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CHAPTER 3

SYSTEM ANALYSIS

The objective of this chapter is to determine if the existing system facilities can supply enough quality and quantity of water to meet existing and projected demands in the District's water service area. In this section, five primary planning elements will be reviewed in detail:

- system design standards
- water quality analysis
- system description and analysis
- summary of system deficiencies
- selection and justification of proposed improvements

The design standards identify the design criteria that apply to District water system facilities. The design and water quality standards for Group A public water systems are summarized in Chapter 246-290 WAC. These standards provide a set of minimum design and performance criteria for new water utilities and for all existing utilities planning to install capital facilities for expansion purposes.

System description and analysis includes a description of the system configuration and general condition, hydraulic analysis and study, and determination of the deficiencies of the components of the District's water system. The discussion is summarized with identification of the improvements proposed to eliminate existing and anticipated deficiencies.

3.1 System Design Standards

This chapter establishes the criteria to be used in the planning, analysis and construction of facilities that will be required by the District to meet future customer demand. The criteria include consideration of adequate water quality and supply and the sizing of storage and distribution facilities. The design criteria are based on historical District records, design standards recommended by the DOH and other accepted standards normally used in the design and construction of water facilities.

The DOH *Water System Design Manual (WSDM)*, dated December 2009, was utilized for this system analysis. The primary design criteria included maintaining 30 psi in the distribution system under peak hourly demand flow conditions and 20 psi under maximum day demands and fire flow conditions.

3.1.1 Abbreviations

In this report, a number of common technical terms and expressions have been abbreviated. These terms and their abbreviations are presented in the introduction.

3.1.2 Reference Datum

The planning of facilities in this study is based on the National Geodetic Vertical Datum (NGVD) of Mean Sea Level at elevation zero.

3.1.3 Period of Design

In the planning of water facilities, it is necessary to design facilities that can provide for projected system demands for a specific period of time. This window of time is known as the *period of design*, and for this plan the period spans from the date of this plan to the year 2038.

In planning facilities with capacities adequate for the design period, it should be noted that these requirements do not need to be fulfilled immediately. A more realistic approach to the development and improvement of water system facilities is a plan which reflects the phasing of improvements.

3.1.4 Water System Design Standards

DOH relies on various publications, agencies and the utility itself to develop and establish design criteria. Chapter 246-290-200 WAC, Design Standards, lists the various criteria allowed by DOH. It provides that:

- (1) Purveyors shall ensure that good engineering criteria and practices are used in the design and construction of all public water systems, such as those set out in:
 - (a) Department guidance on design for Group A public water systems;
 - (b) The most recent published edition of the *International Building Code (IBC)*, the *Uniform Plumbing Code (UPC)*, and other national model codes adopted in Washington state;
 - (c) The most recent published edition of *Recommended Standards for Water Works, A Committee Report of the Great Lakes - Upper Mississippi River Board of State Public Health and Environmental Managers*;
 - (d) Standard specifications of the American Public Works Association (APWA), the American Society of Civil Engineers (ASCE), the American Water Works Association (AWWA), or the American Society for Testing and Materials (ASTM);
 - (e) Design criteria, such as contained in current college texts and professional journal articles, acceptable to the department;
 - (f) Chapter 173-160 WAC *Minimum Standards for Construction and Maintenance of Water Wells*;
 - (g) The latest edition of the PNWS-AWWA *Cross-Connection Control Manual*, or the University of Southern California (USC) *Manual of Cross-Connection Control*.

(2) In addition, purveyors of new or expanding public water systems shall consider and use, as appropriate, the following design factors:

- (a) Historical water use;
- (b) Community versus recreational uses of water;
- (c) Local conditions and/or regulations;
- (d) Community expectations;
- (e) Public Water System Coordination Act considerations where appropriate;
- (f) Provisions for systems and component reliability in accordance with WAC 246-290-420;
- (g) Wind pressures, seismic risk, snow loads, and flooding;
- (h) Other risks from potential disasters, as feasible; and
- (i) Other information as required by the department.

3.1.5 Average Day, Maximum Day and Peak Hour Demands

The Average Day and Maximum Day Demands (ADD and MDD, respectively) are discussed in Chapter 2, Sections 2.1.4 and 2.2.6. The water demand for the District's system is forecast through the year 2038 based on historical water use patterns by customer class and projected growth within each customer class, both with and without estimated impact of future water conservation efforts.

Actual flow data for PHD for the District is not available. Therefore, DOH equation 5-1 was used to develop PHD. PHD is a function of MDD and the number of service connections for systems with more than 500 connections.

The following equation from the DOH WSDM was used:

$$\text{PHD} = (\text{MDD}/1440)[(1.6)(\# \text{ ERU's}) + 225] + 18 \quad \{\text{WSDM Equation 5-1}\}$$

For the District, the resulting ratio of PHD to MDD is 1.64 through 2026 and 1.63 from 2027 through 2038.

The detailed projections are presented in Tables 2.9 through 2.12, but the key numbers are summarized in Table 3.1 for reference.

TABLE 3.1
SUMMARY OF FORECAST ADD, MDD AND PHD
2019-2038

Type	2019	2020	2021	2022	2023	2024
<i>Without Additional Projected Savings</i>						
ADD (mgd)	1.35	1.37	1.39	1.41	1.44	1.46
MDD (mgd)	2.62	2.66	2.71	2.75	2.79	2.84
PHD (gpm)	2,986	3,032	3,078	3,126	3,175	3,224
<i>With Additional Projected Savings</i>						
ADD (mgd)	1.30	1.31	1.33	1.35	1.37	1.39
MDD (mgd)	2.52	2.55	2.59	2.62	2.66	2.71
PHD (gpm)	2,870	2,907	2,945	2,983	3,029	3,076

Type	2025	2026	2027	2028	2033	2038
<i>Without Additional Projected Savings</i>						
ADD (mgd)	1.48	1.51	1.53	1.56	1.68	1.82
MDD (mgd)	2.88	2.93	2.98	3.02	3.27	3.54
PHD (gpm)	3,274	3,325	3,377	3,429	3,706	4,005
<i>With Additional Projected Savings</i>						
ADD (mgd)	1.42	1.44	1.46	1.48	1.61	1.74
MDD (mgd)	2.75	2.79	2.84	2.88	3.12	3.38
PHD (gpm)	3,124	3,173	3,222	3,272	3,536	3,822

3.1.6 Storage Requirements

There are five components of storage that must be considered when designing a water system: operational, equalizing, standby, fire suppression and dead storage. Chapter 9 of the DOH WSDM provides recommendations and equations for determining the quantities of each component. Each of the five components is explained below with the respective equation or criteria for determining the required value.

A. Operational Storage

Operational storage (OS) is the volume of a reservoir reserved for supplying system demands during times that the supply system, usually pumps, is not delivering water.

B. Equalizing Storage

Equalizing storage (ES) provides water during periods of heavy consumption when the source of supply cannot meet the PHD. It allows

the use of smaller, more economical pumps and places less demand on the water source. Supply transmission mains can also be designed smaller because they do not have to supply peak demands.

The volume of storage required for equalizing purposes depends upon the peak hour demand, diurnal variations in demand and the rate of supply from the source(s). The DOH manual sets forth a procedure for determining the required equalizing storage utilizing the typical variables historically found in most systems. Under continuous source of supply, a mass analysis must be prepared to determine the minimum volume of ES.

Under an “on-call” demand scenario, DOH Equation 9-1 relates supply (pumping) capacity with PHD to determine an applicable ES volume.

Equation 9-1:

$ES = (PHD - Q_s)(150 \text{ min})$, where:

PHD = Peak Hourly Demand (gpm)

Q_s = sum of all installed and active sources of supply (gpm)

C. Standby Storage

Standby storage (SB) is defined as the storage necessary to augment the available supply in the event that the system’s largest source is out of service for a period of time. With five connections to SPU’s two transmission mains, and each SPU main served from a different part of the SPU system, the District’s system can be considered a multiple source system. Therefore, standby storage is determined by DOH Equation 9-3 for multiple sources which assumes the loss of the supply from the source with largest capacity.

Equation 9-3:

$SB = (2 \text{ days})(ADD)(N) - t_m (Q_s - Q_L)$, where:

ADD = Average day demand for design year (gpd/ERU)

N = Number of ERUs

Q_s = Sum of all installed and continuously available sources (gpm)

Q_L = The largest capacity source (gpm)

t_m = time remaining sources are pumped (min., usually 1440 min.)

In any event, DOH recommends that SB volume be no less than 200 gallons per ERU.

According to WAC 246-290-235, standby and fire suppression storage volumes may be nested with the larger of the two volumes being the minimum available, provided the local fire protection authority does not require them to be additive.

D. Fire Suppression Storage

The fourth component of required storage is the amount needed for fire suppression storage (FSS). Fire flow rates for the District are set forth by the local fire official. Fire flow rates are determined based on a variety of factors including land use, construction materials, building use(s), size, access and related risk-based considerations. The maximum flow for the highest risk structure in an area determines the fire flow rate requirement for that area. For commercial land uses, this determination is largely based on the requirements of the *International Fire Code*, as adopted by the local land use jurisdiction (see Appendix G).

The determination of the fire suppression storage volume is determined by DOH Equation 9-4 which multiplies the required rate by the required duration.

Equation 9-4:

$$FSS = (FF)(t_m), \text{ where :}$$

FF = required fire flow rate (gpm)

t_m = required duration (min.)

The source of supply should be adequate to replenish the fire suppression storage within 72 hours while concurrently supplying the system MDD.

E. Dead Storage

Dead storage (DS) is the volume of water not available for the system such as the lower volume in a standpipe or the upper volume in a reservoir too high to be filled by the system's source of booster pumps.

3.1.7 Distribution System

The water distribution system is required to provide dependable service. This is accomplished through interconnection and proper pipeline sizing which results in adequate water pressure and fire protection for the community. It is recommended that water pressure be maintained between 30 and 80 psi through the use of pressure reducing valves, booster pump stations, and water storage reservoirs.

All water mains shall be designed in accordance with good engineering practice by a professional engineer to suit actual conditions at the project location. All pipelines shall be constructed in accordance with the requirements of the District's methods and standards which are referenced in Chapter 7 of this plan. All water mains maintained by the District shall be owned and operated by the District. Under special circumstances the District does serve privately owned and maintained systems through master meters. This is the case with areas owned by the Port of Seattle.

In general, all water mains should be looped where feasible thus minimizing dead-end lines. The minimum size for water mains constructed within the District is 8 inches in diameter.

