CHAPTER 3

WATER SYSTEM ANALYSIS

OBJECTIVE

The objective of this chapter is to determine if the existing system components are capable of supplying a sufficient quantity of water of suitable quality to meet existing as well as projected demands.

The ability of a water utility to meet current and anticipated future demands is an important consideration in water system planning. In addition to demand considerations, water quality plays a major role in determining the adequacy of a water system. The components that will be analyzed in this chapter are listed as follows:

- System Design Standards
- Water Quality Analysis
- Facility Analysis
- System Deficiencies and Proposed Improvements

Design standards identify performance and design criteria that are applicable to the Association. Water quality and the existing facilities will be evaluated according to identified standards. Based on these analyses, water system deficiencies and recommendations to meet design standards are provided.

SYSTEM DESIGN STANDARDS

Performance and design criteria typically address the sizing and reliability requirements for source, storage, distribution, and fire flow. WAC 246-290 contains general criteria and standards that must be followed in development of public water systems. In addition, the DOH *Water System Design Manual* (April 2001) provides specific guidance for water system design. The design standards are discussed below.

GENERAL FACILITY STANDARDS

DOH relies on various publications, agencies, and the Association to establish design criteria. A brief description of the most widely recognized performance and design standards are listed as follows:

- **<u>WAC 246-290, Group A Public Water Systems</u>, Washington State Board of Health (July 2004).**

  WAC 246-290 is the primary drinking water regulation that authorizes DOH to assess capacity and water quality, and enforce compliance with adopted drinking water standards.

- **<u>Water System Design Manual (WSDM)</u>, Washington State Department of Health (August 2001).**

  These design standards serve as guidance for the preparation of plans and specifications for Group A public water systems in compliance with WAC 246-290. The standards also establish a benchmark against which existing systems are judged for conformance with current standards to ensure the system is adequately protected from contamination and can meet current day expectations of customers.

- **<u>Recommended Standards for Water Works (RSWW)</u>, A Committee Report of the Great Lakes - Upper Mississippi River Board of State Public Health and Environmental Managers (1997).**

  Commonly known as the Ten States Standards, this document formalizes the design standards recommended by a water supply committee representing ten Midwestern and upper Great Lakes States including the Province of Ontario. The first report of the Water Supply Committee was published in 1953, and it was subsequently revised in 1962, 1968, 1976, 1982, 1992, and 1997. The report presents recommendations for both design and construction standards. The construction standards in the report are somewhat general in nature with minor emphasis on materials specifications. Since surface water treatment is common in the Midwest and Upper Great Lakes, the Committee report also tends to concentrate on water treatment plant design and operation.

Table 3-1 provides a summary of the minimum design standards put forth by DOH and the 10-States Standards.

TABLE 3-1

Minimum Allowable Design Standards

Standard & Authority	Source Development	Booster Pump Stations	Distribution	Storage
Chapter 43.20 Revised Code of Washington (RCW), WAC 246-290 Group A Public Water Systems standards, DOH, 2004	• The water source(s) must have sufficient capacity and water rights to meet the maximum day demand (MDD) on a reliable basis not including emergency sources.	• Booster pumping facilities should be designed to accommodate at least 10 years of system development. • All new closed system booster pump stations shall be designed to provide PHD while maintaining 30 psi throughout the system with the largest pump out of service.	• Minimum distribution main size shall be 6-inches unless justified by hydraulic analysis. • Minimum line size supplying a fire hydrant shall be 6-inch if looped and 8-inch if a dead end line. • New public systems or additions shall provide the peak hourly demand while maintaining a minimum pressure of 30 psi throughout the distribution system. • Required fire flows must be provided in addition to MDD while maintaining a minimum pressure of 20 psi throughout the distribution system.	The sum of: 1. Equalizing Storage V_{ES}-(Q_{PH} – Q_S)*150 2. Standby Storage V_{SB}=2*(ADD)*N-1440(Q_s-Q_l), with 200*N Minimum 3. Fire Suppression Storage V_{FSS}-NFF*T Q_{PH} = Peak hour demand Q_S = Sum or all source capacities except emergency sources Q's = Sum of all source capacities minus the largest source our of service NFF = Needed Fire Flow T = Time (Minutes)
Recommended Standards for Water Works, A Committee Report of the Great Lakes-Upper Mississippi River Board of State Public Health and Environmental Managers (10-States Standards), 1997	The quantity of water at the source must: • Meet the maximum projected water demand of the service area as shown by calculations based on the extreme drought of record. • Provide a reasonable surplus for anticipated growth. • Compensate for all losses such as silting, evaporation, seepage, etc. • Provide ample water for other legal users of the source.	• Each booster pumping station should contain not less than two pumps with capacities such that peak demand can be satisfied with the largest pump out of service. • Commercial power shall be provided from at least two independent sources or a standby or auxiliary source shall be provided.	• All water mains including those not designed to provide fire protection, shall be sized based on hydraulic analysis. The system shall be designed to maintain a minimum pressure of 20 psi. • Pressure reducing valves shall be installed as necessary to keep pressures below 100 psi. • Minimum water main size for fire protection shall be 6 inches.	• The minimum storage capacity for systems not providing fire protection shall be equal to the average day consumption. This requirement may be reduced when the source and treatment facilities have sufficient capacity with standby power to supplement peak system demands. • Where fire protection is provided, fire flow requirements of the appropriate state insurance services office should be satisfied.

