City of Shoreline

Shoreline Water System Engineering Review

May 2012

Prepared by:

EES Consulting

570 Kirkland Way, Suite 200
Kirkland, Washington 98033

A registered professional engineering corporation with offices in Kirkland, WA; Bellingham, WA; and Portland, OR

Telephone: (425) 889-2700 Facsimile: (425) 889-2725

Contents

Introduction

The City of Shoreline is evaluating the feasibility of acquiring and operating Seattle Public Utilities' water system infrastructure within the city limits of Shoreline. The acquisition would take place in the year 2020. This report provides an initial engineering review of the Seattle Public Utilities (SPU) water system assets which are under consideration for acquisition by the City of Shoreline. The author based the review on his experience of operating and managing staff and infrastructure at a large water utility, along with review of relevant engineering documents related to the Shoreline water system, interviews with SPU and Shoreline staff, and site visits to key facilities. The report outlines the overall operation of the system, including pump stations, storage facilities, pressure reducing stations and distribution system infrastructure. Condition of the facilities is evaluated, and deficiencies and other issues are identified. The Shoreline water system is presently an integral part of the SPU system and will need to be modified to become a separate water system, so separation alternatives, issues and costs are outlined. Operation and maintenance costs of the new utility are estimated, as are staffing levels and capital improvement budgets. Since the acquisition will occur a number of years in the future, recommended maintenance and capital improvements are also listed for the period prior to acquisition. During the years prior to the transfer of assets to Shoreline, additional engineering review and evaluation work will need to be carried out. Next steps in the engineering process are identified in this report. This report is prepared as a feasibility evaluation and is not intended to provide a design level of detail.

Status and Condition of Existing System

Summary of Existing Facilities and Operations

The City of Shoreline receives water service from Seattle Public Utilities (SPU) and from the Shoreline Water District, as shown on Figure 1. Most of the SPU service area is located west of I-5, although a small area in the southeast corner of the City also is served by SPU.

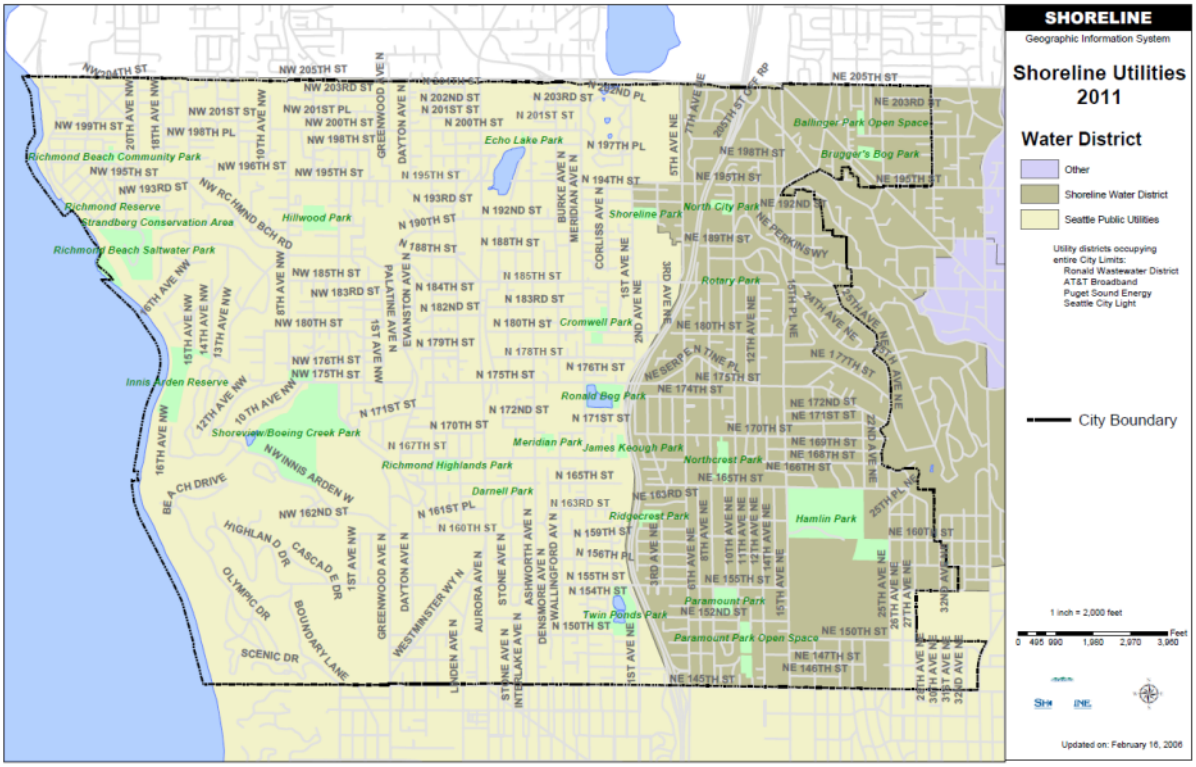

Figure 1 - Water Utility Service Areas

Water is supplied to the City of Shoreline from SPU's Tolt system through the 550 Pipeline, although water from the Cedar River system can also be delivered if the Tolt system is unavailable. Most of the system to be acquired from SPU is located to the west of I-5. This area is presently supplied through the North City Pump Station, the Foy Pump Station, and at times, the Bitter Lake Pump Station. A small area in the southeast corner of the City of Shoreline would also be acquired. This area would be fed from the adjacent SPU distribution system through a metered connection.

SPU provides wholesale water service to the Olympic View Water District through connections located on the north boundary of the City of Shoreline. Water for these connections is pumped

through the Shoreline area by the North City and Foy Pump Stations. SPU also provides wholesale water service to the Shoreline Water District using the North City Pump Station.

Storage in the Shoreline area is provided by the 2 million gallon Richmond Highlands elevated Tank 2, located at Fremont Ave and N 195th Street, the adjacent 1 million gallon Richmond Highlands elevated Tank 1, and by the 1 million gallon Foy Standpipe, located at Dayton Ave N and N 145th Street.

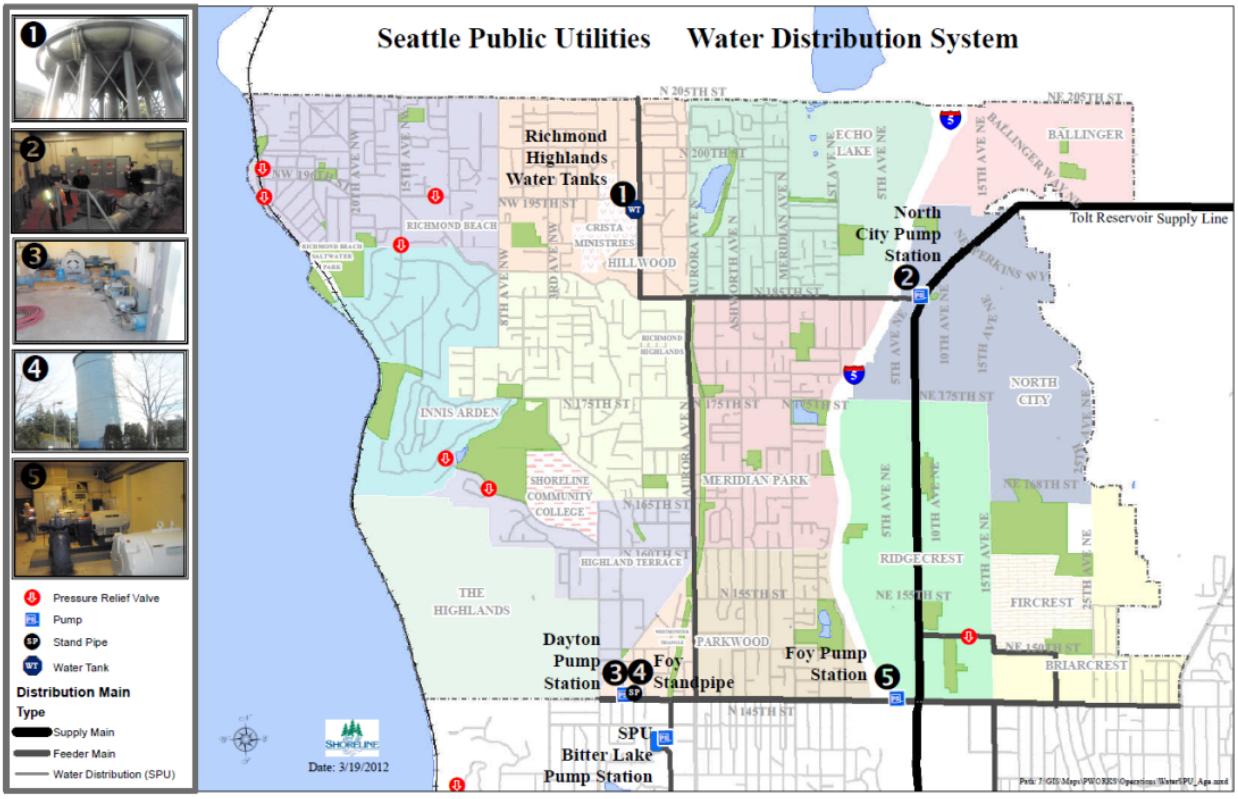

Figure 2 - SPU Water Facilities within Shoreline

The largest pressure zone in the Shoreline area is the 590 zone, fed by pumping from the Tolt 550 Pipeline. The 590 pressure zone extends into Seattle to the south of Shoreline as shown in Figure 3. The 590 zone supplies the 480, 430, 290 and 210 pressure sub-zones through pressure reducing valves. The lower zones are equipped with pressure relief valves. The closed loop 660 pumped zone is fed by the Dayton Pump Station, located by the Foy Standpipe.

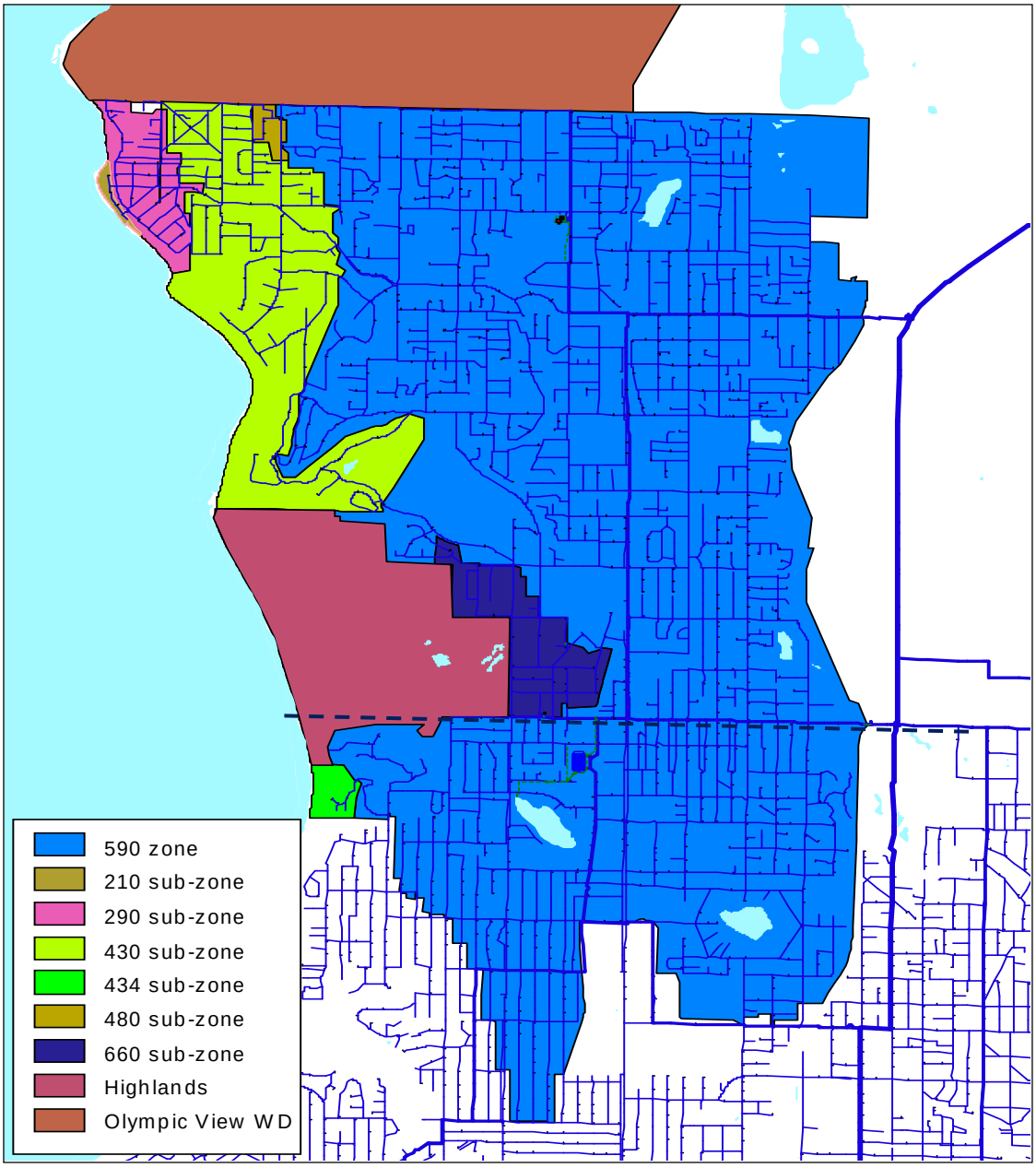

Figure 3 - 590 Pressure Zone and Sub-Zones

Pump station capacities are summarized below. North City and Dayton Pump Stations would be acquired by Shoreline under all scenarios, and Foy Pump Station would provide service to Shoreline under some alternatives. Bitter Lake Pump Station would not be acquired and would not provide supply to Shoreline, and consequently is not listed here.