All decisions about required fire flow, fire hydrant quantity, spacing and location are subject to the approval of the local fire official. Hydrant spacing within the District is a maximum of 500 feet for residential areas and as close as 200 feet for commercial/industrial areas with high fire flow requirements (see *International Fire Code*, as adopted by local land use jurisdiction, Appendix G). Any hydrant branch exceeding 50 feet in length shall be 8 inches in diameter. Where the rate of fire flow for a specific building is greater than 1,000 gpm, more than one point of supply from the system is required, with a maximum of 1,000 gpm per fire hydrant. For example, if a commercial building requires 2,500 gpm fire flow, two hydrants and an additional fire service line, or a minimum of three fire hydrants, would be required to deliver that flow.

3.1.8 Fire Flow Standards and Performance

Fire protection is of primary importance in nearly all communities. In most circumstances, water flows for fighting fires produce the highest demand on the water system. The 2015 IFC was adopted by the City of Burien effective June 2016. Appendix B & C of the 2015 IFC are in Appendix G of this Plan for reference.

Under these standards the current fire flow requirements are a minimum of 1,000 gpm for a period of one hour for all single family residences under 3,600 square feet. All commercial buildings and residences larger than 3,600 SF are governed by size and type of structure. These standards are presented in Table B105.1 of the 2015 IFC.

In addition to IFC requirements, the City of Burien code requires automatic sprinkler systems to be installed in all buildings over 5,000 square feet and all residences over 3,600 square feet. The City of Normandy Park requires all residences to be sprinklered. The installation of sprinkler systems reduces the fire flow requirements for the structure to 50% of the required flow or 1,000 gpm, whichever is larger.

Single family dwellings under 3,600 square feet, which are located in areas that cannot provide the 1,000 gpm minimum fire flow, can also have sprinkler systems installed to reduce fire flow requirements. If sprinklers are installed, the required fire flow is lowered to 500 gpm for a period of half an hour. Very large (e.g. 6,200 to 11,300 sf) residences will require up to 1,375 gpm fire flow, with sprinkler protection.

The highest commercial building fire flow requirement, with sprinkler protection, is 4,000 gpm for four hours.

3.1.9 System Pressure

According to WAC 246-290-230 and Chapter 8 of the WSDM, water systems shall be designed to maintain a minimum residual pressure of 30 pounds per square inch (psi) at the meter, under PHD conditions, excluding fire demand. A residual pressure of 20 psi shall be provided throughout the system under combined fire flow and MDD conditions.

As stated in the District's *Developer Extension Manual* (DEM), the size of a new water line shall be as necessary to meet the WAC 246-290-230 and WSDM requirements stated above, with a maximum velocity of eight feet per second (fps). The District goal is to provide a minimum pressure of 40 psi throughout the system under PHD conditions. The maximum pressure at the point of customer connection should be 80 psi. (Some portions of the existing distribution system are subject to pressures in excess of 80 psi, due to pressure zone and local topography variations.)

Booster pump stations should be designed with multiple pumps of such capacity that the MDD of the service area could be provided, at 30-psi minimum, with the largest pump out of service. The station should be designed to provide a minimum of 20 psi at the pump suction manifold under fire flow plus MDD conditions. The station should include an automatic shutdown feature should the suction pressure drop below 10 psi.

3.1.10 Minimum Pipe Sizes/Looping

Water line extensions shall be continued through or along the property being developed for potential future connection or extension.

Water mains shall be a minimum of 8-inch diameter if providing fire flow, or larger in accordance with this plan. Mains not providing fire flow may be smaller under certain conditions. Details are presented in the District DEM. Engineering analysis should be completed for each extension considering the specific fire flow requirements and hydraulic conditions for the development.

Velocities in the pipe system should not exceed eight fps under PHD conditions, but all pipes should ideally be capable of being flushed at 2.5 fps under ADD conditions.

The water mains shall be "looped" where feasible within the proposed development and/or designed with multiple connections to the existing water distribution system in accordance with this plan or as required by the District to provide the required adequate flow and pressure and reliable supply to the most remote hydrant and service in the proposed water extension.

3.1.11 Telemetry and Control Systems

Telemetry and control systems shall be included with each reservoir and pump station. These systems shall be designed for local or remotely controlled automatic operation. Telemetry communication shall be via the existing radio system, where feasible and authorized by the FCC or by phone depending on local topography. Critical levels, flow, pressure, function, etc. shall be continuously monitored and unusual conditions shall be annunciated locally, to the water headquarter office or via the auto-dialer to the “on-call” operator.

3.1.12 Standby Power Requirements

The main objective of standby power requirements is to assure that the system is pressurized at all times to minimize cross-connection contamination concerns and maintain minimum service pressures. Each booster pumping station should contain no less than two pumps with capacities such that peak demand can be satisfied with the largest pump out of service. Standby power shall be provided from at least two independent sources or a standby or an auxiliary source should be provided.

The District’s water system can continue regular service during power outages because of multiple taps to SPU’s transmission system. There are no provisions at the pump station to allow connection of a portable generator for electrical power supply during extended power outages.

District staff recommends consideration of a natural-gas powered standby power generator at the existing reservoir booster pump station. This consideration should be made in the context of additional storage capacity and related pump facilities.

3.1.13 Valve and Hydrant Spacing

Fire hydrants shall be installed along all water mains in the distribution system and shall be placed within 250 feet of any structure. Maximum spacing of fire hydrants shall be 500 feet in single family residential areas and can be as close as 200 feet for commercial/industrial areas with high fire flow requirements or as required by the local fire district requirements, if more stringent.

Valves shall be installed at all branches of tee and cross pipeline intersections unless otherwise approved by the District. Valves shall be installed at intersections, at intervals not to exceed 800 feet in the distribution system and 1/4 mile in transmission mains. Mainline valves shall be installed at fire hydrant locations so that only one fire hydrant is out of service at any one time. Auxiliary valves shall be installed on each hydrant branch.

Details regarding hydrant materials and installation are included in the District DEM (referenced per Chapter 7).

3.1.14 Summary of System Design Standards

The system design standards described in the previous sections, in addition to other standards, have been summarized in Table 3.2 below.

**TABLE 3.2
SYSTEM DESIGN STANDARDS**

Parameter	Minimum Standard
Water Quality	Federal Safe Drinking Water Act and State Statutes (DOH) for Maximum Contaminant Levels (WAC 246-290-310)
Maximum Day Demand	2 x ADD
Peak Hour Demand	Per DOH Equation 5-1
Storage	Per DOH WSDM Chapter 9
Fire Flow	1,000 gpm for 60 minutes for single family residence under 3,600 sq. ft. Commercial and larger residences per adopted IFC (Maximum anticipated: 4,000 gpm for four hours)
Minimum System Pressure	30 psi during PHD conditions 20 psi under MDD plus fire flow conditions
Minimum Pipe Size (for additions to system)	8 inch
Valve Spacing	At all tees or crosses and 800 ft. max. on pipe runs
Hydrant Spacing	Per local fire official Generally 500' maximum in single family residential areas and as close as 200' for commercial/industrial areas with high fire flow requirements
Construction Standards	See Developer Extension Manual
Cross-Connection Control	Per WAC 246-290-490 and most current <i>Cross-Connection Control Manual</i> by the Pacific Northwest Section of the American Waterworks Association Cross-Connection Control Committee

The performance and design criteria address the size and reliability requirements for source, storage, and distribution to meet the domestic and fire flow water demands of the system. Construction standards set forth the actual materials and construction standards that contractors, developers and the District must follow when constructing water system facility improvements.

The design standards include the DOH standards as presented in the December 2009 WSDM and the District 49 DEM, latest edition. In case of conflict between these standards, the most stringent standards shall apply.

3.2 Water Quality Analysis

Public water systems are obligated to supply their customers with healthful, palatable water. Group A public water systems must comply with the provisions of the Safe Drinking Water Act (SDWA). DOH enforces the SDWA and regulates bacteriological contaminants, inorganic chemicals (IOC's), inorganic physical parameters, volatile organic chemicals (VOC's), synthetic organic chemicals (SOC's), lead and copper, radionuclides, trihalomethanes, arsenic and asbestos.

WAC 246-290-200, Design Standards, lists various criteria allowed by DOH. These water quality parameters include maximum contaminant levels (MCL's) for a variety of potential organic, inorganic and radioactive constituents in the water supply. The water supply must be free from pathogenic bacteria and carry a residual of chlorine for disinfection throughout the water system.

There are also secondary MCLs for constituents which may not result in health problems, but may lead to taste, odor and other aesthetic objections from water system customers. Additionally, the water must be periodically tested for asbestos, lead and copper, to determine the interaction of the water with the distribution piping and private service/plumbing piping used for delivery of water to the customer's tap.

Additional drinking water regulations will become effective in the next several years. These regulations will impose new regulatory requirements for sulfate, radionuclides, additional IOCs and SOCs, and additional disinfection by-products and bacteriological contaminants.

DOH is the primary agency responsible for ensuring state drinking water laws are implemented and enforced. Washington State must adopt laws at least as stringent as the federal regulations. When a federal drinking water law has yet to be included in state drinking water codes, drinking water purveyors are responsible for meeting federal regulatory requirements as put forth by the USEPA.

SPU is responsible for monitoring the water sources and water quality directly after treatment. Since the District does not own or operate any drinking water source, the District is responsible solely for monitoring and maintaining compliance with drinking water regulations that apply to distribution system water quality. The appropriate water quality regulations and the status of the District with respect to each regulation is included in Table 3.3.

**TABLE 3.3
SUMMARY OF APPLICABLE REGULATIONS AND COMPLIANCE STATUS**

Regulation	Requirements	District Status	Compliance?
Phase I (VOCs) and Phase II and Phase V (IOCs and SOCs)	Written Plan/ Monitoring	SPU monitors after treatment prior to SPU's distribution system	Yes
Surface Water Treatment Rule/ Interim Enhanced Surface Water Treatment Rule	Written Plan/ Monitoring	SPU monitors	Yes
Total Coliform Rule	Written Plan/ Monitoring	SPU collects routine TCR samples and District Staff collects repeat TCR samples within the distribution system	Yes
Chlorine Residual	Written Report/ Monitoring	District collects samples	Yes
Lead and Copper Rule	Monitoring/ Treatment for corrosion control	District Monitors, Meets MCLs	Yes
Stage 2 D/DBP Rule	Monitoring	District samples and SPU monitors D/DBPs throughout distribution system, meets MCLs	Yes
Radionuclides Rule	Monitoring	SPU monitors, meets MCLs	Yes
CCR and Public Notification Rules	Annual Reports / Reporting as needed	District Publishes Confidence Reports annually	Yes

Table 3.4 provides a summary of water quality monitoring requirements for the District, including the parameters to be monitored, sampling location, and frequency. The District is in compliance with monitoring requirements.

