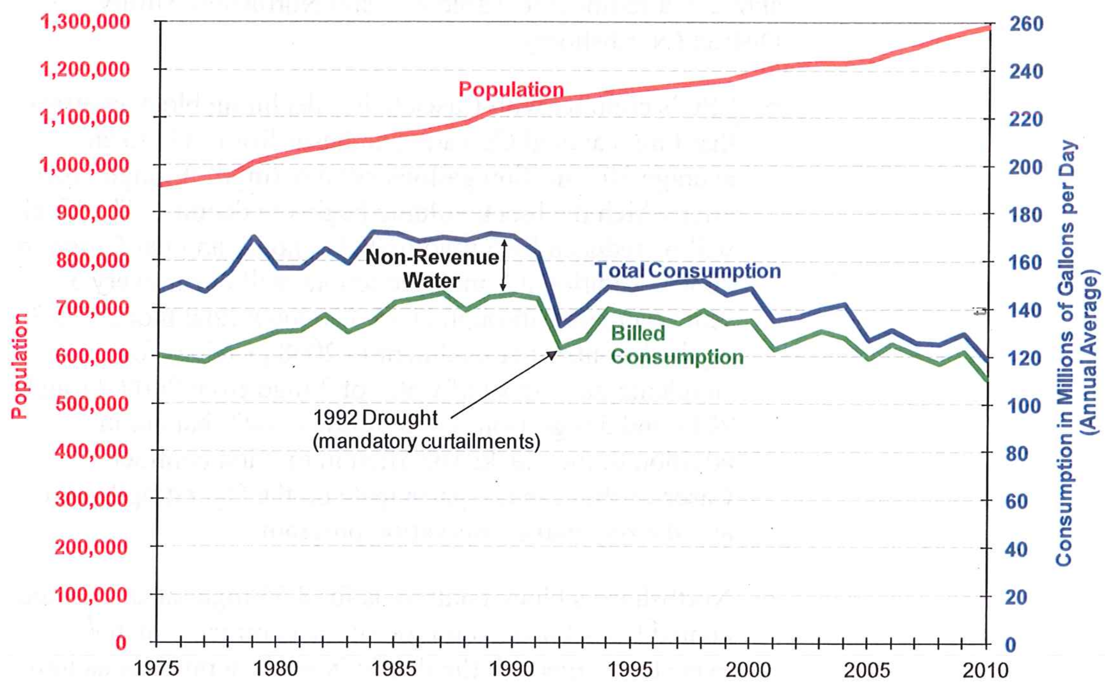
For most of Seattle's history, water consumption increased along with its population. However, that link was broken around 1990 when consumption reached its highest level. Since then, water consumption has steadily declined despite continued population growth. By 2010, consumption was lower than it had been since 1957 when the regional service area was smaller.

Are people using less water?

Yes! Today, people in SPU's regional water supply system use 30% less water than they did In 1990. Total water consumption is now lower than it was in 1957, despite population growth.

2.3.2.1 Historical Water Consumption

Figure 2-2 displays Seattle system water consumption and service population since 1975. While population has steadily risen since 1975, water demand leveled off during the 1980's before dropping off sharply in 1992 due to a severe drought and mandatory curtailment measures. Since then, the combined effects of higher water and sewer rates[1], new federal and state plumbing codes, utility conservation programs, and improved system operations kept both billed and total consumption significantly below pre-1992 drought levels. Also, water consumption in recent years has also been impacted by the ongoing economic recession. Between 1990 and 2010, consumption has decreased about 30 percent (50 mgd) while population increased by 15 percent.



Note: Population is adjusted to reflect the proportion of resident service area population actually using SPU water (i.e., excludes those that receive water from other sources).

Figure 2-2. Population Growth and Water Consumption from SPU Sources

[1] Seattle's sewer rates are based, in part, on water use, so that using less water may result in a lower sewer bill, thereby increasing a retail customer's incentive to conserve water.

One benefit of the lower demand is a reduced need for treated water storage and their associated costs and water quality impacts.

Peak water demand has fallen even more than annual average demand since the 1980's when hot summer weather could produce peak day consumption of over 330 mgd. In the last ten years however, peak day consumption has stayed below 250 mgd even on the hottest days. Recent years with cool summers, peak day consumption has been below 200 mgd. Peak month and peak week consumption have also been trending downwards over the past twenty plus years, though not as steeply as peak day consumption.

2.3.2.2 Non-Revenue Water

SPU's system non-revenue water is calculated by subtracting total metered water sales, both retail and wholesale, from total water production. Distribution System Leakage, as reported to the state, is a component of non-revenue water. Since the *2007 Water System Plan*, the amount of non-revenue water has declined due to reduced use of water for system operations. As the remaining open reservoirs have been covered and buried, overflowing for water quality reasons has been substantially reduced, as has the need to empty the reservoirs for cleaning. Table 2-4 reflects SPU's best estimates of the components of non-revenue water for 2010.

Table 2-4. Components of Non-Revenue Water and Estimated Magnitudes

Total Non-Revenue Water	**8.0 mgd**
System Operations	**0.3 mgd**
Reservoir Overflowing	<0.1 mgd
Reservoir Draining/Cleaning	0.2 mgd
Water Main Flushing	<0.1 mgd
Public Uses	**0.3 mgd**
Sewer flushing, fire fighting, etc.	0.3 mgd
System Losses	**7.4 mgd**
Measured Losses (Reservoir Leaks/ Net Evaporation)	0.3 mgd
Unmeasured Losses (Pipeline Leaks and Other)	3.7 mgd
Meter Inaccuracies[a]	3.4 mgd

Note: All the above categories except meter inaccuracies were estimated by water planning and operations staff. Meter inaccuracies were calculated by subtracting the estimates for all other types of non-revenue water from total non-revenue water. To the extent the estimates for all other types of non-revenue water are (on average) too low, the estimate of unmeasured losses will be too high, and vice versa.

2.3.3 Water Conservation Programs

***Passive Savings* are reductions in water use that occur as customers, without SPU intervention, purchase new plumbing fixtures and water-using appliances that meet, or in many cases exceed federal and state codes.**

SPU's water conservation strategy includes a comprehensive regional program for Seattle and participating wholesale customers, as well as a targeted effort for Seattle's low-income residents. Savings also come from water rates designed to promote conservation, passive savings, and system efficiencies.

2.3.3.1 Regional Conservation 2000-2010

In 1999, SPU took on an ambitious goal: keep water demand from increasing over the next ten years, despite projected regional population and economic growth. At the time, Seattle was one of the few large cities in the country attempting to manage expected growth in water demand through conservation.

A key component of SPU's water conservation approach was achieved by its Saving Water Partnership – a collaborative program run by Seattle and 17 of SPU's wholesale customers[1]. The program emphasized long-term water use efficiency without customer sacrifice. The regional program set a savings target of about 1 mgd per year, or a cumulative average annual total savings of 11 mgd.

Conservation measures promoted by the program eliminated unnecessary, wasteful use of water while customers and the community continued to enjoy high-quality drinking water.

With support of residential, commercial and institutional customers, the Saving Water Partnership achieved a cumulative savings total of 9.6 mgd from the year 2000 through 2010, at a cost to the participating utilities of $35 million. Highlights of the measures implemented during the program are shown in Table 2-5. The *Saving Water Partnership 2010 Annual Report and Ten Year Program Review* provides additional detail on the program's accomplishments and is available on the Saving Water Partnership web-site.[2]

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[1] The City of Renton joined the Saving Water Partnership in 2011, bringing the total number of participating wholesale customers to 18. As of January 2012, Saving Water Partnership members include SPU along with Northshore Utility District, and all Full and Partial Requirements Contract utilities: Cedar River Water & Sewer District, City of Bothell, City of Duvall, City of Mercer Island, City of Renton, Coal Creek Utility District, Highline W.D., Olympic View Water & Sewer District, Shoreline W.D., Soos Creek Water & Sewer District, W.D. 20, W.D. 45, W.D. 49, W.D. 90, W.D. 119, W.D. 125, and Woodinville W.D.

