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Chapter 5
Water Distribution System

This chapter focuses on the SPU water distribution system, the business area that involves delivery of water for retail use and for fire flow. SPU's water distribution system consists of watermains, distribution storage facilities and pump stations, and related appurtenances such as valves, hydrants, service connections, and retail billing meters. The supervisory control and data acquisition (SCADA) system used to monitor and control the water system is also discussed in this chapter. Proper management of the distribution system ensures that SPU meets its service levels for retail customers.

5.1 Accomplishments Since 2007 WSP

Since completion of the *2007 Water System Plan*, SPU has implemented the following improvements to the water distribution system:

- Pressure Improvements: Completed improvements to raise pressure in areas where services had less than 20 psi on Queen Anne Hill, in the lower Queen Anne 326 pressure zone, and in the Maple Leaf 530 pressure zone (2009).
- Queen Anne Pipe Replacement: Replaced watermain to withstand increased pressure associated with the new Queen Anne tank and pump station projects (2008).
- Backbone Pipeline System Seismic Upgrades:
  - Upgraded the seismic backbone along South Spokane Street from west of 1st Ave South to the Burlington Railroad tracks just east of Airport Way South.
  - Upgraded the seismic backbone along 1st Avenue South between South Stacy Street and South Spokane Street.
- New Taps: Installed over 5,300 new customer taps from 2007 through 2010.
- Service Renewals: Renewed or replaced over 3,400 services, primarily those made of plastic tubing, from 2007 through 2010.

- Water system improvements and watermain replacement associated with third-party projects:
  - Hidden Lakes Combined Sewer Overflow Betterments: Replaced approximately 1,100 feet of sub-standard watermain and associated fire hydrants to improve fire flow in the Shoreline service area (2007).
  - State Highway 99 (Aurora Avenue): Made various water system improvements along this highway between 145th Street to 192nd Street in the City of Shoreline.
- Steel Tank Recoating: Recoated Myrtle Tank #2 (2010).
- Tank Decommissioning: Decommissioned, but did not demolish, Maple Leaf Tank and Woodland Park Standpipe based on asset management business cases and to avoid the costs needed to upgrade the facilities (2009).

Additionally, Beacon and Myrtle Reservoirs, which are part of the distribution system, were replaced with below-grade reinforced concrete tanks, as described in Part I, Chapter 3.

5.2 Service Level Performance

SPU consistently responds to reported distribution system problems within one hour more than 90 percent of the time.

SPU developed service levels to manage its water distribution system assets and describe what retail customers can expect of SPU in terms of water pressure and problem response. Also, a service level was developed to limit the amount of water lost to leakage. Many of the drinking water quality service levels, as stated in Chapter 3, also apply to the distribution system. Table 5-1 summarizes the distribution system service level objectives and targets used by SPU to manage its distribution system assets.

SPU has been meeting these service level targets. Since completion of the pressure improvement projects in early 2009, pressures at all retail service connections are greater than 20 pounds per square inch (psi) during normal operations. SPU also designs new or expanded parts of the distribution system to deliver a minimum of 30 psi during peak hour demand.

For each year since 2006, SPU consistently responded to reported distribution system problems within one hour more than 90 percent of the time. Because of this high level of performance, SPU raised the service level target in 2009 to 90 percent from the minimum of 80 percent that was documented in the *2007 Water System Plan*.

Table 5-1. SPU's Service Levels for Managing Distribution System Assets

Service Level Objective	Service Level Target
Provide adequate pressure for drinking water supplies.	• New or expanded parts of the distribution system designed to deliver peak hour demand at a minimum of 30 pounds per square inch (psi) at the meter. • No retail customers with less than 20 psi during normal operations.
Respond quickly and effectively to water distribution system problems.	• 90 percent of distribution system problems (emergency situations such as a pipe break; potential contamination of water supply; hydrant damage) responded to within 1 hour.
Meet water use efficiency goals to ensure wise use and demonstrate good stewardship of limited resource.	• Distribution system leakage losses of no more than 10 percent of total supplied, as defined by Washington Department of Health guidelines.

Distribution system leakage (DSL) has been reported to WDOH since 2006, as required by the 2003 Municipal Water Law (WAC 246-290-820). By definition, DSL is the difference between the total amount of water produced and the amount authorized for consumption. DSL includes water lost from pipe and service line breaks, as well as from storage facilities. It also includes metering inaccuracies and unauthorized uses. Due to the location of SPU's meters, losses in the transmission system are included in the reported DSL figures.

SPU's estimate of authorized consumption consists of water sold to retail and wholesale customers based on metering data, and estimates of water used to drain and clean treated water storage reservoirs and in overflowing of open reservoirs for water quality management. Small amounts of water used for authorized purposes such as firefighting, hydrant testing, watermain flushing, sample stand usage, and permitted hydrant usage (e.g., for building construction) have not been included in the estimate of authorized consumption because it would be costly to meter the use, compute an estimate, or determine the amount used in a calendar year. Exclusion of these authorized uses increases the amount of reported distribution system leakage. As shown in Figure 5-1, SPU's DSL has increased from less than 3 percent in 2006 and 2007 to more than 6 percent in 2010 and 2011. However, the 3-year rolling average has remained below the WDOH standard of 10 percent.