The District has developed a Coliform Monitoring Plan and a Stage 2 Disinfection By-Products Rule (DBPR) Monitoring Plan which guide monitoring for these particular parameters. The State of Washington identifies rules and guidelines for other monitoring requirements.

The yearly sampling requirements for the Stage 2 DBPR and the final Individual Distribution System Evaluation (IDSE) report have been completed and submitted to United States EPA. The USEPA has approved the standard monitoring report and a

copy of the approval letter is included in Appendix C. Stage 2 DBPR compliance monitoring began in 2012.

**TABLE 3.4
SUMMARY OF EXISTING MONITORING REQUIREMENTS**

Parameter	Regulatory Requirement	Location	Frequency
Inorganic Compounds	Primary Drinking Water Regulation	Point of entry into SPU's distribution system	Once every 9 years under a waiver from the Washington DOH. Nitrate once/year.
Organic Compounds	Phase I, II and IV	Point of entry into SPU's distribution system	SPU collects once every 3 to 9 years, depending on the parameter
Secondary Inorganic Compounds	Secondary Drinking Water Regulations	Point of entry into SPU's distribution system	Once every 9 years under a waiver from the Washington DOH
Bacteriological	Total Coliform Rule	Throughout the District's distribution system	15 samples/month
Chlorine Residual	Surface Water Treatment Rule	Throughout the District's distribution system	Daily
Lead and Copper	Lead and Copper Rule	Customer taps	Once/ three years
TTHM & HAA5	Stage II DBPR Compliance Monitoring	Throughout the District's distribution system	4 sampling sites at high TTHM & HAA5 locations, 4 times per year
Radionuclides	Radionuclides	Point of entry into SPU's distribution system	Once/four years

The District utilizes the following state certified laboratories to perform water quality testing. The contact information is listed below:

Seattle Public Utilities – Water Quality Laboratory
 800 S. Stacey Street
 Seattle, WA 98134
 206-684-7834

Pace Analytical Services, Inc.
940 S. Harney Street
Seattle, WA 98108
206-767-5060

The District presently purchases all of its water from SPU. WD 49 has no district-owned sources of water and does not foresee any plans in the near future for developing its own water source.

The SPU system currently has two major sources of water supply: the Cedar River System located southeast of Seattle which provides approximately 70% of SPU's total water supply and the Tolt River system located east of Duvall which provides approximately 30% of Seattle's total water supply. Since SPU provides the water to the District, SPU is responsible for source water quality.

At times of peak demand, SPU can supplement its existing water supply system by utilizing three on-line production wells (two wells at the Riverton well field and one well at the Boulevard Park well field) located near the Riverton Heights Reservoir. The wells are located north of SeaTac airport and have a total capacity of 10 MGD. The wells are operated under a temporary water rights permit. A portion of WD 49 is situated within the Boulevard Park well field recharge area.

In accordance with the SDWA, the District informs all of its water customers about the quality of the water provided to them with an annual Water Quality Report. This report is prepared each year and furnishes the results of the water quality analysis covering the previous calendar year. SPU is responsible for the water quality delivered to the District and provides the analysis results for District notification. There have been no reported violations in the inorganic water quality contaminants.

Copies of the District's 2015, 2016 and 2017 Annual Water Quality Reports are included in Appendix F.

3.3 SYSTEM DESCRIPTION AND ANALYSIS

3.3.1 Source

In 2011, the District signed a new water supply contract with SPU for the purchase of water through the year 2062. A copy of the signed contract is included in Appendix D.

Under normal operating conditions the water supplied to the District is generally supplied from the Cedar River Watershed, with water from the Tolt River Watershed never reaching the District. However, SPU's system is configured to deliver water from either source.

The *2019 SPU Water System Plan* indicates their source of supply system has an estimated firm yield of 172 mgd. The revised forecast shows total demand increasing

gradually to 137 mgd by 2039 and then declining to stay relatively flat at about 133 mgd through 2060.

The portions of SPU's regional supply system which are directly related to the operation of the Water District No. 49 system consist of a 24-inch line which runs along SW 146th Street and a 24-inch line that runs along Des Moines Way. The line running along SW 146th Street, which is referred to by the District as the north line or the "pumped" water line, originates at the Burien Pump Station at South 146th Street and 8th Avenue South. This line is also interconnected to the West Seattle Reservoir by a 12-inch and a 20-inch line.

The line running along Des Moines Way, known by the District as the east line or the "gravity" water line, is also supplied by the Riverton Heights Reservoir. However, this line is not connected to the booster station.

WD 49 purchases all of its water from SPU. As stated above, the water supplied by SPU reaches the District at two different hydraulic gradient levels creating two separate major pressure zones within the District. The District has five master meter connections to SPU's regional transmission system. The District manages the supply of water in each zone and can transfer water from zone to zone if required.

The District has two master meters on the "pumped" water system. The water is pumped from SPU's Riverton Heights reservoir to a hydraulic gradient of at least 575 feet by the Burien Pump Station. This system supplies water to the District's 575 pressure zone. This zone makes up the majority of the District's service area.

The District has three master meters on SPU's "gravity" system which has a hydraulic gradient of at least 430 feet. These meters supply water to the District's minor pressure zones and to the reservoir.

System demands are generally evenly spread across the District. The main pressure zone, which is fed by the "pumped" water line, covers approximately 56% of the District. The second largest pressure zone, which is fed by the "gravity" water main, covers approximately 37% of the District. The minor pressure zones, which are fed by these two larger pressure zones, cover the remainder of the District.

The District's connections to the regional distribution system and the transmission mains operated by SPU are reportedly in good condition. The combined delivery capacity of the District's five connections to the regional system, in gallons per minute, is much greater than the projected MDD of the District.

The most recent SPU contract included more detail about SPU's responsibility for water supply, through the five interties with the District. These are indicated in Exhibit II to the water supply contract (see Appendix D). Three interties are designated for primary use and two are designated for backup supply purposes. However, all are readily available for service. SPU is obligated to deliver up to 1,500 gpm (2.16 mgd) through the two

interties serving the District's 575 pressure zone, at minimum hydraulic gradients of 550 feet and 540 feet. SPU is obligated to deliver up to 1,000 gpm (1.44 mgd) at a minimum hydraulic gradient of 430 feet to the District's 425 pressure zone. The two backup sources are connected to the 425 pressure zone, with minimum supply hydraulic gradients of 420 and 395 feet.

The total commitment from SPU is for 2,500 gpm or 3.6 mgd. This is intended to cover fully the maximum day supply requirements for the foreseeable future and is 1.6 percent higher than the year 2038 MDD forecast of 3.54 mgd (see Table 3.1).

Generally, an additional quantity of water is available from the SPU interties, but SPU is not obligated to meet delivery rates higher than indicated in the contract, subject to the needs of their direct customers, other purveyors in the region or operations, maintenance or construction activities in the SPU delivery system. SPU addressed this in a clarifications letter in late 2014 (see Appendix D).

The District is not aware of any circumstances that would limit the ability of SPU from providing the necessary quantity and quality of water to meet the projected needs of the District. Therefore, the source capacity of the District is not foreseen to be a limiting factor in the growth of the District. Further information regarding the Cedar River and Tolt River sources can be found in the Seattle Public Utilities *2019 Water System Plan*.

Major elements of the District's system are shown on Figure 3-1.

3.3.2 Seattle Master Meters

Water is purchased from SPU at five points of delivery through master meters owned, operated and maintained by SPU. One master meter (Station 143) is used exclusively as an emergency supply to provide fire flows to a large apartment complex and the south end of the District.

Water is supplied directly into the District's distribution system. Station 139 and 142 each have a pressure reducing station and flow control installed on the primary feed and a pressure reducing station installed on the secondary parallel feed. Station 143 only has a primary feed and has one pressure reducing station installed. The supply points at Stations 25 and 140 do not have pressure reducing valves installed; therefore the hydraulic gradient provided by the SPU system also establishes the District's pressure zones gradients at these stations. All of the pressure reducing stations noted above belong to the District and are downstream of the SPU supply meters.

Location and size of the master meters are shown in Table 3.5. The minimum hydraulic gradient (head) that SPU provides at each location is also shown.

**TABLE 3.5
SPU MASTER METERS**

METER			Meter No.	Min. Head Ft.	Elevation	PSI
Location	SPU Number	Size of Meter (In)				
<i>575 (Main) Pressure Zone</i>						
SW 149 th St.& 10 th Ave SW	139	10	70025553	540	369	74
SW 146 th St. & 8 th Ave SW	142	8	70069777	550	385	72
<i>425 Pressure Zone</i>						
S. 168 th St. & Des Moines	25	8	70081077	420	241	78
S. 160 th St. & Des Moines	140	12	14482003	430	271	69
Ambaum Bl. & Des Moines	143	10	5149253	395	253	62

Seattle Public Utilities Demand Charges

By the early 1970's the City of Seattle Water Department, now Seattle Public Utilities (SPU), realized that its regional system was near capacity during the summer months of June, July and August. In an effort to reduce this peaking of the regional system, SPU established a demand charge to be levied against purveyors that draw peak demand water from the regional system. The demand charge was based on the peak usage of the 10 maximum consumption days during the months of June, July and August. The intent of the demand charge was to encourage purveyors to construct and operate storage facilities to limit peak demands on SPU's transmission mains and facilities.

The construction of the District's reservoir, which is further detailed in Section 3.3.4, resulted from an agreement between the District and SPU to help prevent the District from receiving demand charges.

SPU has not imposed a demand charge on the District for many years. However, the current water supply contract retains SPU's right to calculate and impose a demand charge where excessive peak flow withdrawals are occurring. This provision encourages local purveyors to construct and maintain adequate storage facilities.

3.3.3 Water Treatment

SPU is responsible for treatment of the water supply.