North City Pump Station	11,000 gallons per minute
Foy Pump Station	11,000 gallons per minute
Dayton Pump Station	1,400 gallons per minute

Storage facility capacities are also summarized. Richmond Highlands Tanks 1 and 2 would be acquired by Shoreline under all scenarios. Although Foy Standpipe would not be acquired, it is listed here since Shoreline would be required to upgrade or replace the facility for SPU's use.

Richmond Highlands Tank 1	1,000,000 gallons
Richmond Highlands Tank 2	2,000,000 gallons
Foy Standpipe	1,000,000 gallons

Summary of System Demands

SPU has 10,570 services in the 590 zone (including the sub-zones as shown on Figure 3) in Shoreline, and 340 services in the 430 zone located in the southeast portion of Shoreline.

Figure 4 shows annual billed consumption converted to average day demand for the SPU system within the City of Shoreline. Total consumption would include an additional amount of non-revenue water, estimated at 5%.

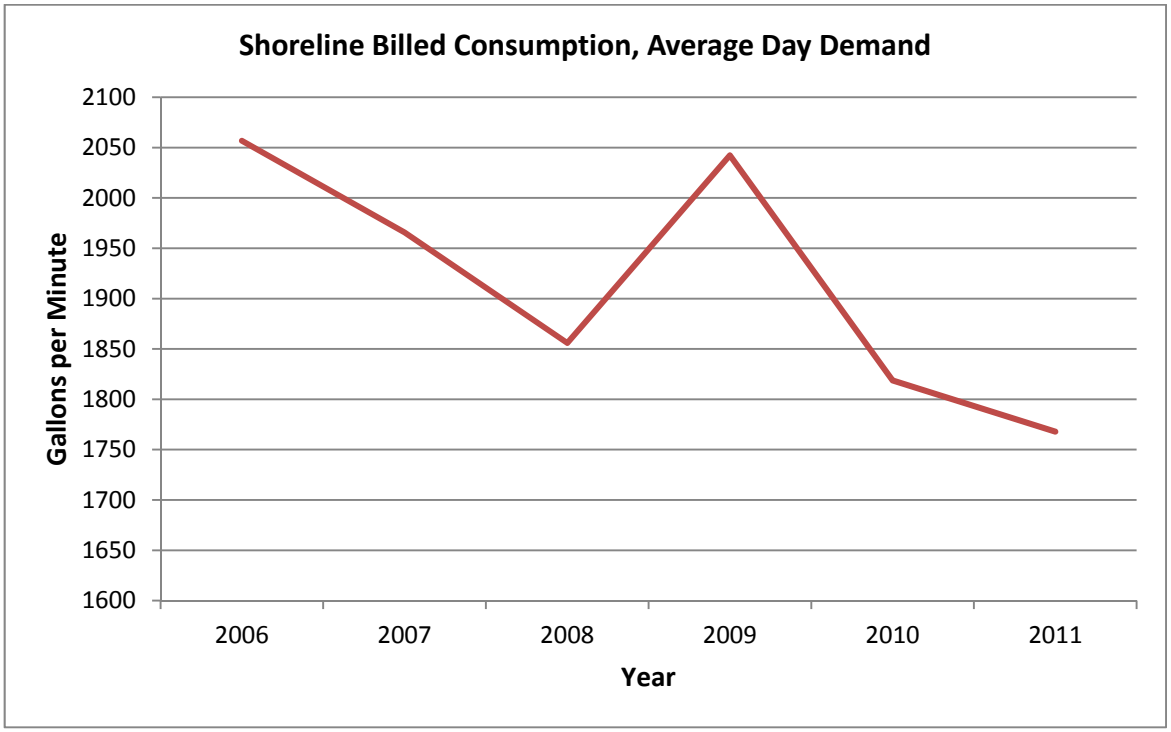

Figure 4 - Average Day Demand

Maximum day demand is estimated at 1.8 times average day demand, and is shown in Figure 5. These demands also reflect billed consumption, and would increase by an estimated 5% to provide total maximum day demand.

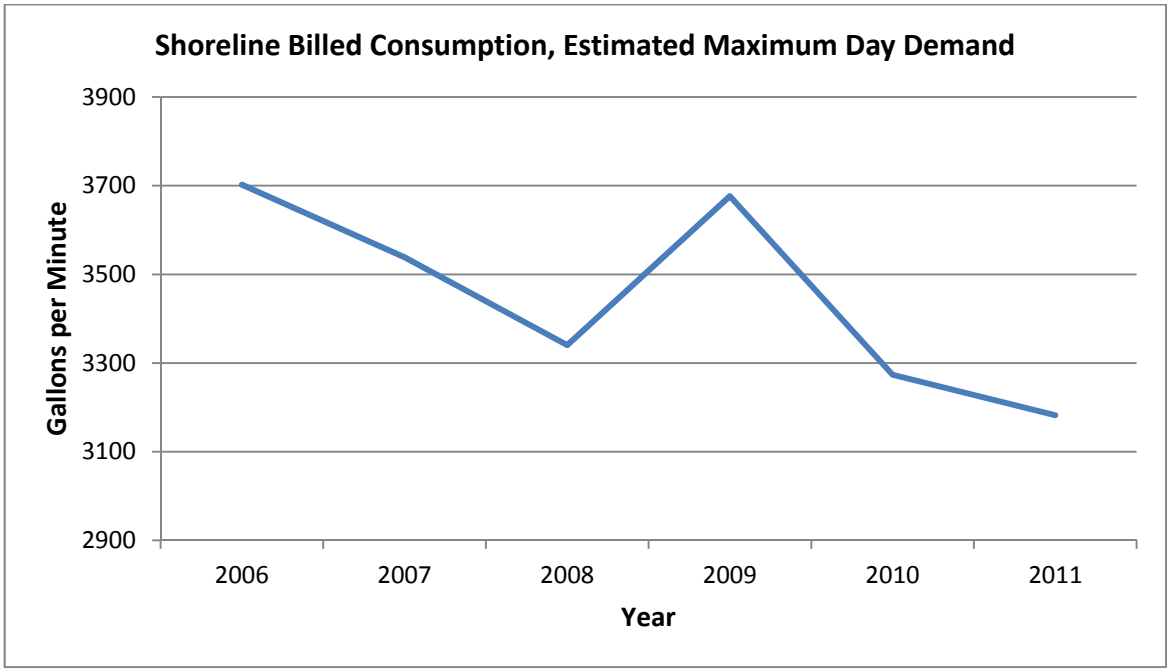

Figure 5 - Maximum Day Demand

In addition to the water used within the SPU system in Shoreline, wholesale water is also pumped through the Shoreline area to the Olympic View Water & Sewer District and Shoreline Water District. Average daily demand through the 590 pressure zone to these services is approximately 700 gallons per minute.

Description of Facilities and Operations

North City Pump Station

Figure 6 – North City Pump Station Interior

North City Pump Station is located on NE 185th Street, between 8th and 9th Ave NE. North City Pump Station is used as the primary feed to the Shoreline area. The underground station was constructed in 1968 and is located adjacent to the 550 Pipeline. The station includes two pumps, each rated at 6,500 gpm and powered by a 250 hp motor. The pumps can be operated in parallel, with a combined output of 11,000 gpm. The inlet flow meter at the pump station is used for operational purposes but would not be suitable as a revenue meter.

Telemetry at the station includes pump start/stop control from SPU's Operations Control Center (OCC), pump status, suction and discharge pressure, inlet flow, and a station intrusion alarm. The station has a flood alarm but not a fire alarm. OCC operators start and stop the pumps as needed to maintain the water level in the Richmond Highlands tanks.

Figure 7 – North City Pump Station Exterior

In the event of loss of power at the pump station, a check valve along with a remotely controlled 12" bypass valve can be opened to allow 550 Pipeline pressure to feed the Shoreline area at sufficient pressure to keep the system pressurized. The bypass would only be used when SPU's Lake Forest Reservoir is taken offline and the 550 Pipeline is operated at 590 feet. The station does not have standby power or a connection for portable standby power. An additional manually operated 24" bypass line is located outside the pump station.

Foy Pump Station

Figure 8 – Foy Pump Station Interior

Figure 9 – Foy Pump Station Exterior

Foy Pump Station is located at the intersection of 5th Ave NE and NE 145th St. The pump station is an above ground concrete building with a pitched roof. It can draw suction from either the 550 Pipeline or the 430 pressure zone, with the station normally drawing from the 550 Pipeline. The building and piping were originally constructed in 1933. New pumps were installed in the early 1990's, including two 400 hp 4,400 gpm pumps and one 6,000 gpm pump. A separate set of impellers is kept at the station for use when pumping from the 430 zone; however they are no longer used due to the similarity of pump performance with either set of impellers installed.

Telemetry at the station includes pump start/stop control from the OCC, pump status, suction and discharge pressure, smoke, flood, and station intrusion alarms. A circular chart recorder is installed but is not in use. OCC operators start and stop the pumps as needed to maintain the water level in Foy Standpipe and the Richmond Highlands tanks.

The station does not have standby power or a connection for portable standby power.

Bitter Lake Pump Station

This pump station would not be acquired by Shoreline, and would continue to serve SPU's portion of the 590 zone. Its relevance to Shoreline is that it currently provides the only pumped backup source if North City and Foy Pump Stations are offline. To replace this function, North City Pump Station would be equipped with backup power, as discussed later in this report. Bitter Lake Pump Station is located south of Shoreline, at Bitter Lake Reservoir at Linden Ave N and N141st St. It can be used to pump from the reservoir to the 590 zone, and presently can be used as a backup supply to the Shoreline area. After system acquisition, this station will continue to be a component of the SPU system which is able to provide backup supply on an 'as available' basis. The station includes three pumps rated at 4,000 gpm each, one of which has a diesel powered standby generator. This location also includes a pressure relief valve for the 590 zone. The pump station's normal use is to improve turnover of the storage at the reservoir. When operated on standby power, the

generator must be started onsite, and must be staffed continuously while running. Addition of remote start capability is planned for 2012.

Dayton Pump Station

Figure 10 – Dayton Pump Station Exterior

Figure 11 – Dayton Pump Station Interior

The Dayton Pump station was constructed in 1978 to supply the higher elevation area to the north of Foy Standpipe. The pump station building is located in an above ground concrete building next

to Foy Standpipe on N 145th St and Dayton Ave N. The station operates as a closed loop system, with two pumps. A 3 hp, 70 gpm pump operates continuously, and a 50 hp, 1,400 gpm pump cycles as needed to maintain pressure within a 20 psi operating band. Two 10,000 gallon hydropneumatic tanks are used to allow the pumps to cycle based on pressure. At peak demands, the large pump is reported to cycle as much as 80 times a day. The station does not have standby power, but is equipped with check valves to feed from the 590 zone if needed.

Scada includes pump start/stop control, discharge flow and pressure. Alarm functions include intrusion and flood, but no smoke alarm is installed.

Richmond Highlands Tanks 1 and 2

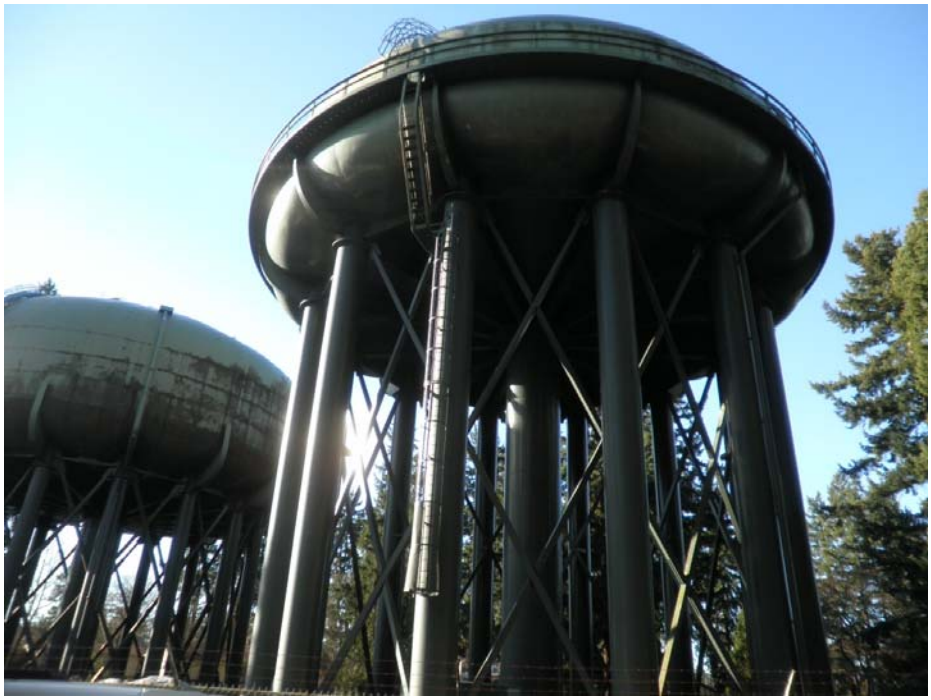

Figure 12 – Richmond Highlands Tank 1 (right) and Tank 2 (left)

The Richmond Highlands Tanks are located at N 195th St and Fremont Avenue N. Both are elevated steel tanks of similar design. Tank 1 was constructed in 1954 and Tank 2 was built in 1958. Both were seismically upgraded in 1994. Tank 1 has a bowl diameter of 86 feet and height of 25 feet, providing 1 million gallons of capacity. Tank 2 has a bowl diameter of 101 feet and height of 35 feet, providing 2 million gallons of capacity. Both tanks have a spill elevation of 590 feet. The top of the concrete base is at elevation 492.5 for Tank 1, and 488.5 for Tank 2.

Tank 1 has interior coal tar lining, which was found to need replacement in the most recent inspection by SPU. The tank bowl's exterior is painted with lead based paint which also was found to need replacement. Tank 1's legs were repainted as part of the 1994 seismic upgrade work, but the coatings on the bowl were not replaced during the seismic work.

