SEATTLE PUBLIC UTILITIES
2007 WATER SYSTEM PLAN

IV. DISTRIBUTION

APPENDIX A
DISTRIBUTION SYSTEM ASSETS INVENTORY

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Distribution System Reservoirs					
Reservoir	**Total Capacity (MG)**	**Year Constructed**	**Overflow Elev. (feet)[1]**	**Under-Drain**	**Construction Type**
Covered Reservoirs					
Bitter Lake	21.3	1956/57	509	Yes	Reinforced concrete slab. Hypolon liner and floating cover added in 2001.
Lincoln	12	2004	326	Yes	Reinforced concrete reservoir. Below grade.
Magnolia	5.5	1993/94	330	Yes	Reinforced concrete tank. Part below grade.
View Ridge	2.5	1977/78	276	Yes	Reinforced concrete tank. Below grade.
Beacon[2,3]	50	1911	326	Yes	To be constructed as below-grade reinforced concrete reservoir.
Myrtle[3]	5	1946/47	498	Yes	To be constructed as below-grade reinforced concrete reservoir.
Open Reservoirs					
Roosevelt	50.3	1910	326	Yes	Unreinforced concrete slab. HDPE liner.
Volunteer	20.5	1901	430	No	Unreinforced concrete slab.

Source: Albarracin and Stumpf, July 1999, and Mantchev and Capron, 2006

1. All elevations based on North American Vertical Datum (NAVD).
2. Beacon South has been empty since March 1976; information not shown.
3. Scheduled for demolition and replacement beginning April 2006; data shown for replacements.

Prepared April 2006

Distribution System Pump Stations

Pump Station	Pump #	Manufacturer	Model	Design Flow (gpm)	Head (feet)	Speed (rpm)	Horse-Power	Comments
Bitter Lake	1	Gould	3405	4,000	162	1,775	200	
	2	Gould	3405	4,000	162	1,775	365	Diesel standby use only
	3	Gould	3405	4,000	162	1,775	200	
Broadway	1	Fairbanks Morse	2844C	4,700	245	1,781	400	
	2	Fairbanks Morse	2844A	2,800	237	1,784	250	
	3	Fairbanks Morse	K65226	4,000		1,150	300	
Dayton Ave.	1	De Laval	56064	1,400	110	1,750	50	
	2	MP		100	100	3,450	5	
First Hill[1]	3	Fairbanks Morse	2824C	2,800	180	1,775	200	Computer link with Broadway
	4	Fairbanks Morse	2824C	4,900	190	1,775	350	Pump Station pumps 1 and 2
Green Lake	1	De Laval	98851	900	331	1,750	93	Water Turbine Powered
Interbay	1	Worthington	10 LN 18	3,500	110	1,185	125	Low service
	2	Worthington	8 LA 4	3,500	230	1,785	300	High service
Lincoln	1	Worthington		3,900	117	1,540	125	Water turbine powered
Northgate	1	Allis Chalmers	205-603-502	5,500	182	1,760	300	
	2	Allis Chalmers	205-603-501	5,500	182	1,760	300	
Roosevelt	1	Allis Chalmers	201-052-501	3,000	110	1,760	100	
	2	Allis Chalmers	201-052-501	3,000	110	1,760	100	
Scenic Heights	1	Aurora	411 BF	450	95	1,750	20	
	2	Aurora	411 BF	450	95	1,750	20	
	3	Aurora	411 BF	1,100	100	1,750	40	
	4	Aurora	411 BF	1,100	100	1,750	40	
SW Spokane	1	Allis Chalmers	207-52-510	4,000	290	1,760	400	New starters and transfer switch in
	2	Allis Chalmers	207-52-510	4,000	290	1,760	400	1997; can be powered by diesel gen.
Viewridge	1	Layne		2,500		1,750	100	To 316 zone
	2	Layne		3,500		1,750	350	To 520 zone
Volunteer	1	Allis Chalmers	201-194-502	4,000	108	1,760	125	
	2	Allis Chalmers	201-194-501	4,000	108	1,760	125	
Warren Ave.	1	Allis Chalmers	207-521-510	4,000	265	1,770	350	Can be powered by diesel generator.
	2	Allis Chalmers	207-521-509	4,000	265	1,770	350	
West Seattle	1	Ingersol Rand	10 AFV	4,500	62.3	1,750	100	
	2	Ingersol Rand	11 AFV	4,500	62.3	1,750	100	

Footnote:

(1) First Hill pump station has two pumps, they are labeled 3 and 4. The pumps work in conjunction with pumps 1 and 2 and the Broadway pump station.

Notes:

gpm = gallons per minute

rpm = revolutions per minute

Vert. = vertical

Prepared April 2006

Distribution System Standpipes and Elevated Tanks													
Facilities	Capacity (MG)	Year Const.	Base Elev.[1] (feet)	Overflow Elev. (feet)	Diameter (feet)	Tank Height on Riser (feet)	Tank Material	Date of Last Inspection	Interior Coating		Exterior Coating		Seismic Upgrade (or Date Scheduled)
									Type[a]	Date Applied	Type[b]	Date Applied	
Standpipe													
Barton	1.40	1927	277	326	80	-	Riveted Steel	Jan 98	CTE	1960	Lead base	1981	To be determined
Charlestown	1.26	1996	424	498	58	-	Welded Steel	Feb 99	epoxy	1996	epoxy/urethane	1996	Not needed
Queen Anne[6]	2.00	2007	460	530	75	-	Welded Steel	N/A	epoxy	2007	To be determined	2007	N/A
North Trenton	1.19	1932	296	330	92	-	Riveted Steel	Jan 98	Vinyl	1979	Lead base[2]	1990	Not needed
South Trenton	1.19	1932	296	330	92	-	Riveted Steel	Oct 98	Vinyl	1979	Lead base[2]	1990	Not needed
Volunteer Park	0.88	1907	460	530	50	-	Masonry/Riveted Steel	Apr 99	Vinyl	1981	Lead base	1981	To be determined
Woodland Park	1.00	1925	356	430	50	-	Riveted Steel	Oct 98	Vinyl	1984	Lead base	1980	To be determined
Elevated Tanks													
Magnolia Bluff	1.00	1947	369	480	86	25	Welded Steel	Mar 99	epoxy	1988	Zn/Alkyd[3,4]	1988	1993
Maple Leaf	1.00	1949	431	530	84.25	25	Welded and Riveted	Jan 98	epoxy	1988/95	Lead base[5]	1988	2002

Source: Jacobsen, June 1999, and Mantchev 2006.

All elevations based on NAVD 88.

a CTE = Coal Tar Enamel; p-urethane = Monolithic polyurethane lining

b epoxy = NSF epoxy primer and intermediate coats; anc Zn/Alkyd = Zinc yellow primer and silicone alkyd enamel top coat

1. Top of concrete base.
2. Trenton tanks were power tool cleaned and overcoated with an urethane/epoxy/urethane paint system in 1990.
3. Magnolia Bluff was commercially blasted and coated with a non-lead alkyd system. Some lead remains on the tank.
4. 1993 seismic upgrade added all new steel to legs and riser, and coated legs and riser with a non-lead alkyd enamel paint system. The bowls still have the lead based primer as noted.
5. Maple Leaf has some remaining red lead primer then coated with moisture cured urethane primer and top coats.
6. Queen Anne Tanks #1 and #2 scheduled for replacement with single tank in 2007.

Prepared April 2006

Meters by Classification														
	Meter Size													
Classification	**3/4**	**1**	**1-1/2**	**2**	**3**	**4**	**6**	**8**	**10**	**12**	**16**	**20**	**24**	**Total**
Residential	139,204	15935	1,140	434	1	5	0	2	0	0	0	0	0	156,721
Commercial	6,958	5201	3,413	4387	357	1797	1214	641	25	1	0	0	0	23,994
Key Accounts	461	359	285	654	129	255	284	208	45	15	0	2	0	2,697
Total	146,623	21,495	4,838	5,475	487	2,057	1,498	851	70	16	0	2	0	183,412

Source: Water Meter Count by Billing Size (Run Date 2/21/06); Lanning

Prepared Feburary 2006

SEATTLE PUBLIC UTILITIES
2007 WATER SYSTEM PLAN

IV. DISTRIBUTION

APPENDIX B
SYSTEM DESIGN STANDARDS

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This appendix to the *2007 Water System Plan* summarizes standards used by Seattle Public Utilities (SPU) for design or analysis of the water system serving retail customers. These standards are generally the same as those included in the *2001 Water System Plan Update*. The only significant changes are those related to the System Pressure.

1. Average Day, Maximum Day, and Peak Hour Demands

The average day demand values used in the SPU hydraulic network models are based on actual billing records from 2005. To simulate peak hourly demand (PHD) and maximum day demand (MDD) conditions, the 2005 ADD models were set up and calibrated to simulate actual records from the year 1998 peak demand day, July 27, 1998. The 1998 peak day had a total system consumption of 264 million gallons (MG). The PHD peaking factors are taken from the maximum demand hour from the simulation, and the MDD peaking factors are taken from the overall average for that day.

2. Storage Requirements

Hydraulic modeling of various scenarios proved to be an effective way to evaluate storage needs in the complex Seattle system. Scenarios representing peak week conditions, as well as a range of emergency conditions, provided the basis for the analysis. The suite of modeling scenarios provides a benchmark for storage needs of the water system. The attached July 14, 2004 paper "Seattle's Reservoir Replacement Program" provides more detail on this analysis of storage needs.

3. Fire Flow Rate and Duration

Both the City of Seattle and King County have adopted the International Fire Code (IFC), and the fire flow rates and duration specified in the IFC are used in the analysis of distribution hydraulics and storage requirements.

4. Minimum and Maximum System Pressure

Minimum pressure criteria for new water mains are 30 pounds per square inch (psi) under peak hour demand conditions, and 20 psi when flows are a combination of average maximum day demand and required fire flow. In no case shall pressure at the customers meter be less than 20 psi. Pressures within distribution mains are not limited to a set maximum. All new services with static pressure above 80 psi require a pressure-reducing valve (PRV) per plumbing code requirements.

5. Hydraulic Modeling Process for Direct Service Area

Since the *2001 Water System Plan Update*, SPU has completed a reconnaissance-level analysis of the Direct Service pressure zones using EPANET-based models as the main tool for the analysis. The work produced a calibrated, working hydraulic network model of each pressure zone; identification of areas not meeting planning-level pressure and fire flow requirements; and identification of possible system improvements and related costs. The results of the hydraulic analysis were used to develop policies on low and high pressures in the Direct Service Area.

The hydraulic models are periodically updated to reflect system changes, and their calibration is improved as more field data is gained from fire flow tests and other opportunities. The models are used to determine fire flow availability and developer-required improvements, as well as for other special analyses of the distribution system.

6. Distribution Water Mains and Appurtenances

SPU design standards for water mains and related distribution system appurtenances are described in the attached memorandum. These standards include minimum pipe sizes, valve and hydrant spacing requirements, and other applicable standards.

7. Telemetry Systems

SPU has replaced its analog tone telemetry SCADA system with a PC-based frame relay system and is in the process of expanding the number of monitoring locations. After the first phase of SCADA expansion is completed, the standard information collected by type of facility will include the following:

- Source treatment plants: Clearwell level, inflow, outflow, chlorine residual, pH, turbidity, fluoride
- Reservoirs: Level, inflow, outflow, control valve position
- Reservoir hypochlorite treatment plants: Chlorine residual concentration, hypochlorite feed rates
- Tanks and standpipes: Level
- Pump stations: Flow, suction pressure, discharge pressure, pump status
- Control valves: Flow, upstream pressure, downstream pressure, valve position
- Transmission pipelines: Pressure
- Pressure zones (more than 500 service connections): Pressure

8. Standby Power

SPU's water system largely serves its customers by gravity flow. Therefore, the need for standby power is limited to the source treatment plants, open reservoir outlet treatment plants, the control center, and some pump stations that raise water to the higher elevations in the system that cannot be served by gravity flow. These situations are diverse enough that a single set of standards does not apply. SPU's approach is best illustrated by specific examples.