Seattle has two large regional watersheds, the Cedar and Tolt, which supply Seattle and surrounding communities with drinking water. The Cedar River Watershed is located southeast of Seattle. This watershed provides about 70% of the drinking water to people in the greater Seattle area. Melting snow and rain are gathered and stored in the Chester Morse Lake and the Masonry Pool reservoirs created by the Masonry Dam. The dam diverts the water into two large penstocks which drop water 620 feet to the

hydroelectric power plant at Cedar Falls, the birthplace of Seattle City Light. The water is released back in to the river and continues flowing to the Landsburg diversion dam. At Landsburg, a portion of the water is diverted from the river into two large pipelines which run to Lake Youngs in Renton. From Lake Youngs, water is pumped a short distance to the Cedar Water Treatment Facility. The Tolt River Watershed is in the foothills of the Cascades in east King County. It supplies about 30% of the drinking water for the people in the greater Seattle area. The Tolt Reservoir captures water and snow from the Tolt watershed. Most of this water is released from the dam directly to the South Fork Tolt River. A portion of the water is drawn through penstocks to a small hydroelectric facility. There it enters a small body of water called the regulating basin. The water then continues its journey, all by gravity, to the Tolt Water Treatment Facility. While the source water is good to start with, the Tolt and Cedar Water Treatment Facilities improve on that source quality in order to meet health standards and SPU's taste and odor requirements. The Tolt facility uses a variety of compounds to achieve optimal water quality and includes filtration, ozonation, chlorination, fluoridation and the addition of minerals for corrosion control. The Cedar facility uses ozonation, UV disinfection and chlorination for treatment. From the treatment facilities, the drinking water enters one of several large pipelines which run the 20 miles or more to Seattle and surrounding communities. Transmission mains branch off into smaller pipes, to water storage tanks and reservoirs, sometimes to water pumping stations, and to adjacent cities and water districts.

Additional information about the SPU water source and testing is available in the SPU water quality annual report available online at:

http://www.seattle.gov/util/MyServices/Water/Water_Quality/WaterQualityAnnualReport/index.htm

The District does not provide treatment of water within its distribution system.

SPU collects water samples monthly at eight sampling stations located throughout the District's distribution system, for routine analysis for coliform, temperature and chlorine. SPU will contact the District if a routine coliform sample is positive so that District staff can collect the required repeat coliform samples within the distribution system within 24 hours, per the WAC. The District collects samples quarterly at four additional locations for disinfection byproduct sampling. If other water quality problems exist in the distribution system (i.e. contamination), it is the responsibility of the District staff to be aware of it and take appropriate action. The District recently completed installation of an automated continuous chlorine analyzer to facilitate daily monitoring of chlorine residual in the distribution system.

3.3.4 Storage

A. General Description and Condition

In 1984, the District investigated storage alternatives to avoid SPU demand charges. A deep well and pump system located at 4th Avenue SW and SW 146th Street was determined to be potentially more cost effective than construction of a reservoir.

An aquifer test of an exploratory well, drilled in the spring of 1985, concluded that a potential interference existed between the District's proposed well and SPU's wells and that a District well would impact SPU's deep well program.

The District and SPU negotiated to find a mutually acceptable solution to lowering the District's demand charges. As a result, the District agreed to sell its water rights to SPU, and in exchange, SPU would contribute funding toward the construction of a reservoir.

In the summer of 1988, the District completed construction of a reservoir located at SW 158th Street and 4th Avenue SW. The reservoir is a partially buried, above-grade circular concrete reservoir with pump station which was constructed to transfer water from the 425 pressure zone to the 575 pressure zone during periods of high demand. Water in the reservoir is supplied to and drawn from the bottom through separate piping. Under typical demand conditions, water within the reservoir is replaced approximately every day.

The District's reservoir structure is approximately 57 feet in diameter and 25 feet in height. Water volume is about 500,000 gallons of storage capacity; however, the purpose of the reservoir is to reduce or eliminate the demand charges from SPU. The following section analyzes the District's required level of storage capacity.

The interior of the reservoir was cleaned and inspected in 2013.

A booster pump station was constructed as an integral part of the reservoir structure. The station has three pumps with all related controls, valves, electrical and mechanical systems and telemetry. There are two pumps of 400 gpm capacity with 60 horsepower motors and one pump of 800 gpm capacity with a 125 horsepower motor.

The reservoir receives water from the SPU "gravity" water supply system in Des Moines Drive through the District's 425 pressure zone distribution system.

The reservoir is filled at a constant rate over each 24-hour period. The water is pumped from the reservoir into the 575 pressure zone during high demands periods, thus reducing the peak demands on SPU's regional system.

Table 3.6 presents the general description of the reservoir.

**TABLE 3.6
EXISTING RESERVOIR**

Ownership – WD 49	100%
Type of reservoir	Surface Partially buried
Material type	Concrete
Total capacity	0.5 mg
Size of Facility	57' diam, 25' high
Pressure Zone Served (With Pump Station)	575 pressure zone
Age/future life expectancy	27 yrs/50 yrs
Pumps – 2 units	400 gpm/60HP
1 unit	800 gpm/125HP
Painting –Interior (PS)	2000
- Exterior	N.A.
Last inspection/ Cleaning	2013
Isolation valves	Yes
Sample tap	Yes
High & low level alarms	Yes
Low level indication	Yes
Drain facilities	Yes
Overflow pipe	Yes
Air Gap on overflow/drain	Yes
Tank atmospheric vents w/ non-corroding insect screen	Yes
Locks/fences to prevent unauthorized entry	Yes
Water tight, insect proof access hatches, vents	Yes
Access ways and ladders for maintenance access	Yes
Removable silt-stop on the outlet pipe	No
Slope of Reservoir roof	Minimal
Piping material below reservoir & extending 10'	Ductile Iron
Separate inlet and outlet pipes	Yes
Seismic Restraint	No

B. Storage Capacity Analysis

Prior to 1988, the District operated with no storage facilities. The District continues to function primarily as a distributor with limited storage capacity.

As discussed in Section 3.3.1, the District relies on two pipelines from SPU's regional system. The "pumped" north line and "gravity" east line both provide water to the

District and pass through the District to supply water to other districts as well. To analyze possible storage needs, the hypothetical loss of one of these pipelines or an individual supply meter has been considered.

The loss of service from the gravity east supply line is one potential challenge. South of South 156th Street, SPU's 24" main is a dead end pipe. Problems with the SPU pipe between South 156th Street and South 160th Street would cut off the District's supply to the 425 pressure zone. However, with the SPU north line still operating under this scenario, the District's two connections to the north line could provide water to the entire District including the 425 pressure zone through PRV interconnections from the major to the minor zones.

Complete loss of service from SPU's pumped north line is also possible but unlikely. Because of valve arrangement and spacing, geometry of SPU's pumped water system and the flexibility in operation that is possible in the SPU system regarding pumping and supply from their various reservoirs, it is highly unlikely that their entire pumped water system would be off at one time. However, a short section of the SPU main or an individual master meter (meter 139 or 142) could be shut off individually.

Loss of water supply from an individual SPU master meter also occurs during SPU's shutdown of the meter during its yearly routine maintenance and testing program.

As described in Section 3.3.6 and Chapter 4, the District has five interties with King County Water District No. 20 (WD20), and two with Highline Water District (HWD). The WD20 interties are all between the WD20 575 pressure zone and the District's 575 pressure zone, both of which are supplied by multiple connections to the SPU "pumped" water supply system. Two of these interties are set up for automatic delivery from one system to the other, on a drop in local system pressure. The other three are manually operated. Depending on local conditions, each intertie can supply upwards of 1,500 gpm to the system in need. WD20 has five interties to its 575 pressure zone and, in addition, can pump water to this zone from its six million gallon reservoir, supplied directly by an additional SPU service. WD20 shares the volume of that reservoir with King County Water District Nos. 45 and 125.

The interties with Highline (one each for supply typically in each direction) are intended for service for local emergency or planned maintenance situations and do not appreciably impact the total supply for the District.

Calculations of the various components and minimum recommended total storage volumes have been determined as outlined in Section 3.1.6 of this report and are based on the DOH WSDM Chapter 9. Specific storage results for the recent conditions (2018) and the future conditions (2038) are summarized below.

The District is concurrently preparing a Project Report in anticipation of completing design and construction of a second storage reservoir. The geometry of the second

reservoir indicated below is based on preliminary analysis. Details will be presented in the Project Report.

Operational storage (OS) is necessary to meet system demands when water is not being supplied by the source. The District relies on a continuous supply from the SPU regional supply system. Even though the risk of loss of this continuous source is very low, it is prudent to plan for a small amount of OS. The OS of the existing gallon reservoir is 4.0 feet (or 0.08 MG) and should be accounted for in the current and future OS volume. Preliminary analysis for a second reservoir suggests an allowance of 0.5 feet (or 0.05 MG) from overflow to normal low water level for OS volume. The two combined results in an OS of 0.13 MG for year 2018 and 2038.

Equalizing storage (ES) provides water during periods of the day when system demands are higher than source capacity. Under normal operating conditions, the capacity of the District's connections to the regional system is much greater than the projected demands of the District. However, the contract supply rate from SPU is less than the PHD throughout the planning period.

A mass demand analysis was developed to evaluate ES. A diurnal curve was developed based on a summer holiday weekend demand pattern, adjusted to achieve the planning level ratio of Q_{peak} to Q_{avg} and then escalated for the MDD in 2018 and 2038. Once these curves were developed, the volume above the SPU supply rate of 2,500 gpm was calculated to determine ES. ES required for year 2018 is 0.05 MG and for year 2038 ES is 0.40 MG.

Standby Storage (SB) for a multiple-source system assumes the loss of the largest capacity source to the system. Because of the number and size of the connections to SPU supply mains and the District's well-looped, hydraulically-efficient distribution system downstream of the supply points, total supply capacity is at least 9,000 gpm, but this rate is not guaranteed and is limited to 2,500 gpm by contract.

Though highly unlikely, the loss of the largest SPU source of supply (1,000 gpm) was considered. It was also assumed, for this analysis, that the WD20 emergency interties would not provide supplemental supply. Using DOH WSDM Equation 9-3, the resulting SB storage for 2018 is 1.16 MG and for 2038 is 2.2 MG.

DOH recommends that regardless of the amount calculated by Equation 9-3, standby storage should not be less than 200 gallons per ERU. Standby storage calculated by this method was greater than the value for 2018 but slightly less than the value for 2038, as calculated using Equation 9-3. The minimum recommended SB storage for 2018 is 1.52 MG and for 2038 is 2.20 MG.

Fire suppression storage (FSS) is based on a flow rate of 4,000 gpm for a duration of four hours. Therefore, required FSS for both year 2018 and 2038 is 0.96 MG.

Dead storage (DS) is the unusable water in the bottom of a reservoir. The DS in the existing reservoir is controlled by minimum water elevation for the booster pumps and amounts to 0.06 MG. Preliminary analysis for a second reservoir suggests an allowance of approximately 1.25' (about 0.11 MG) of DS for the new facility, based on control levels for low water level. The total DS volume for both year 2018 and 2038 is 0.18 MG.