Table 3-2 lists the suggested DOH *Water System Design Manual* guidance and the Association's policies with regard to each standard for general facility requirements. :

TABLE 3-2

General Facility Requirements

Standard	DOH *Water System Design Manual* (August 2001)	Water Association Standards
Average Day and Maximum Day Demand	Average Day Demand (ADD) should be determined from metered water use data. Maximum Day Demand (MDD) is estimated at approximately two times the ADD if metered data is not available.	ADD = Metered consumption using 5-year average with adjustments for anomalies. MDD = Based on peaking factor from historical data
Peak Hour Demand	Peak hour demand (PHD) is determined using equation 5-3: PHD = (MDD*N/1440)*(C*N+F)+18 Where C=1.6 and F=225 for this system as a whole and the zones served by the Rattlesnake/uplands Reservoirs and X and Y for the XX Zones.	Same as DOH *Water System Design Manual*, Chapter 5, Equation 5-3.
Source Capacity	Capacity must be sufficient to meet MDD and replenish fire suppression storage within 72 hours.	Same as DOH *Water System Design Manual*, Chapter 7.
Storage Requirements	The sum of: Operational Storage Volume sufficient to prevent pump cycling. Equalizing Storage $V_{ES} = (Q_{PH} – Q_S) * 150$ Standby Storage $V_{SB} = (2 * ADD * N) – t_m * (Q_S – Q_L)$ with a minimum of (200*N) Fire Suppression Storage V_{FSS} = NFF * T ADD = average day demand, gpd/ERU N = number of ERU's Q_{PH} = peak hour demand, gpm Q_S = capacity of all sources, excluding emergency sources, gpm Q_L = capacity of largest source, gpm t_m = daily pump source run time, min (1440) NFF = Req'd fire flow, gpm (set by Fire Marshall) T = fire flow duration, min (set by Fire Marshall)	Same as DOH *Water System Design Manual*, using the formulas provided in the manual, Chapter 9.
Minimum System Pressure	The system should be designed to maintain a minimum of 30 psi throughout the distribution system under peak hour demand and 20 psi under emergency conditions, including fire flow conditions during MDD.	Same as DOH *Water System Design Manual*, Chapter 8.

TABLE 3-2 (Continued)

General Facility Requirements

Standard	DOH *Water System Design Manual* (August 2001)	Water Association Standards
Fire Flow Rate & Duration	The minimum fire flow shall be determined by the local fire authority or WAC 246-293 for systems within a critical water supply service area (CWSSA).	The Association's fire flow requirements are based on King County Standards and Fire Marshal's determination of required flows for non-residential structures.
Minimum Pipe Size	The diameter of a transmission line shall be determined by hydraulic analysis. The minimum size distribution system line shall not be less than 6 inches in diameter and if fire hydrants are installed, the 6-inch lines must be looped. Fire hydrants on dead end lines require 8 inch minimum line size.	Same as DOH *Water System Design Manual*, Chapter 8.
Reliability Recommendations	• Well sources capable of supplying MDD within an 18-hour period • Sources meet ADD with largest source out of service • Backup power equipment for pump stations unless there are two independent commercial power sources • Provision of multiple storage tanks • Standby storage equivalent to ADD x 2, with a minimum of 200 gpd/ERU • Low and high level storage alarms • Looping of distribution mains when feasible • Pipeline velocities not > 8fps at PHD • Flushing velocities of 2.5 fps for all pipelines	Same as DOH *Water System Design Manual*, Chapter 5.
Valve and Hydrant Spacing	Sufficient valving should be placed to keep a minimum of customers out of service when water is turned off for maintenance or repair. Fire hydrants on laterals should be provided with their own auxiliary gate valve.	Valve and hydrant standards are outlined in the Association's Development Standards.
Water Quality Standards	The primary drinking water regulation utilized by DOH to assess water quality and overall compliance with drinking water standards.	WAC 246-290

CONSTRUCTION STANDARDS

Construction standards set forth the materials and construction standards that contractors, developers, and the Association must follow when constructing water system facility improvements. The Association's Development Standards are included in Appendix E.

WATER QUALITY STANDARDS

Group A public community water systems in Washington State must comply with the drinking water standards adopted by Washington State Department of Health (DOH) and the federal Safe Drinking Water Act and its amendments. DOH has adopted the federal standards under WAC 246-290, which was updated in July 2004. The adopted standards regulate water quality parameters, including bacteriological contaminants, inorganic chemicals and inorganic physical parameters (IOCs), volatile organic chemicals (VOCs), synthetic organic chemicals (SOCs), radionuclides, and total trihalomethanes (TTHMs). The Association is also required to conduct distribution system monitoring for bacteriological contaminants, disinfection by-products, and lead and copper. A summary of the water quality standards is included in Appendix F.

Table 3-3 lists existing drinking water regulations and whether or not the regulation requires the Association to conduct monitoring or take other action.

TABLE 3-3
Existing Drinking Water Regulations[1]

Rule	Contaminants Affected[2]	Association Action Required?
Bacteriological	Coliform	Yes
Stage 1 Disinfectants/Disinfection By-Products Rule (DBPR)	TTHMs, HAA5, Chlorite, Bromate	No[3]
Residual Disinfectant	Total Free Chlorine	No[3]
Lead and Copper Rule	Lead, Copper	Yes
Inorganic Chemicals, and Physical Parameter	IOCs	Yes
Volatile and Synthetic Organic Compounds	VOCs, SOCs	Yes
Surface Water Treatment Rule (SWTR)	Microbial Contaminants	No
Information Collection Rule	Bacteriological	No
Consumer Confidence Report	Reporting Only	Yes
Radionuclides Rule	Radionuclides	Yes
Filter Backwash Recycling Rule	Bacteriological	No[3]
Interim Enhanced Surface Water Treatment Rule	Bacteriological	No[3]
Long Term 1 Enhanced Surface Water Treatment Rule	Bacteriological	No[3]

(1) Drinking water regulations as of December 2005.
(2) TTHM = Total Trihalomethanes; IOCs = Inorganic Chemical and Physical Characteristics; VOCs = Volatile Organic Chemicals; SOCs = Synthetic Organic Compounds
(3) The Association uses ground water and does not disinfect or treat sources.

WATER QUALITY ANALYSIS

This section provides analyses of the Association's current water quality and the system's ability to meet existing and future water quality standards At the conclusion of the analyses, system deficiencies are identified.

WATER QUALITY MONITORING SCHEDULE

Water quality monitoring is required for regulatory compliance and to monitor water system conditions. DOH provides guidelines for inorganic and organic monitoring under WAC 246-290-300, Monitoring Requirements, which requires each system to prepare a Monitoring Plan that will define monitoring schedules and sample locations.

Table 3-4 lists water quality monitoring required by State regulations. Water quality monitoring requirements for VOCs and SOCs depend, in part, on the availability of monitoring waivers from DOH.