[2] http://www.savingwater.org/docs/2010_Annual_Report.pdf

Table 2-5. Summary of Regional 1% Program Accomplishments 2000-2010

Measures Implemented	Strategies Implemented
RESIDENTIAL INDOOR	
• Replace washing machines • Replace toilets, showerheads & faucets (multifamily) • Fix leaks (toilets) • Change behaviors (faucet use, shower time, full loads)	• 180,392 showerheads distributed to single-family residents • 78,770 washing machine rebates and 1,073 multi-family coin-op rebates • 32,838 multifamily and 5,773 single family toilet rebates • 36,693 showerheads and aerators distributed to multifamily properties • Behavior messaging • Collaboration with energy utilities • Program recruiting through retailers, radio, TV and print ads, ads in property manager trade publications, website • Promotion of Flush Star and Water Sense toilet performance
RESIDENTIAL LANDSCAPE	
• Improve irrigation system performance • Change landscape watering behaviors • Encourage practices that affect watering (e.g. mulch, soil prep and plant selection)	• 1,015 Irrigation system efficiency rebates • Right Plant, Right Place promotion via retailer partnerships (nurseries, home and garden centers) • Savvy Gardener e-newsletter and classes – 3,451 subscribers; 4,149 class attendees • The Garden Hotline – 134,152 questions answered • Natural Lawn & Garden Guides (how-to materials) – 590,440 distributed • Training for irrigation professionals • Develop irrigation technology performance testing through Irrigation Association Smart Water Application Technologies Initiative • Online weather data, watering index, water budgeting and irrigation scheduling tools
COMMERCIAL PROCESS/DOMESTIC	
• Upgrade toilets and other domestic water use fixtures • Upgrade industrial and commercial water-using equipment • Improve building cooling performance • Upgrade efficiency of specific water consuming medical and lab equipment • Outreach to ethnic businesses	• Financial incentives (723 custom projects & standard rebates) • Targeted promotion through vendors, trade groups, agencies with focus on Mexican and Korean businesses • Restaurant targeting – Commercial Kitchen Equipment Partnership with multiple energy and water utilities • Outreach to business groups through Resource Venture (www.resourceventure.org) • Technical assistance, assessments, workshops • End-use metering to build cost-effective conservation recommendations
COMMERCIAL LANDSCAPE	
• Upgrade irrigation equipment (controllers, rain sensors, drip) • Improve scheduling and maintenance • Train irrigation contractors and installers	• Targeted outreach to large commercial customers • Site-specific recommendations and technical assistance • Financial incentives (custom projects and set rebates) – 375 businesses and institutions • Targeted recruiting and promotion to large commercial customers • Market transformation by establishing and building vendor and contractor relationships • Online weather data, watering index, water budgeting and irrigation scheduling tools • Training for irrigation professionals – 500 attendees
YOUTH EDUCATION	
• Build conservation awareness and residential measures	• Educator resources – teacher trainings and materials online • Classroom and take-home materials – 43,660 conservation kits distributed; 12,900 water system posters distributed; 9,000 activity books distributed • Web-based interactive activities – 44,911 Water Buster game players • Support of water festivals and events
OVERALL MESSAGING	
• Conservation awareness supporting recruitment of residential and commercial customers	• Market EPAWaterSense labeled products • Promote regional website: www.savingwater.org • Water conservation hotline: 684-SAVE • Collaboration with Partnership for Water Conservation • Festivals, utility open house events • Radio, TV, public transit, and print advertising

After ten years, the overall goal of keeping demand flat was not only achieved, but exceeded. The programmatic savings were complimented by additional savings from standards, codes, rates, and system operation changes. Average annual demand was lower in 2010 than in 2000. Figure 2-3 illustrates the components that have contributed to a greater than 30 mgd reduction in water use since 2000.

While population has steadily increased, water consumption has decreased by over 30 mgd since 2000.

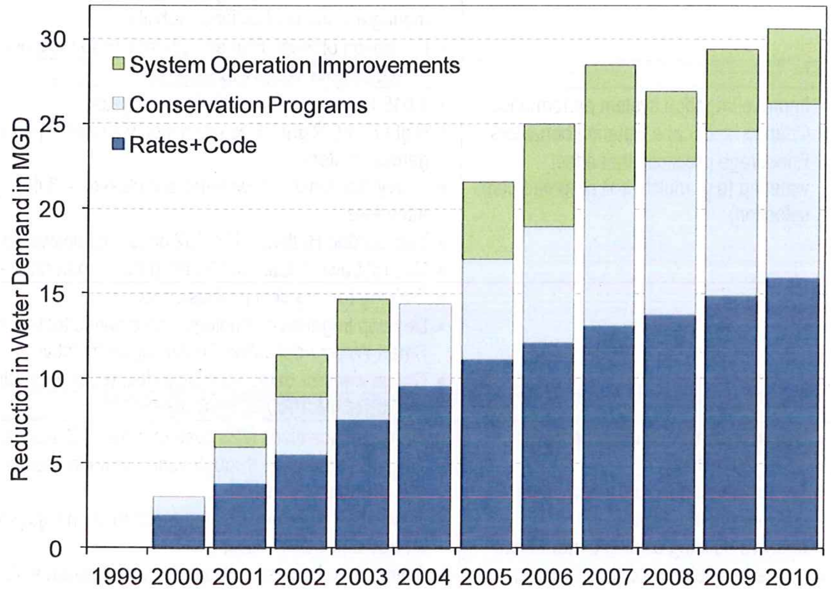


Figure 2-3. Cumulative Water Savings from Conservation, in Average Annual mgd, 1999-2010

2.3.3.2 Seattle-Only Conservation 2003-2010

In addition to the regional program, SPU has implemented a water conservation program exclusively for low-income customers in Seattle. The City of Seattle adopted the I-63 Settlement Ordinance in 2001 (Ordinance 120532), which committed the City to pursue conservation beyond the Regional Program in the SPU direct service area and to focus on low-income housing conservation assistance by establishing the "Everyone Can Conserve Program." From 2002 through 2010, the program retrofitted over 20,000 income-qualified housing units with water conservation fixtures and equipment. A similar but modified Program continues post-2010 as part of the City's efforts to help low-income customers manage their water bills.

Ordinance 120532 directed SPU to provide 3 mgd of water savings in the Seattle retail service area by 2010 through the low-income conservation program, rate structures that provide conservation incentives, increased system efficiencies resulting from the accelerated in-town reservoir replacement program, and other cost-effective measures. SPU has met these requirements.

2.3.3.3 Water Use Efficiency Goal and Program 2007-2012

As part of the process to comply with the WDOH Water Use Efficiency Rule, the Saving Water Partnership utilities updated regional policy objectives for water conservation and set a six-year regional goal. These goals were described in SPU's *2007 Water System Plan.* For the Saving Water Partnership, the 2007-2012 regional water conservation objectives were to provide:

- Low-cost insurance for meeting potential future challenges from climate change;
- Efficient management of water resources; and
- Assistance to customers with managing their bills.

For its 2007-2012 Water Use Efficiency Goal, the Saving Water Partnership adopted cumulative average annual regional programmatic water saving targets of 11 million gallons per day from 2000 through 2010 and 15 mgd of both price and programmatic savings from 2011 through 2030. The six-year portion of these two regional targets, from 2007 through 2012, is estimated to total 5.98 mgd. As with earlier programs, the range of services for customers remains a mix of education as well as financial rebates for water saving equipment.

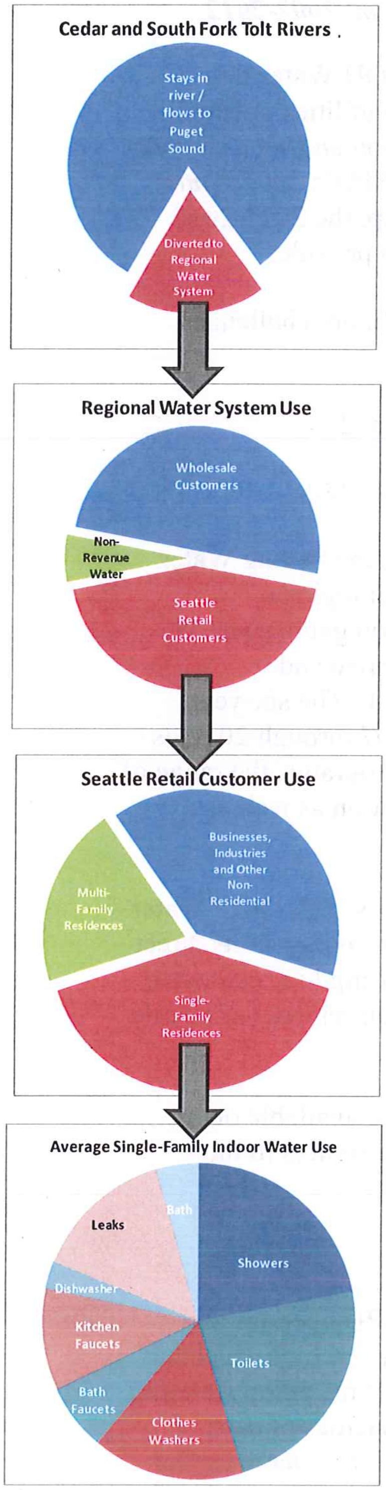
Note that in addition to the regional goal, SPU's 2007-2012 Water Use Efficiency Goal includes additional water savings in its direct service area. Additional water savings of 2.57 mgd are estimated to be achieved from implementation of the requirements of Seattle Ordinance 120532.

SPU's Water Use Efficiency annual reports are available on the WDOH web-site and are reported to SPU's customers in the annual Drinking Water Quality Report.

2.3.4 Existing Water Supply

To meet the water demand of its customers, SPU operates and maintains two surface water sources of supply, each of which has associated infrastructure (such as reservoirs, dams, pump stations, and pipelines). This section describes the capacities of each of Seattle's water sources and provides information concerning the City's water rights and firm yield.

Where is all of the water from the Cedar and Tolt used?



2.3.4.1 Supply Sources

Seattle obtains approximately 70 percent of its raw drinking water supply from the Cedar River and most of the remaining 30 percent from the South Fork Tolt River. Seattle's two well fields are available to provide drought and emergency supply. Additional information about each supply source is included below. The few changes that have occurred since the *2007 Water System Plan* are noted.