Tank 2 is currently being internally and externally recoated, with the exception of the legs and substructure. Tank 1 is planned to be taken out of service once Tank 2 is recoated. The current plan is to leave Tank 1 empty and out of service but intact and physically connected to the system. SPU proposes Tank 1 would be minimally maintained and placed into service in its current condition during times that Tank 2 is out of service for scheduled cleaning or other maintenance. Tank 1's failed internal and external coatings are not scheduled for replacement, but the tank would be maintained in mothballed condition such that it could be recoated and returned to regular service at some point in the future.

The Richmond Highlands tanks have telemetry to monitor water level. The tanks are not outfitted with internal cathodic protection systems to prevent internal corrosion and subsequent coating failure. The tanks do not have intrusion alarms on the hatches but are padlocked. Ladders are caged with locked gates at the bottom of the cages.

Foy Standpipe

Figure 13 – Foy Standpipe

Foy Standpipe is located on the north side of NE 145th St at Dayton Avenue N. It is a riveted steel standpipe and was constructed in 1933, with a diameter of 46 feet and height of 85 feet. Its capacity is 1 million gallons, of which 130,000 gallons are available to support a minimum pressure

of 30 psi in the 590 zone. An additional 290,000 gallons support a minimum pressure of 20 psi. The standpipe is used as an antenna mount by a cellular communications provider.

The tank exterior was last repainted in 1980. An inspection in 2005 found the interior lining to be in good condition. The roof was determined to need repair and recoating. The exterior coating is presently in poor condition particularly on the south face, and results in periodic complaints from neighbors.

The structure has not been seismically upgraded. A ribbon anode cathodic protection system is reported to be installed.

Telemetry at the site consists of water level. There is no intrusion alarm.

Distribution Mains

SPU's distribution system within the Shoreline city limits consists of 614,962 feet of main, or about 116 miles. The predominant materials are cast and ductile iron, which together make up 89% of the system. The galvanized iron total on Table 1 also includes piping listed as galvanized steel. The miscellaneous materials included in the 'Other' category consist of copper, polyvinylchloride, concrete cylinder, kalamein, plastic, and a small amount of pipe listed as unknown material.

Table 1
Distribution Main Materials

Material	Length (ft)	Percent of Total
Cast Iron	395,487	64.3
Ductile Iron	152,689	24.8
Steel	51,029	8.3
Galvanized Iron	10,221	1.7
Other	5,535	0.9
Total	614,962	100

Table 2 shows the distribution of ages and lengths in feet for the various types of piping used in the system. Note that the oldest material in the system is steel pipe, followed closely by cast iron. SPU transitioned from using unlined cast iron to lined cast iron pipe approximately 65 years ago, and transitioned from using cast iron to ductile iron pipe about 40 years ago. Unlined cast iron loses capacity over time as internal corrosion reduces available flow area. Cast iron, whether lined or unlined, is more susceptible to main breaks than is ductile iron.

Table 2 Main Material & Length by Age							
	Cast Iron	Ductile Iron	Steel	Galv. Iron	Other	Total, ft	% of Total
0 - 10 years	0	11,524	0	0	131	11,655	1.9
10 - 20 years	0	26,547	0	0	12	26,559	4.3
20 to 30 years	117	25,051	0	30	336	25,535	4.2
30 to 40 years	12,339	79,072	6	30	1,244	92,691	15.1
40 to 50 years	146,954	10,215	18,619	310	808	176,906	28.8
50 to 60 years	150,766	5	12,228	3,258	503	166,760	27.1
60 to 70 years	72,003	0	1,918	3,289	7	77,217	12.6
70 to 80 years	11,020	159	18,260	3,155	0	32,594	5.3
over 80 years	300	0	0	0	0	300	0.0
unknown	1,986	115	0	90	2,494	4,686	0.8

Approximately 75% of the system is over 40 years old. About 6% of the system has been installed in the last 20 years, and 2% has been installed in the last ten years.

In general, utilities have found that a good quality distribution main that is properly installed can be expected to last 100 years. However, mains are not normally replaced solely based on age. Some of the oldest cast iron pipe was made using a process that resulted in very thick pipe walls which have proven to have very long life. Some other types of pipe such as small diameter galvanized iron will have much shorter service lives. Main replacement is typically carried out based on frequency of repairs and adequacy of size or capacity. From a long term perspective, average service life of the water mains in a system can be expected to be approximately 100 years.

Summary of Existing Operations

Most water delivered to the Shoreline area is pumped at North City Pump station, which is manually controlled by the OCC operators as they monitor the water level at Richmond Highlands Tanks. North City Pump Station provides the most economical source of supply to the Shoreline area. Additional water is pumped by Foy Pump Station using the same manual control method, based on the OCC operators monitoring the water level in Foy Standpipe and in Richmond Highlands Tanks. The Bitter Lake Pump Station provides a third available supply, and is the only one of the three pump stations which has backup power. SPU has determined that backup power is not considered necessary at North City or Foy Pump Stations due to the availability of gravity pressure in the 550 Pipeline when operated at elevation 590, and due to the availability of backup power at the Bitter Lake pump station. North City Pump Station is equipped with a 12”bypass system, including a check valve and a remotely controlled valve. A 24” bypass line is located near the pump station on a separate connection to the 550 Pipeline. The control valve for this bypass is no longer electrically operated, although the manually operated valve remains in place.

Due to power failures caused by storms, North City and Foy Pump Stations have simultaneously failed in the past. In this situation, the 590 zone including the Shoreline area would be fed by storage at Richmond Highlands Tanks and by Foy Standpipe storage. The only available pumped

supply to the area would be provided by the Bitter Lake Pump Station; however it requires staff onsite to start the pump station, which takes up to 2 hours. Remote start capability is planned to be installed in 2012. Depending on demand and on storage tank levels, Richmond Highlands and Foy Standpipe storage can be expected to last a minimum of 12 to 24 hours. Should storage be depleted before the Bitter Lake pump is started, or should demand exceed the capacity of the Bitter Lake pump, the check valve from the 550 Pipeline at North City Pump Station would open to provide a reduced level of system pressure. The bypass valve at North City can also be manually opened, but not by remote control during a power failure, due to lack of battery backup for the valve operator. Given several hours to reconfigure valves on SPU's transmission system, the 550 Pipeline can be operated at elevation 590, in which case the area could be returned to near normal pressure. Available storage at Richmond Highlands provides sufficient time to allow for SPU to start the Bitter Lake pump or to make any needed system changes to provide transmission supply at normal 590 zone pressure.

Olympic View Water District has about 5,000 services and is supplied from the 590 zone on the north side of Shoreline. Olympic View has its own 2.5 million gallon tank and several emergency interties with the City of Edmonds. Check valves on the Olympic View supply points would allow Olympic View to maintain normal pressure in the event of a loss of pressure in Shoreline and the 590 zone.

In order to provide sufficient storage to the 590 zone and the Shoreline area, SPU relies on three large reservoirs in the SPU system, Lake Forest Park, Maple Leaf, and Bitter Lake. A portion of the storage in these reservoirs, along with the Richmond Highlands Tanks and Foy Standpipe, provides needed storage for the area. However, should Shoreline become a wholesale customer, the reservoirs outside of the Shoreline boundaries would no longer be designated to provide storage for Shoreline except on an 'as available' basis, unless Shoreline were able to negotiate an arrangement with SPU which allowed access to SPU storage. Without such an agreement, Shoreline would need additional storage capacity, as discussed later in the capital improvements section.

SPU staff has recommended that Foy Standpipe be decommissioned. Once it is out of service, and assuming Richmond Highlands Tank 1 is mothballed as proposed by SPU, Richmond Highlands Tank 2 will be the only operational storage facility at 590 elevation in the zone. When Richmond Highlands Tank 2 is out of service for cleaning or maintenance, the zone will no longer have a storage facility online which can be used to regulate pressure in the zone. One of two methods would need to be used in order to operate without Richmond Highlands Tank 2: Tank 1 could be temporarily returned to service, or water in excess of demand can be pumped at North City or Foy Pump Station, with the excess water released to Bitter Lake Reservoir through the pressure relief valve at that location. The feasibility of temporarily placing Tank 1 in service is unknown and would need to be discussed with the DOH engineer. The tank would need to be cleaned and disinfected prior to being returned to service, and after an extended period of being out of service, it may be difficult to return the tank to a condition suitable for storing potable water due to the poor internal coating condition.

Facilities Condition

Based on site visits, review of documentation, and discussions with SPU and Shoreline staff, the following observations on facility conditions are noted:

Pump Stations

North City, Foy and Dayton Pump stations were toured. They were found to be clean, dry and generally appeared in good repair. Paint was in good condition both internally and externally. Safety measures were in place, including signage and cages around moving parts. All had overhead cranes marked with load limits. The Dayton pump station appeared to be less maintained than the larger North City and Foy pump stations.

North City Pump Station is located in a large underground vault which is not considered by SPU as a confined space. The station is accessed by stairs rather than by ladder, and at the time of the tour, a ventilation fan was in continuous operation.

Chart recorders are no longer in service, which makes it more difficult for field staff to diagnose failures. The control panel for the North City bypass valve did not appear to be functioning correctly and may not have been fully in service. Staff reported they did not carry out wire-to-water pump and motor efficiency testing, and pump performance does not appear to be tracked. Vibration monitoring was carried out at North City pumps in the past but was discontinued. Electrical switchgear is not checked by infrared scan for loose connections or overheated wires, however an annual switchgear inspection is carried out and connections are checked at that time. As part of the annual electrical check, larger motors are reported to be electrically tested to check winding insulation quality.

SPU staff reported that all stations are checked weekly. North City and Foy Pump Stations are manually controlled by the OCC operators, who operate the stations by monitoring water levels in the receiving reservoirs. While this process easily lends itself to automation, SPU prefers the manual approach as a way to more actively engage the OCC operators in the operation of the water system. SPU also relies on OCC operator intervention to protect pumps against failures such as pump control valves not opening or closing as needed. Standard industry practice relies on automated control systems to protect equipment in the case of local malfunctions.

North City, Foy and Dayton Pump stations are all without backup power systems. In the event of loss of line power, check valves and alternate sources such as the Bitter Lake Pump Station are relied on to provide sufficient pressure to keep the distribution system pressurized once local storage is depleted. Storage at Richmond Highlands Tank 2 would last less than a day at average day demand. It is expected that the alternate means of supplying the area could be initiated within the amount of time that local storage would last.

Dayton Pump Station uses a hydropneumatic system, where pumps cycle based on the pressure in two hydropneumatic tanks. The large pump at this station has been reported to cycle off and on up to 80 times per day at peak demands, with the station's discharge pressure cycling between 60 psi and 80 psi. This type of system is no longer the industry standard for closed loop pumping

systems. Variable speed pump control systems are commonly used in this application which allow the pumps to run at any speed needed to maintain a constant discharge pressure. Pump speed is automatically controlled by altering the frequency of the power supplied to the pump motor. This type of system also has the advantage of being energy efficient.

Control systems at the pump stations appear to be fairly basic. They are appropriate for a system which uses control system operators but would need modification to be suitable for a system that did not have control station operators but that instead relied on automated control. Some flow and pressure readouts are provided but circular charts or data loggers are not in service at the stations. Stations do not appear to have programmable logic controllers (PLC's) for overall station local control, alarms and motor protection; instead some or all functions either appear to be handled by the operator at the OCC or by local relay systems.

Pump controls include Hand-off-Auto control, which allows pumps to be turned on at the station or by the OCC. Transducers are labeled according to function.

All stations had sufficient space to accommodate their equipment and to provide ample work space.

Storage Tanks

The Foy Standpipe and Richmond Highlands Tank sites were toured. Foy Standpipe is in need of exterior paint, with numerous rust streaks visible from the street. Richmond Highlands tanks also need exterior paint, and recoating work on Tank 2 is presently underway. Tank 1 has extensive rusting on the roof, which is visible from the street. The legs of the tanks were repainted in 1994 and the paint remains in fair to good condition, with some oxidation on the south faces and some areas in need of touch up.

The bowl of Richmond Highlands Tank 2 is currently being relined and repainted. The tank's structure was seismically updated and painted in 1994. Richmond Highlands Tank 1 is reported to have poor internal coal tar enamel coating and has poor exterior paint on the tank bowl. SPU plans to take this tank out of service with the possibility of returning it to service at some future time after recoating.

SPU staff has recommended that Foy Standpipe be decommissioned. Its exterior coating is in poor condition and draws complaints from neighbors. The tank has been found to need substantial work if kept in service, including roof repair, new internal and external coatings, installation of an internal mixing system, and seismic upgrade work. The standpipe has lead based paint on the exterior (under the visible coat of paint which was installed in 1980) and vinyl internal coating. Standpipes contain a high proportion of unusable dead storage which can lead to poor water quality unless the contents are well mixed. Foy Standpipe presently does not have a mixing system.

Hydrants

Hydrants are not routinely exercised by either SPU or by the local fire jurisdiction. SPU responds when a hydrant is reported in need of repair, but does not have a regular hydrant exercising or testing program. SPU relies on local fire jurisdictions to notify SPU if a hydrant is in need of repair. The Shoreline Fire Department reports that there are numerous hydrants with inadequate flow capacity. The Fire Department also reports that SPU responds in a timely manner when hydrants are reported out of service.

Mains, Services & Meters

Gate valves are not routinely exercised. Also, Shoreline staff reported difficulty in getting SPU to raise gate boxes in response to street paving. This, along with the gates not being exercised, increases the possibility that some gate boxes have been paved over or lost.

Mains are not routinely flushed. The local fire jurisdiction reported that mud, sand and rocks are often discharged when hydrants are flowed. Flow tests are infrequently done, and would be SPU's responsibility except in emergency situations.

Services and meters are replaced as needed.

Pressure Reducing Valve Stations

Figure 14 – Pressure Reducing Valve, 9th Ave NW & Innes Arden Way

Discussion with SPU maintenance staff indicated that pressure reducing valves are maintained on a 2 to 8 year interval, depending on criticality rating, activity of the valve, and valve size. The valves and pilot systems are standardized with units from high quality manufacturers. Most

pressure zones that are fed by pressure reducing valves are also equipped with pressure relief valves. Pilot lines are copper or, in some cases, stainless steel.