TABLE 3-4
Water Quality Monitoring

Parameter	Sample Location	Frequency Applicable To The Association	Consequence of Exceeding Standard
Bacteriological	Distribution System	6 per Month	Follow-up and Repeat Sampling – Imposition of Required Disinfection for Continuing to Exceed Standard
Inorganics	Source	Every 3 Years	Possible Required Treatment
Nitrates	Source	Annually	Follow-up and Repeat Quarterly Sampling
VOCs	Source	Every 3 Years	Possible Required Treatment
SOCs	Source	Every 3 Years	Possible Required Treatment
Lead and Copper	Distribution System	20 Samples Every 3 Years	Possible Required Treatment
Radionuclides	Source	Await DOH Instructions	Possible Required Treatment

WATER QUALITY MONITORING RESULTS

Bacteriological

The Association monitors for bacteriological contaminants in accordance with its Coliform Monitoring Plan included in Appendix G.

According to current population levels, the Association is currently required to collect 6 monthly routine bacteriological samples. Requirements for routine monthly bacteriologic sampling are detailed in WAC 246-290-300 according to water service population.

Routine sampling during in 2006, 2007 and 2008 one non-acute positive bacteriological result was received each year. Immediate notification was provided to all customers. The Association investigated the cause of the occurrence, took the required repeat samples, and found no further evidence of contamination.

Inorganic Chemicals and Physical Characteristics

Existing State law contains maximum contaminant levels (MCLs) for inorganic chemical and physical characteristics, as summarized in Appendix F. Primary MCLs are based on health effects, and secondary MCLs are based on other factors, including aesthetics. Sampling for inorganics is required every three years, under WAC 246-290. The Association's latest Inorganic sampling results, from 2005, showed the system inorganic water quality meets the DOH standards with no regulated parameter MCL being exceeded. Copies of the inorganic reporting forms are included in Appendix F.

Sampling for nitrates is required annually. The MCL for Nitrate is 10 mg/L. The Association's latest nitrate sampling results for 2008, show the system nitrate level meets the DOH standards with the MCL not being exceeded. Results ranged from 0.4 mg/L to <0.2 mg/L (Appendix F).

Volatile Organic Chemicals and Synthetic Organic Chemicals

The State has adopted primary MCLs for a broad class of manufactured organic chemicals. These chemicals are further divided into volatile organic chemicals (VOCs) and synthetic organic chemicals (SOCs). The regulations and monitoring requirements for these chemicals were established by EPA and are listed in Chapter 40 of the Code of Federal Regulations (CFR), Part 141. Test results for all VOCs or SOCs monitored by the Association in 2008 were reported as being below detectable levels in the Water Association's wells (Appendix F).

Disinfection Byproducts

At this time, the Water Association is not required to monitor for Trihalomethanes, as the source water is not currently disinfected.

Lead and Copper

Lead and Copper Rule compliance is measured by comparing the 90^{th} percentile sample to lead and copper "action levels." The action level for lead and copper at individual water systems is based on the level of lead and copper in 90 percent of the samples or when 10 percent of the samples exceed the action level.

The Association is required to take 20 samples every 3 years. The most recent samples were taken in 2008. As shown in the Table 3-5, the Association is in compliance with no reported results exceeding the action level for lead or copper in 2008.

TABLE 3-5

2008 Lead And Copper Monitoring Results

	Lead (mg/L)	Copper (mg/L)
Action Level, mg/L	0.015	1.3
Number of Samples Taken	20	20
Number of Samples Exceeding Action Level	0	0
Range of Results	<0.002	<0.02 – 0.35

Radionuclides

Radionuclide data was collected in 2007, and, as summarized in Table 3-6, all results were reported as non-detectable, indicating conformance with the applicable MCLs.

TABLE 3-6

Radionuclide Data Summary

Wells	Gross Alpha Radiation (pCi/l)	Gross Beta Radiation (pCi/l)	Radon (pCi/l)
1	ND	ND	ND
2	ND	ND	ND
3	ND	ND	ND

ANTICIPATED FUTURE DRINKING WATER QUALITY REGULATIONS

Groundwater Rule

The Groundwater Rule is one of the requirements of the 1994 Amendments to the Safe Drinking Water Act. Final action on the rule was expected in 2005, however, no final action was taken. The anticipated date of final action is unknown at this time. This rule would establish a method for determining if disinfection of a groundwater source is required, and it would establish disinfection standards for those sources where disinfection is required.

SYSTEM ANALYSIS

SOURCE OF SUPPLY ANALYSIS

According to Department of Health 2004 Group A Water Systems standards, a combination of source production capacity and storage must be sufficient to supply maximum day demands. In addition, the maximum instantaneous and maximum annual withdrawal limitations of associated water rights must be sufficient to supply maximum day and average day demands over the planning period.

WATER RIGHTS ANALYSIS

All appropriations of water for public use within Washington State must be made in accordance with existing water rights and the established procedures that govern their implementation and use. The Association's projected future water demands and its existing water rights, including maximum instantaneous and total annual withdrawal limitations, are compared in Table 3-7.

The City of North Bend received a water right permit for 3,094 ac-ft and a maximum instantaneous withdrawal of 2,646 gpm in April of 2008 contingent upon Sallal providing mitigation water for instream flows as needed. This permit provides the City of North Bend with sufficient water to serve its planned water demand, including that portion of the Sallal Water Association service area within the North Bend Urban Growth Area with an estimated annual demand of 967 acre feet. Water will thus be available to allow Sallal to purchase water wholesale from North Bend to meet the demand shown in Table 3-7. The City and Sallal are developing an interlocal agreement to address the sale of water between them, which will address the projected deficit and allow Sallal to provide service to future connections to the system.

New wells for the City of North Bend will provide the increased supply. These wells will draw from the Snoqualmie River basin. Minimum instream flows have been established for the Snoqualmie River, therefore flow augmentation may be required in the future to maintain those flows. Flow augmentation, if needed, is planned to come primarily from Hobo Springs (owned by Seattle Public Utilities), and be discharged into Boxley Creek, a tributary to the South Fork of the Snoqualmie River, with backup mitigation supply from the Sallal Water Association's wells. The volume of water North Bend will need from the Sallal system will depend upon the flow conditions in the Snoqualmie River and Hobo Springs. Use of mitigation water by North Bend from the Sallal wells will not cause an impact on Sallal's water rights as the water provided to North Bend will be replaced by North Bend using water produced under its newly granted water right. The combined water rights for North Bend and Sallal should be sufficient to meet future growth. Sallal has sufficient instantaneous water rights to provide seasonal mitigation. North Bend will provide water to Sallal as needed during off-peak periods to prevent violation of annual water rights.