New chlorination facilities at the outlets of open reservoirs are equipped with emergency generators to support full treatment capacity during power outages. The Tolt Treatment Facility has emergency generator capacity to operate critical components of the facility, allowing it to meet the quantity and quality performance standards of the design-build-operate (DBO) service agreement. The Cedar Treatment Facility has emergency generator capacity to produce average day demands in accordance with the performance criteria of the DBO service agreement. The Cedar Treatment Facility also provides standby power for the Lake Youngs Pump Station, which serves Cedar River and Soos Creek Water Districts.

Higher elevations in the distribution system can typically receive water from one of several pump stations, some of which are equipped with hydraulically-powered pumps unaffected by power outages. Combined with the reliability of the electric grid within city limits, the probability of losing all pumps serving a particular pressure zone is relatively low. Where this assumption cannot be made, an emergency generator connection or a diesel-driven pump is provided.

A service reliability analysis was done in preparation for the Y2K turnover. A new diesel drive pump was added at Bitter Lake Reservoir. Otherwise, the analysis found SPU has portable emergency generator capability to supply vulnerable areas in response to a regional power failure.

Seattle's Reservoir Replacement Program

The System Storage and Reliability Analysis and its Application

July 14, 2004 AMC Session

Introduction

This paper describes the development and evolution of the plan for covering open reservoirs from its beginning in the mid-1990's. It describes the drivers and summarizes the analysis that helped shape the plan, and is organized into three parts:

Development of the Reservoir Burying Plan and Current Status of the Reservoir Burying Program

Determining Storage Requirements – the System Storage and Reliability Analysis (SSRA) as an objective benchmark of Water System Reliability

Issues for Further Analysis

Appendix 1 – Additional Detail on the Reservoir Burying Program

Appendix 2 - Non-storage Recommendations from the SSRA Analysis

Objectives and Desired Outcomes

1. Brief the AMC on the Reservoir Burying Plan recently adopted by City Council;

2. Brief the AMC on the analysis and rationale that the plan is based on, in particular, the proposed reductions in reservoir volumes;

3. Lay the ground for PDPs of projects spawned by the SSRA, in particular, the Maple Leaf Gate House Improvements;

4. Concur with the need to develop and present to the AMC within six months a clear and concrete plan to begin "trying it out" without Roosevelt and Volunteer Reservoirs;

5. Confirm that no individual PDPs will be prepared for each reservoir replacement project. Possible (partial) exceptions may include:

    - In case significant disagreements arise internally over significant project elements, those may be brought to the AMC for resolution

    - In case project costs increase more than 10 percent

Development of the Reservoir Burying Plan and Current Status of the Reservoir Burying Program

The plan for covering the open reservoirs has evolved since it was first formulated in the mid-1990's in response to a new Department of Health rule. The initial plan was to cover most of the reservoirs with relatively inexpensive floating covers, which would retain most of the existing storage volume. Primarily because of increased concerns about security, the current thinking is to replace most of the storage with new underground concrete reservoirs. To control costs, some of the new underground reservoirs will be significantly smaller than the open reservoirs they replace, and some open reservoirs may be de-commissioned without a covered replacement.

1996 Plan to Cover Open Reservoirs

In 1994, the Washington Department of Health adopted a rule requiring water systems with open distribution reservoirs to develop before January, 1996 an acceptable plan and schedule for covering or replacing these facilities. This rulemaking was significant for Seattle because its then nine open reservoirs, totaling 369 million gallons, represented about 90 percent of the storage in its distribution system.

In December 1995, with the endorsement of the Mayor and City Council, SPU submitted a preliminary plan and schedule to DOH. It called for the covering or replacement of the nine open reservoirs in a phased approach over 25 years, with the details to be developed in the ongoing updates of the Capital Improvement Program and Water System Plan.

The plan identified factors that would require further investigation and likely cause the covering plan to evolve during its implementation. These included:

- Update of storage needs of the distribution system.
- Community involvement and expectations.
- Schedule and budget of other capital projects.
- Condition of existing reservoirs.
- Schedule for conversion to hypochlorite disinfection.
- Maintaining system reliability during construction

In developing a preliminary sequence for covering the reservoirs, the 1996 covering plan used eight criteria, including:

- Need for reservoir rehabilitation.
- Need for eliminating chlorine gas disinfection.
- Turnover time of reservoir contents
- Chlorine contact time downstream of reservoir.
- Whether water came from Tolt source.
- Proximity to urban villages.
- Availability of open space nearby.
- Amount of bird-related contamination.

Based on these criteria, the preliminary sequence for covering the open reservoirs was:

By 2003: Bitter Lake, Lake Forest, and Lincoln
2003 to 2010: Beacon, Maple Leaf, and Volunteer
2010 to 2020: Roosevelt (formerly Green Lake), Myrtle, and West Seattle.

The plan described three covering technologies, (1) floating covers, (2) lightweight rigid covers, and (3) new underground concrete reservoirs. The plan estimated the cost of applying each of the cover types to the existing volume at each open reservoir, but did not propose a cover type for each site.

April 2001 Water System Plan

As anticipated in the 1996 covering plan, the April 2001 update of the Water System Plan (WSP) further refined the covering plan. The list of evaluation criteria was modified to include security and the urban village and open space criteria were combined into a single land use criterion:

- General condition
- Security
- Chlorination
- Water turnover
- Chlorine contact time
- Source of supply
- Land use
- Contamination from birds.

The WSP also modified slightly the covering sequence:

- By 2003: Bitter Lake, Lake Forest, and Lincoln
- 2003 to 2010: Volunteer, Beacon, and Myrtle
- 2010 to 2020: Roosevelt (Green Lake), Maple Leaf, and West Seattle.

The WSP also expressed a long-term goal to replace all of these reservoirs with new underground structures. In the near-term, only Lincoln and Volunteer would have such replacements. Because of financial conditions, the remainder would be covered with floating covers.

Post 9/11

Council Resolution 30422, adopted in November 2001, directed SPU to accelerate its reservoir covering program using a combination of floating covers and undergrounding two reservoirs, completing the program by 2005. In May 2002, the Mayor proposed an alternative Council resolution to underground all six of the City's remaining open reservoirs and thereby create 76 acres of open space. The Mayor proposed to finance the $245M (nominal dollars) program from water rates and complete it by 2011. In place of adopting the Mayor's proposal, in August 2002 Council adopted Ordinance 120899 authorizing SPU to proceed with undergrounding the Volunteer Park and Beacon reservoirs and directing the Executive to study and submit to Council a range of funding options for covering the four remaining open reservoirs (Myrtle, West Seattle, Maple Leaf, and Roosevelt). The Ordinance required SPU to consider an option that would limit the amount to be paid through water rates to the cost of installing floating covers, with any additional amounts necessary to construct underground replacement reservoirs provided through alternative funding sources. Other conditions of the ordinance are listed in Appendix 1.

Since 2003, the Adopted Water CIP has budgeted funds to underground the City's remaining six open reservoirs. The 2004 Adopted Budget included a proviso that prohibited spending any 2004 Water Fund appropriation on burying five of these remaining six reservoirs – Maple Leaf, West Seattle, Beacon South, Myrtle, or Roosevelt – until authorized by ordinance.

On April 19, 2004 the Council passed an Ordinance (Council Bill Number 114861) removing the restriction on the 2004 Budget, revising the schedule for individual burying projects, and amending SPU's 2004 - 2009 Capital Improvement Program to reflect the new schedule. Table 1 shows this revised schedule. The Council took this action after reviewing additional information provided by SPU, as summarized below.

Impact of Asset Management on the Reservoir Program

In 1997, SPU completed a detailed and sophisticated study (described in detail further on in this paper) which found that significant volume reductions could be possible and economical if reservoirs were buried. The decision at the time to put floating covers on the reservoirs made the issue of volume reductions moot as it was cheaper to cover the existing large reservoirs with floating covers than to bury them at the smallest possible size identified by the study. In addition, downsizing the existing reservoirs while installing floating covers would not result in savings due to the costs to reconfigure the structural berms to create the smaller containment.

The current policy direction away from floating covers in favor of new buried reservoirs, and SPU's adoption of Asset Management as a business model, warrant a reconsideration of reservoir sizes.

SPU continues to explore downsizing opportunities as identified by the 1997 study. Based on additional modeling completed recently (see below), the **preferred option** now calls for significant reductions at several reservoirs (Beacon, West Seattle, and Volunteer), and for the decommissioning of Roosevelt Reservoir. This makes the whole program more affordable while still meeting pre-defined performance criteria under various emergencies.

Additionally, SPU plans to further explore the possibility of retiring Volunteer Reservoir.

A decision to retire a major facility has far reaching implications, and could not be easily reversed. It could only be made after a thorough and deliberate analysis, and to the extent possible, confirmed by real-time operational experience over several years. SPU will perform further analytical work (see below) to assess how the water system would perform in a wide range of normal, unusual, and emergency conditions without these reservoirs. Subsequently, SPU would actually operate the water system without the reservoir(s) for several years before a final decision is made. Nonetheless, SPU has a high degree of confidence that at least one of the two reservoirs would be decommissioned.

Consistent with asset management principles, SPU has examined the life-cycle costs of the floating covers over the existing reservoirs versus new buried reservoirs. In general, floating covers have lower initial installation costs and higher maintenance and security costs. Floating covers also have a shorter useful life and must be replaced several times over the span of the life-cycle analysis. Despite their higher maintenance costs, the life cycle cost of a floating cover is lower than the option of burying a reservoir. On the other hand, buried reservoirs provide acres of open space, a higher level of security, and little if any visual intrusion into the neighboring community. Looking at both benefits and costs suggests that the preferred option is to bury the remaining reservoirs.

Revising the Sequence of Reservoirs to be Buried

The original Executive proposal from May 2002 called for the buried reservoirs to be constructed in pairs, starting with Beacon and Volunteer, followed by Roosevelt and Myrtle, and West Seattle and Maple Leaf at the end. A commitment to explore retirement opportunities for Volunteer and Roosevelt reservoirs triggers a need to move them to the end of the program in order to provide sufficient time for verification and operational testing. This in turn triggers a need to revise the overall sequencing of the individual projects so as to maintain the pace of the program.

New buried reservoirs at Volunteer and Myrtle would be the same size, and have the similar cost estimates. Myrtle is also the last remaining reservoir whose disinfection facility still uses gas chlorine, a public safety issue. Myrtle was therefore moved up into the first pair of reservoirs to take the place vacated by Volunteer. This works well operationally, and maintains near term revenue requirements unchanged.

If Beacon and Myrtle are the first pair, and Volunteer and Roosevelt are the last, it leaves Maple Leaf and West Seattle reservoirs as the middle pair to be constructed.

While construction at Maple Leaf and West Seattle reservoirs is not proposed to begin until 2007, SPU believes significant design efficiencies and savings could be captured if a portion of the design of all four reservoirs that are certain to be buried is done concurrently. Given that, SPU proposes to take the first four reservoirs - Beacon, Myrtle, Maple Leaf and West Seattle - concurrently through predesign and up to about 60 percent design by mid-2005. (Roosevelt and Volunteer would not be included in this effort.) This approach would also maintain the option to do alternative contracting for any combination of the four reservoirs.

The Reservoir Projects and Park Development Issues

While a new buried reservoir has already been addressed by community and parks master planning for the **Beacon Reservoirs** property, at all other sites it is a new opportunity that has not been through any community involvement and open space planning process. At each site, a new buried reservoir prevents the unattractive industrial look of a floating cover, and creates open space. How this newly created open space is planned, developed, and paid for is a question the City and the communities face.

The larger reservoir sites - **Maple Leaf, West Seattle, and Roosevelt** - can support any combination of active and passive recreational use. In fact, they are large enough to accommodate multiple play fields as well as some passive use.

The much smaller **Myrtle** Reservoir property is not big enough for a ball field, and could only be developed into a neighborhood mini park, and some funding is available ($860k from the 2000 Parks Levy) for park development.

