Astoria Water System Master Plan

Astoria, Oregon

April 23, 2021

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Certification

This 2021 Water Master Plan for the City of Astoria was prepared by HDR Engineering, Inc., and City of Astoria staff, under the direction of the following Registered Professional Engineer:

REGISTERED PROFESSIONAL ENGINEER
18934PE
OREGON
February 3, 1997
LISA YONEYO TAMURA

Expires: 6/30/2022

Lisa Tamura, PE
HDR Engineering, Inc.

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Acronyms and Abbreviations

AACE	Association for the Advancement of Cost Engineering
ADD	Average Day Demand
AWWA	American Water Works Association
CCHSR	Clatsop County Housing Strategies Report
CCT	corrosion control treatment
cfs	cubic feet per second
CIP	Capital Improvement Plan
City	City of Astoria
CPF	Coordinated Population Forecast
CSZ	Cascadia Subduction Zone
DBP	Disinfection Byproduct
DOGAMI	Oregon Department of Geology and Mineral Industries
DRC	direct responsible charge
EPA	U.S. Environmental Protection Agency
GIS	geographic information system
gpm	gallons per minute
HDPE	high density polyethylene
HGL	hydraulic grade line
LOS	level of service
LSL	lead service line
LSLR	lead service line replacement
M	magnitude
MDD	Maximum Day Demand
MG	million gallons
MGD	million gallons per day
mg/L	milligrams per Liter
NTU	nephelometric turbidity unit
O&M	operations and maintenance
OAR	Oregon Administrative Rule
ODFW	Oregon Department of Fish and Wildlife
OHA	Oregon Health Authority
OWRD	Oregon Water Resources Department
PFAS	per- and poly-fluoroalkyl substances
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PGD	permanent ground deformation
PHD	Peak Hour Demand
Plan	Water System Master Plan
Port	Port of Astoria
PRV	pressure reducing valve
psi	pounds per square inch
PVC	polyvinyl chloride

RCM	reliability centered maintenance
SCADA	Supervisory Control and Data Acquisition
SDC	system development charges
SOC	Soluble Organic Chemical
UCMR	Unregulated Contaminant Monitoring Rule
UDF	Unidirectional Flushing
UGB	urban growth boundary
URA	Urban Renewal Agency
URD	Urban Renewal District
USGS	United State Geological Survey
WMCP	Water Management and Conservation Plan
WQP	water quality parameters
WTP	water treatment plant

Executive Summary

The City of Astoria (City), a port city located in the northwestern corner of Clatsop County, Oregon, provides water service to residents and businesses located in and around Astoria, Oregon. This Water System Master Plan (Plan) describes the City's water production and distribution facilities, operations, and compliance with state and federal drinking water regulations. The Plan also identifies capital improvements needed to resolve system deficiencies, support continued system maintenance, and to supply future growth within the water service area. This Plan was developed in accordance with Oregon Health Authority (OHA), Drinking Water Services requirements outlined in Oregon Administrative Rule (OAR) 333-061-0060 (5).

Water Source and System Description

The City's water system reliably provides potable water to the City's approximately 10,000 residents, commercial and industrial users, and approximately 3,000 additional people in seven outlying water districts. Large-scale water users include breweries and the fishing industry. Though it has declined from its peak due to canneries closing, water usage for seafood processing remains important.

The City's water is supplied from Bear and Cedar Creeks, and the three reservoirs they feed, Wickiup Lake, Middle Lake, and Main Lake (Bear Creek Reservoir). Surface water from Bear and Cedar Creeks is treated at a slow sand filtration plant located near Bear Creek Reservoir, where treatment consists of filtration followed by chlorination.

Water is conveyed from the filtration plant to the distribution system via approximately 12 miles of 21-inch-diameter transmission main. Four reservoir locations provide storage capacity to meet routine system operational needs and support fire suppression requirements. Approximately 80 miles of piping delivers water throughout the City's distribution system. On average, the City's water system produces and distributes more than 2.0 million gallons (MG) of water to the community per day. More than 4.0 MG may be produced per day during the peak summer season.

Water Quality

As the primacy agency, OHA oversees Oregon's drinking water standards (*OAR, OHA, Public Health Division, Chapter 333, Division 61, Drinking Water*), and largely follows the specifications and regulations outlined by the U.S. Environmental Protection Agency (EPA). OHA makes a point of keeping the stringency of regulations on par with what has been approved by the EPA, and therefore is largely similar to the federal regulations. Regular monitoring is conducted by Astoria Public Works employees to ensure that regulatory standards are met.

Emerging federal requirements considered in this Plan include:

- Lead and Copper Rule Long-Term Revisions.
- Per- and Poly-Fluoroalkyl Substances (PFAS) Regulations.

The City continually strives to maintain compliance as state and federal requirements are updated and has been in compliance for the past five years.

Demand Forecast

The water demand forecast presented in this Plan was used to evaluate the ability of the City's existing water rights, source and storage capacities, and distribution system to support current and future water usage (Table ES 1). The City's population has remained steady for most of its history; residential growth and the associated increase in water usage is expected to be minimal. However, some commercial and industrial growth is anticipated. Note that the Demand Scenarios 2, 3, and 4 reported in this section reflect the Port operating at an estimated demand of 1.87 MGD and unaccounted for water of approximately 25 percent of total production.

Table ES 1. Water Demand Forecast 2020 through 2070

Demand Scenario	Planning Year	ADD (MGD)	MDD (MGD)	PHD (MGD)
1	Existing (2020) – Port Non-Operational/Low Season	1.62	2.72	3.76
2	Existing (2020) – Port Operational/Peak Season	4.01	5.14	6.11
3	2040 – Port Operational/Peak Season	4.39	5.79	6.99
4	2070 – Port Operational/Peak Season	4.39	5.79	6.99

ADD=average day demand
MDD=maximum day demand
PHD=peak hour demand

Seismic Resilience

OHA requires water systems fully or partially located in areas having the potential to experience moderate to heavy damage due to a major earthquake to develop a seismic risk assessment and mitigation plan. The City of Astoria is located in this designated area, and therefore has prepared the required risk assessment and mitigation plan. The City identified a backbone of transmission and distribution piping to restore water service to critical facilities as quickly as possible after a major seismic event. The City also evaluated four critical water system structures as part of this project - Reservoir 2 Gate House, Reservoir 3 Gate House, East Astoria Tanks, and Skyline Tank. The City will revisit resilience concepts and the findings of the structural evaluation during the risk and resilience assessment required by America's Water Infrastructure Act, which is scheduled for completion in 2021.

System Operations and Maintenance

City staff assigned to operate and maintain the water system receive training and certifications that meet or exceed Oregon state requirements. A variety of plans and procedures are employed to address both routine and non-routine operating conditions, including emergency response procedures.

The City has a spreadsheet-based maintenance management program in place to address routine and recurring preventive and corrective maintenance. City staff feels the program is effective for the tasks being managed.

However, City staff also expressed concern that they do not have adequate resources to maintain all utility assets, notably the water distribution system valves and hydrants. City staff is justifiably concerned that distribution system valves because they have not been exercised regularly, may already be broken or will break or leak when they are operated. For this reason, implementation of a valve exercising program may require a phased approach where the first phase includes repair and replacement of valves and valve boxes in a multi-year program until all system valves are known to be operable. After this first phase, maintenance would include regular valve exercising.

Source, Storage, and Distribution Capacity Analyses

The water distribution system is comprised of two primary pressure zones, the High Zone and the Low Zone. Within these zones are sub-zones, including Skyline and Emerald Heights. Each pressure zone should have water storage facilities to provide operating storage, fire storage, and emergency storage. The total storage required is the sum of these three elements. The City's present system includes four storage facilities (Table ES 2).

Table ES 2. Astoria Storage Facilities

Facility	Volume (MG)	Primary Pressure Zone Served
Reservoir No. 3	20.0	High Zone [a]
Reservoir No. 2	5.5	Low Zone
Skyline Tank	0.13	Skyline Zone
East Astoria Tanks	0.30	Emerald Heights

[a] Reservoir No. 3 serves the Low Pressure Zone through pressure reducing valves (PRVs)

Based on accepted water industry practice and guidelines, no additional storage need is projected for the High Zone, the Low Zone, or Emerald Heights. Hydrants in the Skyline Zone are not connected to the pumped network but are rather fed by Reservoir No. 3. If hydrants are connected to the Skyline system as recommended, there is a projected storage deficiency for the Skyline Zone of approximately 0.03 MG.

Transmission and distribution system capacity analyses were conducted using the calibrated hydraulic model of the City's water system developed for this master plan. The model was used to evaluate the ability of system piping to provide sufficient pressures and fire flows under current and future water demand conditions. Specific areas were identified for improvement, either through replacement with larger piping or increased connectivity with other water mains to enhance fire flows and improve service pressures.

Capital Improvement Plan and Finance

The proposed capital improvement plan (CIP) was developed based on information presented in this study and additional City-provided projects based on known operational needs. Improvements were prioritized into four categories (high, medium, low, and aspirational) based on need and feasibility.

The 20-year (2021-2040) CIP includes approximately $79.6 million in improvements of which high priority improvements account for approximately $15.7 million (Table ES 3).

Table ES 3. High Priority Recommended CIP Improvements

Project	Description of Recommended Improvement	Estimated Capital Cost (2020$)
1	Install 10,350 LF 12" main to complete waterfront looped backbone	$4,310,000
2	Install 900 LF 12" main from Portway St/Industry St to Hamburg St/Industry St	$370,000
3	Install 2,500 LF 12" main from the Port to W Marine View/Denver St	$1,040,000
4	Install 1,100 LF 14", 1,400 LF 18" transmission main from Reservoir 2 to Low Pressure Zone	$1,280,000
5	Install 2,600 LF 8" main from 8th St/Irving Ave to 1st St/W Grand Ave	$850,000
6	Project to improve fire flow at Skyline	$580,000
7	Install fire pump at East Astoria Tanks	$350,000
8	a. Upgrade existing main from 35th St/Irving Ave to 36th St/Grand Ave (1,200 LF) b. Install new main from East Astoria pipeline (Emerald Heights) to 43rd St/Franklin Ave (2,500 LF)	$1,430,000
9	Install 1,100 LF 12" main from 16th St/Jerome Ave to 18th St/Irving Ave	$460,000
10	Replace existing water meters with AMR system	$1,500,000
11	Install 430 LF 8" main to 2nd St/Franklin Ave, 2,500 LF 12" main from 1st St/Kensington Ave to 6th St/Grand Ave, 1,200 LF 12" main from 6th St/Grand Ave to 3rd St/Franklin Ave	$1,680,000
12	Install 2,800 LF 12" main from 20th St/Irving Ave to 28th St/Irving Ave	$1,170,000
13	Install 600,000-gallon clearwell tank at WTP	$700,000
	TOTAL	**$15,720,000**

Projected financials were prepared to determine whether current revenues are sufficient to fund future projected expenditures (operating and capital). Including high, medium, and low priority projects, projected financials show expenditures and capital costs exceeding revenue beginning in 2022 indicating rates need to be increased by 27.7 percent in 2022 with annual adjustments growing to 49.5 percent by the end of the analysis period to fully fund the utility. In other words, after a one-time increase of 27.7 percent, annual increases of 2 to 3 percent would be required thereafter. Including aspirational projects, projected financials indicate rates would need to be increased over 100 percent in 2022 with additional annual increases of about 4 to 5 percent.

It is recognized that this CIP far exceeds the funding currently available to the City. Historical rate increases have on average only kept up with inflation (2 to 3 percent) and have not provided for capital projects. It is recommended the City develop a funding strategy to begin implementing the CIP. Projects can be funded through a combination of water utility rates, capital facilities charges such as system development charges (SDCs), loans and reserves, and sources such as grants.

Stakeholder Engagement

Key stakeholders include local, county, and state authorities as well as local commercial and industrial customers potentially impacted by the master plan. Stakeholders invited to review and comment on the plan include:

- Astoria Fire Department
- Astoria School District
- Clatsop County
- Oregon Infrastructure Finance Authority
- Clatsop Community College
- Columbia Memorial Hospital
- Port of Astoria
- Large Fish and Seafood Processors (only consulted on demand projection)
- Large Breweries (only consulted on demand projection)

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Chapter 1. Existing Water System Description

The City of Astoria (City) is a port city located in the northwestern corner of Clatsop County, Oregon on the south shore of the Columbia River, the oldest American settlement west of the Rockies, and the second oldest city in Oregon. The City's population has remained steady for most of its history. The City's water system reliably provides potable water to the City's approximately 10,000 residents, commercial and industrial users, and approximately 3,000 additional people in seven outlying water districts. Large-scale water users include breweries and the fishing industry. Though it has declined from its peak due to canneries closing, water usage for seafood processing remains important.