TABLE 3-7

Analysis Of Projected Water Consumption Versus Existing Water Rights

Year	ERUs	Average Daily Production Demand w/o Anticipated Industrial Development (gpd)	Average Daily Production Demand For Anticipated Industrial Development (gpd)(1)	Total Average Daily Demand Incl. Anticipated Industrial Development (gpd)	Annual Water Production Demand (acre-ft)	Annual Water Rights (acre-ft)(2)	Annual Water Right Surplus/ (Deficit)(2)	Maximum Day Demand (gpm)(3)	Instantaneous Water Rights (gpm)	Instantaneous Water Right Surplus/ (Deficit) (gpm)
2008	2,392	542,984		542,984	610	696	86	848	1,691	843
2009	2,464	559,328		559,328	627	696	69	874	1,691	817
2010	2,538	576,126	32,583	608,709	670	696	26	923	1,691	768
2011	2,614	593,378	65,166	658,544	715	696	(19)	972	1,691	719
2012	2,692	611,084	97,749	708,833	762	697	(65)	1,023	1,692	669
2015	2,942	667,834	130,332	798,166	848	696	(152)	1,134	1,691	557
2020	3,411	774,297	130,332	904,629	970	696	(274)	1,300	1,691	391
2025	3,954	897,558	130,332	1,027,890	1,105	696	(409)	1,493	1,691	198

(1) Projected industrial demand of 50 acre-ft/yr in 2009 and 100 ac-ft/yr for 2010 and beyond used over 250 days per year.
(2) Sallal may purchase up to 967 acre feet per year from North Bend as needed to supply demands and avoid water rights deficit.
(3) Includes a maximum day demand of 90 gpm for 24 hours for industrial development.

SOURCE CAPACITY ANALYSIS

The Association has three wells available. Wells 1 and 2 produce 725 gpm each. Well 3 produces 80 gpm. Currently, Well 1 and 2 are not operated at the same time, however upgrades to the telemetry system are anticipate within the next 6 months allowing simultaneous operation of the wells. Therefore, the Association's total source capacity is assumed to be 1,652,400 gpd (1,530 gpm * 18 hrs/day). Table 3-8 presents an analysis of current production capacity to MDD.

TABLE 3-8

Source Production Capacity Analysis

Year	ERUs	Maximum Day Well Production Capacity(1) (gpd)	Maximum Day Demand Production Requirement (gpd)	Well Production Capacity Supply (Deficit)(2)	
				(gpd)	(gpm)
2008	2,392	1,652,400	1,221,120	431,280	300
2009	2,464	1,652,400	1,323,360	329,040	229
2010	2,538	1,652,400	1,360,800	291,600	203
2011	2,614	1,652,400	1,465,920	186,480	130
2012	2,692	1,652,400	1,504,800	147,600	103
2015	2,942	1,652,400	1,632,960	19,440	14
2020	3,411	1,652,400	1,872,000	(219,600)	(153)
2025	3,954	1,652,400	2,149,920	(497,520)	(346)

(1) Well production capacity is based on the production of both Well 1 and Well 2 at 725 gpm each, plus Well 3 at 80 gpm for a total instantaneous of 1,530 gpm and limiting wells to 18 hrs of pumping/day/well.

(2) Does not include purchase of water North Bend as previously discussed. In addition, running all three wells for 24 hours during the maximum demand period would provide sufficient water to eliminate the projected deficit.

Sallal has sufficient water rights to meet maximum day demand when the additional capacity associated with running Wells 1 and 2 simultaneously. This additional well production capacity can be achieved by implementing changes in the control system to allow concurrent operation of Wells 1 and 2, or by replacement of, or adding an additional line in parallel to, a segment of 10-inch line on Cedar Falls Road to remove the impediment to operating both Wells 1 and 2 at the same time.

BOOSTER STATION ANALYSIS

The Water Association has four existing booster stations that move water through the system between pressure zones. It is anticipated that the existing Tanner Booster Station will be replaced with a larger booster station when the first phase of the new Tanner Reservoir project is constructed. The DOH *Water System Design Manual* establishes certain criteria for booster pumps that pump to open systems (pumping into a zone in which the hydraulic grade line (HGL) is governed by a storage tank open to the atmosphere). During normal operating conditions, a booster station pumping to an open system should be able to meet average day demand with the largest pump out of service and must meet maximum day demand with all pumps in service. Likewise the DOH Manual provides criteria for booster stations pumping to closed pressure zones in which the HGL is established by the pumping system itself and there is no reservoir open to the atmosphere. These criteria include the requirements that the booster station must be able to maintain required system pressures under all specified conditions, including maximum day demand plus fire flow and peak hourly demand. Table 3-9 provides an analysis of the booster stations within the system.

TABLE 3-9

Booster Station Analysis – Normal Operating Conditions

Booster Station	Pumps to	ADD (gpm)	MDD (gpm)	Peak Hour Demand (gpm)	BPS Capacity Largest Pump out of Service	BPS Capacity	Meet ADD Req[1]	Meet MDD Req[2]
Tanner - Existing	793 Zone – Edgewick Res	43	98	166	150	300	yes	yes
Tanner - Future	793 Zone – Edgewick Res	372	837	1,358	1,500	1,500	yes	yes
Edgewick	920 Zone – Closed, and Feeds to 883 Zone - Open	22[3]	49[3]	83[3]	1,500[4]	1,500[4]	yes	yes
Lower Mt. Si	840 Zone – River Point Res	27	61	104	125	250	yes	yes
River Point	1009 Zone – Terrel Res.	14	31	52	0	100	no	yes

(1) Meet ADD with largest pump out of service.
(2) Meet MDD with all pumps in service.
(3) Current Demand prior to new school that just opened within 883 Zone and development of the industrial park that is under construction in the 920 Zone. Anticipated ADD, MDD and PHD will increase by approximately 10 gpm, 20 gpm and 120 gpm in the near future when the school is in operation, when school property irrigation begins its normal operation, and the industrial site opens for production, respectively. Until these impacts are assessed, the listed values will be used, recognizing that the pumping capacity of the Edgewick BPS is more than sufficient to supply the water and the projected system changes to accommodate North Bend water will provide the source capacity.
(4) Upgrades to Edgewick Booster Station are planned in 2009 that will increase the capacity of the station to 3,000 gpm.