Ordinance 120899 limits the above ground improvements that may be funded from water rates to grass and low maintenance landscaping. Funding from other sources for recreational facilities over the buried reservoirs has not been secured yet, and may not be available for some time into the future. While ideally reservoir burying and parks development would occur as one seamless project, lack of assured funding for the parks at this time, and a need to move ahead with the reservoir burying projects may necessitate that reservoir construction and parks development occur several years apart. The fact that parks uses at some sites have not yet been defined further supports separating the two projects.

Ordinance 120899 actually requires that each underground reservoir shall be designed to accommodate "a reasonable range" of future active recreational and passive park uses on the cover. To assure that the new reservoirs are designed so as not to preclude future beneficial parks uses, SPU and Department of Parks and Recreation (DPR) have agreed to the following approach:

1. Park related work for Beacon and Myrtle Reservoirs is funded from the 2000 Pro-parks Bond Levy. DPR will work with SPU to assure the new reservoirs fit in with park improvements to be funded by the bond levy, and fund its effort from the bond levy;

2. SPU will pay Parks (on an hourly basis) for design review of the Maple Leaf and West Seattle reservoir designs to ensure that SPU's plans can support a reasonable range of active and passive uses on these sites in the future. It is anticipated this may be as much as 1/2 an FTE of work in the next year and a half.

3. To the extent that community engagement is required for the reservoir burying projects, and to determine appropriate "interim uses" on these sites, SPU will lead that process and will offer two choices (fence around perimeter or open and passive). Any screening or buffers will be done in consultation with Parks to preserve future design alternatives;

4. SPU may share in the planning and design of parks over the buried reservoirs at these sites in the future, to the extent that is necessary to protect SPU's interests in long term operation of these reservoirs.

These principles would be reflected in a brief MOU between SPU and DPR.

Determining Storage Requirements

The System Storage and Reliability Analysis (SSRA) and setting an objective benchmark of Water System Reliability

This part summarizes the analysis of storage needs that has supported the plan for covering reservoirs. It begins with a discussion of how the criteria and context for sizing storage facilities have changed since the early 1900's when the majority of the open reservoirs were constructed. It then describes the innovative approach of using a hydraulic model of the water system and emergency scenarios to analyze future storage requirements.

Historic Perspective

The majority of the open reservoirs (Beacon North and South, Roosevelt, Lincoln, Maple Leaf, and Volunteer) were designed and constructed about a century ago under much different conditions. Reservoir size was then and still is primarily driven by the need to provide adequate flows for fire fighting and to ensure water supply during source or transmission emergencies. Fire and emergency storage needs, as well as the cost of constructing distribution storage, have changed significantly for the Seattle system during the last 100 years.

Fire flows. Construction of the water system began in the late 1800's in direct response to the Great Seattle Fire. Providing fire storage to prevent a repeat of this disaster had to have been a primary factor in sizing storage at that time. Today, modern building and fire codes (e.g., fire sprinklers in buildings) make such a fire highly unlikely. Accordingly, even the highest fire flow required by today's standards (8000 gallons per minute for 4 hours) can be provided from about 2 million gallons of storage.

Source emergencies. The most likely source emergency for the early water system would have been the need to shut down the Cedar source due to excess turbidity at the intake. Although strict EPA limits on turbidity did not then exist, the active logging of the watershed at that time would have produced turbidity levels of sufficient aesthetic concern to warrant closure of the intake. Before Lake Youngs was placed in service in 1928, the system would have depended entirely on the in-city storage during these events. Later addition of the Tolt source, the Highline wellfield, and the Tolt treatment plant provided additional source reliability. Although the 10 MGD capacity of the wellfield may not seem significant, during a week-long emergency it would be the functional equivalent of a 70 million gallon reservoir.

Transmission emergencies. The early water system was fed through wood-stave transmission lines along a single corridor from the Cedar. Today, the system is fed through steel and concrete pipes in two different corridors located at opposite ends of the system.

Economics. Given the above reasons for providing abundant storage in the early water system, the cost of constructing the storage was not a serious limitation. Land was cheap, and construction basically consisted of digging a hole and lining it with concrete panels. Modern requirements for covered reservoirs and seismic design result in much greater unit storage costs.

Overview of System Storage and Reliability Analysis (SSRA)

The 1996 covering plan identified the need for an updated evaluation of the storage needs of the distribution system. As discussed above, the open reservoirs were designed as much as a century ago, under much different conditions, and their present size is unlikely to match the current and future needs of the water system. Because covered storage is expensive, it was prudent to support the covering program with an up-to-date evaluation of the storage needs of the distribution system.

In late 1995, SPU began an evaluation of the storage needs with the assistance of a consultant. The System Storage and Reliability Analysis (SSRA) approached the analysis in an innovative way. It used a PC-based hydraulic model of the water system to determine how it would perform with various amounts of storage under a range of normal and emergency conditions and demand levels projected for the year 2020 by the 1993 Water Supply Plan, or an average day demand (ADD) of 199 MGD for the entire system. Because of recent conservation efforts, this level of demand is now projected for beyond 2080 using the 2004 official long-range demand forecast.

The use of modeling has several advantages over traditional methods for evaluating storage and reliability, especially in larger water systems. The traditional approach has been to size storage as some function of average or peak day demand for the system, with allowance for reducing storage if multiple sources of supply exist. This works well for small water systems with relatively simple configurations, but is less effective with large systems with many pressure zones. Large systems typically have many pressure zones linked in complex ways, and some of the larger pressure zones may be served by multiple storage facilities.

The traditional method is not helpful in determining how to best distribute multiple facilities within a single pressure zone, nor in evaluating how individual pressure zones reinforce each other, much in the way interties between individual water systems improve reliability. However, unlike individual water systems with a single intertie, pressure zones within a large system are linked in multiple ways, usually through a complex mix of pump stations, gravity feeds, pressure reducing valves, and check valves. In the Seattle system, an additional complexity is that some reservoirs function as part of both the regional transmission system and the distribution system of the direct service area. By effectively incorporating all of these features, a model-based evaluation provides the greater analytical capability needed to address these complexities.

Analyzing performance with a model is simple in concept. After the model is constructed and calibrated, it is used to evaluate how the system would perform with various storage configurations (locations and volumes) during a representative set of emergency scenarios. A storage configuration is considered acceptable if, during all emergency scenarios, system pressures are maintained and some water is maintained in all storage facilities. Various acceptable storage configurations may be compared by examining the amount of water left in storage at the end of each scenario and how well it is distributed in the system.

SSRA Emergency Scenarios

A panel of SPU staff, the Reservoir Advisory Panel (RAP), developed the emergency scenarios. The RAP included representatives of all portions of the utility concerned with storage, including: engineering, water quality, community relations, planning, finance, water supply, maintenance, and operations. The scenarios recommended by the RAP for hydraulic modeling were:

- S1 – Tolt Supply Line failure with Maple Leaf Pump Station out of service.

- S2 – Cedar Control Works failure.
- S3 – Cedar River Pipelines (CRPL's) 1, 2, and 3 failure below Wye.
- S4 – 550 Pipeline failure with CRPL 4 out of service.
- S5 – 550 Pipeline failure with Maple Leaf Pipeline out of service.
- S6 – 550 Pipeline failure with Maple Leaf Pipeline and Volunteer Reservoir out of service.
- S7 – CRPL 4 failure with West Seattle Pipeline out of service.
- S8 – Spokane Street Pump Station failure with West Seattle Low Service Pump Station out of service.
- S9 – Cedar Supply shutdown for water quality event.

▪ Peak Week "2020" (currently 2050 or beyond)

In general, the emergency scenarios were based on an assumption that a major system component would fail unexpectedly while another major system component is unavailable due to major maintenance or repair.

The emergency scenarios actually used in the hydraulic modeling differed somewhat from the recommended list. Through preliminary analysis, the modelers determined that Scenarios 4 and 8 were not severe enough to stress storage, that Scenarios 5 and 6 were similar enough to be combined, and that Scenario 3 had two sub-scenarios that required separate analysis. The final list for hydraulic modeling was:

- S1 - Tolt Supply Line failure with Maple Leaf Pump Station out of service.
- S2 - Cedar Control Works failure.
- S3a - Cedar River Pipelines 1, 2, and 3 between the Wye and Interstate 405 while the Maple Leaf Pipeline is out of service for rehabilitation.
- S3b - Cedar River Pipelines 1, 2, and 3 downstream from Interstate 405 while the Maple Leaf Pipeline is out of Service for rehabilitation.
- S5&6 - 550 Pipeline near 195th Street while the Maple Leaf Pipeline and Volunteer Reservoir are out of service.
- S7 - Cedar River Pipeline No. 4 with the West Seattle Pipeline out of service.
- S9 - Cedar supply shutdown due to a water quality problem
- Peak Week 2020

<u>Duration of the Emergencies – Restoration Times</u>

The RAP defined the emergencies as having a duration of seven (7) days, with the exception of S9, which assumed a duration of three (3) days. It is reasonably conservative to assume that within such period of time at least one of the unavailable system components would be at least partially brought back in service. For example, the repairs to the Tolt Pipeline No. 1 when it failed unexpectedly in 1987 took only three days to complete; however, no other system component failed/was unavailable during that time. Another example would be the 2003 Tolt Treatment Facility Failure, during which Scenario S1 was virtually realized but only for a period of about four (4) hours when electrical failure took Maple Leaf Pump Station out of service; it was, however, quickly repaired.

Customer Demands to be met during the Emergencies

Demands to be met during the emergencies were assumed to be unrestricted indoor water use at 0.8 times Average Daily Demand (ADD), or 160 MGD (0.8 times 199 MGD) for the entire system. This is equivalent to winter usage levels, which could be achieved by banning outdoor water use. Based on the 2004 official long-range demand forecast, this level of demand is not expected until at least 2080.

It is important to note that normal winter demands of Seattle's wholesale customers were included in the demand to be met during the emergency. This is a conservative assumption since each water purveyor is expected (if not required) to have at least 1-2 average days of emergency storage in its distribution system. Furthermore, use of local sources of supply by those customers that have them could be maximized to reduce demand on the regional system. Finally, Seattle wholesale customers adjacent to water utilities not served by Seattle could activate emergency interties and thereby reduce demand on the Seattle system.

Analytics

EPANET software, a modeling tool available at no cost from the Environmental Protection Agency and in wide use by utilities and consultants, was used to create the hydraulic models. It has been adopted as a de facto standard by SPU for hydraulic modeling.

The analysis synthesized alternative storage configurations by varying storage size in increments of 10 million gallons at each open reservoir site. This approach resulted in over 21,000 different configurations, which were too many to evaluate with hydraulic modeling. To resolve this problem, the consultant developed a spreadsheet-based model to pre-screen the configurations. It screened out unsuitable configurations by identifying those that were short on storage and thus had no possibility of meeting the emergencies when the additional constraints of pipes and pump stations would be taken into account with hydraulic modeling.

It was found that the storage configurations passing the screening process were in a group that could be described by a few equations or rules. These included:

- Maple Leaf + Roosevelt > 35 million gallons (MG)
- Beacon > 48 MG
- Beacon + Myrtle + West Seattle > 85 MG
- Bitter Lake + Maple Leaf + Roosevelt > 85 MG
- West Seattle + Myrtle > 25 MG

- Lincoln + Volunteer + Maple Leaf + Beacon > 120 MG

Strict application of these rules results in a storage reduction from 369 mg to 238 MG, or 35 percent of the original volumes.

Selection of a specific storage configuration for hydraulic modeling was further influenced by the findings of a parallel study. This study looked at the state-of-the-art in the technology of reservoir covering. In particular, it found that floating covers had improved to where SPU could consider them as a viable method for covering.

As a result, the configuration selected for modeling assumed most of the open reservoirs would be covered with floating covers at their present volumes. The exceptions were a reduction from 20 to 10 million gallons at both Lincoln and Volunteer, and a reduction from 60 to 49 million gallons at Beacon. At Lincoln and Volunteer, limited setback distance would make floating covers subject to vandalism. At Beacon, a value of 49 million gallons was used to be conservative, since this is the volume of the smaller reservoir at the site, and a decision had not been made on which of the two reservoirs will be covered for future use. Table 2 summarizes the storage assumed in the model. Table 3 shows the minimum reservoir level reached during the hydraulic modeling as a percent of the reservoir capacity.