On average, the City's water system produces and distributes more than 2.0 million gallons (MG) of water to the community per day. More than 4.0 MG may be produced per day during the peak summer season.

1.1 Water Supply

The City's water is supplied from Bear and Cedar Creeks, and the three reservoirs they feed, Wickiup Lake, Middle Lake, and Main Lake (Bear Creek Reservoir). The City also diverts water at Spur 14, between Wickiup Lake and Middle Lake. The creeks and reservoirs are located 10 miles east of the City and about 5 miles south of Svenson, an area entirely owned by the City.

Wickiup Lake, built in 1939, is formed by a 30-foot-high earth embankment dam with 110-MG capacity that is rarely full. Normally, leakage through the bottom exceeds inflow, rendering this reservoir of no storage value for the later summer or fall period.

Middle Lake, also built in 1939, is a 52-MG off-channel reservoir filled by Spur 14, which is a spring fed from Wickiup Lake and a small tributary to Bear Creek. A 38-foot-high earth embankment forms a dam and its spillway discharges into Bear Creek to the west.

Bear Creek Reservoir serves as the City's primary raw water storage reservoir. It is a 200-MG reservoir controlled by Bear Creek Dam; a concrete dam set in a narrow canyon. The dam was first constructed to a height of 75-feet between 1912 and 1923, then raised in 1954 to its present height of 90 feet. A 2016 seismic stability evaluation of the dam conducted by Cornforth Consultants concluded the dam would perform acceptably during the design Cascadia Subduction Zone earthquake considered in the study due to abutments provided.

1.2 Water Treatment

Surface water from Bear and Cedar Creeks is treated at a slow sand filtration plant located near Bear Creek Reservoir, where treatment consists of filtration followed by chlorination and fluoridation. The plant was originally constructed in 1993 with three filter cells and a small outlet flow control structure.

Each of the three filter cells can produce approximately 1,100 gallons per minute (gpm). With the later addition of a fourth larger filter cell (1,900 gpm), the plant is currently rated to treat up to 6.0 million gallons per day (MGD). Filters 1, 2, and 3 were recently rehabilitated with new liners and all filters received new filter sand media. The filters are regularly cleaned (approximately every 4 to 8 weeks) and re-sanded every five to six years.

Chlorination and fluoridation occur a short distance downstream of the slow sand filtration plant outlet structure. The required chlorine contact time is achieved in the transmission pipeline prior to any turnouts or wholesale customers.

1.3 Transmission System

Water is conveyed from the filtration plant through approximately 12 miles of 21-inch-diameter pipe to Reservoir No. 3, the entry point to the City's distribution system. The existing transmission main was constructed between 1963 and 1964 of reinforced concrete without restrained joints. The capacity of the transmission main is approximately 6.9 MGD.

The existing transmission main route is subject to landsliding, particularly in the event of a large earthquake. A 2019 geotechnical resilience study of the transmission main was conducted by Hart Crowser, Inc. to evaluate the vulnerability of the existing route and identify possible new, more resilient routes.

1.3.1 Tongue Point and Emerald Heights

Upstream of Reservoir No. 3, a 14-inch high density polyethylene (HDPE) transmission main connects to the primary transmission main and conveys flow to the East Astoria Tanks. The Tongue Point and Emerald Heights areas are served from these tanks.

1.3.2 Outlying Water Districts

By legal agreement, the City supplies water to seven outlying water districts, five of which are upstream of Reservoir No. 3. These five districts are residential communities located outside of City limits: Burnside, Fernhill, John Day, Olney Walluski, and Willowdale (including Riverpoint). In recent years, the combined water use of the seven districts accounted for approximately 10 percent of the City's total metered water usage.

1.4 Distribution System

Major components of the City's water distribution system include:

- Reservoir No. 3, a 20-MG covered finished water reservoir.
- Reservoir No. 2, a 5.5-MG covered finished water reservoir.
- East Astoria Tanks, two 0.15-MG (0.3-MG total) ground storage tanks.
- Re-chlorination facilities at Reservoirs 3 and 2.
- Approximately 80 miles of distribution mains, ranging in size from 1.5 to 18 inches in diameter.
- Skyline system, an upper service zone with a small ground storage tank (131,000 gallons) and three pumps, that serves an area too high for adequate pressures from Reservoir No. 3.

Apart from Tongue Point, Emerald Heights, and outlying water districts, water distributed from the transmission main passes through Reservoir No. 3. Its elevation is sufficient to provide gravity service to the mid-level elevations within the City.

Water from Reservoir No. 3 also flows into Reservoir No. 2. Reservoir No. 2 is lower than Reservoir No. 3 and serves the lower elevations of the City.

The Skyline system serves the highest elevation zone. From the Skyline Tank, a 131,000-gallon ground storage tank, water is pumped into the Skyline system to provide adequate pressures in that zone for homes. Hydrants in the vicinity are fed by gravity from the Skyline Tank combined with Reservoir No. 3.

The East Astoria Tanks serve the Emerald Heights Zone, a small area on the eastern edge of the City that is geographically isolated relative to the rest of the water system. The East Astoria Tanks can also serve Tongue Point through PRVs.

The general location and layout of the water system is illustrated in Figure 1-1. The water system is schematically illustrated in Figure 1-2. The City monitors remote facilities and controls booster pumping equipment of its water system using a supervisory control and data acquisition (SCADA) system.

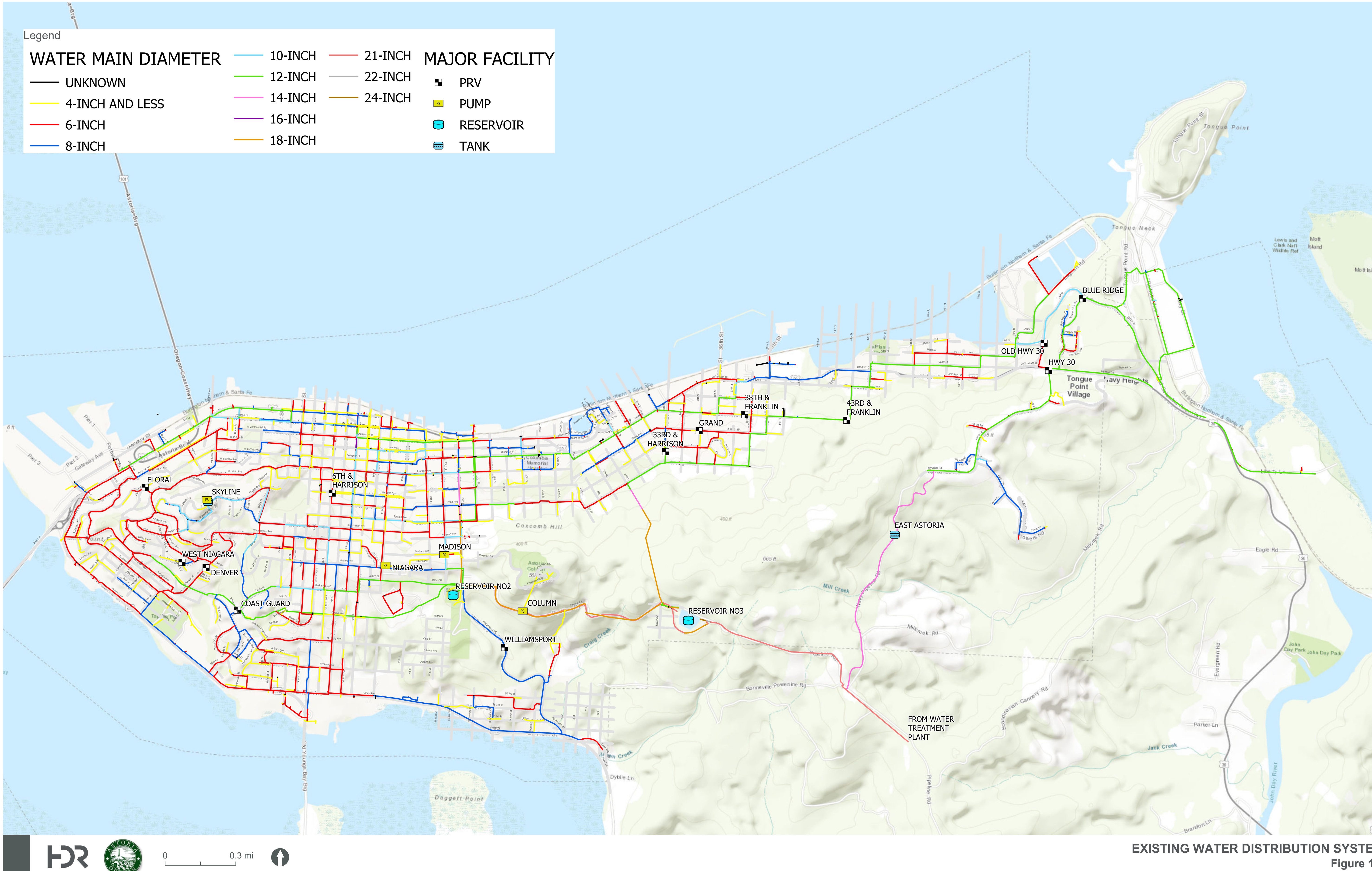
1.4.1 Pressure Zones

The City water distribution system consists of 11 pressure zones that provide water service to a range of elevations throughout the City (Figure 1-3). Of the 11, five main pressure zones serve most of the customers. The remaining six minor pressure zones serve small geographical areas due to localized low or high elevations. Table 1-1 summarizes the existing range of elevations served within each pressure zone.

Table 1-1. Summary of Pressure Zones

Pressure Zone	HGL (feet USGS)	Elevations (feet USGS)	Pressures[1] (psi)
Major			
Low	281	0 - 268	< 20 - 122
High	426	112 - 438	< 20 - 136
Skyline	472	272 - 398	32 - 86
Emerald Heights	426	162 - 392	< 20 - 114
Blue Ridge	351	88 - 194	68 - 114
Minor			
West Niagara	326	162 - 174	66 - 71
Column	587	276 - 596	< 20 - 135
Floral	303	128 - 188	50 - 76
Madison	514	314 - 366	64 - 87
Niagara	466	300 - 302	71 - 72
Harrison	332	164 - 194	60 - 73

Notes: HGL = hydraulic grade line; psi = pounds per square inch; USGS = U.S. Geological Survey
[1] Pressures will vary depending on system conditions (demands, facilities operating, etc.). Pressures presented above are assuming reservoirs/elevated tanks are full and typical discharge pressure from booster stations or pressure reducing valves (PRVs).
Elevations shown exclude transmission mains which may have higher elevations closer to the reservoirs.