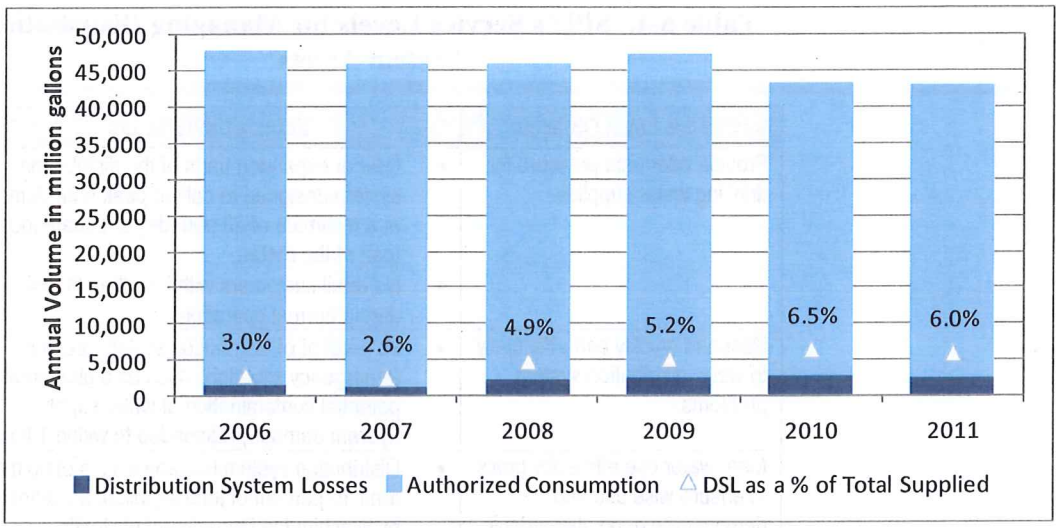

Figure 5-1. Distribution System Leakage

5.3 EXISTING SYSTEM AND PRACTICES

SPU's distribution system contains more than 1,680 miles of watermains, 2 open reservoirs, 6 covered reservoirs, 16 pump stations, 6 elevated tanks and standpipes, 21,000 valves, and 18,920 fire hydrants, as well as more than 188,000 retail service connections.

The water distribution system consists of the facilities that deliver treated water to SPU's retail water customers. Distribution system facilities include watermains, storage facilities, pump stations, retail customer meters, and other appurtenances. The water distribution system contains more than 1,680 miles of watermains, most of them 6 to 12 inches in diameter. Seattle's water distribution system also includes two open reservoirs, six covered reservoirs, 16 pump stations, and six elevated tanks and standpipes. In addition, the City has more than 21,000 valves, 18,920 fire hydrants and 188,000 service lines and meters serving individual residential and non-residential properties.

The following sections provide a description of the major classes of distribution system assets and a brief summary of their condition. The distribution system facilities O&M practices are also described, with attention given to changes in these practices or facilities since the *2007 Water System Plan*.

5.3.1 Existing Infrastructure

A description of the major components of SPU's water distribution system, a summary of their condition, and SPU's replacement/ renewal strategy is summarized below. A detailed inventory of the major asset classes is provided as an appendix.

5.3.1.1 Watermains

Seattle owns a network of more than 1,680 miles of watermains within its retail service area. Since the *2007 Water System Plan*, many watermain improvement projects have been completed, with a number completed in conjunction with re-development and other agency projects, such as transportation projects within the City limits and in Shoreline. However, the overall configuration of the distribution system remains unchanged since 2007.

The condition of SPU's watermains varies based on a number of factors including age, material, size, date of installation, and site specific conditions such as soil type and water table depth. The year of installation by decade and material type of distribution watermains is shown in Figure 5-2. Mainly unlined cast iron pipe was installed through the 1930s, followed by lined cast iron pipe. Since the 1970s, ductile iron pipe has been installed in almost all instances.

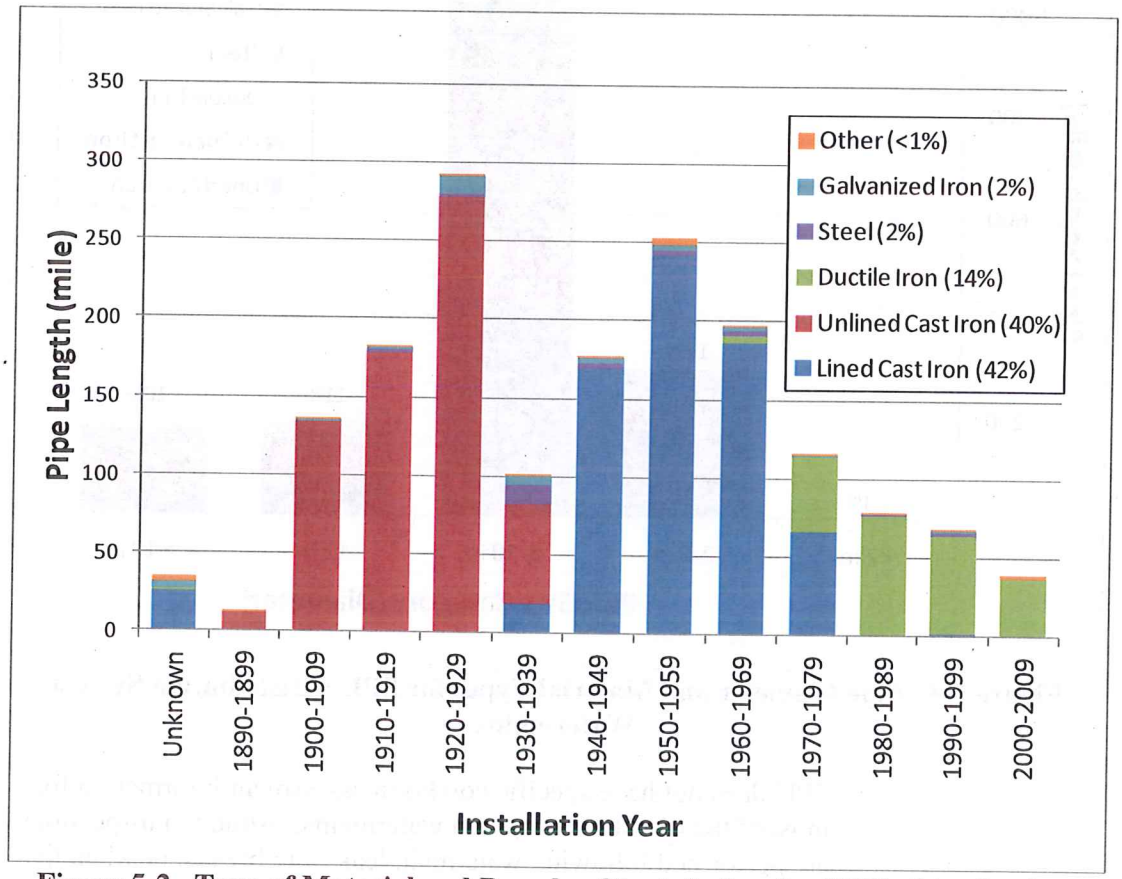

Figure 5-2. Type of Material and Decade of Installation for SPU's Distribution System Watermains

Currently, cast iron pipe is the most common type of pipe material used in SPU's distribution system. More than 80 percent of the pipes are cast iron, with roughly one-half of that unlined and one-half lined. Ductile iron pipe, the current standard and most common pipe material installed since the 1970s, is the third largest material type, at 14 percent. Galvanized iron and steel each make up about 2 percent of the system. The remaining pipe is made of other materials, including concrete cylinder (0.3 percent), polyvinylchloride (plastic) (0.2 percent), copper (0.1 percent), and kalamein (a type of steel) (0.1 percent). There is no asbestos pipe in the system. Figure 5-3 provides a breakdown of material types by pipe size. As indicated by the figure, the majority of pipe, or approximately 61 percent, is 8 to 10 inches in diameter.

