FINAL REPORT

Water System Master Plan

Prepared for

Kernville-Gleneden Beach-Lincoln Beach Water District, Gleneden Beach, Oregon

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Acronyms and Abbreviations

AC	Asbestos-cement
ADD	Average day demand
AWWA	American Water Works Association
CPC	Contaminants of potential concern
CT	Product of chlorine residual (mg/L) and contact time (minutes)
DBP	Disinfection By-Products
DEQ	Department of Environmental Quality
District	Kernville-Gleneden Beach-Lincoln Beach Water District
DOGAMI	Department of Geology and Mineral Resources
EPA	Environmental Protection Agency
GIS	Graphical information system
gpm	Gallons per minutes
HAA5	Haloacetic acids (5 regulated compounds)
HDD	Horizontal directional drilling
HDPE	High density polyethylene pipe
LCR	Lead and copper rule
LSWD	Lower Siletz Water District
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
MCL	Maximum contaminant level
MDD	Maximum day demand
MG	Million gallons
mgd	Million gallons per day
OAR	Oregon Administrative Rules
ODOT	Oregon Department of Transportation
ORP	Oregon Resiliency Plan
OWRD	Oregon Water Resources Department
PHD	Peak hour demand
PVC	Polyvinyl chloride pipe
Stage 2 DBP	Stage 2 Disinfection By-Products Rule
TTHM	Total trihalomethanes
WHO	World Health Organization

Introduction

This report provides Kernville-Gleneden Beach-Lincoln Beach Water District with a water system master plan. The plan examines existing and future needs and presents recommendations and costs for improvements. It updates the District's year 2000 plan.

The following technical topics are covered:

- Historical and projected water use
- Water quality and regulations
- Service goals and policies
- Intake and treatment evaluation
- Distribution system evaluation
- Seismic needs evaluation

An update to the District's Water Management and Conservation Plan was being prepared and submitted to the state in parallel to development of this plan. It provides a detailed analysis of the District's water supply and its adequacy for meeting future needs.

A chapter specific to seismic risks and resiliency has been added to this master plan update. Since the preparation of the 2000 master plan, it has become known that the Northwest and particularly, the Oregon coast, is vulnerable to a major earthquake and possibly a tsunami. A major event could cripple coastal water utilities for years. The goal is for the District to take measured steps over many years to reduce risks and improve the ability of the system to respond in the event of a Cascadia Subduction Zone earthquake.

The final chapter of this report provides an updated capital improvements plan to guide the District's investments in the coming years.

1.1 Acknowledgements

This master plan was completed with the assistance of District staff, particularly Mike Bauman, District Superintendent. The principal staff from CH2M were the following:

Paul Berg, PE, project manager
Sheryl Stuart, PE, water use and projections planner
Adam Nielsen, distribution system modeling
Nason McCullough, PE, seismic evaluation

Description of Existing System

The Kernville-Gleneden Beach-Lincoln Beach Water District (District) operates a public community water system (Public Water System Identification No. 4100324). This chapter describes major facilities of the District's water system. A system schematic is included as Figure 2-1.

2.1 System Overview

The District supplies water to approximately 2,400 accounts between Depoe Bay to the south and Lincoln City to the north. The District also supplies treated water to the Lower Siletz Water District (LSWD) as a wholesale customer.

Water from Drift Creek is treated in the District's slow sand filtration plant and then is pumped to the North Reservoir. Water flows by gravity from this reservoir to most of the service area. A small portion is pumped to the upper elevations in Salishan Hills development.

2.2 Source

The District has two sources of supply. The District's primary source is Drift Creek. An unnamed tributary to Drift Creek serves as a backup supply during periods of high turbidity in Drift Creek. The original point of diversion on Drift Creek is located about three miles inland from the Pacific Ocean. As a result of an agreement in 2005 the District's permits were modified to provide an additional downstream point of diversion at Lincoln City's surface water diversion on Drift Creek. The District holds certificates to all of its surface water rights. The District also holds a claim for groundwater as a back-up source of supply.

The District obtains its water from Drift Creek through an infiltration gallery system underneath the streambed or through a direct surface intake. There are two sections of infiltration galleries; the newer one was constructed in 2013 to replace the original infiltration gallery. The District can supplement the withdrawals through the infiltration galleries with a direct surface intake but does not generally use that approach. The infiltration galleries and direct intake deliver water by gravity to a concrete pump well, from which water is pumped to the slow sand filters.

The District has a certificate for a second source of water to be used during storm events. This source is an unnamed tributary of Drift Creek that enters Drift Creek a few hundred feet downstream of the District's existing point of diversion on Drift Creek. This certificate does not increase the District's total quantity of water rights. Its use is conditioned so that it only may be used in lieu of the District's other rights during high-turbidity events on Drift Creek and only from October 15 to May 15.

2.3 Interconnections with Other Systems

The District serves water to and is the only supply source for the Lower Siletz Water District (LSWD), which is Public Water System Identification No. 41001428. The two systems are connected through a 6-inch main. The master meter is located on the shoulder of the Siletz Highway. The District has considered an installation of a finished water interconnection with Lincoln City to allow for mutual emergency backup, but no interconnection exists at this time.

2.4 Intergovernmental Agreements

The District signed an intergovernmental agreement with Lincoln City on July 12, 2001. Among other accomplishments, the Intergovernmental Agreement authorized the sale of 1.5 cubic feet per second (cfs) of the District's water rights from permit S-54187 to Lincoln City, established an emergency backup supply for Lincoln City of up to 1.5 cfs from permit S-54186 or S-54187, and established a cooperative arrangement to make full beneficial use of permits S-54186 and S-54187. The assignment and numerous water right transactions needed to move the Intergovernmental Agreement forward were approved in the Supplemental Settlement Agreement executed September 8, 2005. The District has no other intergovernmental agreements in force. Water right permits S-54186 and S-54187 were certificated on December 18, 2009.

2.5 Service Characteristics

The District's 2,371 customer accounts are divided into residential and commercial categories. Residential customers include both full-time residents and vacation homes. The commercial accounts include commercial establishments (restaurants, motels, and stores), apartment complexes, and time-share vacation homes. In recent years, the residential customers used about 58 percent of the total metered consumption and the commercial accounts used about 41 percent. The remaining 1 percent was for public use (primarily firefighting and main flushing).

2.6 Treatment

The slow sand filtration plant was constructed in 1991-1992 to bring the District in compliance with the federal Surface Water Treatment Rule of the Safe Drinking Water Act. Recent studies continue to confirm slow sand filtration's effectiveness for removing microorganisms such as *Giardia* and *Cryptosporidium*. The primary limitation of slow sand filtration is that the filters clog too quickly when raw water turbidities are high. It is most effective for water sources with average turbidities of less than 5 nephelometric turbidity units, which is the case for Drift Creek. The infiltration galleries are useful for limiting the solids loading to the slow sand filters. Filtered water is chlorinated at the plant, and chlorine contact time is provided by the transmission main from the plant to the North Reservoir, in the North Reservoir, and in the transmission line from the North Reservoir to the first customer along Highway 229.

The plant has a rated capacity of 1.2 mgd. It has three filters, each sized at 2,904 square feet. At the capacity of 1.2 mgd, the filtration rate is 138 gallons per day per square foot.

Water from Drift Creek is pumped to the filter plant using one or both of the raw water pumps, each sized at 420 gallons per minute (gpm) at 47 feet of head. They are powered by 10 horsepower motors. Water from the unnamed tributary flows by gravity to the plant. Chlorine is added to the filtered water and then it is pumped from the small clearwell to the North Reservoir. There are three filtered water pumps, each sized at 420 gpm and 320 feet of head. They are powered by 50 horsepower motors.

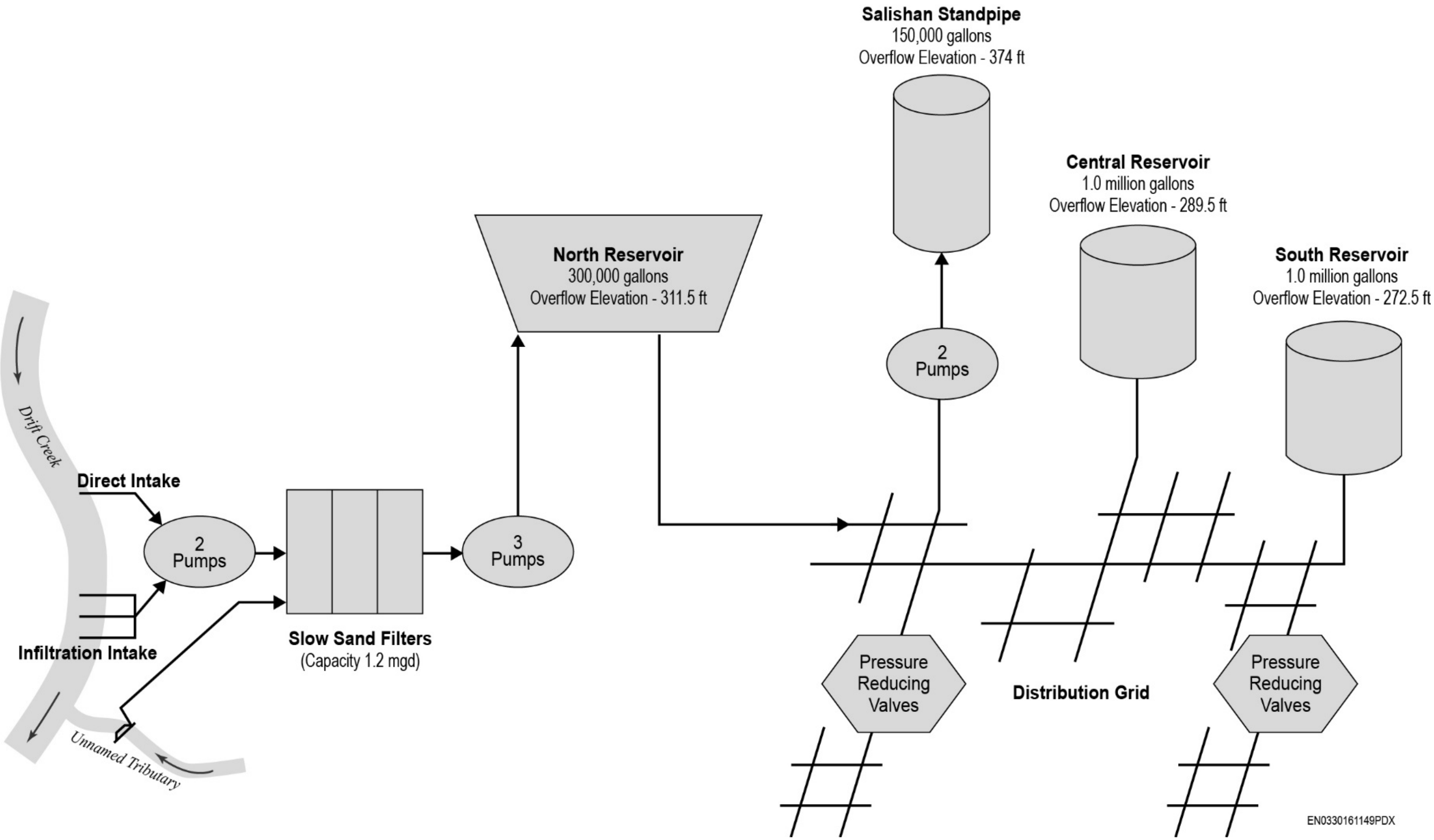

Figure 2-1. Kernville-Gleneden Beach-Lincoln Beach Water District System Schematic

2.7 Storage

The District's system includes four finished water storage reservoirs. Their combined capacity is 2,450,000 gallons. Water flows by gravity from the North Reservoir through the distribution grid to the Central and South Reservoirs. These two reservoirs are said to float on the system. They fill and empty depending on system demands and system pressures. Table 2-1 describes the reservoirs. A third reservoir, the Salishan Standpipe, is fed by a pump station.

Table 2-1. Storage Reservoirs
Water System Master Plan

Name	Capacity (gallons)	Overflow Elevation (feet)	Height (feet)	Material	Date of Construction
North	300,000	311.5	8.5	Concrete (metal roof)	
Salishan Standpipe	150,000	374	64	Steel	1982
Central	1,000,000	289.5	39.5	Steel	1992
South	1,000,000	272.5	31.5	Steel	1971

Until 2016, the Salishan Hills (aka Bluffs) Pump Station was equipped with two pumps, each with a capacity of 60-70 gpm, configured in a lead/lag mode. However, the District was implementing changes to this pump station as this report was being prepared, in advance of the repainting planned for the Salishan Standpipe. The goal of the changes was to enable the upper zone served by the Salishan Standpipe to operate as a closed-end system with no reservoir storage for the approximately eight weeks the tank will need to be off-line for painting. To enable this operation, the District replaced one of the two pumps with a 300 gpm pump, to provide higher flows for firefighting, and added a small pump to operate as a continuously-running (aka jockey) pump to meet the low demands during the nighttime. The improvements included the addition of a new pressure-switch controller so the pumps will operate automatically.

2.8 Distribution System

The distribution grid consists of 2-inch through 16-inch pipes. The majority of pipes in the system are either polyvinyl chloride (PVC) or asbestos cement (AC). The main backbone of the system is a 10-inch AC main that runs along Highway 101 from Salishan south to Surfrider Restaurant.

Water pressures on the west side of Highway 101, in areas with low elevations, are limited by means of District-owned pressure reducing valves. The operators have set the pressure-reducing valves to reduce high pressures to about 40 to 50 pounds per square inch (psi). Much of the system uses asbestos cement pipe of poor quality (Simplex brand) that is prone to joint failure at pressures higher than 50 psi.

The pipe inventory for the District's system is provided in Table 2-2 and Figure 2-2. As illustrated in Figure 2-2, there are roughly equal percentages of PVC and AC pipe in the system, with only small percentages of the system made with high-density polyethylene (HDPE) and ductile iron. Figures 2-3 and 2-4 provide a further breakdown of the PVC and AC pipe according to diameter.

Table 2-2. Pipe Material Inventory
Water System Master Plan

Material	Length (ft)
PVC	106,649
AC	102,586
HDPE	4,972
Ductile iron	813
Unknown	1,587
Total	215,020

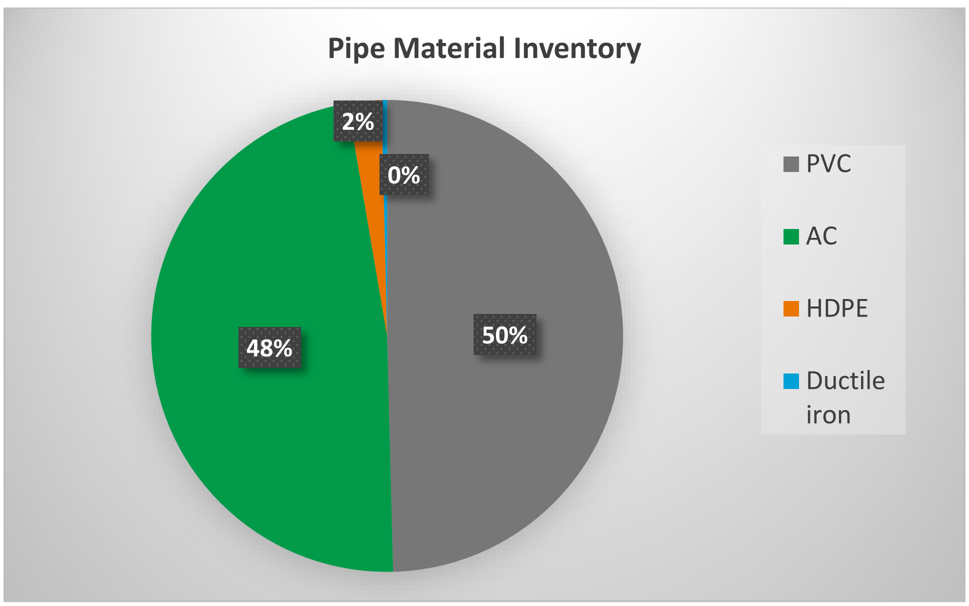

Figure 2-2. Pipe Material Inventory

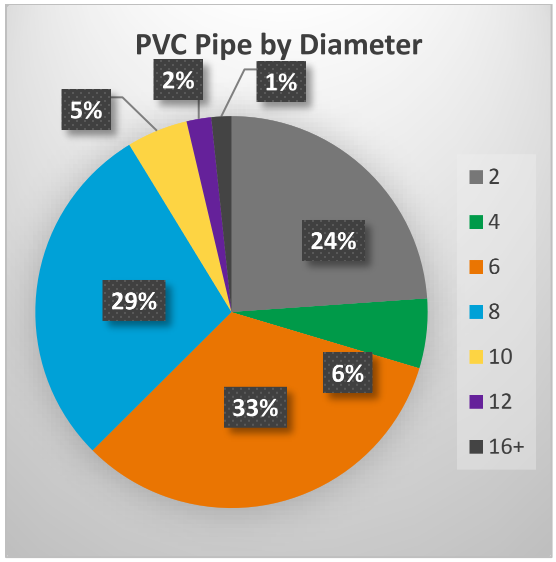

Figure 2-3. PVC Pipe Inventory by Diameter

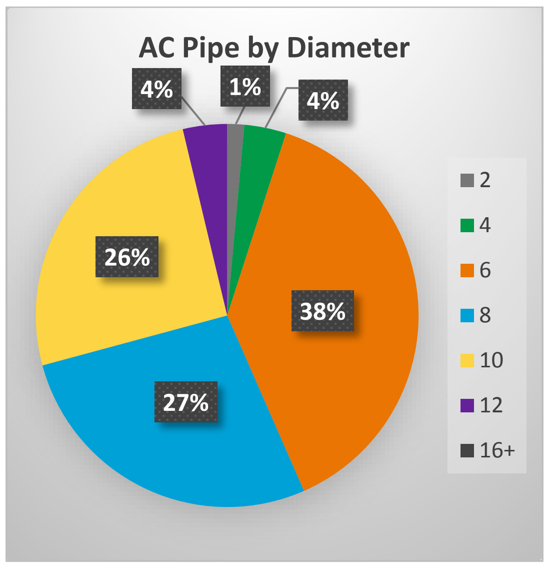

Figure 2-4. AC Pipe Inventory by Diameter

SECTION 3

Historical and Projected Water Use

This chapter describes the customer base and water use records for the District, and presents projections for future water use.

3.1 Chapter Summary

The District provides drinking water to about 2,400 customer accounts. About 90 percent of these are residential accounts, with the remainder being comprised of restaurants, stores, motels, apartments, and time-share rentals.

On average, the District produced about 420,000 gallons per day in 2015. The total production was 153 million gallons during the year. On a peak day, the District produced 933,000 gallons per day. About 74 percent of the production reaches customers and is metered and recorded as sales to customers. The remaining 26 percent is unauthorized, nonrevenue water. The term unauthorized, nonrevenue water is specifically defined within this chapter. It includes metering inaccuracies, incorrectly estimated authorized use that is not metered (such as flows from hydrants for flushing or fire-fighting), and leaks from pipes.

Demand projections have been developed by considering population trends within Lincoln County and using an estimation of per capita water use. According to this approach, demands are expected to grow by 0.9 percent per year.

3.2 Definition of Terms

Demand refers to total water use; that is, the sum of consumption (residential, commercial, public, and industrial) and public uses (for example, firefighting or hydrant flushing), plus water lost to leakage, reservoir overflow, and evaporation.

Demand is equal to the water that must be pumped from the District's slow sand filter treatment plant into the system. Demand and production have equal values according to this definition.

Generally, demands and consumption in municipal systems are expressed in units of gallons per day (gpd) or million gallons per day (mgd). They may also be expressed in cfs or gallons per minute (gpm). One mgd is equivalent to 1.55 cfs or 694 gpm. For annual or monthly values, it is typical to refer to the total quantity of water in million gallons (MG). Water use per person (per capita use) is expressed in gallons per capita per day.

The following terms are used to describe specific values of system demands:

- ADD equals the total annual production divided by 365 days.
- Maximum day demand (MDD) equals the highest system demand that occurs on any single day during a calendar year.
- The three-day maximum day demand (3-day MDD) equals the average of the daily demands for the 3 consecutive days with the highest demand.
- Monthly demand equals the total volume of water produced in a month divided by the number of days in the month.

- Maximum monthly demand equals the highest demand in one of the 12 months of a calendar year.
- Peaking factors are the ratios of one demand value to another. The most commonly used peaking factor is the ratio of the MDD to the ADD.

MDD is an important value for water system planning. The river withdrawal systems, treatment plant, and plant high service pumping capacities must all be capable of meeting the MDD. If demands exceed the capacity of these facilities then storage volumes in the storage tanks will be depleted that day. In such a case, a series of high demand days would eventually put the system into a shortage. Therefore, the general rule of sizing water system supply facilities is to ensure they are larger than the MDD. Since it may take several years to expand such facilities, when the multiple steps of planning, permitting, designing, and constructing larger facilities is considered, it is important to initiate expansions when the projected MDD is within 8-10 years of equaling the maximum capacity of the supply facilities.

The most common units for expressing demands are million gallons per day (mgd). One mgd is equivalent to 695 gallons per minute (gpm) or 1.55 cubic feet per second (cfs).

3.3 Service Area Description

U.S. Census block data for areas overlapping the District's boundaries indicate that the permanent residential population in both single-family and multifamily households in 2010 was less than 4,600 people. However, because of the tourist destination nature of coastal community, on any given day the population served can be much higher. For example, Lincoln City to the north of the District experiences population swings of between 8,000 and 30,000 during certain times of the year.

The 2014 Lincoln County Economic Study indicates that second homes represented more than 25 percent of total housing units in Lincoln County in 2010. The term second home uses the U.S. Census Bureau definition for vacant seasonal, recreational, or occasional use housing units. "A housing unit could be a detached dwelling, condominium, etc."

> "The second home housing is an important public services demand indicator. The owners and/or renters who use this housing would not be counted as residents. The actual housing occupancy of second homes will be higher in the summer months. That along with summer time visitor counts, boost the numbers of people that providers need to anticipate for service supply levels. Public service infrastructure as well as fee schedules for public services need to be calibrated to accommodate these peak capacity levels." Lincoln County Economic Study 2014 p.17.