EXISTING WATER DISTRIBUTION SYSTEM

Figure 1-1

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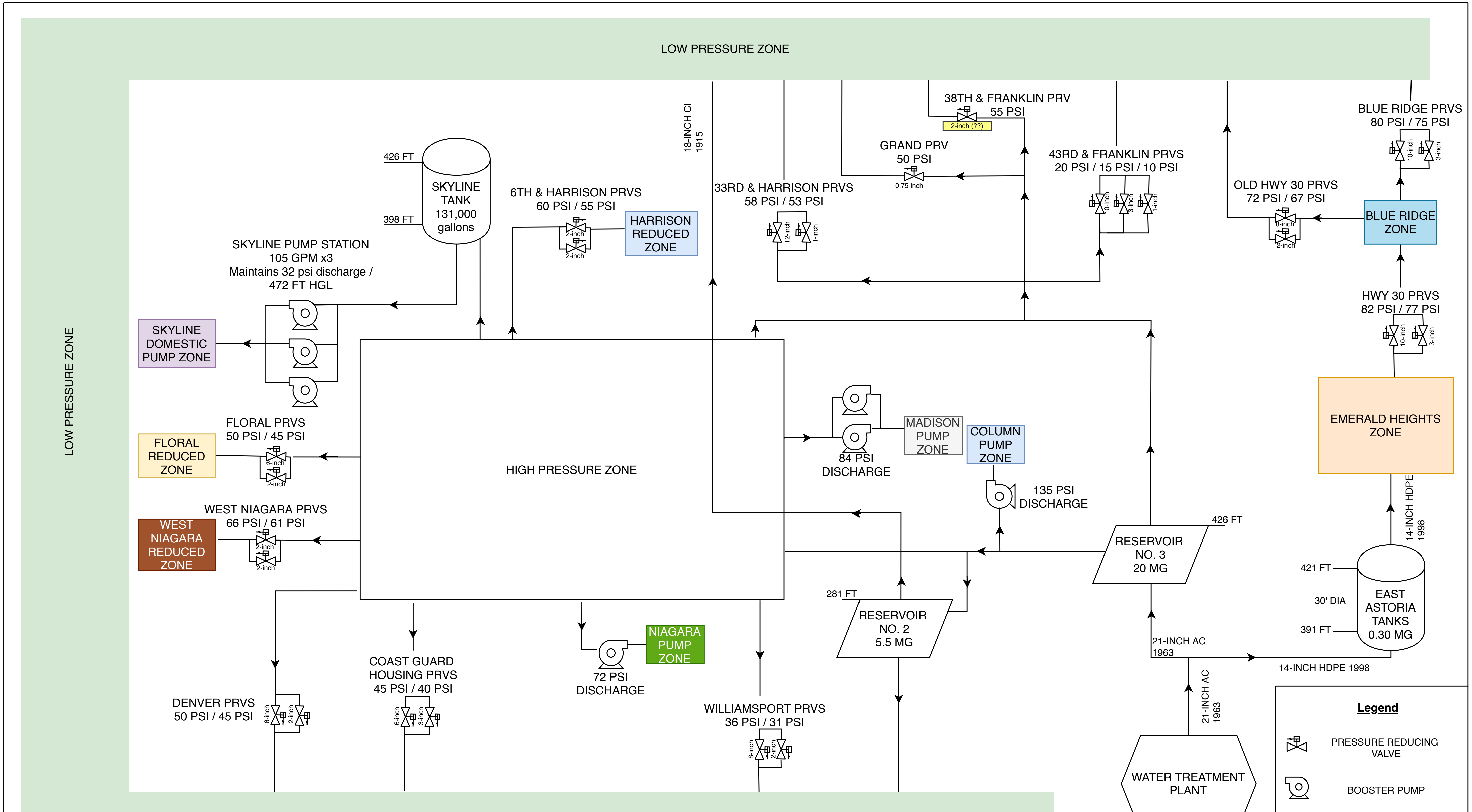
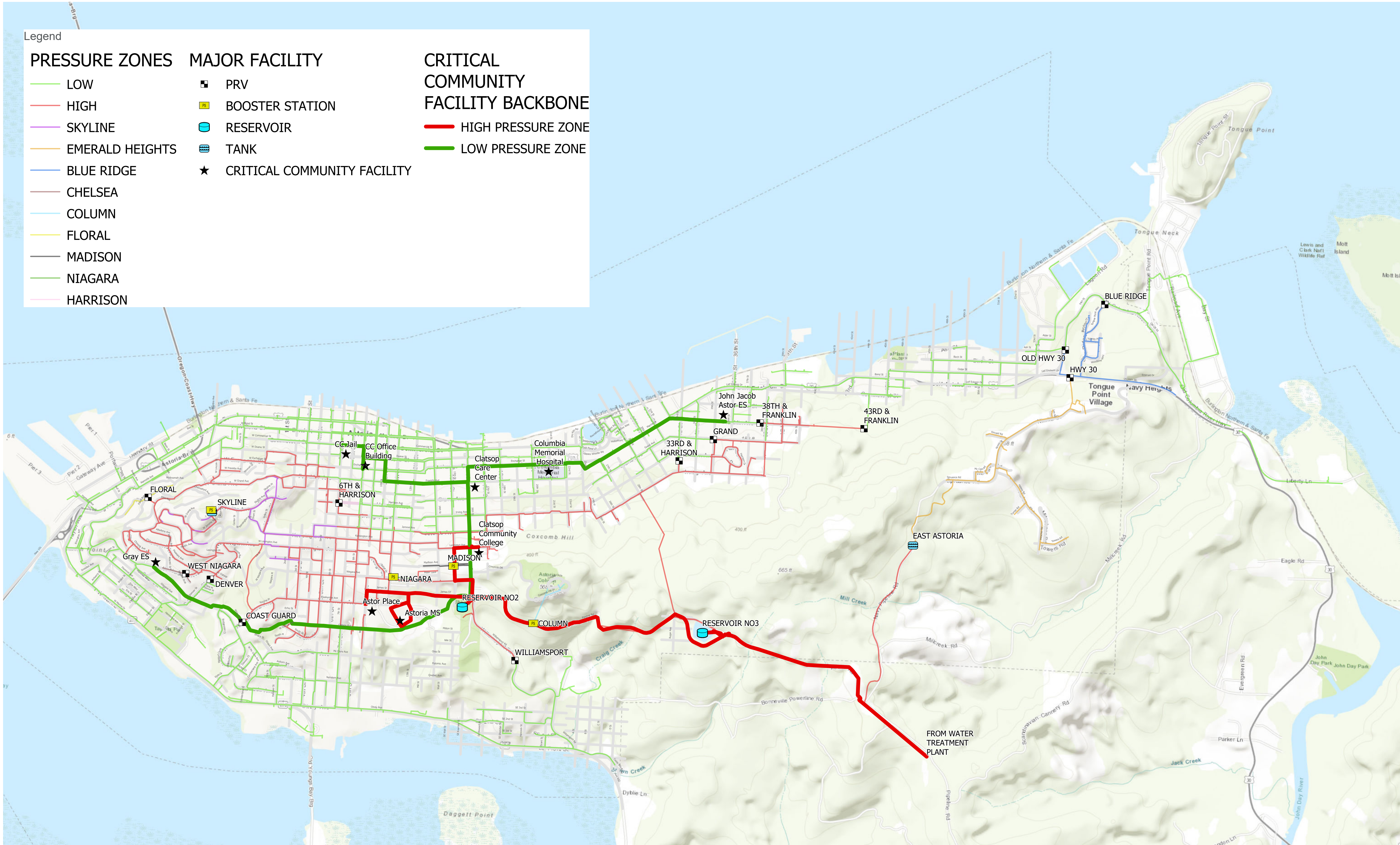


FIGURE 1-2
ASTORIA
WATER DISTRIBUTION SYSTEM SCHEMATIC
ASTORIA, OR



EXISTING WATER DISTRIBUTION SYSTEM - PRESSURE ZONES

Figure 1-3

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1.4.2 Water Main Inventory

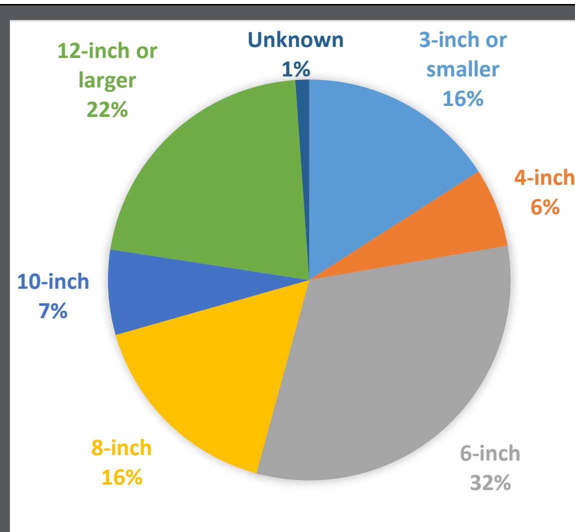
The City's water distribution system provides a means of conveying water from the supply sources to water usage locations. The distribution system must be capable of supplying adequate quantities of water and water pressures throughout the City under a range of operating conditions. Furthermore, the distribution system must be able to distribute water during normal and peak conditions but must also be capable of delivering adequate water supply for fire protection purposes.

For the purpose of this evaluation, the 21-inch-diameter primary transmission main from the water treatment plant to Reservoir No. 3 was excluded. The distribution system was defined to include all mains up to 18 inches in diameter. An inventory of the existing water distribution system mains is presented in this section.

As of June 2020, the City's water distribution system consists of approximately 80 miles of water main ranging in diameter from less than 3 inches to 18 inches in diameter (Table 1-2 and Figure 1-1). Approximately 22 percent of the water mains are 12 inches in diameter or larger, and represent the potable water system's primary distribution mains. The City's water distribution system includes these larger distribution mains throughout the system; however, in several areas, older and smaller diameter water mains exist and restrict flow capacity in the distribution network.

Table 1-2. Water Main Inventory – Diameter Percentage of Total

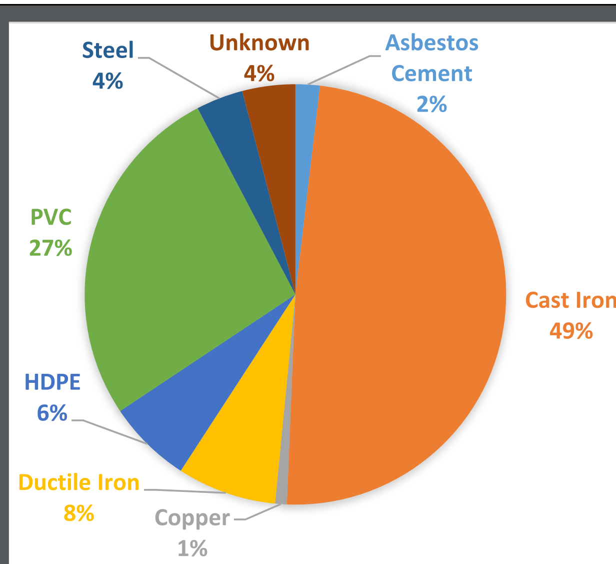
Diameter	Approximate Total Length (feet)	Percentage of Total (%)
3-inch or smaller	62,360	16
4-inch	25,010	6
6-inch	125,440	32
8-inch	64,170	16
10-inch	26,940	7
12-inch or larger	84,180	22
Unknown	4,350	1
Total	**392,450**	**100**

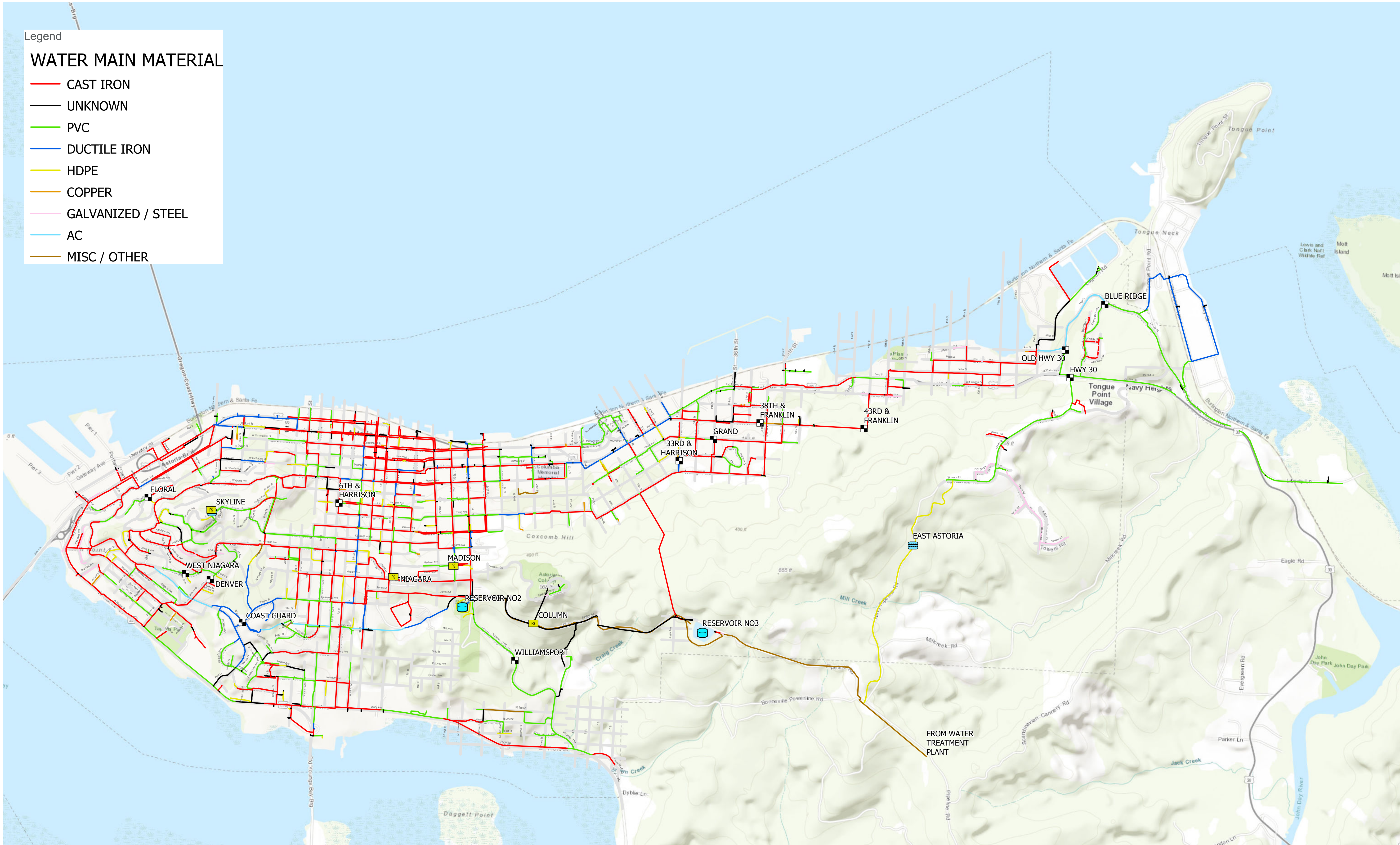


The distribution system is comprised of many materials, the most common being cast iron and polyvinyl chloride (PVC). Cast iron accounts for roughly half of the water mains currently in the system, while PVC accounts for another quarter. The water main material inventory is summarized in Table 1-3. A map showing the distribution of materials throughout the system is presented in Figure 1-4.