Cedar River. The Cedar River Municipal Watershed is located in the Cascade Range within southeast King County. The watershed contains the 1,680-acre Chester Morse Lake, formed behind Masonry Dam. The reservoir stores 13 billion gallons (40,000 acre-feet) between elevations 1563 and 1538 feet.

The Chester Morse Lake pumping plants, two sets of barge-mounted pumps, each with the capacity to pump 120 mgd, are stationed year-round on the lake and can be anchored near its outlet to draw additional water from below the outlet level and discharge dike during low reservoir conditions (below approximately elevation 1538 feet). Use of the pumping plants requires rental and installation of mobile diesel generators, installation of flashboards at the Discharge Dike, and other set up activities which necessitate a lead-time of up to two months prior to actually needing to pump.

Water stored in Chester Morse Lake flows downstream to the Landsburg Diversion Dam and fish passage facility, which is located about 14 miles downstream from the Masonry Dam. Here, water is diverted through pipelines to Lake Youngs Reservoir. Lake Youngs Reservoir, with a useable storage capacity of approximately 1.5 billion gallons (4,600 acre-feet), provides additional storage and regulates flows to the Cedar Water Treatment Facility.

Some of the Cedar River source water is lost from Masonry Pool, the portion of the reservoir between the Overflow Dike and Masonry Dam, via seepage into a moraine on the Pool's northern bank. Water leaks out of the Masonry Pool mostly in the spring and early summer, when water is relatively abundant, fills an underground "reservoir" or aquifer, then a portion returns to the river in the summer, when it provides a water supply benefit in the critical fall season, before the fall rains return. About 75 to 80 percent of the water that leaks from Masonry Pool is "stored" in this way and finds its way back to the Cedar River, while the remainder ends up in the Snoqualmie River basin. Some of this seepage is discharged through Hobo Springs. In 2009, piping was installed to divert water from Hobo Springs to Boxley Creek for the city of North Bend to mitigate use of their wells on the Snoqualmie River. The amount of water provided was 0.09 mgd in 2009 and 0.05 mgd in 2010.

The Cedar Moraine Safety Study identified that the West Boxley area of the Cedar Moraine could result in a groundwater burst failure under seismic conditions when steady-state groundwater levels reach those associated with Masonry Pool elevation 1555 feet and above. The flood resulting from the groundwater burst failure could impact people downstream. The annual probability of failure for the seismically-induced groundwater burst was estimated at 1 chance in 2,400. This annual probability of failure does not meet Department of Ecology Dam Safety Office requirements of a less than one in 10,000 year probability of failure.

In order to meet Ecology requirements, SPU constructed a subsurface drainage system into the face of the moraine hillside embankment. The purpose of the drainage system is to capture groundwater prior to reaching the slope face, thereby reducing the potential for a groundwater burst flow event. An additional result of the installation of the drains is that SPU received Ecology authorization to officially have a normal permanent refill level of elevation 1563 feet in Chester Morse Lake.

South Fork Tolt River. The South Fork Tolt River Municipal Watershed is located about 13 miles east of Duvall in King County. The South Fork Tolt Reservoir, which went online in 1964, provides 18.3 billion gallons (56,160 acre-feet) of storage. Water from this reservoir is conveyed to the Tolt Regulating Basin and the Tolt Water Treatment Facility.

Seattle Well Fields. In addition to the major surface water supplies, Seattle operates two small well fields in the City of SeaTac to provide additional drought capacity and emergency supply, as needed. The Riverton well field has two wells, and the Boulevard Park well field has one well. In total, the three wells can supply up to 10 mgd for approximately four months. The well fields are naturally recharged, but the wells can also be artificially recharged using a method known as aquifer storage and recovery (ASR), if needed. When used, ASR injects treated water from the Cedar River into the production wells to supplement natural recharge into the aquifer.

2.3.4.2 Water Rights

Seattle holds various water rights for use of water from the Cedar River, South Fork Tolt River, and Seattle Well Fields. Also, Seattle has water right applications on file with the Washington State Department of Ecology (Ecology) for potential future sources of supply, as indicated by the Water Rights Evaluation contained in the appendices. One change in status of these water rights is that the term permit for the Cedar River (Morse Lake) Pumping Plant has expired. Since SPU's Cedar River claim includes the use of this water, it is not necessary to renew the permit.

Also, SPU received a water right permit in 2007 to capture and put to use rainwater that falls on rooftops of structures in the combined and partially separated sewer basins of the City of Seattle. This permit includes a map for areas covered. Under this permit, Seattle would authorize, with conditions, individuals, businesses and other entities within the mapped area to collect and use rainwater. After receiving the permit, Ecology released in 2009 Interpretative Statement / Policy 1017 regarding collection of rainwater for beneficial use to clarify that a water right is not required for on-site storage and use of rooftop-collected rainwater.

SPU is requesting its water rights place of use be changed to include small portions of southern Snohomish County.

Through the *2007 Water System Plan*, SPU changed its place of use for the Cedar River and Lake Youngs claims to be the service area described in that plan as allowed by the 2003 Municipal Water Law (WAC 246-290-107). Through this water system plan and the State review process, SPU is modifying its service area so as to clarify that the service area includes small areas in Snohomish County currently served by Northshore Utility District, the City of Woodinville, and the City of Bothell, as well as potential service area additions proposed by Water District 119. These areas are shown in Figure 2-1 and are based on the following:

- Northshore Utility District, Water System Comprehensive Plan, December 2006, retail service area, including retail service area by Agreement, as shown in Figure 3-1 of that document.
- Woodinville Water District, 2008 Comprehensive Water System Plan, water service area, including interim service, as shown in Figure 2-1 of that document.
- City of Bothell, Water System Plan, February 2011, water system retail service area, as shown in Figure 1-2 of that document.

- Proposed service area additions as indicated by Water District 119, which consist of Snohomish County Sections 31, 32, 33, and 34 of Township 27 North, Range 7 East, east of Highway 203. This area includes properties for which Water District 119 has received requests for service in the recent past due to poor groundwater conditions and the lack of other nearby water purveyors. Any new service to this area is subject to approval by SPU, Snohomish County, King County, WDOH and other jurisdictions.

An evaluation of specific Seattle water right claims, permits, and applications as called for in WDOH planning guidelines is included as an appendix. Forecasts indicate that Seattle does not need to apply for any new water rights within the 20-year planning horizon.

2.3.4.3 Firm Yield and Supply Reliability

Firm yield of SPU's water supply has been updated to 172 mgd, an increase of 1 mgd.

Firm yield is the amount of water that SPU is able to supply system-wide at a given delivery pattern while meeting the supply reliability standard, instream flow requirements, treatment and transmission capacity, and other system constraints, including diversion limits for the Cedar River as set forth in the 2006 Agreement with the Muckleshoot Indian Tribe. Firm yield is expressed as an average annual delivery rate in mgd from all sources operating conjunctively. Calculating firm yield for SPU's existing supply sources is critical to ensuring that SPU can meet existing and future demands reliably. The firm yield can be compared to long-term forecasts of water demand to determine when new sources or additional conservation programs need to be online to maintain the desired level of supply reliability. Firm yield calculations are also useful in determining the quantity of water that can be expected from a potential new source of supply.

SPU uses a computer simulation model to calculate the firm yield from its existing water supply sources and potential new water sources. This model is known as the Conjunctive Use Evaluation (CUE) model. The model is used with 81 years of reconstructed historic flow records that takes into account past weather and hydrologic variability to produce a system-wide firm yield estimate. SPU's supply reliability standard is 98 percent. Therefore, SPU's firm yield is the amount of water that is assured for delivery in all but the driest 2 percent of years without lowering reservoirs below normal minimum operating levels. The firm yield calculation was updated in 2011 to include inflow dataset through 2009 and to represent current operating conditions, namely the use of the current spring refill target of elevation 1563 feet for Chester

Morse Lake and the use of a revised monthly demand distribution based upon the actual demand of 2005 through 2009. The result was that the firm yield increased by one mgd. The combined firm yield of all SPU supplies is currently estimated to be 172 mgd.

2.3.5 Operations

The surface water supply facilities on the South Fork Tolt and Cedar Rivers are operated primarily for water supply and protection of instream flows, but are also used for hydroelectric power generation and flood management. The reservoirs are drawn down and refilled each year. The groundwater supply facilities at the Seattle Well Fields supplement these sources, if needed. Should a drought or other water supply emergency occur, SPU would activate the Water Shortage Contingency Plan (WSCP) contained in the *2007 Water System Plan.* Since the *2007 Water System Plan*, the WSCP has not been activated, and the only time that these wells were used was in 2008. Groundwater elevations during this period are provided in the appendices. Water resource management and operations have changed since the *2007 Water System Plan.* The changes include the following and are described more fully below:

- Installation of the moraine drains resulting in Chester Morse Lake refill elevation of 1563 feet being authorized and changes to seepage from Masonry Pool.
- Operations intended to maintain higher pool levels to better avoid the use of the floating pumps in Chester Morse Lake.
- Management of outlet water temperatures at South Tolt Reservoir in support of South Fork Tolt River fisheries.
- Adjustments to the instream flow requirements for the Cedar River due to the change in hydrology when Walsh Lake Ditch was disconnected and became a tributary to flows above Landsburg on the Cedar River.