STORAGE ANALYSIS

Storage requirements for the Water Association are determined according to the Department of Health Draft Group A Public Water Systems Waterworks Standards, April 2001. The storage requirements are based on the sum of the following:

- Operational Storage
- Equalizing Storage
- Standby Storage
- Fire Suppression Storage
- Dead Storage

The Rattlesnake and Uplands reservoirs both serve the 1215, 1159, 1100, 1090, 1087, 1054, 903, 872 and the 701 Zones. A portion of the 701 Zone fire flow is provided by the Edgewick and River Point Zone Reservoirs through PRVs. With anticipated changes to accommodate receipt of water from North Bend, the 701 Zone will be also be able to be served from the new reservoir (Tanner future) anticipated to be installed starting in second half of 2009 as well as from North Bend.. The three Edgewick Reservoirs serve the 793 zones. The Middle Fork Reservoirs receive water from Edgewick booster station via the closed 920 zone and serve the 883 Zone (Figure 1-4).

Operational Storage

Operational storage is the volume of the reservoir devoted to supplying the water system under normal operating conditions while the source(s) of supply are in "off" status. This volume is typically established to prevent excessive cycling of wells and booster pumps. Operational storage in a reservoir has generally been fully utilized once the reservoir is drawn down into the other storage components.

Booster pumps and well pumps used to fill reservoirs are called on and off by water level sensors in the reservoirs. The sensors in the Association's system have been set two feet apart; therefore each reservoir has two feet of operational storage. Table 3-10 provides the operational storage for each reservoir.

TABLE 3-10

Operational Storage

Press Zone	Rattlesnake Uplands	Edgewick	Proposed Future Tanner Reservoir	Middle Fork	River Point	Terrel
Operational Storage ft	2	2	3	2	2	2
Operational Storage gal	18,500	71,500	264,400	21,200	8,000	8,000

Equalizing Storage

Equalizing storage is typically used to meet high diurnal demands that exceed the average daily and maximum day demands. The volume of equalizing storage required depends on peak system demands, the magnitude of diurnal water system demand variations, the source production rate, and the mode of system operation. Sufficient equalizing storage must be provided in combination with available water sources and pumping facilities such that peak hour demands can be satisfied.

Equalizing storage is calculated using the following equation:

$$V_{ES} = (Q_{PH} - Q_S)150 \text{ minutes}$$

V_{ES} = Equalizing storage component (gallons)
Q_{PH} = Peak hourly demand (gpm)
Q_S = Total source of supply capacity, excluding emergency sources (gpm)

The equalizing storage required for the Water Association is summarized in Table 3-11.

TABLE 3-11

Equalizing Storage

Pressure Zone	Rattlesnake/ Uplands	Edgewick	Proposed Future Tanner Reservoir	Middle Fork	River Point	Terrel
Peak Hour Demand (gpm)	1,172	200	1,500	20	51	53
Source of Supply[(1)] (gpm)	435	1,500	1,000	75	140	68
Equalizing Storage Requirement (gal)	100,600	0	75,000	0	0	0

(1) The capacity of the source of supply for each zone fed by pumping is normally established by the pumping capacity feeding into that zone. For this analysis, the booster pump capacities of pumps fed by the pumping capacity of an upstream supply pump are deducted from the capacity of the upstream supply pump. For instance, the Rattlesnake/Uplands source is the Rattlesnake Wells at 725 gpm, however, the capacities of the River Point BPS and the current normal pumping capacity of the existing Tanner BPS have been deducted from the Rattlesnake Well capacity in recognition of the cascading effect upon the required ES in the Rattlesnake/Uplands Zones and the recognition of the need for additional storage to reduce those impacts.

Standby Storage

Standby storage is provided in order to meet demands in the event of a system failure such as a power outage or an interruption of supply. The amount of standby storage should be based on the reliability of the water supply, the pumping equipment, standby power sources, and the anticipated length of time the system could be out of service.

The DOH recommended standby storage volume is calculated using the following equations:

SB = The larger of:
For Systems With A Single Source
SB = (2)*(ADD)
For Systems With Multiple Sources
SB = (2 days)*(ADD) – t_M*(Q_S – Q_L)
or
SB = (200)*(ERU's)

SB = Recommended standby storage volume (gallons)
ADD = Average daily demand for the design year (gpd)
Q_S = Total source capacity, excluding emergency sources (gpm)
Q_L = Largest capacity source unavailable (gpm)
t_M = Time the remaining sources are pumped (minutes)

Standby storage calculations are based on the assumption that adequate source capacity will be developed to meet average daily demands with the largest source or related system component out of service. Therefore, for the purposes of this analysis, projected average daily demands are used to estimate the total source of supply capacity with the largest component or source out of service. In all cases, the calculated standby storage exceeds the minimum requirement of 200 times the number of residential connections, plus the average daily demand of all other users on the system. Standby storage requirements are summarized in Table 3-12.

TABLE 3-12

Standby Storage

Pressure Zone	Rattlesnake/ Uplands	Edgewick	Proposed Future Tanner Reservoir (1)	Middle Fork	River Point	Terrel
Reliable Source Capacity (gpm)	725	230	750	1500	0	0
Estimated ERUs in Each Zone	1,564	467	4,293	48	93	73
Average Daily Demand (gallons)	355,000	106,000	1,063,858	10,900	21,100	16,600
Minimum Standby Requirement (gallons)	224,000	0	0	0	42,200	33,200
Standby Storage (SB) - 200 G/ERU	223,600	93,400	858,669	9,600	18,600	14,600
Required Standby Storage (SB) -	224,000	93,400	858,669	9,600	42,200	33,200

(1) For lack of better information on future on growth in the North Bend UGA, and to develop a sense of the ultimate volume of storage needed, the number of ERUs has been calculated based upon the 967 Acre-Feet of water North Bend has projected for the UGA area.