One station was toured, at 9th Ave NW & Innes Arden Way. This station has ductile iron main with galvanized bypass piping. Reducing valves have isolation valves installed. Access is through a standard circular manhole equipped with a steel ladder. The vault is located out of traffic, and provides sufficient space to access and maintain the valves. The vault had no standing water and appeared to be well drained. The floor of the vault was partially covered by sand and gravel. The station appeared to be consistent with standard utility practices, with the minor exception of sand and gravel on the floor. While a rectangular access hatch is preferable to circular manhole access, the industry practice of using rectangular access hatches at pressure reducing valve stations is relatively recent and most pressure reducing vaults in service typically still have manhole access.

The PRV station at 23rd Ave NW and NW 197th St is connected to Scada to monitor the 430 and 290 zone pressures.

Current Maintenance Programs

SPU's maintenance plans, as described in the 2007 Comprehensive Water System Plan (CWSP), are summarized below. Following the description from the CWSP, maintenance practices as reported by SPU staff are noted where different from the CWSP descriptions:

Pump Stations

At pump stations, the CWSP reports that a mechanic checks the station twice weekly and grounds maintenance staff checks the sites weekly. Pump motor starters are maintained twice a year. Annual maintenance includes a building inspection and valve operator inspection and maintenance. Every two to five years, flow meters are inspected and overhauled if needed, and pressure regulator valves are overhauled. Every five to seven years, pump efficiency is tested and pumps are overhauled if needed. Emergency maintenance is carried out when a critical piece of equipment has failed. Each pump's criticality has been predetermined and is incorporated into SPU's work management system in order to minimize the length of time that critical equipment is out of service.

SPU staff reported they carry out weekly station checks. Pressure regulating valves are serviced monthly based on criticality. Staff reports that meters are serviced monthly or semiannually depending on lubrication requirements.

Storage Tanks

The CWSP indicates that elevated storage facilities supplied by the Tolt system are inspected every 5 years and internally cleaned every 25 years unless it is determined cleaning is needed sooner for water quality purposes. The water supplying the Shoreline area is filtered so sediment load in the water delivered to Shoreline is negligible. Tanks are painted approximately every 15 years or as needed.

SPU staff reported that the actual practice is to clean tanks every three to five years and to conduct sanitary inspections annually.

Hydrants

The CWSP reports that maintenance of hydrants consists of repair or replacement of broken or obsolete hydrants. SPU does not routinely exercise or test hydrants, instead relying on local fire jurisdictions to report defective hydrants to SPU. Hydrants are classified either as In Service or as Out of Service. As soon as a hydrant is identified as out of service and until it is repaired, a white engine port cap is installed to alert fire authorities that the hydrant is unavailable. SPU replaces broken or obsolete hydrants when the opportunity arises and as a result of other construction occurring at the hydrant's location. Hydrants are normally repainted on a five year cycle.

Mains, Services & Meters

The CWSP indicates that maintenance of mains, services and meters is primarily in response to failure of components, such as replacement of broken valves, repair of main breaks, replacement of nonfunctioning small meters, and replacement of leaking service lines. SPU does not routinely exercise distribution valves. Internal condition of the distribution mains is noted when main breaks are repaired, but there is no overall condition assessment of the internal condition of the mains. Main flushing is carried out as needed to address water quality issues including low chlorine residuals, but is not done routinely throughout the system. Large meters are tested and repaired; however this category of meters consists of only 3% of all retail meters. For smaller meters, particularly residential meters, it is more economical to replace rather than repair the meters. Problems with meters are generally identified through the billing system.

Leaking service lines are replaced with copper lines.

Pressure Reducing Valve Stations

No documented maintenance practices are described in the CWSP for these facilities. Similar pressure regulator equipment at pump stations is overhauled every two to five years.

Discussion with SPU maintenance staff indicated that pressure reducing valves are maintained on a 2 to 8 year interval, depending on criticality rating, activity of the valve, and valve size.

Current Capital Improvement Plan

SPU's 2007 Comprehensive Water System Plan addresses capital improvements, in some cases specifying individual projects, but in other cases focusing more on broad programs. Within the Shoreline area, one specific project in the CWSP was the recoating of Richmond Highlands Tank 2, work on which is presently nearing completion. The CIP also included budget for replacing mains that are impacted by other projects, which would include the Aurora Avenue work in Shoreline. Beyond these two projects, specific work in the Shoreline area cannot be identified. While the CIP includes funding for categories such as relining and replacing mains, replacing leaking services, or replacing service meters, these types of work are system-wide and, while some work can be assumed to fall within Shoreline, it is not specifically identified in the CIP.

An approximation can be made for the proportion of general distribution capital improvement work in the Shoreline area by assuming such work is carried out uniformly across the SPU distribution system. This assumption is likely to be more accurate for general categories such as meter or service replacements and less accurate for categories where the work consists of larger, more discrete projects such as water main relocations or main extensions. Table 3 is based on the premise that the distribution CIP is spread uniformly across the SPU distribution pipe network, which consists of 1640 miles of distribution mains. This number does not include SPU's 160 miles of transmission mains. The City of Shoreline includes 116 miles of SPU mains, or 7.1% of the SPU system. Table 3 allocates 7.1% of SPU's annual distribution CIP to the SPU mains located within Shoreline. Actual expenditures may be less than indicated in the table.

Table 3
SPU Distribution CIP Estimated for Shoreline
Based on Proportional Length of Mains

SPU Distribution CIP Category	SPU Annual CIP	Proportionate Share in Shoreline
Reline or replace aging water mains and improve pressures and fire flows where cost effective.	$5,500,000	$390,500
Extend water mains to new developments.	$1,000,000	$71,000
Relocate water mains impacted by other projects and upgrade water mains in redevelopment areas.	$3,000,000	$213,000
Replace leaking service connections and install new services.	$10,000,000	$710,000
Replace meters.	$600,000	$42,600
Total	$20,100,000	$1,427,100

Proposed Maintenance Prior to Shoreline Acquisition

Shoreline would not be acquiring the SPU water system until 2020, or approximately eight years from the present time. During this period, SPU would continue to own, operate and maintain the system. Shoreline has an interest in having the system be in a well maintained condition at time of acquisition. In addition to SPU's current maintenance practices, the following are recommendations for Shoreline to request of SPU.

Pump stations

Wire-to-water pump and motor efficiency tests should be carried out on each pump at the pump stations to be acquired and data should be provided to the City of Shoreline. Any units needing repair or replacement should be identified and repairs should be made. Wire-to-water efficiency testing evaluates the combined efficiency of the pump and motor, and measures the percent efficiency of the conversion of electrical power input to hydraulic energy output. Acceptable minimum efficiency varies by pump and motor size, but ranges from about 45% for small pumps to 60% for large pumps. Pump units that fall below the normal acceptable range for their size often have older, inefficient motors, worn internal pump clearances, or other condition issues that should be remedied.

Infrared scans should be taken of the electrical switchgear, pumps and motors. Infrared scans detect locations that are hotter than would be expected, such as loose electrical connections. Identifying and correcting such problems can prevent fires, and detect failing bearings, undersized wiring, and other issues which otherwise may not be detected. Any deficiencies should be identified and repaired.

Storage Tanks

Richmond Highlands Tank 2's legs were repainted in 1994 as part of the seismic upgrade, and the reservoir bowl exterior will be repainted in 2012. Based on a 15 year painting cycle, the legs were due to be repainted in 2009, however the 1994 paint remains in fair to good condition at present. The legs and substructure will need repainting prior to 2020.

Richmond Highlands Tank 2 presently does not have an internal cathodic protection system. A system should be installed as soon as possible following completion of recoating the tank interior.

Richmond Highlands Tank 1 is not in service but will still need exterior painting for aesthetic purposes prior to 2020. Prior to repainting the exterior, a determination should be made regarding if the tank will eventually be returned to service or decommissioned.

If not decommissioned, Foy Standpipe would need exterior painting in the near future.

Hydrants

Responsibility needs to be established for monitoring hydrant condition. SPU's policy is that the local fire jurisdiction is responsible for reporting hydrant problems. Hydrants should be tested for basic operation and repaired as needed. Any broken or inadequate hydrants should be clearly marked as out of service.

Mains, Services & Meters

An initial priority should be to exercise distribution gate valves and hydrants. In order to do so without causing widespread dirty water complaints, a planned main flushing program should be carried out, in conjunction with exercising the distribution system gates and hydrants. SPU has used the unidirectional flushing process in the past, a method which would be appropriate in this area. Unidirectional flushing begins at the upstream end of a system and works downstream, so increased velocities due to flushing only occur in mains that have already been flushed, and water always flows in the same direction. Discharged water is dechlorinated and filtered as required by the receiving sewer utility or environmental requirements. Planning a main flushing program is often done using a hydraulic pipe model. While the water supplying the Shoreline area is presently filtered, most of the Shoreline piping system predates construction of the Tolt filter plant, which began service in 2000. If system-wide flushing was not carried out prior to construction of the filter plant, the mains are likely to still contain significant amounts of settled sediment which restricts flow in the mains and which generates dirty water during fire flows, peak demands, or when flow direction is changed as system valves are operated.

The main flushing program will also provide an opportunity to further calibrate the hydraulic pipe model in the Shoreline area. Models are typically calibrated by flowing hydrants and by comparing modeled results with actual pressures and flows. A well-calibrated model is essential for efficient operation of a water system, including prediction of available fire flows and prioritizing individual main replacement projects.

If distribution gates have not been operated for years, it can be expected that some valves will break when operated. A program should be in place to replace or at least identify and document broken valves as they are found.

Pressure Reducing Valve Stations

Pressure reducing valves are presently maintained but specific tasks and frequency are unclear. Pressure reducing valves should be maintained regularly in order to avoid valve failures which can overpressure lower elevation zones. While pressure relief valves can reduce the consequences of over pressurization, they are considered to be a safety feature rather than relied on to allow the main pressure relief valve to run to failure. Pressure reducing and pressure relief valve pressure settings and basic operation should be checked on a six month cycle. Depending on the activity and criticality of the valve, pilot systems should be rebuilt on a one to three year cycle. Galvanized piping in vaults should be inspected and replaced if needed.

Proposed Post-Acquisition Maintenance Program

When Shoreline assumes responsibility for operating and maintaining the water system infrastructure, long-term operation and maintenance plans will be needed. The following maintenance programs and activities are recommended to be implemented upon Shoreline's acquisition of the water system.

General Practices

- Make arrangements for on-call staff to respond to after-hours emergencies
- Maintain written and electronic maintenance records for all equipment
- Determine criticality of equipment and respond to failures accordingly
- Critical equipment will not be run to failure
- Preventive maintenance will be carried out on all equipment
- Staff will be equipped with the tools and training they need
- Spare parts will be stocked for typical repair needs
- A safety program will be established or expanded to include the water utility
- Staff in responsible charge of daily operations will be State certified
- Staff responsible for water quality sampling will be State certified

Pump Stations

- Conduct a weekly station check by a mechanic
- Check and adjust pump control and pressure relief valves in accordance with pressure reducing valve maintenance procedures
- Check and maintain oil levels weekly
- Remove motors for repair as needed
- Change out or repair pumps and meters as needed
- Paint piping and structure as needed
- Rebuild control valve pilots in accordance with pressure reducing valve maintenance procedures
- Overhaul relief valves and control valves in accordance with pressure reducing valve maintenance procedures
- Change charts weekly, or install data loggers at stations
- Electrical maintenance including cleaning switchgear every five years, checking connections, infrared scans and megging motors (checking winding insulation) every five years or more frequently as needed
- Conduct periodic wire to water efficiency tests and track results in a database

Storage Tanks

- Inspect tanks every 5 years to evaluate cathodic protection systems, screens and vents, lining systems and structural integrity.
- Clean tanks at 5 year intervals.

- Periodically clean exterior of tanks as needed (contracted work)
- Remove graffiti within one week if possible
- Conduct weekly site checks
- Perform spot painting as needed
- Check and maintain ladders, climbing systems and security features as needed

Hydrants

- Exercise hydrants and valves annually to ensure working order
- Lubricate the operating shaft bearing as needed
- Check accessibility of control valves
- Clear any brush and debris around the hydrant
- Repair any faults found during inspection
- Paint hydrants every five years or as needed

Mains & Services

- Exercise inline valves every five years or as part of the flushing program
- Repair or replace inoperable valves
- Clean out valve boxes, and ensure they are visible and at grade
- Flush dead end mains as needed to maintain water quality
- Carry out unidirectional flushing to help maintain system capacity and water quality
- Repair or replace service lines as needed
- Install new services as needed
- Abandon old services as needed
- Respond to turn on / turn off requests
- Provide locate service (contract)
- Take water quality samples as required

Meters

- Replace meters 1” and smaller as needed or when renewing service lines
- Test, repair or replace meters 1 ½” and larger based on age or as needed
- Read meters bimonthly

Pressure Reducing Valves

- Visually inspect the pilot valve and related piping every 6 months
- Clean the pilot screen and check the valve operation every 6 months
- Check and reset the pressure annually
- Rebuild the pilot valve every 1 to 3 years, depending on activity of the valve
- Rebuild the main valve every three to five years
- Replace pilot piping in the chamber every five years
- Inspect & replace galvanized piping as needed

Structures

- Clean roofs & gutters annually
- Repair and replace roofs and gutters as needed
- Paint as needed
- Maintain landscaping to a defined standard appropriate to the location

Proposed Post-Acquisition O&M Budget

Projected Annual Labor Expense

SPU presently operates and maintains its system in the Shoreline area with crews that are assigned to work throughout SPU's northern service area. Labor hours and costs are not directly tracked with regard to city boundaries, and complete estimates of labor and cost were not available from SPU at the time this report was written.