2.3.5.1 Chester Morse Lake Refill and Masonry Pool Seepage

As noted previously, some of the Cedar River source water can be lost as a result of seepage through the porous soils of the Cedar moraine on the northern bank of Masonry Pool. The losses are directly proportional to Masonry Pool Reservoir level.

The authorization to allow refill to an elevation of 1563 feet does result in more storage but also leads to increased loss to the moraine. With installation of the moraine drains, some increase in loss to the Snoqualmie Basin has been observed, but the magnitude and timing of this increase is still under evaluation. However, past studies have shown that the seepage provides an overall net benefit to water supply because of the additional storage provided by the moraine aquifer and the timing of water returning to the Cedar River. As noted in the *2007 Water System Plan*, analysis conducted by SPU found that if seepage from Masonry Pool were completely eliminated, an estimated 24 mgd of firm yield would be lost.

Installation of the drains in Cedar Moraine has allowed refill of Chester Morse Lake to elevation 1563 feet.

Presently, water levels in the lake and pool are managed to minimize moraine embankment instability and the potential loss in water supply yield. These management practices are focused on manipulating the water surface elevation in the Masonry Pool to selectively manage seepage to the moraine.

2.3.5.2 Operational Changes to Avoid Use of Floating Pumps

Surveys in 2002 and in subsequent years have revealed that a portion of the Outlet Channel between Chester Morse Lake and Masonry Pool had filled in with sediment resulting in a diminished capacity to convey a sufficient volume of water to meet water supply and instream flow objectives. The channel was dredged in 2002 and 2010, which partially restored the flow capacity. In addition, the Discharge Dike crest elevation was raised in 2002 to 1538 feet, and effectively moved up the minimum elevation at which gravity flow can be maintained and established a new elevation below which pumping is required. This has led to a need to activate the pumps sooner, and consequently more frequently, than what would have occurred in the past. In addition, the existing floating barge system has numerous mechanical and electrical components that are in need of replacement.

Water resource operations in recent years have taken into consideration the condition of the existing floating pumps and channel. The current operational goal is, to the maximum extent practicable, reduce the likelihood that the floating barge system would need to be mobilized during the fall or winter by keeping as much water as practical in Chester Morse Lake. To meet this objective, the river and reservoir system is managed to maximize refill during the spring, maintain the level as long as possible, avoid releases when possible during the summer and early fall, reduce seepage losses in the summer and fall, use more Tolt water, optimize use of Lake Youngs, and use the wells if necessary. While the Morse Lake Pump Plant Project, described below, will improve the floating pump system, SPU intends to continue operating the reservoir in this same manner so as to reduce the likelihood of needing to pump.

2.3.5.3 Temperature Management at South Fork Tolt Reservoir

SPU has been successful at meeting water temperature objectives in the South Fork Tolt River.

SPU uses existing reservoir intake gates to release water from different water depths in the South Fork Tolt Reservoir to provide beneficial water temperatures for instream resources in the river downstream of the reservoir. Specific objectives of this program are to maintain water temperatures throughout the lower South Fork Tolt River within Washington Department of Ecology Standards and at levels that are similar in pattern to temperatures in the unregulated North Fork Tolt River. Since implementation of this program began in 2004, SPU has been successful at meeting these objectives without compromising water supply.

2.3.5.4 Walsh Lake Ditch Disconnect

From 1904 to about 1947, the town of Taylor, Washington, was a large mining and manufacturing community in the western Cedar River Municipal Watershed. In the 1930's, the City of Seattle constructed the Walsh Lake Diversion Ditch (Ditch) to divert the water contaminated by this community. The water was diverted just above the natural confluence with Rock Creek, a tributary of the Cedar River in the Municipal Watershed, and conveyed 1.7 miles to a discharge point on the Cedar River downstream of the Landsburg Diversion Dam (the diversion point for Seattle's Cedar River municipal water supply). Following abandonment and decommissioning of the Taylor townsite in 1947, water quality impairment in the 4.3 sq mi Walsh Lake Basin naturally recovered, making the Ditch obsolete. The Ditch—contained by a constructed earthen levee—is located in a steep ravine above Rock Creek. During a January 2009 storm event, a 300-foot section of the Ditch catastrophically failed, resulting in the natural reconnection of the Walsh Lake sub-basin to its historic tributary flow into Rock Creek—effectively disconnecting and largely dewatering the downstream section of the Ditch.

To account for this change in hydrology with regards to Seattle's water supply and instream flow management, SPU in consultation with the Cedar River Instream Flow Commission adjusted the instream flow requirements in the river by the mean weekly flow contribution from the Ditch (annual mean of 8.6 cfs). In 2012, SPU plans to improve the now-reconnected confluence of Rock Creek and Walsh Lake Ditch, to stabilize the area, and to make long term improvements to stream habitat at the confluence. This work includes the removal of the former concrete diversion weir structure, and breaching of the remnant section of the earthen Ditch levee to stabilize the hillslopes in the area adjacent to the former Ditch.

2.3.6 Maintenance

SPU's water resource maintenance activities focus on the City's watershed dams and particularly on dam safety. The water system includes seven dams located in the Cedar and Tolt water supply systems that are owned by SPU. These dams are maintained to ensure operability and safeguard against damage or failure in large floods, earthquakes, malevolent acts, and general deterioration from aging. The Dam Safety Section of the Washington State Department of Ecology (Ecology) and Federal Energy Regulatory Commission (FERC) regulate the maintenance of SPU's dams to ensure continued safe performance. Both Ecology and FERC require regular inspections of these dams and related infrastructure, such as spillway gates and dam failure warning systems; inspections that can result in requirements for maintenance work or major capital improvements.

SPU is developing a strategic asset management plan (SAMP) for the major dams that are part of the water supply system. A SAMP for Lake Youngs has been completed and one for the Tolt is expected to be completed in 2012. These SAMPs will analyze how SPU should maintain and repair the dams and make recommendations as to any renewals of the existing dams or their components. They will also include recommendations regarding elements such as the mechanical and electrical equipment associated with the dams, including the dam failure warning systems. The key result from the Lake Youngs SAMP is the recommendation to begin analysis of the eastern Cascades Dam for ways to reduce impacts of a seismic induced failure on water quality (see Section 2.4.2.5 for more information).

2.4 Needs, Gaps, and Issues

Needs, gaps, and issues facing the Water Resources business area include appropriately planning for water supply in the face of uncertainty and potential climate change impacts and improving water supply infrastructure and operational practices to make the best use of existing supplies. The Water Use Efficiency Goal and program for the 2013-2018 time period is also described, along with an updated water demand forecast. Each of these specific issues is discussed in the following section, along with how SPU plans to address them.

COUNCIL CLERK

2.4.1 Future Water Demand and Supply

There are uncertainties affecting both future water demand and future water supply. Future water demand is dependent on population growth, income, conservation, climate, weather, and other factors, such as changes in water appliance efficiency standards. Future water supply depends on the condition of water supply infrastructure, new operating constraints, climate, the feasibility of developing new supplies as needed, and other factors, such as legal and regulatory issues. SPU has developed water demand forecasts and analyzed future water supply using frameworks that incorporate these relative uncertainties. The results of SPU's analyses are described in the following sections.

2.4.1.1 Water Use Efficiency Goal and Program 2013-2018

For over twenty years, SPU and its wholesale utility customers have successfully designed and delivered water conservation programs for residents, businesses and institutions throughout the regional service area. Conservation has proven to be an effective and flexible strategy. In the early years, conservation programs helped educate customers about the efficient use of water and successfully built an ethic of stewardship. Having an established program was a key response strategy during droughts when voluntary and mandatory customer water curtailment was needed. Later, conservation programs helped to decrease per capita water use when the need for a new source of supply was forecast.

Experience has demonstrated the value of periodically assessing the reasons for and role of customer-based conservation programs in water system planning -- to ensure that the program emphasis supports utility needs, reflects customer preferences, and recognizes changing regulatory and market factors that affect water use efficiency.

As of January 2012, in the Seattle water system, SPU and 18 of its wholesale utility customers operate regional conservation programs collaboratively as the Saving Water Partnership[1]. Utility members set and oversee conservation goals, objectives, and program intensity through the Operating Board. Staff from the utilities comprise the Water Conservation Technical Forum, which is tasked with designing programs within parameters defined by the Operating Board. In SPU's retail area, a customer-based Water

[1] For Saving Water Partnership member listing and website, and regional conservation goals, programs, and accomplishments through 2012, see Sections 2.3.3.1 and 2.3.3.3.

System Advisory Committee provides additional customer input and feedback on conservation goals, objectives, and programs.

To scope and scale regional conservation initiatives for the 6-year planning timeframe required by the Washington State Water Use Efficiency (WUE) Rule, the Saving Water Partnership reviewed the current water demand forecast, which is described in the next section, prior to adopting a Water Use Efficiency Goal and Program. The demand forecast indicates that a new source of supply is not needed before 2060 despite continued growth in regional population. This is, in part, due to increased attribution of passive conservation savings as a factor in reducing per capita demand.