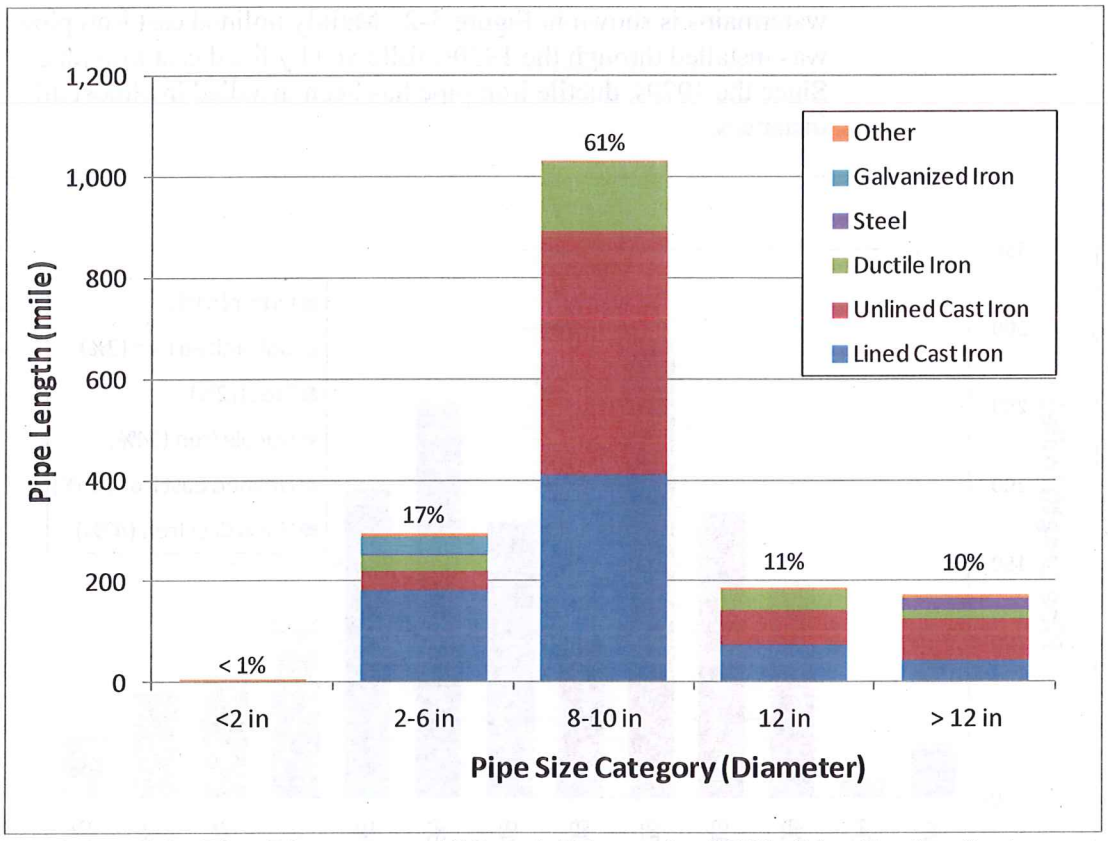

Figure 5-3. Pipe Diameter and Material Types for SPU's Distribution System Watermains

SPU does not have specific condition assessment information for most of the distribution system watermains. Although inspections are performed following watermain leaks and breaks, or when the watermain is exposed by potholing or adjacent construction, additional condition assessment activities are planned in the near term. Without specific condition assessment data, the most

appropriate measure of condition of the watermains is the pipe material, soil type, age and number and types of leaks and breaks. Based on data from 2004 through 2010, the rate of watermain leaks and breaks remains low, averaging less than 10 reported leaks or breaks per 100 miles per year in the distribution system. This is less than the rate experienced by other major water utilities in the United States[1]. SPU's approach to replacing and rehabilitating watermains is described in Section 5.4.

Not all leaks or breaks require water service delivery outages. However, if a repair does require an outage, it is considered unplanned. Distribution system improvement projects can lead to planned or scheduled outages. From 2006 through 2010, approximately one-half of all outage events were unplanned, and one-half were planned. During this period, fewer than 2 percent of all customers experienced water service delivery outages of more than 4 hours per year from all planned or unplanned events.

5.3.1.2 Distribution System Water Storage Facilities

SPU's distribution system includes eight in-city reservoirs and six elevated tanks and standpipes to provide operating and standby storage capacity to its retail customers. The amount of storage provided is explained more fully in the appendix on System Storage Level of Reliability.

Distribution System Reservoirs. The City of Seattle owns and SPU operates and maintains eight reservoirs in the distribution system. The Myrtle and Beacon reservoir replacement projects were completed and placed in service in mid-2008 and early 2009, respectively. SPU is investigating the possibility of retiring the last two open reservoirs, Volunteer and Roosevelt, as noted in Chapter 3.

Condition assessment of in-town reservoirs follows the same procedure as described for the water transmission system reservoirs. Based on inspections, the structures are in good condition. When last tested in 2009, the leakage rate at Magnolia Reservoir was negligible. The leakage rate from Volunteer Reservoir was 0.9 gallons per minute per million gallons (gpm/MG) in 2011. View Ridge Reservoir leakage was measured to be 2.9 gpm/MG in 2005. The leakage rates from Bitter Lake and Roosevelt Reservoirs were low and estimated to be 0.82 and 0.04 gpm/MG, respectively, when tested in 2009.

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[1] Neil S. Grigg, 2007, *Main Break Prediction, Prevention, and Control*. Report 91165. AwwaRF and AWWA.