In the November 2004 report prepared for the Shoreline Water District, *Seattle Public Utilities within the Cities of Shoreline and Lake Forest Park, Water System Valuation Report,* RH2 Engineers assessed the level of effort needed to operate and maintain the SPU system located within the City of Shoreline, plus a small portion of the SPU system located within Lake Forest Park. RH2 Engineers surveyed the Cities of Bellingham, Renton and Kirkland regarding their water utility staffing and level of effort applied to typical water utility activities. Based on unit levels of effort, RH2 Engineers determined that 15.17 full time equivalent (FTE) staff would be required to service the study area, consisting of 1.54 FTE office/clerical, 11.83 FTE field, and 1.79 FTE supervision.

In evaluating the current validity of the 2004 RH2 Engineers report's staffing evaluation, the following are considered:

- The full area evaluated in the 2004 RH2 report included 626,283 feet of main. Shoreline presently has 614,962 feet of main, or 98% of the amount in the 2004 study area. Adjustment of the results to compensate for the small amount of Lake Forest Park service area in the 2004 report falls within the rounding error and does not affect the results as applicable to Shoreline.
- Census results for the years 2000 and 2010 indicate a stable population at 53,000 in Shoreline.
- No major changes have occurred since 2004 which would alter general productivity or job duties in water utility field or office work.
- The 2004 report was based on the assumption that the additional staff would be added to existing staff at Shoreline Water District (SWD). In the case of the City of Shoreline establishing a new water utility, staff will be required beyond those identified in the 2004 report.

The 2004 RH2 report defined additional staff positions in terms of SWD classifications, but in more general terms, the identified staff positions would consist of 3 customer service staff, 4 lead or senior field crew workers, 4 crew workers and 4 crew helpers. These staff would be needed to support field operations and maintenance, customer service, and meter reading functions.

Since Shoreline would need to form an entirely new water utility, other functions will need to be supported. These include a water utility manager, water operations manager, office manager, mapping technician, water quality technician, warehouse technician and administrative and financial support. Some of these functions may be handled by existing City staff or by utility staff supporting the planned wastewater utility. For estimating purposes, all

these functions with the exception of administrative and financial support will be assumed to be included as water utility staffing. Administrative and financial support expense is included as a separate cost in the O&M budget calculations.

Determination of market based salaries will require salary surveys of utilities considered comparable to the proposed Shoreline water utility. For estimating purposes, the salaries in Table 4 are based on salaries in the 2004 RH2 report, escalated to 2011 dollars. Costs shown are direct costs and do not include overhead expense.

Table 4
Staffing Requirements and Salary Cost

Classification Title	Required Staff	Classification Salary	Total Salary Cost
Water Utility Manager	1	$117,973	$117,973
Water Operations Manager	1	$85,471	$85,471
Water Quality Technician	1	$59,329	$59,329
Mapping technician	1	$63,018	$63,018
Office Manager	1	$64,420	$64,420
Customer Service Assistant	3	$47,468	$142,404
Lead Field Crew Worker	4	$68,354	$273,416
Field Crew Worker	4	$47,468	$189,872
Field Crew Helper	4	$46,107	$184,428
Warehouse Technician	1	$47,468	$47,468
Total	21		$1,227,799

Projected Annual Non-Labor Expense

The 2004 RH2 report also estimated the unit material and supply costs required to support the operation and maintenance of the SPU system within Shoreline, based on SWD unit costs. The report noted that reliance on the SWD unit costs assumes the SPU system is in comparable condition with the SWD system, which appears to not be the case. Material and supply costs for a system in need of more maintenance can be expected to be higher than those for a more updated system. Table 5 shows the SWD unit costs, escalated to 2011 dollars. To reflect increased maintenance materials expenses and engineering services, proposed unit costs for Operations and Engineering are two times the SWD unit costs. Proposed unit costs reflect additional costs for hydrant and valve maintenance and repair, and for additional engineering services related to the transition to an independent water utility.

Table 5 Estimated O&M Material & Supply Costs					
Program Area	**SWD Unit Cost**	**Proposed Unit Cost**	**Measure**	**Number of Units in System**	**Estimated Costs**
Operations	$0.43	$0.86	ft of main	614962	$528,867
Engineering	$0.04	$0.08	ft of main	614962	$49,197
Water Quality	$5.56	$5.56	connections	10739	$59,709
Customer Service	$2.04	$2.04	connections	10739	$21,908
Total					$659,681

Projected Annual O&M Budget

Table 6 includes labor cost from Table 4, materials and supplies from Table 5, employee benefits estimated at 40% of base salary and administrative expense. Administrative expense is the general fund overhead estimated cost as outlined in a May 9, 2012 memo prepared by Shoreline staff.

Table 6 Annual O&M Budget	
Category	**Annual Budget**
Labor	$1,227,799
Materials & Supplies	$659,681
Employee Benefits	$491,120
Administrative	$1,093,585
Total	$3,472,184

Separation Options, Issues & Costs

The water system in Shoreline is presently an integral part of the SPU system. Physically separating the Shoreline portion of SPU's system will involve construction of additional infrastructure in order to enable the two systems to operate independently. At present, most of the storage that supports the Shoreline area is located in large regional reservoirs outside of Shoreline. By policy, SPU does not allow wholesale customers to rely on SPU storage capacity for planning purposes; wholesale customers must provide their own storage as needed to meet regulatory requirements. Any physical separation option may need to include construction of additional storage in Shoreline. Additional storage is discussed in the Capital Improvements section.

Separation Options

SPU has presented the following two conceptual or base options:

Alternative A

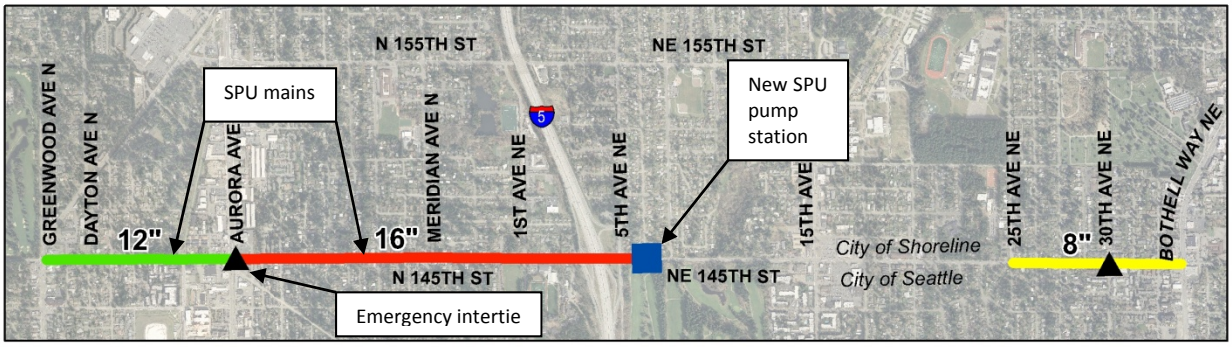

Figure 15 – New Mains, Connections and Pump Station, Alternative A

Shoreline would acquire North City and Foy Pump Stations. Shoreline would also acquire the 24" main in N 145th St. Shoreline would install a new pump station for SPU adjacent to the 550 Pipeline in the vicinity of Foy Pump Station, and approximately 8,600 feet of 12 and 16" of new SPU main in 145th St. from the new pump station to Greenwood Avenue. Mains and services feeding south from the 24" line in N 145th would be disconnected and transferred to the new main. Shoreline would install a new elevated tank for SPU in the vicinity of Bitter Lake Reservoir, or, if a new tank is not acceptable to the community, Shoreline would refurbish Foy Standpipe for SPU and connect it to the new SPU main in N 145th St. A bi-directional emergency metered intertie would be added at a point along N 145th St. and an agreement would be made between SPU and Shoreline allowing use of the intertie when SPU's 590 zone storage facility is out of service for cleaning or maintenance. The new mains and pump station constructed under Alternative A would be for SPU's use, with the exception of the 8" main between 25th Ave NE and Bothell Way NE, which would be a Shoreline main. This section of 8" main is included in all alternatives.

Alternative B

Shoreline would acquire North City Pump Station. Foy Pump Station and the 24" main in N 145th would remain with SPU, and mains and services to the north of N 145th would be disconnected from the main. Shoreline would make modifications elsewhere in its system to replace the function of the 24" main. These modifications are described in the following Alternatives B1 through B5. Foy Pump Station would be modified to operate with the smaller SPU 590 pressure zone by downsizing two pumps and upgrading electrical equipment. Shoreline would install a new elevated tank for SPU in the vicinity of Bitter Lake Reservoir, or, if a new tank is not acceptable to the community, Shoreline would refurbish Foy Standpipe for SPU. A bi-directional emergency metered intertie would be added at a point along N 145th St. and an agreement would be made between SPU and Shoreline allowing use of the intertie when SPU's 590 zone storage facility is out of service for cleaning or maintenance.

Discussion of Alternatives A and B

An underlying concept for any separation alternative is that SPU's existing 590 zone is being divided into two adjacent but independent zones, each of which will need storage and supply mains. Alternatives A and B are identical with regards to storage needs for SPU, and with regards to a mutually beneficial emergency intertie. The primary difference is in who retains the Foy Pump Station and the existing 24" line in N 145th St. Alternative A requires construction of a new main across I-5. Although not described in Alternative B, Shoreline would need a means to receive water from the 550 Pipeline at or near the southern city limits, and any new Shoreline main from the 550 Pipeline would also need to cross I-5.

Under any alternative, provision for flow in either direction between SPU's 590 zone and Shoreline's 590 zone would need to be provided for the benefit of both utilities. Also, SPU would deliver wholesale water to current SPU wholesale customers at the boundary between the SPU and Shoreline water systems. Shoreline would transmit the water to the customers' existing points of delivery. All demands in Shoreline, including those of SPU's wholesale customers, can be met entirely by the supply point at North City Pump Station. The connection to the SPU system in south Shoreline would either serve as an alternate wholesale connection or as an emergency connection, depending on negotiations with SPU. If only an emergency connection is provided, it would be located in the vicinity of Aurora Avenue and 145th St.

There are five variations of Alternative B that could be considered as options for Shoreline to replace the function of the 24" main as mentioned in SPU's Alternative B. These each provide a different means to interconnect and supply the southern part of Shoreline but are otherwise as described by SPU's Alternative B. Alternatives B1 and B5 include construction of new pump stations and alternatives B2, B3 and B4 rely on pumped supply from SPU's Foy Pump Station, which would require payment of an additional surcharge in the supply contract with SPU. This cost will need to be included as part of the cost of water supply for Shoreline. All of the B alternatives also include costs to retrofit Foy Pump Station.

All new mains, connections and pump stations shown for the following alternatives would be owned by Shoreline.

An 8" main and wholesale service connection is provided in all alternatives to supply the area in southeast Shoreline that is currently served by SPU. Although shown as located in 145th St, another option would be to locate this main in 150th St as discussed later in this report.

Alternative B1

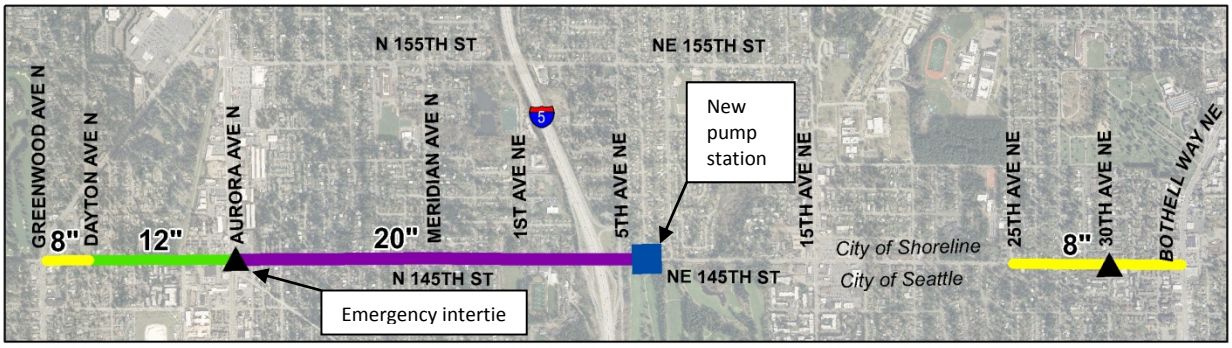

Figure 16- New Mains, Connections and Pump Station, Alternative B1

Alternative B1 would have Shoreline construct a new pump station near Foy Pump Station on N 145th, along with 20", 12" and 8" mains in N 145th St, similar to the description in Alternative A. Under Alternative B1, the new pump station and all new mains would be part of the Shoreline system. All mains and services presently connected to the north side of the 24" main in N 145th would be transferred to the new main. An emergency intertie would be provided at Aurora Avenue. A major drawback to this option is the cost of construction of infrastructure that duplicates the function of the existing SPU infrastructure. Also, Shoreline does not need additional pump capacity beyond that provided by North City Pump Station to meet normal system demands. While a new main is needed in 145th to support the southern part of the Shoreline distribution grid, its size for that purpose would be much less than 20" diameter.

Alternative B2

Figure 17 - New Mains and Connections, Alternative B2

Alternative B2 is a variation on Alternative B1. Rather than Shoreline constructing a new pump station, Shoreline would build only the portion of new main beginning west of I-5 and extending to Greenwood Ave N., consisting of 7,300 feet of main varying from 20" to 8". This main would connect with all existing mains and services on the north side of N 145th St. and would be fed by SPU through a meter near 1st Ave NE and N 145th St. An emergency intertie would also be provided at Aurora Avenue. The connection to the SPU system may require a check valve to prevent the connection from reversing flow as Shoreline filled its storage using the North City Pump Station. SPU would continue to operate Foy Pump Station, and supply to Shoreline through this connection would depend on the level in Shoreline's storage as well as how North City Pump Station was operated. Under normal conditions, supply from Foy Pump Station would not be needed to meet Shoreline demands. This option has the advantage that if in the future, should Shoreline wish to receive supply through its own pump station from the 550 Pipeline, the new pump station could be built on N 145th, along with construction of the main from the pump station across I-5 to the main as described in this alternative. It has the disadvantage that the new main would be larger than needed should Shoreline decide not to construct the future pump station. As with Alternative B1, additional pump station capacity is not needed to meet current or anticipated demands.