According to the DOH WSDM Chapter 9, water systems can exclude the smaller of the standby or fire suppression storage (nesting), as long as this practice is not prohibited by local ordinance or the local fire official. In this case, the local fire official recommends, but does not require, that SB and FSS not be nested. Because of the high reliability of the SPU continuous supply, it would be reasonable to nest SB and FSS and use the larger of the standby and fire suppression storage to calculate the total storage volume for the District, even though this approach is not recommended by the local fire official.

Table 3.7 summarizes the minimum recommended storage volumes for 2018 and 2038.

**TABLE 3.7
STORAGE ANALYSIS**

Storage Component	Year 2018	Year 2038
Operational Storage	0.13	0.13
Equalizing Storage	0.05	0.40
Standby Storage	1.52	2.20
Fire Suppression Storage	0.96	0.96
Dead Storage	0.18	0.18
Total Required	2.84	3.86
Available	0.48	0.48
Surplus/(Deficit)	(2.36)	(3.38)

(Volumes in million gallons)

It is recommended that the District construct a new reservoir with a total volume of 3.4 MG, which assumes the continued use of the existing 0.48 MG reservoir. Pre-design work in support of this project has concluded that the new facility should have a nominal capacity of 3.7 MG.

3.3.5 Pipe Distribution System

The District's distribution system is made up of two major pressure zones, which are both connected to SPU's regional distribution system. Each zone operates independently of the other; however, water can be transferred between zones if required. Several minor pressure zones receive water from the larger, major zones through pressure reducing valve stations.

A hydraulic profile of the District is included as Figure 3-3.

The 575 pressure zone, which encompasses most of the District, is fed through a 24-inch line from SPU's Burien Pump Station. The pump station boosts water from the Riverton Heights Reservoir to a hydraulic gradient of at least 575 feet. The 425 pressure zone is supplied by the same reservoir through a separate 24-inch line. Its hydraulic gradient is at least 430 feet.

The District's transmission and distribution system is a well-looped, hydraulically efficient system covering generally all of the service area. Large 10-inch and 12-inch mains convey water from the areas of the regional system connections to outlying areas. Distribution mains are primarily 8-inch in diameter; however, about 53,600 feet of 6-inch and smaller cast iron mains still remain in use. An ongoing main replacement program schedules the replacement of these smaller cast iron mains with 8-inch ductile iron. Most of the system has been installed or replaced since 1960.

The lowest pressures in the District are in the higher elevation areas along the west side of the airport in the south portion of the District. Service pressures in these areas are in the range of 40-50 psi.

In some places the system pressures exceed 80 psi. These areas are in the lowest elevation areas of the pressure zones. Residents in these areas have been advised of these pressures and are instructed to maintain pressure reducing valves on their water service to regulate their individual system pressure.

As mentioned above, the system is generally well looped; however, there are numerous short dead end lines located within the service area. A complete inventory of the District's distribution system is included in Table 3.8 and a map of the water system, including appurtenances, is included as Figure 3-2.

Evidence from District maintenance records and routine inspections suggests that the overall system is in acceptable condition with isolated locations highlighted as trouble spots. The majority of system repairs are made on the aging cast iron mains and the related galvanized service connections. In these areas, leaks are commonly caused by the deterioration of the galvanized service line between the water main and the service meter.

All water system “as-built” records are kept by computer mapping and include the locations of all facilities, pipe sizes and hydrant and valve locations. Dates of installation for pipelines are also noted for all new pipelines.

Fire hydrants generally have adequate spacing and coverage per the requirements of the local fire official. Locations of isolation valves are generally good with limited areas having greater than desired valve spacing. The addition of valves and fire hydrants where identified are included in main replacement projects and developer extensions.

The District’s water system includes approximately 640 fire hydrants and 60 miles of ductile iron and cast iron pipe. There are no asbestos cement (AC) mains or large diameter steel water mains remaining in service. There are minor amounts of plastic and galvanized steel water main below 4” diameter, primarily 2” diameter.

Installation of a water system improvement or extension can be by District capital improvement project, a Developer Extension or by a utility local improvement district (ULID) process. The District’s system inventory is shown in Table 3.8.

**TABLE 3.8
SYSTEM INVENTORY**

Water Main Size and Material	Linear Feet
Unknown diameter and material	1,711
Less than 4” Galvanized and Plastic	2,085
4” Ductile Iron and Cast Iron	11,832
6” Ductile Iron and Cast Iron	39,928
8” Ductile Iron and Cast Iron	218,160
10” Ductile Iron and Cast Iron	21,400
12” Ductile Iron and Cast Iron	22,114
(Total Length = 317,230 Linear Feet or Approximately 60.1 Miles)	
Fire Hydrants	Quantity
2 and 3 Port Hydrants	677
Valves	1,231

In 2016 the Governor issued Directive 16-06 which, part, directed Group A water systems to identify all lead service lines and lead components in their systems, and plan to remove them within 15 years. The present District Superintendent has worked for the District for approximately 25 years, in roles of increasing responsibility. He reports that he has never observed or seen record of lead service lines or lead components in the existing system and therefore believes they are none in the system. The District has completed numerous water main replacement projects over his years of service and all those projects include replacement of the main and service lines. While there are galvanized lines in some areas he has not observed lead goosenecks in the system.

3.3.6 Interties with Adjacent Purveyors

As described above, in addition to the five connections to SPU’s regional supply system, the District maintains seven interties with two of the adjacent water districts. Status of these interties is shown in Table 3.9.

**TABLE 3.9
INTERTIES WITH ADJACENT PURVEYORS**

Location	District	Open/Closed	Metered
SW 144 th & Ambaum Blvd	WD 20	Closed	No
S. 152 nd St. & 4 th Ave. S.	WD 20	Closed	No
SW 154 th & 21 st Ave. SW	WD 20	Open	Yes
SW 152 nd & 16 th Ave. SW	WD 20	Open	Yes
1 st Ave. S. & SW 144 th	WD 20	Closed	No
SW 170 th & 27 th Ave. SW	Highline WD	Open	Yes
S. 177 th St. & 10 th Ave. S	Highline WD	Open	Yes

All of these interties are normally inactive and are maintained as emergency interties between the districts. The three closed interties are isolation valves which are normally closed and which must be opened manually to transfer water to either district. The remainder are metered interties with automatic control valves.

3.3.7 Pressure Zones

Along the north side of the District, SPU maintains a “pumped water” system which provides a minimum hydraulic gradient of 550 feet. This system supplies water to the District’s 575 pressure zone at master meter stations 139 and 142.

Along the east side of the District, SPU operates a “gravity water” system that provides a minimum hydraulic gradient of 430 feet. This system supplies water to the District’s 425 pressure zone at master meter stations 25, 140 and 143.

Because of low ground elevations along the west and south sides of the District, the District maintains four minor pressure zones which receive water from the two major zones through pressure reducing valve stations.

These minor zones are the 497, 483, 380 and 336 pressure zones.

Figure 3-1 shows a map of the hydraulic pressure zones. Figure 3-3 shows the District's hydraulic profile. The pressure zones are summarized as follows:

A. 575 Pressure Zone (1)

As can be seen from Figure 3-1, the 575 pressure zone covers the majority of the District encompassing approximately 1,217 acres or 56.0% of the total area within the District. This pressure zone serves the bulk of the District lying above 300-foot elevation mean sea level.

The 575 pressure zone is supplied water from the SPU "pumped water" transmission main through Master Meters 139 and 142. This pressure zone is also supplied water from the "gravity water" system through the District's 425 pressure zone, reservoir and pump station.

B. 425 Pressure Zone (2)

The 425 pressure zone is the other major pressure zone covering about 806 acres or 37.1% of the District. Ground elevations are primarily between 175 and 330 feet mean sea level.

This pressure zone receives water from SPU's "gravity" water system in Des Moines Drive through master meters 25, 140 and 143. The pressure zone can also receive water from the 575 pressure zone through pressure reducing valve stations.

C. 497 Pressure Zone (5)

The 497 pressure zone is a very small zone of about 5 acres (0.2%) in the south end of the District. Ground elevations generally lie between 190 and 250 feet above mean sea level.

This pressure zone is supplied water from the 575 pressure zone through a pressure reducing valve station.

D. 483 Pressure Zone (6)

The 483 pressure zone is a small zone of about 57 acres (2.6%) along the west side of the District. The ground level elevations within this area generally lie between 125 and 325 feet above mean sea level.

This pressure zone receives its water supply from the 575 pressure zone through pressure reducing valve stations.

E. 380 Pressure Zone (3)

The 380 pressure zone is a small zone of 48 acres (2.2%) located in the southerly portion of the District. The ground level elevations within this area generally lie between 140 and 210 feet above mean sea level.

This pressure zone obtains its water through a pressure reducing valve station from the 575 pressure zone.

F. 336 Pressure Zone (4)

The 336 pressure zone is another small zone located in the extreme southerly portion of the District. The zone is approximately 41 acres (1.9%) with ground elevations primarily between 110 and 190 feet above mean sea level.

This pressure zone receives its water through pressure reducing valve stations from the 380 pressure zone.

3.3.8 Pressure Reducing Valve Stations

The District operates and maintains nine pressure reducing valve stations that supply water from a zone with a high pressure gradient to a zone at lower elevations requiring a lower pressure gradient.

The majority of these stations supply water from the major pressure zones (the 575 and 425 pressure zones) to the minor pressure zones (the 497, 483, 380 and 336 pressure zones). However, several stations can supply water from the 575 pressure zone to the 425 pressure zone. This provides a reliable, flexible supply system to each zone.

Most of the PRV stations consist of a small (2" or 3") valve for low flows and a larger (6", 8" or 10") valve for higher flow rates.

Table 3.10 shows the current information, location, size and pressure settings of each station.

**TABLE 3.10
PRESSURE REDUCING VALVE STATIONS**

PRV No.	Location	Zone Served	Size of Valves (in)	Valve Elevation (ft)	Outlet Setting (psi)	Outlet Hydraulic Gradient (ft)
1	SW 157 th St / 23 rd Ave SW	483	2, 6	318	60, 55	456, 445
2	Sylvester / 6 th Ave SW (Highline Community Hospital)	425	8	240	80	425
3	SW 167 th St / 31 st Ave SW	483	2, 6	322	65, 60	472, 460
4	Sylvester / 12 th Place SW	336	2, 6	190	70, 65	352, 340
5	Sylvester / 11 th Place SW	336	2, 4	163	61, 56	303, 292
6	SW 158 th St / 4 th Ave SW	425	3, 8	288	60, 50	426, 403
7	SW 170 th St / 12 th Ave SW	497	2, 6	243	65, 60	393, 381
8	Sylvester / 8 th Place SW	380	6	200	75, 70	373, 361
9*	SW 155 th St / 1 st Ave S	425	3, 10	260	92, 74	472, 431

**PRV-9 has a pressure relief valve in addition to a pressure reducing valve*

3.3.9 Telemetry

The District's existing telemetry system was upgraded in 1998. The system is run by a sole computer station located in the District office. Only a portion of the District's facilities (SPU stations 139, 140, 142 and the booster pump station) are connected to the telemetry system.