Distribution System Elevated Tanks and Standpipes. In addition to its in-town reservoirs, the SPU water distribution system includes one elevated tank and five standpipes. The elevated tanks and standpipes were constructed between 1907 and 2008. They range in capacity from 0.9 mg to 1.9 mg. Maple Leaf Tank and Woodland Park Standpipe have been decommissioned but not demolished. In addition, Barton Standpipe is planned to be decommissioned in 2012 after its bypass is completed. Trenton Standpipes and Volunteer Park Standpipe are also being considered for decommissioning. The appendix on System Storage Level of Reliability provides more information on the approach used to analyze the system without these facilities.

Distribution system tanks and standpipes are inspected and maintained in the same manner as transmission system tanks, as described in Chapter 4.

5.3.1.3 Distribution System Pump Stations

SPU operates 16 distribution system pump stations with a total of 36 individual pump units. These pump stations are inspected regularly to ensure that they continue to function properly and equipment is repaired or replaced as needed. The most significant change to SPU's pump station assets is the addition of a new pump station on Queen Anne Hill to address low-pressure problems experienced by customers. An 8-inch pressure regulating valve (PRV) and bypass line were installed at the View Ridge Pump Station to allow water to recirculate through the reservoir and prevent over-pressurizing the 550 pressure zone, if the connection to the pressure relief at Roosevelt Way Pump Station is out of service.

One change planned for the pump stations is to retrofit the permanent stand-by diesel pump at Bitter Lake Pump Station with remote-manual start capability. This change will allow the pump to be started from the Operations Control Center to supply the 590 pressure zone in the event of a power outage. After this change is implemented, Richmond Highlands #1 Tank, which serves the northwest sub-regional system, will no longer be needed to supply the zone and could be decommissioned.

Distribution system pump stations are maintained in the same manner as transmission system pump stations, as described in Chapter 4.

5.3.1.4 Distribution System Appurtenances

Distribution appurtenances include various parts, features and elements that are incidental, integral, or subordinate to the system, such as valves and hydrants.

The SPU water distribution system includes a number of smaller appurtenances, such as valves, hydrants, service lines, and meters. The paragraphs below summarize SPU's inventory and replacement approach for each class of appurtenance.

Distribution System Valves. SPU's water distribution system includes more than 21,000 valves. More than 16,600 line valves exist to reconfigure the flow of water through the distribution system as needed, while other valves regulate pressure and flow, provide for bypassing of facilities, or allow air to escape the system. Most valves within the distribution system are gate valves.

SPU asset management approach focuses attention on assessing the condition of critical valves and conducting preventative maintenance or corrective repairs, based on condition. For non-critical valves (valves that isolate flow on non-critical watermains discussed in Section 5.4.1.1), repairs are initiated as needed when defects are noted during valve operation. Valve replacement is initiated when the repair or resolution of a defective condition is impossible, or would cost more than valve replacement. Valve replacement also occurs when distribution mains are replaced or relocated.

The valve chamber replacement program will continue through the next several years. This program replaces existing chamber lids and access maintenance holes with larger diameter lids and new access ladders. This program will provide SPU maintenance staff with safer valve chamber access and meet industry safety standards.

Distribution System Hydrants. SPU maintains more than 18,920 fire hydrants. Annual condition assessment of fire hydrants is performed by various fire service agencies operating in Seattle's retail service area[1]. Damage to fire hydrants is also commonly reported between routine condition assessment cycles.

SPU resolves problems observed and reported by the fire service agency and the public. Problems are categorized into two levels. First, problems that make a hydrant unusable or unsafe to use are given the highest priority to repair or replace. Second, problems

[1] Fire departments with jurisdiction in Seattle's retail service area include the Seattle Fire Department, Shoreline Fire Department, Northshore Fire Department, North Highline Fire District, Burien / Normandy Park Fire Department, and King County Fire District 20.

such as minor leaks that do not affect a hydrant's availability for fire fighting and main flushing are given a low priority for repair or replacement. SPU's hydrant replacement strategy for obsolete hydrants is to replace these hydrants in areas when other water system projects are being constructed and where excavation costs are low and future costs are likely to be much higher. Other than these "opportunity projects," SPU replaces hydrants that are found to be inoperable and repairs are not possible or exceed the cost of replacement. New hydrants may also be installed as part of new development.

Since 2006, approximately 5% of all services have been shifted from plastic to copper.

Distribution System Service Connections. SPU has more than 188,000 retail service connections, an increase of more than 5,000 services since 2006, mainly for new residential customers. Most of the services (86 percent) are for residential customers, almost 12 percent are for commercial customers, and the remaining 2 percent are for fire service. Of all service connections, 80 percent are ¾-inch diameter pipes. Currently 74 percent of service lines are copper, 15 percent are plastic, and 6 percent are galvanized steel. The remaining 5 percent are made of other materials.

Service lines made of plastic or galvanized steel are more susceptible to failure and are now no longer used. Prior to 1947, all of the service lines were made of galvanized steel, and these have been primarily replaced with copper. Between 1968 and 1984, SPU installed or replaced approximately 40,000 small services (3/4-inch to 2-inch) with plastic tubing. The past 4 years of data shows that approximately 60 to 80 percent of small service failures were due to leaks on substandard pipes such as plastic and galvanized steel.

Prior to 2003, SPU's approach to renewal of small water service lines was "fix when fail." The cost of this primarily reactive strategy for some services has been high in both SPU's direct repair cost and social impact costs, such as damage to customer property, roads, and the environment. In 2003, a plastic service renewal pilot program began whereby blocks of plastic services were proactively renewed. In 2005, the programmatic approach was modified from block renewal to critical service renewal whereby plastic pipes with high risk costs were identified and renewed first. As part of the service renewal program, approximately 5 percent of all services have shifted from plastic to copper since 2006.

The current water service renewal program consists of both reactive and proactive components and is described more fully in Section 5.3.3.4.

Distribution System Meters. Each service line is fitted with a water meter used to determine customer consumption and charges. Nearly 92 percent of SPU meters are small (3/4-inch and 1-inch).