The District serves the unincorporated area of Kernville and the urbanization exception area of Lincoln Beach-Gleneden Beach area. The area is located along US Highway 101 approximately 3 miles south of Lincoln City and 2 miles north of Depoe Bay. Table 3-1 summarizes land use data for these areas from the Lincoln County Transportation Plan 2007. As shown in Table 3-1, in 2004 Kernville covered 28 acres and had 21 developed lots and 9 developable lots. The Lincoln Beach-Gleneden Beach area covered 1,510 acres and had 1,511 developed lots out of a total 2,997 potential lots (671 existing undeveloped lots and 840 potential undeveloped lots). The Lincoln Beach-Gleneden Beach area had 2,157 dwelling units within the community boundary. Figure 3-1 is a map of the District service area.

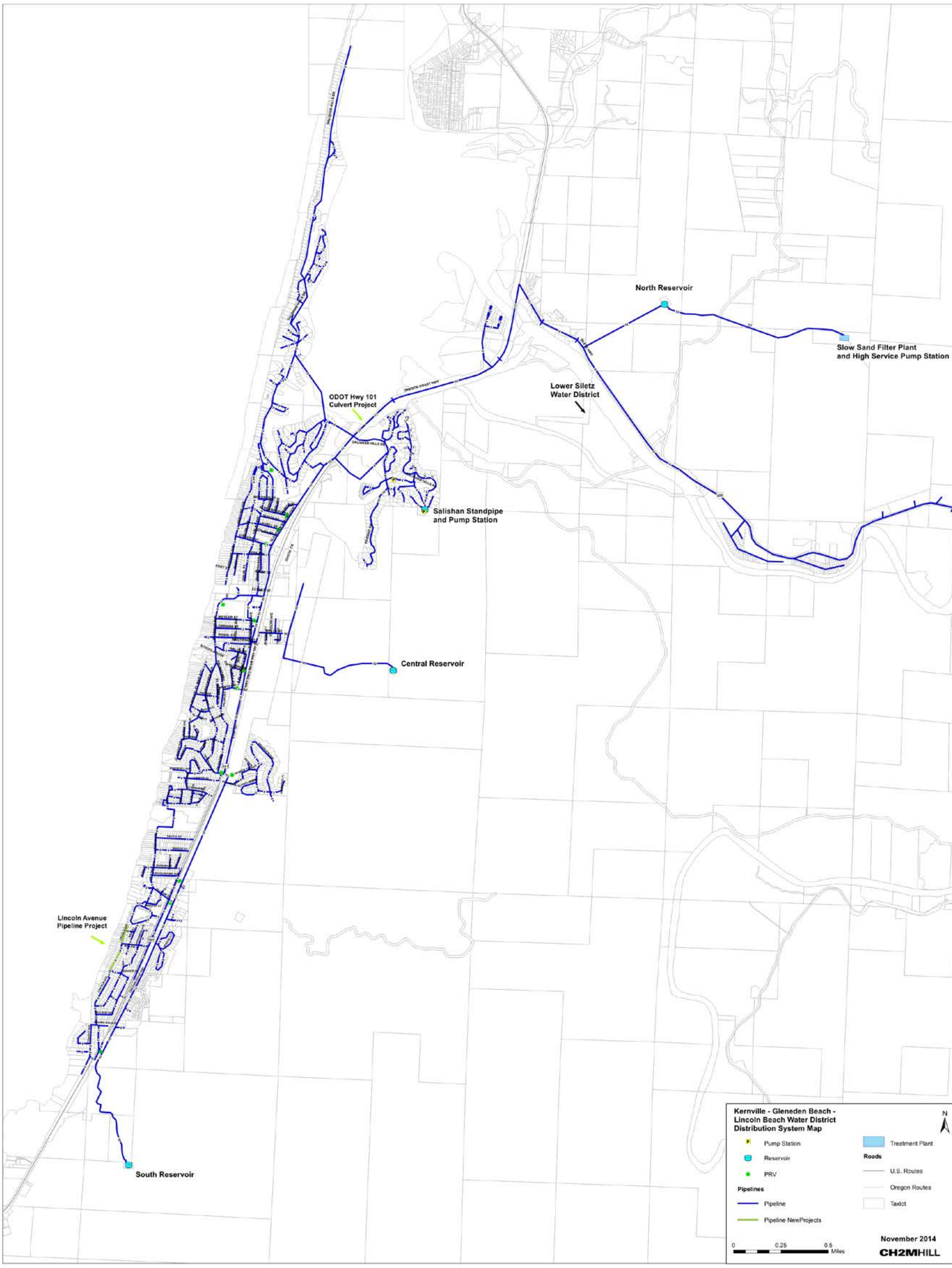

Figure 3-1. Kernville-Gleneden Beach-Lincoln Beach Water District Service Area

Table 3-1. Kernville-Gleneden Beach-Lincoln Beach Development Potential
Water System Master Plan

Site	Zoning Designation	Area (Acres) (2004)	Developed Lots (2004)	Developable Lots (2004)	Total
Kernville	Residential 1; Planned Marine	28	21	9	30
Lincoln Beach-Gleneden Beach	Residential 1, 1A, and 4; Residential 1 Planned Development; Retail Commercial 1; Tourist Commercial; Public Facilities	1,510	1,486	1,511	2,997
Total			**1,507**	**1,520**	**3,027**

Developable lots are vacant or result from potential subdivision regardless of possible physical limitations (e.g., septic requirements).

Source: Lincoln County Planning Department, 2005; *Lincoln County Transportation Plan*, 2007.

3.4 Demand Records

3.4.1 Terminology

Production refers to the quantity of water delivered to the distribution system from the water treatment plant. "Production" and "demand" are synonymous as used within this report and refer to the amount of water pumped to the North Reservoir from the high-service pumps at the water treatment plant. Production (demand) may be divided into two broad categories: water that provides revenue to the utility, and water that does not provide revenue, also known as nonrevenue water. This breakdown is shown in the International Water Association/American Water Works Association (IWA/AWWA) water audit schematic shown in Table 3-2. Revenue water consists of all billed, metered water consumption, and billed unmetered consumption, for example, water sold for construction but not metered. Nonrevenue water consists of authorized, unbilled metered or nonmetered consumption such as use for firefighting and hydrant flushing; unauthorized consumption; water loss because of meter inaccuracies; and real losses such as through leaks, reservoir overflows, and evaporation.

Table 3-2. IWA AWWA Water Audit Methodology
Water System Master Plan

<table>
<tr><td rowspan="9">System Input Volume</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Nonmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="7">Nonrevenue Water</td></tr>
<tr><td>Unbilled Nonmetered Consumption</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="2">Apparent Losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Metering Inaccuracies</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on Transmission or Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections to Customers' Meters</td></tr>
</table>

The District is fully metered, so metered consumption represents the District's revenue water. Demand minus metered consumption equals nonrevenue water.

3.4.2 Annual Production (Demands)

Table 3-3 summarizes annual demand records for the District for the period of 1999 through 2015. Figure 3-2 is a graph of demand data for the entire period.

Table 3-3. District Demand Records 1999-2015
Water System Master Plan

Calendar Year	Average Day Demand (gpd)	Maximum Day Demand (gpd)	3-Day MDD (gpd)	Date of MDD	Ratio of Maximum Day to Average Day
1999	471,000	820,000			1.7
2000	492,000	800,000			1.6
2001	410,000	850,000			2.1
2002	430,000	880,000			2.0
2003	484,000	900,000			1.9
2004	433,000	860,000			2.0
2006	385,000				
2007	397,000				
2008	403,000				
2009	355,000				
2010	421,000				
2011	432,000	769,000	607,000	4-Sep	1.8
2012	463,000	799,000	590,000	5-Mar	1.7
2013	450,000	760,000	617,000	1-Aug	1.7
2014	383,000	654,000	535,000	20-Jul	1.7
2015	420,000	933,000	647,000	5-Jul	2.2
Average	**430,000**	**820,000**	**599,000**		**1.9**
Minimum	**367,000**	**654,000**	**535,000**		**1.6**
Maximum	**492,000**	**933,000**	**647,000**		**2.2**

Blanks in table indicate that data were not available.

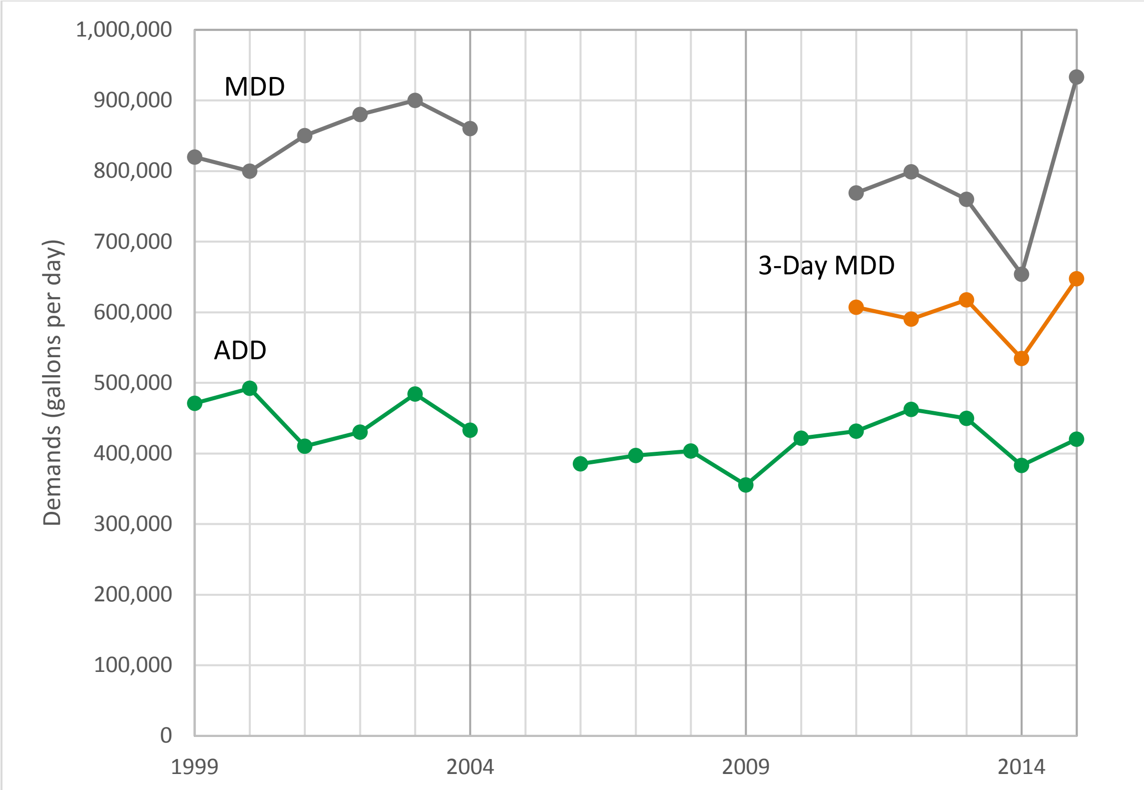

Figure 3-2. Average, Maximum Day, and 3-Day Maximum Day Demand Records 1999-2015

The ADD remained relatively constant over the 16-year period, averaging 430,000 gpd and ranging from 376,000 to 492,000 gpd.

For the District's system, the MDD typically occurs during peak tourist days in the summer. However, in 2012 the MDD value occurred in March and in 2011 the MDD was in September. MDD values ranged from 654,000 to 933,000 gpd and averaged 820,000 gpd. The MDD to ADD ratio ranged from 1.6 to 2.2, with an average of 1.9 for the period.

The 3-day MDD gives an indication of the demand that a supplier must meet over a longer period than a single day. The District's 3-day MDD for 2011 through 2015 fell roughly halfway between the average day and the maximum day demands, averaging 599,000 gpd between 2011 and 2015.

3.4.3 Monthly Production

Figure 3-3 presents the District's monthly total surface water withdrawals as reported in annual Water Use Reports to OWRD, and metered production from the District's slow sand filtration plant. Plant operations include routine overflow of the slow sand filters back to Drift Creek, therefore the creek withdrawals exceed production. Figure 3-4 shows the ratio of creek withdrawal to water treatment plant metered production. This ratio ranged from 1.3 to 3.0, and averaged 1.9 for the period shown.

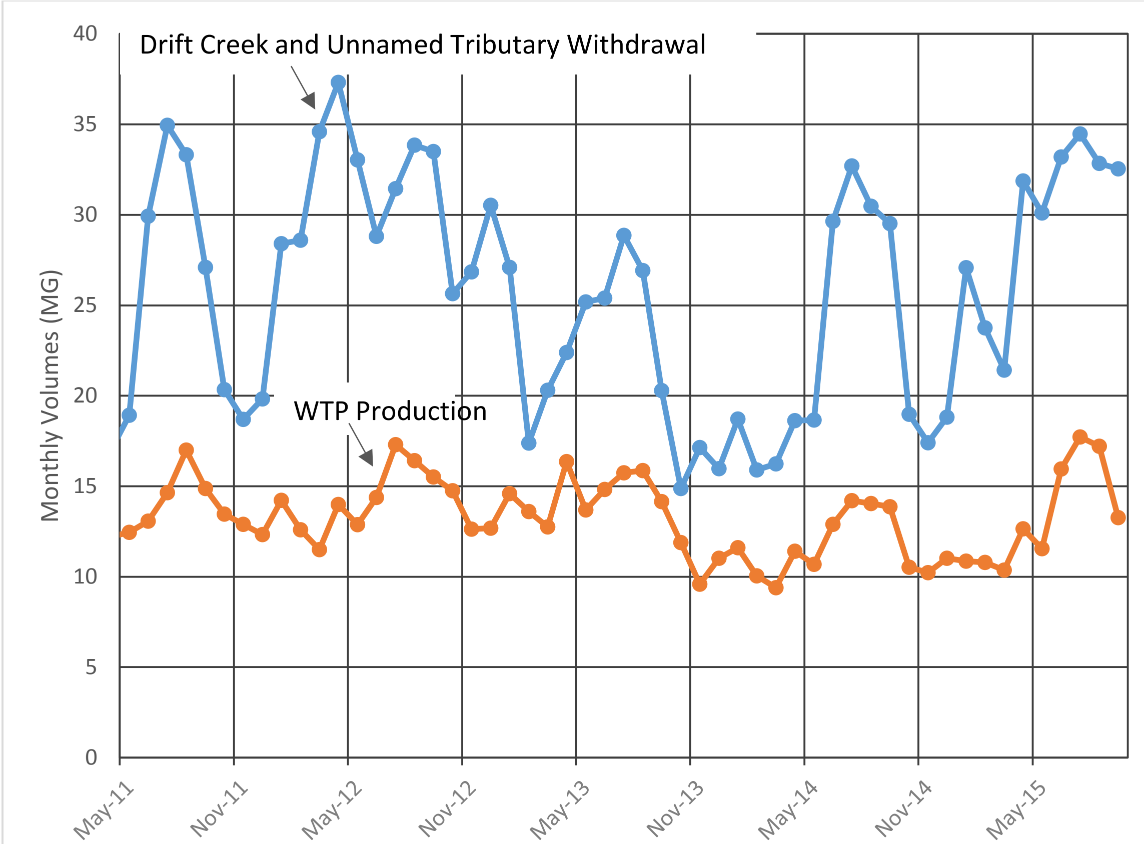

Figure 3-3. District Surface Water Withdrawals and Water Treatment Plant Metered Production 2011-2015

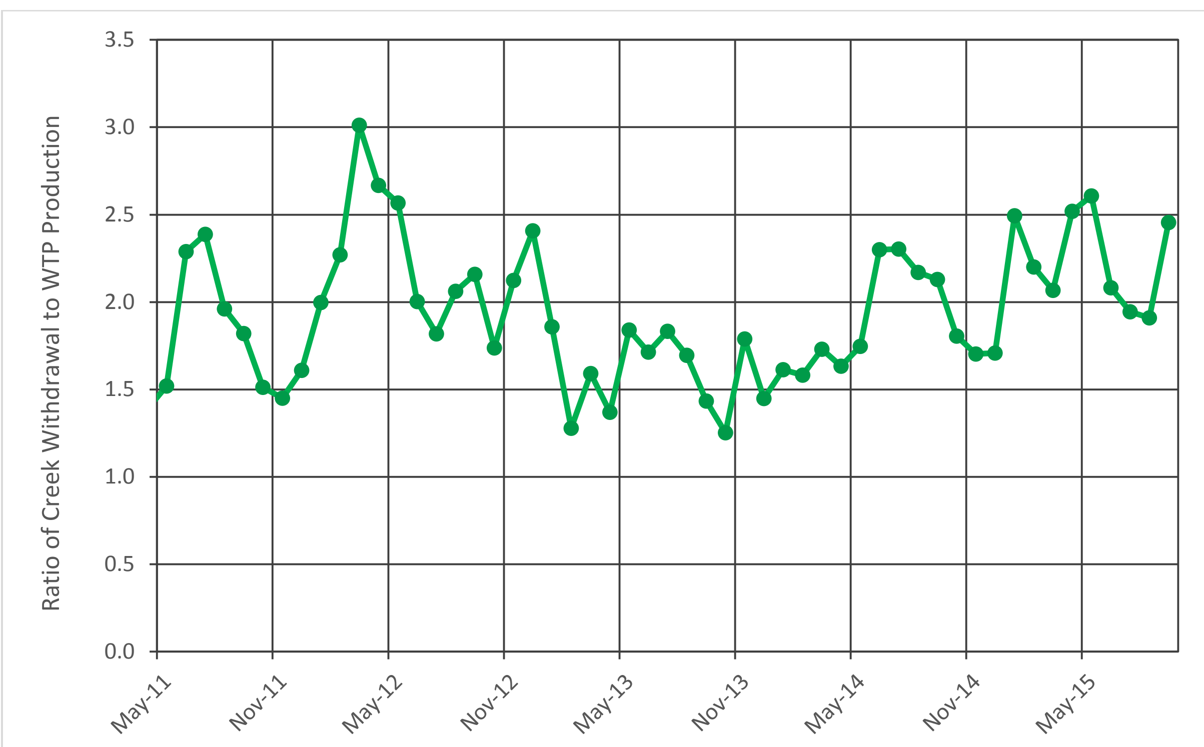

Figure 3-4. Ratio of Surface Water Withdrawals to Water Treatment Plant Metered Production 2011-2015

Figure 3-5 shows the total monthly withdrawals for water years 2008 through 2015 with the District's two sources indicated. Withdrawals from the unnamed tributary only occurred in response to higher turbidity in Drift Creek over the fall to spring period between October 15 and May 15 of each year.

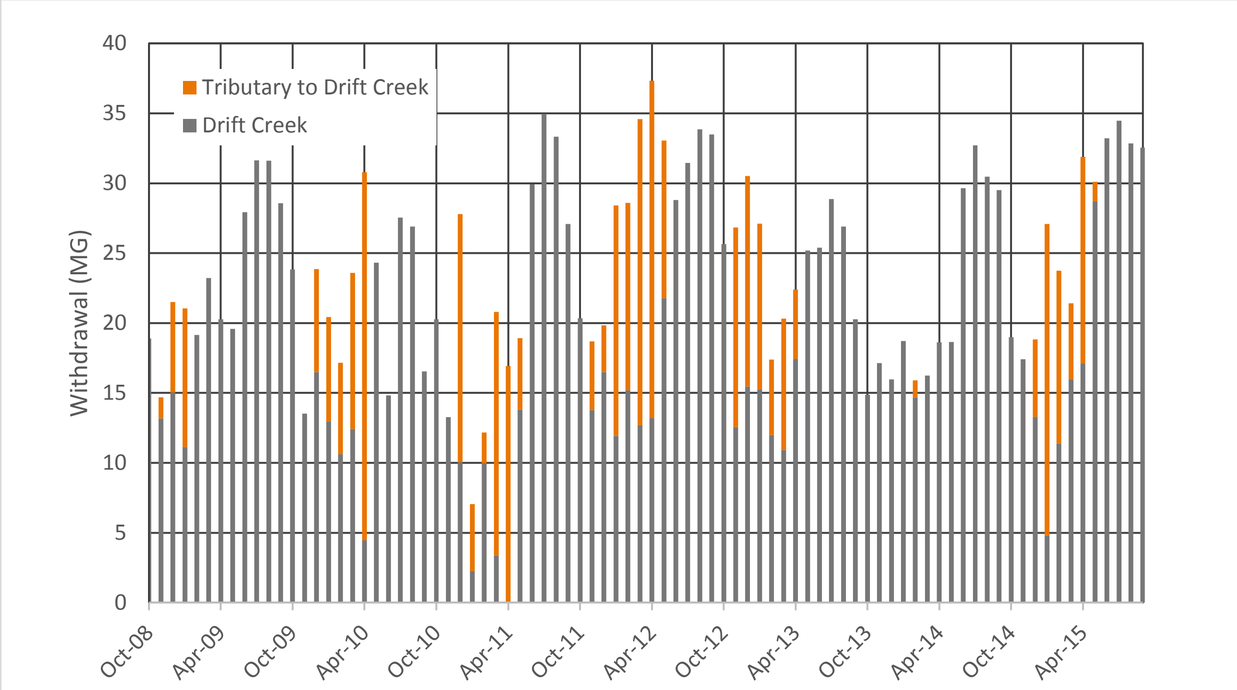

Figure 3-5. Monthly Withdrawals from Drift Creek and an Unnamed Tributary to Drift Creek Water Years 2008 to 2015.

Figure 3-6 is a bar chart presenting monthly metered production for 2015. Figure 3-7 gives the monthly percentage of annual production for each month. If there was no seasonal variation, each month would account for 8.3 percent of the annual production. For the District, the summer season of June through September represented 42 percent of annual production. In systems with high summer time irrigation rates, these 4 months can account for well over 50 percent of annual production. A significant portion of the summertime increase is caused by higher motel, rental, and vacation home occupancies during the summer months.