The rules derived from the pre-screening spreadsheet model and the minimum reservoir levels reached during hydraulic modeling suggest that the actual amount of storage needed by the system is less than the reservoir volumes assumed in the hydraulic modeling. However, for budgetary reasons the SSRA did not attempt to identify this absolute minimum through additional hydraulic modeling.

Current Status

Because of the heightened concern for security since September 2001, the current plan is to bury or decommission all open reservoirs, except for Bitter Lake and Lake Forest Park, which have new floating covers. To help compensate for the greater cost of buried structures, reduced storage volumes are planned at some of the sites. Table 2 compares the new assumptions with current storage volumes and the capacities assumed in the SSRA hydraulic modeling. The new sizes specified in column 3 satisfy the sizing rules generated from the spreadsheet model. However, the adequacy of these volumes needed to be confirmed by additional analysis with the SSRA hydraulic model.

Table 2
Summary of Storage Volumes for Reservoir Covering

Reservoir	Open Reservoir (MG)	SSRA Value (MG)	New Concept (MG)
Bitter Lake	22	22	22
Lake Forest Park	60	60	60
Lincoln	20	10	12
Volunteer	20	10	0
Beacon	61	49	50
Myrtle	7	7	5
Roosevelt	50	50	0
Maple Leaf	60	60	60
West Seattle	68	68	30
Total	369	336	239

Updated SSRA Modeling

Because analysis with the hydraulic model is time consuming, it was felt important to begin with the scenario or scenarios most likely to be constraining with the reduced reservoir volumes. The results of these scenarios would then be used to help determine if modeling of the remaining scenarios should occur.

Table 4 shows the data used to identify the priority scenarios. For each of the spreadsheet-based rules, it shows the total amount of drawdown that occurred during the original SSRA work in the reservoirs referenced in the rule. The shaded cells are the cases where the total drawdown exceeded the quantity that the rule suggested was adequate. This does not necessarily indicate a fatal flaw, since the model could possibly be run in a way that would reduce the draw on the particular reservoirs and increase the draw on other reservoirs with greater reserve.

Table 4 indicates that Scenarios 2, 7, and 9 could be constraining, and Scenarios 2 and 7 were selected for hydraulic modeling. Scenario 9 was not selected because it is quite similar to Scenario 2, as verified by the almost identical reservoir drawdowns shown in Table 4 for the two scenarios.

The hydraulic modeling results have the greatest disparity in the case of the rule specifying Myrtle + West Seattle > 25 million gallons. The three scenarios mentioned above result in total drawdowns over twice this amount. Intuitively, these two reservoirs seem the most likely facilities to show a discrepancy in results between the spreadsheet-based rules and hydraulic modeling. The spreadsheet model assumes that water can be readily transferred between portions of the system, while the hydraulic model incorporates the constraints posed by the actual pipes and pumps linking the system. The West Seattle portion of the water system is relatively isolated from the remainder of the system, especially under certain scenarios.

Subsequent hydraulic modeling of Scenarios 2 and 7 verified that the reduced amounts of storage were adequate. Table 5 summarizes the results of the modeling. The minimal levels of storage remaining after Scenario 2 shows that the reduced storage configuration currently being planned may be close to the minimum amount required by the system.

Hydraulic modeling also identified new facilities, such as valves, that would be important in operating the system with this reduced storage. These are summarized in Appendix 2.

Issues for Further Analysis

De-commissioning certain reservoirs and reducing the size of others will result in a modified system with different operational considerations. Construction of new reservoirs will also provide opportunities for improvements in the valving, piping, and controls at the sites. The planning and design of the reservoir burying program needs to address these factors and adapt as necessary. Various discussions have identified the following issues as possibly requiring further analysis:

Issues Specific to some Reservoirs

1. When would be the optimum time to remove Roosevelt and Volunteer from continuous operation? This decision must consider the security needs at those sites and other changes taking place in the system (i.e., the new Cedar Treatment Facility and the temporary elimination of storage at other sites for construction of the replacement reservoir). Working out the details of the schedule would require a meeting of staff knowledgeable in the various factors that need to be considered. These factors would include the timing of other system changes and the security needs at these sites.

2. Does Volunteer Reservoir act as an important distribution system vent (pressure relief) for the portion of the 430 Pressure Zone located south of the Ship Canal? If so, how will this function be accomplished if the reservoir is de-commissioned? This function could be met by using either the old Cedar River Pipeline No.2 or the Maple Leaf Pipeline to provide a low head loss connection between the Volunteer 430 zone and Maple Leaf Reservoir.

3. The outlet piping at Beacon Reservoir appears to make it possible to construct the new reservoir with a bottom elevation 5 feet lower than the bottom of the existing reservoir at the site. Would this be cost effective? This is being considered since it would reduce the "footprint" of the new reservoir and the associated excavation costs.

4. Will de-commissioning of Roosevelt make it more difficult to maintain adequate chlorine residuals in the Ballard area? EPANET modeling could address this question. Modeling could investigate the alternative of feeding Ballard from Bitter Lake Reservoir through the 430 Pressure Zone. Three factors to consider: (1) The Ballard re-lining pilot project may make this a moot point by demonstrating that re-lining can mitigate the chlorine residual problem. (2) Feeding the Ballard 326 zone from Bitter Lake would require significant modifications to the distribution system. (3) The potential for a chlorine residual problem can be checked when Roosevelt is out of service, and alternative solutions evaluated if necessary. One alternative would be to maintain the Roosevelt hypo-chlorination plant and use it to re-chlorinate water from Maple Leaf when it reaches the Roosevelt site.

5. In the past, the open reservoirs have been a convenient place to route the large volumes of water resulting from flushing and disinfection of transmission lines. Will loss of Roosevelt and Volunteer Reservoirs require alternative means of accomplishing this in some situations? How expensive would the alternatives be? The existing drain lines can be maintained at the two sites, and a de-chlorination chamber can be added to the drain lines as part of the de-commissioning of the reservoirs.

General Reservoir Issues

1. What criteria will be used to decide if a new reservoir should be single-cell or double-cell? The criteria will be to maintain redundancy of storage within a pressure zone. If the new storage configuration will result in a pressure zone having only one large reservoir, then that reservoir will be double-celled. (For single celled reservoirs, a partial “dual cell” functionality will be provided for seismic events by placing outlets at two levels, with the lower outlet equipped with a seismic shut-off valve.)

2. Will the new storage configuration be compatible with new 180 MGD flow limit from the Cedar Treatment Facility? SSRA modeling indicates that the reduced storage will be satisfactory during the emergency scenarios with a 180 MGD Cedar supply. Although the original SSRA modeling assumed a 275 MGD capacity for the Cedar, the demands were such that maximum draw on the Cedar was 180 MGD. If there is a constraint, it may be during the peak week scenario. The SSRA peak week model should be re-run with the reduced storage configuration both under current demands and 180 mgd Cedar capacity, and “ultimate” demands and 275 mgd Cedar capacity.

3. What impact would the reduced storage have in the event of a sudden loss of the Cedar supply - which would typically require a rapid increase in the output of the Tolt source? While the Tolt is brought up to full capacity, water would be drawn from in-town storage that could have otherwise come from the Tolt. For example, if the Tolt were furnishing a typical 60 MGD, every hour delay in bringing the Tolt to its full 120 MGD capacity would draw an extra 2.5 MG from in-town storage that would have otherwise come from the Tolt. The reduced storage volumes will add urgency to bringing the Tolt up to capacity. Hydraulic modeling could assist development of SOP’s for a rapid transition to full Tolt production. Periodic drills with the SOP’s on the actual system could then help maintain operator proficiency.

Appendix 1

Additional Detail on the Reservoir Burying Program

Conditions of Ordinance 120899

Other conditions set forth in the ordinance include:

- The replacement reservoirs shall be designed and constructed so that the chlorine facilities and other essential access best serve the reliability and safety of the water supply system, as determined by SPU.
- Each underground reservoir shall be designed to accommodate "a reasonable range" of future active recreational and passive park uses on the cover.
- The open space created is not subject to the restrictions of Initiative 42 applicable to other parklands.
- SPU and the Water fund are responsible for an earth covering over the reservoir lid and grass or low maintenance plantings to allow for passive public use. SPU can contract with DPR for lawn mowing.
- DPR and its fund sources are responsible for master planning, designing, constructing and maintaining any additional landscaping or recreational amenities including an irrigation system or a water feature.
- Development of active recreational uses cannot be funded by water rates.
- SPU is required to commission a study and consider using design-build contracting as a cost-saving approach for reservoir replacement projects. The study should recommend a schedule for completing the reservoir projects by 2020.
- In January 2006, SPU is required to provide a report to Council, which details the cost and project experience to date on the reservoirs.

Updates to Cost Estimates and Schedules since August 2002

In early 2003, SPU advertised the Lincoln Reservoir project for construction. Bids received were well under the engineer's estimate, which provided current and reliable information to re-assess the estimated costs of other reservoir burying projects.

Given the cost information from Lincoln Reservoir, and the higher degree of certainty with regards to scope and public process based on Ordinance 120899, SPU revised its estimates for the reservoir program in August 2003. The program was then estimated to cost **$173 million** (nominal dollars), which was a reduction of **$72 million** from the $245 million May 2002 estimate. The currently adopted Water CIP is based on the August 2003 update, and budgets funds to bury all reservoirs (including Roosevelt), and construct a 50 MG reservoir at West Seattle.

As discussed above, SPU has since then completed an evaluation of the feasibility to further reduce the size of West Seattle Reservoir (25 MG instead of 50 MG), and to decommission Roosevelt Reservoir.

This lowers the total program cost from $173 million to $151 million (nominal $). The reduction in nominal dollars is somewhat less than the reduction in 2003 constant dollars since the duration of the program has been extended by one year to reflect the impact of unanticipated program deliberations.

Cost and schedule details for the preferred option by reservoir and by year can be found in Table 1. On this schedule, the estimated cost in nominal dollars to bury the remaining five open reservoirs where work has yet to begin is $120 million. The remaining $31 million have already been spent or committed to for the floating covers at Bitter Lake and Lake Forest reservoirs, and for the burying of Lincoln Reservoir.

Alternative Contracting for the Reservoirs

SPU initiated a consultant-led study to identify any cost saving opportunities, as well as other possible benefits from alternative contracting and/or packaging of the reservoir projects. The study culminated with a day-long expert panel discussion with representatives from utilities that have used alternative contracting on similar projects, several contractors, engineering firms, and academia. An effort was made to invite representatives with experience and interests in alternative contracting as well as traditional contracting. The conclusions of the study are summarized below:

- With regards to **cost savings, due to the conventional nature of the facilities to be built**, alternative contracting is not likely to come even close to the 15 percent savings threshold specified in Ordinance 120899. Savings are more likely to be in the 3-6 percent range, which is within the margin of error of the assessment . The study therefore concluded that a decision to proceed with a design-build approach can not be based primarily on cost.

- With regards to **quality** of the constructed reservoirs, design-build has a slight edge given that only larger and more experienced contractors are likely to compete under such a contracting approach. The owner-contractor relationship in a design-build is also more cooperative. High quality under design-built can only be assured if the owner is relatively prescriptive with regards to major project elements, design criteria, and equipment specifications. This amounts to taking the project to at least 60 percent design before soliciting proposals.

- With regards to **owner control** of the project and process, traditional contracting is better. Clear definition of the "project" in terms of performance criteria, and a high degree of scope certainty by the owner are critical to the success of design-build. Unless such scope certainty can be attained, design-build should not be attempted as the premium paid for changes is likely to be more than the potential savings, with the project costing more in the end.

- Regardless of contracting method, no more than two reservoirs should be **packaged** into a single contract due to operational constraints which allow no more than two reservoirs may be out of service at the same time. Due to these constraints, the entire program is of considerable length. Contracting for work that would occur several years in the future carries a market uncertainty premium that is unlikely to be offset by economy of scale savings.