Table 1-3. Water Main Inventory – Material Percentage of Total

Material	Approximate Total Length (feet)	Percentage of Total (%)
Asbestos Cement	7,330	2
Cast Iron	191,440	49
Copper	3,510	1
Ductile Iron	29,900	8
HDPE	25,440	6
PVC	104,690	27
Steel	14,200	4
Unknown	15,950	4





EXISTING WATER DISTRIBUTION SYSTEM - MATERIALS

Figure 1-4

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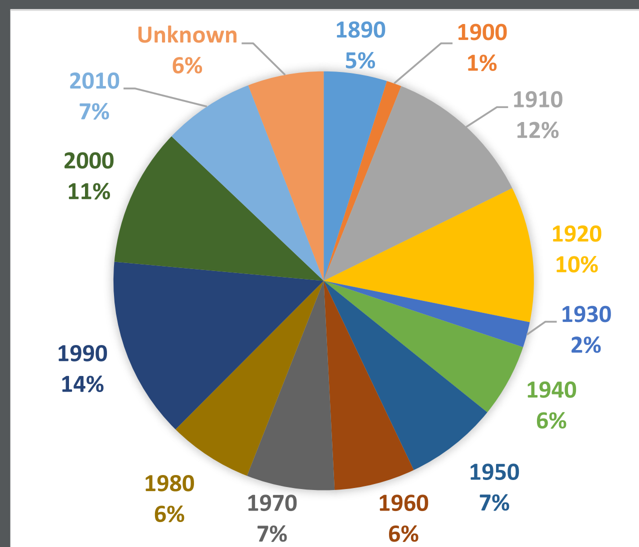
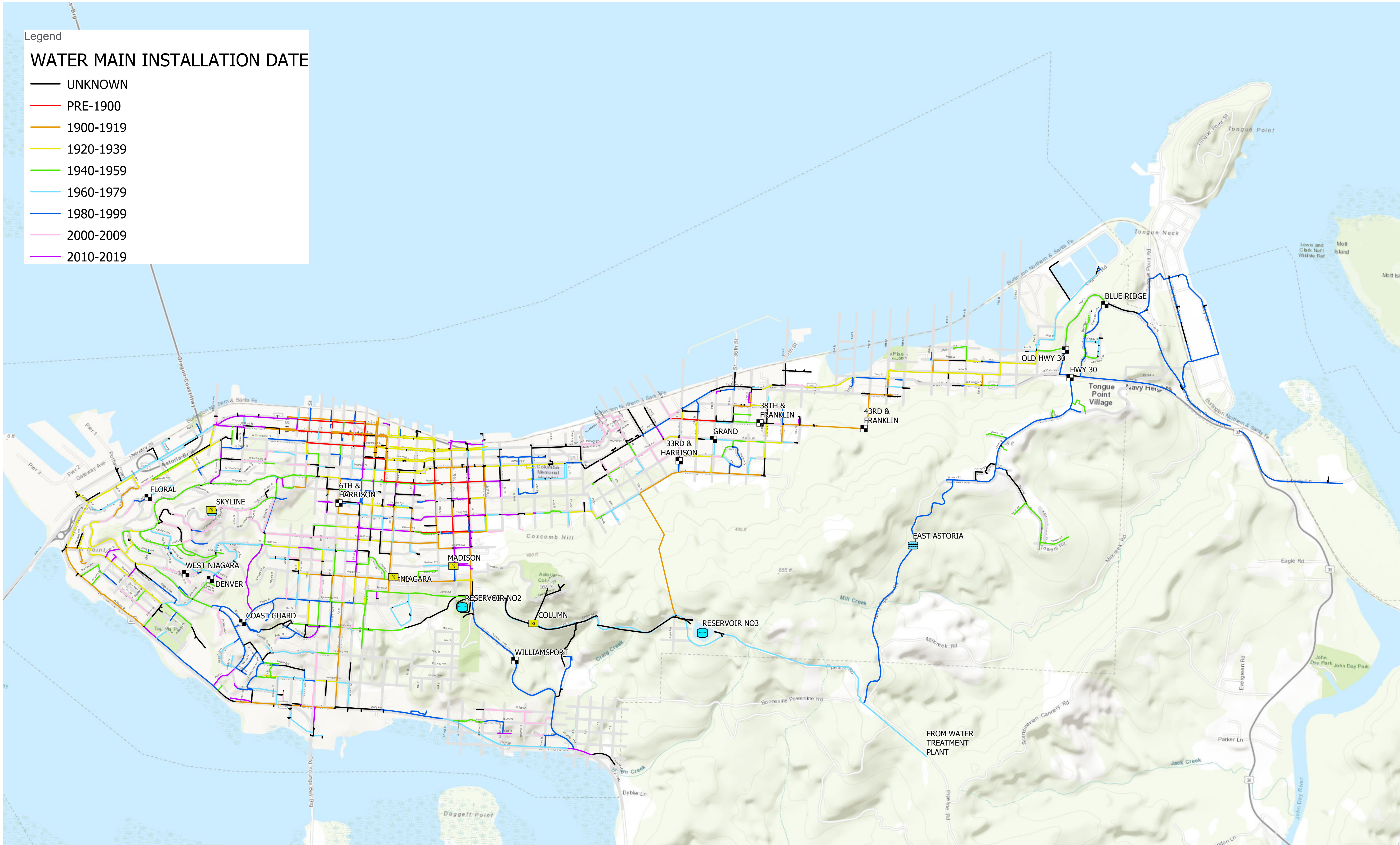
The water main inventory by installation decade is summarized in Table 1-4. The age of pipe varies widely throughout the system, with approximately 18 percent of the system installed more than 100 years ago (prior to 1920), 43 percent installed prior to 1960, and 18 percent installed within the last 20 years (2000 and after; Figure 1-5).

Table 1-4. Water Main Inventory – Installation Decade Percentage of Total

Installation Decade	Approximate Total Length (feet)	Percentage of Total (%)
1890	19,090	5
1900	4,520	1
1910	45,890	12
1920	41,040	10
1930	7,720	2
1940	22,250	6
1950	28,060	7
1960	24,400	6
1970	26,580	7
1980	25,530	7
1990	54,950	14
2000	41,860	11
2010	27,620	7
Unknown	22,930	6





EXISTING WATER DISTRIBUTION SYSTEM - INSTALLATION DATE

Figure 1-5

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1.4.3 Major Facilities

Table 1-5 summarizes major facilities within the water distribution system.

Table 1-5. Water System Facilities

Reservoirs	Pressure Zone	Description
Reservoir No. 2	Low Pressure Zone	- 5.5 MG Reservoir
Reservoir No. 3	High Pressure Zone	- 20 MG Reservoir
Water Storage	**Pressure Zone**	**Description**
Skyline Tank	Skyline Pump Zone	- 131,000 Gallon Ground Storage Tank
East Astoria Tanks	High Pressure Zone	- 2 x 150,000 Gallon Ground Storage Tanks
Booster Pumping Facilities	**Pressure Zone**	**Description**
Skyline Pump Station	High Pressure Zone to Skyline Pump Zone	- 3 x STA-Rite pumps - 3 HP - 140 gpm each
Niagara Pump Station	High Pressure Zone to Niagara Pump Zone	One Pump PACO 1-12507-10061-1471 PIP109
Madison Pump Station	High Pressure Zone to Madison Pump Zone	- Two Pumps - Berkeley 31-1/2 TPMS - 3,600 RPM - 5 HP
Astoria Column Pump Station	High Pressure Zone to Astoria Column Pump Zone	One Pump Cornell 1.25Y-15-2
Pressure Reducing Facilities	**Pressure Zone**	**Description**
Williamsport PRVs	High Pressure Zone to Low Pressure Zone	- One 8-inch PRV - One 2-inch PRV - 36 psi discharge
Coast Guard Housing PRVs	High Pressure Zone to Coast Guard Pressure Zone	- One 6-inch PRV - One 3-inch PRV - 45 psi discharge
Denver PRVs	High Pressure Zone to Denver Pressure Zone	- One 6-inch PRV - One 2-inch PRV - 50 psi discharge
West Niagara / Niagara Stub	High Pressure Zone to Chelsea Pressure Zone	- Two 2-inch PRVs - 66 psi discharge
Floral PRVs	High Pressure Zone to Floral Pressure Zone	- One 6-inch PRV - One 2-inch PRV - 50 psi discharge
6th & Harrison PRVs	High Pressure Zone to Harrison Pressure Zone	- Two 2-inch PRVs - 60 psi discharge
33rd & Harrison PRVs	High Pressure Zone to Low Pressure Zone	- One 12-inch PRV - One 1-inch PRV - 58 psi discharge
Grand PRV	High Pressure Zone to Low Pressure Zone	- One 0.75-inch PRV - 50 psi discharge

Pressure Reducing Facilities	Pressure Zone	Description
38th & Franklin PRV	High Pressure Zone to Low Pressure Zone	- One 2-inch PRV - 55 psi discharge
43rd & Franklin PRVs	High Pressure Zone to Low Pressure Zone	- One 10-inch PRV - One 3-inch PRV - One 1-inch PRV - 20 psi discharge
Hwy 30 PRVs	Emerald Heights Pressure Zone to Blue Ridge Pressure Zone	- One 10-inch PRV - One 3-inch PRV - 82 psi discharge
Old Hwy 30 PRVs	Blue Ridge Pressure Zone to Low Pressure Zone	- One 8-inch PRV - One 2-inch PRV - 72 psi discharge
Blue Ridge PRVs	Blue Ridge Pressure Zone to Low Pressure Zone	- One 10-inch PRV - One 3-inch PRV - 80 psi discharge

RPM=rotations per minute
PRV=pressure reducing valve
psi=pounds per square inch

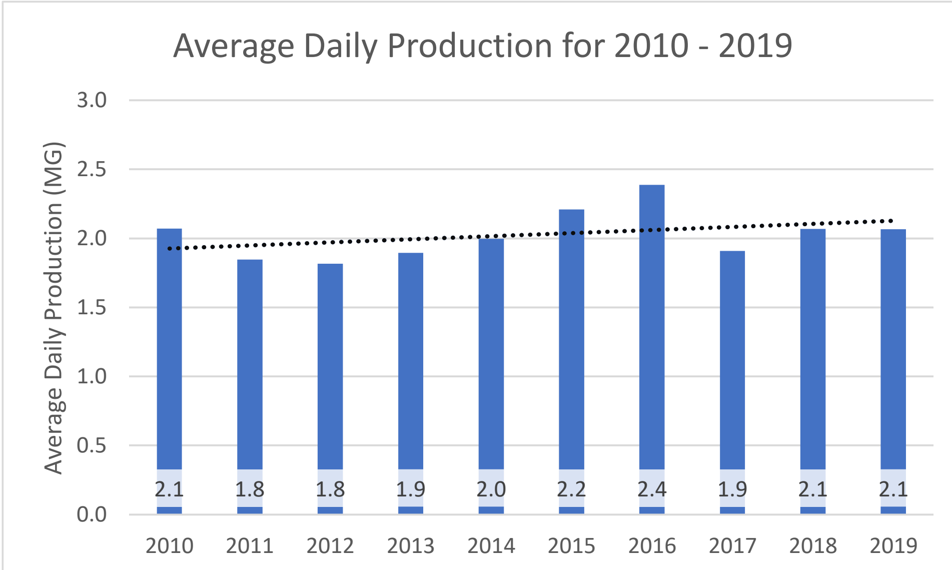
1.5 Existing Water Usage

The City's existing water usage was estimated by reviewing available past water production records for the past ten years (2010–2019) and bimonthly billing meter data for the past four years (2016–2019). Hourly data, provided for 2019, was used to characterize peaking factors for maximum day demand (MDD) and peak hour demand (PHD).

1.5.1 Production

In the past decade, average daily production at the treatment plant has ranged from 1.8 to 2.4 MG, with an average daily production of 2.0 MG (Figure 1-6). Data indicates production is trending slightly upward over the past decade, but average daily production is steady at approximately 2.0 MG for the most recent three years.