Conservation prepares the region for potential water supply challenges, helps customers use water wisely, and preserves the ethic of stewarding natural resources.

The Saving Water Partnership recognizes that the utilities and their customers benefit from a regional conservation program that ensures staff expertise and strong industry partnerships are available to meet a variety of water system needs. This "conservation infrastructure" prepares the region for potential water supply challenges, helps customers use water wisely, and preserves the ethic of stewarding natural resources.

As a statement of objectives for its regional conservation efforts from 2013-2018, the Saving Water Partnership will:

- Ensure core capacity is available to deliver conservation programs that prepare the utility to be resilient for curtailment events and future supply challenges from climate change, as well as help customers use water wisely;
- Preserve customers' ethic of conservation as one element of stewarding our water resources and the environment; and
- Meet regulatory and contractual requirements.

The Saving Water Partnership utilities set a regional combined conservation goal that reflects a reduction in per capita water demand – for residents, businesses, and institutions throughout the regional service area – and holds total water use below a specified level despite population growth being forecasted to increase by 3.9 percent over the six-year period. The goal is formally adopted by each utility's governing body and is reported on annually by each utility. The goal for the Saving Water Partnership service area captures the cumulative effect of all demand-side conservation indicated in the water demand forecast including water savings from utility funded customer-based programs, price-induced conservation from customer response to water and sewer rate increases, and passive savings.

The Saving Water Partnership's regional 2013-2018 Water Use Efficiency Goal is to:

> **Reduce per capita water use from current levels so that total average annual retail water use of members of the Saving Water Partnership is less than 105 mgd from 2013 through 2018 despite forecasted population growth.**

The metric for determining success of the Water Use Efficiency Program measures reductions in metered retail water consumption in the Saving Water Partnership members' service areas, regardless of whether the water is supplied by SPU or a member's own source of supply.

The Saving Water Partnership defined the regional utility-funded customer-based program in its 2013-2018 Water Use Efficiency Program to support its objectives and 6-year goal. The customer-based conservation program is one component of demand management included in the regional 2013-2018 Water Use Efficiency Goal. Selection of measures for the customer-based conservation program is based on an understanding of national appliance and fixture codes, estimates of sales in the market that exceed code, reviews of regional conservation potential analysis and Saving Water Partnership program impact evaluations, market research with utility customers to assess program acceptance and effectiveness, and opportunities for partnerships to leverage water utility funds. Considerations also include ensuring balanced service across customer classes, providing conservation services across utility member service areas, and opportunities to reach traditionally under-served populations. Because the current demand forecast does not indicate that a new source of water supply is needed until sometime after 2060, a set level of avoided water supply cost with which to compare conservation measures is not available.

The 2013-2018 Water Use Efficiency Program renews emphasis on consumer and youth education along with a priority to benchmark customer attitudes about water conservation. It also includes educational campaigns for leak prevention and water use in the landscape. Additionally, the program continues to share costs with customers who retrofit old water-using equipment with new equipment that is more efficient than national and State appliance and fixture codes. Conservation measures for the 2013-2018 Water Use Efficiency Program are summarized in Table 2-6.

Table 2-6. Summary of Saving Water Partnership 2013-2018 Water Use Efficiency Program

General Activities	Specific Measures
CUSTOMER BEHAVIOR CHANGE	
• Community events, schools support, customer education	• Schools outreach • Festivals, shows and fairs • Customer technical assistance • Regional phone hotline: 684-SAVE • Tips on Tap articles for utility newsletters • Media promotion and advertising • Customer mailings • Regional web site: www.savingwater.org • Partnerships with vendors, trade groups, agencies and energy utilities • Awards and recognition • Education on water pricing and conservation rates • Equitable customer access to conservation messages and services
• Leaks and indoor water use education	• Find and fix leaks instructional videos and information on web and in print • Leak detection dye strips distributed via direct mailings
• Landscape water use education	• Landscape classes for residential gardeners • Irrigation scheduling and maintenance • Expert one-on-one advice through the Garden Hotline • Natural Lawn & Garden Guides (how-to materials) and other brochures • Online weather data, watering index, water budgeting and irrigation scheduling tools • Irrigation training in multiple languages for professionals • Smart Water Application Technologies testing
• Benchmarking customer behavior	• Customer research including identification of traditionally underserved populations and program design options to meet their needs • Technical studies and end-use metering • Conservation measure evaluation
WATER EFFICIENT EQUIPMENT UPGRADES	
• Residential indoor water use	• Single-family toilet rebates • Multi-family toilet rebates
• Residential and Commercial irrigation systems	• Weather-based irrigation controllers • Pressure regulating and efficient spray heads • Drip irrigation and micro sprays • Seasonal adjust (percentage) controllers • Irrigation system leak monitoring alarms
• Businesses and institutions	• Technical assessments and outreach • End use metering and monitoring • Plumbing fixture rebates for toilets, urinals, showerheads, aerators, etc. • Cooling and process water rebates • Food service equipment rebates • Medical and lab equipment rebates • Laundry equipment rebates • Steam condensate equipment rebates • Partnerships with energy utilities • Evaluation of reclaimed water opportunities

COUNCIL CLERK

The Saving Water Partnership estimates the average savings from the 2013-2018 Water Use Efficiency Program will be 0.3 to 0.4 mgd of annual savings at an estimated annual utility cost of $2,150,000 (2011 dollars). The estimated annual mgd savings from the Water Use Efficiency Program are one component of the 6-year regional Water Use Efficiency Goal, which captures all sources of demand reductions.

2.4.1.2 Water Demand Forecast

The new water demand forecast includes passive conservation savings and is lower than the last forecast – and still indicates that no new supply needed before 2060.

Long-term water demand forecasting is critical for water system planning. SPU has updated and improved the Demand Forecast Model developed for the *2007 Water System Plan*. This new model incorporates the best features of various model types found in applicable literature. Like simple "fixed flow factor" models, the new SPU model is easy to understand and has relatively modest data requirements. However, like more complex econometric models, the model reflects the impacts of variables such as price, income, and conservation on water use factors over time. This approach takes advantage of past econometric analysis to provide estimates of how price and income can affect demand. The model incorporates estimates of the impacts of passive savings on the water use factors over time, as described below. More information on the model, data sources and assumptions are provided in an appendix.

SPU's official water demand forecast is presented in Figure 2-4, and the various components that add up to the total demand forecast are shown in Figure 2-5. The demand forecast is considerably lower than the *2007 Water System Plan* forecast, particularly in the outer years, and remains considerably below SPU's current firm yield of 172 mgd until well after 2060. Total demand is forecast to remain relatively flat through 2023, at which point the Cascade block begins to step down. Over the two decades that follow, water demand is forecast to decline as the periodic reductions in Cascade's block more than offset what would otherwise be a modest amount of growth in demand. Once the Cascade block has been reduced to its minimum level in 2045, water demand is forecast to begin rising again, finally reaching 132 mgd – back to current levels – by 2060. Peak demands are also forecasted to remain below historic high levels. Given the current firm yield estimate for SPU's existing supply resources, this forecast indicates that no new source of supply is needed before 2060.