Flow monitoring can be observed for Stations 139, 140 and 142. Station 143 is for emergency supply only and is not connected to the system. Station 25 was constructed in 2001 and is not connected to the system.

The system can monitor and report on incoming flow rates and pressures from the SPU master meter stations, water level in the reservoir and outgoing flow rate from the pumps at the District's booster station. Reservoir filling and pumping functions can be, and are, performed from the computer station. The reservoir is filled at a constant rate

over each 24 hour period and the pumps are programmed to operate for a two to four hour period during the peak demand times of the day. Length of the pumping cycle each day depends on weather and time of the year.

Expansion of the system to monitor all five connection points to the regional system has not been completed and is not planned. Upgrades to the existing system are proposed in connection with the addition of a second reservoir.

3.3.10 Hydraulic Capacity Analysis

A computer model simulating the existing primary elements of the distribution system has been developed. The computer model can be used to determine the adequacy of the distribution system under normal demand and fire flow conditions.

As an aid in identification of present and future demands and recommended improvements, the District's water system was modeled utilizing the WATERGEMS software program developed by Bentley.

King County Water District 49's computer model has been developed as one large network which covers the entire District. Incorporated in the model are the individual pressure zones, supply points, pipes, junction nodes and pressure reducing valves. The computer model is regularly updated upon completion of a construction project.

The model uses the minimum pressures that SPU is obligated to provide at the supply points. Normally, SPU provides more than the minimum pressure, but the model uses the minimums that SPU must provide under the terms of the water supply contract.

The model uses the existing current pipe network; however, the demands used at each node are "future" demands.

The computer model is used to analyze the conditions in the water system under various conditions. Various input conditions such as supply pressure and residential or fire flow demands can be input and easily changed. The computer calculates the various output conditions such as node pressures, flows and velocities in each pipe, incoming flow rates from the various supply points, etc.

The District's system was analyzed under three demand conditions. These were the MDD condition, the MDD with fire demand condition and the PHD condition. All three cases used the flows as detailed above, for years 2016 and 2036.¹

Since the fire demand condition typically presents the greatest challenge for the hydraulics of the system, analysis of the results of the fire demand situation revealed

¹ The hydraulic analysis presented in the February 2017 Water System Plan was not updated for the 2019 Plan. The prior analysis did not reveal distribution system needs other than fire flow through 2036. The Plan and hydraulic model will be updated well before 2036, so the additional modeling effort at this time was deemed to be of minimal value.

the system deficiencies. This was used to develop the elements of the Capital Improvement Program detailed in Chapter 8 of this WSP.

The fire flow criterion for single family residential areas is 1,000 gpm. Nodes for residential areas were considered deficient if the available fire flow was less than 1,000 gpm.

The maximum anticipated fire flow in the District is 4,000 gpm, and this is considered as potentially required for all non-residential (i.e., non-single family) areas served by the District.

A minimum system-wide residual pressure of 20 psi was used for the MDD plus fire demand condition and 30 psi was used for the MDD and PHD demand conditions.

Summary of System Deficiencies

The 2016 total MDD in the District was forecast as 1,722 gpm. With the PRV and master meter hydraulic gradients as shown in Table 3.5, water normally enters the District at the South 160th Street, the South 168th Street, the SW 146th Street and the SW 149th Street master meters. Minimum pressure in the District is 46 psi and the maximum pressure is 154 psi. Pressures are over 120 psi at 12 nodes in the District. These are at the lower elevation areas of the pressure zones, but in general, pressures are not considered excessive throughout the District. Maximum velocity is 2.2 ft/sec in the 10" supply pipes at the SW 146th Street master meter. Flow velocities throughout the District are not excessive.

The 2016 total PHD in the District was forecast as 2,823 gpm. Minimum pressure in the District is 46 psi and the maximum pressure is 154 psi. Maximum velocity is 3.3 ft/sec at in the 12" supply pipes at the SW 149th Street master meter. Flow velocities throughout the District are not excessive.

Under the 2016 MDD with fire flow condition criteria, a total of 35 nodes did not satisfy the 1,000 gpm (residential) or 4,000 gpm (multi-family residential, commercial or industrial) flow criterion.

The District is planning to replace existing 4" and 6" water mains, typically cast iron, over time. The replacement piping is planned to be a minimum of 8" diameter. This replacement program constitutes a majority of the projects identified in the Capital Improvement Program (CIP) presented in Chapter 8.

The 2036 total MDD in the District is 2,382 gpm. Minimum pressure in the District is 46 psi and the maximum pressure is 154 psi. Pressures are over 120 psi at 12 nodes in the District. These are at the lower elevation areas of the pressure zones, but in general, pressures are not considered excessive throughout the District. Maximum velocity is 2.8 ft/sec in the 10" supply pipes at the SW 146th Street master meter. Flow velocities throughout the District are not excessive.

The 2036 total PHD in the District is 3,883 gpm. Minimum pressure in the District is 45 psi and the maximum pressure is 154 psi. Maximum velocity is 4.5 ft/sec at in the 12” supply pipes at the SW 149th Street master meter. Flow velocities throughout the District are not excessive.

Under the 2036 MDD with fire flow condition criteria, a total of 36 nodes did not satisfy the 1,000 gpm (residential) or 4,000 gpm (multi-family residential, commercial or industrial) flow criterion. With the planned CIP improvements, 16 of these nodes satisfy the fire flow criterion. The remaining nodes have been reviewed individually and are in existing previously developed and served areas. Future redevelopment in those areas may require higher fire flows, which may lead to need for system improvements. Such analysis and action would be addressed at time of redevelopment.

Potentially deficient nodes are shown in Figure 3-4. Table 3.11 compares the available fire flow at the deficient nodes before and after implementation of the water main replacement projects in the CIP.

TABLE 3.11 - POTENTIAL FIRE FLOW DEFICIENT NODES

Node	Fire Flow Need (gpm)	Before CIP (2016 MDD w/FF, gpm)	After CIP (2036 MDD w FF, gpm)	Comment (Notes below)
J30	1,000	895	1,000+	1
J121	4,000	2,229	3,668	3, 4
J122	4,000	1,550	2,852	3, 4
J123	4,000	1,271	2,437	3, 4
J124	4,000	1,244	2,407	3, 4
J125	4,000	728	2,203	3, 4
J153	4,000	1,411	4,000+	1
J172	4,000	3,621	4,000+	1
J173	4,000	3,501	4,000+	1
J184	4,000	2,492	4,000+	1
J191	4,000	3,731	3,740	3, 4
J199	4,000	3,327	3,527	3, 4
J241	1,000	795	1,000+	1
J259	4,000	4,000	3,988	3, 4
J263	4,000	1,319	2,307	3, 4
J264	4,000	3,824	3,851	3, 4
J287	4,000	3,277	4,000+	1
J290	4,000	2,557	2,618	3, 4
J324	4,000	3,567	3,577	3, 4
J325	4,000	3,079	3,086	3, 4
J326	4,000	2,869	2,875	3, 4
J328	4,000	2,705	2,710	3, 4
J329	4,000	2,678	2,683	3, 4
J363	1,000	701	1,000+	1
J382	1,000	980	980	2
J426	1,000	610	1,000+	1
J462	4,000	3,932	4,000+	1
J467	4,000	2,590	4,000+	1
J468	4,000	2,810	4,000+	1
J473	4,000	2,671	3,345	3, 4
J475	4,000	2,579	3,097	3, 4
J476	4,000	2,537	2,987	3, 4
J522	4,000	2,532	4,000+	3, 4
J531	4,000	2,536	2,987	3, 4
J532	4,000	3,779	3,792	3, 4
J622	4,000	3,516	3,597	3, 4
1. CIP planned. 2. N/A Local node not intended to provide fire flow. 3. Existing system in developed neighborhood. 4. Action TBD upon development – no action recommended until need demonstrated.				

3.4 SYSTEM DEFICIENCIES / PROPOSED SOLUTIONS

The following system deficiencies have been identified from the preceding system analysis.

3.4.1 Source of Supply

The existing sources are projected to be adequate to serve the system through the design period. The District's current contract with SPU expires in 2062. No deficiencies are expected for the source of supply.

3.4.2 Water Treatment

All water treatment is provided by SPU. The treatment capacity projections from SPU do not indicate the need for addition treatment facilities for the design period. No deficiencies are expected for the water treatment.

3.4.3 Storage

Under the current conditions, the existing reservoir is functioning as it was intended as an equalizing storage reservoir. However, because of the small volume available, there is a deficiency of storage volume of 2.36 MG presently and 3.38 MG for the future conditions. Pre-design work in support of this project has concluded that the new facility should have a nominal capacity of 3.7 MG.

The recommended action is construction of a new reservoir with sufficient additional volume for present and future deficiencies. The most desirable location for a new structure would be at a high elevation and near the existing SPU regional supply mains. Because the District's service area is nearly fully developed, existing vacant parcels suitable for a reservoir are very limited. Considering purchase of existing property, and installation of transmission mains and potentially construction of a new master meter tap to SPU's regional supply system, this action will be a significant element of the District's near-term capital improvement plan.

In 2016 the District initiated a study to determine the minimum property size needed for a new storage facility, preferred material for the new facility and preferred location in the system considering hydraulic conditions, geotechnical and critical area conditions, proximity to existing supply connections and land use constraints. The study concluded that at least one acre of land was necessary and four general areas were identified for further evaluation. The preferred facility material was determined to be prestressed concrete. A property for sale in the 575 pressure zone was identified as a preferred site based on its size, immediate proximity to an SPU meter location, with commercial zoning. The District completed a due-diligence evaluation including geotechnical and environmental assessments. Ultimately the District purchased the property in 2017. The property is on the south side of SW 146th St., between 8th Ave. SW and 9th Ave.