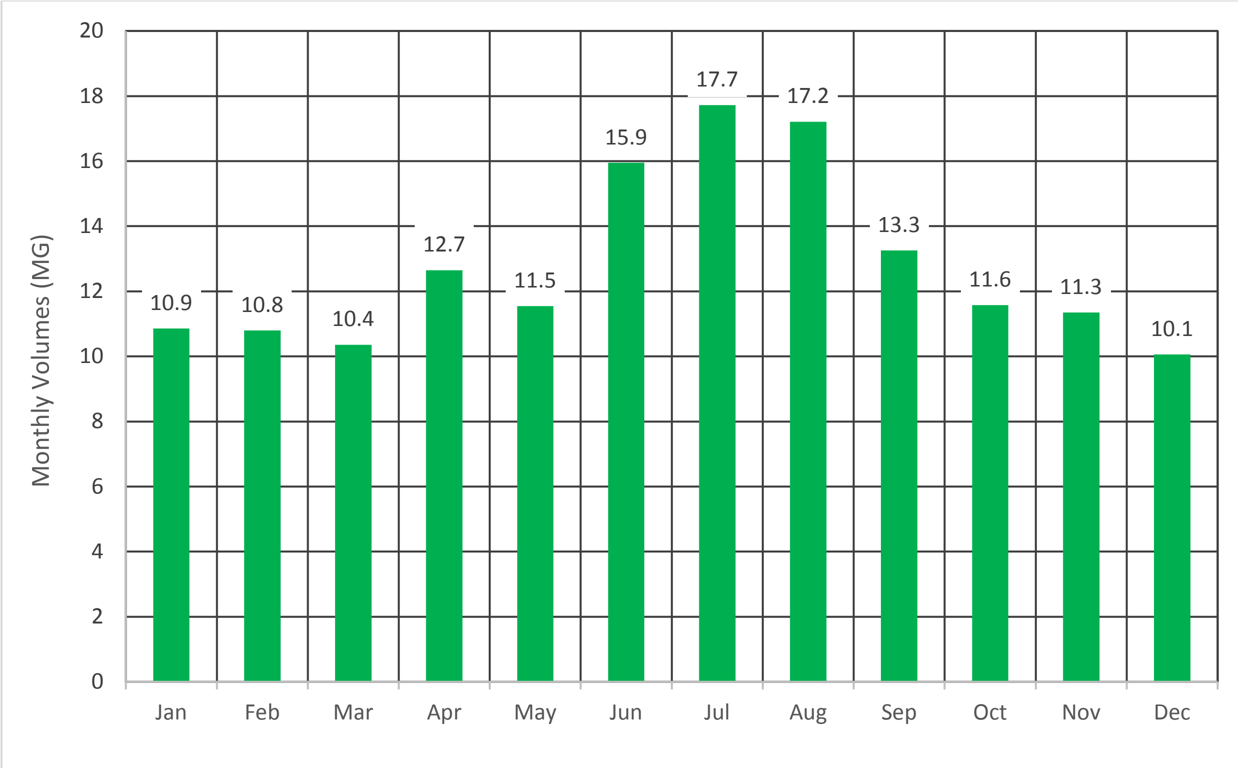

Figure 3-6. Monthly Demand 2015

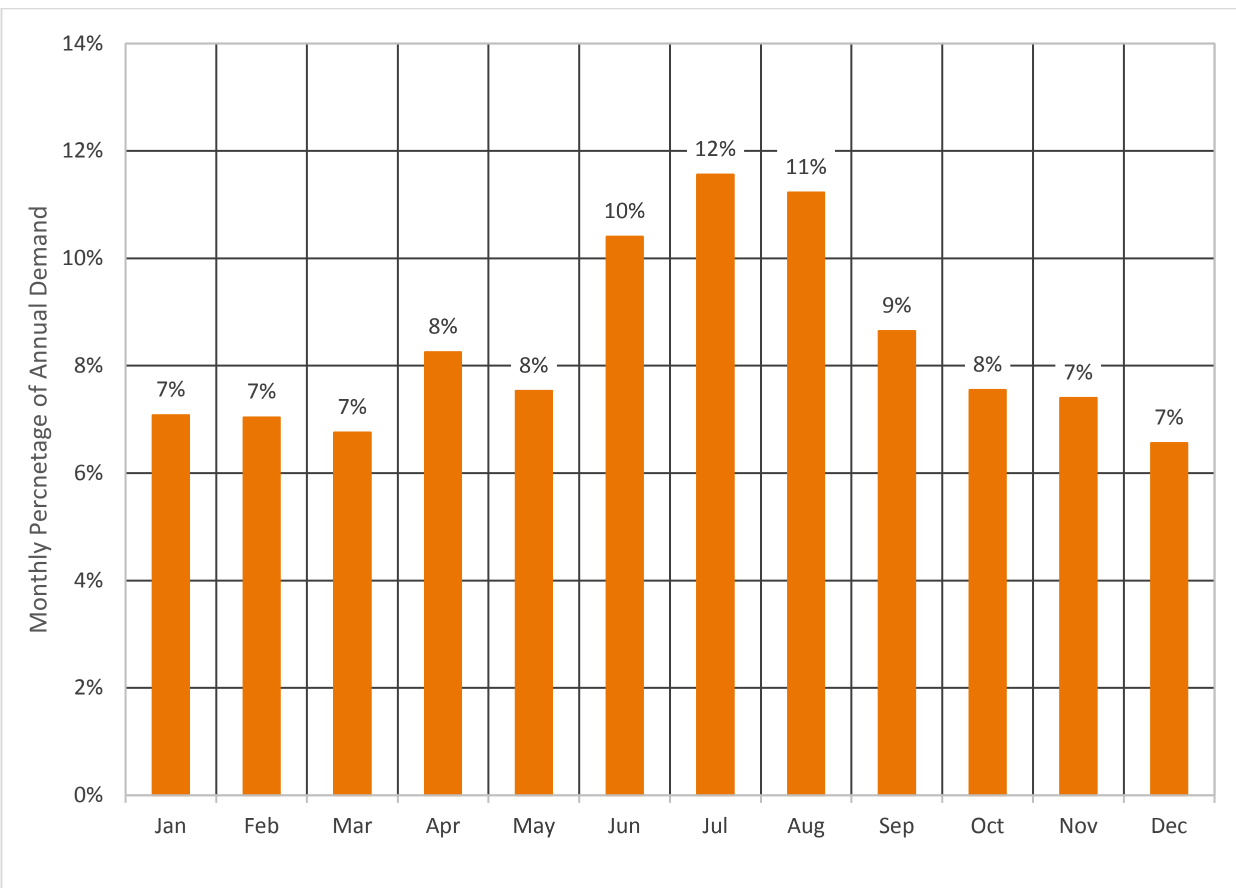

Figure 3-7. Monthly Demand percentage of Annual Demand 2015

3.4.4 Consumption and Nonrevenue Water

Consumption values are based on metered water use within the system. All of the District's customers are metered, and *the total of the metered amounts is the system consumption.* The difference between production and metered consumption is nonrevenue water. As discussed earlier, nonrevenue water sources include authorized uses such as hydrant flushing and system losses. Losses result from meter inaccuracies (both master and customer meters), and water lost to leakage, reservoir overflow, or evaporation.

Table 3-4 presents production, consumption, and nonrevenue water values for 2006 through 2015. For the last 5 years (2011 to 2015), nonrevenue water averaged 47 MG, or 30 percent of total produced water.

Table 3-4. Production Consumption and Nonrevenue Water 2006 through 2015
Water System Master Plan

Year	Production (MG)	Authorized Consumption (MG)	Unauthorized Nonrevenue Water (MG)	Unauthorized Nonrevenue percentage of Production (MG)
2006	141	130	10.6	7.5%
2007	145	131	14.4	9.9%
2008	147	126	20.8	14.1%
2009	130	120	9.3	7.2%
2010	154	119	34.3	22.3%
2011	158	117	40.8	25.9%
2012	169	110	58.5	34.6%
2013	164	114	50.1	30.5%
2014	140	114	26.2	18.7%
2015	153	122	31.6	20.6%

3.4.5 Customer Characteristics and Use Patterns

The District bills its customers according to meter size, and divides customers into residential accounts (3/4" meters), small commercial accounts (3/4" meters), and large commercial and multifamily accounts (meters 1" and greater.). In the past, large commercial and multifamily accounts were grouped together, but recently they are tracked separately. Table 3-5 shows the numbers of customer accounts by category in 2002 and 2015. The total number of accounts has increased 12 percent over the 13-year period, but as shown in Figures 3-2 and 3-3, there has not been a corresponding increase in demand. This may be related to the large number of second homes and vacation properties in the District.

Table 3-5. Accounts by Customer Category
Water System Master Plan

<table>
<tr><th>Account Type</th><th>2002</th><th>2015</th></tr>
<tr><td>Single-family Residential</td><td>1984</td><td>2206</td></tr>
<tr><td>Small commercial</td><td>77</td><td>71</td></tr>
<tr><td>Multifamily Residential</td><td rowspan="2">58</td><td>56</td></tr>
<tr><td>Large commercial</td><td>38</td></tr>
<tr><td>Total</td><td>2119</td><td>2371</td></tr>
</table>

Table 3-6 presents water use by customer category, including water sold to the LSWD for 2005 through 2010. (Similar data for more recent years were not available.) Figure 3-7 presents a pie chart depicting the percentage of use by category for 2010.

Table 3-6. Water Use by Customer Type
Water System Master Plan

Year	Single-family Residential (MG)	Small Commercial (MG)	Large Commercial and Multifamily Residential (MG)	Lower Siletz WD (MG)	Estimated Authorized Nonrevenue (MG)	Unauthorized Nonrevenue (MG)	Total Metered Consumption (MG)
2005	63.0	9.4	39.8	6.2	1.7	10.7	118
2006	69.9	10.0	41.4	7.9	0.9	18.8	129
2007	70.7	11.3	38.7	7.6	2.5	27.0	128
2008	68.4	10.0	37.1	6.9	4.0	13.6	122
2009	64.2	9.6	35.8	6.8	4.0	41.1	116
2010	62.5	10.5	33.8	8.1	4.7	41.6	115

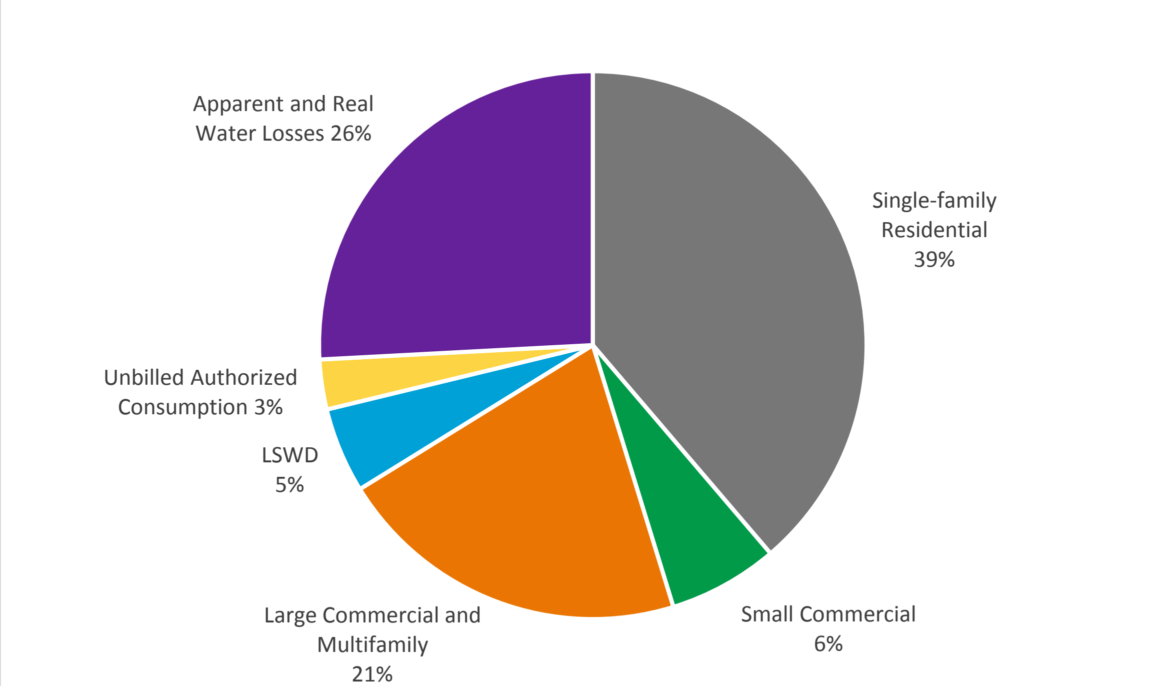

Figure 3-8. Percentage of Use by Category 2010

As shown in Figure 3-8, single-family residential use was the largest component of use at 39 percent of produced water, followed by nonrevenue water at 29 percent.

Data were available for the largest water users in 2015. Table 3-7 presents the 25 customer accounts with the highest annual water use. These 25 meters accounted for 20 percent of production in 2015. The 4-inch meter serving LSWD accounted for an additional 4 percent of production in 2015.

Table 3-7. Largest Water Accounts 2015
Water System Master Plan

Type of Facility	Account Type and Meter Size[a]	Annual Metered Use (gal)	Use as a Percentage of Annual Production
Restaurant and Pool	LC 2"	4,613,000	3.0%
Trailer Park	MF 2"	3,140,000	2.0%
Laundry	LC 2"	3,017,000	2.0%
Condos/Vacation Rentals	MF 2"	2,160,000	1.4%
Trailer/RV Park	LC 2"	1,887,000	1.2%
Condos/Vacation Rentals	MF 2"	1,741,000	1.1%
Motel, Restaurant, Pool, and Mobile Park	MF 2"	1,331,000	0.9%
RV Park	MF 2"	1,307,000	0.9%
Sanitary District	SC 3/4"	1,268,000	0.8%
Condos	MF 2"	1,158,000	0.8%
RV Park	MF 2"	1,081,000	0.7%
Spa	LC 2"	963,000	0.6%

Table 3-7. Largest Water Accounts 2015
Water System Master Plan

Type of Facility	Account Type and Meter Size[a]	Annual Metered Use (gal)	Use as a Percentage of Annual Production
12-Unit Annex and Cottages	MF 2"	942,000	0.6%
Resort/Condo	LC 3"	785,000	0.5%
Golf Course Restaurant	LC 2"	737,000	0.5%
Hotel	LC 2"	654,000	0.4%
Trailer Park	MF 2"	622,000	0.4%
Recreation Center and Pool	LC 2"	592,000	0.4%
Hotel	LC 2"	528,000	0.3%
Golf Course Restaurant	LC 2"	510,000	0.3%
Resort	LC 2"	462,000	0.3%
Resort	LC 2"	440,000	0.3%
Nursery	LC 2"	429,000	0.3%
Resort	LC 2"	419,000	0.3%
Restaurant	SC 3/4"	419,000	0.3%
Total		31,204,000	20.4%

[a] LC = Large Commercial; MF = Multifamily; SC = Small Commercial

The District’s water production has remained relatively constant while the number of accounts has increased. The result is that the per account annual water use has decreased from 202 gallons per account per day in 2002 to 177 gallons per account in 2015. With an estimated service population of 4,600 people, the average day per capita demand for 2015 was 91 gallons per person per day (153,000,000 gallons per year/4,600 people x 365 days per year).

3.5 Population Projections

Based on U.S. Census Block data from 2010, the 2015 permanent residential service area population was estimated at 4,600. The August 2000 *Master Plan* for the District estimated a buildout population of 8,125. The actual buildout population will depend on a variety of factors such as changes in zoning, expansion of sewer service, and the ratio of commercial to residential development.

According to the *Ten-Year Update on Lincoln County, Oregon’s Economy 2014*, the coastal region population trends indicate a shift from younger families toward retirees and second homeowners. More than 29 percent of the housing in Lincoln City is designated a second home. The population of the unincorporated area of the county grew approximately 1 percent in the 10-year period 2000 to 2010. However, Lincoln City grew 9 percent over this 10-year period, equal to an average annual growth rate of 0.87 percent (rounded to 0.9 percent). As the District shares proximity and characteristics with Lincoln City, an average annual growth rate of 0.9 percent was used to project future population growth for the District. The District is unaware of any major development plans within its service area for the near term that would suggest a different growth rate is appropriate.

3.6 Demand Forecast

The procedure selected for projecting the District's demands is the per capita methodology. It assumes the following: a) per capita use will remain unchanged compared to recent years, and b) the mix of commercial to residential water use will remain unchanged compared to recent years. The District will periodically monitor both factors to determine their validity.

The following values were used to project future demands:

- 2015 service population = 4,600
- Annual growth rate = 0.9 percent
- Per capita ADD = 90 gallons per capita per day
- MDD to ADD ratio = 1.9
- Source withdrawals = 190 percent of production

Table 3-8 summarizes projections for the District using these criteria. The resulting projections indicate that that by 2036, at the end of the 20-year planning horizon, the District's demands will equal 551,000 gpd for ADD and 1,025,000 gpd for MDD. Figure 3-9 graphically displays projected ADD, MDD, and river withdrawal projections through year 2036.

The 2016 Water Management and Conservation Plan compares the projected demands to the District's water rights. It appears that the District's water rights are sufficient to meet demands for the foreseeable future, although it may become necessary to reduce overflows from the filters as system demands grow.

Table 3-8. Demand Projections
Water System Master Plan

Year	Estimated Service Population	ADD projection (gpd)	MDD Projection (gpd)	River Withdrawal (gpd)
2015	4600	460,000	855,000	1,620,000
2016	4640	464,000	863,000	1,640,000
2017	4680	468,000	870,000	1,650,000
2018	4721	472,000	878,000	1,670,000
2019	4761	476,000	885,000	1,680,000
2020	4803	480,000	893,000	1,700,000
2021	4844	484,000	900,000	1,710,000
2022	4886	489,000	909,000	1,730,000
2023	4929	493,000	917,000	1,740,000
2024	4971	497,000	924,000	1,760,000
2025	5014	501,000	932,000	1,770,000
2026	5058	506,000	941,000	1,790,000
2027	5101	510,000	948,000	1,800,000
2028	5146	515,000	958,000	1,820,000
2029	5190	519,000	965,000	1,830,000

Table 3-8. Demand Projections
Water System Master Plan

Year	Estimated Service Population	ADD projection (gpd)	MDD Projection (gpd)	River Withdrawal (gpd)
2030	5235	524,000	974,000	1,850,000
2031	5280	528,000	982,000	1,870,000
2032	5326	533,000	991,000	1,880,000
2033	5372	537,000	999,000	1,900,000
2034	5419	542,000	1,008,000	1,920,000
2035	5466	547,000	1,017,000	1,930,000
2036	5513	551,000	1,025,000	1,950,000

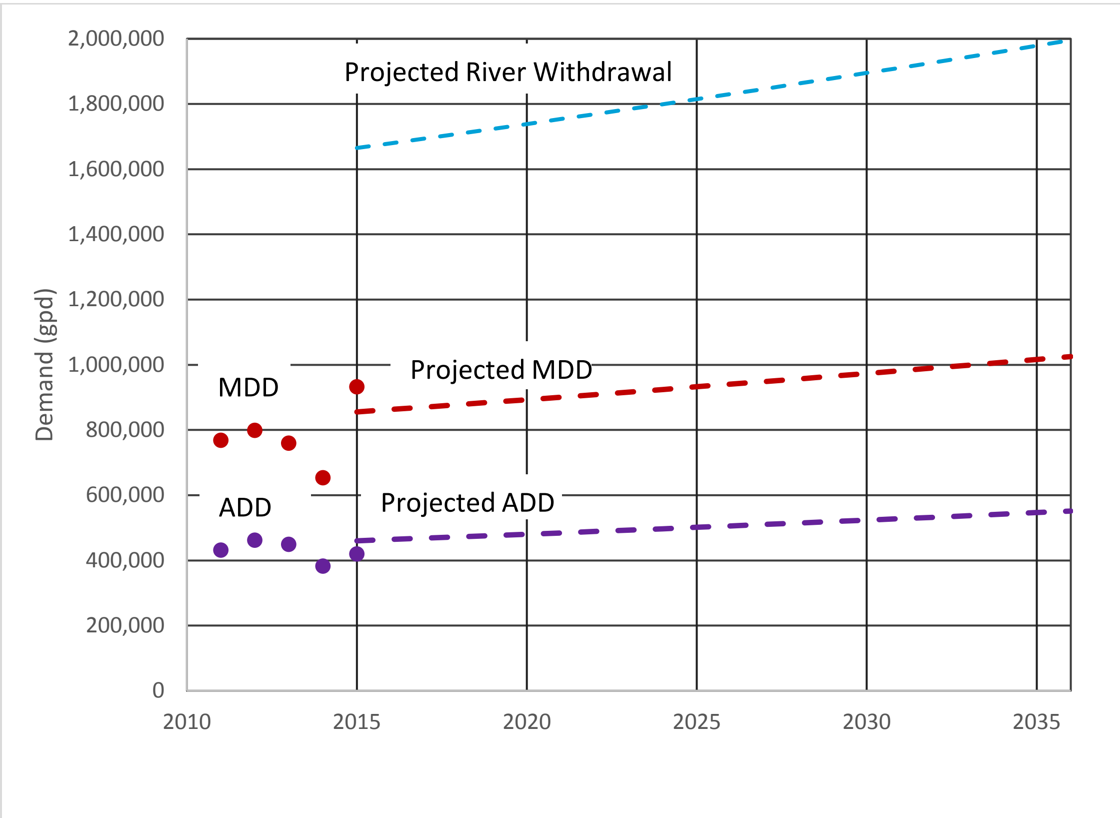

Figure 3-9. Projected Demands and Source Withdrawal

SECTION 4

Water Quality, Regulations, and Service Goals

This chapter describes existing and emerging drinking water regulations, with a focus on those that are most likely to impact the District's system. It also presents a list of proposed service goals for the District.

The chapter is organized as follows:

- Overview of state and federal regulations
- Potential regulatory impacts
- Proposed new regulations
- Monitoring schedule for the District
- Service goals

4.1 Overview of State and Federal Regulations

Both state and federal agencies regulate public drinking water systems. Most federal drinking water regulations stem from the Safe Drinking Water Act, which was amended in 1996. For the federal government, the U.S. Environmental Protection Agency (EPA) establishes standards for water quality, monitoring requirements, and procedures for enforcement. Oregon, as a primacy state, has been given the primary authority for implementing EPA's rules within the state.