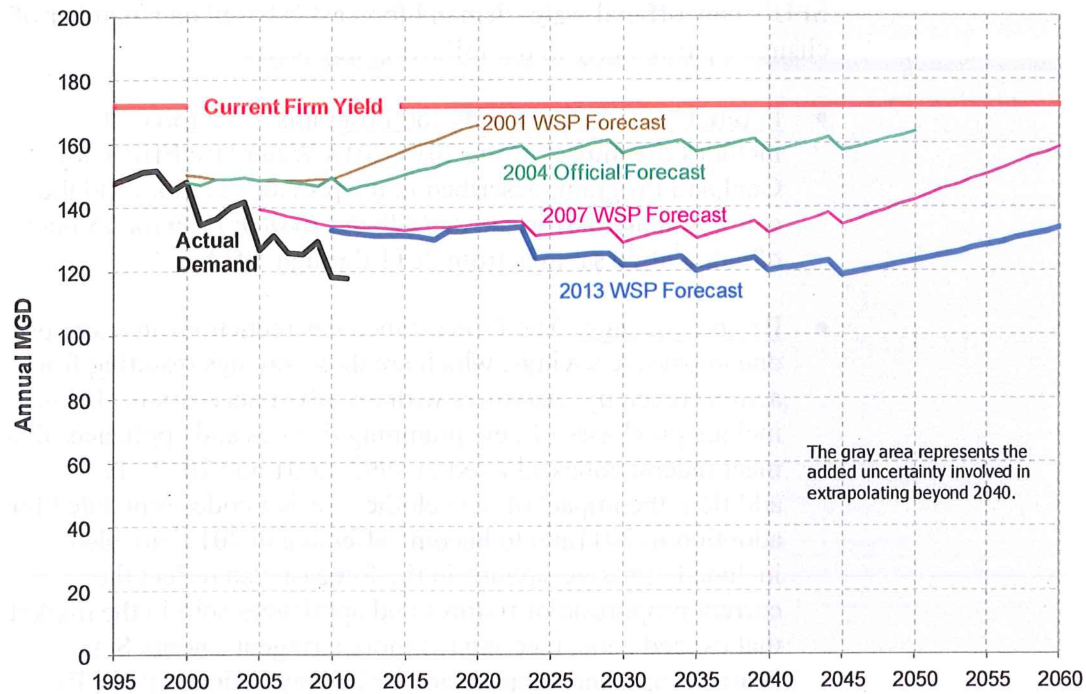


Figure 2-4. SPU's Official Water Demand Forecast

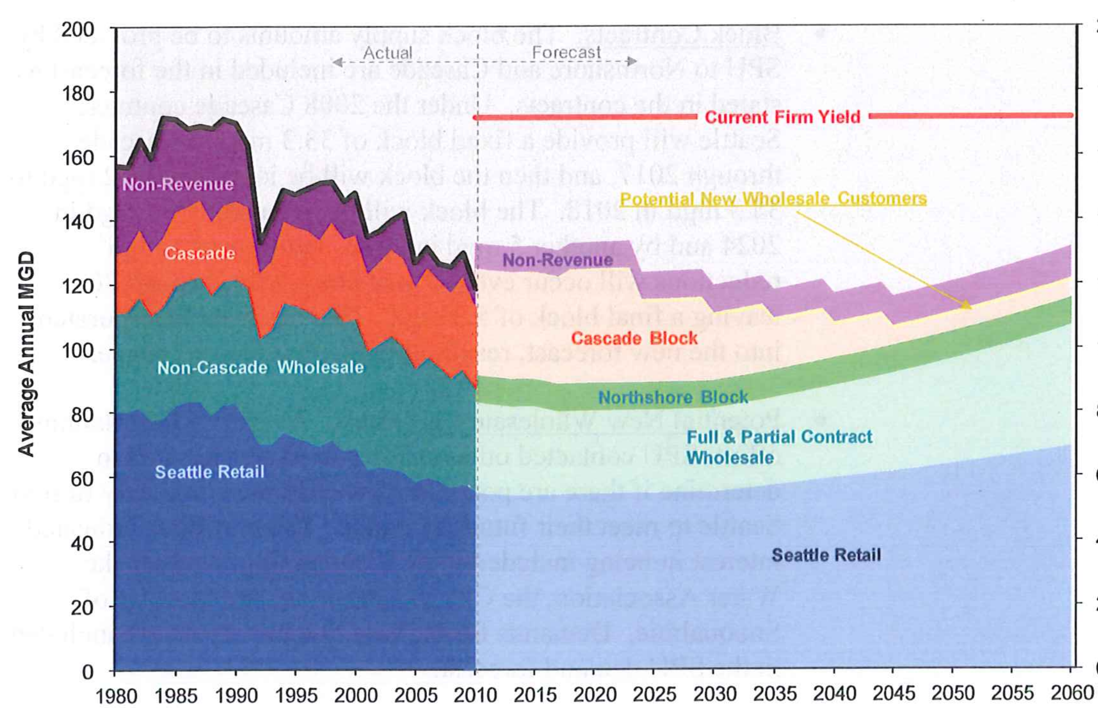


Figure 2-5. Components of Actual and Forecasted Demand

Note: Forecast demand is higher than actual demand in 2010 because the forecast includes all block contract amounts, whereas the actual demand by Cascade and Northshore has been less than their block contract amounts. Additionally, the forecast is for average weather conditions, whereas 2010 and 2011 were wetter and cooler than average, resulting in lower actual demand.

SPU's new official water demand forecast is based on a number of changes, particularly in the following key areas:

- Future Conservation Goals and Programs. The forecast includes the impact of the 2013-2018 Water Use Efficiency Goal and Program, described in the previous section, and the commitment made in the *2007 Water System Plan* for 15 mgd of cumulative savings from 2011 through 2030.

- Passive Savings. The forecast includes reductions in water use due to passive savings, which are those savings resulting from actions taken by customers without SPU intervention. These include purchases of new plumbing fixtures and appliances that meet federal codes adopted in 1992, 2001 and 2002. In addition, the impact of new clothes washer codes scheduled for adoption in 2011and to become effective in 2015[1] are also included. Passive savings in the forecast also reflect the current proportion of fixtures and appliances sold in the market that exceed code, meeting the more stringent Energy Star, Water Sense, and Consortium for Energy Efficiency (CEE) standards, as well as how those proportions are expected to continue shifting in the direction of higher efficiency over time.

- Block Contracts. The block supply amounts to be provided by SPU to Northshore and Cascade are included in the forecast as stated in the contracts. Under the 2008 Cascade contract, Seattle will provide a fixed block of 33.3 mgd to Cascade through 2017, and then the block will be increased by 2 mgd to 35.3 mgd in 2018. The block will be reduced by 10 mgd in 2024 and by another 5 mgd in 2030. Additional 5 mgd reductions will occur every 5 years thereafter through 2045, leaving a final block of 5.3 mgd. This has been incorporated into the new forecast, resulting in the "saw tooth" shape.

- Potential New Wholesale Customers. As part of this planning effort, SPU contacted other utilities in its service area to determine if there are potential new customers that may turn to Seattle to meet their future demands. Three utilities indicated interest in being included in SPU's planning: Ames Lake Water Association, the City of Carnation, and the City of Snoqualmie. Demands for the first two purveyors are included in the SPU demand forecast.

1 The US Department of Energy has proposed a two phase clothes washer efficiency standard with the first phase effective March 7, 2015, and the second, more stringent phase, effective for Janunary 1, 2018. This federal proposal has yet to be adopted as a final rule..

- Non-Revenue Water. Combined transmission and Seattle distribution system non-revenue water is assumed to increase from 8 mgd in 2010 to 10 mgd by 2060. This increase is expected to be caused by the increasing number of leaks that are likely to occur as the distribution system ages.

Forecasting future water demand with certainty is virtually impossible. The official water demand forecast is based on forecasts of income, water prices, households, and employment, all of which are subject to uncertainty. Additional uncertainty surrounds the forecast model's assumptions about price elasticity, income elasticity, and future conservation (the model assumes no programmatic conservation past 2030). These uncertainties were modeled by estimating probability distributions for each source of uncertainty. These distributions became inputs to an aggregate uncertainty model employing a Monte Carlo simulation[1] to characterize uncertainty associated with the official demand forecast.

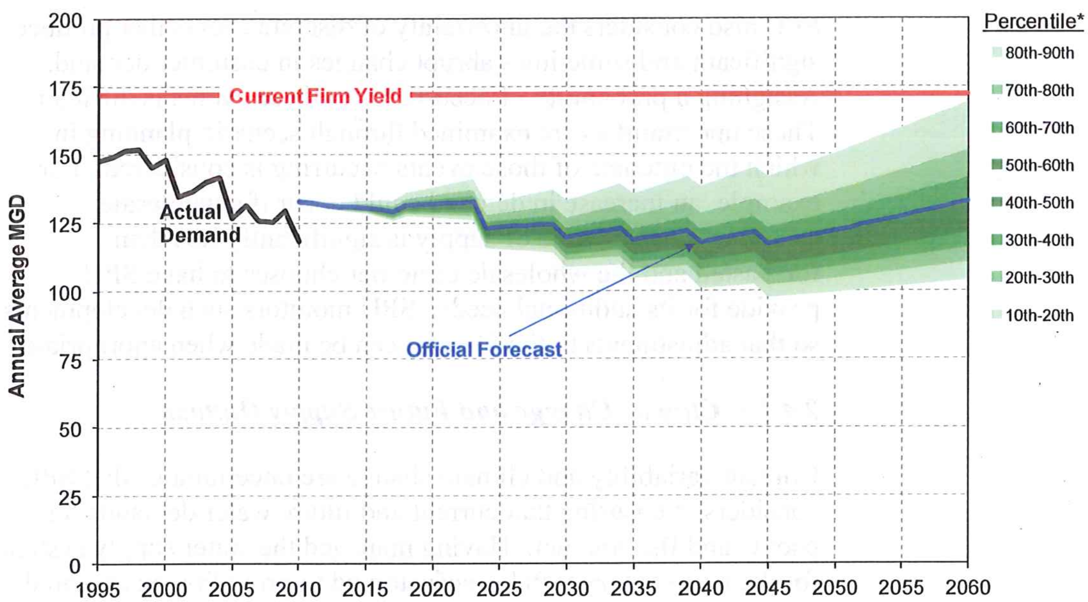


Figure 2-6. Uncertainty in Water Demand Forecast[2]

[1] A Monte Carlo simulation calculates multiple scenarios of a model by repeatedly sampling values from the probability distributions for the uncertain variables. The data generated from the simulation can be represented as probability distributions or confidence intervals. Because the method is based on random chance, it was named after the city of Monte Carlo which is known for its gambling.

[2] Percentiles represent the probability that actual demand will be less than the value shown. Ranges reflect uncertainty in projected household, employment, price and income growth, price elasticity, income elasticity, and conservation. Note that the official forecast is at about the 58th percentile.