SW. The reservoir will be situated at ground level and fill from the 575 pressure zone distribution system. The site is immediately adjacent to SPU meter 142. A booster pump station will be necessary for transferring stored water from the reservoir back into the 575 pressure zone. Water will be circulated through the reservoir on a more or less ongoing basis to maintain good water quality. Preliminary evaluation of the station's necessary capacity suggests a total capacity of 5,500 to 6,000 gpm. This is based on the SPU source available at the contract amount (2,500 gpm), with SPU pumped source out of service (less 1,500 gpm), less the District's year 2038 MDD (less 3.54 mgd or 2,459 gpm), less 4,000 gpm fire flow demand, for a forecast need of 5,459 gpm. A station configured with three large pumps operating together is proposed to provide approximately 6,000 gpm total. Two smaller pumps at 650 gpm each can be utilized as a primary and backup pump for water quality circulation. All pumps will have variable frequency drives to support operation in response to specific system needs.

3.4.4 Distribution System/Hydraulics

Telemetry As noted in Section 3.3.9, the District's telemetry system has not been connected to all of the District's facilities. SPU supply meter stations 25 and 143 are not controlled or monitored at this time. Possible improvements to the telemetry system would include the addition of these stations to the system in order to have a fully controlled system. The system will be upgraded to include the proposed new storage facility and booster pump station.

Water Main Replacement The Capital Improvement Program described in Chapter 8 of this WSP lists the projects that are recommended to resolve or eliminate the existing and anticipated system deficiencies. The projects are listed in order with the highest priority projects listed first but actual scheduling may depend on availability of District resources and proposed projects by other governmental agencies such as roadway improvements by the cities.

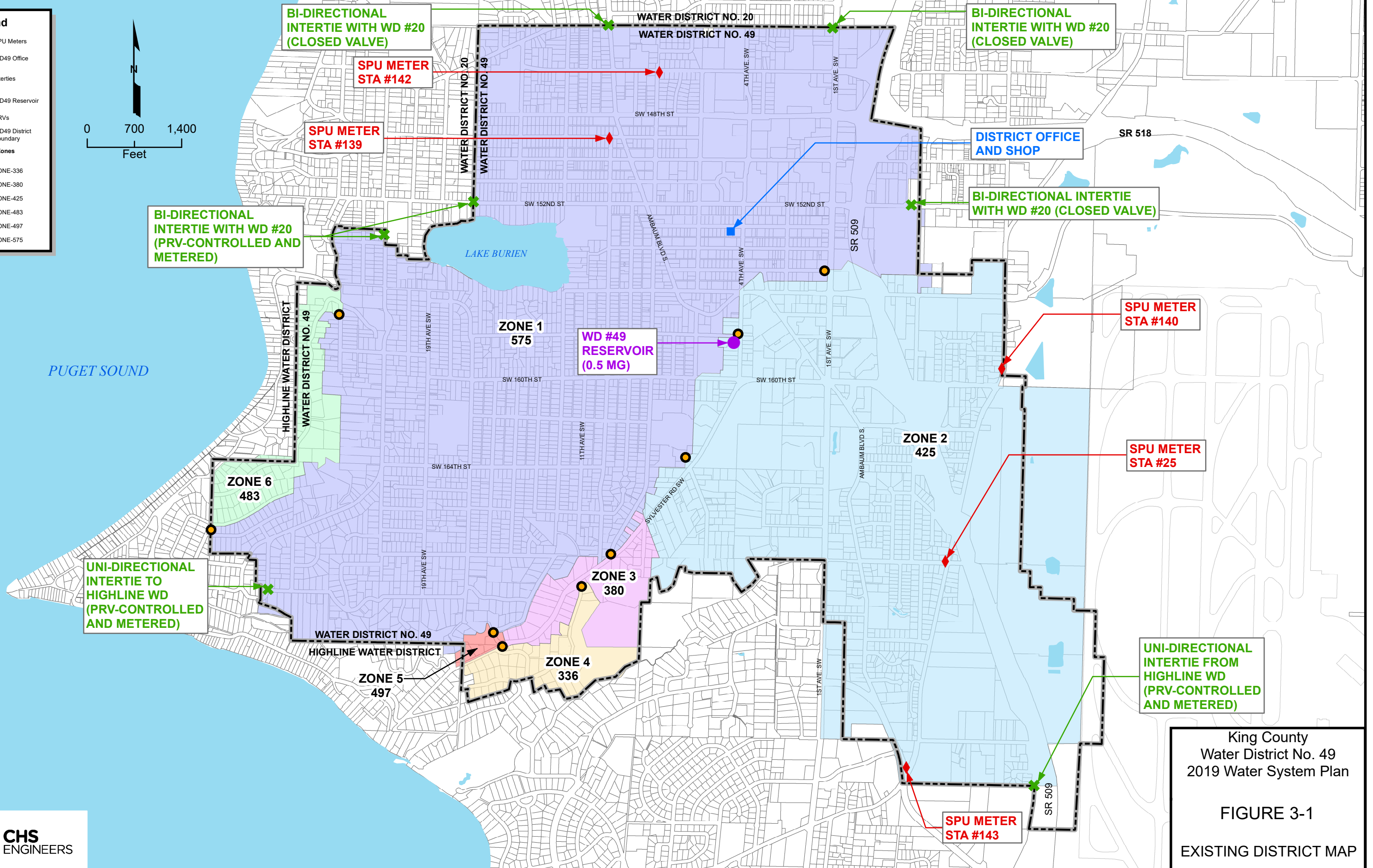
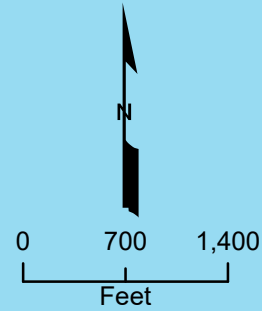
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Legend

- ◆ SPU Meters
- WD49 Office
- ✕ Interties
- WD49 Reservoir
- PRVs
- WD49 District Boundary

Pressure Zones (HGL)

- ZONE-336
- ZONE-380
- ZONE-425
- ZONE-483
- ZONE-497
- ZONE-575

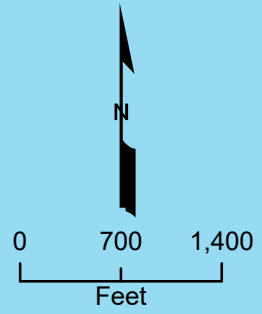


King County
 Water District No. 49
 2019 Water System Plan

FIGURE 3-1
 EXISTING DISTRICT MAP

Legend

- Fire Hydrant
- WD49 Reservoir
- WD49 Office
- Water Main Diameter (inches)
- Unknown
- 1
- 1.25
- 1.5
- 2
- 3
- 4
- 6
- 8
- 10
- 12
- ▭ WD49 District Boundary