Fire Suppression Storage

Fire suppression storage is provided to ensure that the volume of water required for fighting fires is available when necessary. The amount of water required for fire fighting purposes is specified in terms of rate of flow in gallons per minute (gpm) and an associated duration, both of with are established by the King County Fire Marshal and King County Code. Fire flows must be provided while maintaining a minimum residual water system pressure of at least 20 pounds per square inch (psi) at each service throughout the system.

Fire suppression storage is calculated using the following equation:

$$V_{FSS} = NFF * T$$

V_{FSS} = Required fire suppression storage component (gallons)
NFF = Needed fire flow (gpm)
T = Duration (minutes)

The residential fire flow requirement within the Association's service area is 1,000 gpm for 2 hours. Commercially zoned areas, such as Truck Town, have higher required flow rates, and the Middle Fork Business Park, has the highest fire flow requirement of 3,000 gpm for 2 hours. The Opstead School has a fire flow requirement of 2,500 gpm for 2 hours. Table 3-13 provides the fire suppression storage calculation for each pressure zone based on existing fire flow commitments. The River Point area can receive half of its fire flow from the Terrel Reservoir, and the Middle Fork Zone will be able to receive up to 3,000 gpm from the Edgewick Zone, if needed.

TABLE 3-13

Fire Flow Storage

Pressure Zone	Rattlesnake/ Uplands(1)	Edgewick	Proposed Future Tanner Reservoir	Middle Fork	River Point(2)	Terrel
Fire Flow Rate (gpm)	1,000	3,000	1,500	2,000	1,000	1,000
Fire Flow Duration (hours)	120	120	120	120	120	120
Fire Suppression Storage Requirement (gal)	120,000	360,000	180,000	240,000	120,000	120,000

(1) 750 gpm of fire flow can be provided from both the River Point and Edgewick Zones to augment flows in the 701 Zone. The future Tanner Reservoir and BPS will be able to provide 1,500 gpm to either the 701 Zone or the Edgewick Zone when it is completed.
(2) Additional storage is available from the Terrel zone.

Dead Storage

Dead storage is defined as the reservoir capacity that cannot be used for other storage components due to low pressures in the distribution system associated with lower water levels in the reservoir. All storage that is either below the water level that corresponds to

20 psi at the highest service connection, or above the source shut-off set point in the reservoir is considered dead storage. Table 3-14 provides the dead storage analysis for each pressure zone.

TABLE 3-14

Dead Storage

Pressure Zone	Rattlesnake/ Uplands[(1)]	Edgewick[(2)]	Proposed Future Tanner Reservoir	Middle Fork	River Point	Terrel
Highest Service Elevation (ft)	1,100	709	500	800	746	917
Required HGL at 20 psi (ft)	1,146	755	546	846	792	963
Bottom of Reservoir Elevation (ft)	1,165	733/760/ 760	585	848	800	969
Dead Storage (ft)	19	20/3/3	3	3	2	2
Dead Storage (gallons)	175,900	103,255	264,357	31,700	7,900	7,900

(1) The top 2.5 feet of the Uplands Reservoir cannot be filled because it is higher than the Rattlesnake Reservoir overflow. The unusable space is considered dead storage.

(2) The Edgewick Reservoirs are considered to be dead storage below elevation 763, because the two new reservoirs have outlet piping above the floor elevation. The dead storage volume is the total of this volume plus the lower 20 feet in the old reservoir. .

The highest service in the 793 Zone (Edgewick Reservoir) is the Shell gas station, which is at 709 feet. If the level in the reservoir drops to elevation 755 feet (17 feet above the original Edgewick reservoir bottom), the pressure at the Shell gas station would be 20 psi, and any further drop below 17 feet would cause a the service pressure to drop below 20 psi. The total dead storage in the Zone consists of all storage below 3 feet above the floor elevations of the new reservoirs, however, to allow for outlet piping in the two new reservoirs.

Combined Storage Capacity Analysis

The total required storage volume is calculated based on the sum of the operational storage, equalizing storage, standby storage, and fire suppression storage components. For reservoirs with dead storage components, the sum of the above components must be provided at elevations above the upper limit of the dead storage component. In addition, the lower level of the equalizing storage must be at an elevation above that which will provide 30 psi under normal operating conditions.

Fire suppression storage and standby storage can be “nested” if allowed by the Fire Marshal. Nesting is only recommended if the reservoir can be refilled in a timely and reliable manner, and if the relative volumes of standby and fire suppression storage are in a ratio of 4:1 or 1:4 minimum. The basis for this recommendation is that with smaller ratios, the depletion of the smaller portion will come close to depleting all of the other, and vice-versa. Unrestricted nesting is accepted by the King County Fire Marshal.

The storage requirements for each pressure zone are shown in Table 3-15.

TABLE 3-15

Storage Capacity Analysis

Storage Component	Rattlesnake/ Uplands	Edgewick	Proposed Future Tanner Reservoir	Middle Fork	River Point	Terrel
Operational Storage (OS)	18,500	71,500	264,400	21,200	8,000	8,000
Equalizing Storage (ES)	100,050	0	75,000	0	0	0
Standby Storage (SB)	224,000	93,400	858,669	9,600	42,200	33,200
Fire Suppression Storage (FSS)	120,000	360,000	300,000	240,000	120,000	120,000
Total Required Storage	**342,550**	**431,500**	**1,198,069**	**261,200**	**128,000**	**128,000**
Storage Volume	383,000	480,000	1,469,000	370,000	158,000	158,000
Dead Storage	13,200	103,300	264,400	31,700	7,900	7,900
Total Effective Storage	**369,800**	**376,700**	**1,204,600**	**338,300**	**150,100**	**150,100**
Storage Surplus	**27,200**	**(55,000)**	**6,500**	**77,100**	**22,000**	**22,000**

Storage Deficiencies

With the proposed Tanner Reservoir and booster station the storage deficiency in the Edgewick Reservoir will be addressed. Until that time, the storage deficiency is offset by flow from the Middle Fork Reservoirs at the point that the Edgewick booster station pumps run out of water and pressure drops to the point that the Middle Fork Zone pressure is higher than the 920 Zone and the PRVs allow backflow into the 920 Zone.