Given the somewhat ambiguous outcome of the alternative contracting study, SPU is proposing an approach for the first two reservoirs (Beacon and Myrtle) that defers the contracting decision until early 2005 while allowing the projects to proceed without any delay or extra cost. Taking the projects to a 60 percent design between now and mid-2005 would provide an opportunity to better define the scope of the projects, and if certainty with respect to community issues can be attained, design-build may be used. Otherwise traditional contracting would be used without additional delay or cost. Finally, if bids received under a possible design-build are found to be high, they could be declined and the projects could be easily re-directed to the traditional bidding process.

Appendix 2

Status of Non-Storage Recommendations of the System Storage and Reliability Analysis (SSRA) July 7, 2004

Introduction

The System Storage and Reliability Analysis study produced a series of reports that described how the water system would respond to a representative set of emergency conditions. The descriptions were based on the use of computer hydraulic models to simulate the various emergencies. In the course of the modeling, the study found that certain non-storage improvements would improve the reliability of the system by either improving redundancy or by facilitating the operation of the system during an emergency. This appendix summarizes the original 1997 recommendations, listed according to their status of July 2004.

Improvements Completed

1) Remote control valves at the inlets of the following reservoirs:

    a) Lincoln Reservoir, both directly from CRPL2 and through the turbine(s).

    b) Lake Forest Reservoir, on restored 72 inch inlet. Also install new inlet flow meter and provide for automatic operation of control valve as a pressure sustaining valve and a flow control valve.

    c) West Seattle Reservoir.

2) Remote control on the 36-inch ball valve on TPL at TESS Junction, and on the west 24-inch valve into TESSL. Keep east 24-inch valve normally closed or provide remote control to it as well.

3) Upgrade Lake Hills and Maplewood Pump Stations.

4) Upgrade facilities to transfer Tolt water from TESSL into CESSL at or near Lake Hills PS while minimizing headloss.

Project Underway

1) Piping and control valve improvements around Maple Leaf Reservoir, the Maple Leaf Pipeline, and the terminus of the 550 PL at Maple Leaf Reservoir Gatehouse.

Projects Requiring Additional Analysis

1) Remote control valves at the inlets of the following reservoirs:

    a) Beacon Reservoir, between the inlet line and CRPL1 and CRPL2 (in addition to the existing reservoir inlet valve, which is downstream of the above connections).

    b) Volunteer Reservoir

    c) Green Lake Reservoir, from the MLPL.

    d) Maple Leaf Reservoir, from the MLPL.

2) Remote control on the valve between CRPL1 and the MLPL at 18th & Prospect.

3) Remote control on Foy Pump Station bypass valve.

4) Remote control valve between the end of CRPL1, and the 430 Pipeline at Volunteer reservoir.

5) Upgrade TESS Junction Pump Station (to 10 MGD).

6) Line valve in the 550 Pipeline between North City PS and Lake Forest Reservoir.

7) Line valves or equivalent functionality on one of CRPLs 1, 2, and 3 south of Augusta Gatehouse to allow isolation of the section through Renton while still delivering water north from the WSPL into that CRPL.

8) Line valve on CRPL1 or CRPL3 just south of the branch line to Beacon Reservoir inlet.

9) Pressure relief valves at Lake Hills PS or somewhere along CESSL or the Mercer Island Pipeline to allow robust operation of the CESSL system without the Control Works surge tanks while using the 24-inch BV in Kamber Road to drop Tolt water into CESSL.

Alternative Proposal for the Reservoir Program - Bury ALL Remaining Reservoirs, Decommission Roosevelt

Reservoir	TOTAL	thru end of 2002	2003 (Actual)	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Bitter Lake Reservoir Cover [3]	3,860	3,855	5												
Lake Forest Reservoir Cover [3]	7,651	7,256	395												
Lincoln Reservoir [4] - 12 MG	19,822	6,592	7,007	6,223											
Beacon Reservoir - 50 MG	30,000	300	384	250	1,000	316; 6,500	18,250	3,000							
Myrtle Reservoir - 5 MG	6,000	180	17	250	953	100; 2,000	2,500								
West Seattle - 30 MG	20,600	155	9	250	500	261	300	300; 5,000	10,000	3,825					
Maple Leaf Reservoir - 60 MG	32,000	147	13	250	500				257	400	100; 11,000	18,000	1,333		
Volunteer Reservoir - 10 MG	14,000	75	19							231	1,000	500	250; 3,550	6,905	1,470
Roosevelt Reservoir - Retired	150	135	15												Decommissioned
TOTAL Capital Costs - 2003 Constant $	134,083	18,695	7,864	7,223	2,953	9,177	21,050	8,300	10,257	4,456	12,100	18,500	5,133	6,905	1,470
TOTAL Capital Costs - Nominal $	154,604	18,695	7,864	7,425	3,121	9,970	23,508	9,529	12,105	5,406	15,091	23,720	6,766	9,356	2,048

Notes:

1. ONLY costs that are consistent with provisions of Ord. 120899 have been included.
2. All detailed costs shown are in thousands 2003 constant dollars.
3. Projects at Bitter Lake and Lake Forest Reservoirs completed; floating covers installed, and covered reservoirs are in service. Enhanced security systems to be installed separately under the Water System Security Program.
4. Lincoln Reservoir Project currently under construction. Reservoir is out of service.

Table 3
Minimum Reservoir Levels in Percent for Each SSRA Scenario

Storage Facility	Original Size (MG)	SSRA Size (MG)	Current Proposed Size (MG)	Emergency Scenario							Peak Week
				# 1	# 2	# 3a	# 3b	# 5&6	# 7	# 9	
Bitter lake	22.5	22	22	75	37	60	60	37	60	37	40
Maple Leaf	60	60	60	79	96	92	96	75	79	96	77
Volunteer	21	10	0	79	13	86	16	95	81	27	67
West Seattle	68	68	30	90	26	49	89	90	21	22	74
Myrtle	7	7	5	60	45	60	80	60	32	45	37
Lincoln	20.5	10	12	82	28	70	28	71	69	29	62
Roosevelt	50	50	0	75	16	83	46	71	81	16	48
Beacon	60	49	50	83	22	81	23	82	93	24	63
Lake Forest	60	60	60	15	51	85	88	96	94	46	31
TOTAL	369	336	239								

Scenario Failures:

1 - Tolt Pipeline while the Maple Leaf Pump Station is out of Service for Major Rehabilitation

2 - Cedar Control Works

3a - Cedar River Pipelines 1, 2, and 3 between the Wye and Interstate 405 while the Maple Leaf Pipeline is out of service for rehabilitation.

3b - Cedar River Pipelines 1, 2, and 3 downstream from Interstate 405 while the Maple Leaf Pipeline is out of Service for rehabilitation

5&6 - 540 Pipeline near 195th Street while the Maple Leaf Pipeline and Volunteer Reservoir are out of service

7 - Cedar River Pipeline No. 4 with the West Seattle Pipeline out of service

9 - Cedar supply shutdown due to a water quality problem

Table 4 Spreadsheet-Based Rules and Hydraulic Model Results										
	SSRA	Current Proposed	Hydraulic Model Drawdown Totals (MG)							Peak Week
Rule from Spreadsheet Model	Total (MG)	Total (MG)	# 1	# 2	# 3a	# 3b	# 5&6	# 7	# 9	
Maple Leaf + Roosevelt > 35	110	60	25	45	13	29	29	22	44	40
Beacon > 48	49	50	9	38	9	38	9	4	37	18
Beacon + Myrtle + West Seattle > 85	124	85	18	92	47	46	18	62	95	40
Bitter Lake + Maple Leaf + Roosevelt > 85	132	82	31	58	22	38	43	31	58	53
West Seattle + Myrtle > 25	75	35	10	54	37	9	10	59	57	22
Lincoln + Volunteer + Maple Leaf + Beacon > 120	129	122	25	56	19	56	27	22	54	39

Note: Shaded cells show cases where 1997 hydraulic modeling results did not confirm the spreadsheet-based rule.

Scenario Failures:

1 - Tolt Pipeline while the Maple Leaf Pump Station is out of Service for Major Rehabilitation

2 - Cedar Control Works

3a - Cedar River Pipelines 1, 2, and 3 between the Wye and Interstate 405 while the Maple Leaf Pipeline is out of service for rehabilitation.

3b - Cedar River Pipelines 1, 2, and 3 downstream from Interstate 405 while the Maple Leaf Pipeline is out of Service for rehabilitation

5&6 - 540 Pipeline near 195th Street while the Maple Leaf Pipeline and Volunteer Reservoir are out of service

7 - Cedar River Pipeline No. 4 with the West Seattle Pipeline out of service

9 - Cedar supply shutdown due to a water quality problem

Table 5 Minimum Reservoir Levels in Percent for Updated SSRA Scenarios 2 and 7				
Storage Facility	SSRA Size (MG)	Current Proposed Size (MG)	Emergency Scenario	
			# 2	# 7
Bitter lake	22	22	32	60
Maple Leaf	60	60	5	40
Volunteer	10	0	N/A	
West Seattle	68	25	10	40
Myrtle	7	10	44	50
Lincoln	10	12	38	67
Roosevelt	50	0	N/A	
Beacon	49	50	0	95
Lake Forest	60	60	0	92
TOTAL	336	239		

Scenario Failures:

2 - Cedar Control Works

7 - Cedar River Pipeline No. 4 with the West Seattle Pipeline out of service

Seattle Public Utilities

MEMORANDUM

DATE: February 10, 2006

TO: File

FROM: Charles Oppelt, Capital Projects Coordinator, SPU Engineering Division

SUBJECT: Design Standards and Definition of Standard Water Main

Attached is a new version of the Design Standards for Distribution Water Mains memorandum. This document updates the May 12, 1987 Water Department memo from Walter Anton that SPU provided as an appendix to the 2001 Water System Plan (WSP). The following document includes all of the information in the 1987 memo with the following updates. The updates include changes to the Standard Plan numbers, revisions to the text for Department reorganization from Seattle Water Department to Seattle Public Utilities and Superintendent to Director of said Departments, updating of AWWA Standards to the current versions used by SPU *(see Attachment 1 below)* and changes to the desirable watermain pressure standards resulting from the February 1, 2005 SPU Policy on Distribution System Water Service Pressure – Number: SPU-RM-006.

The Definition of Standard Water Mains *(see Attachment 2)* below, required no updates from the 1987 version.

CAO
Attachments
cc: Michael Brennan
Charlie Madden
Eugene Mantchev

Seattle Public Utilities Distribution Watermain Requirements & Design Standards *

Distribution Watermain Standards – 2" through 12" sizes

Pipe Standards – 2" size

Type K copper soft coil, with brass flared or compression fittings

Pipe Standards – 4" through 12" sizes

Ductile Iron Pipe Class 52 **
- Restrained joint
- Slip joint
- Mechanical joint
- Cement lined

Depth Standards

2", 4", 6" and 8" sizes – 35" of cover below established street grade as determined by the agency having control over the street involved.

10" size – 40" of cover below established street grade.

12" size – 43" of cover below established street grade.

16" to 30" – 36" of cover below established street grade.

Location Standards

Watermain in public, deeded street – Watermain may, at the option of Seattle Public Utilities, be installed in a private street or in an easement.

Platted Streets – 30' or wider (Standard Plan # 030).

10' East of centerline	North-South streets
10' North of centerline	East-West streets

Streets or Easements – 20' to 30'

5' West of margin	North-South streets
5' South of margin	East-West streets

Easements less than 20'

Location to be determined on a case by case basis, if allowed.

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* All standards and requirements subject to change, modification, or use as determined by the Director of SPU in accordance with Seattle Municipal Code 3.22.30 and other Seattle Municipal Code authority.

** PVC pipe, AWWA C-900 may be used in highly corrosive soils if approved by the Director of SPU.

Minimum Size Standards

2” – Dead end streets/easements less than 400’ in length, single family/duplex zoning, no fire hydrants required, maximum of 6 lots to be served, maximum metered service size allowed (1”) – all service tees to be installed with the main.