Alternative B3

Figure 18 - New Mains and Connections, Alternative B3

Alternative B3 assumes Shoreline does not have future plans to construct its own pump station to replace the functionality of the Foy Pump Station. In this case, Shoreline would construct the 7,300 feet of main in N 145th St between Greenwood Ave N. and I-5, but the diameter would be 8" and 12". A wholesale or emergency connection to the SPU system would be located at Aurora Ave N. The connection may require a check valve as described in Alternative B2. This option relies on the use of SPU's Foy Pump Station at times, however most water received by Shoreline can be delivered by North City Pump Station. This option allows for use of Foy Pump Station and Bitter Lake Pump Station as an alternate supply if needed. The new 12" main provides sufficient capacity to support the Shoreline distribution grid either with a wholesale service or an emergency intertie at Aurora.

Alternative B4

Figure 19 - New Mains and Connections, Alternative B4

Alternative B4 is similar to Alternative B3 except that the south side of Shoreline west of I-5 would be served by three wholesale or emergency connections to SPU, at Dayton, Aurora, and Meridian Ave. N. With three feeds, the entire new main in N 145th St. could be 8" diameter. These connections may also need check valves. The additional complexity of having three service connections in the 590 zone on 145th Street makes this alternative less attractive than Alternative B3.

Alternative B5

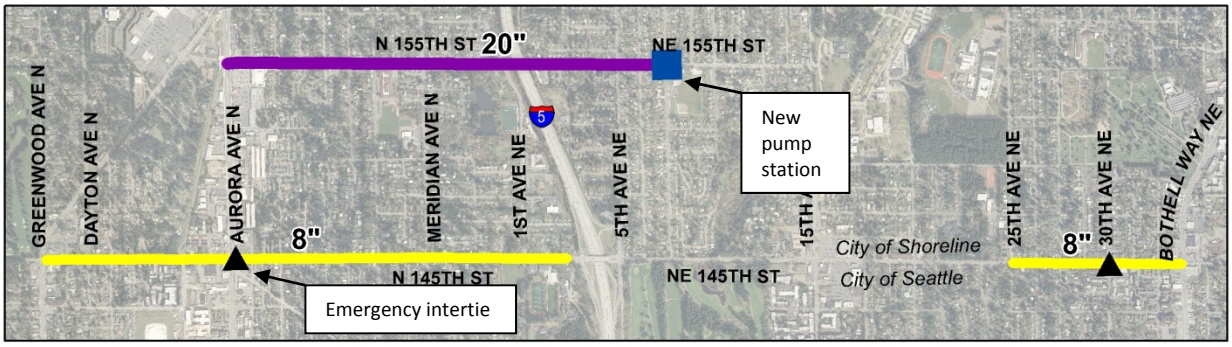

Figure 20 - New Mains, Connections and Pump Station, Alternative B5

Alternative B5 would have Shoreline construct a pump station adjacent to the 550 Pipeline at N 155th St, and 6,000 feet of 20" main from the new pump station to Aurora Ave N. This alignment would take advantage of the underpass under I-5. An emergency intertie would be located on 145th at Aurora Avenue. Although the N 155th St. alignment provides a less expensive location to cross I-5 than the N 145th St. alignment in Alternative B1, it has the disadvantage that approximately 7,300 additional feet of 8" main would still need to be constructed in N 145th St. to tie in the existing mains and services that would be disconnected from the 24" main. This new 8"main is needed to strengthen the east-west distribution grid in south Shoreline, as well as to connect to dead end mains and customers that would be disconnected from SPU's 24" line. This main needs sufficient capacity to provide fire flows from

the Shoreline water system along N 145th St. Alternative B5 also has the disadvantage that by adding a new pump station and discharge line, it is incurring the costs of duplicating existing infrastructure. As with the other alternatives involving new Shoreline pump stations, this alternative involves the addition of capacity which is not needed under normal operating conditions.

Separation of the Southeast Shoreline Area

Approximately 2,300 feet of 8" main would be needed in NE 145th St. to serve the current SPU customers in southeast Shoreline. This section of new main would connect to the mains and services on the north side of NE 145th St from 25th Ave NE to Bothell Way NE, and would be fed by a wholesale connection to the 24" SPU line. It would have sufficient capacity to provide fire flows to Shoreline residents along NE 145th St. One wholesale connection and 2,300 feet of 8" main are included in all alternative estimates. Storage would need to be provided through the SPU system. While SPU does not guarantee availability of fire flows through wholesale connections, such flow can be used on an as-available basis. SPU presently provides wholesale service to other areas that do not have their own storage. If this arrangement is found not to be feasible in this case, construction of a storage facility may be necessary in order for the southeast area to operate separate from the SPU system. An alternate approach would be to provide standby and fire flow to the area from SPU on an 'as available' basis. System design would also include an emergency connection, bypass piping or other means to serve the area during an emergency or during meter maintenance work. This secondary connection may be available from the Shoreline Water District, also providing standby and fire flow on an 'as available' basis. The cost of this secondary means of supply is included in all alternatives as equivalent to an additional wholesale connection. Cost of a storage tank is not included.

An alternate alignment to provide service to the southeast Shoreline area would be to install a new main in NE 150th Street, providing service from SPU's 510 bypass line in 22nd Ave NE. The new line would extend to connect to the existing main in 30th Ave NE. While this option requires addition of a pressure regulating valve, about 100 feet of additional main, and acquisition of a portion of easement, it may warrant consideration due to its favorable location within the service area and its avoidance of construction in the 145th St corridor. Supplying the zone from the SPU 510 bypass line also would allow for increasing the pressure in this area.

Table 7 summarizes separation alternative costs for the alternatives as discussed above. Unit costs are for ductile iron distribution mains, and are listed in Table 10, with the exception of 20" main, which is not included in Table 10 and which has a unit cost of $521 per foot. Costs include 10% contingency for distribution mains and 25% contingency for all other projects, 5% surveying & permitting, 12% engineering, 8% construction inspection, and 10% sales tax. Additional costs are calculated as a percentage of construction cost.

Table 7 Separation Alternative Costs						
	A	**B1**	**B2**	**B3**	**B4**	**B5**
8"main	$529,000	$678,500	$678,500	$1,150,000	$2,208,000	$2,208,000
12"main	$765,850	$578,000	$578,000	$1,329,400		
16"main	$2,493,050					
20" main		$3,099,950	$2,422,650			$3,126,000
I-5 Crossing	$863,000	$863,000				
Pump stations	$2,215,000	$3,210,000	$500,000	$500,000	$500,000	$3,210,000
Foy Standpipe	$2,410,900	$2,410,900	$2,410,900	$2,410,900	$2,410,900	$2,410,900
Metering	$734,000	$734,000	$734,000	$548,000	$724,000	$734,000
Total	$10,010,800	$11,574,350	$7,324,050	$5,938,300	$5,842,900	$11,688,900

SPU has evaluated operation of the system after Shoreline separation and has concluded that North City Pump Station can meet all demands as well as maintain sufficient fire flow and pressure, even without service to the 590 zone along 145thSt. SPU has evaluated their system on the basis of providing an emergency intertie rather than wholesale connection on 145th, and has concluded that Foy Standpipe, or an equivalent new structure, would provide SPU with sufficient elevated storage. The Foy Standpipe cost in Table 7 includes recoating the interior and exterior, seismic modifications, roof replacement, addition of a mixing system, and piping modifications. Modifications at Foy Pump Station would include replacing two of the three pumps with smaller pumps, and retaining a 4,400 gpm pump to provide fire flow or to provide emergency intertie service to Shoreline, in conjunction with the Bitter Lake pump station if needed. This project cost is provided by SPU and is included in all options. Should Shoreline desire a large capacity wholesale service to the 590 zone along 145th St, modifications at Foy Pump Station may be more extensive. Metering costs are facility charges from SPU for meter installations.

The recommended alternative is Alternative B3. Although the estimated cost is marginally higher than Alternative B4, Alternative B3 has the advantage of requiring only a single service connection with SPU on 145th St west of I-5. Alternative B3 is viable with either a wholesale or emergency connection located in the vicinity of Aurora Avenue, where Alternative B4 would require multiple wholesale or emergency connections.

Operations Issues Related to System Separation

SPU presently uses mains within the City of Shoreline to deliver water to several of its wholesale customers. When the mains are acquired by Shoreline, water for the SPU wholesale customers will be delivered at the boundary between SPU and the Shoreline water utility. The wholesale customers, SPU and the City of Shoreline will need to arrive at suitable arrangements

to provide for transmission of wholesale water through Shoreline mains. Under normal conditions, North City Pump Station has sufficient capacity to provide all of the supply to the 590 zone in Shoreline and to the wholesale customers. Supply from SPU's Foy or Bitter Lake Pump Station would be needed if North City Pump Station was offline, or if additional supply was otherwise needed in south Shoreline. In most cases, water pumped at Foy or Bitter Lake Pump Station would only need to be used if an equivalent amount of water was unavailable from North City Pump station. SPU's pump stations would typically not need to be operated simultaneously with North City Pump Station to supply Shoreline or SPU's wholesale customers. Provision of an emergency intertie to the 590 zone would be acceptable in place of a wholesale service in the context of provision of adequate supply, however this would have implications on required storage quantities as discussed later in this report in the Capital Improvements section.

Shoreline would need to establish emergency intertie agreements with adjacent water utilities.

Proposed Capital Improvements and Budget

In addition to costs associated with physically separating the Shoreline system from the SPU system, other capital improvements will be necessary prior to operation of the Shoreline water system as an independent water utility. These include water storage facility improvements, pump station improvements, control systems, utility office and shop space, acquisition of heavy equipment and vehicles, tools and inventory. Distribution system improvements, other than those directly related to system separation, would not need to be in place at the time the independent utility begins operation, but rather would be made on an ongoing basis.

System Reliability Standards

A key driver of capital improvement costs is the standard of service which the utility establishes for its system. In the *2009 Water System Design Manual,* the Washington Department of Health (DOH) recommends the following standards, intended to promote high levels of water system reliability:

Source

Two or more supply sources are available with a capability to replenish depleted fire suppression storage within 72-hours while concurrently supplying the maximum daily demand (MDD) for the water system.

1. Combined source capacity for the water system is enough to provide the MDD in a period of 18 hours or less of pumping.

2. With the largest source out of service, the remaining source(s) can provide a minimum of the average day demand (ADD) for the water system.

3. Pump stations have power connections to two independent primary public power sources, or have portable or in-place auxiliary power available.

4. The firm yield of surface water sources is consistent with the lowest flow or longest period of extended low precipitation on record.

Booster Pump Stations

1. Multiple pumps are installed with capacity to provide the MDD of the service area when the largest pump is out of service.

2. At least 20 psi at the intake of the pumps under peak hourly demand (PHD) or fire flow plus MDD rate-of-flow conditions is always maintained.

3. An automatic shutoff is in place for when the intake pressure drops below 10 psi.

4. Power connections are available to two independent primary public power sources, or there is a provision for in-place auxiliary power if the pumps provide fire flow or are pumping from ground level storage.

Distribution Storage

1. More than one gravity storage tank (wherever feasible) exists with the ability to isolate each tank while continuing to provide service.

2. Storage is sufficient to give standby capacity of at least two times the ADD for all users, and to ensure that fire suppression service will be available while not allowing pressure to drop below 20 psi at any service connection.

3. A minimum standby volume of 200 gallons per day per residential connection, or equivalent, is provided regardless of the capacity of the sources available.

4. An alarm system is included that notifies the operator(s) of overflows, or when the storage level drops below the point where the equalizing storage volume is depleted. This should only occur during abnormal operating conditions.

Distribution System

1. Distribution mains are looped wherever feasible.

2. Pipeline velocities do not exceed eight feet per second under PHD conditions.

3. All pipelines can be flushed at a flow velocity of at least 2.5 feet per second.

4. All mains and distribution lines have appropriate internal and external corrosion protection.

5. If fire flow is provided, the engineer should conduct a hydraulic analysis to determine whether high fire fighting demands may cause very low pressure (below 30 psi) in the distribution system. Very low water system pressure presents an increased risk of contamination from cross-connections and pathogen intrusion at joints.

DOH recognizes that different communities and utilities may want to operate at different standards of reliability, and notes that doing so is acceptable as long as public health is not put at risk and as long as the standards are consistent with WAC 246-290. DOH requires that all points in the system maintain a minimum of 30 psi at peak hourly demand with all equalizing storage depleted, and a minimum of 20 psi during fire flows at maximum daily demand with all standby and fire suppression storage depleted, in accordance with WAC 246-290.

SPU has established its own design standards, which are included as an appendix to SPU's *2007 Water System Plan.* As a complex system, SPU calculates storage requirements based on

hydraulic modeling scenarios rather than on the methodology in the DOH *2009 Water System Design Manual.* New construction in the SPU system is done in accordance with the DOH minimum pressure requirements, but some older areas were built when the minimum pressure requirement was 20 psi, and some of these areas are unable to meet the current 30 psi requirement.