The state agency that administers most of EPA's drinking water rules is the Drinking Water Services section of the Oregon Health Authority. Oregon's rules for water quality standards and monitoring are adopted directly from the EPA. Oregon is required to adopt water quality rules at least as stringent as federal rules and OHD has generally elected not to implement more stringent water quality or monitoring requirements. Generally, the water quality standards are captured in the setting of maximum contaminant levels (MCLs). The one place where Oregon has implemented more stringent water quality regulations is the establishment of acute toxicity levels for algal toxins.

In some areas not directly related to water quality, Oregon's rules cover a broader scope than EPA rules. These include general construction standards, cross connection control, backflow installation standards, and other water system operation and maintenance standards. Oregon's complete drinking water regulations are contained in Oregon Administrative Rules 333-61.

The District's system is governed by the Oregon Water Resources Department with respect to water rights. Other state agencies such as the Division of State Lands, Department of Environmental Quality (DEQ), and Fish and Wildlife Department, may have regulations that apply to the District for specific construction or periodic maintenance activities. For example, DEQ regulates discharges into open bodies of water; their regulations apply when reservoirs are drained.

The regulatory environment for drinking water utilities is currently and probably will continue to be in a state of flux as the EPA balances the need to provide increased protection against pathogens such as *Cryptosporidium* with the goal of reducing disinfection by-products. Additionally, an area of particular concern as this report was being prepared was the finding of elevated lead from drinking water taps. This issue was brought to the U.S. public's attention by the occurrences in Flint, Michigan, when the city changed to a new water source and treatment system and did not carefully anticipate the impacts on lead release from pipes and fixtures in the system. Subsequently, Oregon cities such as Portland, Corvallis, and Medford conducted monitoring beyond that required by the Lead and Copper Rule and found elevated lead levels in schools and other public facilities.

4.1.1 Surface Water Treatment and Disinfection By-Products Rules

The large 1993 outbreak of cryptosporidiosis in Milwaukee, Wisconsin, and subsequent outbreaks in other U. S. cities prompted more stringent requirements for systems treating surface water. It was recognized that higher levels of disinfection would help to control *Cryptosporidium* but higher chlorine levels would also contribute to higher levels of disinfection by-products. The 1996 Amendments to the Safe Drinking Water Act required EPA to develop new rules to balance the risks between microbial pathogens and disinfection by-products. The resulting rules are labeled the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) and the Stage 2 Disinfection By-Products Rule (Stage 2 DBP Rule).

The District was required to sample untreated Drift Creek water once every two weeks for one year for *E. coli* prior to 2009 to determine the level of required treatment. Since the E. coli levels were low, the District did not need to monitor for *Cryptosporidium* nor change the treatment process.

The Stage 2 DBP Rule lowered the MCLs for total trihalomethanes (TTHMs) and haloacetic acids (HAA5) to 80 and 60 µg/L, respectively, and subsequently, revised the determination of compliance to consider each sample location independently, rather than averaging the results from all sample locations. The Stage 2 rule also changed compliance so that it is based on a running annual average for systems collecting samples on a quarterly basis. The District had been allowed to sample annually, not quarterly, because DBP levels have been low in the system.

The District was in full compliance with this rule until the most recent sampling conducted in October 2016. The results for both TTHMs and HAA5 exceeded the MCLs for one of the two locations, and were higher than recent samples from both locations. Table 4-1 summarizes the recent test results.

Table 4-1. October 2016 Routine Monitoring Results
Water System Master Plan

Sample Location	TTHMs (µg/L)	HAA5 (µg/L)
MCL	80	60
2DBP-01 Salishan Spit	85.7	64
2DBP-02 Palisades	40.2	51.8

The October 2016 levels were unexpectedly high, based on historical values. Prior to this sampling, the District’s had monitored for DBPs 13 times since August 2012. The average TTHM result for these samples was 21 µg/L and the highest measured value was 44.5 µg/L. The average HAA5 result for these samples was 21 µg/L and the highest measured value was 33 µg/L. The October 2016 result for sample site 2DBP-01 was nearly two times the recent averages for both TTHMs and HAA5. The results for both locations were higher than the averages, with the HAA5 results for both locations being the highest measured values for the past five years.

The District was investigating possible reasons for the high DBP results in October 2016 as this report was being prepared. Possible causes include raw water quality changes in Drift Creek, changes in the chlorine level, longer water age in the distribution system, flushing activities in the distribution system, and changes in the operations of the slow sand filter plant. To date, the District has not determined the likely cause for higher DBP levels. Because the results exceeded the MCLs, the state has changed the District’s DBP monitoring schedule from annually to quarterly.

4.1.2 Lead and Copper Rule

The Lead and Copper Rule (LCR), though not new, warrants specific mention because of the heightened concerns about high lead levels in drinking water in U.S. water utilities that occurred in 2015 and 2016. Lead is almost never present in measurable levels in source waters. Rather, it is introduced into public water supplies through internal pipe corrosion. Small amounts of lead may be used in plumbing fixtures or in older solder compounds for copper pipe. Therefore, the LCR required sampling to be conducted at consumer taps.

All of the District's monitoring results for lead and copper have complied with current standards. The system is currently required to conduct sampling at 20 homes that are classified as the highest risk locations once every three years. These "high risk" sites are single family homes built between January 1, 1983, and June 30, 1985. The last monitoring was conducted in August 2016. The results showed a 90^{th} percentile lead level of 0.00 mg/L (below laboratory detection limit) compared to the lead action level of 0.015 mg/L. The 90^{th} percentile copper level was found to be 0.777 mg/L, below the copper action level of 1.3 mg/L. Since the every three year sampling began in 1998, the District has had only one 90^{th} percentile value for lead above 0.00 and that was 0.0041 mg/L in 1998, which was still well below the 0.015 mg/L action level. The 90^{th} percentile copper values over the same period averaged 0.90 mg/L, also below the action level of 1.3 mg/L.

At the time this report was being prepared, the public across the U.S. was alarmed by the experience in Flint, Michigan, where a change in water sources without proper evaluation of corrosion control treatment resulted in higher corrosion rates, leading to higher lead levels. This problem was compounded by a failure to take action by some or all of the city, state, and federal employees and regulators. Primarily as a result of this highly publicized incident, the EPA implemented short-term changes to the Lead and Copper Rule (LCR) and proposed additional long-term changes. The short-term changes were the following:

- Changes to sampling procedures (no pre-flushing, no removal of aerators, run water as if filling up a glass to drink when collecting sample (not at low flow), use wide mouth bottles.
- Complete materials inventory – including lead service line locations and lead plumbing material in the distribution system. Remove all lead lines. Update maps to show lead locations.
- Improve transparency – post all lead and copper results. Update website with lead information. Conduct public outreach. Collaborate with other organizations.
- Re-evaluate high risk sample locations.
- Optimize corrosion control treatment to minimize the leaching of metals into the drinking water (the intent of the LCR).

EPA's proposed long-term changes to the LCR included the following:

- Separation of lead and copper sampling from one another, meaning they may have different location and frequency requirements.
- For those systems with water quality that is susceptible to copper corrosion, they may need to monitor at newly constructed houses or conduct pipe loop tests.
- Broaden the extent of lead monitoring sites. The current LCR provides a good overview of corrosion rates and lead levels, but there is concern that it may overlook some locations with high levels.
- Depending on monitoring results, a system may need to develop an optimal corrosion control plan and receive approval for the plan from the state. The plan may require review and approval every few years.

- Remove all lead pigtail lines by 2050.
- Increase monitoring

It remains to be seen if EPA's proposed changes will be adopted. In late April 2016, U.S. Congressman Kildee introduced a House bill that would reduce the lead action level from the current level of 15 micrograms per liter (µg/L) to an eventual level of 5 µg/L, being phased in over the course of a decade. The District's 2016 reported lead levels, at the 90th percentile value, were below the 5 µg/L level that was proposed.

In light of the special focus on lead occurrences in drinking water, including findings of elevated lead levels in Portland, Corvallis, and Medford schools, the District conducted extra sampling in August 2016 from 20 Tier 2 multi-family sites constructed between January 1, 1983 and June 30, 1985 to help determine if there were previously undetected problems in the District's system. Only two of 20 samples had detectable levels of lead at a laboratory detection limit of 0.002 mg/L, compared to the current lead action level of 0.015 mg/L. These two values were 0.0027 and 0.0037 mg/L, well below the action level. The copper measurements averaged 0.57 mg/L, with a high of 1.0 mg/L, also below the action level. The results were encouraging for the District in that lead and copper levels were below the action levels, but the levels measured were higher than the levels found in the routine monitoring in August 2016 of the supposed worst-case locations. This may illustrate a shortcoming in the LCR. The goal was to focus the monitoring on the houses that would have the highest levels of lead but it may be difficult to determine that the selected sample sites do indeed reflect the locations with the highest levels.

4.1.3 Distribution System Regulations

Oregon's rules include specific requirements related to the distribution system, as follow:

- Distribution piping shall be designed and installed so that the pressure measured at the property line of any user shall not be reduced below 20 psi.
- Wherever possible, dead ends shall be minimized by looping. Where dead ends are installed, blow-offs of adequate size shall be provided for flushing.
- Wherever possible, distribution pipelines shall be located on public property. Where pipelines are required to pass through private property, easements shall be obtained from the property owner and shall be recorded with the county clerk.
- Wherever possible, booster pumps shall take suction from reservoirs to avoid the potential for negative pressures on the suction line, which could result when the pump suction is directly connected to a distribution main. Pumps that take suction from distribution mains shall be provided with a low-pressure cutoff switch on the suction side set at no less than 20 psi.

4.2 Emerging Drinking Water Regulations

The EPA continues to review existing regulations for possible revisions and to examine potential drinking water contaminants for possible regulation. The newest regulation issued by EPA is the Revised Total Coliform Rule, which eliminated an MCL for total coliform but kept the MCL for *E. coli*. *E coli* has been found to be a better indicator than total coliform of the microbiological safety of drinking water. A total coliform positive now triggers system evaluation requirements rather than an MCL violation. This rule has no significant impacts on the District's operations.

4.2.1 Algal Toxins

Oregon has issued Health Advisories for cyanotoxins, also known as algal toxins, which are toxins introduced into water supplies by cyanobacteria blooms. Cyanobacteria are photosynthetic bacteria, formerly known as blue-green algae. The State of Oregon issued Health Advisories for algal toxins and

EPA released similar Health Advisories in June 2015. Health Advisories are non-regulatory values that serve as informal guidance to assist state regulatory agencies and managers of public water systems in their role of protecting public health.

EPA issued Health Advisories for Microcystin and Cylindrospermopsin as follows:

- For children under 6 years of age, the 10-day Health Advisories levels are 0.3 µg/L for Microcystin and 1.6 µg/L for Cylindrospermopsin
- For children 6 years and above and adults, the 10-day Health Advisory levels are 0.7 µg/L for Microcystin and 3.0 µg/L for Cylindrospermopsin

On August 7, 2015, President Obama signed into law the Drinking Water Protection Act that amends the Safe Drinking Water Act with the intent to control harmful algal blooms in drinking water. The legislation required EPA to submit a plan to Congress by November 2015 to evaluate algal toxins' risk to human health and to recommend feasible treatment options to mitigate any adverse public health effects. EPA's plan was essentially a compilation of ongoing and planned research needs, noting that many questions remain about occurrence levels, health effects, and treatment approaches.

The EPA has listed three algal toxins on the Candidate Contaminant List 3 (CCL3): Anatoxin-a, Microcystin-LR, and Cylindrospermopsin. According to EPA's current timetable, regulations for algal toxins will not occur until 2025. However, EPA's Administrator has the authority to issue an emergency regulation if circumstances warrant such action.

The World Health Organization (WHO) has established a health-based drinking water guideline of 1.0 ppb for one algal toxin, Microcystin-LR. The Australian standard is 1.3 ppb for total microcystins, while Health Canada has proposed a similar standard of 1.5 ppb for total microcystins.

The State of Oregon Health Authority, Drinking Water Program has developed guidance for water systems that recommends monitoring for algal toxins when algal counts are above a certain level, or if a public health advisory has been issued. If algal toxins are detected in the finished water above threshold levels (Microcystin >1.6 µg/L, Anatoxin-a >3 µg/L, Cylindrospermopsin >3 µg/L and Saxitoxin > 1.6), the guidance says to issue an immediate "Do Not Drink" public notice.

It is thought that the District's water supply from Drift Creek has low levels of cyanobacteria and low levels of algal toxins. Additionally, the subsurface infiltration gallery collectors are expected to provide good protection against the introduction of cyanobacteria and algal toxins into the system. The District should be observant of watershed conditions and possible increases of cyanobacteria in the future, but it does not appear that this rule will have an impact on the District.

4.2.2 Cybersecurity

One other regulatory area that may have implications for water utilities is cybersecurity. Cyber-criminals have invaded highly secured federal and private networks, such as the U.S. State Department and Sony Corporation, so the vulnerability of water utilities is certainly a legitimate concern. To date, water utilities have not been a target of terrorist cyber-attacks; it is uncertain if they will become a target in the coming years.

The federal Critical Infrastructure Partnership Advisory Council issued the Water Sector Cybersecurity Strategy report in April 2015. The American Water Works Association (AWWA) has since issued guidance and tools to support the water industry's voluntary application of the CIPAC recommendations. The District is not required to take cybersecurity actions but it would be prudent to monitor AWWA's continuing efforts in this field and to consider cybersecurity as the District develops a more extensive remote monitoring and control system.

4.2.3 Contaminants of Potential Concern

Since the 1980's, researchers have investigated the occurrence of traces of inorganic and organic contaminants in water. These contaminants, called contaminants of potential or emerging concern (CPC) or micro-constituents, include industrial chemicals, metals, natural or synthetic hormones, pharmaceuticals, household chemicals, and personal care products. Very few studies have investigated the effect of these trace contaminants on human health. The contaminants of greatest current concern are a class of compounds called endocrine disruptors. Endocrine disrupters have been shown to cause adverse effects in a variety of animal species. Only some of the CPCs are endocrine disrupters.

CPC's enter source water from both point (effluent pipe) and non-point (overland runoff) sources. The District's Drift Creek source, with no municipal discharges upstream, should be protected from CPCs.

4.2.4 Source Water Protection

The LT2ESWTR does not mandate source water protection measures for the District but watershed protection should be considered by the District. The high turbidities on Drift Creek experienced in 1999 and 2000 highlight concerns about protecting source water quality. Turbidities exceeded 500 ntu on two occasions in November and December 1999, and have exceeded 50 ntu for several days in succession.

A watershed protection program could include:

- Characterizing the watershed hydrology and land ownership.
- Identifying the watershed characteristics, including soil types, contaminant sources, and other factors that affect water quality.
- Identifying watershed activities that have or may have an adverse impact on water quality.
- Monitoring the occurrence of activities that may have an impact on source water quality. This may include water quality monitoring as well as identifying and performing field assessments of activities.

4.3 Monitoring Requirements and Schedule

The District fulfills the monitoring requirements of the state and federal regulations. As was noted in the year 2000 master plan, at that time, the District's system did not include an online chlorine analyzer that either sounds an alarm or automatically shuts off the water if a lack of chlorine feed is detected. The District installed a telemetry system in 2016, using cell phone technology, that now reports the finished water chlorine level from the high service pump discharge line, and this signal is alarmed so the operators are automatically alerted if the chlorine residual drops below a set point.

Table 4-2 summarizes the approximate water quality monitoring schedule for the District. The state plans to conduct a routine sanitary survey of the system in April 2017 or shortly thereafter and will confirm the monitoring schedule at that time. Other monitoring may also be required as the EPA and the state adopt new drinking water regulations in coming years. In addition to water quality monitoring and reporting, the District must also track the quantity of water withdrawals from Drift Creek and Side Creek and report these values to the Oregon Water Resources Department. These requirements are described in the District's Water Management and Conservation Plan update, which was submitted to the state in 2016.

In recent years the District was required to monitor for disinfection by-products once per year from two locations, based on historically low levels. However, both trihalomethanes and haloacetic acid levels exceeded the MCLs from one of the two locations in the October 2016 monitoring. Therefore, the state revised the sampling frequency to quarterly.

Table 4-2. Monitoring Schedule
Water System Master Plan

Parameter	Sampling Location	Minimum Frequency	Next Sample Due
Arsenic	Entry	Once every 9 years	January 2020
Inorganic contaminants	Entry	Once every 9 years	January 2018
Nitrate	Entry	One location, annually	January 2017
Nitrite	Entry	Once every 9 years	January 2018
Radionuclides (gross alpha, Radium 226/228, Uranium)	Entry	Once every 9 years	January 2023
Synthetic Organic Contaminants	Entry	Once every 3 years	April 2019
Total organic carbon	Raw	Once each quarter	4th quarter 2016
Volatile organic contaminants	Entry	One location, annually	January 2017
Disinfection by-products (DBPs)	Distribution (Salishan Spit & Palisades)	Two locations, quarterly (January, April, July, October)	January 2017
Lead and copper rule	Select houses	20 locations, every 3 years	August 2019
Asbestos fibers	Distribution	One every 9 years	January 2018
Coliform bacteria and chlorine residual	Distribution	4 locations; monthly	Every month

Note:

Under sampling location column, "Entry" means a sampling location downstream of all treatment processes but upstream of the first customer; "Distribution" means at pre-selected, representative locations in the distribution system; "Select houses" means from customer taps at pre-selected houses.

4.4 Proposed Service Goals and Policies

The District will adopt the following service goals and policies when this master plan is adopted by the board:

1. Pressures. Maintain at least 35 psi at all customer connections during a peak hour demand condition. Limit maximum at customer connections to 80 psi because the Oregon Plumbing Specialty Code requires pressure reducing valves on services where the meter connection pressure exceeds 80 psi.
2. Fire flow. The system shall be capable of supply at least 1,000 gpm for 2 hours at all hydrants, while maintaining at least 20 psi distribution pressures at all locations in the system. This service goal is in line with the Insurance Services Office (ISO) criteria. ISO downgrades a community's insurance rating if fire flows are less than 1,000 gpm for 2 hours. Further, the system goal is to provide 2,500 gpm to 4,000 gpm for up to 4 hours for commercial facilities located along Highway 101 or Gleneden Loop.
3. Hydrant spacing. The goal is to have every house and commercial building located within 300 feet of a hydrant.
4. Pipeline materials. Acceptable materials for new mains are PVC, ductile iron, and in some cases, HDPE. For transmission line segments, the use of HDPE or ductile iron is recommended for durability and resiliency. HDPE is the most resilient pipe material to earthquake damage, followed by ductile

iron, and then PVC. The system includes a substantial amount of AC pipe, which is the most vulnerable of pipe materials to earthquake damage, as well as normal leaks and breaks occurring from age.

5. Pipeline size. Generally use 8-inch pipes for the distribution grid, with 6-inch lines used for dead-ends that are about 300 feet or less in length. Transmission pipelines are to be sized based on estimated current and future maximum flow requirements. Limit maximum velocities to 8-10 feet per second during peak hour demands.
6. Distribution storage volume. Size distribution storage to meet equalization needs equal to 30 percent of the MDD, fire supply needs equal to 4 hours at 4,000 gpm, and emergency needs equal to one times the ADD.
7. Valve exercising. Operate all valves at least once per year to keep them reliably functional.
8. Flushing. Flush all lines at least once per year to avoid water quality problems with stagnant water.
9. Backflow prevention standards. Comply with the requirements of OAR Chapter 333.
10. Water use and other records. In addition to complying with OAR Chapter 333 and the Water Resources Department's rules for annual water use reporting, track average day and maximum day demands, and determine nonrevenue water rates monthly.
11. System development charges. System development charges (SDCs) can be used to fund growth-related projects.
12. Conservation. Implement the conservation recommendations developed in the 2016 Water Management and Conservation Plan.
13. Emergency water supply and earthquake recovery. In addition to implementing the capital projects recommended in this master plan, develop an emergency action plan, develop communication procedures, stockpile essential supplies, and work with customers to help them prepare for significant events. Develop intergovernmental service agreements with Lincoln City and Depoe Bay that define procedures and costs for exchange of water or equipment during emergencies. Consider if there is value in operationalizing the abandoned well as an emergency supply.
14. Staff training and certification. Define goals for continuing education, professional society involvement, and certification for the District staff.
15. Supply expansion. Initiate steps toward expanding the capacity of the Drift Creek slow sand filter plant and pumping system when the MDD is projected to reach 1.0 mgd within five years. The nominal plant capacity rating is 1.2 mgd but whether water can reliably be produced at this rate must be tested.

SECTION 5

Intake and Treatment Evaluation

5.1 Intakes

The District's system uses two water supplies, Drift Creek and Side Creek. The District's primary source is Drift Creek. A small tributary to Drift Creek, unofficially referred to as Side Creek, serves as a backup supply during periods of high turbidity in Drift Creek.

Per the District's water rights, the maximum allowable withdrawal from Drift Creek is 3.5 mgd. An additional water right allows for withdrawals from Side Creek to be used in place of withdrawals from Drift Creek up to 1.3 mgd, between October 15 and May 15 of each water year. The intent is that Side Creek is used when its water quality is more favorable than water quality from Drift Creek.

Water from Drift Creek is withdrawn through either of two infiltration gallery systems. Both consist of perforated pipes placed in 3-4 feet of imported gravel, installed under the bed of the creek. The older of the two infiltration galleries was constructed in the 1980s. It has five perforated 12-inch diameter pipes, each about 60 feet in length. A 1986 evaluation of the older infiltration gallery system rated its capacity as approximately 0.35-0.5 mgd.[1] The report suggested that higher rates of withdrawal would result in excessive plugging of the gravel laid over the perforated pipes, with eventual irreversible clogging of the system.

The District replaced the older infiltration gallery system, which had been constructed in the early 1980s, in 2015. The replacement system was designed to withdraw up to the District's full plant capacity of 1.2 mgd, although operating at less than this capacity is desirable to limit deep infiltration of particulates into the gravel around the collector pipes. The infiltration system uses eight collector pipes, each about 60 feet in length. Between this new infiltration gallery and the older one, the District can reliably withdraw 1.2 mgd from Drift Creek.