4” – Dead end streets/easements less than 400’ in length and no fire hydrants required. More than 6 lots to be served or zoning other than single-family/duplex.

6” – Dead end streets/easements in single family/duplex zoning or single hydrant required (1000 GPM fire flow available).

8” – Through streets and easements – residential areas.

12”- Through streets and easements – industrial, commercial and mixed use areas.

Corrosion Protection Standards

To be applied in areas where soil resistivity is less than 3000 ohm-cm, or shale rock areas, garbage fill areas, organic soil areas, or other soil where corrosive conditions exist. One or more of the following may be required:

1. Poly-wrap, Tape Coating or other protective coating
2. Select backfill – bedding
3. Joint bonding
4. Cathodic protection

Hydrant Spacing Standards

Approx. 400’ on centers – residential areas

Approx. 300’ on centers – industrial, commercial areas

Valve Spacing Standards

Valves located at margins of street intersections where mains intersect, and otherwise such that a break or other failure will not affect more than 1/4 mile of arterial mains, 500 feet of mains in commercial districts, or 8OO feet of mains in residential districts.

Separation Standards – Sewer/Water

In accordance with the sewer/water separation standard drawings #286 a&b.

Desirable Watermain Pressure Standards

Minimum – 30 psi for new installations.
Maximum – none

If an SPU-initiated system reconfiguration causes a permanent pressure increase of 10 psi or greater at a water service, customers expected to see resultant pressures at their meters above 80 psi shall be given written notice of the pressure increase. In addition, an offer shall be extended by SPU to cover the cost of a PRV to be installed on the private property (with any limitations on cost and what method of installation would be used – SPU contractor, property owner installation and reimbursement, etc.), when a PRV is not already pre-existing on the property water system.

Watermain Appurtenance		Standard Plan
Pipe	Connections to Existing Watermain	300a
	Connections to Existing Watermain	300b
	Connections to Existing Watermain	300c
Hydrants	Hydrant Setting Detail	310a
	Hydrant Setting Detail	310b
	Hydrant Setting Detail	311a
	Hydrant Setting Detail	311b
	Fire Hydrant Marker Layout	312
	Wall & Requirements for Hydrants	313
	Fire Hydrant Locations & Clearances	314
Valve	Cast Iron Valve Box & Operating Nut Extensions	315a
	Cast Iron Valve Box & Operating Nut Extensions	315b
Concrete Blocking	Watermain Thrust Blocking Vertical Fittings	330a
	Watermain Thrust Blocking Vertical Fittings	330b
	Watermain Thrust Blocking Horizontal Fittings	331a
	Watermain Thrust Blocking Horizontal Fittings	331b
Blow Off	2” Blow-Off Detail Non-traffic	340a
	2” Blow-Off Detail Traffic	340b
Pipe Bedding	Watermain Pipe Bedding (Special)	350
Misc. Plans	Watermain Electrolysis Test Station	360
	Type 361 Valve Chamber Ring & Cover	361
	Joint Bonding for D.I.P. Watermains	362
	Isolating Coupling	363
	Pressure Reducing Valve Assemblies	
	Pressure Relief Valve Assemblies	
	Sample Station	
	Drinking Fountain	

Water Service Installation Standards - ¾"- through 12" sizes

Domestic Services

Standard Plan No.	735-1	3/4"	Domestic
	735-1	1"	Domestic
	735-2	1 1/2"	Domestic
	735-2	2"	Domestic
	735-8	4"	Domestic Compound
	735-9	6"	Domestic Compound
	735-8	3"	Domestic Compound

Combination Fire/Domestic Services

Standard Plan No.	735-4	4"
	735-5	6"
	735-6	8"
	735-11	10"

Fire Services

Standard Plan No.	735-3	2" fire
	735-10	4" fire
	735-10	6" fire
	735-10	8" fire
	735-10	10" fire
	735-10	12" fire

Watermain Extension Applications and Agreements (Developer extensions)

Watermain Extension Application and Agreement

Miscellaneous Standards

Watermain construction and financing options – LID – Special tap charge or private contract.

The contributing properties shall be zip tone shaded (Format #7*045* or equal) and labeled "contributing properties".

At all fittings where the watermain changes direction, and at dead-ends, concrete thrust blocking or shackles shall be shown in accordance with the appropriate standard plan(s).

A profile shall be included on all plans.

Blowoffs or hydrants on all dead-ends. Drainage course for disposal of blowoff water.

Appropriate cross or tee for future extension.

Dead-end mains shall normally extend across the full width of property served.

Plans and profiles shall show existing or proposed underground utilities within the margins of the street.

Appurtenant pipe runs to hydrants, meters, blowoffs, etc., shall have alignment perpendicular to the watermain.

<u>Other Reference Standards/Requirements</u>

City of Seattle Fire Code
City of Seattle Plumbing Code
City of Seattle Zoning and Land Use Code
City of Seattle Water Code
City of Seattle Water Department Water Service Policy and other Administrative Rules
King County Fire Code.
King County Zoning and Land Use Codes
King County Road Standards
King County Plumbing Code
King County Franchises
Washington State RCWls, especially Chapter 35
Washington State Department of Transportation Franchises
Washington State Department of Transportation 1984 Standard Specifications for Roads, Bridges, and Municipal Utilities
Washington State Department of Transportation Utilities Accommodation Policy

City of Seattle Supplement to Washington State Department of Transportation 1984 Standard Specifications for Roads, Bridges and Municipal Construction

WAC-248-54-550 through 850
Design Standards for Public Water Supplies – D.S.H.S.

Minimum Design Standards for Community Water Supply Systems – H.U.D.

Recommended Standards for Water Works – Great Lakes – Upper Mississippi River Board of State Sanitary Engineers (Ten State Standards)

AWWA Standards – American Water Works Association (primarily material standards) – See attached Standards list

Grading Schedule for Municipal Fire Protection and Guide for Determination of Required Fire Flow – Insurance Services Office

Various AWWA Manuals (e.g., M-ll, Steel Pipe Design and Installation)

Charles Oppelt
Design Standards and Guidelines Coordinator

TO FILE,
Design standards and guidelines program

ATTACHMENT 1

Current AWWA Standards - December 2005

This list includes American Water Works Standards in effect on Dec 31, 2005
WITHDRAWN standards listed are noted as such and have been retained by the SPU for Engineering Branch reference on existing systems.

Groundwater and Wells

A100-97: Water Wells

Filtration

B100-01: Filtering Material
B101-01: Precoat Filter Media
B102-04: Manganese Greensand for Filters

Softening

B200-03: Sodium Chloride
B201-03 Soda Ash
B202-02: Quicklime and Hydrated Lime

Disinfection Chemicals

B300-04: Hypochlorites
B301-04: Liquid Chlorine
B302-05: Ammonium Sulfate
B303-05: Sodium Chlorite
B304-05: (ANSI) Liquid Oxygen for Ozone Generation

Coagulation

B402-00: Ferrous Sulfate
B403-03: Aluminum Sulfate: Liquid, Ground, or Lump
B404-03: Liquid Sodium Silicate
B405-00: Sodium Aluminate
B406-97: Ferric Sulfate
B407-05: Liquid Ferric Chloride
B408-03: Liquid Polyaluminum Chloride
B451-04: Poly (Diallyldimethylammonium Chloride)
B452-98: EPI-DMA Polyamines
B453-01: Polyacrylamide

Scale and Corrosion Control

B501-03: Sodium Hydroxide (Caustic Soda)
B502-05: Sodium Polyphosphate, Glassy (Sodium Hexametaphosphate)
B503-05: Sodium Tripolyphosphate
B504-05: Monosodium Phosphate, Anhydrous
B505-05: Disodium Phosphate, Anhydrous
B510-00: Carbon Dioxide
B511-05: Potassium Hydroxide
B512-02: Sulfur Dioxide
B550-05: Calcium Chloride

Taste and Odor Control

B600-05: Powdered Activated Carbon

B601-05: Sodium Metabisulfite

B602-02: Copper Sulfate

B603-03: Potassium Permanganate

B604-96: Granular Activated Carbon

B605-99: Reactivation of Granulated Activated Carbon

Prophylaxis

B701-99: Sodium Fluoride

B702-99: Sodium Fluorosilicate

B703-00: Fluorosilicic Acid

Ductile-Iron Pipe and Fittings

C104/A21.4-03 Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water

C105/A21.5-05: Polyethylene Encasement for Ductile-Iron Pipe Systems

C110/A21.10-03: Ductile-Iron and Gray-Iron Fittings for Water

C111/A21.11-00: Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings

C115/A21.15-99: Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges

C116/A21.16-03: Protective Fusion-Bonded Epoxy Coatings Int. & Ext. Surf. Ductile-Iron/Gray-Iron Fittings

C150/A21.50-02: Thickness Design of Ductile-Iron Pipe

C151/A21.51-02: Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids

C153/A21.53-00: Ductile-Iron Compact Fittings for Water Service

Steel Pipe

C200-97: Steel Water Pipe 6 In. (150 mm) and Larger

C203-02: Coal-Tar Protective Coatings & Linings for Steel Water Pipelines, Enamel & Tape, Hot-Applied

C205-00: Cement-Mortar Protective Lining and Coating for Steel Water Pipe, 4 In. (100 mm) and Larger, Shop Appli

C206-03: Field Welding of Steel Water Pipe

C207-01: Steel Pipe Flanges for Waterworks Service, Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm)

C208-01: Dimensions for Fabricated Steel Water Pipe Fittings

C209-00: Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipe

C210-03: Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines

C213-01: Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines

C214-00: Tape Coating Systems for the Exterior of Steel Water Pipelines

C215-04: Extruded Polyolefin Coatings for the Exterior of Steel Water Pipelines

C216-00: Heat-Shrinkable Cross-Linked Polyolefin Coatings for the Exterior of Special Sections, Connections, and Fitting

C217-04: Petrolatum and Petroleum Wax Tape Coatings for Exterior of Connections and Fittings for Steel Water Pipelines

C218-02: Coating the Exterior of Aboveground Steel Water Pipelines and Fittings

C219-01: Bolted, Sleeve-Type Couplings for Plain-End Pipe

C220-98: Stainless-Steel Pipe, 4 In. (100 mm) and Larger

C221-01: Fabricated Steel Mechanical Slip-Type Expansion Joints

C222-99: Polyurethane Coatings for the Interior and Exterior of Steel Water Pipe and Fittings

C223-02: Fabricated Steel and Stainless Steel Tapping Sleeves

C224-01: Two-layer Nylon-11 Based Polyamide Coating System for Interior and Exterior of Steel Water Pipe and Fittings

C225-03: Fused Polyolefin Coating Systems for the Exterior of Steel Water Pipelines

Concrete Pipe

C300-04: Reinforced Concrete Pressure Pipe, Steel-Cylinder Type

C301-99: Prestressed Concrete Pressure Pipe, Steel-Cylinder Type

C302-04: Reinforced Concrete Pressure Pipe, Noncylinder Type

C303-02: Concrete Pressure Pipe, Bar-Wrapped, Steel-Cylinder Type

C304-99: Design of Prestressed Concrete Cylinder Pipe

Asbestos-Cement Pipe

C400-03: Asbestos–Cement Pressure Pipe, 4 In.–16 In. (100 mm–400 mm), for Water Dist. & Trans.