Figure 1-6. Average Daily Production for 2010-2019



1.5.2 Demand

Customer demand was evaluated using the most recent four years of billing data. Note that the City's billing data includes all billed usage as well as unbilled, metered water usage for City purposes (e.g. City facilities, Parks and Recreation Department, hydrant flushing). The total consumption was calculated including all metered usage, billed and unbilled. The ADD has ranged from 1.4 to 1.9 MG, and on average is approximately 1.6 MG (Table 1-6).

Table 1-6. Consumption Records Summary 2016-2019

Year	Annual Billed Consumption (MG)	Annual Unbilled, Metered Consumption (MG)	Total Annual Consumption (MG)	Average Daily Consumption (MG)
2016	562	127	690	1.9
2017	484	24	508	1.4
2018	537	21	559	1.5
2019	533	29	562	1.5
Average	**526**	**60**	**580**	**1.6**

1.5.3 Non-revenue Water and Unaccounted for Water

Non-revenue water is defined by the American Water Works Association (AWWA) as the distributed volume of water that is not reflected in customer billings. AWWA outlines three major types of non-revenue water:

1. Unbilled Authorized Consumption (water for firefighting, flushing, etc.)
2. Apparent Losses (customer meter inaccuracies, unauthorized consumption, and systematic data handling errors)

3. Real Losses (system leakage and storage tank overflows).

Together, Unbilled Authorized Consumption, Apparent Losses, and Real Losses make up the total volume of non-revenue water occurring in the water utility.

The percentage of non-revenue water occurring can be calculated as follows:

Percentage of Non-revenue Water (%) = (Volume of Water Supplied – Volume of Customer Billed Water) / (Volume of Water Supplied)

Billing meter data was compared to production data from the water treatment plant for the last four years (2016-2019) to determine the City's percentage of non-revenue water (Table 1-7).

Table 1-7. Non-Revenue Water 2016-2019

Year	Annual Production (MG)	Annual Billed Consumption (MG)	Annual Volume of Non-revenue Water (MG)	Percentage of Non-revenue Water (%)
2016	874	562	312	36%
2017	697	484	213	31%
2018	757	537	219	29%
2019	752	533	220	29%
Average	**775**	**529**	**241**	**31%**

The City's metered water usage is non-revenue water and accounts for much of the unbilled authorized consumption. The remaining portion of non-revenue water attributed to leakage, meter inaccuracies, and other unknown losses is often termed "unaccounted for water" or "water loss" and can be an indicator of the condition of the water system. The percentage of unaccounted for water occurring can be calculated as follows:

Percentage of Unaccounted for Water (%) = (Volume of Water Supplied – Volume of Metered Water) / (Volume of Water Supplied)

While imperfect and simplistic, this calculation provides a quick performance indicator for a utility to assess its apparent and real water loss (Table 1-8).

Table 1-8. Unaccounted for Water 2016-2019

Year	Annual Production (MG)	Annual Metered Consumption (MG)	Annual Volume of Unaccounted for Water (MG)	Percentage Unaccounted for Water (%)
2016	874	690	184	21%
2017	697	508	189	27%
2018	757	559	198	26%
2019	752	562	191	25%
Average	**775**	**586**	**188**	**25%**

The average percentage of unaccounted for water in the last four years was approximately 25 percent, which is higher than the Oregon Water Resources Department (OWRD) recommended maximum of 10 percent.

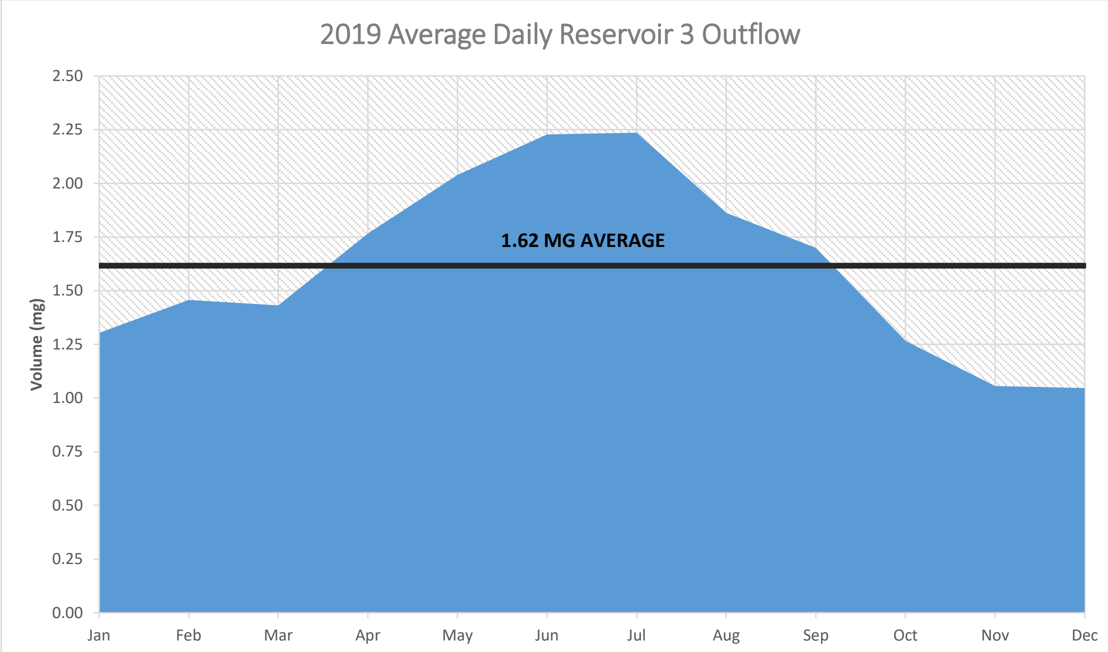
Current water right use permits issued by ORWD do not require the City to submit a Water Management and Conservation Plan (WMCP); however future permit extensions likely will require one which requires an annual water audit. If results of the water audit indicate losses exceeding 10 percent, the City must identify potential factors for the loss and selected actions for remedy (OAR 690-086-0120).

The City is proactively reducing unaccounted for water by replacing meters with known issues and repairing and replacing leaking assets in the distribution system. The City is also considering implementing an automated meter reading system to reduce discrepancies that occur with manual meter reading.

1.5.4 Seasonal Variation in Usage

Seasonal fluctuation in water usage is an important factor in designing and sizing of water supply and storage facilities. The City's seasonal variation in water consumption was characterized using a full year (2019) of hourly outflow data from Reservoir No. 3 (Figure 1-7). In 2019, average daily outflow from Reservoir No. 3 was approximately 1.6 MGD. Outflow was highest in June and July at approximately 2.2 MGD (140 percent of average) and lowest in November and December at approximately 1.1 MGD (70 percent of average). The seasonal variation experienced at Reservoir No. 3 was assumed reasonably representative of the variation within the City. Since industrial seafood processors are only located within City limits, the outlying water districts are expected to have less seasonal variation.

Figure 1-7. 2019 Average Daily Outflow - Reservoir No. 3



MDD is defined as the daily demand occurring on the maximum day of the year. Using the 2019 hourly outflow data from Reservoir No. 3, the maximum daily outflow from Reservoir 3 occurred on June 2, which corresponds with the peak outflow months (Figure 1-7). The outflow from Reservoir 3 on June 2 was approximately 2.72 MG, reflecting a peaking factor of 1.7 when compared to the average outflow of 1.62 MG. MDD was determined to be approximately 1.7x ADD.

1.5.5 Daily Variation in Usage

The hourly variation in customer demands is also an important characteristic used to evaluate water supply and storage requirements. PHD is defined as the demand occurring during the maximum hour of the maximum day. As with MDD, PHD is typically expressed as a ratio to compare it against annual ADD.

The maximum hourly outflow from Reservoir No. 3 on June 2 was equivalent to 3.76 MGD, a peaking factor of 2.3 when compared to the average outflow of 1.62 MGD. The daily variation experienced at Reservoir No. 3 was assumed reasonably representative of the variation within the City. Daily variation was assumed to follow a typical residential pattern in the outlying water districts. PHD was determined to be approximately 2.3x ADD.

1.5.6 Existing Water Usage Summary

The historical domestic ADD from 2016 to 2019 is 1.62 MGD. The applied peaking factors and resulting demands for MDD and PHD are listed below:

- ADD: 1.62 MGD
- MDD: 2.72 MGD (1.7x ADD)
- PHD: 3.76 MGD (2.3x ADD)

Note that the water usage established above does not reflect operations at the Port of Astoria (Port) or unaccounted for water, both of which have been included in the capacity and storage analyses.

With the Port operational (estimated demand 1.87 MGD) and unaccounted for water (approximately 25 percent of total production), the resulting demands are approximately:

- ADD: 4.01 MGD
- MDD: 5.14 MGD
- PHD: 6.11 MGD

Note that Port operations were assumed to remain constant throughout the day, so MDD and PHD peaking factors were not applied to the Port demand.

1.6 Status of Water Rights

Under Oregon water law, with a few exceptions, the use of public water requires a water right from OWRD. The City holds 12 water rights that are held in the City's name in OWRD's records.

Five of the water rights are evidenced by water right certificates and provide the City's current water supply. Four certificates authorize the storage of water from Bear Creek in three reservoirs, and the use of stored water from the reservoirs and natural flow from Bear Creek. One certificate authorizes the use of water from Cedar Creek. The City also diverts water at Spur 14, and OWRD considers this water use consistent with the City's existing water right certificates.

In addition, the City holds four water use permits. Three permits authorize water storage from Youngs River, and the use of water from the reservoir and the Youngs River watershed. A fourth permit authorizes the use of water from Big Creek. The City does not currently use water under these permits.

Finally, the City holds three water rights certificates for the storage and use of stored water for irrigation of Ocean View Cemetery. Although water continues to be stored in Smith Lake Reservoir, the stored water is not currently being used for irrigation.

A more detailed summary of the City's water rights, prepared by GSI Water Solutions, Inc., is included as Appendix A.

1.7 Status of Water Quality and Compliance

The City's drinking water system services some 13,000 water customers, including large-scale consumption by breweries and the fishing industry. Historically, the water treatment plant has not experienced major issues with contaminants (e.g., inorganics, volatile organic chemicals, and soluble organic chemicals), and monitoring and water quality goals are largely established by the regulatory compliance requirements. The treatment system experiences consistency in chlorine and fluoride levels, low turbidity levels, and generally consistent pH levels. Summer months can prove more challenging with elevated pH levels, but operational adjustments regarding water sources used aid in keeping pH levels consistent with other months. Managing disinfection byproducts (DBPs) can be challenging in the fall, but levels are typically maintained within regulatory limits. In the past six years, the City has experienced two drinking water violations (one

DBP, one residual contact time violation), which were addressed and mitigated to ensure ongoing treated water quality meets or exceeds all drinking water regulations.

1.7.1 Current Federal and State Regulations

The Oregon Health Authority (OHA) oversees Oregon's drinking water standards (*OAR, OHA, Public Health Division, Chapter 333, Division 61, Drinking Water*), and largely follows the specifications and regulations outlined by the U.S. Environmental Protection Agency (EPA). OHA makes a point of keeping the stringency of regulations on par with what has been approved by the EPA, and therefore is largely similar to the federal regulations.

Regular monitoring is conducted by Astoria Public Works employees to ensure that regulatory standards are met. Ten samples per month are collected to check for bacteriological organisms. Water is monitored daily throughout the treatment and distribution systems for free chlorine, fluoride, turbidity, and pH. Source waters are further monitored for turbidity, pH, and temperature. Additional compliance sampling is conducted based on a schedule provided by OHA to test for: DBPs, lead and copper, inorganic and organic compounds, pesticides and herbicides, and radiological contaminants. Supplemental sampling (outside of regulatory requirements) is conducted at varying frequencies - typically a few times a month - to measure UV_{254} absorbance from source waters. UV_{254} is used as a surrogate for Total Organic Carbon concentrations and likely DBP formation. Decisions regarding which source waters to use rely on this UV data so as to limit DBPs in finished water.

Tables B-1 through B-5 in Appendix B illustrate the federal and state monitoring requirements. Tables C-1 through C-5 in Appendix C summarize the City's data for compliance sampling, as compiled over the past 6 years (since 2014).

1.7.2 Recent Regulatory Changes and Potential Future Regulations

1.7.2.1 Lead and Copper Rule Long-Term Revisions

The Lead and Copper Rule was promulgated in 1991 with multiple small modifications since; however, the EPA proposed major revisions in October 2019 to further protect public health by strengthening nearly all lead-related aspects of the rule, while leaving the copper requirements unchanged (Federal Register 2019). The comment period ended in February 2020, and the EPA revisions were signed by EPA administration on December 21, 2020 (Federal Register 2021). Key elements of the current revisions are outlined below, but certain requirements within the revised Lead and Copper Rule may become even more stringent under the new administration.