If the City of Shoreline acquires the water system within its boundaries, it is recommended that the DOH guidelines be used as system reliability standards. Any new construction, such as new storage, will need to be designed in accordance with the current edition of the DOH *Water System Design Manual.*

Storage Capital Improvement Recommendations

Water storage at a utility is provided in accordance with Washington Department of Health requirements which break storage capacity into five components. The top portion of storage is defined as operational storage, and consists of the range that the storage fluctuates as pumps are turned on and off. Next is equalizing storage, which is the amount that gets drawn down when demand exceeds pump capacity at peak demands, and which refills in time for the next day's peak demands. Both of these storage components must be available at a minimum of 30 psi to all customers. Next is standby storage, which is needed in order to continue to provide a reliable supply with pump outages or other disruptions that may occur, and which must provide a minimum of 20 psi. The next lower volume of storage is fire suppression storage, which also must be at a sufficient elevation to maintain 20 psi for all customers during fire fighting. Any remaining volume is considered dead storage. In general, standby storage and fire suppression storage can be 'nested' in determining overall storage requirements, in which case the larger of the two components is considered to suffice for both components.

In development of a comprehensive water system plan, Shoreline and its planning engineer will have some flexibility in determining how much storage is appropriate. Shoreline will have sufficient supply capacity such that equalizing storage will not be necessary, although it may be desired in order to reduce peak flows. There is also some flexibility in determining standby storage quantities, based on community expectations of reliability and on DOH guidance. Standby storage is intended to provide system reliability under abnormal conditions such as the loss of a source. While DOH provides recommendations for standby storage quantities, they do not specify a required amount of standby storage for a particular system. DOH expects to see standby storage provided in sufficient quantity to meet the community's expectations of reliability, and in accordance with DOH guidance unless an alternate approach can be successfully proposed and supported by the community.

DOH provides guidance on appropriate levels of standby storage. For a system with a single source, DOH recommends having enough standby storage to last two days at average day demand. For a system with multiple sources, DOH recommends having a volume equivalent to two days of average day demand, reduced by the amount of available source capacity with the largest source out of service. As a minimum regardless of availability of other sources, DOH

recommends having at least 200 gallons of standby storage per Equivalent Residential Unit (ERU).

As an independent water utility, the 590 zone portion of Shoreline may have two sources including a wholesale connection feeding North City Pump Station on 185th Street, and a wholesale connection on 145th Street at Aurora (under Alternate B3). While these are both fed by the SPU transmission system, SPU can draw their supply from the Tolt system or from the Cedar system, and supply to the connection on Aurora can be pumped at Foy Pump Station from either the 550 Pipeline or from the 430 zone Maple Leaf Reservoir. Supply to the Aurora connection can also be pumped from storage at Bitter Lake Reservoir, which in turn can be supplied from the Cedar source. There is enough difference between these two sources that they can be considered to be independent sources. Either source by itself would be sufficiently large to fully provide average day demand to Shoreline with the other source out of service, and the large diameter mains in Aurora, 185th St., and to the north of Richmond Highlands are sufficiently large for either source by itself to maintain sufficient pressures throughout the system. Applying the DOH guidance for systems with multiple sources to the 590 Shoreline system, if the largest source is out of service, the other source can still meet average day demand on its own. In that case, the DOH minimum standby storage recommendation of 200 gallons per ERU would apply. The 590 zone in Shoreline has 16,400 ERU's, for a DOH minimum recommended standby storage quantity of 3,280,000 gallons.

If Shoreline were to use the North City Pump Station as its only wholesale connection, with the connection at Aurora Avenue as an emergency intertie, standby quantities should be calculated on the basis of a single source system. While an emergency intertie can provide a replacement supply if needed, emergency interties are typically not automatically activated and may not be immediately available so cannot be considered equivalent to a wholesale connection. In addition, DOH only considers emergency interties as a source if the intertie agreement specifies that the emergency intertie can be used for provision of storage. Applying the DOH guidance for systems with a single source to the 590 Shoreline system, standby storage should be equivalent to twice the average day demand. Average day demand is dependent on the years used to calculate demand, but if average day demand is considered to be 1850 gpm (see Figure 4), the resulting amount of standby storage would be 5,330,000 gallons, or about 325 gallons per ERU.

As presently operated, Foy Standpipe and Richmond Highlands Tank 1 are in service, with Richmond Highlands Tank 2 out of service for recoating and repainting. Upon completion of the Tank 2 work in May 2012, SPU's intent is to take Tank 1 out of service and only perform minimum aesthetic maintenance on Tank 1 as required.

The Richmond Highlands Tanks are presently operated with a 10 to 15 foot operating range. A 10 foot range is larger than would typically be used for pumped storage, but in this case the large range is necessary in order to avoid excessively cycling the North City and Foy Pump Station pumps. If at least some of the pumps supplying the zone were equipped with variable speed drives, a much narrower range, such as 3.5 feet, could be used for operational storage. If

both the existing Richmond Highland tanks were operated with a 3.5 foot operating range, they would provide approximately 2,630,000 gallons of standby storage and 367,000 gallons of operating storage. In order to meet the standby quantities needed for a system with two sources, Shoreline would need to have 3,280,000 gallons of standby storage. To provide this quantity, a new 2.0 million gallon elevated tank could be constructed at Richmond Highlands, replacing the existing Tank 1. This improvement would provide 3,546,000 gallons of standby and fire suppression storage and 454,000 gallons of operating storage. Table 8a lists the capacity and cost of additional storage needed for Shoreline if operated with two available sources, with standby storage per the DOH minimum recommended amount of 200 gallons per ERU.

Table 8a
New Storage for 590 Zone, Multiple Sources Scenario

Facility	Cost
2.0 Mg Elevated Tank	$4,072,000

Should Shoreline use North City Pump Station as its only wholesale connection, a larger volume of standby storage would be required. Rather than construct the full quantity of standby storage as elevated storage, a preferable approach would be to construct a new ground level standpipe at the Richmond Highlands site. The tank would be constructed with the same spill elevation as the existing tanks, with a diameter of 79 feet, and with a capacity of 3,700,000 gallons. A pump station with backup power would be located adjacent to the new tank. The pump station would be designed to pump Shoreline's maximum daily demand, or about 3,300 gpm, from the new tank to Richmond Highlands Tank 2. In this manner, all of the volume of the new tank, with the exception of the top 3.5 feet of operational storage, would be available as standby storage. The new tank would provide 3,570,000 gallons of standby storage and Tank 2 would provide 1,773,000 gallons, for a total of 5,343,000 gallons of standby storage and 356,500 gallons of operating storage. Tank 1 would be decommissioned. This approach would exceed the recommended standby storage amount for a system with a single source. Table 8b lists the facility costs of the additional tank and standby pump station needed for Shoreline if operating with a single source. The standby pump station is included as a storage cost since it is an integral component necessary to provide standby storage under this approach.

It is not known at this time if the connections to the 590 zone on 145th St. will be wholesale service connections or emergency interties, which will determine if Shoreline's storage capacity will need to be based on multiple sources or on a single source. For purposes of this evaluation, the costs as shown in Table 8b will be used for determining overall capital costs.

Table 8b New Storage & Standby Pump Station for 590 Zone, Single Source Scenario	
Facility	**Cost**
3.7 Mg Standpipe	$3,251,600
Standby Pump Station	$1,604,500
Total	$4,856,100

Estimated costs include 25% contingency, 5% surveying & permitting, 12% engineering, 8% construction inspection, and 10% sales tax. Additional costs are calculated as a percentage of construction cost.

The 430 zone in southeast Shoreline presently has no storage facilities and relies entirely on SPU transmission system storage. The southeast area contains 480 ERU's. The needed amount of standby storage would be about 150,000 gallons, or two days worth of storage at average day demand. The area also needs access to fire suppression storage, which would be 1,020,000 gallons based on the structures with the highest fire flow requirements in the zone, at 4250 gpm for 4 hours. However, the recommended approach is to first consider the continued reliance on SPU storage on an 'as available' basis, as is done with some other small wholesale systems supplied by SPU. Supply would be supported by a secondary connection, possibly to Shoreline Water District, also on an 'as available' basis. Construction of a storage facility for this small area should only be considered once other options have been fully explored.

Pump Station & Control System Capital Improvement Recommendations

North City Pump Station

It is recommended that both pumps at this station be equipped with variable frequency drives to allow use of a smaller operating range at the Richmond Highlands tanks. It is also recommended that by the time of system acquisition that this station be equipped with a standby generator sized to operate one pump. The generator installation should include an automatic transfer switch to automatically start the generator and transfer the station to backup power should line power fail. Provision of standby power would reduce reliance on local storage and would allow the Shoreline system to have a higher reliability of remaining at normal operating pressure in the case of extended power outages.

Foy Pump Station

The recommended separation alternative leaves Foy Pump Station with SPU. Total project costs of modifying Foy Pump Station are estimated by SPU at $500,000 and are included in Table 7. Modifications are necessary to enable Foy Pump Station to satisfactorily serve the SPU 590 zone while also retaining the ability to support the Shoreline 590 zone if needed.

Modifications include replacing two pumps with smaller pumps and upgrading electrical equipment

Dayton Pump Station

It is recommended that the hydropneumatic system used at this station be replaced with a variable frequency drive closed loop pumping system. Such a system allows pumps to run more efficiently and to avoid cycling off and on. The station should also be equipped with a standby generator sufficient to operate the largest pump in the station. This installation should also include an automatic transfer switch for the generator. Without backup power, in the event of a power failure at Dayton Pump Station, the hydraulic gradient in the Dayton 660 zone drops to slightly less than that in the adjacent 590 zone, or about 20 to 25 psi at the highest locations in the Dayton 660 zone. In the event of a widespread loss of power that also affects the North City and Foy Pump Stations, pressure in the 590 zone is initially supported by storage at Richmond Highlands Tanks and Foy Standpipe (as presently operated). Under both current and proposed practices, backup power would be used to support the 590 zone prior to storage being excessively drawn down. Should backup power fail or otherwise not be available, the 590 zone would be supported by gravity flow from the Tolt 550 Pipeline. In this situation, the hydraulic gradient in the Dayton 660 zone would be less than elevation 550 and the highest locations in the zone would be only minimally pressurized at about 5 psi or less. Addition of backup power at the Dayton Pump Station would enable sufficient pressure and fire flow to be maintained under all foreseeable conditions.

Dayton Pump Station presently has only one primary pump. In order to provide redundancy and additional capacity to meet fire flows, a twin pump is recommended. The station piping was constructed to allow for installation of the second pump without the need for extensive piping modifications. Hydraulic modeling of the distribution system may indicate that the Dayton 660 zone could be enlarged to include adjacent areas that have marginal pressure. Addition of the second pump would enable the zone to be expanded if needed.

Supervisory Control and Data Acquisition (SCADA) System Upgrades

Shoreline will need to establish its own Scada system in order to operate the water utility independently of SPU. To do so, Shoreline will need to have its own control center, which would consist of a central programmable logic controller (PLC), data logger, modems and other equipment including a desktop terminal which would be located in the Water Operations manager's office. The new system would be designed to be much more automated than the existing SPU system, such that the primary operational requirement of staff will be to respond to alarms as needed. The new system should be designed to include an autodialer to direct alarms to an assigned duty person. The pump stations should be equipped with distributed control systems so they can function automatically at times the control center is offline or otherwise unavailable. The pump station systems will require station PLCs that are programmed to respond to reservoir levels and alarm conditions without direction from the control center.

Shoreline's Scada system will connect its central control station to North City Pump Station and Dayton Pump Station, to wholesale meter connections from the SPU system, to the 590 zone wholesale connections to Olympic View Water & Sewer District and Shoreline Water District, and to the Richmond Highlands tanks. The system will also need to be connected to SPU's Scada system to obtain status information on Foy Pump Station.

Cost of the upgraded Scada system is dependent on the required complexity of design, software licensing costs, features desired by Shoreline and by the state of the art at the time the system is designed and constructed. For preliminary estimating purposes, cost of the Scada system is estimated at $400,000.

Table 9 includes costs for pump station and control system upgrades. Pump station costs include 25% contingency, 5% surveying & permitting, 12% engineering, 8% construction inspection, and 10% sales tax. Additional costs are calculated as a percentage of construction cost.

Table 9
Pump Station & Control System Capital Improvements

Project	Estimated Cost
North City PS Standby Power	$339,200
North City PS Variable Frequency Drives	$192,000
Dayton PS Pump & Drive Upgrades	$64,000
Dayton PS Standby Power	$188,800
Scada System	$400,000
Total	$1,184,000

Distribution System Capital Improvement Recommendations

The following distribution system improvements would not need to be completed prior to operation of the Shoreline water system as an independent utility, but instead could be made as part of a long term main replacement program.

Two reports have been written describing improvements needed to provide adequate fire flows and to meet service standards in the SPU service area in Shoreline. The June 2000 SPU report, *590 Richmond Highlands Pressure Zone Hydraulic Analysis Report,* evaluated upgrades for fire flow deficiencies. This report identified the need for 1,263 feet of 6" main and 28, 824 feet of 8" main, including hydrants.

A review of the existing SPU mains in Shoreline was conducted by RH2 Engineers in the November 2004 report, *Seattle Public Utilities within the Cities of Shoreline and Lake Forest Park, Water System Valuation Report,* prepared for the Shoreline Water District (SWD). This report evaluated the distribution mains against SWD's standards, which are substantially equivalent to the DOH system reliability standards. The review identified mains, in addition to

those identified in the June 2000 SPU report, in need of upgrade to bring the system into compliance with the SWD standards. The proposed mains within the City of Shoreline consisted of 15,435 feet of 4", 4,990 feet of 6", 71800 feet of 8", 12,260 feet of 12" and 4,345 feet of 16" main. It is important to note that the standards for new construction are more stringent than the standards that would have been in place at the time these mains were constructed. There is no DOH standard requiring main replacements. However, evaluating existing mains against current standards provides a reasonable means to help identify and prioritize mains for an ongoing main replacement program. More specific prioritization of main replacements will require that the hydraulic model for the Shoreline system be accurately calibrated as noted earlier.