The results of the Monte Carlo simulation are displayed in Figure 2-6. The green bands indicate the range of uncertainty associated with the official forecast. Each band represents a 10 percent increase (from the band immediately below it) in the probability that actual demand will be equal to or less than the level shown. For example, the bottom of the lowest band represents the 10th percentile, meaning that there is an estimated 10 percent chance that actual demand will be at or below that level (i.e., 104 mgd in 2060) and, thus, a 90 percent chance it will be above. The top of the uppermost band is the 90th percentile, corresponding to an estimated 90 percent probability that actual demand will be at or below that level (i.e., 169 mgd in 2060).

This type of analysis provides insight into the uncertainty that surrounds the various inputs to the demand forecast model. It estimates a more than 90 percent probability that a new source will not be necessary before 2060 given the range of uncertainty in demand that was tested.

SPU also considers the uncertainty of discrete events that produce significant and sometimes abrupt changes in customer demand. Assigning a probability of occurrence to these events is difficult. These uncertainties are examined through scenario planning in which the outcome of those events occurring is considered. For example, an increase in demand could occur if a wholesale customer's own source of supply is significantly less than forecasted and the wholesale customer chooses to have SPU provide for its additional needs. SPU monitors such developments so that adjustments to the forecast can be made when appropriate.

2.4.1.3 Climate Change and Future Supply Outlook

Climate variability and climate change are uncertainties that SPU considers in ensuring that current and future water demands for people and fish are met. Having managed the water supply system for the past century, SPU is accustomed to providing an essential and reliable service in the face of climate variability. In the Pacific Northwest, two major drivers of climate variability are El Nino Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO), both of which are natural phenomena that affect meteorological conditions and in turn SPU's water supply and demand. Climate change is caused by an increase in heat-trapping atmospheric gases, known as greenhouse gases. Climate change can also alter weather patterns and affect air temperatures, humidity, evaporation, cloud cover, rainfall, snowfall, snowpack, and runoff, in terms of averages, extremes, timing and distribution. The timing and magnitude of these changes and their affect on

SPU's water supply and demand is uncertain but better understanding of the implications of climate change for SPU is a programmatic area of focus within SPU. Climate variability and climate change are often used interchangeably but, for purposes of distinction, in this document when SPU refers to climate variability SPU is referring to a phenomenon that is cyclical and natural in nature, while references to climate change denote persistent change that is largely human induced. SPU's policies for Supply Reliability and Planning for Uncertainty require that the potential impacts of long-term climate change on water supply and demand be addressed in developing supply investment strategies based on the most current knowledge and a wide range of climatic conditions.

The *2007 Water System Plan* presented the results of a University of Washington Climate Impacts Group (UW-CIG) study initiated in 2002 on the potential impacts of climate change on SPU's water supply. Since then, and as part of the process that resulted in the Water Supply Forum's *2009 Regional Water Supply Outlook*, SPU evaluated the potential impact of climate change on the future availability of its water supply as well as future water demands using information from a second study conducted by UW-CIG. This evaluation was further updated in developing the *2013 Water System Plan*.

The recent work builds off of a downscaling study[1] completed in 2007 by UW-CIG that explored a range of climate change scenarios produced by model runs that coupled three different global climate models with two different emissions scenarios[2]. UW-CIG used these model runs to create meteorologic datasets for the Central Puget Sound region at four different 31-year time periods centered around 2000, 2025, 2050 and 2075. Individual model projections of average daily air temperature for 2075 produced increases above the 1928-2004 historic period that range from 3.8°F to 9.0°F for summer and from 1.4°F to 8.1°F for winter, when averaged across the stations in the study area. Precipitation changes were less consistent for each model and between models, with changes in seasonal precipitation in 2075

[1] Palmer, R.N. 2007. "Final Report of the Climate Change Technical Committee." A report prepared by the Climate Change Technical Subcommittee of the Regional Water Supply Planning Process, Seattle, WA.

[2] The three global climate models used are the GISS model from the Goddard Institute for Space Studies coupled with Special Report on Emissions Scenarios (SRES) emission scenario B1 ("warm" scenario), the ECHAM model from the Max Planck Institute for Meteorology coupled with SRES emission scenario A2 ("warmer" scenario), and the IPSL model from Institute Pierre Simon Laplace coupled with SRES emission scenario A2 ("warmest" scenario).

relative to the historic period ranging from -29 percent to +11 percent in summer and -6 percent to +48 percent in winter.

Using these datasets, UW-CIG ran hydrologic models that simulate snow accumulation, snow melt and runoff to create streamflow datasets for the major water supply drainage basins in the region. For the primary sites used to characterize inflows into the reservoirs, by 2075 the average of all models across all five basins compared to historic flows decrease by 37 percent during the summer and increase by 48 percent during the winter. SPU used the inflow data from these models to assess the impacts on available supply. In addition, SPU used the temperature and precipitation data to determine how peak season and annual water demands could change in the future under these scenarios.

The results of this assessment indicated that climate change could lead to reductions in supply ranging from 6 percent to 21 percent in 2050 and a possible 4 percent increase in demand under the warmest scenario. SPU identified a series of adaptation options and modeled how effective they would be in offsetting the reductions of supply. In two of the three scenarios in 2050, the adaptation offsets would fully compensate for the reductions in supply. In all of the scenarios there would be sufficient supply to meet demand if adaptation options were deployed.

Updated climate change analyses show less of an impact on water supply availability than previous studies because of the updates to assumptions to the firm yield estimates and lower forecasted water demands.

SPU's analysis was updated in 2011 to include the same assumptions used in the latest firm yield estimate, including the recently authorized higher refill level of 1563 feet for Chester Morse Lake, as well as the latest water demand forecast. This analysis is based on meeting water demands at 98 percent reliability after satisfying instream flow requirements and limiting diversions from the Cedar River according to the MIT Agreement, as described in the *2007 Water System Plan*. The analysis also assumes that an improved Chester Morse Lake Pump Plant and associated facilities would allow normal access to water stored between elevations 1538 and 1532 feet in Chester Morse Lake.

Under the three model scenarios, the impact of climate change on supply and demand would increase over time, with the greatest impact occurring with the warmest scenario. Assuming no change in system operations, available supply under the warmest scenario is estimated to be reduced by as much as 4 percent in 2025, 6 percent in 2050, and 13 percent in 2075. The reduced supply would exceed forecasted demand for all years. However, under the warmest scenario, average annual demand is estimated to increase by 1 percent in 2025, 2 percent in 2050, and 5 percent in 2075, assuming no change in forecasted demographics and no new conservation programs to reduce this increase. Even so, the reduced supply would still exceed climate-impacted demands for all years except 2075, in which demand would exceed supply by approximately 3 percent.

For this scenario, SPU identified system modifications that could be pursued to mitigate the reductions in supply from climate change. These modifications are no or low cost options that would increase useable storage to capture more of winter runoff for release during the summer. These options include:

- Chester Morse Lake refilled to 1566 feet: current refill is to 1563 feet; adds more than 6,000 acre-feet or 11 percent more storage in the Cedar system with no new infrastructure and no change to water rights.

- South Fork Tolt Reservoir drawdown to 1690 feet: current minimum is 1710 feet; adds 7,500 acre-feet or 18 percent more storage in the Tolt system with no new infrastructure and no change to water rights.

- Overflow Dike at 1554 feet: crest is currently at 1550 feet; change would store 6,500 acre-feet in Chester Morse Lake, reducing seepage to the moraine and loss to the Snoqualmie River Basin. This option is under study as a repair alternative and would require modifications of existing infrastructure and amendments to the Cedar River Habitat Conservation Plan.

These system modifications would essentially restore supply to historic levels. Under the warmest scenario in 2075, the available supply with these system modifications would exceed forecasted climate-impacted demands by almost 10 percent if all modifications are made. Additional options to manage the impacts on supply may be possible through optimization of system operations.

The results of this analysis indicate that no new source of supply is needed before 2060 (the ending year of the official demand forecast) even when potential climate change impacts are considered. This updated evaluation shows less of an impact on water supply availability than previous studies because of the updates to assumptions to the firm yield estimates and lower forecasted water demands. Even so, future climate change could potentially increase the frequency of low reservoir levels and for requests to customers to curtail water use, depending on the system modifications that are implemented and the timing and magnitude of climate change impacts.

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The above analysis does not assess the effect of climate change on several key factors that influence water resources and supply operations. For example, climate change impacts on water quality, particularly the frequency of high turbidity events and algal blooms that can be disruptive to supply operations, have not been evaluated but can reduce supply availability. Also, changes to the watershed forests and potential increases in fires have not been assessed, but could have a significant impact on hydrology and water quality. SPU's water supply could also be affected if climate change were to significantly delay the return of fall rains or lead to sustained droughts of longer duration than those experienced in the past. These issues are a sampling of topics for further research and analysis.