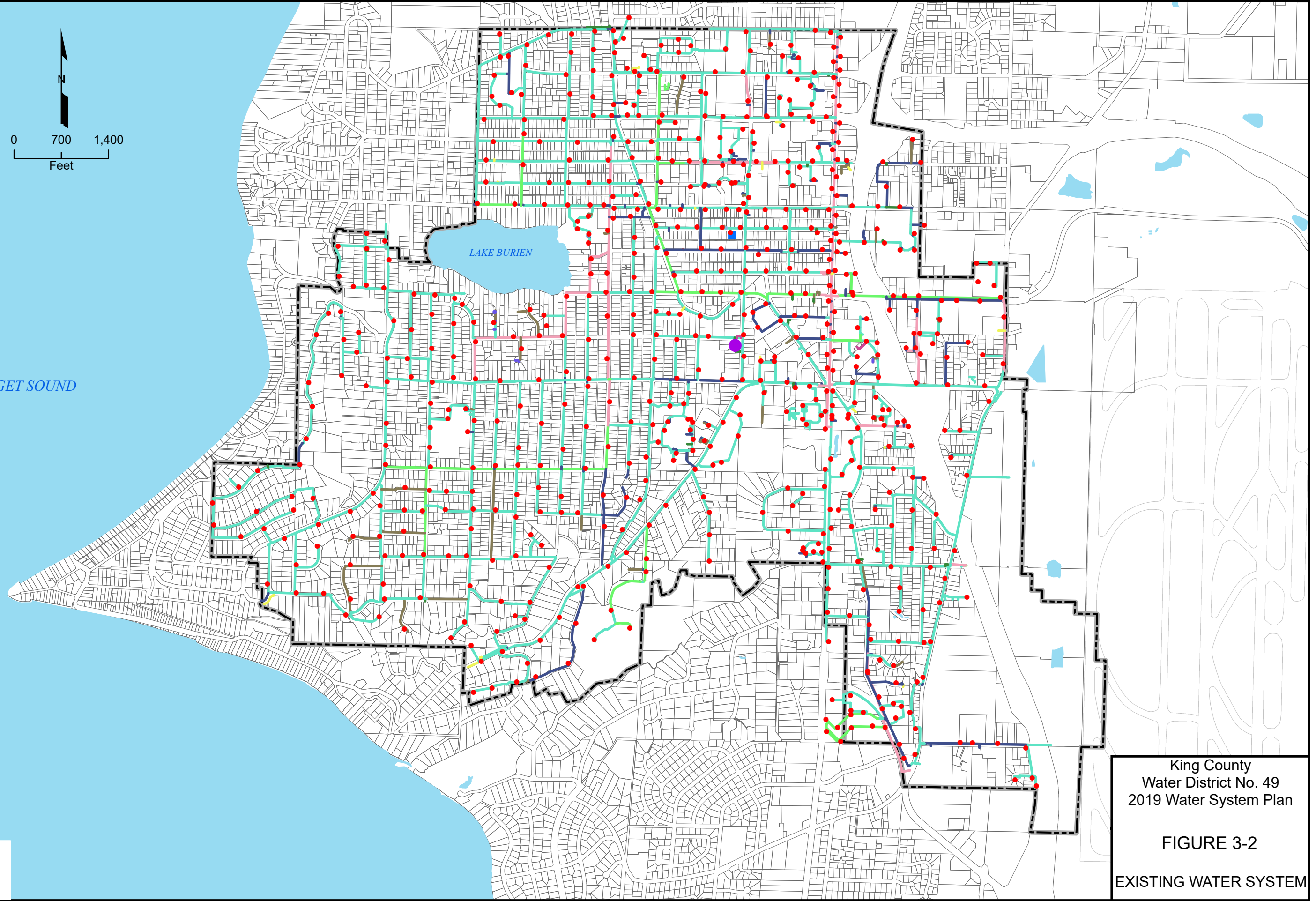


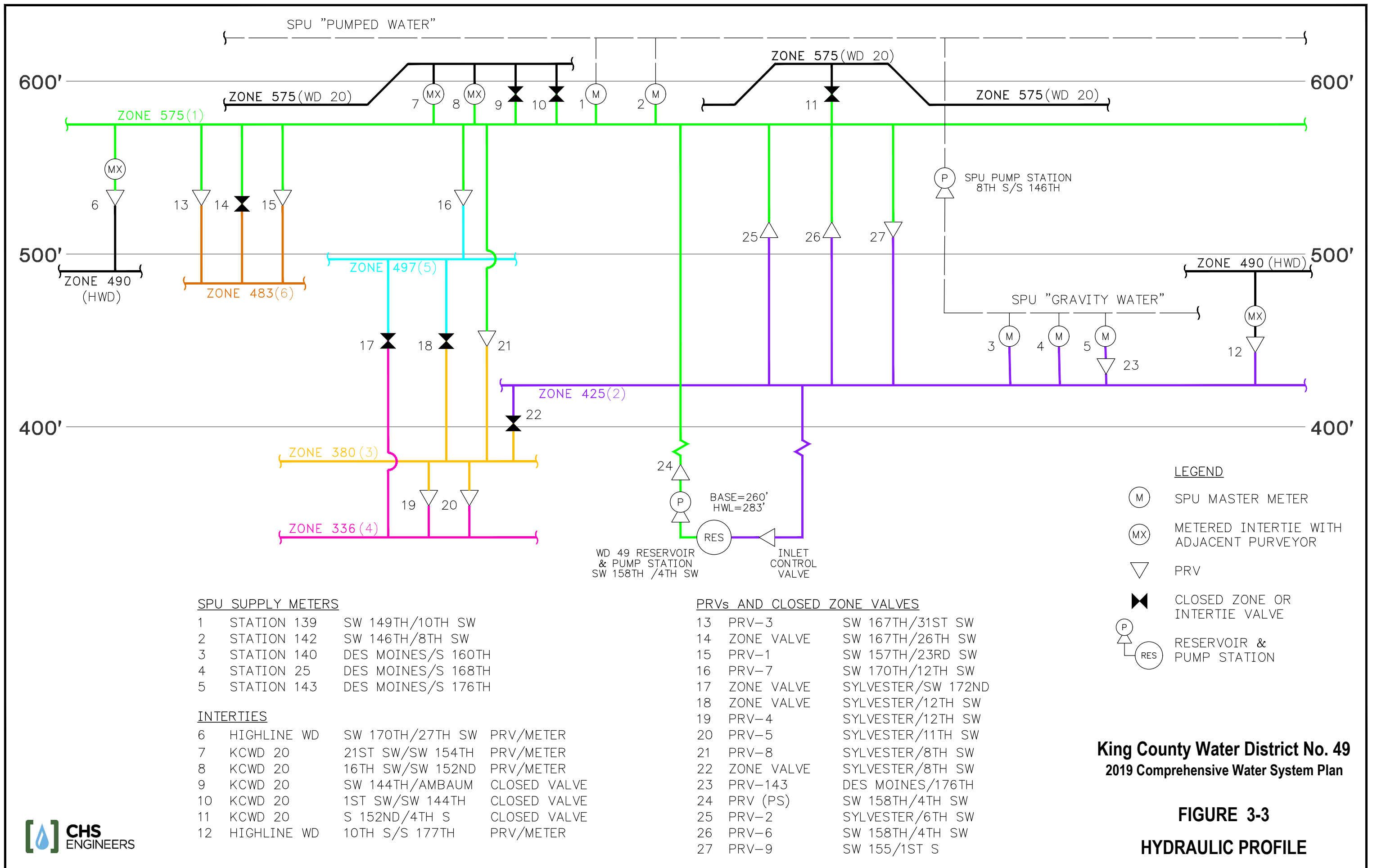
PUGET SOUND

LAKE BURIEN

King County
Water District No. 49
2019 Water System Plan

FIGURE 3-2
EXISTING WATER SYSTEM





SPU SUPPLY METERS

1	STATION 139	SW 149TH/10TH SW
2	STATION 142	SW 146TH/8TH SW
3	STATION 140	DES MOINES/S 160TH
4	STATION 25	DES MOINES/S 168TH
5	STATION 143	DES MOINES/S 176TH

INTERTIES

6	HIGHLINE WD	SW 170TH/27TH SW	PRV/METER
7	KCWD 20	21ST SW/SW 154TH	PRV/METER
8	KCWD 20	16TH SW/SW 152ND	PRV/METER
9	KCWD 20	SW 144TH/AMBAUM	CLOSED VALVE
10	KCWD 20	1ST SW/SW 144TH	CLOSED VALVE
11	KCWD 20	S 152ND/4TH S	CLOSED VALVE
12	HIGHLINE WD	10TH S/S 177TH	PRV/METER

PRVs AND CLOSED ZONE VALVES

13	PRV-3	SW 167TH/31ST SW
14	ZONE VALVE	SW 167TH/26TH SW
15	PRV-1	SW 157TH/23RD SW
16	PRV-7	SW 170TH/12TH SW
17	ZONE VALVE	SYLVESTER/SW 172ND
18	ZONE VALVE	SYLVESTER/12TH SW
19	PRV-4	SYLVESTER/12TH SW
20	PRV-5	SYLVESTER/11TH SW
21	PRV-8	SYLVESTER/8TH SW
22	ZONE VALVE	SYLVESTER/8TH SW
23	PRV-143	DES MOINES/176TH
24	PRV (PS)	SW 158TH/4TH SW
25	PRV-2	SYLVESTER/6TH SW
26	PRV-6	SW 158TH/4TH SW
27	PRV-9	SW 155/1ST S

LEGEND

- (M) SPU MASTER METER
- (MX) METERED INTERTIE WITH ADJACENT PURVEYOR
- ▽ PRV
- ⊘ CLOSED ZONE OR INTERTIE VALVE
- (P) RES. RESERVOIR & PUMP STATION

King County Water District No. 49
2019 Comprehensive Water System Plan

FIGURE 3-3
HYDRAULIC PROFILE



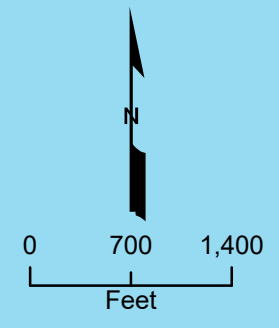
Legend

- Node with Deficient Fire Flow
- FIRE HYDRANT
- WD49 Reservoir
- WD49 OFFICE

Water Main Diameter (inches)

- Unknown
- 1
- 1.25
- 1.5
- 2
- 3
- 4
- 6
- 8
- 10
- 12

■ KCWD No.49



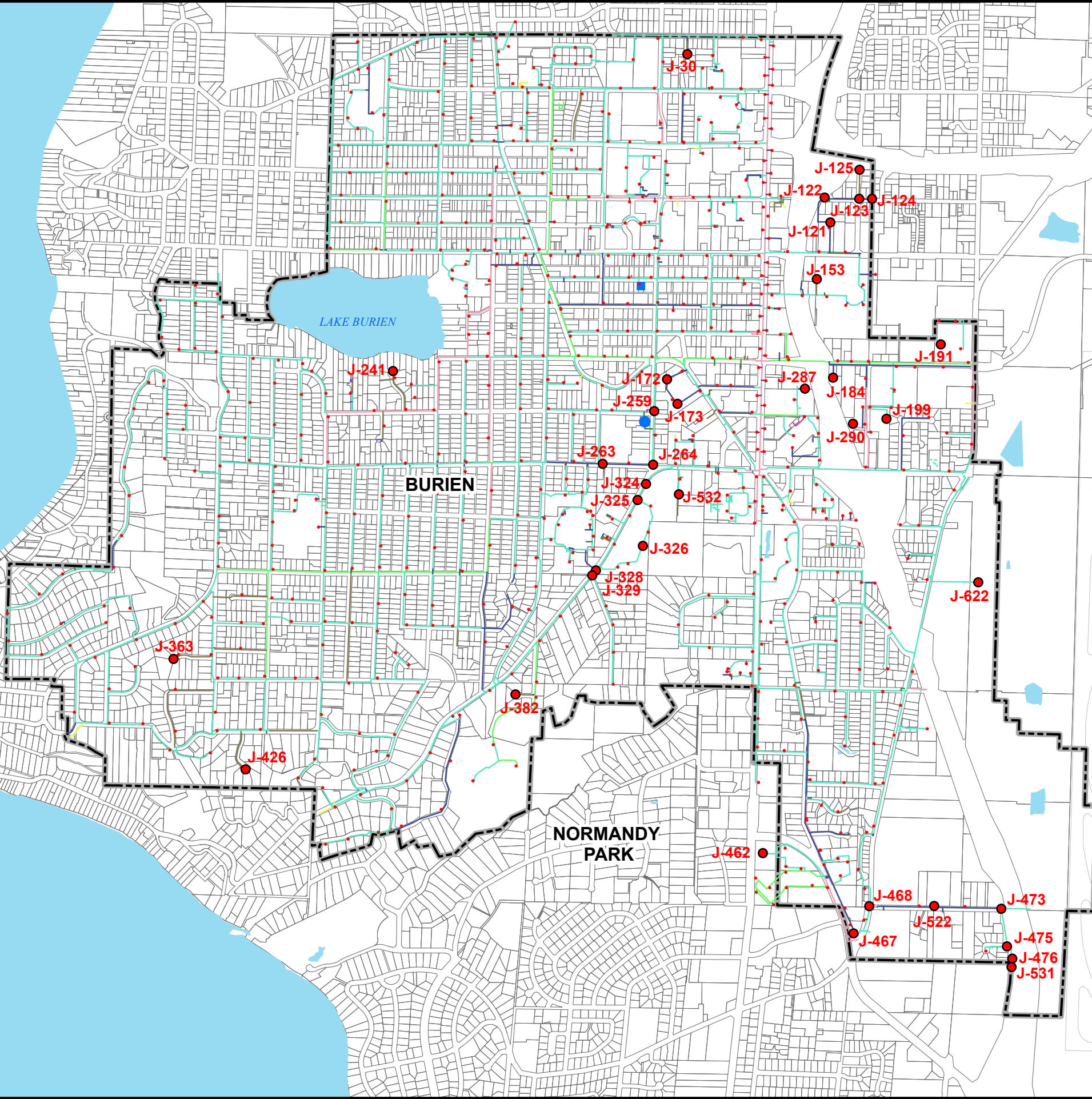
PUGET SOUND

LAKE BURIEN

BURIEN

NORMANDY PARK

SEATAC



King County
Water District No. 49
2019 Water System Plan

FIGURE 3-4

FIRE FLOW
DEFICIENT NODES