C401-03: Selection of Asbestos–Cement Pressure Pipe, 4 In.-16 In. (100 mm-400 mm), for Water Dist. Sys.
C402-05: Asbestos-Cement Transmission Pipe, 18 In Through 42 In. (450 mm Through 1,050 mm) for Water Supply Service
C403-05: The Selection of Asbestos–Cement Transmission Pipe, Sizes 18 In. Through 42 In. (450 mm Through 1,050 mm),

Valves and Hydrants

C500-02: Metal-Seated Gate Valves for Water Supply Service

C501-92: WITHDRAWN -Sluice Gates

C502-05: Dry-Barrel Fire Hydrants

C503-05: Wet-Barrel Fire Hydrants

C504-00: Rubber-Seated Butterfly Valves

C506-78(R83): WITHDRAWN - Backflow Prevention devices

C507-05: Ball Valves, 6 In. Through 48 In. (150 mm Through 1,200 mm)

C508-01: Swing-Check Valves for Waterworks Service, 2 In. (50 mm) Through 24 In.(600 mm) NPS

C509-01: Resilient-Seated Gate Valves for Water Supply Service

C510-97: Double Check Valve Backflow Prevention Assembly

C511-97: Reduced-Pressure Principle Backflow Prevention Assembly

C512-04: Air Release, Air/Vacuum, and Combination Air Valves for Waterworks Service

C513-05: Open-Channel, Fabricated-Metal, Slide Gates and Open-Channel, Fabricated-Metal Weir Gates

C515-01: Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service

C540-02: Power-Actuating Devices for Valves and Slide Gates

C550-05: Protective Epoxy Interior Coatings for Valves and Hydrants

C560-00: Cast-Iron Slide Gates

C561-04: Fabricated Stainless Steel Slide Gates

C563-04: Fabricated Composite Slide Gates

Pipe Installation

C600-05: Installation of Ductile-Iron Water Mains and Their Appurtenances

C601-81: WITHDRAWN - Disinfecting Water Mains

C602-00: Cement-Mortar Lining of Water Pipelines in Place—4 In. (100 mm) and Larger

C603-05: Installation of Asbestos Cement Pressure Pipe

C605-05: Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water

C606-04: Grooved and Shouldered Joints

Disinfection of Facilities

C651-05: Disinfecting Water Mains

C652-02: Disinfection of Water-Storage Facilities

C653-03: Disinfection of Water Treatment Plants

C654-03: Disinfection of Wells

Meters

C700-02: Cold-Water Meters—Displacement Type, Bronze Main Case

C701-02: Cold-Water Meters—Turbine Type, for Customer Service

C702-01 : Cold-Water Meters—Compound Type
C703-96 (R04): Cold-Water Meters—Fire Service Type
C704-02 : Propeller-Type Meters for Waterworks Applications
C706-96 (R05): Direct-Reading, Remote-Registration Systems for Cold-Water Meters
C707-05: Encoder-Type Remote-Registration Systems for Cold-Water Meters
C708-05: Cold-Water Meters Multijet Type
C710-02: Cold-Water Meters—Displacement Type, Plastic Main Case
C712-02: Cold-Water Meter--Singlejet Type
C713-05: Cold-Water Meters: Fluidic-Oscillator Type
C750-03: Transit-Time Flowmeters in Full Closed Conduits

Service Lines

C800-05: Underground Service Line Valves and Fittings (Also Included: Collected Standards for Service Line Materials)

Plastic Pipe

C900-97: Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 In.-12 In. (100 mm-300 mm), for Water Dist.
C901-02: Polyethylene (PE) Pressure Pipe and Tubing, ½ In. (13 mm) Through 3 In. (76 mm), for Water Service
C903-05: Polyethylene-Aluminum-Polyethylene Composite Pressure Pipes
C905-97: Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In.-48 In. (350 mm-1,200 mm)
C906-99: Polyethylene (PE) Pressure Pipe and Fittings, 4 In. (100 mm) Th. 63 In. (1,575 mm), for Water Dist. and Trans.
C907-04: Injection-Molded Polyvinyl Chloride (PVC) Pressure Fittings, 4 In. Through 12 In. (100 mm Through 300 mm)
C908-01: PVC Self-Tapping Saddle Tees for Use on PVC Pipe
C909-02: Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe, 4 In.-24 In. (100 mm-600 mm), for Water Distribut
C950-01: Fiberglass Pressure Pipe

Storage

Custom Manual/Standard Set: Flexible-Membrane Storage
Custom Manual/Standard Set: Steel Tanks
D100-96: Welded Steel Tanks for Water Storage
D101-53(R86): WITHDRAWN - Inspecting and repairing steel water tanks, standpipes, reservoirs, and elevated tanks, for water storage
D102-03: Coating Steel Water-Storage Tanks
D103-97: Factory-Coated Bolted Steel Tanks for Water Storage
D104-04: Automatically Controlled, Impressed-Current Cathodic Protection for the Interior of Steel Water Tanks
D110-04: Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks
D115-95: Circular Prestressed Concrete Water Tanks With Circumferential Tendons
D120-02: Thermosetting Fiberglass-Reinforced Plastic Tanks
D130-02 : Flexible-Membrane Materials for Potable Water Applications

Pumping

E101-88 WITHDRAWN - ANSI Std for Vertical turbine pumps - Line shaft and submersible types

Plant Equipment

F101-02: Contact-Molded, Fiberglass-Reinforced Plastic Wash Water Troughs and Launders
F102-02: Matched-Die-Molded, Fiberglass-Reinforced Plastic Weir Plates, Scum Baffles, and Mounting Brackets

Utility Management

G100-05: Water Treatment Plant Operation and Management
G200-04: Distribution Systems Operation and Management

ATTACHMENT 2

Definition - Standard Watermains

Under the following conditions watermains would be considered standard:

A. Existing Watermains

1. Single family/duplex residential zoning *

Dead end streets/easements less than 400 feet in length - no Fire hydrants required.

4 inch or larger cast iron or
Ductile iron pipe, and 2" copper pipe

Dead end streets/easements with single standard fire hydrant and 1000 GPM fire flow available.

6 inch or larger cast iron or
Ductile iron pipe. (8 inch size or larger cast iron or
Ductile iron pipe if more than one standard fire hydrant.)

Through streets and easements with standard fire hydrant(s) and 1000 GPM fire flow available.

6 inch or larger cast iron or Ductile iron pipe

2. All other zoning *

8 inch or larger cast iron or ductile iron pipe.

* NOTE: All zoning - existing 16" and larger watermains shall all be considered as standard. For 12" and smaller size watermains, all existing watermains constructed before 1984 and constructed of materials other than cast iron, ductile iron pipe, or copper pipe shall be considered substandard.

B. New Watermains

New watermains shall conform to the latest Seattle Public Utilities Distribution Watermain Requirements and Design Standards.

Definition - Standard Fire Hydrant

Standard fire hydrant is a 6" or larger nominal size fire hydrant connected by a 6" or larger pipe to a 6" or larger watermain. New fire hydrants must conform to current Seattle Public Utilities requirements.

SEATTLE PUBLIC UTILITIES
2007 WATER SYSTEM PLAN

IV. DISTRIBUTION

APPENDIX C

DISTRIBUTION FACILITIES DESIGN AND CONSTRUCTION STANDARDS

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This appendix to the *2007 Water System Plan Update* (WSP) describes the standards and procedures followed by Seattle Public Utilities (SPU) in the installation of new water mains and the interior coating of water storage facilities. These requirements are intended to meet or exceed the design and construction standards referenced in WAC 246-290. Together with the City of Seattle's Standard Specifications (Seattle, 2000a) and Standard Plans (Seattle, 2000b), this material is intended to meet the requirements of the Department of Health (DOH) submittal exception process for distribution main construction and tank painting. By qualifying for this process and following the approved procedures and standards, SPU is provided a waiver from the requirement of DOH approval of individual projects.

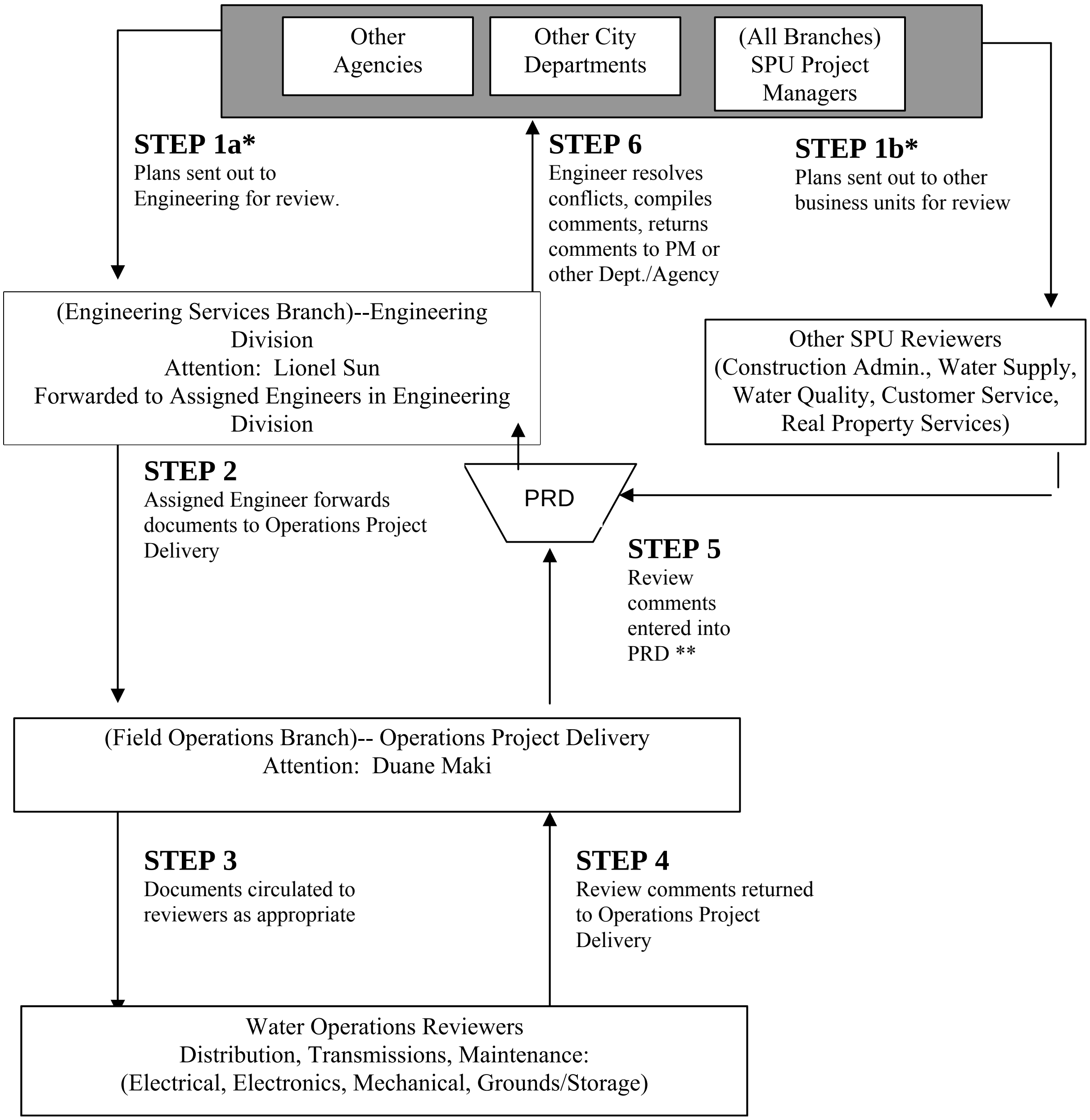
1. Project Review Procedures

All improvements and modifications to the water distribution system follow the Project Document Review Procedure. The distribution system Project Document Review Procedure process is presented as Exhibit 1. The Project Document Review Procedure is triggered at a point in the design phase when preliminary project documents are received from an external source such as a developer or other agency or at the point when internal SPU circulation of preliminary project documents occurs. These project documents are prepared in accordance with SPU Standards, Policies, and conditions set forth in the Water Availability Certificate (see Section 2 of this appendix). This phase of the project is represented in the schematic by the shaded box at the top.

Step 1a and 1b of the Project Document Review Procedure occur concurrently and are designed to initiate project review from Engineering services and other SPU organizational units. Project documents prepared within one unit of the Engineering Division are routed to one of the other units for review (Step 1a) and are also routed to other appropriate non-engineering SPU reviewers (Step 1b). Similar routing for review occurs for projects which include modifications of some sort to the water distribution system. Steps 2, 3, and 4 show the SPU internal document review routing process through the Field Operations Branch. All reviews are compiled at Step 5 when comments are entered into the Plan Review Database. In Step 6, the Engineering Division and Customer Service are responsible for resolution of conflicts, comment compilation including City Standards, and transmittal of materials to the SPU Project Manager and other City Departments, outside agencies, and developers. Once plans are approved, a permission letter, SPU Right-of-Way Permit, or City Street Use Permit is sent as appropriate for the project's location.