The lists of deficient mains in the 2000 and 2004 reports have been reviewed by the Shoreline Fire Department (SFD) to ensure that all known areas of deficiency are addressed. SFD noted four areas in particular where problems had been identified. These include the 660 Dayton pressure zone, the western portion of the 430 pressure zone in southeast Shoreline, the Echo Lake vicinity near 199th St and Aurora, and the Innes Arden area. With the exception of the Echo Lake area, these locations have been identified in the 2000 and 2004 reports as needing improvements. Recommended main replacements and upgrades in these areas are shown on Figures 4 and 6 of the 2004 RH2 Engineers report. The Echo Lake area includes approximately 1400 feet of 4" cast iron main, including about 900 feet which would need to be upgraded to support development along Aurora Avenue. As main replacement projects are prioritized, areas of deficiency should be further evaluated by hydraulic modeling and flow tests.

The main replacements identified in these two reports are included on Table 10, plus an additional 900 feet of 8" main to upgrade the 4" main on Aurora as identified as deficient by SFD. Total length of the main replacements equals approximately 139,800 feet, which constitutes 23% of the system's 615,000 feet. Replacement of these mains would bring the water system into compliance with current DOH reliability standards and would provide distribution system capacity and hydrants to provide sufficient fire flows.

Unit costs in Table 10 are based on 2011 unit construction costs from Tacoma Water, which has an active main replacement program in place, using ductile iron pipe. Unit costs shown in Table 10 include construction cost plus 5% survey & permitting, 12% engineering design, 8% inspection, 10% sales tax and 10% contingency. Additional costs are calculated as a percentage of construction cost. Contingency cost for distribution main construction is less than the contingency used in this report for other construction types due to the lower level of complexity in main construction.

Table 10 Distribution Main Replacements						
Diameter	**4**	**6**	**8**	**12**	**16**	**Total**
Length, ft	15435	6250	101522	12261	4345	139813
Unit cost	185	217	230	289	419	
Total Cost	$2,855,560	$1,355,931	$23,321,989	$3,548,223	$1,820,205	$32,901,909

As with any utility with aging infrastructure, Shoreline can expect to eventually need to replace its entire distribution system as it reaches the end of its service life. Shoreline has an advantage over older utilities in that only 5% of the Shoreline system is currently more than 70 years old. A system that is constructed of good materials and that is well maintained can expect service life of 100 years from its distribution mains. Viewed purely from the perspective of infrastructure age, Shoreline would not need to begin replacing most of its mains until about 25 to 30 years from now. This gives Shoreline a window of opportunity to establish a main replacement program to address the deficiencies in Table 10 during the next 25 to 30 years and then to shift the main replacement program's focus to ongoing replacement of infrastructure due to age. Replacing the mains in Table 10 over a 23 year period would equate to replacing an average of 1% of the system annually, ultimately resulting in replacing the entire system on a 100 year cycle. As a main replacement program is developed and individual projects are prioritized, some mains identified above may be found to have lower replacement priority than others, such as mains in need of replacement due to new development. In any case, an assumption of replacement of approximately 1% of the system per year, on average, provides for a reasonably conservative ongoing replacement rate.

Water Utility Buildings, Tools & Equipment Capital Improvement Recommendations

A new water utility will require shops, office space and yard space to store materials. It will also require heavy equipment, service vehicles and tools for the field crews. Some functions, such as office space and a customer service counter, may be incorporated into existing space at City Hall or combined with similar functions at the wastewater utility which is anticipated to be established prior to establishment of the water utility. Similarly, the water utility's shop and yard space may be combined with the wastewater utility or with other City field operations facilities.

Table 11 shows the estimated required square footage and cost for office and shop space sufficient to support the level of staffing discussed earlier in this report. Office space is assumed to be available in City Hall, and is estimated at 50% of the cost of new construction. Shop space is assumed to be located at the same site as other city utility shops. Estimated costs include construction, outfitting and furnishing the office and shop space but do not include land or site development cost. The City is presently pursuing options to obtain a suitable site for consolidated utility shops through an intergovernmental land trade.

Table 11 Water Utility Space Requirements		
Building	**Area, sq ft**	**Cost**
Office	2625	$329,440
Shops	5290	$714,150
Total	7915	$1,043,590

Crews will require heavy equipment, service vehicles and tools. Table 12 lists estimated quantities and costs of heavy equipment and vehicles. Service van costs include outfitting with work benches, cabinets, generator sets and work lighting. Costs reflect retail internet pricing plus 10% tax. The equipment in Table 12 is intended to meet the routine needs of the utility. Large equipment such as track hoes or mobile cranes are not included and would typically be rented for jobs where such equipment is needed. In case of emergencies requiring large equipment, mutual aid agreements with other utilities may also provide access to larger or specialized equipment.

Table 12 Heavy Equipment & Vehicle Cost			
Equipment	**Quantity**	**Unit Cost**	**Total**
Backhoe	2	$96,800	$193,600
Backhoe trailer	2	$5,500	$11,000
Shoring Box	2	$11,000	$22,000
Shoring box trailer	2	$4,400	$8,800
Dump truck	2	$77,000	$154,000
Boom truck	1	$154,000	$154,000
Service van	3	$66,000	$198,000
Pickup	5	$38,500	$192,500
Total			$933,900

Table 13 lists the initial cost of tools and materials to outfit the utility shops and the field crews. Inventory cost represents a minimum needed to deal with day to day operations and assumes that supplies can be readily replenished by local suppliers. Costs in this table were developed by itemizing typical tools and materials and their estimated costs, plus 10% tax.

Table 13 Initial Tools & Inventory Cost	
Category	**Estimated Cost**
Shop Tools	$46,970
Field Tools	$127,160
Inventory	$101,750
Total	$275,880

Capital Improvements Summary

Table 14 summarizes the capital improvements that need to be completed in order for the Shoreline system to operate as an independent water utility, including a 3.7 million gallon standpipe and standby pump station as shown on Table 8b, pump station & control improvements listed in Table 9, building space listed in Table 11, heavy equipment and vehicles in Table 12, and tools & inventory shown in Table 13. Table 14 does not include the separation costs shown in Table 7 nor the distribution main improvements shown in Table 10. Separation costs as shown in Table 7 are additive to those in Table 14. Distribution main replacement costs in Table 10 are shown as an annual capital expense in Table 15.

Costs related to starting up the new water utility's operations (Tables 11, 12 & 13) may be incurred at the time of acquisition or may be phased, depending on operating arrangements Shoreline may make with SPU or other utilities.

The largest capital improvement expense facing Shoreline is the cost of bringing the distribution system up to current standards. This cost should be addressed as an annual expense for an ongoing main replacement program. Assuming the main replacement program is planned to replace 1% of the system on average per year, the total cost to replace the mains as shown on Table 10 would be incurred over 23 years, at an annual cost of $1,430,518. This cost is shown in Table 15 as an annual expense.

Table 14 Required Capital Improvements Prior to Independent System Operation	
Category	**Estimated Cost**
3.7 MG Standpipe & Standby Pump Station	$4,856,100
Pump Stations & Controls	$1,184,000
Utility Buildings	$1,043,590
Heavy Equipment & Vehicles	$933,900
Tools & Inventory	$275,880
Total	$8,293,470

Annual Capital Improvement Costs

In addition to the capital improvements in Table 14, Shoreline's water utility will also have annual capital expenses. Table 15 summarizes estimated annual capital costs, with vehicle replacement and tool replacement costs estimated at 10% of the initial costs from Tables 12 and 13. Costs for distribution main extensions and relocations, and service replacements are as shown in Table 3, based on SPU's capital costs. The annual main replacement program is included as discussed above. Meter replacement cost has been increased beyond SPU's cost to reflect meter replacement based on age rather than on replacement due to failure. The remaining costs in Table 15 are approximations based on system size.

Table 15
Annual Capital Improvements

Category	Estimated Cost
Vehicle Replacements	$93,390
Tool Replacements	$17,413
Distribution main extensions	$71,000
Distribution main relocations	$213,000
Main replacement program	$1,430,518
Service replacements	$710,000
Meter replacements	$72,000
Hydrant Replacements	$50,000
Valve Replacements	$50,000
Water Quality Improvements	$10,000
Cathodic Protection Improvements	$10,000
Pump & Storage Improvements	$50,000
Scada & communications Improvements	$20,000
Total	$2,797,321

Additional Water Utility Functions

In addition to the core functions supported by a water utility's field operation and maintenance staff, customer service support, and by billing and administrative staff, certain other functions must be addressed. Some may be covered by existing City staff, by contracting, or possibly by addition of utility staff.

Grounds Maintenance

Reservoir and pump station sites, shops and offices grounds, and non-street right-of-way areas will need to be maintained to a level comparable to neighborhood standards. This typically includes mowing, landscaping maintenance, and removal of litter and illegal dumping.

Property Management

Adjacent property owners may have complaints about the utility's property, or may wish to obtain easements, permits, or other property rights on utility property, in particular any undeveloped or right-of-way properties outside of City streets. Cellular phone providers may inquire about installation of antennas on the utility's storage tanks, and any resulting contracts will need to be administered.

Water Quality Testing

Routine bacteriological and chlorine residual sampling is required, as are a number of organic and inorganic samples as required by the EPA. In addition, sampling will be required in order to put newly constructed projects in service or in cases where the system has been subject to contamination. While the utility's water operations manager and water quality technician can track required samples and field staff can take samples under the technician's guidance, the samples will need to be processed by a certified laboratory. SPU has a water quality laboratory that is used by other utilities in the region, and other private laboratories are also available.

Scada Maintenance and Modifications

Expert support is needed when Scada components fail or when system changes require programming changes and revision of Scada screens. This level of expertise is often provided through contract support from the vendor that originally designed and started up the system.

Electrical Maintenance and Modifications

Some basic electrical work can be performed by the utility's trained field operations and maintenance staff, but more involved work requires a licensed electrician, typically on an as-needed contract.

Cathodic Protection Systems Maintenance and Modifications

Cathodic protection systems are in place on the large diameter steel mains in Shoreline, and are recommended in existing and proposed steel storage tanks. A cathodic protection engineer should verify that all large diameter steel mains in Shoreline are bonded and under adequate levels of protection against external corrosion. After the cathodic protection systems are known to be operating as needed, periodic inspection of the systems is required to ensure continued satisfactory operation. This function is typically contracted out to a cathodic protection engineer.

Meter Reading

The proposed level of staffing provides for meter reading by field operations and maintenance staff. Shoreline may consider contracting this function out to an adjacent utility that has an established meter reading function.

Permits and Inspections

New services will require permits and inspections, which may be a function to be addressed by the City's existing building inspection staff. Other permits will be required such as for the use of hydrants by contractors or other special purposes. Construction inspection of new mains and other capital projects can be provided by existing City inspection staff if available, or can be contracted out to inspection and testing services providers.

Extraordinary Maintenance

Some maintenance functions occur infrequently or are highly specialized, and are typically contracted out, such as cleaning or painting large structures such as storage tanks.

Locating

One-call locating service is often contracted out.

Main Tapping

While smaller service taps such as routine residential connections may be installed by utility staff, larger connections are often made by specialty tapping services.

Large Meter Maintenance

Small residential meters are more economical to replace rather than repair, but larger sized meters are typically tested, repaired and returned to service. This function is commonly carried out by larger water utilities, but Shoreline may find it more cost effective to contract this function out to a utility that has an existing meter testing and repair facility.

Professional Services

Engineering and financial services are typically contracted for tasks such as preparation of comprehensive water system plans, rate setting, long range planning, or for evaluation of complex operational changes.

Further Engineering Review & Evaluation

Shoreline may need additional engineering expertise to provide ongoing assistance in discussions with SPU regarding separation issues, and to provide hydraulic modeling expertise in addition to that provided by SPU. Engineering support will also be required for evaluating and modeling the operation of the system as outlined below.

Separation Issues

The separation alternatives as presented by SPU are not yet at a detailed level. As discussions continue with SPU, specific components of the separation plans may need to be reviewed and modeled.

Hydraulic modeling of the overall operation of the proposed Shoreline system will be an important aspect as the separation process develops. Evaluation of the conditions under which emergency or wholesale connections operate will be carried out using the hydraulic model. The hydraulic model will also be used to evaluate fire flow availability at specific locations within the service area.

SPU's proposed separation alternatives include new or renovated storage facilities for SPU as a Shoreline expense. Engineering assistance may be needed as replacement or renovation proposals are considered.

Additional Review of Distribution Grid Deficiencies

The Shoreline Fire Department has extensive experience in working with the distribution system in Shoreline. Areas identified by the Fire Department should be hydraulically modeled and reviewed to verify that low flows are a result of undersized mains rather than closed line valves, improperly set pressure regulating valves, or other operational problems. Any additional areas not already identified as having undersized mains should be added to the list of known distribution main deficiencies to be considered for replacement in the main replacement program.

The pumped Dayton 660 zone is adjacent to some points in the 590 zone that may have low pressure. Hydraulic modeling of expansion of the 660 zone would be required to determine the extent and feasibility of expanding the zone to encompass potential low pressure areas. This report includes the proposed addition of a second large pump at the Dayton Pump Station. Evaluation of any expansion of the 660 pressure zone would be carried out prior to installation of the new pump. If needed, the size of the proposed pump could be increased to accommodate expansion of the 660 zone.

The hydraulic model for the Shoreline system can be expected to be in need of further calibration, as discussed earlier in the report. Models are typically calibrated by flowing hydrants and by comparing modeled results with actual pressures and flows. A well-calibrated

model is essential for efficient operation of a water system, including prediction of available fire flows and prioritizing individual main replacement projects.

Storage Issues

With only Richmond Highlands Tank 2 in service, Shoreline's 590 zone would have insufficient storage capacity to meet the Department of Health minimum storage recommendations. This engineering review provides an estimate of the additional storage Shoreline would need to construct to meet the recommended reliability standards, but additional engineering evaluation should also be conducted to optimize the capacity of a new storage facility with regard to payment of wholesale rate storage demand charges to SPU. Shoreline has the option of having less than the minimum recommended amount of standby storage capacity if the ratepayers are willing to accept the reduced level of reliability. Consideration of source availability, reliability standards, and demand charges will all play a role in ultimately deciding on what amount of storage is desired for Shoreline.