Booster Pump Station Capacities Considerations Impacting Reservoir Deficiencies

The existing Tanner Booster Station supply to the Edgewick Reservoir cannot be considered totally reliable as automatic transfer to auxiliary power is not available at the Tanner Booster Station. The Tanner Booster Station is, however, equipped with a redundant pump, and has a plug-in auxiliary power connection for the Association’s mobile generator. Planned future upgrades to this facility in conjunction with the future reservoir will eliminate these deficiencies. The supplies to the River Point Reservoir and Terrel Reservoir are also considered as non-reliable sources since the Mt. Si Booster Station has two new pumps, but no auxiliary power, and the River Point Booster Station contains only one pump and has no auxiliary power. Several projects are identified later in this report that address booster station reliability.

DISTRIBUTION SYSTEM ANALYSIS

This section presents information on the computer hydraulic model of the Association's water system and the results of hydraulic analyses conducted to evaluate the existing hydraulic capabilities of the water system. The Washington State Department of Health's WAC 246-290 requires hydraulic modeling as a component of water system plans.

The water system was analyzed using MWHSoft's H2ONet hydraulic modeling software, which operates in an AutoCAD computer-aided design and drafting environment. The H2ONet model was created using a water system base map. Reservoir elevations, well capacities, and booster station settings were determined from planning documents and construction drawings.

The H2ONet model is configured with a graphical user interface. Each water system element (pipes, pumps, control valves, and reservoirs) is assigned a unique graphical representation within the model. Each element is assigned a number of attributes specific to its function in the actual water system. Typical element attributes include spatial coordinates, elevation, water demand, pipe lengths and diameters, and critical water levels for reservoirs. With attributes of each system element as the model input, the H2ONet software produces the model output in the form of flows and pressures throughout the simulated water system.

Model Demands

A key element in the hydraulic modeling process is the distribution of demands throughout the water system. Total demands on the system are based on the existing production records shown in Chapter 2. Demands in the model are distributed throughout the water system based on eight customer billing routes. Demands for the Wilderness Rim wholesale purveyor are split evenly between the two master meter locations.

Five demand sets were used in the hydraulic analysis.

- 2003 Average Day Demands (ADD): These demands were used to calibrate the model. Demands were based on the 2003 water production records.

- 2003 Maximum Day Demands (MDD): These demands were used to evaluate fire flow availability. Maximum Day Demands were based on the ADD multiplied by a peak day factor of 2.5.

- 2003 Peak Hour Demands (PHD): These demands were used to evaluate system pressures during peak hour demand conditions. Peak Hour Demands were based on the MDD multiplied by a peak hour factor of 2.0.

- 2012 Maximum Day Demands (MDD): These demands were used to evaluate future fire flow availability with the proposed improvements in place. Demands were taken from the 2001 Comprehensive Water System Plan.

- 2012 Peak Hour Demands (PHD): These demands were used to evaluate system pressures during future peak hour demand conditions with the proposed improvements in place. Demands were taken from the 2001 Comprehensive Water System Plan.

Calibration

The calibration of a hydraulic model provides a measure of assurance that the model is an accurate and realistic representation of the actual system. The H2ONet hydraulic model of the Association's water system was calibrated using data obtained from fire hydrant tests at various locations throughout the water system. Ten fire hydrant tests were conducted in June 2004 with the assistance of the Water System Superintendent. Two tests were redone in July to verify unexpected results. Two additional tests were conducted in August to calibrate the model more accurately along Edgewick Road, south of I-90.

During these tests, the static and residual pressures were recorded while an adjacent hydrant was opened and its flow rate recorded. Static pressure is system pressure at a specific location under normal daily operation. Residual pressure is the pressure recorded adjacent to a fire hydrant that has been opened up and is flowing freely. Typically this pressure is recorded at the fire hydrant nearest to the one being flowed. Field results were used to calibrate the hydraulic model through verification of pipe type, size, and elevations and adjustment of pipe friction coefficients.

A description of each testing location is presented in Table 3-16. The location of each test is shown on the model node map located in the back of the report.

TABLE 3-16

Hydrant Testing Locations

(1) The water line in 170th Street east of Cedar Falls Road has since been replaced with a 12-inch water line running from Cedar Falls Road to SE 159th Street, and the Moody BPS has been removed from the system.

The system conditions at the time of each test were recorded. The water level in each reservoir was recorded prior to hydrant testing in each zone. The status of each well and booster station was recorded.

Using the system conditions observed during each hydrant test, the hydraulic model was adjusted to generate static pressure and residual pressures at the measured hydrant before and during the flow test. The total system demands at the time of the hydrant tests were assumed to be the average day demand for 2003. Model output was calibrated to points in the model equivalent to the locations of the hydrant tests.

The pressure in the system is in part dependent upon the friction within the pipes. The friction is dependent upon pipe material, the amount of tuberculation within the pipes and age of the pipes. Friction factors for the pipes in the modeled system are adjusted throughout the calibration process until the model output best approximates the measured values. Hazen-Williams C-factors (friction factors) between 120 and 150 are used throughout the system. These friction factors are typical values for most pipe materials. The friction factors for the pipe also compensates for minor system losses through valves and fittings.

The model output was produced for two data comparisons, static pressure and residual pressure. The values measured in the hydrant flow tests are compared to the model output values in Table 3-17.

TABLE 3-17

Calibration Results

		Field			Model		
Test No.	**Flow (gpm)**	**Static (psi)**	**Residual (psi)**	**Headloss (psi)**	**Static (psi)**	**Residual (psi)**	**Headloss (psi)**
1	1,360	69	51	18	69	51	18
2	1,150	106	73	33	106	73	33
3	1,060	103	61	42	103	60	43
4	1,160	87	61	26	87	61	26
5	1,290	100	80	20	100	76	24
6	1,050	46	39	7	46	39	7
7	1,070	62	47	15	62	44	18
8	1,030	42	38	4	42	36	6

9	1,060	72	44	28	72	38	34
10	1,170	58	39	19	58	39	19
11	690	75	19	56	75	19	56
12	1,220	64	46	18	64	42	22

The calibrated hydraulic model produced the same static pressure as measured in the field. Modeled residual pressures are within 6 psi of actual field test data and in all cases the model over estimates headlosses. Hydraulic models are required to be within 5 psi of measured pressure readings for long-range planning, according to the DOH Design Manual, Table 8-1.