Goals of the current revisions:

- Provide greater and more effective protection of public health
- Better identify high levels of lead
- Improve reliability of lead tap sampling results
- Strengthen corrosion control treatment (CCT) requirements
- Expand consumer awareness

- Improve risk communication
- Accelerate lead service line replacement (LSLR)

Ongoing considerations (beyond current regulations) may include more aggressive LSLR requirements during EPA's Lead and Copper Rule revisions.

Key aspects of the Lead and Copper Rule revisions:

- **Action Level and Trigger Level**
    - There have been no changes to the 90th percentile action levels (15 µg/L for lead, and 1.3 milligrams per liter [mg/L] for copper), but more actions are required when these action levels are exceeded
    - A trigger level for lead has been established (10 µg/L at the 90th percentile) that triggers additional planning, monitoring and treatment
- **Lead Service Line (LSL) Inventory and LSLR Plan**
    - LSL inventory (or demonstration of LSL absence) must be developed within three years of rule publication.
    - Inventory must be updated annually, or triennially, based on tap sampling frequency.
    - Systems with known or possible LSLs must develop an LSLR plan
    - If P90 > 15 µg/L, utilities must fully replace 3% of LSLs per year based on a 2-year rolling average for at least four consecutive 6-month monitoring periods.
    - If P90 > 10 to 15 µg/L, utilities must implement an LSLR program with replacement goals in consultation with the primacy agency (i.e., OHA) for two consecutive 1-year monitoring periods.
    - Annual LSLR rate is based on the number of LSLs requiring replacement when the system first exceeds the action level plus the current number of lead status unknown service lines.
    - Only full removal counts toward LSLR rates.
    - Systems must replace their portion of an LSL if notified by consumer of private side replacement within 45 days.
    - Following LSLR, systems must provide customers with pitcher filter/cartridges with 24 hours and continue for 6 months.
    - Lead tap samples must be collected at LSLR locations within 3 to 6 months after replacement.
    - Galvanized service lines downstream of LSLs must also be replaced.
- **Lead and Copper Tap Monitoring**
    - Sampling prioritized around sites served by LSLs.
    - Improved tap sample site selection tiering criteria.
    - Requires collection of the fifth-liter sample in homes with LSLs, with a minimum of 6 hours stagnation; maintain first-liter sample in homes without LSLs.
    - Samples must be collected in wide-mouth bottles.

  - Prohibited sampling instructions with aerator cleaning/removal and pre-stagnation flushing prior to collection.
  - Lead monitoring schedule is based on P90 level as follows:
    - P90 > 15 µg/L: Semi-annually at the standard number of sites.
    - P90 > 10 to µg/L: Annually at the standard number of sites.
    - P90 ≤ 10 µg/L: Annually at the standard number of sites and triennially at reduced number of sites using same criteria as previous rule (every 9 years based on current rule requirements for a 9-year monitoring waiver).
- **Corrosion Control Treatment and Water Quality Parameters (WQPs)**
  - Specifies CCT requirements for systems with 10 < P90 ≤ 15 µg/L:
    - No CCT: must conduct CCT study if required by primacy agency
    - With CCT: must follow the steps for re-optimizing CCT
  - Systems with P90 > 15 µg/L:
    - No CCT: must complete CCT installation regardless of subsequent P90 levels
    - With CCT: must re-optimize CCT
  - CCT Options: calcium hardness is no longer an option; phosphate inhibitor must be orthophosphate.
  - Regulated WQPs: eliminates WQPs related to calcium hardness (i.e., calcium, conductivity, and temperature).
  - WQP Monitoring: systems serving ≤ 50,000 people must continue WQP monitoring until lead and/or copper action levels are not exceeded for two consecutive 6-month periods.
  - CCT and WQP data must be reviewed during sanitary surveys against most recent CCT guidance issued by EPA.
  - Find-and-Fix (if individual tap samples > 15 µg/L): collect tap samples within 30 days, conduct WQP monitoring at or near site, perform needed corrective action, document customer refusal/nonresponse after 2 attempts, provide into to local public health officials.
- **Public Outreach and Education**
  - Inform consumers annually that they are served by LSL (or unknown service line)
  - Community Water Systems must provide updated health effects language in all education materials and the consumer confidence report
  - Customers can contact the Community Water Systems to get materials translated in other languages
  - All systems are required to include information in the consumer confidence report on how to access the LSL inventory and tap sampling results
  - Systems must notify consumers of P90 > action level within 24 hours

  - Systems must notify consumers whose individual tap lead sample is > 15 ug/L within 3 days.
- **Changes in Source Water or Treatment**
  - Systems on any tap monitoring schedule must obtain prior primacy agency approval before changing their source or treatment.
  - Systems must also conduct tap monitoring biannually.
  - Primacy agencies can waive continued source water monitoring if: a system has already conducted source water monitoring for a previous P90 > action level, **OR** the primacy agency has determined that source water treatment is not required **AND** the system has not added any new water sources.
- **Lead in Schools**
  - Community Water Systems must conduct sampling of 20% of elementary schools and 20% of childcare facilities per year and conduct sampling at secondary schools on request for one testing cycle (5 years) and conduct sampling on request of all schools and childcare facilities thereafter.
  - Proposed revisions require testing at 20% of K-12 schools and licensed childcare facilities every 5 years.
  - Sample results and public education must be provided to each sampled facility, primacy agency, and local or state health department.
  - Excludes facilities built after January 1, 2014.

1.7.2.2 Per- and Poly-Fluoroalkyl Substances

PFAS are a group of man-made chemicals manufactured and used in a variety of industries since the 1940s. The EPA initially established a provisional lifetime health advisory level for perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA; EPA 2009). Six PFAS were included in the third Unregulated Contaminant Monitoring Rule (UCMR 3). The two most frequently detected PFAS during UCMR 3 were PFOS and PFOA. As a result, the EPA replaced the provisional health advisory level with a formal health advisory level for these two compounds, individually or combined, of 70 nanograms per liter (EPA 2016a,b).

The EPA developed a PFAS Action Plan in February 2019 with seven goals:

1. Conduct the Maximum Contaminant Level process for PFOS and PFOA and evaluate information to determine if a broader class of PFAS should be regulated.
2. Strengthen enforcement authorities and clarify cleanup strategies by designating PFOS and PFOA as hazardous substances and develop interim groundwater cleanup recommendations.
3. Determine if PFAS should be added to the Toxics Release Inventory and if rules to prohibit the use of certain PFAS should be developed.
4. Include additional PFAS in UCMR 5 that were not previously part of UCMR 3.
5. Increase research related to PFAS, including improved detection and measurement methods.

6. Utilize EPA enforcement tools, when necessary, to address PFAS exposure in the environment and assist states in enforcement activities.
7. Develop a risk communication toolbox for federal, state, tribal, and local partners to use with the public.

In February 2020, EPA announced that it is proposing to regulate PFOS and PFOA under the Safe Drinking Water Act. EPA is seeking information related to other PFAS and comments on potential monitoring requirements and regulatory approaches for PFAS. If a positive regulatory determination is finalized, EPA would begin the process for establishing a National Primary Drinking Water Regulation for PFOS and PFOA.

1.7.3 Drinking Water Violations

There have been two drinking water violations since 2014, one for failing to meet chlorine residual requirements in 2014, and one for elevated DBPs in 2016:

In July 2014, the City's water treatment plant failed to meet contact time requirements. This violation was caused by a power bump that shut off power to the water pump which feeds the chlorination system and did not automatically restart when power was restored. Following this event, the magnetic contactors used to power the pumps were removed and replaced with continuous contactors that do not automatically disengage during power loss. Additionally, an emergency blow-off was installed to prevent non-chlorinated water from reaching the first customer.

In November 2016, the City experienced challenges maintaining DBP levels. Following requirements of the Stage 2 DBP Rule, samples were collected at points in the distribution system exhibiting the highest DBP levels. The MERTS Center and 1st & D Street are two locations that consistently exhibit elevated DBPs. Table C-4 (Appendix C) illustrates the range in values for the Annual Running Average from quarterly sampling for both total trihalomethanes and Haloacetic acids five.

Operational changes have been implemented since Stage 2 monitoring started in 2013 to reduce the levels of DBPs in the system including keeping the reservoirs at lower levels to reduce detention times, adjusting flushing of the system, and using source waters with lower organic matter content. The development of Spur 14 source water was further implemented to reduce DBPs.

In November 2016, however, unusual weather instigated high levels of organic matter in the Main Lake water, lowering the pH and requiring higher chlorine doses (around 3.0 mg/L as Cl_2, compared to the typical dose of 2.0-2.5 mg/L as Cl_2). These conditions led to unusually high DBP levels, and in a City violation of Haloacetic acids five. The City had to issue a Tier II public notice about the violation within 30 days of receiving the test results.

1.7.4 Drinking Water Quality and Compliance Summary

The City strives to provide consistently high-quality water to its customers. Regular water quality monitoring is conducted by Astoria Public Works employees to ensure that federal and state regulatory standards are met. The City had two recorded drinking water violations between 2014 and 2016, both of which were promptly remedied. No violations have been recorded since 2016.

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Chapter 2. Water Demand Forecast

To determine water infrastructure needs related to capacity, it is important to understand water demand. This chapter summarizes planning assumptions made regarding future service area characteristics for the City of Astoria (City) and includes population forecasting, changes in land use and zoning, and planned growth within the community. Information used to determine the water demand forecast was collected from the City and other public agencies. The planning horizons considered in this forecast are 20 years (2040) and 50 years (2070).

2.1 Population

Astoria's population has remained relatively constant over the past 100 years apart from the period during World War II. The City is not expecting significant growth and therefore not projecting substantial change in City water usage due to change in population.

2.1.1 Census-Based Population Forecast

Generally, population forecasting is based on historic trends within the focus area. These trends and the process used for population forecasting in Astoria are outlined in the *Coordinated Population Forecast for Clatsop County, its Urban Growth Boundaries (UGB), and Area Outside UGBs 2020-2070* report (CPF). This report was completed in 2020 by the Population Research Center, in consultation with the Oregon Department of Land Conservation and Development, at Portland State University (2020). Forecast methods are used to estimate population projections up to 25 years, and a modified projection method is used for estimates from 25 to 50 years. Population growth information from the CPF was used to estimate the water demand forecast in Astoria for this master plan.

Near-term population forecasting for the City of Astoria was completed using the cohort-component model and is based on CPF assumptions made about trends in fertility, mortality, and migration between 2010 and 2019. According to the CPF, the City of Astoria experienced an average annual out-migration of 82 people between 2000 and 2010. However, in the following decade between 2010 and 2020, the net migration leveled out and became almost equal (net zero). By this same metric, the City is expected to experience a net in-migration of 70 residents per year from 2020 to 2045. This increase in residents is offset by a decrease in natural growth (births minus deaths), resulting in a minimal population change overall for the City beyond 2020. Table 2-1 shows the total population forecast for years 2020 through 2070, at five-year intervals. For planning years 2040 and 2070, the estimated population for the City of Astoria is forecast to be 9,900 and 9,876, respectively. Note that the table illustrates the slight increase in population up to year 2035 and then fluctuates and levels off in the following years.

Table 2-1. Local Population Forecast 2020 through 2070

Area/Year	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Astoria	9,815	9,889	9,901	9,910	9,900	9,852	9,840	9,799	9,804	9,833	9,876

2.1.2 Clatsop County Housing Study

In 2019, Clatsop County completed the Clatsop County Housing Strategies Report (CCHSR) to understand current and projected housing conditions in its five incorporated cities, including Astoria. In general, the research determined there was a sufficient supply of housing overall, but not enough long-term housing for year-round residents. The current market consists of 1.4 housing units per permanent resident household, a 27 percent vacancy rate, and 67 percent single-family detached homes. However, the study found that second homes, short-term rentals, and residential homes being used for commercial purposes are creating a gap in available housing for permanent residents; particularly in beachside communities. It is estimated that 1,500 new homes will be required to accommodate future county-wide population growth. While it is unclear how many of these homes are expected to be built in Astoria, the CCHSR indicates that denser forms of housing, such as townhomes and condos, would be most beneficial in all areas. This type of development would effectively redistribute water usage throughout the City, even without a significant change in population.