SPU has installed approximately 1,500 radio frequency modules on difficult-to-read meters. This form of automated meter reading (AMR) allows these meters to be read in walk-by mode more safely and at less cost than traditional meters. Examples of where AMR is cost-effective and used at SPU include:

- Meters that are a safety hazard and/or require costly setup to read visually, mostly due to being located in an area with traffic hazards.
- Clusters of meters located in larger vaults with heavier lids, which pose an injury risk to meter readers when repeated frequently.
- Meters located in parking areas that are unreadable when a vehicle is parked over them, leading to frequent estimated bills.
- Meters that tend to get buried and/or overgrown and require frequent clearing.
- "Deduct" meters owned by the customer and located on private property in hard to access locations, leading to lengthy time required to get a reading.

5.3.2 Distribution System Operation

SPU's water distribution system is primarily served by gravity, but pumps are used to serve some pressure zones. To control flow and storage levels, SPU water system operators at the Operations Control Center operate pump stations, valves and other water system components using the remote control capability of the SCADA system or by directing crews to locally operate field equipment. The current SCADA system, which was installed in 2006, provides real-time data regarding pressure, flow, storage facility water level, and pump/valve status to system operators. Archived SCADA data are also useful for hydraulic network modeling, system planning, and engineering design.

In addition to the control room at the Operations Control Center, SPU has a backup control room at the SPU North Operations Center. The backup control room has been improved to substantially reduce start up time to begin system monitoring and control from that location.

Additional information on system operations, particularly the Operations Planning and Scheduling function, is provided in the appendix for Water System Management and Operator Certification.

5.3.3 Distribution System Maintenance

SPU has prepared a number of SAMPs for each major class of distribution system infrastructure components and plans on updating as needed.

Proper maintenance of distribution system components ensures that SPU will be able to deliver reliable water service by reducing the risk of unexpected failures. SPU has prepared a number of strategic asset management plans (SAMPs) for major classes of distribution system infrastructure components. The SAMPs outline maintenance strategies for each asset. Summaries of those maintenance strategies are provided below.

5.3.3.1 Watermains

The most significant maintenance for watermains is leak assessment and control, watermain repairs and flushing. Watermain break/leak data from the past 22 years indicate that approximately 100 to 170 watermain failures (leaks and breaks) occur each year, with an average of 150. Approximately one-third of the failures, however, are joint leaks which do not always require a complete watermain shutdown. Also, repair of leaks from corrosion-related pinholes do not usually require complete shutdowns. Small watermain leaks can be repaired "live" by throttling adjacent valves and reducing the flow in the watermain. Only large breaks involve a complete watermain shutdown.

Watermain failures require immediate response. SPU distribution staff has been consistently meeting the service level target for problem response (90 percent problems responded to within one hour). To further optimize resource utilization, reduce lifecycle cost, enhance asset data and knowledge, the following improvements are being made:

- Implementing a Field Operations Mapping System with Automatic Vehicle Location capability: This improvement displays active maintenance crew/vehicles and work order locations on computerized maps, allowing the nearest equipped crew/vehicle to be dispatched quickly and address the problem.

- Implementing a MAXIMO Upgrade: This project improves the work order management process and asset data using SPU's computerized maintenance management software called MAXIMO.

- Proactive leak survey and condition assessment to reduce high risk watermain failures.

Other watermain maintenance practices include watermain flushing. Additional information on watermain flushing is provided in Chapter 3.

5.3.3.2 Reservoirs and Tanks

Storage facility cleaning is also performed to remove sediment, debris, and/or microbial growth as described in Chapter 3.

5.3.3.3 Water Pump Stations

Pump stations in the distribution system are maintained in the same manner as described for the transmission system pump stations in Chapter 4. The asset management approach used by SPU to optimize pump station inspection and repair is Reliability Centered Maintenance (see RCM in Transmission Section Maintenance – Water Pump Stations). RCM programmed maintenance procedures have been completed for Augusta, First Hill, Broadway, and View Ridge Pump Stations, and the preventative maintenance schedules have been optimized and updated in MAXIMO. Additional pump stations are planned for RCM review in the future. In cases where changing the type or frequency of maintenance will not bring the asset to acceptable functional performance, RCM identifies capital improvements needed to address the performance requirement. Other capital improvements may also be revealed during the RCM process. For example, the RCM process for View Ridge Pump Station identified a change in the operational requirements for View Ridge Pump Station which, in turn, resulted in installation of an 8-inch pressure regulating valve (PRV) and bypass line at View Ridge Pump Station.

5.3.3.4 Water Appurtenances

SPU also performs maintenance activities for its valves, hydrants, service lines, and meters to ensure their continuing operation. A brief description of each follows.

Valves. Between 2005 and 2011, SPU responded to an average of 110 valve-related problems per year, or approximately 0.5 percent of all valves. Most valve problems can be categorized as leaks, casting failures, mechanical inoperability, and valves being buried by new pavement. Deterioration of interior packing, broken and bent stems, and construction projects are usually the causes of valve problems.

Due to a shift in priorities, the routine operation work of exercising large valves, 16 inches or larger, is performed less frequently than in the past (prior to 2003). There have been no demonstrated negative impacts from this reduction in routine exercising.

As part of the Shutdown Block Analysis described in section 5.4.1.2, a GIS layer is being developed to identify the need for new isolation valves, or relocation of existing isolation valves. Cost effective system improvements can then be implemented as opportunities arise (e.g. third-party projects or asset failure).

SPU plans on reviewing and updating its maintenance strategy for distribution system gate valves in 2012.

Hydrants. Each fire service agency inspects hydrants located within its service area, generally on an annual basis. Defects are reported to SPU for repair. In 2010, SPU responded to approximately 2,200 work orders to address fire hydrant defects. During maintenance visits, SPU paints hydrants to prevent exterior corrosion and improve their appearance.

SPU will review and update the Hydrant SAMP and associated maintenance strategy in the near future.

Service Connections. Maintenance related to service connections includes leak investigations, minor repairs on service lines, and replacement of broken valves, rods, or fittings. In 2011, an analysis was performed to define the asset management strategy for services, which is summarized here. SPU's water service renewal program consists of both reactive and proactive components:

- Reactive renewals include asset failure renewals due to emergency or non-emergency breaks, leaks, or mechanical failures (shutoff valve or meter failures), typically reported by customers. Reactive renewals called "demand renewals" are also identified by SPU staff when other projects trigger the need for a service connection replacement, such as during watermain relocation/replacement, service upsizing/downsizing, or "companion" renewals (substandard service pipes located in the same trench as another excavated water asset, which would likely fail during backfill and compaction).