In only one case did the modeled headloss exceed the 5-psi requirement. Test No. 9 was conducted on two occasions, both of which produced similar results. In both cases, the headlosses measured in the field was less than the modeled results. It is possible to "force" the calibration to close through application of certain assumptions; however, we do not believe it prudent to utilize this approach in this case as the assumptions fall well beyond reasonable explanation. As noted, the model conservatively underestimates the available fire flow for this area and we believe it is prudent to accept these conservative results until further investigation into actual field conditions can be completed.

Peak Hour Analysis

According to WAC 246-290, a water system must maintain a minimum pressure of 30 psi in the distribution system under peak hour demand conditions. The existing distribution system has been modeled under 2003 peak hour demand scenarios. Results of these analyses are located in Appendix G.

The peak hour analysis identified pressures below 30 psi in three areas. Table 3-18 identifies the low pressure areas.

TABLE 3-18

Peak Hour Pressure Deficiencies

Location	Zone	Model Node Numbers	Peak Hour Pressure	Elevation	Comment
Mt. Si Road, west of River Point Reservoir	840	J-576, J-586	15.6 psi – 28.6 psi	770 ft. – 800 ft.	Low pressure only at hydrants, not service meters
480th Avenue SE, south of Terrell Reservoir	1,009	J-690, J-692, J-694	28.2 psi	940 ft.	Several homes located along this road.
477th Avenue and 157th Street, in Cascade East	793	J-838	29.4 psi	720 ft.	Few homes located on a hill.

Available Fire Flow Analysis

The DOH *Water System Design Manual* states that a water system should be designed to provide adequate fire flow under maximum day demand conditions, while maintaining a minimum system pressure of at least 20 psi throughout the system.

The majority of the service area is zoned residential, which requires 1,000-gpm fire flow for 2 hours. The Middle Fork Industrial Park requires 3,000 gpm of fire flow for 2 hours. Complete results of fire flow modeling are presented in Appendix H. A map showing the available fire flow at each model node can also be found in back of the report.

Table 3-19 lists the range of flows in each zone within the water system and their required flow during 2003 maximum day demand conditions with the 20-psi constraint. The available flow rate may be greater than that shown; however, the flow rates shown are those that are available while maintaining a minimum service pressure of 20 psi at all service connections.

TABLE 3-19

Available Fire Flow Results with Existing System(1)

Pressure Zone	Range of Available Fire Flows(2) (gpm)	Greatest Required Fire Flow (gpm)	Meets Fire Flow Requirement?
1,215	1,000 – 2,500	1,000	Yes
701	650 – 2,500	2,500	In most areas(4)
793	300 – 3,180(3)	3,000	Residential requirement is not met in some areas. Commercial requirement will be fully met with new Tanner Reservoir and Booster Station.
883	1,000 – 2,000	1,000	Yes
920	1,000 – 3,000	3,000	Yes
840	700 – 1,250	1,000	In most areas
1,009	560 – 1,100	1,000	In some areas

(1) A complete list of results and a model node map can be found in Appendix H.

(2) Available fire flow is limited by a minimum system pressure of 20 psi, not specifically the fire flow at any specific location. The flow rates shown are with reservoirs depleted of OS, ES, SB and FSS.

(3) Fire flow availability in this zone is restricted south of I-90 due to head losses in the long run of 8-inch pipe under the freeway and the dead-end 6-inch lines at the far southeast corner of the zone.

(4) Two areas cannot meet the residential fire flow requirement. Fire flow is limited at the south end of 432nd Avenue because the area is supplied by a dead-end 6-inch water main. Fire flow is limited at the west end of 149th Street because the area is supplied by a dead-end 6-inch water main.

Hydraulic Deficiencies

The analysis identified a fire flow deficiency at all services south of I-90, along Edgewick Road. Two factors cause the low fire flow availability in the area.

- First, the water main supplying the area south of I-90 is approximately 2,400 LF of 8-inch water main. Headlosses through this section of water main significantly reduce the available pressure downstream of the area south of I-90. A flow rate of 480 gpm to the intersection of Edgewick Road and 153rd Street reduces the service pressure to 20 psi at 477th Avenue and 157th Place. All flow to this area must pass this intersection, therefore, the maximum available fire flow is limited to 480 gpm.

- Second, while limited to 480 gpm maximum as discussed above, the water mains branching from the intersection of Edgewick Road and 153rd Street are dead-end water mains in which additional headloss occurs, causing further reduction in available flow. The available fire flow (and water quality) along these dead-end mains could be increased by looping the end of these mains together.

SUMMARY OF SYSTEM DEFICIENCIES

WATER RIGHTS

Based on the current projections, the Association will exceed its annual water rights allotment in approximately 2016 as shown in Table 3-10. This is based upon a growth rate of approximately 50 connections per year. The Association is currently working with the City of North Bend to obtain additional source of supply to alleviate this potential shortfall.

SOURCE OF SUPPLY

The Association will require additional instantaneous source capacity by approximately 2016, as indicated in Table 3-8. The Association has sufficient instantaneous water rights to meet their peak day demand, but does not currently have the system set up to maximize available well pumping capacity. Wells 1 and 2 (capacity – 725 gpm each) cannot currently be used at the same time due to hydraulic capacity limitations in the main line leading from the wells to the point of entering the distribution system. This problem can be addressed with the installation of additional telemetry controls for the operation of the wells and an altitude valve on the Rattlesnake Reservoir, or increasing the capacity of the main from the wells to the distribution system. This project will be further discussed in Chapter 8 -CIP.

STORAGE

With the planned first phase of the Tanner booster station and reservoir, all of the minor storage deficiencies within the system will be eliminated.

BOOSTER STATION

Some of the Association's smaller booster stations are unable to meet the ADD requirement with the largest pump out of service. This is due to one or both of two items: a single pump at the booster station and the lack of auxiliary power in the case of a power outage. Chapter 8 –CIP provides an explanation of the projects the Association will undertake in order to rectify the deficiencies.

DISTRIBUTION SYSTEM

The Water Association has a few areas in the system that will not receive adequate fire flow even with the recent and proposed source, storage, and booster station improvements. Projects to address these deficiencies will include upsizing existing water mains and provide looping in other sections of the system. A list of these projects can be found in Chapter 8 CIP.

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