The Engineering division provides engineering reviews and acts as the centralized coordinator for all project documents related to the water utility infrastructure. All review comments are recorded in the Plan Review Database (PRD) managed by the Engineering Division.

Exhibit 1
Distribution System Project Document Review Procedures



***Steps 1a and 1b occur concurrently**
**** PRD is the Plan Review Database, used for review comment routing and is currently being upgraded.**

2. Policies and Requirements for Outside Parties

SPU has in place established developer requirements for design and installation of extension or replacement of Seattle's water distribution system. These documents and requirements are accessible through the City of Seattle website at www.seattle.gov/util/engineering/obtain_utility_services/index.asp. The documents available for outside parties include:

Developers and Property Owners

- Application to Change SPU's Distribution System
- Hydrant Testing
- Property Owner Contract
- Standard Charges
- Surety Instrument
- Transfer of Ownership
- Easement Information

Engineers

- General Notes on Plans: 4" – 12" Mains
- Selective Notes on Plans: 4" – 12" Mains
- Information Sheets for Engineers
- Hydrant Test Request Procedure

Contractors

- General Information
- Insurance Requirements
- Hydrant Information
- Water Quality Checklist
- Survey Requirements

Outside parties alter the water distribution system and the ability to deliver water if development requires replacement or extension of existing water mains, pressure zones, etc. These changes to water supply due to development are stated on the Water Availability Certificate that is issued at the time of a building permit or land use change application. Developers must follow established requirements and procedures in both the design and installation of new water infrastructure. SPU reviews and approves the design submitted by the developer and inspects the installation by the developer's contractor. Infrastructure design is based on SPU's engineering design requirements, Policies and City Standard Specifications (Seattle, 2005), as well as other engineering considerations.

Before a developer can begin construction, the developer is required to contract with SPU to change the water distribution system. The developer-SPU contract addresses the standard charges for plan review, easement processing if needed, construction inspection, water quality testing, connection to the existing SPU system, and any other work which SPU performs related to the developer's project. Additionally, the developer must also provide SPU with a surety instrument. All developer plans must be submitted by the developer's engineer for SPU review and approval. Finally, the developer's contractor must conduct a preconstruction meeting with SPU staff to identify and agree upon construction start dates.

3. Design Standards

Performance Standards and Sizing Criteria are addressed in a separate appendix on System Design Standards.

4. Construction Standards

The 2005 City of Seattle Standard Specifications (Seattle, 2005) includes:

- Pipe and Fittings
- Trench Excavation
- Bedding and Backfill
- Pipe Installation
- Valves
- Hydrants
- Service Connections
- Irrigation System (Backflow Prevention)
- Water (for concrete, irrigation and hydrant use)
- Distribution Materials

These specifications include construction materials and methods of construction. Performance standards desired and expected are reflected in the construction standards. All public and private construction within the City of Seattle public right-of-way must comply with the Standard Specifications. The 2005 City of Seattle Standard Plans (Seattle, 2005) supplement the Standard Specifications.

Where applicable, specific standard references to professional and technical society standards (such as AWWA, APWA) have been incorporated. As standards are upgraded, there is a system in place to incorporate these updates and revisions. For the painting of the interior of water tanks, coatings are limited to those that have been certified to meet NSF standard 61.

5. Construction Certification and Follow-up Procedures

5.1 Preconstruction

SPU's construction standards, the 2005 City of Seattle Standard Specifications (Seattle, 2005) and the 2005 Seattle Standard Plans (Seattle, 2005), serve as the basis for all public works project contract documents. These standards are made available to all prospective bidders along with the bid documents for each project at SPU's Engineering Records Vault bid counter. The standards are revised and supplemented in individual water distribution main project plans and specifications.

Prior to the start of a water distribution main construction project, a preconstruction meeting is held with representatives of SPU design, project management, construction, water quality, and operations staff; the contractor and subcontractors; and other involved parties, such as a developer or consulting engineer. At the preconstruction meeting, SPU's procedures for submittals, inspection, water quality control, connection(s) to the existing water system, and installation of meters are discussed.

Submittals are required from the contractor for review by SPU before water distribution main installation is allowed to begin. When contractors perform their own survey, grade sheets are submitted to verify pipeline grade during construction. The contractor's proposed sources of construction materials are submitted and reviewed by SPU's Materials Testing Laboratory. Specific construction materials submittals, including shop drawings, catalog cuts, and technical data are also reviewed, as required.

5.2 Construction Inspection

SPU Construction Engineering personnel perform continuous on-site inspection during installation of water distribution mains to verify conformance with appropriate AWWA, DOH, and City of Seattle Standard Specifications. The procedures listed below are followed during inspection:

Grade and Alignment. Grade and alignment of the new water distribution main are verified by SPU Construction Engineering personnel. Deviations from the plan grade and alignment are noted.

Existing Utilities. Encounters with existing utilities, both marked and unmarked, are noted by SPU Construction Engineering personnel. Proper separation between the new water distribution main and existing utilities is ensured. In the case of encountered sanitary sewers and storm drains where sufficient separation is not available, replacement of the section of sewer/drain pipe crossing over or under the pipe with new ductile iron pipe is required.

Trench Excavation. Trench excavation is observed to verify sufficient depth of cover over water distribution mains (35 inches of cover for 8-inch diameter and smaller mains, 40 inches of cover for 10-inch diameter mains, and 43 inches of cover for 12-inch diameter mains as per Seattle Standard Specifications 7-10.3(5)C and Seattle Standard Plan No. 030). Extra excavation is required if unsuitable material is found at the bottom of the trench.

Pipe Bedding and Backfill. Proper pipe bedding is ensured by SPU Construction Engineering Personnel, in accordance with Seattle Standard Specifications 7-10.3(9). Trench backfill is also observed to conform to Seattle Standard Specifications 7-10.3(10). Unsuitable backfill material is rejected. Proper compaction of the bedding and backfill is ensured and tested by SPU Materials Laboratory personnel, or a private, certified testing firm in accordance with Seattle Standard Specifications 7-10.3(11).

Pipe Installation. Prior to installation of new water distribution mains, SPU Construction Engineering personnel inspect pipe and appurtenances for proper size, material, thickness class, and type of joint. Proper storage and handling of the pipe before it is placed in the trench is ensured. All standing water in the trench is directed to be removed by the contractor before the pipe is laid. Proper cutting of pipe is also observed.

All pipe bell and spigot ends are inspected for cleanliness before jointing. Proper assembly and tightening of mechanical or restrained joint systems is observed. Deflection of joints is observed to not exceed allowable limits of the type of joint.

Thrust Restraint. Thrust restraint measures are observed to conform with the design requirements. Thrust blocking is ensured to cover a sufficient amount of area based on pipe diameter and soil type (Seattle Standard Plans No. 330.1a&b, 331.1a&b) and be of an appropriate mix of concrete. Shackle rods, when used, are observed to be of the proper type, number, and diameter.

Corrosion Protection. When corrosion protection and/or electrolysis monitoring measures are specified, SPU Construction Engineering personnel observe that they are properly installed. Prior to exothermic pipe bonding, the bonding surface is observed to be clean and free of paint, primer, and other coating materials. The soundness of the welds is observed and tested with a glancing blow with a 16 ounce hammer. Joint continuity tests, when specified, are observed to meet minimum levels. Polyethylene wraps are observed to be continuous and free from tears.

Installation of Appurtenances. SPU Construction Engineering personnel verify proper installation of valves, hydrants, blowoffs, and other appurtenances. Proper installation of hydrant tee thrust restraint systems is observed and verified.

5.3 Pressure Testing

SPU Construction Engineering personnel perform hydrostatic pressure tests of all installed water distribution mains according to the requirements of Seattle Standard Specifications 7-11.3(11). Ductile iron water distribution mains 12 inches in diameter or smaller are tested to a pressure of 300 psi. Pipes 16 inches in diameter or larger are tested to 250 psi unless otherwise specified. The test pressure is maintained without pumping for 15 minutes for sections of water distribution main up to 1,500 feet long. A pressure drop of not more than 15 psi, with no visible leaks, during this time is considered acceptable. In-line gate valves will be acceptable if no immediate loss of pressure is registered on gauge when the valve is being checked. Hydrant valves are tested for five minutes. In-line valves are tested on each side and hydrant valves are tested on the water distribution main side only. A pressure drop of not more than 5 psi during this time, with no visible leaks, is considered acceptable. Water distribution mains not passing a pressure test are corrected and retested.

Pressure tests are recorded using a Bristol Babcock portable pressure recorder, using a 0-500 psi chart set at a 96-minute duration. Each test interval is indicated on the chart, along with whether the entire test was considered acceptable. Project information, date of test, and the name of the inspector performing the test are also recorded on the chart. Charts are maintained with project records.

5.4 Disinfection, Flushing, and Water Quality Sampling

SPU Construction Engineering personnel ensure that proper disinfection and flushing are performed and sample ports are provided during water distribution main installation. They coordinate sampling of the main with SPU Customer Service Water Quality Control staff.

Disinfection. SPU Construction Engineering personnel verify that chlorine for pipeline disinfection is applied through one of three allowed methods. In water distribution main installation, dry calcium hypochlorite (65-70 percent chlorine) is applied on a pipe-by-pipe basis in an amount sufficient to provide an initial dosage of at least 25 mg/l free chlorine. In circumstances where this is not feasible, gas chlorine or liquid sodium hypochlorite is applied as the disinfectant. The amount of chlorine required for each method for each diameter of pipe is specified in section 7-11.3(12) of the Seattle Standard Specifications.

Flushing. After a sufficient chlorine residual and contact time has been verified by SPU Water Quality Control personnel, the installed water distribution main is flushed. If dry calcium hypochlorite is the method of disinfection, a flushing velocity of at least 2.5 feet per second is required. Installed water distribution mains are flushed for at least five minutes for every 150 feet of new water distribution main and at least a 30-minute minimum.

Water Quality Sampling and Testing. Water quality samples are collected by SPU Water Quality Control personnel at intervals of 500 lineal feet or less along a new water distribution main. Samples are analyzed by the SPU Water Quality Laboratory for total coliform. Samples showing a presence of coliform bacteria are considered unsatisfactory and disinfection, flushing, and sampling of the distribution main is repeated (Seattle Standard Specifications 7-11.3(12)M). If samples exceed requirements for any reason other than coliform, the water distribution main is flushed and re-sampled.

Connection to Existing Distribution System. After satisfactory laboratory results are obtained, the installed water distribution main is connected to the existing distribution system. SPU water distribution crews make the physical connection with the aid of the contractor. SPU personnel ensure that, when possible, the total length of pipe required to connect the end of the installed water distribution main to the existing system is less than one standard pipe length of 18 feet. When this is not possible, SPU personnel require the contractor to predisinfect the connection pieces and arrange for water quality sampling of those pieces.

5.5 Procedures for Preparation and Retention of Design and Construction Drawings

Water distribution main design drawings are produced by both SPU Water Design staff and outside engineering staffs. Contract drawings are used to record bid item pay quantities, "as-built" notations and corrections, and all work added or deleted by change order. At the completion of construction, a set of "as-built" drawings is transmitted to SPU Technical Resources Section in the Engineering Support Division of the Engineering Services Branch for transfer to a reproducible medium. A copy is created on a storage medium and given to the SPU Engineering Records Vault, a repository of project information. All projects are assigned a unique vault plan number that is used to catalog the completed construction record drawings. Electronic design drawing files are stored by SPU Technical Resources Section. They are used to create contract drawings that are stamped and signed and then reproduced for advertisement and the use of the contractor and SPU Construction Engineering personnel. Corrected "as-built" record drawings are also transmitted to SPU Geographic Information Systems (GIS) personnel (Data Services, Information and Technology Division, Finance and Administration Branch), who transfer the project information to the City of Seattle GIS database. Within 60 days of completion of all water distribution main projects, a *Construction Report for Public Water System Projects* is submitted to DOH, in accordance with WAC 246-290-040.

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