Until 1998, the District employed two cleaning methods for removing the solids that accumulated in the infiltration gallery gravels: backflushing the infiltration gallery pipes with finished water from the North Reservoir or backflushing the collector pipes with an air system. The combination of the two approaches was effective but in 1998, the Oregon Department of Environmental Quality (DEQ) imposed a restriction on the District, disallowing continued use of the water backflush because it used chlorinated water. The DEQ was concerned that chlorinated water could enter Drift Creek and result in injury or death to fish. The District installed a larger air backflush system as part of the 2015 infiltration gallery replacement project, to improve the cleaning using only air. This has generally proved effective.

The District also has a direct surface intake on Drift Creek, which was regularly used prior to the reconstruction of the older infiltration gallery system and prior to the use of Side Creek. It consists of a concrete intake box located on the riverbank. Water is diverted into the box and passes through a coarse screen (with an opening of ¼-inch) and then a fine screen. The fine screen is a 24-inch long section of 18-inch diameter stainless steel wedge wire screen, with a screen area of 7.0 square feet. The slot opening is 0.10-inches and the wire thickness is 0.071-inches. It has an open area of 58.5 percent. The District has generally avoided the use of the direct surface intake since 2015, because the water quality derived from the infiltration galleries and Side Creek is better than obtained from the direct surface intake.

Water from either the infiltration gallery or direct surface intake flows by gravity to one of two concrete caissons from which it is pumped to the slow sand filters. There are two raw water pumps, each a

[1] *Engineering Report in Expansion of the Drift Creek Infiltration Gallery*, CH2M HILL, May 1986.

vertical turbine pump with a 10-hp motor. These raw water pumps were installed in 1992 as part of the plant construction project. Both are constant speed pumps. With one pump running, the flow rate is about 450 gpm; with both running the flow is about 830 gpm.

The Side Creek withdrawal uses a Coanda screen, which is a specially shaped screen that sheds leaves and other debris using the excess creek flow to flush over the top of the screen. The District purchased the screen from a manufacturer and then constructed the diversion dam and installed the screen using their own staff in 2012. This has provided an effective system, requiring a minimum of maintenance. Water from the intake flows by gravity to the slow sand filters.

5.2 Slow Sand Filter Treatment Plant

The slow sand filtration plant was constructed in 1991-1992 to bring the District in compliance with the federal Surface Water Treatment Rule of the Safe Drinking Water Act. Recent studies continue to confirm slow sand filtration's reliability for removing pathogens such as *Giardia* and *Cryptosporidium*.

The plant has a nominal capacity of 1.2 mgd. It has three filters, each sized at 2,904 square feet. At the capacity of 1.2 mgd, this results in a hydraulic loading rate of 138 gpd per square foot or 0.10 gpm per square foot. This hydraulic loading rate is at the high end of the range recommended in Oregon's *Draft Slow Sand Filtration Optimization Goals and Guidelines* (April 2015).

The primary limitation of slow sand filtration is that the filters too quickly clog when raw water turbidities are high. Slow sand filtration is most effective when raw water turbidities are less than 5 ntu. High levels of algae can also clog filters, although algae levels in Drift Creek are typically low and have not been a concern. The use of the infiltration galleries and Side Creek have limited the raw water turbidity of water introduced onto the filters, which has been critical for the success of this filtration technology. The lower raw water turbidities lengthen the time between filter cleanings. Since each filter cleaning removes a portion of the fine sand media, less frequent cleanings lengthen the time between filter sand replacements, which is a significant expense. Less frequent cleanings also reduce labor requirements, since cleaning is a labor-intensive activity.

5.2.1 Plant Operations

Detailed information on recommended plant operational procedures is included in Appendix A. The most important operational procedures are to operate all filters continuously and to only make gradual flow rate changes. The continuous operation of all filters is necessary to maintain a mature biological population in the sand media, which is essential for effective removal of pathogenic organisms. The slow rate changes prevent detachment of particles from the sand media. The state's guidance recommends that rate changes be limited to no more than 50 percent over a 24-hour period.

Rather than operating all three filters continuously, the District has at times maintained one filter off-line, in a ready mode. They have found this approach limits algae growth over the filters by reducing the residence time for water standing above the sand media. Despite this benefit, it is recommended that all three filters be operated continuously. Continuous operation reduces the overall hydraulic loading rate, which can improve treatment. More importantly, it maintains a mature biological population in all filters. The biological population in an off-line filter will decline resulting in less effective treatment from that filter when it is first returned to service.

The algae concern is real, and a move to continuous operation of all filters will require the District to investigate other options for reducing algae growth over the filters. In 2012, CH2M developed a budget-level cost for installing a roof over the filters of $400,000. In recognition that covering the filters represents such a major investment, the recommendation is for the operators to evaluate results from operating the filters with varying supernatant depths. There is an adjustable weir built into each filter control box to accommodate this change.

The slow sand filters use effluent flow control. Raw water from Drift Creek is delivered to the filters using either one or two raw water pumps. Since the raw water pumps and the high service pumps that deliver the filtered water to the North Reservoir are constant speed, it is usually necessary for the raw water pumps to deliver excess flow to the filters, with the excess being overflowed from the filters back to Drift Creek. The Side Creek flow is delivered by gravity to the filters and its flow rate can be controlled by adjusting the inlet valve to match needed production from the filters.

In addition to the limitations imposed by the pumps, the operators have found it advantageous to maintain a higher water surface above the filters. This does not necessarily require an overflow from the filters, but an overflow ensures the maintenance of a high water surface.

As described in the water use chapter of this report, the ratio of creek withdrawals to filter production has averaged 190 percent for 2011 through 2015. It would be beneficial to reduce the overflow rate for the following reasons:

- Reduce energy used by raw water pumps
- Reduce particulate loading on filters; a portion of particulates carried by overflow water settle onto the filters
- Extend adequacy of water rights; the District will use up their available water rights more quickly when withdrawals exceed production
- Conserve natural flows in Drift Creek

In addition to adjusting the operating strategy, it may also be necessary to install variable speed raw and filtered water pumps to limit overflows. The District staff have investigated operating strategies and believe the addition of variable speed raw water pumps, without the use of variable speed filtered water pumps, may provide the needed operating flexibility. A project to modify the raw water pumps to variable speed operation has been included in the capital improvements plan. A larger storage volume at the North Reservoir site would also be beneficial, to minimize the need for rate changes and to allow such changes to be made more gradually. Replacement of the North Reservoir with a larger tank is also included in the capital improvements plan.

5.2.2 Plant Expansion

The plant has a nominal capacity rating of 1.2 mgd. By nominal, it means although the plant was designed for a production of 1.2 mgd, its actual, reliable capacity could not be known with certainty except based on full-scale performance. Its actual capacity may be as low as 1.0 mgd.

Therefore, as system demands grow and the plant is called upon to produce greater flows, the operators should carefully monitor its performance and estimate its reliable capacity. For planning purposes, it is recommended that expansion of the plant should be initiated when the MDD reaches 1.0 mgd. In addition to accounting for the uncertainty with the plant’s reliable capacity, the additional time this early trigger affords is also necessary to finalize funding, and to complete the permitting, designing, and constructing phases of expansion.

Figure 5-1 illustrates projected maximum day demands compared to the 1.0 mgd trigger line. According to the projections presented in this plan and the using the 1.0 mgd value, the District will need to begin the expansion project in approximately 2034.

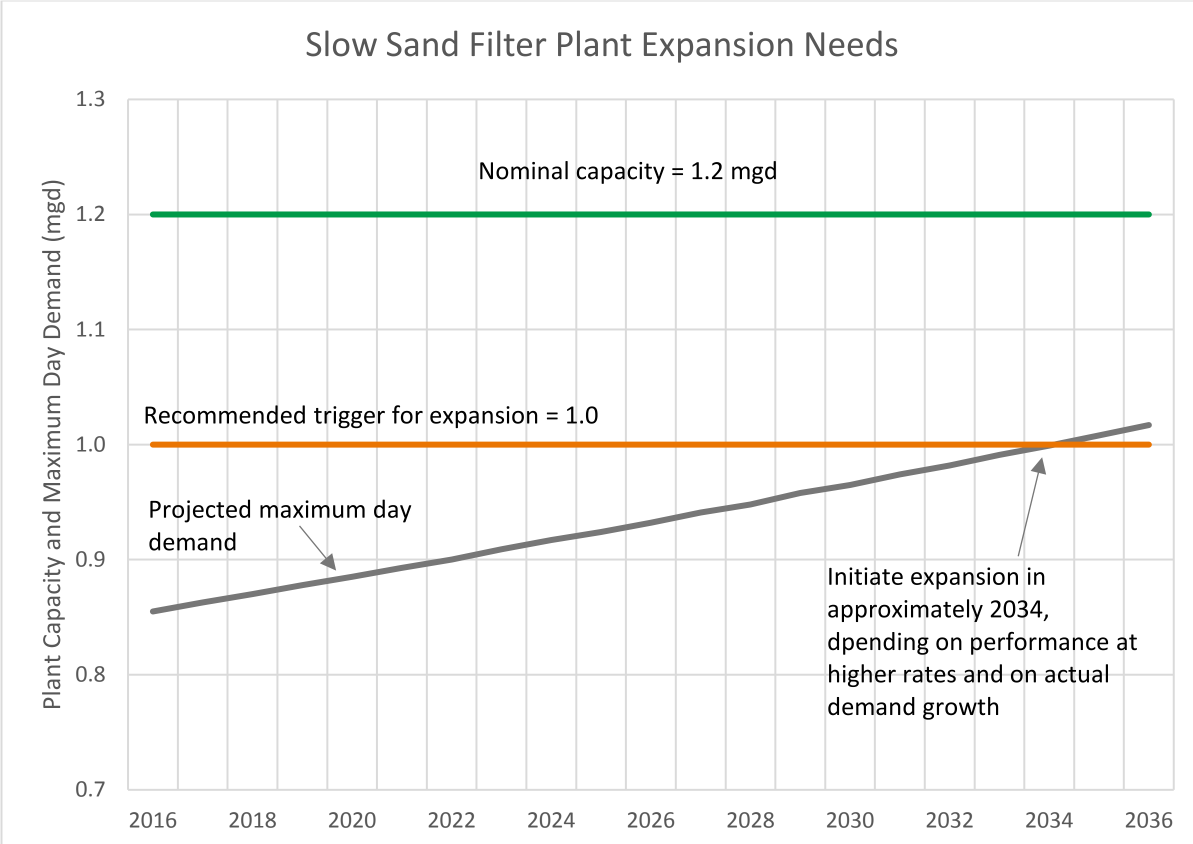

Figure 5-1. Slow Sand Filter Plant Expansion Planning Chart

A detailed cost estimate for adding a fourth filter was included in the 2000 master plan. The construction cost was updated and adjusted in this master plan to account for advanced seismic requirements that are now in effect, plus escalation from 2000 to 2016. Additionally, an allowance was added to the construction cost to account for engineering services for permitting, bidding, design, and construction services. The total estimate for the expansion is $650,000.

5.2.3 Filter Resanding

Through normal operation of the filters, sand media is gradually removed when the filters are cleaned by scraping. The first resanding was needed after six years of operation (from 1992 to 1998). The District has improved cleaning procedures and developed improved water withdrawal facilities and has lengthened the resanding interval to eight years or more. The next resanding is anticipated to be needed in 2022. A cost for this resanding, although a routine operating cost, is included in the capital improvements plan in recognition of it being a periodic and significant cost.

Distribution, Transmission, and Storage Evaluation

This chapter contains an analysis of the District's transmission and distribution system, and storage reservoirs. The analyses build on previous evaluations conducted for the 2000 Water Master Plan and an intermediate fire flow evaluation conducted by CH2M in 2009. A computer model of the system, developed and used in the previous work, was updated to reflect pipe changes in the current system and recent water demands, and was used to review the performance of the distribution system.

The distribution system was analyzed using standard water system criteria. It must be capable of supplying water to all locations at acceptable pressures during a peak hour demand (PHD) condition. It must also be apply to deliver adequate fire flows to hydrants coincident with a maximum day demand condition. A peak hour demand condition represents the highest expected demands that the system needs to supply, being defined as the highest demand hour on the maximum day. Evaluating the ability of the system to supply fire flows during a maximum day demand condition is a typical approach used for evaluating fire flows. It represents a condition of delivering adequate flows to fire hydrants during a summer day.

A large wall map showing the distribution system is included as an insert to this report.

6.1 Description of Existing Distribution System

Water is pumped from the slow sand filter plant to the North Reservoir and then flows by gravity to the remainder of the system. A single transmission pipeline, varying in size from 12 to 16 inches, delivers water from the North Reservoir to the primary customer base beginning south of Salishan Heights Drive. About 7,000 feet of the transmission is 16-inch diameter high density polyethylene (HDPE) or PVC, and about 5,900 feet of the line is 12-inch diameter ductile iron, welded steel, PVC, and asbestos cement pipe. One portion is 12-inch ductile iron fastened to the Siletz River Bridge and another is 16-inch ductile iron fastened to the underside of the Millport Slough Bridge.

The first section of transmission line from the North Reservoir to the system follows a logging road easement and then the power line easement from North Reservoir down to the Siletz Highway. From there, it follows the Siletz Highway to Highway 101. This line was replaced in 2015 with 16-inch HDPE and 16-inch PVC.

From the intersection of the Siletz Highway with Highway 101, the transmission pipeline consists of sections using various materials and installed at different dates. The section mounted on the Siletz River Bridge is 12-inch ductile iron. From the end of the bridge south to Salishan Hills Drive, the line includes 12-inch AC, 16-inch ductile iron, and a short section of 14- and 12-inch welded steel.

South of Salishan Hills Drive, the primary transmission pipeline is 10-inch diameter line paralleling Highway 101. It feeds 4-, 6-, and 8-inch distribution pipelines. For most of this section of transmission pipe, the smaller distribution network provides redundancy.

The system has three service levels. The lower level ranges from approximately 20 to 70 feet elevation. This includes most of the system west of Highway 101 and Seagrove development to the east of the highway. Service areas below 70 feet elevation are separated from the main 10-inch transmission main by pressure reducing valves (PRVs). The PRVs are set to limit pressures on the downstream side (lower elevation side) to 35 to 52 pounds per square inch (psi). The base level is the area with elevations between 70 and 170 feet. This level is served by gravity flow from the North Reservoir. The North

Reservoir has an overflow elevation of 311.5 feet. This results in static pressures in the base level from approximately 61 to 105 psi. The Central Reservoir has an overflow level of 289.5 feet and the South Reservoir 272.5 feet. The hydraulic grade line in the base level in the southern end of the distribution system will generally be lower than in the northern end. The Central and South reservoirs have altitude valves to prevent overfilling.

There is a small, higher elevation service level in the Salishan hills area, east of Highway 101. This is fed by a pump station, with gravity storage provided in the Salishan Standpipe Reservoir. The overflow of this 65-feet tall tank is 374 feet. The service level elevation ranges from about 170 feet up to 300 feet.

6.2 Storage

The four reservoirs (North, Central, South, and Salishan Standpipe) have a combined storage volume of 2,450,000 gallons. Of this total, the 300,000 gallons of the North Reservoir is dedicated to chlorine contact time. The remaining volume of 2,150,000 gallons is available to meet distribution system needs.

As this report was being prepared, the District was moving forward through a long-term contract with a service company to repaint and implement seismic improvements at the Salishan, Central, and South Reservoirs. The seismic improvements will consist of improving the flexibility of the pipe to tank connections at the Central and South Reservoirs, and adding seismic isolation valves to these tanks. The seismic isolation valves will automatically close an isolation valve in the event of a significant earthquake to prevent the contents of these tanks from draining through broken pipes. The Salishan tank is scheduled for repainting in 2017, with repainting of the other two steel tanks to following in the next few years.

6.2.1 North Reservoir

All supply from the slow sand filter plant passes through the North Reservoir, which is a concrete, hopper bottom tank with a wood-framed, metal roof. It represents a single point of failure. It could be bypassed by closing and opening valves on the piping supplying the tank, but if it was out of service, the system would not reliably meet disinfection contact time requirements and it would be difficult to match production from the plant to system demands. Its age (more than 50 years) and relatively small size indicate that its replacement would be a valuable addition to the system.

The North Reservoir establishes the hydraulic grade line for the gravity zone of the system. The water level in the tank is used to start and stop the high service and intake pumps at the slow sand filter plant. The volume supplied in this reservoir provides the dual purposes of meeting chlorine contact time requirements and of providing a buffer, allowing the treatment plant to operate at a steady rate even as demands fluctuate in the system.

The state and federal drinking water regulations stipulate that a minimum of 1-log inactivation of *Giardia* cysts by disinfection be provided following filtration by slow sand filter plants. A 1-log level of inactivation means that disinfection reduces the viable *Giardia* cysts by 90 percent. Slow sand filtration is credited with 2-log removal (99 percent), giving a total treatment reduction of 3-log (or 99.9 percent).

The Surface Water Treatment Rule contains required CT levels that must be met to assure 1-log inactivation. A CT value is the product of the chlorine concentration in mg/L ("C") at the first customer, multiplied by the time of detention in minutes ("T") between chlorine addition and this point.

The required CT depends on the water pH, temperature, and the chlorine residual. Using extreme (worst-case) values for the District's system, the required CT in the winter months is 60 (mg-min)/L. For the summer months, the required minimum is 45 (mg-min)/L. These values are based on a pH of 7.5, a chlorine residual of 1.0 mg/L, a winter water temperature of 5^{o} C, and a summer temperature of 10^{o} C.

These CT levels can be met by providing at least 60 minutes of detention time in the winter and 45 minutes in the summer. Although summer demands are usually much higher than winter demands, there are occasions when the system is operated at higher flows during cold water periods. These may occur during freezing weather when lines break or during the shoulder months when water temperatures are low but demands increase because of a high number of tourists. Therefore, it is advisable to design the system to always provide at least 60 minutes of detention time.

In the District's case, the detention time is provided in the transmission line between the plant and the North Reservoir and by storage in the North Reservoir.

The total volume of the pipeline from the plant to the North Reservoir is approximately 25,000 gallons. The total volume of the finished water pipeline to the first customer is about 32,000 gallons. For the current plant capacity of 1.2 mgd, this provides about 68 minutes of detention time, the full amount needed. For the future plant flow of 1.6 mgd (which is projected buildout capacity of the treatment plant), the detention time is 51 minutes. Since a replacement reservoir is a long-term investment, it is appropriate to size it for the buildout capacity of 1.6 mgd. Therefore, the North Reservoir should be sized to provide at least 9 minutes of detention time at its lowest operating level. Even with accounting for short-circuiting in the tank, which occurs in all reservoir tanks, the needed volume for disinfection contact time is only about 100,000 gallons.

The other component to consider in sizing this tank is storage to allow steady-state operation of the plant and to account for short-term shutdowns. The importance of steady-state operation of the plant is discussed in the treatment chapter. It is advantageous in meeting water quality goals to operate the plant with gradual rate changes, rather than abrupt changes to match changes in the system demands. Additionally, there will be times when the plant is off-line altogether, as might occur if there was an electrical failure or to allow a period of high turbidity water to pass the intake.

In general, the greater the volume for plant operational storage, the better. One approach to determining a minimum acceptable level of storage is to consider the expected downtime for the plant and the storage that is needed to ensure that the North Reservoir does not empty. It is conceivable that the plant could be off-line for up to 8 hours because of raw or finished water pump failures, or extreme water quality problems in Drift Creek. If system demands are at a MDD level during this period, the North Reservoir would empty at 830 gpm. When the plant capacity is increased to 1.6 mgd, the reservoir will empty at 1,100 gpm. The higher, future flow rate should be used for long-term planning.

A flow of 1,100 gpm for 8-hours is equal to a volume of 530,000 gallons. This is a reasonable volume for plant operational storage. This volume should be provided at the North Reservoir location in addition to 100,000 gallons needed for disinfection.

With consideration of these factors, a replacement North Reservoir could be sized from 600,000 gallons to 1,000,000 gallons. It appears that the property owned by the District would accommodate a new tank with a volume of up to 1,000,000 gallons while keeping the existing tank on line. The final volume and dimensions of the tank warrant further detailed evaluation in a preliminary design. This evaluation should also consider the material of construction. Welded steel is a good option and provides good seismic resiliency; however welded steel requires periodic repainting and it must be removed from service for about two months for the repainting. A concrete tank would have a higher first cost and particularly when it is designed to withstand a major seismic event, but it offers the advantage of not needing to be repainted. A cost for a 1,000,000 gallon welded steel tank is included a placeholder in the capital improvements plan.

6.2.2 Distribution Storage

Storage in the distribution system is provided to meet the following three needs. Storage tanks are not divided into separate sections for the various components, but a review of storage needs using these divisions is helpful for determining how much storage is needed.

- Equalization: storage to meet peak demands
- Fire: storage required for fire fighting
- Emergency: storage that provides a reserve for system failures

Another factor in determining storage size is water quality. Even when treated water meets all regulations and is aesthetically pleasing, storage of this water for an extended time can result in a deterioration of its quality. Long detention periods can impart an unpleasant taste and odor, or allow bacteriological growth. Therefore, sizing and design of storage reservoirs must also consider water quality.

The amount of equalization storage needed varies from system to system, depending on factors such as the proportion of commercial to residential users, climate, and typical lot size. One of the primary water uses that affect equalization storage needs is irrigation. For communities with large irrigation use, the peak hour rate can be more than two times the maximum day rate. The District’s peak hour rate is expected to be less because of wetter summers, but the actual ratio of peak hour to maximum day is not known.

In the absence of specific data, it is recommended that typical criteria be applied. Equalization values in the Pacific Northwest range from 18 to 35 percent of the MDD. A value of 25 percent is a reasonable estimation for the District’s system.

Oregon’s public water system rules stipulate that finished water storage be increased if the system includes hydrants, as the District’s system does. The District’s 1977 Master Plan recommended that the system provide 4,000 gpm for 4 hours in the Salishan area, and 2,500 gpm for 2 hours near commercial areas on Highway 101. These rates were based on feedback from the Insurance Services Office (ISO). These rates remain valid and provide a basis for determining the storage needed for fire-fighting. This recommended rate of 4,000 gpm for 4 hours equals a storage volume of 960,000 gallons.