It is anticipated that some of these issues will be considered through SPU's next impacts assessment, which SPU will initiate in 2012. SPU is participating in a collaborative venture between Water Utility Climate Alliance members and climate researchers called Piloting Utility Modeling Applications (PUMA[1]). PUMA is intended to identify state of the art climate modeling tools and techniques to generate climate data that utilities can use to conduct impacts assessments and inform the development of adaptation strategies. In conducting its assessment through PUMA, SPU intends to use the next generation of climate data and will share the results of this assessment when it is finalized. Given the dynamic nature of climate research, SPU is committed to remaining engaged in future research, conducting new assessments on a periodic basis to identify potential impacts and system vulnerabilities, and planning for adequate water supply while ensuring that decisions do not result in unnecessary or premature financial and environmental costs for the region.

2.4.1.4 Future Supply Opportunities

While both the firm yield update and climate change analysis indicate that no new supply is needed well into this century to meet forecasted demand, the supply alternatives identified in the *2007 Water System Plan* remain as opportunities for SPU to consider should future forecasts indicate the need to develop a new supply source. Included in the list of alternatives is reclaimed water, and because new information is available, that alternative is discussed more fully here.

[1] For additional information about PUMA see: http://www.wucaonline.org/html/actions_puma.html

Over the past decade, SPU has engaged in several evaluations of providing reclaimed water as an alternative to its potable supply. None were implemented, however, because projects were either not cost-effective or not welcomed by the potential user.

With the Brightwater Treatment Plant, there is an opportunity for large volumes of reclaimed water to be distributed in the north part of the SPU service area. The Brightwater Reclaimed Water Backbone Project will be able to carry up to up to 9 mgd south to large non-potable water users in the Sammamish River valley, and about 12 mgd west to northern King County to the Ballinger Way portal. The Ballinger portal is at the very northern end of SPU's retail service area.

Knowing that King County is interested only in selling reclaimed water wholesale to potential retail distributors such as SPU, SPU conducted an economic analysis of the potential use and cost-effectiveness of distributing reclaimed water from the Brightwater portal to large irrigators and other potential users of non-potable water in the north part of SPU's retail service area. The analysis is summarized in *An Economic Analysis of the North Seattle Reclaimed Water Project* completed by SPU in 2010.

For the analysis, a total of 50 potential customers with 1.7 mgd of potential use were identified. Distribution of the reclaimed water would require 27 miles of pipeline plus pumping facilities at a cost of $87 million in initial capital improvements and $109 million in total life-cycle costs, as well as any on-property improvements. Both the supply and environmental benefits of this project were determined to be minimal.

The overall conclusion of the analysis was that the proposed North Seattle Reclaimed Water Project would not be a sound investment for the region due to high costs, a low level of benefits, and the availability of lower-cost alternatives for achieving comparable benefits.

2.4.2 Infrastructure Needs and Improvements

SPU maintains its water resources facilities for safe and reliable operation to ensure water supply is available for its customers. Several infrastructure improvement projects and operational studies have been identified to improve the reliability and flexibility of the existing water supply system. These projects and studies are described below.

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2.4.2.1 Morse Lake Pump Plant Project

The Chester Morse Lake floating barge pump system is intended to be used to access water in storage when levels in the lake are below elevation 1538 feet. Pumping provides additional flow to the Masonry Pool and the Cedar River to meet customer needs and instream flow requirements.

The Morse Lake Pump Plant option selected for further analysis, design and implementation is a new floating pump system using purchased mobile diesel generators and additional channel improvements.

In recent years, maintenance work has been completed in an attempt to achieve operability and restore flow capacity of the pumping plants and associated facilities. This work included maintenance dredging of the channel, testing and replacing electrical cable, and making electrical mechanical safety improvements and repairs. Even with these improvements and repairs, concerns remain over the reliability and readiness of these facilities. Of particular concern is the long-term stability of the outlet channel and its flow capacity. Infilling of the outlet channel has resulted in the need to begin pumping operations sooner to supplement gravity flow to the Masonry Pool. Also of concern is the long lead-time needed to mobilize the pumping plants prior to actual use due to the need to rent and install mobile diesel generators that power the pumps. Up to two months are needed to ready the plants, which can lead to costly efforts that later prove to be unnecessary when the plants are then not subsequently needed or put to use.

SPU completed preliminary engineering and value engineering studies to evaluate options for repairing or replacing the current floating barge pump system. The Morse Lake Pump Plant option selected for further analysis, design and implementation is a new floating pump system using purchased mobile diesel generators and additional channel improvements. This project is currently in the implementation phase.

2.4.2.2 Overflow Dike Replacement

The existing Overflow Dike used to separate Cedar Lake from Masonry Pool has wooden flashboards with the tops at elevation 1550 feet. The top of the Overflow Dike structure is at elevation 1555 feet, with the invert of the dike notch at 1546 feet. The wooden flashboards were damaged in 2008 during a flood event. SPU will conduct an analysis to determine if a variable crest dam replacement for the flashboards would be beneficial. One benefit of a variable crest dam would be improved flood management by allowing a faster flood pocket recovery. A part of this analysis will include the evaluation of the potential benefits of having a higher elevation for the top of the flashboards, up to elevation 1554 feet. The additional four feet of elevation would be useful in allowing an earlier pool split, saving water in Cedar Lake and reducing seepage at Masonry Pool. The analysis will also include the environmental impacts of higher pool levels during the pool split period.

2.4.2.3 Refill of Chester Morse Lake to 1566

One of the projects evaluated as a part of the Operations and Optimization Study was raising the refill level of Chester Morse Lake to elevation 1566 feet. This analysis will be continued to further determine feasibility and costs. Just as raising the refill level to elevation 1563 feet added storage and resulted in an increase to firm yield, raising the refill level to 1566 is expected to do the same. The benefits of the higher refill could be optimized in conjunction with an increase in the Overflow Dike as described above. The feasibility analysis will also preliminarily investigate the impacts of the higher refill level on tributary habitat, flood management issues, moraine seepage and dam safety.

2.4.2.4 Landsburg Flood Passage Improvements

Since the Cedar River flooded in fall 1990, there have been concerns about flood debris, such as large trees uprooted during high flows, blocking the spillway gates at Landsburg Diversion Dam during major floods. SPU has completed new studies of large woody debris management since completion of the *2007 Water System Plan*, and this information will be used to update the evaluation of flood passage at the Landsburg Diversion Dam. SPU is in the process of reviewing the options for structural modifications of the Landsburg Dam and non-structural approaches that include increased log handling during storm events. Analyses have been completed on preliminary engineering and life-cycle cost analyses to improve the flood passage capabilities at the dam using modifications to existing spill gates, large woody debris handling upstream, and modifications to the south abutment to allow passage of the 500-year design storm. These approaches reduce the risk of overtopping of the dam during large flood events, which could potentially cause severe erosion of the embankments and place the dam at risk of failure and impede the delivery of water.

2.4.2.5 Lake Youngs Cascades Dam

Water stored in Lake Youngs is impounded by two earth embankments, the Outlet Dam to the south and Cascades Dam to the east, and the perimeter dikes around the lake. A third dam, Inlet Dam, east of Cascades Dam, normally does not store water and was constructed as a backup embankment to retain the reservoir water in case of a failure of Cascades Dam, which shows signs of movement and is considered to be somewhat unstable. As noted previously, SPU plans to conduct further investigations and studies to determine the potential impact on water quality that could be caused by failure of Cascades Dam, particularly with respect to material existing in the area between Cascades Dam and the Inlet Dam.

2.4.2.6 South Fork Tolt Reservoir Studies

As noted in the *2007 Water System Plan*, there is potentially significant benefit to expanding the historical operating range of the South Fork Tolt Reservoir. SPU plans to conduct studies and analyses to increase the understanding of the constraints and environmental issues associated with South Fork Tolt Reservoir operations to support drawdown below elevation 1710 feet.

2.5 Implementation/Action Plan

In the absence of a need to develop new water supplies for several decades, SPU's implementation/action plans in the Water Resources business area will focus on continuing conservation efforts, improving infrastructure reliability and operational flexibility to optimize existing supply, and pursuing additional work to assess climate change impacts. A summary of the implementation/action plan for the Water Resources business area is as follows:

- Reduce per capita water use from current levels so that total average annual retail water use of members of the Saving Water Partnership is less than 105 mgd from 2013 through 2018 despite forecasted population growth.
- Continue to implement water conservation efforts that help low-income customers in Seattle manage their water bills.
- Complete infrastructure and operational improvements:
    - Implement the Morse Lake Pump Plant Project to recover water from Chester Morse Lake during low water level conditions and other emergencies.
    - Investigate raising the Overflow Dike to elevation 1554 feet and using a variable crest dam for that purpose.

- Complete investigations that are required to determine if the Chester Morse Lake refill elevation can be raised to elevation 1566 feet.
- Implement the Landsburg Dam Flood Passage Improvements.
- Conduct further investigations to determine the potential impact on water quality that could be caused by failure of Lake Youngs Cascades Dam and potential improvements to mitigate this risk.
- Learn more about what level of additional drawdown the South Fork Tolt Reservoir can accommodate to support additional future supply.

- Remain engaged in future research on climate change by participating in the PUMA project, conducting new assessments on a periodic basis to identify potential impacts and system vulnerabilities, and planning for adequate water supply while ensuring that decisions do not result in unnecessary or premature financial and environmental costs for the region.

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