- Proactive renewals include opportunity renewals and critical renewals. Opportunity renewals are performed when other projects, typically transportation-related projects, are restoring

street pavement at no cost to SPU, which can be as much as 40 percent of the total cost to replace service connections. Critical renewals target small services where the remaining life is projected to be short and the consequences of a break would likely be significantly higher than typical. For example, a "critical" site may be in a steep slope or landslide area, or in high volume traffic roads offering few options for detouring traffic.

In addition, SPU has observed through practice that proactive service retirement is not cost effective, and, therefore, most service retirements are carried out reactively. Inactive service pipes are typically retired when leaks develop, new services replace the obsolete service, or the unused service is in conflict with or is abandoned with new right-of-way improvements or watermain work.

Meters. SPU's retail water meters ensure proper billing for water use as well as for wastewater services. Meter problems may be identified at the time of meter reading, such as when broken meter dials are found, or by the billing system, such as when consumption is much higher or lower than what is expected for a customer based on historical information. Metering issues may also be discovered when customers inquire about unusually high bills. Such issues may lead to testing, repair or replacement of a meter depending on its size and customer class.

A large meter outside the 97 to 103% accuracy range is either repaired to restore its performance or replaced. SPU does not typically repair small meters since it is generally less expensive to replace than repair them.

SPU has a meter testing and maintenance program for its large meters, which represent less than three percent of all retail meters. SPU's goal is to maintain accuracy of large meters to between 97 and 103 percent as per the guidelines of the American Water Works Association. A large meter with an accuracy falling outside that range is either repaired to restore its performance or replaced. In 2009 and 2010, SPU replaced approximately 125 large retail meters per year.

SPU does not typically perform maintenance activities for small meters since repairing small meters is not cost-effective and it is generally less expensive to replace a small meter than repair it. In 2009 and 2010, SPU replaced about 1,700 small meters each year, or less than one percent of all meters each year.

Existing meters may be retrofitted, or new meters may be equipped, with radio units for AMR to allow walk-by meter reading when more cost-effective than visual reading. Currently, this type of installation is determined on a case-by-case basis.

Update of the Meter SAMP is planned for 2012.

5.3.3.5 Record Keeping and Reporting

SPU uses its MAXIMO work management system to capture asset failure and maintenance history. A MAXIMO reimplementation project commenced in March 2010 and is planned to be completed in 2012. This project will accomplish the following objectives:

- Improve data collection reliability and consistency.
- Improve data accuracy to assess asset maintenance needs and asset life-cycle costs.
- Improve service delivery problem response and remedy through improved work planning and improved GIS interfaces for field crews to access information and enter data.

SPU uses a geographic information system (GIS) to record and display locations of physical assets and problems. This tool is also used to review shutdown blocks, gridding and hydrant spacing, identify critical assets and develop asset management strategies.

5.4 Needs, Gaps, and Issues

The primary needs, gaps, and issues facing SPU's distribution system in the coming years are related to distribution system assessment, asset management planning, distribution system improvements, and opportunities presented by third-party projects. The following subsections summarize these issues and SPU's approach to addressing them.

5.4.1 Distribution System Assessment

The Distribution System business area is the most asset-intensive of the business areas for the drinking water system. In recent years, SPU has been reviewing needs and gaps related to maintenance, rehabilitation and replacement of these assets. SPU identified as near-term priorities the need for conducting watermain condition assessments and a shutdown block analysis, as described below.

5.4.1.1 Watermain Condition Assessment

Parts of SPU's water distribution system, in particular many of its pipelines, have been in place for more than a century. Although the existing system is in good condition, as evidenced by its low leakage and break rates, SPU has limited information of the

condition of watermains, especially those in critical locations. SPU uses an asset management framework to prioritize capital investments for watermains. Priority is given to replace or rehabilitate pipes that have reached the end of their economic life, and replace or rehabilitate critical pipes before they fail. Critical watermains are defined as pipes essential for service delivery or those with high consequences of failure. Critical watermains, which meet threshold criteria will undergo watermain condition assessment, if feasible. The threshold criteria used to determine criticality are under review.

As noted in Chapter 4, SPU conducted in 2007 a leakage test of Cedar River Pipeline 2 from Volunteer Reservoir to Maple Leaf Reservoir (also known as the 430 Pipeline) using "smart ball" technology to assess its condition. This initial phase of a proactive leak detection pilot was successful, and the program is being expanded. The expanded pilot will ascertain the condition of several of the most critical watermain segments by assessing for leaks and/or remaining pipe wall thickness. If critical watermains are found to be in need of repair, they will be repaired or given a high priority for capital investment to rehabilitate or replace prior to pipe failure. This evaluation will be based on asset management principles.

5.4.1.2 Shutdown Block Analysis

When one or more valves are closed to isolate a portion of the distribution system to make repairs or install new pipes or appurtenances, the area that no longer has water flowing is called a "shutdown block." Any water services or hydrants within the shutdown block area would experience a service interruption. A simple example is when a pipe segment is taken out of service by closing valves at each end and service delivery is interrupted along the pipe segment. Depending on the pipe network configuration, a shutdown block may cover more than one city block.

SPU has completed a shutdown block analysis in which each pipe segment in the retail service area was evaluated to determine the service delivery impact if that pipe segment is taken out of service. In this context, service delivery impacts are based on the number of customers, the number of hydrants, and the flow rate in the pipe. Pipe segments associated with High Impact Shutdown Blocks (HISB) will be identified on a GIS layer. The HISB GIS layer will be used during the planning phase of redevelopment and third-party projects to reduce the size of the shutdown block and mitigate service delivery impacts with the installation of additional isolation valves or watermains. The HISB GIS layer will also be

used during emergency shutdowns to improve operational response and customer service.

5.4.2 Asset Management Planning

What do you mean by "asset management"?

Asset Management is an approach to making decisions about operations and maintenance work and capital investments that is based on a long-term view of financial, social, and environmental costs and benefits, otherwise known as the "triple bottom line." Asset management provides the highest long-term value to ratepayers while minimizing life-cycle cost.