Sizing finished water storage for emergencies is the most subjective among the storage volume criteria. It depends on how vulnerable the water system is to failure. In the District’s case, the factors to consider include the source water quality, operation of the slow sand filter plant, the raw and finished water pumping, and the transmission pipeline to and from the North Reservoir.

Raw water quality problems, slow sand filter operational problems, or failures of the raw or finished water pumping systems could all require times of 24-hours or longer to repair. Therefore, it is recommended that storage provide at least 24-hours of average day demand volume to protect against these failures.

Table 6-1 summarizes estimated storage needs for distribution equalization, fire, and emergency needs. Using this approach, it does not appear that additional storage is needed to meet these needs in the 20-year planning period. A surplus is projected through the end of the 20-year planning period. The equalization and emergency volumes depend on demands, and if demand growth exceeds the projected rate, storage for these needs may be required within the next 20 years.

Table 6-1. Storage Needs Analysis
Water System Master Plan

			Storage Needs (MG)				Storage Evaluation (MG)	
Year	ADD (mgd)	MDD (mgd)	Equalization	Fire	Emergency	Total	Existing	Surplus (+) or Deficit (-)
2016	0.46	0.86	0.26	0.96	0.46	1.68	2.15	0.47
2017	0.46	0.86	0.26	0.96	0.46	1.68	2.15	0.47
2018	0.47	0.87	0.26	0.96	0.47	1.69	2.15	0.46
2019	0.47	0.88	0.26	0.96	0.47	1.70	2.15	0.45
2020	0.48	0.89	0.27	0.96	0.48	1.70	2.15	0.45
2021	0.48	0.89	0.27	0.96	0.48	1.71	2.15	0.44
2022	0.48	0.90	0.27	0.96	0.48	1.71	2.15	0.44
2023	0.49	0.91	0.27	0.96	0.49	1.72	2.15	0.43
2024	0.49	0.92	0.28	0.96	0.49	1.73	2.15	0.42
2025	0.50	0.92	0.28	0.96	0.50	1.73	2.15	0.42
2026	0.50	0.93	0.28	0.96	0.50	1.74	2.15	0.41
2027	0.51	0.94	0.28	0.96	0.51	1.75	2.15	0.40
2028	0.51	0.95	0.28	0.96	0.51	1.75	2.15	0.40
2029	0.52	0.96	0.29	0.96	0.52	1.76	2.15	0.39
2030	0.52	0.97	0.29	0.96	0.52	1.77	2.15	0.38
2031	0.52	0.97	0.29	0.96	0.52	1.78	2.15	0.37
2032	0.53	0.98	0.29	0.96	0.53	1.78	2.15	0.37
2033	0.53	0.99	0.30	0.96	0.53	1.79	2.15	0.36
2034	0.54	1.00	0.30	0.96	0.54	1.80	2.15	0.35
2035	0.54	1.01	0.30	0.96	0.54	1.80	2.15	0.35
2036	0.55	1.02	0.31	0.96	0.55	1.81	2.15	0.34

6.3 Water Storage for Lower Siletz Water District

The 1977 Master Plan reviewed the storage needs for the Lower Siletz Water District (LSWD). The report projected a saturation population of 300 people. Based on this value, it recommended that the LSWD install a 250,000 gallon reservoir. The report provided a preliminary recommendation for the overflow elevation of 235 feet, and the location to be at the far end of the pipeline. However, the report recommended that the volume, location, overflow and elevation should be evaluated by the LSWD before project implementation.

With no current storage, the LSWD is relying on the District's North Reservoir to meet its finished water storage needs. It is recommended that the LSWD install its own finished water storage reservoir or that

LSWD contribute financially to over-sizing the proposed new tank that the District will install at the North Reservoir. The LSWD should provide a storage needs analysis to determine the needed storage volume for either alternative.

6.4 Distribution Piping Analysis Approach

A hydraulic computer model was used to simulate the performance of the system during various conditions. The model was first developed for the District's system and used in the 2000 master plan and was further updated for the 2009 fire flow analysis. The model data set, consisting of information describing pipe diameters, pipe materials, pipe connections, and pressure reducing valves, was reviewed and updated by District staff to reflect recent changes in the system, and to correct some data. The modeling software[2] was linked to Lincoln County's graphical information system (GIS) to facilitate allocation of customer water demands (based on meter records) throughout the system and to allow for printing of maps.

A number of modeling runs were made to simulate the performance of the system during a range of water demands, and to simulate performance with proposed distribution system improvements. The computer model output lists pressures and hydraulic grade lines at pipe junctions, velocity and friction losses through the pipes, the status of the PRVs (whether open or closed), and the flows into and out of the reservoirs.

The water demand information presented in Section 3 was distributed throughout the system by first assigning demands for the 25 customers having the highest water use at their specific connection locations. The remaining demands were divided equally among remaining nodes throughout the system. Customer meter records provide monthly totals; these values were multiplied by global factors to simulate maximum day demand (MDD) or peak hour demands (PHD) conditions. The performance of the system was modeled for the following conditions:

- Average day demands (ADD)
- Maximum day demands (MDD)
- Peak hour demands (PHD)
- Reservoir refill during nighttime low demands
- Maximum day demand with fire flows

6.5 Distribution System Modeling Results

6.5.1 Transmission Pipelines

The transmission pipelines from the slow sand filter plant to the North Reservoir, from the North Reservoir to the main distribution system beginning at Salishan, and along Highway 101 through the distribution system, are adequately sized to meet current and future flow requirements. The Central and South Reservoirs allow flow to be delivered from two directions to most locations in the system, which helps to hold pressures stable during peak hour demands.

The District completed replacement of the transmission line from the North Reservoir to Highway 101 in 2015. The remaining vulnerable sections include the line from the plant to the North Reservoir, particularly the portion of this line that climbs the steep hillside. This line may be more prone to failure from landslides and corrosion of the joint couplings than other sections, but even more importantly, it would be extremely difficult for the District staff to repair this section of line in an emergency.

[2] Software used was a product of Innovyze.

The other vulnerable sections of transmission lines include those portions that use AC pipe. AC pipe is more vulnerable to ground movement or impact breakage than other materials, and often softens and weakens with age so that failures occur even without a known factor. An important section for replacement is the AC pipe between the Siletz River Bridge and Salishan Hills Drive because there is only a single line and its failure would isolate most customers from the water supply.

The main transmission pipeline includes approximately 3200 feet of 10-inch AC line along the shoulder of Highway 101 from Hillcrest Street on the north end to Lancer Street on the south end. This section is considered to be particularly vulnerable to breaks and leaks that may not be readily observable because about 1000 feet of the line passes through the Schoolhouse Swamp area. The large diameter of the pipeline, long length of this section, and challenging excavation conditions because of the swamp make the replacement of the line beyond the scope of work that could be expected from the District's own staff.

The swamp conditions will make open-cut trenching difficult, so one option being considered is using horizontal directional drilling (HDD) to install the section of line through the swampy area, with open-cut trenching on each end. HDD installation is attractive for avoiding existing, shallow utilities and minimizing disruption along the highway, but it is also risky from the standpoint of encountering unknown obstacles deep underground. This can particularly be the case for low-elevation, swamp areas along the coast because the drilling may encounter buried trees. Therefore, without further subsurface information, the option to use HDD installation is questionable.

Additionally, the use of HDD can be two to three times the cost of open-cut, trenched installations for water pipelines. HDD can be a favorable technique for specific applications, such as a river under-crossing, but its high cost means that it is only recommended when there are mitigating circumstances that limit the use of open-cut, trenched installations. Since the high water table could pose challenges for open-cut trenched installation, the project warrants further evaluation during a preliminary design. The final approach will depend on ground conditions, conflicts with existing buried utilities, and permitting limitations from ODOT.

The capital improvement plans assumes that the pipe replacement can be installed using open-cut trenching. Particularly if HDPE is used as the replacement pipe material, which is recommended because of the ground conditions and because there is a limited need for connections in this segment of pipe, the open-cut assumption is reasonable. HDPE is the most seismically resilient pipe material, so it will help to establish a resilient backbone in the distribution system.

6.5.2 System Pressures

The hydraulic modeling indicated that the system performs acceptably for peak hour conditions. Water was provided to all areas with acceptable pressures and velocities in the pipes. The lowest pressures were 38-40 psi. All of the low pressure sites were in the low zone, downstream of the pressure reducing valves (PRVs). If desired, the PRVs could be adjusted to increase the pressures.

6.5.3 Fire Flows

The District's goal for fire flows is to provide at least 1,000 gpm at all hydrants and up to 2,500 gpm, if possible, to commercial facilities along Highway 101 and Gleneden Beach Loop. According to the state's public water system rules, fire flows should be provided while maintaining a minimum pressure of at least 20 psi in all locations in the system.

Only one hydrant location (out of 56 hydrants in the District) was found to have a fire flow capability of less than 1,000 gpm. The model predicted a flow of 740 gpm for the hydrant on El Mundo Avenue. This flow can be increased to over 1,000 gpm by replacing the 4-inch pipe on El Mirador and Coronado Drive between El Mundo and El Prado with an 8-inch line.

The model predicted that 2,500 gpm can be provided from the main transmission line along Highway 101 without any system improvements.

6.6 Recommended Storage and Distribution System Improvements

The following recommendations were developed by examining storage and distribution needs. The capital improvements in this list have been captured in the capital improvements plan table. Some of these projects are discussed in the seismic chapter.

- Upsize 4-inch pipe on El Mirador and Coronado Drive between El Mundo and El Prado to 8-inch diameter, to increase the fire flow in the hydrant in this section to above 1,000 gpm.
- Replace the 950 feet section of the transmission line from the slow sand filter plant to North Reservoir that ascends the steep grade from the Drift Creek valley to the crest of the hill.
- Keep land above elevation 170 feet out of water system service area if possible, or there will be significant expense for installing pump stations and reservoirs.
- Replace the North Reservoir with a 1 million gallon tank, to accommodate growth and to improve system resiliency.
- Replace the 4,300 feet of 10-inch diameter AC transmission pipeline that passes through Schoolhouse Creek swamp with new 14-inch HDPE pipe. This will provide greater reliability since the existing line is prone to breaks or failure from poor quality pipe and poor soil support.
- Replace the 8,600 feet of transmission main from South Immonen Road to Westwind Street with 16-inch HDPE pipe, to improve system resiliency.
- Replace the 7,900 feet of transmission main from NW Lancer Street to the South Reservoir connection point on Highway 101 with 14-inch HDPE pipe, to accommodate growth and improve system resiliency. Located on west side of highway and connect to pressure-reducing valve distribution lines.
- Replace the 5,330 feet of 10-inch PVC pipe connection to the Central Reservoir with 12-inch HDPE, to accommodate growth and improve system resiliency.
- Replace the 3,500 feet of 10-inch AC pipe connection to the South Reservoir with 12-inch HDPE, to accommodate growth and improve system resiliency.
- Replace existing AC pipes serving homes on Salishan Spit with PVC lines to accommodate growth and improve system resiliency.

SECTION 7

Seismic Resiliency

One task of this master plan update was to examine the seismic vulnerabilities of the District's system and to develop recommendations for improving its seismic resiliency.

The seismic vulnerability evaluation was guided by the Oregon Resiliency Plan (ORP). The development of the ORP was by mandate of the Oregon legislature in 2011, in recognition of the likelihood and magnitude of the Cascadia Subduction Zone earthquake in Oregon. According to Oregon State University researchers, a Cascadia Subduction Zone earthquake with a magnitude 8 to 9 intensity has a one in three likelihood of occurrence in the next 50 years.[3] This would be an unprecedented event for our region in the time since it has become widely populated and developed. The goals of the ORP, which are appropriate goals for the District, were to help utilities recognize their vulnerabilities and to implement phased improvements over the next 50 years to protect lives and provide rapid economic recovery.

7.1 Seismic and Tsunami Vulnerabilities

The District's location is vulnerable to a Cascadia Subduction Zone earthquake and an associated tsunami. Oregon coastal areas are expected to experience the greatest ground movement during this major earthquake. Several regions within the District's service appear to have liquefiable soils, further amplifying the damage caused by an earthquake.

According to maps prepared by the Oregon Department of Geology and Mineral Resources (DOGAMI), the Gleneden Beach – Siletz River region is highly vulnerable to a tsunami that could result from a Cascadia Subduction Zone earthquake.[4] The tsunami inundation zone may range from 16 feet above sea level to as high as 72 feet above sea level. For a medium intensity tsunami, as defined by DOGAMI, 8 percent of the houses and other buildings within the District are shown to be within the tsunami zone. For a very large tsunami, approximately 50 percent of the houses and buildings within the District's service area will be inundated. Experts have said that among natural disasters, tsunamis may be the closest to being completely unsurvivable. The combination of a Cascadia Subduction Zone earthquake and a tsunami is expected to devastate the District's region, with unimaginable destruction and very likely, considerable numbers of injuries and deaths.

Studies of Oregon's transportation network suggests that the District will be completely cut off from the Willamette Valley and coastal areas to the south and north after a major earthquake.[5] It is unlikely that substantial assistance can or will be provided to the District from outside the area for weeks. For example, the Highway 101 bridge over the Siletz River was designed prior to the current understanding of the area's seismic risks and it will likely fail during a Cascadia Subduction Zone event. This will sever most of the District's customers from the water supply and treatment facilities located north of the river and cut off the District from assistance via roads from the north.

Oregon's water (and wastewater) systems are especially vulnerable to damage resulting from a Cascadia

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[3] "Turbidite Event History—Methods and Implications for Holocene Paleoseismicity of the Cascadia Subduction Zone," by Goldfinger, Chris, et al, U.S. Geological Survey Professional Paper 1661-F. Summarized at: http://oregonstate.edu/ua/ncs/archives/2012/jul/13-year-cascadia-study-complete-%E2%80%93-and-earthquake-risk-looms-large

[4] Local Source (Cascadia Subduction Zone) Tsunami Inundation Map , Gleneden Beach – Siletz River, Oregon, as available online or from Nature of the Northwest Information Center, Portland, Oregon.

[5] According to the findings in the Oregon Seismic Lifeline Routes Identification project, as presented April 2013 to the ACEC/ODOT Partnering Conference, Wilsonville, Oregon.

Subduction Zone earthquake. The ORP identified inherent seismic vulnerabilities of water systems as the following:

- Water systems are distributed over large areas, with numerous potential points of failure
- Water systems are highly dependent on other resources—such as power, transportation, chemicals, and skilled staff—to remain operational and to conduct repairs
- Water systems are financially dependent on consistent revenue streams to fund ongoing operations, maintenance, and debt service obligations
- Essential water system facilities, such as intakes, treatment plants, and pump stations are often located near rivers and lakes and are vulnerable to damage from liquefaction of alluvial soils
- Many critical facilities, such as reservoirs, pump stations, and treatment plants, were designed and constructed before the adoption of seismic design standards that reflect the current predictions of a Cascadia Subduction Zone earthquake
- Water pipeline networks include extensive use of relatively inflexible materials, such as PVC, asbestos cement (AC), and cast-iron pipe, which tend to fail during strong ground motion
- Water pipelines tend to fail at connections to aboveground structures such as reservoirs, and at service connections to homes
- Water from leaks and breaks in water pipelines and private plumbing systems will damage property, drain available water storage, and contribute to loss of water supply and pressure

According to the ORP's estimates, water systems on the coast will require 1-3 years to recover to a functional level, where potable water is distributed to most of the system and water can be delivered to most hydrants. Full recovery of systems is expected to require longer than 3 years. There is no reason to believe the District's system will perform better than these general predictions. The District's system may even perform worse than many coastal communities because a substantial portion of the distribution system is within the tsunami inundation zone.

7.2 Improving the District's Seismic and Tsunami Resiliency

Specific water utility recommendations arising from the ORP include the following:

- Develop resilient 'spine' (a resilient pipeline central to much of the system)
- Undertake facility upgrades to major facilities, such as the intake, water treatment plant, pump station, and reservoirs
- Add redundant facilities and systems, where possible
- Develop plans for providing emergency water supply to meet potable needs
- Continue to implement emergency preparations, in coordination with first responders, the county, state, and Red Cross

The first recommendation on the list is to develop a resilient pipeline central to the system, one that will suffer limited damage and can be rapidly returned to service following an event. Improvements to accomplish this resilient spine are needed within the District because much of the main north to south transmission uses asbestos cement pipe, which is highly vulnerable to damage during an earthquake.

However, a resilient spine will only help to a limited extent because of a fundamental vulnerability with the District's system, which is that the river supply, slow sand filter treatment plant, and North Reservoir are located north of the Siletz River and the vast majority of the service area and customers are located south of the river. It is very likely that the Highway 101 bridge over the Siletz River will fail during a large earthquake, according to the work done by the Oregon Department of Transportation and an understanding that it was designed prior to recognizing the magnitude of the Cascadia Subduction Zone earthquake. Unfortunately, there does not appear to be reasonable and affordable improvements that can be undertaken to address this vulnerability. It would be possible to install a pipeline under the river using a horizontal directional drilling approach, but unless the boring extended from the north river bank to south of the South Millport Slough Road, the portion through the Millport Slough would likely fail because of liquefiable soils in the slough. Even with a bored pipe, it is uncertain if a deep installation would provide protection during a major earthquake. The measures that the District may wish to consider include the following:

- Prepare to provide an emergency water supply south of the river
- For short-term, intermediate response, purchase and stockpile pipe and fittings for installation of a substitute river crossing

7.3 Slow Sand Filter Plant

The slow sand filter plant was designed and constructed in the early 1990s. By this date, designs included greater strengthening against earthquake damage than in previous decades, but the level of potential earthquake considered was still much smaller than a magnitude 9.0 Cascadia Subduction Zone earthquake. CH2M prepared the design for the plant. As part of this master plan analysis, CH2M reviewed the geotechnical investigation report that guided the design at that time. It appears from the geotechnical investigation that the filters are likely constructed on dense to very dense sand/gravel or siltstone/sandstone. However, the borings were all advanced near the middle or uphill side of the filter basins; the river side (north side) of the basins may be sitting on looser sands, since looser sands were observed shallower in the borings. The pre-construction grade on the river side of the filters was elevation 60 feet and the bottom of the filter basins is only slightly lower at elevation 58 feet, suggesting the possibility that looser sands underlie the river side of the basins.

If the filter basins are entirely founded on dense sand/bedrock, then the seismic stability is reasonably good. The shallow pipe and control connections may be disrupted during an earthquake and soil on the uphill slope may slough into the ditch on the south side, but the concrete basins may withstand the event with only minor damage. However, the filter media sand and support gravel may liquefy, with the movement possibly breaking the internal filter underdrain collection piping.

If the river side of the basins is founded on looser, potentially liquefiable sands, then it is likely that the basins will be severely damaged during an earthquake. The shallow sands were noted to be saturated and to have loose to medium density during the explorations, which means they will probably liquefy during an earthquake and the relatively unsupported river end of the basins will cause major cracking.

The survivability and operation of the plant also requires a functioning intake, functioning filter media and collection systems within the basins, and functioning chlorination, pump well, and high service pump system. The liquefaction of the sand media will likely damage the filter underdrain collection piping, requiring removal of the media and replacement of the piping. The deep concrete pump wells for the raw water and high service pumping may survive, but the pipe connections to these basins may be severed. The river infiltration galleries will likely be damaged beyond repair because of subsidence and liquefaction of the river bed. The electrical power to the plant will almost certainly be disrupted and it is uncertain how quickly it will be restored. Access to the plant following a major earthquake will be difficult; it is conceivable that it will be limited to foot traffic until debris and landslides can be removed by equipment. Vehicles may not be able to drive to the plant for weeks after an event.

In summary, the analysis of the District's water supply facilities identified a number of vulnerabilities. The District should carefully consider emergency response measures for withdrawing, treating, and distributing potable water in the aftermath of a major earthquake in lieu of relying on the Drift Creek supply.

7.4 Transmission Pipelines

The transmission piping from the slow sand filter plant to the majority of customers, located south of South Millport Slough Road, is comprised of several sections with varying vulnerabilities.

The section from the plant to the North Reservoir is about 4,500 feet, and consists of the following pipe materials:

- 3,400 feet of 10- and 12-inch PVC (Class 150) installed in 1991
- 950 feet of 12-inch steel pipe, with mechanical joints (up the steep hillside)
- 150 feet of 12-inch AC pipe

The District is currently replacing the short section of AC pipe, which is the most vulnerable to earthquake damage. The PVC pipe could be considered moderately resilient except portions of it may be in liquefiable soils, and thus prone to seismic failures.

The section of steel pipe that is located on the steep hillside from the river valley up to the North Reservoir hill is vulnerable because of the potential for landslides caused by an earthquake. Steel pipe is less vulnerable than PVC pipe to damage from earthquakes, but the location of this steel pipe on the steep hillside warrants special consideration. The hillside is very steep and if a break or leak was to occur, even from a minor earthquake or simply from corrosion, it would be difficult for the District's crews to safely undertake repairs.

The pipe has a coal tar coating on the exterior and an epoxy lining on the interior, providing corrosion protection. However, the joints consist of couplings and restraint was provided by using harnesses over the couplings and thrust blocks. Expansion joints were installed at each end for flexibility. The concern is that corrosion may have weakened the couplings, harnesses, and expansion joints, and that failures could occur in the coming years even without a seismic event.

This pipe is a critical component of the District's system, with no redundancy. Given that special equipment and procedures would be required to repair the line, a near-term replacement of it is an important project for the District.

The finished water transmission pipeline from the North Reservoir down to the Siletz Highway was replaced in 2015 with 18-inch HDPE (with an inside diameter of approximately 16 inches). HDPE pipe was also used along the Siletz Highway for 1100 feet before a transition was made to 16-inch PVC for the remaining 1000 feet to the base of the Siletz River Bridge. HDPE is considered an excellent selection for providing earthquake resiliency because of its ductility. It has performed well in recent earthquakes in Japan, New Zealand, and Chile.[6] However, it is difficult to install main connections or service connections to HDPE pipe so it is generally used for transmission lines and not distribution mains.

The Siletz River Bridge crossing consists of 12-inch ductile iron. The pipe is mounted on the bridge and will fail if the bridge fails. Replacing the line across the bridge with a bored undercrossing is an option but only replacing that section would provide limited value because the pipeline then traverses the liquefiable soils in the Millport Slough.