2.2 Existing Land Use

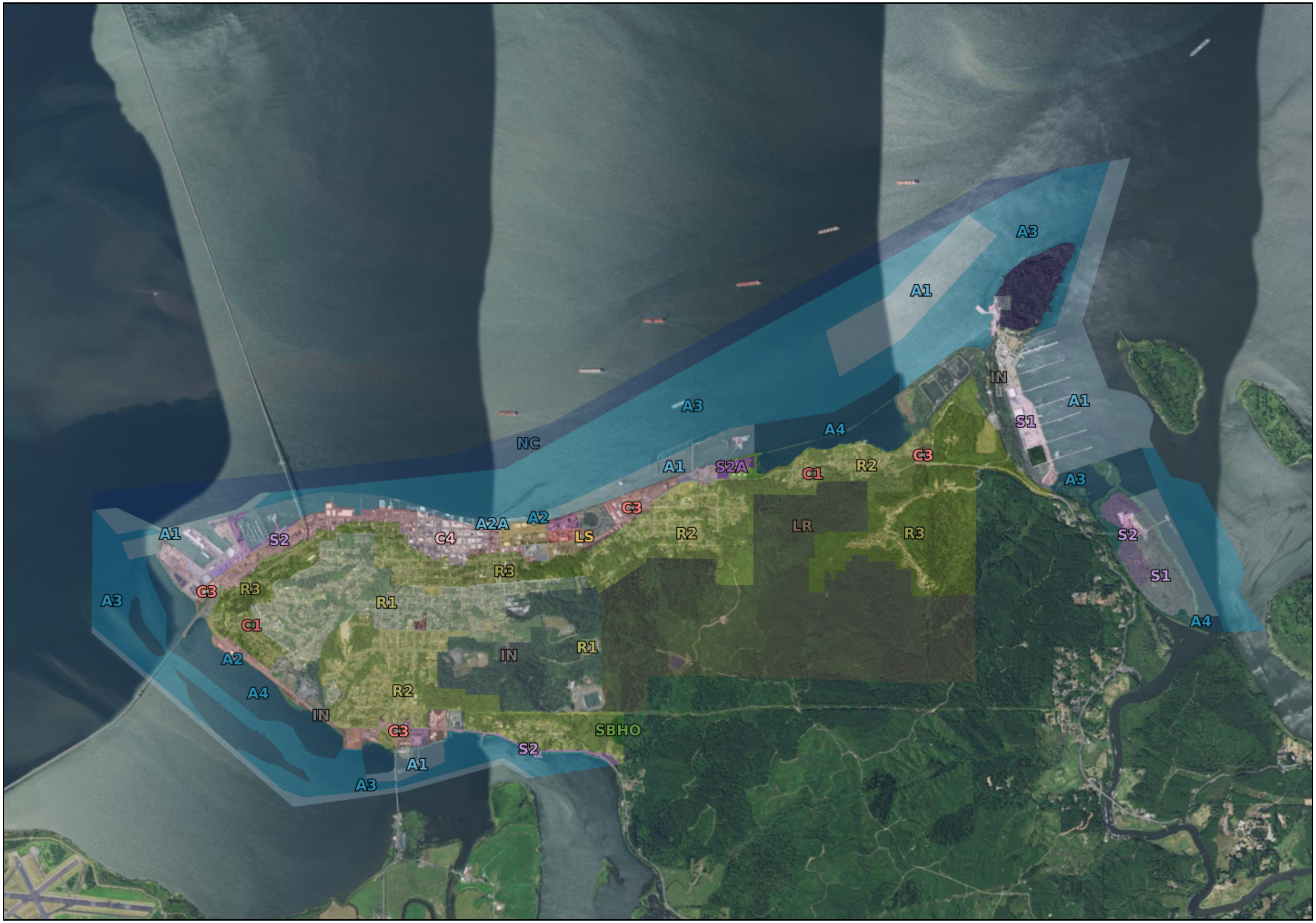
Existing land use within the City was characterized based on current zoning data (Figure 2-1). Like many communities, Astoria is comprised of a mix of residential, commercial, and industrial areas.

Much of the area directly on the waterfront is zoned as general commercial (C3), tourist commercial (C2), and marine industrial shorelands (S1). The residential zones are generally set back from the coastline and range from low-density (R1) to high-density (R3). Residential zones from low to high can accommodate up to an average of 8, 16, and 26 units per net acre, respectively. These zones vary in usage, ranging from almost strictly single-family dwellings for R1 to single-, two-, and multi-family dwellings for R3. Remaining land is generally divided into institutional (IN) and land reserve (LR) zones.

In addition to the CCHSR, the City maintains its *Astoria Comprehensive Plan* to comply with *Oregon's Statewide Planning Goals and Guidelines*. The most recent plan identifies a deficiency of residential buildable land, specifically in the low-density area. In contrast, there is a surplus of high-density buildable land that is currently under-developed. The report also states that, under OAR 660-24-0050, the City must address this deficit either by developing more land already within the UGB, or by expanding the UGB. Findings from both the comprehensive plan and the CCHSR suggest the need for land use changes, UGB expansion, or both. At this time it is unclear which of these circumstances is more likely.

City of Astoria Zoning Map

CITY OF ASTORIA
Founded 1811 • Incorporated 1856



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2.3 Future Community Growth

With minimal population growth and an increasing need for permanent housing, the City may need to modify the current zoning to accommodate future community growth. The CCHSR suggests that more multi-family rentals and medium-density housing will help address current deficiencies, as well as controlling commercial use of residential land. In addition, locating future homes away from desirable riverfront locations will provide more affordable housing that is less likely to become short-term rentals. These strategies could effectively redistribute future residential water usage.

In addition to residential water usage, the City of Astoria Public Works Department completed a survey of future growth potential for large water users. These entities include the City, Port of Astoria (Port), Tongue Point Job Corps, Fort George and Buoy Beer breweries, and outlying water districts (Table 1-2). Planned water conservation efforts for several large water users were not factored into the water demand forecast at this time due to the inability to quantify these measures.

Table 2-2. Large Water Users – Current Usage and Expected Growth

Customer	Current Water Use Notes	Expected Growth
City of Astoria	• Approximately 23.8 MG total consumption in 2019 • Includes Smith Pt Storage Pipe, SE 1st St Flusher, 6550 Liberty Ln Flusher System, and Sewage Lagoon	Minimal increase in usage based on projected population growth
Port of Astoria	• Approximately 180.4 MG total consumption in 2019 • Estimated 1.0-1.5 MGD during peak season • Includes Port operations and seafood processors	Estimated growth of 5% within 20-year planning horizon
Tongue Point Job Corp	• Approximately 11.1 MG total consumption in 2019 • Currently operating at capacity	Future growth limited, minimal increase in usage
Breweries	• Fort George – Approximately 4.8 MG total consumption in 2019 • Buoy Beer – Approximately 4.3 MG total consumption in 2019	Fort George – Approx. 9.6 MG annual consumption by 2030 Buoy Beer – Approx. 8.6 MG annual consumption by 2030
Outlying Water Districts	• Primarily residential usage • Naval Hospital	Future growth estimated to be commensurate with residential growth within City limits

MG=million gallons
MGD=million gallons per day

2.4 Future Utility Service Areas

The City currently provides water to seven water districts, primarily residential, with a combined estimated population of 3,000. The City will continue to provide water to these districts. As a practice, the City will not accept new applications for users outside of the City.

2.5 Summary

Population growth, and related increases in residential water usage, is expected to be minimal for the planning period addressed in this report. Assuming Water Research Foundation's 2016 Residential End Uses of Water, Version 2: Executive Report stating a per capita usage of approximately 60 gallons per capita per day, the total increase in residential water usage between 2020 and 2040 is approximately 6,700 gallons per day. Without clear direction for change within the UGB, there is no basis for redistribution in residential water usage at this time. Within the next 20 years, the most consequential impacts to the City's water system are projected to be large water user growth, specifically the breweries and the Port of Astoria. This growth could result in an additional daily demand of approximately 75,000 gallons per day by 2040. Beyond 2040, there are no specific additional demands expected through 2070.

Table 2-3 provides a summary of the demand forecast. System demands are seasonably variable, primarily due to the nature of Port operations. When the Port demand is low, current average system demand is estimated to be 1.62 MGD (Demand Scenario 1). However, when the Port is operating during peak canning season, average system demand may rise to more than 4 MGD (Demand Scenario 2). The future scenarios (Demand Scenarios 3 and 4) are calculated for the peak season to represent the highest expected demands.

Table 2-3. Water Demand Forecast 2020 through 2070

Demand Scenario	Planning Year	ADD (MGD)	MDD (MGD)	PHD (MGD)
1	Existing (2020) – Port Non-Operational/Low Season	1.62	2.72	3.76
2	Existing (2020) – Port Operational/Peak Season	4.01	5.14	6.11
3	2040 – Port Operational/Peak Season	4.39	5.79	6.99
4	2070 – Port Operational/Peak Season	4.39	5.79	6.99

ADD=average day demand
MDD=maximum day demand
PHD=peak hour demand

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Chapter 3. Water Rights Assessment and Climate Change Adaptation

Sections 3.1 through 3.6 of this chapter contain excerpts from the *City of Astoria: Water Rights Strategy Technical Memorandum*, GSI (Appendix D). Section 3.7 contains considerations for adapting to changing supply conditions due to climate change.

3.1 Water Rights Status

The City's current municipal water supply is provided by five water right certificates. The City also holds four municipal and domestic water use permits that are not yet developed, along with certificates authorizing the use of water for hydroelectric power production and irrigation.

3.1.1 Certificated Status

The City's certificated municipal water rights authorize the use of water from Bear Creek, Cedar Creek, and three reservoirs that are filled with water from Bear Creek:

- Certificates 19543 and 82234 authorize storage of up to 498 acre-feet (162.3 MG) in Middle Lake and Wickiup Lake, and up to 675 acre-feet (219.9 MG) in Bear Creek Reservoir, respectively, for a total storage volume of 1,173 acre-feet (382.2 MG) annually.
- Certificate 19542 authorizes the use of up to 3.0 cubic feet per second (cfs) (1.94 MGD) from stored water in Middle Lake and Wickiup Lake along with live flow from Bear Creek.
- Certificate 82236 authorizes the use of up to 12.0 cfs (7.76 MGD) from Bear Creek and stored water from Bear Creek Reservoir.
- Certificate 82237 authorizes the use of up to 2.0 cfs (1.29 MGD) from Cedar Creek.

Collectively, the certificated water rights authorize a maximum instantaneous diversion rate of 17.0 cfs (11.0 MGD). Because these water rights are certificated, they are secure and require no further action from the City to protect them.

As noted, in the City of Astoria Water Rights Summary memo (2020; Appendix A) the City also diverts water at Spur 14, and OWRD considers this water use to be consistent with the City's existing water right certificates. Spur 14 is a spring that originates mostly from leakage out of Wickiup Lake then empties into Middle Lake or flows past Middle Lake into drainages that eventually find their way to Cedar or Bear Creeks. The City had constructed a diversion to capture this spring flow. Based on communications in March 2015, OWRD indicated the diversions would be considered part of water use from Wickiup Lake and requested that the City meter the water diverted from Spur 14.

3.1.2 Permit Status

The City holds four water use permits that are undeveloped, meaning no water has been used under these rights to date:

- Permit R-2568 authorizes storage of up to 12,000 acre-feet (3910.2 MG) in Youngs River Reservoir.
- Permit S-27092 authorizes the use of up to 26.0 cfs (16.8 MGD) from Youngs River and stored water from Youngs River Reservoir.
- Permit S-7257 authorizes the use of an additional 23.0 cfs (14.9 MGD) from Youngs River.
- Permit S-3945 authorizes the use of up to 16.0 cfs (10.34 MGD) from Big Creek.

Combined, these four permits authorize a total maximum use of 65.0 cfs (42.0 MGD).

The development deadline for each of these permits was October 1, 1995. To preserve the permits, the City filed extension of time applications in 2005 and 2006, which are currently pending with OWRD. The applications for extension of time (included in Appendix D) requested a development period to October 1, 2055. The extension applications identified factors influencing potential water demand growth that indicate that the City would need to use water under the Youngs River and Big Creek permits in the future. These factors included future needs for a non-potable water supply, industrial and commercial growth (particularly associated with the Port of Astoria), a redundant supply for fighting wildfire, and the potential need to supply water to unincorporated communities or a regional supply system.

The City's permits were issued between 1918 and 1961 and have been extended multiple times. In recent years, OWRD's review process for municipal extensions of time has become more complex, and now includes the Oregon Department of Fish and Wildlife (ODFW) determining the need for conditions to "maintain the persistence" of listed fish species in the municipal user's water sources. "Fish persistence" conditions recommended by ODFW are intended to protect streamflows and typically reduce the municipal water provider's access to water during times when identified flow targets are not met.

ODFW provided draft "fish persistence" conditions for the City's Youngs River and Big Creek permits consistent with the flows protected by instream water rights on Big Creek and Youngs River. Historical gage information from a Youngs River gage that operated from 1928 to 1958 suggests that the draft flow targets would significantly reduce the City's access to water from these permits. For example, based on the historical data, ODFW's draft flow targets would be met less than half of the time in the summer months. It should be noted that conditions for the storage rights would likely be different than the permits for diversion.