As noted in the *2007 Water System Plan*, important asset management planning documents that SPU uses include strategic asset management plans (SAMPs). SAMPs are 3- to 5-year planning documents that guide the management of assets to meet defined objectives. Each SAMP covers a class of assets (e.g., pipelines) and describes relevant assets and service levels, operations and maintenance strategies, replacement/renewal capital plans, and decision tools and models for that asset class. In some instances, maintenance strategies may be developed separate from a SAMP. Additionally, ongoing programs may be evaluated to determine near-term investment strategies, which are documented in what SPU calls a Programmatic Business Case. The complexity of the asset class and the complexity of the management strategy for the asset class determine which documents are most appropriate. Watermains, for example, require a Programmatic Business case, a SAMP and a maintenance strategy.

Since the Distribution System Business Area is the most asset-intensive business area for SPU – requiring major investments and significant resources to maintain – SPU has completed initial versions of SAMPs for all of the relevant asset classes in the distribution system. As noted previously in Section 5.3.3.4, in 2012 SPU plans to update the Meter SAMP and gate valve maintenance strategy. Additionally, the Water Distribution Pipes SAMP and Programmatic Business Case will be updated in 2012. SPU also plans on completing in the next few years updates to the Valve SAMP, and Hydrant SAMP and maintenance strategy.

5.4.3 Distribution System Improvements

SPU has a capital program for distribution system improvements. This program is used to identify, prioritize and fund seismic upgrades of the backbone pipeline system and fire flow and pressure improvements. The program may also consider cleaning and lining as an option for making system improvements in areas with unlined cast iron pipes. These aspects of the distribution system improvement program are described in the following subsections.

5.4.3.1 Backbone Pipeline System Seismic Upgrades

The benefits of seismic upgrades will be considered when pipe replacement projects with multiple benefits are prioritized and implemented.

As noted in the *2007 Water System Plan*, SPU investigated cost-effective approaches to mitigating the effects of earthquake pipeline damage on the water system functionality, including line valves to isolate the Duwamish River Valley area and reservoir valves to retain water in storage for drinking water and firefighting. Additionally, replacement of certain existing watermains with seismically resistant pipe can be cost-effective when the watermain needs to be replaced for other reasons, such as when third-party projects require relocation of the watermain. For example, the seismic upgrades in the Duwamish River Valley area occurred when SPU took advantage of opportunities created by Seattle Department of Transportation projects.

SPU has completed some seismic upgrades in conjunction with other projects, but some work remains, specifically completion of the seismic backbone for an 800-foot section of watermain located in the Duwamish River Valley area on the west side of Beacon Hill in the vicinity of Interstate 5 and the Burlington Railroad line at Spokane Street. Also, installation of additional valves along the general boundary of the liquefiable soils in the Duwamish River valley is planned. Exact locations, operating strategy, hardware, and SCADA requirements are yet to be defined. The benefits of other seismic upgrades will continue to be considered when pipe replacement projects with multiple benefits are identified and implemented.

5.4.3.2 Fire Flow Improvements

Although the majority of the SPU's hydrants are able to deliver more than adequate flows to combat fires, there are areas inside and outside of the City of Seattle where SPU's water system has hydrants that cannot deliver fire flows to existing buildings under current codes required for new buildings. This can be caused by a combination of factors including pipes with small diameters or areas with low water pressure due to older design standards, or pipes whose interiors have been reduced by deposits. There are also areas that were originally built to now obsolete fire codes, most notably the Arbor Heights area annexed to the City of Seattle in 1954.

Although SPU is not legally obligated to upgrade the existing system to meet current standards, SPU's distribution system is upgraded to current fire flow standards as needed for development/redevelopment and as other system improvements are made (see section 5.4.4).

In 2011 SPU and the Seattle Fire Department (SFD) formed a Joint Executive Team (JET) to enhance coordination between the departments in delivering fire protection services to the public. The JET will set policies to improve fire hydrant maintenance and testing practices, as well as communication between SFD and SPU's water system control center and emergency crews just prior to and during fire fighting. The JET also reviews and prioritizes fire flow improvement projects, the latest one being the Arbor Heights fire flow improvements expected to be completed by the end of 2012.

SPU also intends to engage in similar discussions with other fire departments having jurisdiction in SPU's retail service area.

5.4.3.3 Watermain Cleaning and Lining

SPU's distribution system contains more than 700 miles of unlined, cast iron pipes – approximately 42 percent of all watermains. As these pipes age, many of them exhibit varying degrees of tuberculation, small mounds and growths of corrosion (rust) inside of pipe. Tuberculation increases the pipe wall roughness inside of the pipe, thereby increasing resistance to water flow which reduces pipe flow capacity, lowers the pressure of water delivered to customers, increases pumping costs, and causes water quality problems such as discoloration, low chlorine residuals, and undesirable tastes and odors.

Replacing all of these pipes with new ductile iron pipes would be very costly. A less costly alternative to pipe replacement is to clean (scrape and remove the tuberculated areas) and then apply a lining to the interior of the pipe. This pipe rehabilitation method has been proven elsewhere to restore flow capacity, eliminate discolored water, reduce pipe leakage, and extend the life of pipes. Since cleaning and lining work generally does not require pipeline excavation, there is also less disruption to the community than with pipe replacement.

SPU completed a pilot cleaning and lining project in 2007 on approximately 19,130 feet of unlined, cast iron pipe in the Ballard area, and found this rehabilitation technique to be successful. The costs for completing the cleaning and relining, including associated costs such as laying temporary water service mains and installing flushing stations, was approximately $153 per foot, which is significantly less than the cost of pipe replacement. Issues with managing high pH levels shortly after construction, which are associated with the lime in the new cement mortar lining leaching out, can be managed through the use of unattended flushing

stations. Water quality, as indicated by chlorine residuals, significantly improved after lining. While customers in the area did complain about brown water from valve operations and tastes and odors associated with the new service lines used by the contractor, the overall impact to the community was minimal in comparison to pipe replacement projects.

In its options analysis to address fire flow, water quality, or pressure issues in the distribution system, SPU considers the use of cleaning and lining as an alternative to replacement of deteriorated unlined, cast iron pipe. To date, no additional clean and line projects have been implemented.

5.4.4 Third-Party Projects

Projects initiated by third parties may require SPU to make system changes or provide an opportunity for SPU to make improvements.