From the bridge south to Salishan Hills Drive, the lines include 16-inch ductile iron, 12- and 14-inch welded steel, and 12-inch AC. The AC pipe is the most likely to fail in a moderate or strong earthquake, although the entire section of transmission pipeline is in liquefiable soils and would likely fail during a major earthquake.

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[6] Water Research Foundation, "Recent Earthquakes: Implications for U.S. Water Utilities," Project 4408, July 2012.

There do not appear to be any reasonable alternatives for replacing or adding redundancy for the Siletz River crossing and the transmission pipeline from the south side of the river to the intersection of Highway 101 and Salishan Hills Drive because of the wide Millport Slough with liquefiable soils. An alternative alignment following South Drift Creek Road from the North Reservoir to the north side of the river was examined, with the idea that a bored undercrossing could be used with an eventual connection to the South Millport Slough Road. However, this alignment results in about 8,000 feet of vulnerable pipe in the liquefiable soils in the slough.

From the intersection of Highway 101 and Salishan Hills Drive to the south, the primary backbone of the system is a 10-inch diameter line. It is located to the west of Highway 101 from Salishan Hills Drive south to Seagrove development and then transitions to the east side of the highway. It is generally located in more stable soils than the section through the slough although the seismic ground movement throughout its length may be extensive and pipe failures are to be expected. The most vulnerable sections are those constructed of AC pipe and the section that passes through the Schoolhouse Swamp, where soils may be liquefiable.

7.5 Reservoirs

The District's four reservoirs were constructed from the 1960s through the early 1990s. The concrete, in-ground, hopper bottom North Reservoir appears to be founded on relatively firm sandstone but cracking and subsequent leaks could be expected in an earthquake.

The Central and South Reservoirs are ground-level welded steel tanks. Although designed prior to current seismic criteria, they may survive an earthquake because of the inherent ductility of steel. The District has begun implementing a project, to be completed over the next few years, of improving the flexibility of the connecting pipes to these two tanks so that they do not break in an earthquake. The project will include the addition of seismic isolation valves to both tanks. Seismic isolation valves are normally open but have automated features to cause an immediate closure of the valves in an earthquake, thereby preventing the contents of the tank from draining through the pipe breaks that will occur in the system. Each tank holds 1.0 million gallons. Since the water levels vary depending on production and use rates, the tanks may provide 1.0 to 2.0 million gallons of emergency water if an earthquake occurred and the seismic isolation valves closed. Both are located at higher elevations, each about one-half mile east of Highway 101. People would have to walk to the tanks to collect water or at least to a point along the lines that connect the tanks to the system where a tap station could be established.

To make the emergency use of the tanks a viable option, the District should install pipe connections with isolation valves on the lines to each tank, to enable supply to emergency tap stands. Additionally, the District should purchase and store, in a readily available location, tap stand kits for emergency water distribution from these stations.

The fourth reservoir is the Salishan Standpipe, a tall welded steel tank located at a high elevation in the Salishan development. CH2M investigated the vulnerability of this tank to seismic events and concluded that its ringwall foundation is insufficient to prevent possible overturning from a major earthquake. The options for preventing overturning were found to be cost-prohibitive. Therefore, it was not deemed beneficial to add flexibility to the pipe connections or add a seismic isolation valve to this tank.

7.6 Distribution Pipes

Recent large earthquakes in Chile, New Zealand, and Japan show that water systems can expect many distribution pipe leaks and breaks. The District's distribution system includes substantial amounts of AC and PVC pipe, both of which are considered vulnerable to failures from earthquakes. The best pipe materials for resilience to earthquakes are HDPE, ductile iron using specialty earthquake resistant joints, and welded steel, followed by ductile iron with standard joints. These materials can be considered for new pipes although the use of HDPE complicates field connections and is therefore, often not appropriate for distribution pipes. Even with earthquake-resistant sections of new pipelines, many areas in the system will fail, with resulting loss of water pressure and loss of water.[7]

7.7 Emergency Preparations

The many vulnerabilities within the District's system suggest that the system will fail in a large earthquake and that full recovery will take years. The District's water supply is separated from the majority of residents by the Siletz River and Millport Slough, which makes the continuance of transmission from the supply to residents unlikely. There are many vulnerabilities associated with the intake, treatment, and pumping facilities that are integral to the water supply system. Furthermore, a major earthquake and the possible resulting tsunami will cause multiple failures in the District's distribution system. Therefore, the District should develop an emergency water supply plan. The goal is to make available 1 to 1.5 gallons of potable water per person per day in the aftermath of an earthquake.

The District's emergency planning should encompass the following actions:

- Have a plan in place for employee procedures and communications. Employees will need to care for their own families following an earthquake and unless the earthquake happens during working hours, will be away from District facilities. A communication plan is needed to coordinate the response in the hours and days following an event.
- The District should consider an incident command system, and should coordinate such planning with other local agencies such as first responders, neighboring systems, the county, the Red Cross, and the state.
- Planning and communication procedures should also be undertaken with the power, phone, and gas companies, to understand their vulnerabilities and their anticipated emergency response plans
- Communicate with customers on topics such as potable water containers, emergency household water treatment, water distribution points, and other resources.
- Obtain needed emergency equipment; ensure operators are adequately trained to use it effectively

7.7.1 Emergency Equipment Recommendations

Certain emergency equipment is essential if the District is to supply potable water following an earthquake. These items need to be stored in a seismically secure building at a location where it appears that the transportation network will allow easy access following an earthquake. The operators should thoroughly train in the use of all equipment items, including full assembly of any item to identify missing fittings, connectors, or tools. After an earthquake, it may be infeasible to travel to Newport or Lincoln City to obtain a necessary tool or part. The following is a preliminary list of recommended equipment for the District:

- Tap stand kits (at least three, one each for the Central and South Tanks, and one for the emergency water treatment unit)
- Emergency water treatment unit, with portable power supply
- Diesel fuel storage tank and fuel for powering the emergency water treatment unit

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[7] *Recent Earthquakes: Implications for U.S. Water Utilities*, Project #4408 for the Water Research Foundation, by Eidinger, John, and Davis, Craig, 2012.

- Rolled potable water hose that can be used for the suction and discharge for the emergency water treatment unit; including an intake screen and weight for the suction line
- One or more portable bladder tanks to be used with the emergency water treatment unit
- Spare batteries for radios
- Unscented liquid chlorine or dry calcium hypochlorite granules (enough to use for chlorinating the reservoirs, emergency water treatment unit, and for distribution to residents for emergency water treatment)
- Potable water containers (not necessarily for all residents but at least some to supplement the ones provided by residents)
- Portable microbiological test kits (kits that can be used in the field, without lab support, to measure *E. coli*, such as those manufactured by Aquagenx)
- Food, inclement weather gear, sleeping bags, and other supplies to enable 24-7 emergency response by the operators and staff

The expensive items on the list are the emergency water treatment unit and the associated diesel fuel storage tank. One manufacturer provides a unit capable of producing up to 7,500 gallons per day of potable water from a fresh water source and up to 3,000 gallons per day from seawater, but the cost for this unit is approximately $60,000.[8] The unit is powered by diesel, so nearby storage of diesel fuel is needed to provide for initial operation of the unit before responders can deliver more fuel. The need to be initially self-reliant for providing fuel is complicated because diesel fuel cannot be stored indefinitely without degradation of the quality of the fuel. Therefore, an appropriate emergency treatment unit needs to be selected, the fuel storage volume needs to be sized according to the use rate specific to the emergency treatment unit, and then appropriate decisions can be made about the quantity of fuel to store. It may be necessary to include a fuel cycling and cleaning system to protect the quality of the fuel. The fuel storage and cleaning components may add $20,000 to $30,000 to the system cost.

In lieu of obtaining an emergency treatment plant, the District could consider promote and/or stockpile household water treatment units that would enable customers to collect and treat their own water. There are currently filtration and disinfection household treatment products available commercially that could be used in emergencies. This probably represents a lower cost option for the District than purchasing a centralized treatment system even if the District was to purchase sufficient household treatment units for all customers. It would represent a shift from putting the responsibility for providing safe drinking water from the District to individuals. If the District proceeds in this manner, it is recommended that the household treatment units either promoted or provided by the District has either NSF certification or be classified as three or two stars according to the World Health Organization Household Water Treatment Scheme.

If an emergency water treatment unit is obtain, it should be stored as close as possible to the intended water source and proposed public distribution point. Additionally, consideration should be given to the storage location's proximity to the airport, since initially, fuel replenishment will need to be airlifted since roads and bridges will be damaged. Most other emergency equipment should be stored near this location. The storage building housing this equipment needs to be designed to withstand a Cascadia Subduction Zone earthquake. If the fuel storage is not immediately adjacent to the location where the

[8] Quote is from 2015 for the SQN unit from ANSA, Inc., with an allowance added for ancillary components. It is a combination water treatment unit (using reverse osmosis for seawater treatment and low pressure membranes for freshwater treatment) and diesel generator unit, weighing 540 pounds, mounted on wheels, and sized to fit in a pickup truck. It requires an external chlorine feed pump, supply and discharge hoses, and bladder tanks to make for a complete unit.

emergency treatment unit will be operated, then plans for delivering the fuel to the unit must be developed.

7.7.2 Emergency Reservoir Use

To make use of the water stored in the Central and South Reservoirs, assuming that the seismic isolation valves perform their intended purpose, it will be necessary to install valved tees to facilitate connecting emergency tap stands, so individual small containers can be filled. A 2-inch tee size is appropriate. At least one such tee should be installed between the seismic isolation valve and the tank, in case there are line breaks in the inlet/outlet line close to (just downstream of) the seismic isolation valve. In addition, it would be useful to install one or more tees close to Highway 101 so that if the pipeline connecting the reservoir remains intact to that location, the emergency distribution point can be closer to the service population. Taps downstream of the seismic isolation valves will require a main-line isolation valve on their downstream side so water is not lost beyond that point to broken pipes in the distribution system.

7.7.3 Emergency Potable Water Containers

The District should promote emergency preparedness among its customers, including asking them to have available a container that can be used for collecting and storing potable water. The District can provide directions on how to disinfect containers to make them suitable for use and for boiling water to make it safe.[9]

7.7.4 Tap Stands

Pre-packaged tap stands are an essential component of an emergency supply system. They consist of connection piping to spring-loaded or one-quarter turn faucets mounted on a stand that can be used by residents to fill water containers. The Red Cross' website provides information on tap stand units, indicating that each one can serve approximately 1,000 people per day in a 12-hour period. Their cost is approximately $1,200 per a 6-faucet set. Immediately following an earthquake, one tap stand set will be needed at each of the Central and South Reservoirs. One will also be needed with the emergency water treatment unit.

[9] Eugene Water & Electric Board provides directions on its website for containers: Use a solution of ¼ teaspoon of unscented liquid bleach in one cup water. Pour into container and stir and shake so that solution touches all surfaces. After one minute or longer, drain container and let air dry. Do not use containers if they were previously used for milk, fruit juice, or chemicals. If water is of unknown microbiological quality or has been stored longer than 5 days, disinfect by bringing to a full boil for one minute.

SECTION 8

Capital Improvements Plan

This chapter summarizes the improvements discussed in the preceding chapters and presents a capital improvements plan for the District. The capital improvements plan will guide the District's investments over the coming years.

The master plan fulfills the requirements of OAR 333-061-0060 Subsection 5, which requires that community water systems maintain an up-to-date master plan. One element of the rules not provided by this plan is a description of alternatives to finance improvements. The intent is the District will review water rates and system development charges based on the findings of this master plan, and determine financing alternatives at that time.

The District has implemented most of the recommended capital projects from its previous master plan, which was issued in year 2000. The major capital investments since then include replacements of finished water transmission pipelines, rehabilitation work for the reservoirs, replacement of the older infiltration gallery, development of the Side Creek alternative water supply system, installation of a remote monitoring, alarm, and control system, and replacement of a number of aging and failing pipelines in the distribution system.

Table 8-1 presents the proposed capital improvements plan for the District with the necessary funding over the 20-year planning period illustrated in Figure 8-1. The project list is weighted toward rehabilitation projects, many of which will contribute to improved seismic resiliency. The proposed dates reflect recommended prioritization of projects based on discussions with District staff and District board representatives.

Although not listed in the capital improvements plan table, the District should develop an emergency water supply strategy to provide residents with potable water following a major earthquake. This will entail developing an emergency action plan for staff, determining communication procedures, promoting awareness and personal preparations by community members, and determining if a portable treatment unit would best serve the needs of the community.

Table 8-1. Capital Improvements Plan

Water System Master Plan

No.	Fiscal Year	Project Description	For Pipelines: Length (feet)	For Pipelines: Diameter (inch)	Reason	Construction Cost	Engineering / Professional Services	Total Project Cost	Comments
1	2016-17	Rate and system development charge study			Rehab & Growth	$0	$10,000	$10,000	Provide basis for updating rates and SDCs; last update was in 2008
2	2016-17	Leak detection survey and repairs			NRW	$10,000	$10,000	$20,000	To address high nonrevenue water rate; $10,000 for leak detection survey and $10,000 allotted for repairs by District staff
3	2017-18	Replace 4-inch pipe on El Mirador and Coronado Drive between El Mundo and El Prado with 8-inch PVC	860	8	Fire	$112,000	$17,000	$129,000	Improves fire flow
4	2017-18	Replace steep hill section of transmission line from plant to North Reservoir with HDPE	950	12	Seismic Resiliency	$226,000	$41,000	$267,000	Section is vulnerable to corrosion, landslides, and seismic events; not feasible to expect District staff to repair because of steep grade
5	2017-18 to 2018-19	Replace North Reservoir with 1 million gallon tank			Rehab & Growth	$1,500,000	$180,000	$1,680,000	Assumes welded steel but material selection & size should be reviewed during design; consider maintaining existing tank to use during repainting of welded tank
6	2018-19	Modify existing raw water pumps to operate as variable speed			Rehab & Growth	$15,000	$0	$15,000	The change would allow operators to reduce overflows to the creek; District to plan and perform work
7	2020-21	Replace section of north to south transmission with 14-inch HDPE from Westwind Street to NW Lancer Street (through Schoolhouse Swamp area)	4,300	14	Seismic Resiliency / Growth	$946,000	$140,000	$1,086,000	Create a resilient backbone for system and increase capacity; approximately 30% growth, 70% resiliency; locate on west side of highway; include new PRV connections to low pressure side; proposed pipe is HDPE DR 9 (ID=11.7")
8	2021-22	Filter resanding; timing depends on frequency of filter cleanings			Rehab	$80,000	$0	$80,000	Routine maintenance; required when sand media depth declines to 18 inches; District will proceed as in past by purchasing sand from same supplier
9	2023-24	Replace section of north to south transmission with 16-inch HDPE from South Immonen Road to Westwind St	8,600	16	Seismic Resiliency / Growth	$2,150,000	$260,000	$2,410,000	Create a resilient backbone for system and increase capacity; approximately 40% growth, 60% resiliency; proposed pipe is HDPE DR 9 (ID=13.3")
10	2025-26	Replace section of north to south transmission with 14-inch HDPE from NW Lancer Street to South Reservoir connection on Highway 101	7,900	14	Seismic Resiliency / Growth	$1,738,000	$210,000	$1,948,000	Create a resilient backbone for system and increase capacity; approximately 30% growth, 70% resiliency; locate on west side of highway; include new PRV connections to low pressure side; proposed pipe is HDPE DR 9 (ID=11.7")
11	2027-28	Replace existing 10-inch PVC connection to Central Reservoir with HDPE line (from Westwind Road to tank)	5,330	12	Seismic Resiliency	$1,013,000	$122,000	$1,135,000	Improve resiliency; proposed pipe is HDPE DR 9 (ID=10.09")
12	2029-30	Replace existing AC connecting pipeline to South Reservoir with HDPE line	3,500	12	Seismic Resiliency	$665,000	$80,000	$745,000	Improve resiliency; proposed pipe is HDPE DR 9 (ID=10.09")
13	2032-33	Replace existing AC pipe serving homes on Salishan Spit with PVC	3,000	8	Rehab	$390,000	$47,000	$437,000	Several individual projects over multiple years
14	2033-34	Replace existing AC pipe serving homes on Salishan Spit with PVC	3,000	8	Rehab	$390,000	$47,000	$437,000	Several individual projects over multiple years
15	2034-35	Slow sand filter plant expansion: add fourth filter			Growth	$540,000	$110,000	$650,000	Recommended trigger for adding fourth filter is when maximum day demand reaches 1.0 mgd
16	2034-35	Replace existing AC pipe serving homes on Salishan Spit with PVC	3,000	8	Rehab	$390,000	$47,000	$437,000	Several individual projects over multiple years
17	2035-36	Replace existing AC pipe serving homes on Salishan Spit with PVC	3,000	8	Rehab	$390,000	$47,000	$437,000	Several individual projects over multiple years

Notes: 1. Reasons: Growth = Needed to accommodate customer growth within system

Seismic Resiliency = Needed to improve system's seismic resiliency (rehabilitation projects with additional seismic driver)

NRW = Needed to help track and decrease nonrevenue water

Rehab = Needed to rehabilitate existing infrastructure

Fire = Needed to improve fire flow at existing hydrants within system

2. Cost estimates are planning level, only. They should be reexamined at the time of project implementation to ensure that budgets are adequate. Additionally, costs should be escalated to the time of implementation. Costs shown are for the October 2016 Engineering News Record Seattle region Construction Cost Index = 10,596

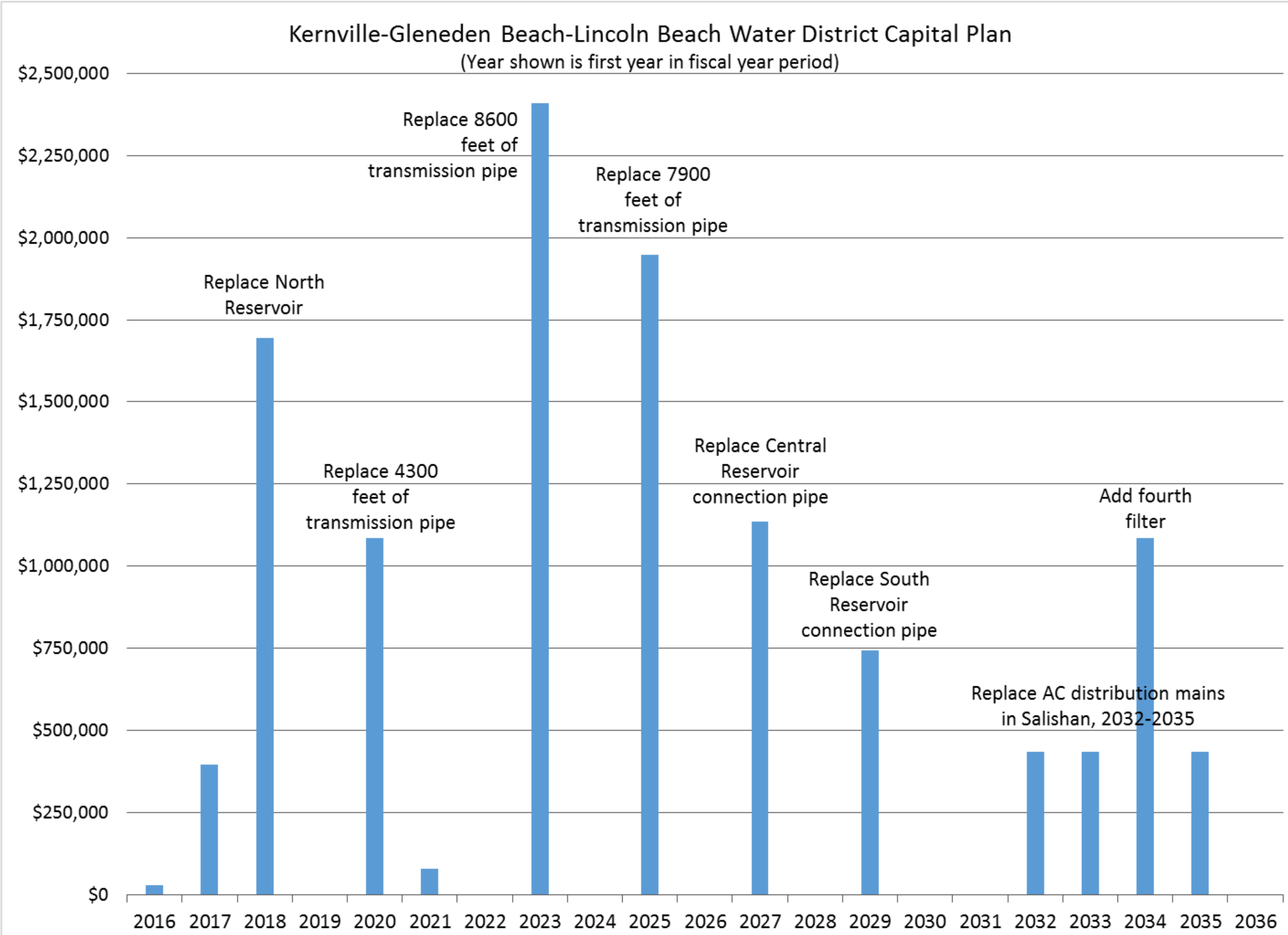


Figure 8-1. Capital Improvements Plan Funding Needs

Appendix A
Slow Sand Filter Operations

Slow Sand Filter Operations

This appendix to the master plan provides information relating to the operations of the District's slow sand filter plant. In addition to this information, the District should become familiar with the slow sand filter optimization guide that has been developed by the Oregon Drinking Water Services program and is available on their website.

Slow sand filtration is a physical-biological process. Some particles and microorganisms are removed through physical straining as the water passes through the sand media. However, slow sand filters are most effective in removing pathogens when they have mature biological activity. The biological activity, which is concentrated on the surface in what is called the schmutzdecke, results in a competitive environmental that kills most pathogens.

Therefore, one of the overall goals is to maintain the water surface above the sand in all filters at all times; otherwise, the desired biological activity will not be sustained. Another goal is to operate the filters at a constant rate with infrequent and minor changes in the flow rate. Sudden and large changes in the flow rate may cause contaminants to 'break through' the filters.

The minimum recommended sand media depth is 18 inches. A depth less than this may not provide the same effectiveness in treatment.

When a filter is removed from service for cleaning (also called scraping), the water level in the filters should be lowered to about 4-12 inches below the top of the sand surface. It should be lowered just enough to allow the sand surface to be firm for walking on the filter. However, the water level should not be lowered too much because it is desirable to keep as much of the media wet as possible to avoid disrupting the biological activity.

The filter cleaning (scraping) should be conducted as quickly as possible to minimize the time at which the top of the sand is above the water level.

When returning a filter to service after cleaning (or after resanding), it should be filled with water from the bottom up to avoid air binding. Air binding refers to trapping air bubbles in the sand media. Air bubbles partially block the downward flow of water and result in high filter rates in areas of the filters without air bubbles.

Once the water level is above the top of the sand, the filter influent valve should be opened. However, the filter effluent valve should remain closed and the drain valve (filter-to-waste) valve should be opened to waste the initial production. The filter should be operated in a filter-to-waste mode for one hour for every hour that the filter was off-line but no less than 24 hours.

Each filter has an adjustable weir plate between the two halves of the filter control box at the end of each filter. While adjustable, the weir plate is bolted in place and therefore, it is not meant to be regularly adjusted. The weir opening should normally be set at an intermediate level, which would make the elevation of the bottom of the opening at 62.5 feet. This prevents the water surface from accidently being lowered too far, thus drying out too much of the sand media.

Schematic Drawings

See the schematic drawings included in this appendix, which illustrate the valve settings and flow paths for each of the following condition:

1. Normal Operation: filter on-line and producing water

2. Draining Filter: in preparation for cleaning (lowering the water surface to slightly below the top of sand)
3. Cleaning (Scraping) Filter: filter completely off-line during cleaning
4. Filling Filter: filling from the bottom up after cleaning or resanding
5. Filter to Waste: wasting the initial production of a filter following cleaning or resanding

Normal Operation

1. Raw water pump (one operating at a time) provides constant flow rate to online filters
2. An overflow in each filter is set at elevation 66.5 feet—if the filter influent pumping rate exceeds the combined filter effluent rate for all on-line filters, (which is set by the filter effluent valve), then raw water from above the filters overflows back to Drift Creek. (Each filter has a flow control valve that sets the effluent rate.)
3. Water is collected in pipe manifolds beneath the sand, and flows through a flow control valve into the first chamber of the effluent box.
4. The flow control valve should be adjusted to a) maintain an equal distribution of flow to each of the filters, and b) to obtain a combined filter effluent flow rate that is close to matching system demands (thus allowing the filters to operate 24/7 at a constant rate). As each filter becomes more and more plugged through a filter run, the valve will need to be progressively opened. The plugging of a filter will be evidenced by rising of the water surface above the sand media and compared to the other operating filters.
5. Water passes to the second (downstream) chamber of the effluent box through a 1’-3” by 6” opening in a weir plate. As noted earlier, this weir plate can be adjusted for major changes in the system but normally, it is intended that it be left in one place, with the bottom of the opening set at 62.5 feet.
6. From the second chamber of the effluent box, the water flows through an 8” filter effluent floor valve to a common 12” filter effluent header.

Taking a Filter Off-line for Cleaning

1. Close 6” Filter Influent Valve.
2. Close Filter Effluent Valve in second (downstream) filter effluent box.
3. Open Drain Valve in upstream filter effluent box.
4. Drain filter to a water level approximately 4-12 inches foot below the level of the sand. (Drain the minimum possible, keeping the water surface as close to the top of the sand as necessary to allow for scraping the filter.)
5. Close filter Drain Valve.
6. Quickly scrape filter to minimize the time when the top portion of the sand media is dry.

Returning a Filter to Service after Cleaning

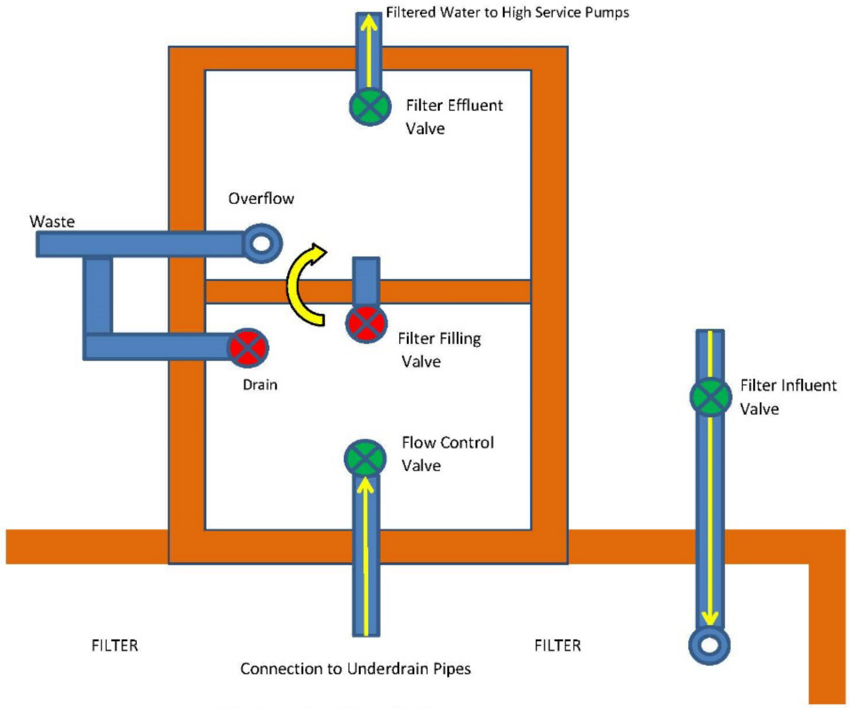
1. Filter Influent Valve will already be closed, because filter is off-line.
2. Close main filter effluent valve at high service pump station.
3. Open 4” Filter Filling Valve in partition (between first and second chambers) of control box.

4. Water from online filters will flow in reverse direction through Filter Effluent Valve and Filter Filling Valve, and will fill the recently cleaned filter through the underdrain pipes from the bottom up.
5. When water level is above the top of the sand, close the 4” Filter Filling Valve. Open the main filter effluent valve at the high service pump station.
6. Open the Drain (filter-to-waste) Valve the first chamber of the control box.
7. Open Filter Influent Valve and operate the filter in a filter-to-waste mode one hour for each hour that it was off-line or at least 24 hours.
8. Open the Filter Effluent Valve and close the Drain Valve.
9. Filter begins to operate normally and deliver water to the high service pump station.

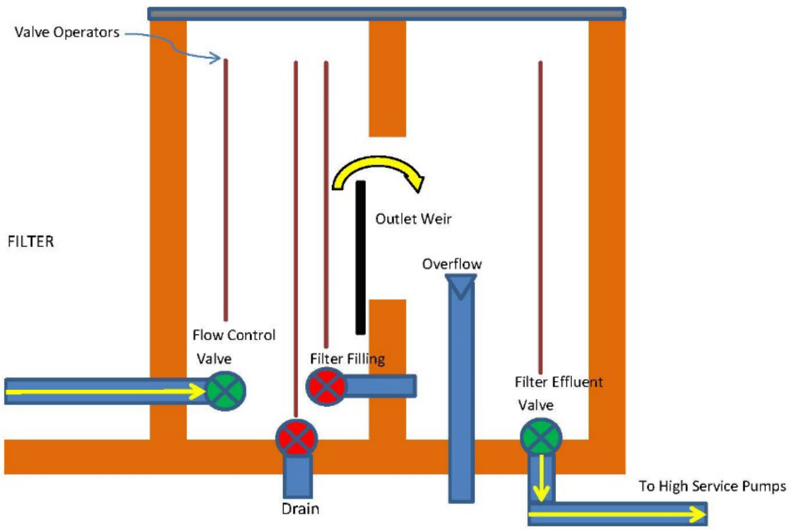
Schematic Drawings

Normal Operation: Filter is on-line and producing water

Green Valves = Open **Red Valves = Closed**



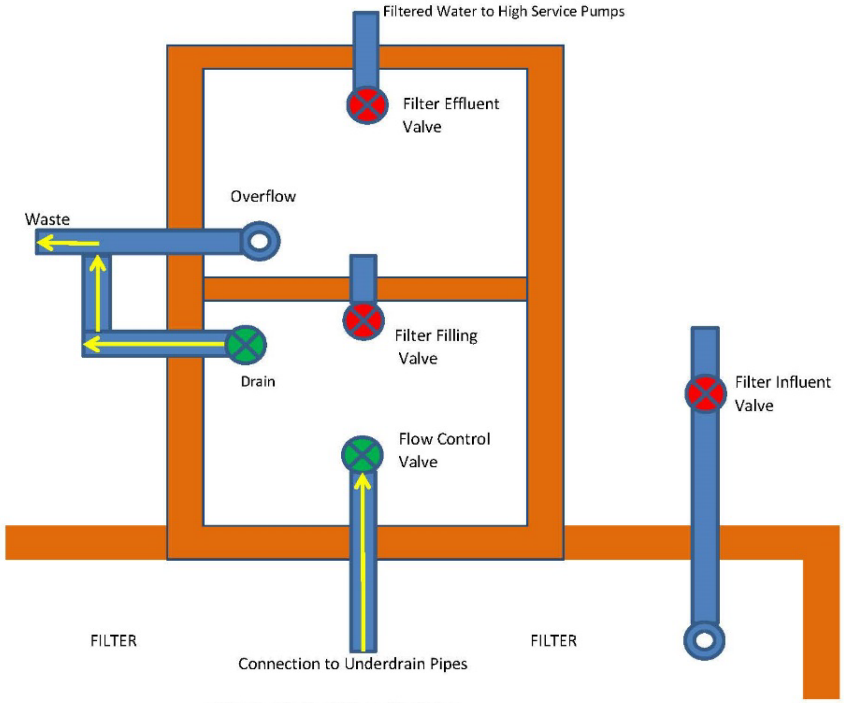
FILTER CONTROL BOX PLAN



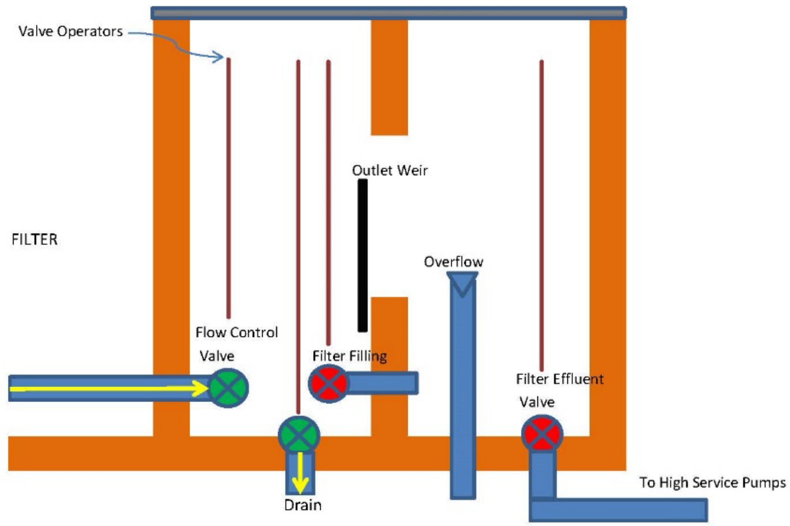
FILTER CONTROL BOX SECTION

Filter Cleaning: Draining Filter to Lower Water Level in Preparation for Scraping

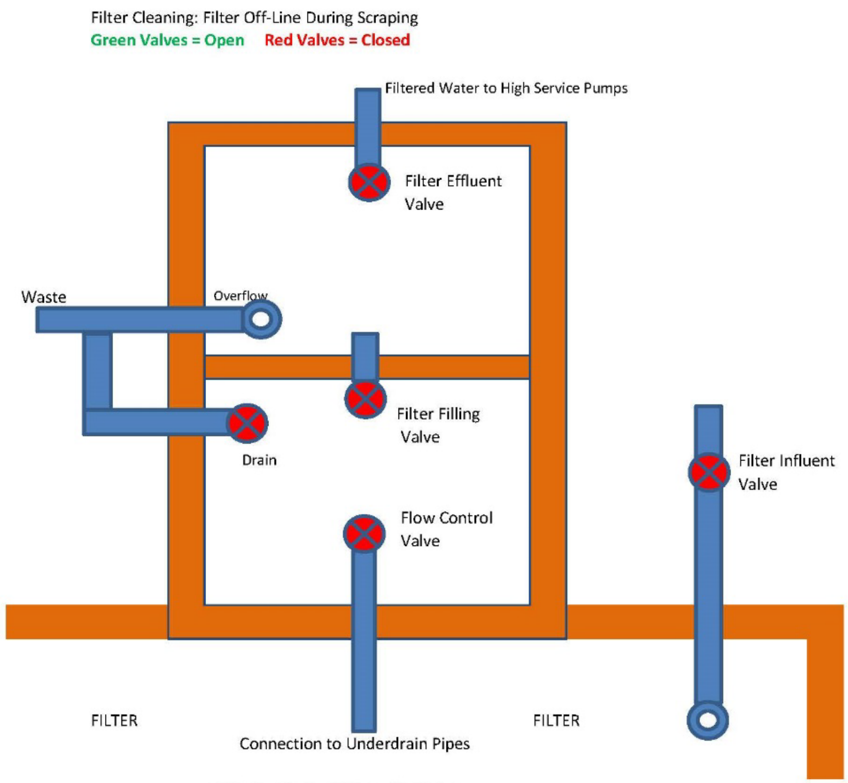
Green Valves = Open **Red Valves = Closed**



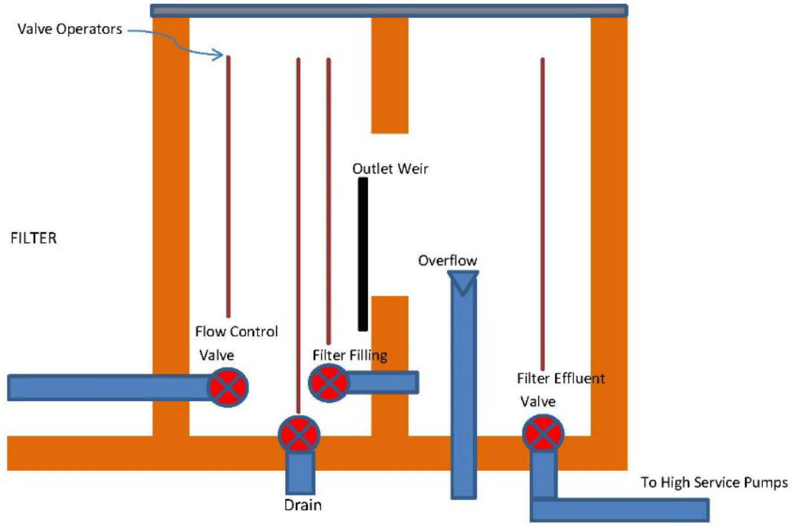
FILTER CONTROL BOX PLAN



FILTER CONTROL BOX SECTION



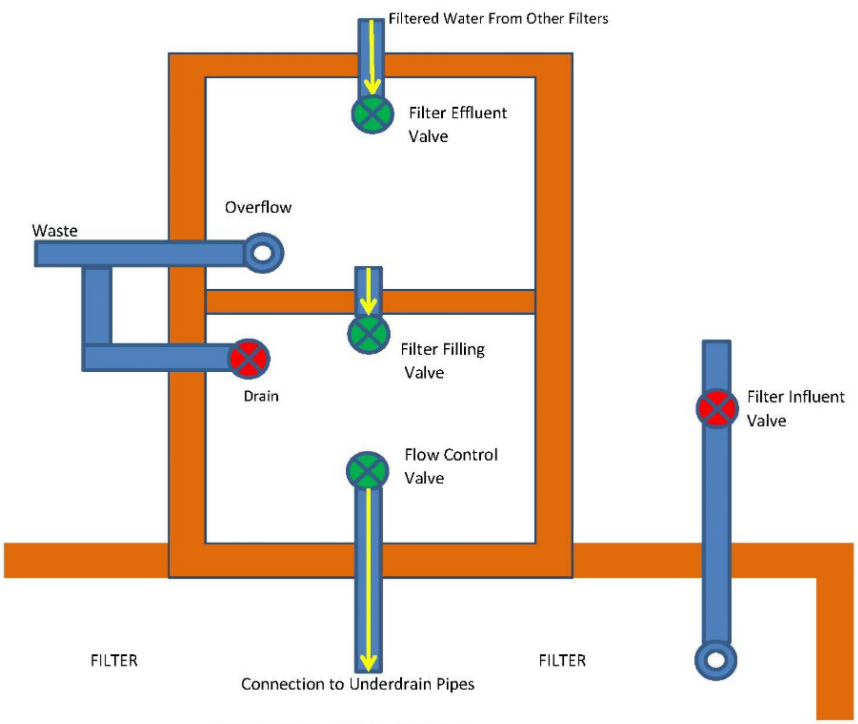
FILTER CONTROL BOX PLAN



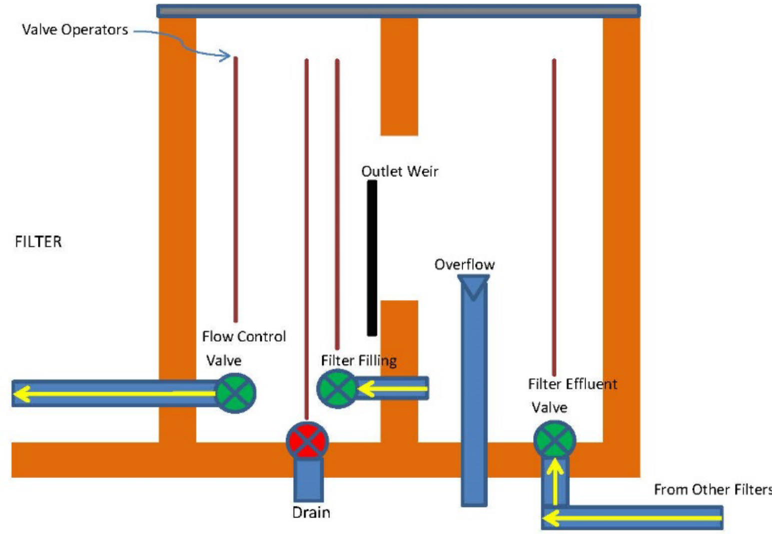
FILTER CONTROL BOX SECTION

Filling Filter After Cleaning (fill from the bottom up with filter effluent from on-line filters, to avoid air binding)

Green Valves = Open **Red Valves = Closed**

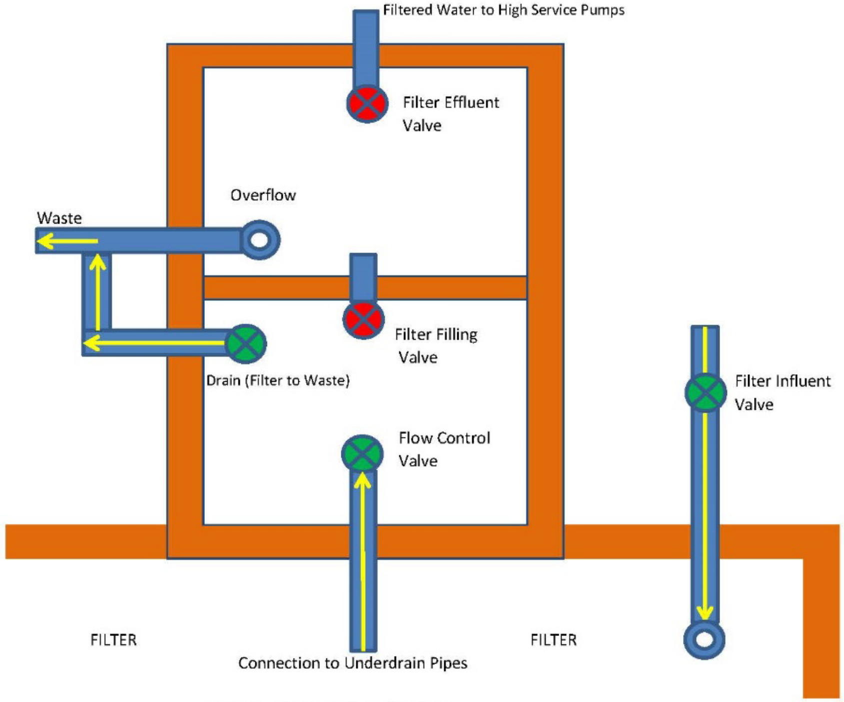


FILTER CONTROL BOX PLAN

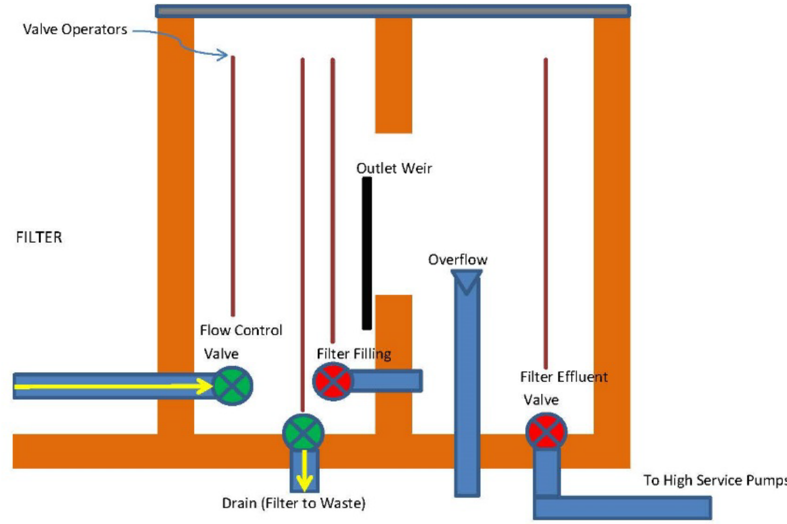


FILTER CONTROL BOX SECTION

Filter to Waste After Cleaning or Resanding (to bring filter back to maturity before using filtered water)
Green Valves = Open **Red Valves = Closed**



FILTER CONTROL BOX PLAN



FILTER CONTROL BOX SECTION