Other agencies, utilities and private developers construct projects in the retail service area that can impact the distribution system. These third-party projects often necessitate SPU to make system changes that it would not otherwise do, but they can also present opportunities for improving flow capacity, pressure, reliability, and water quality in the distribution system at a reduced cost to SPU ratepayers. The following sections describe the impact on the distribution system from transportation projects and new development.

5.4.4.1 Transportation Projects

Transportation projects are third-party projects that can have a significant impact on the water system because of the need to relocate or protect existing water infrastructure. Also, transportation projects often create opportunities to renew or upgrade water infrastructure assets at a lower cost by taking advantage of the street opening and reducing pavement restoration costs.

SPU considers whether to relocate or retire water infrastructure for transportation projects when the existing water infrastructure would not be able to remain in its existing location due to grade conflicts, would no longer be accessible for maintenance and repair, would have increased consequences of failure after the transportation improvements have been built, or would have a high probability of failure due to damage during construction that cannot be remedied by protection measures. Water infrastructure may be retired when it is not needed for water delivery to specific water services or fire hydrants, for the delivery of fire flow to the surrounding area, and for delivery of water to surrounding areas such as usually provided by feeder mains. Watermain gridding is

also considered in watermain decisions as a way to mitigate the impacts that dead-ends have on the system, such as to water quality and shutdown block size. Distribution mains that cannot be retired but are smaller or larger than the standard pipe sizes (8-inch for single–family residential areas and 12-inch for industrial and commercial areas) are evaluated for proper sizing prior to relocation. The evaluation usually involves hydraulic modeling of the present-day water system configuration and expected future uses and densities.

If water infrastructure does not need be relocated and is not slated for retirement, SPU may choose to protect it in place or take the opportunity to renew or upgrade it. SPU has developed a Watermain Replacement Opportunity Model, which was described in the *2007 Water System Plan*, and uses it to make data-driven decisions about whether to protect each existing watermain or to replace it. If the cost savings from the concurrent work with the transportation project are substantial enough, and/or the condition of the existing watermain is deteriorated, the model will indicate that the watermain is a candidate for replacement. The watermain may be replaced in kind, upsized or downsized depending on current and anticipated capacity requirements.

The extent of transportation improvements in Seattle's retail service area by Sound Transit, Washington State Department of Transportation (WSDOT), Seattle Department of Transportation (SDOT), and the City of Shoreline is expected to remain high at least through the first six years of the planning period, with the larger projects being as follows:

- SR99 Improvements through downtown Seattle by WSDOT, including new tunnel construction and demolition of the existing Alaskan Way Viaduct.
- Seattle Central Waterfront Redevelopment by SDOT.
- First Hill Streetcar implementation funded by Sound Transit and led by SDOT.
- Design and construction of the University, North, and East Links of the light rail system by Sound Transit.
- Aurora Ave/SR99 redevelopment between 192nd Street and the King-Snohomish county line by the City of Shoreline.
- The replacement of the SR520 highway, and improvements to the I-5/SR520 interchange by WSDOT.

- Arterial street resurfacing and reconstruction under the "Bridging the Gap" program by SDOT.

Because these transportation projects are led by third-parties, the schedule for completion is not within SPU's control and is subject to change.

5.4.4.2 Redevelopment

Redevelopment activities can have a substantial impact on the ability of the existing distribution system to provide sufficient water to customers and for fire flows. Redevelopment typically increases the population density of an area and can increase the quantity of water that must flow through SPU's distribution system pipes. Rezoning can also change distribution system requirements, particularly when single-family residential parcels are rezoned to mixed or commercial uses. Most often, extension of the distribution system or improvements to existing watermains in the redeveloped area becomes necessary to accommodate higher fire flows. Detailed hydraulic models or hydrant flow tests are used in conjunction with fire flow requirements provided by the fire department[1] to identify potential watermain improvements when properties are redeveloped, as well as when new development takes place.

New developments must meet the current fire code, and new service connections must be made to standard watermains. SPU reviews and provides a water availability certificate for each development as part of the local government's building permitting process. If there is a gap between what the existing system can provide and what the private development needs, the developer will be required to upgrade the existing system to meet requirements. Developers are required to pay for connection to the system. New tap installations are directly billed to the customers.

5.4.5 Service to Shoreline

SPU is in discussion with the City of Shoreline about how SPU's infrastructure within the City of Shoreline could be transferred to the City if they are successful in getting voter approval to form a utility. With conceptual agreement on a sale of assets in 2020, SPU and Shoreline will attempt to reach agreement on how the

[1] See footnote on page 5-9 for fire departments with jurisdiction in SPU's retail service area. For the City of Seattle, fire flow requirements are defined by the Seattle Fire Code (SMC 22.600). Fire flow standards for unincorporated King County are defined by KCC 17.04 and 17.08.

systems would be separated and utility functions would be transferred, and at what cost.

5.5 Implementation/Action Plan

As described in this chapter, the major needs for managing the distribution system to meet service level targets include distribution system assessment, asset management planning, distribution system improvements, and opportunities presented by third-party projects. SPU has identified the following actions to address these needs:

- Manage retail service delivery, problem response and leakage to meet service level targets.
- Complete analyses to determine whether to decommission Trenton Standpipes and Volunteer Park Standpipe.
- In a pilot effort, assess the condition of a portion of the most critical watermain segments and, if needed and supported by analysis, repair, rehabilitate or replace the pipe prior to anticipated failure. Expand the initial condition assessment pilot, if appropriate.
- Improve operational response and customer service by using information from the watermain shutdown block analysis in project and emergency shutdown plans.
- Complete additional asset management documents, including updates to the Meter SAMP, the Hydrant SAMP and maintenance strategy, and the Valve SAMP and maintenance strategy.
- Complete the remaining seismic backbone upgrades to the distribution system that serve the Duwamish River Valley.
- Consider the use of cleaning and lining as an alternative to replacement of deteriorated unlined, cast iron pipe to address pipeline life, fire flow, water quality, and pressure issues in the distribution system.
- Continue to work with the Seattle Fire Department to improve fire hydrant maintenance and testing practices, better coordinate communication between SFD and SPU's water system control center and emergency crews just prior to and during fire fighting, and prioritize fire flow improvement projects. Engage in similar discussions with other fire districts.

- Continue working with developers where watermain replacements or upgrades in redevelopment areas are required to meet current fire flow requirements and watermain standards.

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