3.1.3 Additional Water Rights

The City holds Certificate 89004, which authorizes the use of water from Bear Creek and Bear Creek Reservoir for hydroelectric power production in conjunction with the City's use of water for municipal purposes under Certificate 82236. The City also holds Certificates 28405, 28406, and 28407, which authorize the storage and use of stored water in Smith Lake Reservoir for irrigation of Ocean View Cemetery. As non-municipal water rights and because they require no further action by the City to protect them, these water rights are not considered further in this evaluation of the City's municipal water supply.

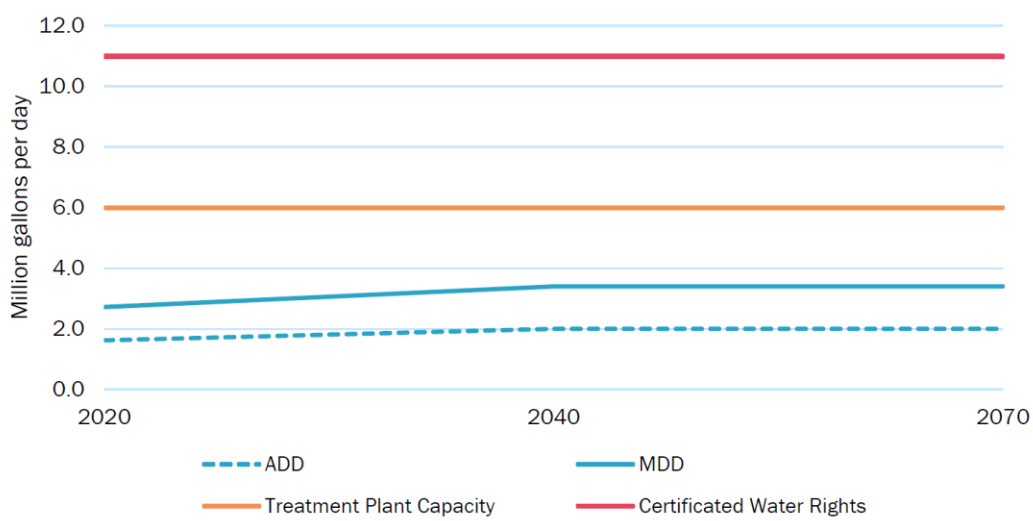
3.2 Water Infrastructure Capacity

The storage capacities of the City's three reservoirs mirror the authorized volumes in the associated storage water rights: Bear Creek Reservoir holds approximately 200 MG, Wickiup Lake holds 110 MG (although it is rarely full), and Middle Lake holds 52 MG. Water diverted from Bear Creek, the reservoirs, and Cedar Creek is conveyed to a water treatment plant (WTP) with a capacity of 6.0 MGD. The City's water operators note that the capacity of the raw water supply is dependent on the water quality conditions of the supply sources. The City has been able to meet peak demands to the WTP, and thus is not a limiting capacity in the system. Finished water is then conveyed approximately 12 miles through a transmission main with a capacity of 6.9 MGD to Reservoir No. 3 where it enters the City's distribution system. Prior to reaching the finished water reservoir, some of the water in the transmission main is also sent to Tongue Point, Emerald Heights, and several outlying water districts. Based on the information above, the WTP capacity of 6.0 MGD is assumed to be the limiting supply capacity.

3.3 Water Demand Forecast

Water demand projections for 2020 to 2070 are described in Chapter 2. Figure 3-1 compares the demand forecast with the maximum capacity of the City's water system (based on the water treatment plant capacity) and the total rate of use authorized by the City's certificated municipal water rights. This graph shows that future demands through 2070 are projected to be within the capacity of the treatment plant and the total maximum authorized rate of the City's certificated water rights.

Figure 3-1. Demand Projection Comparison



Note that the demands used for the analysis above do not reflect operations at the Port or unaccounted for water. With the Port operational (estimated demand 1.87 MGD) and unaccounted for water (approximately 25 percent of total production), future demands are still projected to be within both treatment plant capacity and total maximum authorized rate of certificated water rights.

3.4 Future Water Service Objectives

As described above, the City holds four water use permits that authorize the storage and use of water from Youngs River and Youngs River Reservoir, as well as Big Creek. To date, the City has not used water under any of these water rights. GSI identified the following water service objectives as key drivers for the City's plans for its water use permits.

- Water Service Area: The City's priority is to ensure water supply is available for their existing customers throughout the year. As noted above, the City's water rights for its existing Bear Creek source and infrastructure capacity are sufficient to meet needs for the next 50 years. The City does not currently have plans to serve new wholesale customers or residential communities with new intertie connections from its Bear Creek source.
- Regional Supply: The Northwest Coastal Water Supply Task Force completed a study in 2009 regarding the opportunity to develop a regional water supply source. The study considered the opportunity to use the City's water use permit(s) to provide a new source of supply for the region. However, since the study, the Task Force and other parties in the region have not coalesced to move a coordinated regional supply forward.
- Supply Resiliency: Supply resiliency is an important consideration for City of Astoria, because it has a single source of supply (the Bear Creek watershed) and is vulnerable in particular to loss of water supply due to seismic events along with neighboring communities. As part of the WSMP, the City will finalize level-of-service goals related to its supply resiliency. The draft recommendations from the study by SEFT (subconsultant to HDR for the WSMP) focus on seismic hardening of its existing water system backbone infrastructure and critical facilities. However, the recommendations do not preclude developing interties with neighboring communities, or investments in new supply development in Big Creek or Youngs River to address resiliency goals over the long-term.

3.5 Water Use Permit Management Options

Four water use permit management options have been identified for the Big Creek and Youngs River water rights. Key considerations for each option are described below.

1. Monitor the ongoing application for extension of time. The City filed extension applications for its permits in 2005 and 2006, and it is unclear when OWRD will complete processing of the applications. No action by the City is required for OWRD to complete its review of the City's extensions and having the permit extension applications pending essentially provides the City with a base level of "protection" for the permits without having to actively manage or incur additional costs. The permits will not be cancelled while the applications are pending, and OWRD would not expect the City to develop the permits during this time. The drawback to just waiting for the extensions to be processed without communicating with the agencies is that the City will not have an opportunity to potentially improve the outcome of the process, and ODFW's "fish persistence" conditions will likely significantly diminish the City's access to water under its permits.

2. Actively engage with ODFW. Engaging with ODFW is an opportunity for the City to potentially retain access to more water under its permits. The City can take a range of steps to engage with ODFW, including providing information or working cooperatively on creative conditions in the extension order. This option provides the City an opportunity to elevate engagement with the agencies (OWRD and ODFW) as concerns are identified:
    a. The City can communicate regularly (semi-annually or quarterly) with ODFW to understand their current timeline and any updates to their approach for fish persistence conditions. The City can increase to a higher level of engagement (e.g. moving on to option 2b below) if the City identifies a need or value.
    b. The City could be more proactive and hire a fisheries biologist to provide information that could improve the scientific basis for ODFW's "fish persistence" recommendations. The City could work with ODFW and develop an agreed upon approach to collect field data that would support developing flow targets using empirical data. This study could take on the order of one year to complete. As part of this option, the City could ask potential partners (other water districts) in the area to assist financially with these studies to support the extension process.
3. Cancel the permits. The City could indicate that it does not intend to develop the permits and OWRD could cancel the permits in response. This option is not recommended.
4. Sell or lease water user permits. The City could attempt to sell the water use permits, but the market may be non-existent due to the uncertainty of the use of the permits and difficulty establishing their value. The City could lease the rights through a contractual agreement and then consider selling them after the extension is complete, and after a water right certificate is issued when the water has been put to beneficial use.

3.6 Summary and Recommendations

At this stage, option 2a is recommended to actively monitor and assess the extension process by communicating regularly with OWRD and ODFW. This allows the City an opportunity to check-in with the agencies and determine if more active engagement is needed should opportunities for regional partnership or demands change for the permits.

3.7 Climate Change Adaptation

City staff have prepared an initial screening of potential impacts to City infrastructure due to climate change. While there are numerous impacts, it has been determined that water supply deficiencies during extended dry seasons, and increased landslide potential and erosion affecting water quality during wetter winter seasons are the main concerns. Any future sea level rise is not anticipated to affect the watershed. Severe windstorms have not resulted in major impacts to our watershed forest even when trees fell all over the northwest. The City will need to continue to monitor the health of its watershed forest as one possible climate change impact is forest quality degradation resulting from seasonal precipitation changes consisting of drier summers and wetter winters. Refer to the City's Forest Resources Management Plan for more details.

The City has approximately 100 years of documented history with drought resistance. The total storage capacity in the watershed system is approximately 380 MG. In 1977 (the driest winter for the 1931 to 1991 period of records), the City water supply was reduced to 57 percent of the storage capacity. An emergency was declared and an ordinance passed requiring city-wide mandatory water conservation. The City also had a water shortage in 1992, but storage volume data could not be found. Recently, in 2015 when the west coast of the United States was experiencing the worst drought in over 100 years, the City water supply was reduced to 74 percent of its storage capacity with no curtailment necessary.

Previous studies of the City's water supply indicate that the watershed has the ability to recharge the reservoir storage during the driest of years. The estimated recharge volume during the wet season is 1,860 MG, which far exceeds the 380 MG required to recharge a fully depleted storage capacity. The low storage levels of 2015 were recharged within weeks once the wet season began. Based on historical operation of the City's water system, it appears to be a very resilient system and forest management practices will play a large role in combating climate change. As the watershed forest matures and increases in complexity and volume, it is expected that what is referred to as the "rain pack" will become healthier and more resilient. The City has no ability or need, so far, to supplement with another water supply source.

City staff has served on a State Division of Land Conservation and Development (DLCD) workgroup responsible for developing a template to address climate change adaptation on the North Oregon coast. The workgroup was made up of staff from various federal, state, and local agencies. Having both a planning and public works representative on the team has provided a unique learning and collaboration opportunity. The workgroup prepared a model guideline deliverable titled "Climate Change Adaptation Framework (2017)" for developing individual Adaptation Plans for communities to prepare for climate change and develop long-term resilience. Using this document, the City's updated Natural Hazard Mitigation Plan (2021), and the AWWA's M71 Climate Action Plans (2021) resources, City staff is committed to monitoring potential impacts of climate change on the water system.

Chapter 4. Hydraulic Model Development

The previous master planning effort utilized a now obsolete distribution system hydraulic modeling software, Cybernet 3.0. The City elected to have HDR develop and calibrate a new hydraulic model using Innovyze's InfoWater Pro for this master plan. The model was developed based on principles outlined in AWWA's M32, Computer Modeling of Water Distribution Systems, Fourth Edition, 2018.

This chapter contains excerpts from the *Hydraulic Model Development Technical Memorandum* (Appendix E).

4.1 Model Development

The hydraulic model was developed using City-provided GIS data for its water system. Required data for creation of the model included water main diameter and length, customer billing records, ground elevations, and general operating characteristics of water system facilities (i.e., pump curves, water storage tank gauging tables, PRV settings). In addition to the above data, the model also required pipe roughness coefficients, or Hazen-Williams' C-values, which represent the relative internal condition of the water main. The C-values are used in the hydraulic calculation to determine pressure losses within the modeled pipe network. Water main roughness coefficients were estimated based on diameter, material, and installation date. Field observations of severe tuberculation within cast iron pipe were also incorporated into the roughness coefficient estimate.

4.2 Model Calibration

The hydraulic model was calibrated prior to using it to evaluate water system performance. Model calibration is the adjustment of model parameters so that the hydraulic model accurately simulates actual system performance. The calibration of the City of Astoria water system model was performed under steady-state simulations (micro-calibration). Without significant head loss, the hydraulic grade line of the entire water system can be relatively consistent which can result in an uncalibrated model appearing to closely represent observed system pressures. To effectively assess the level of accuracy of model predictions, it is important to stress the system and verify that the model will correctly represent these changes in hydraulic grade line at higher head loss. A stressed condition with high head loss, such as during a hydrant flow test, produces more meaningful comparisons between field measurements and model predictions.

Steady state model calibration data for the City of Astoria water system model used data obtained from 10 flow and pressure tests performed in June 2020. During each test, pressure data was collected at two hydrants near the flowing hydrant. City of Astoria water system operators performed the flow tests and provided SCADA data for the day of testing. Flow and pressure test results were used to verify the model simulates actual field conditions to a reasonable degree by comparing flows and pressures measured in the field with those simulated by the hydraulic model. During the model calibration process, pump status, PRV status, and reservoir water levels were set to match the field conditions. Pipe roughness coefficients were adjusted until the water system model adequately simulated field test data.

Precise duplication of the field test results at all locations within the water distribution system during steady state calibration of the computer model is unrealistic due to the many factors that influence field test results. Instead, the goal of steady-state calibration is to minimize the error between the field test data and the model simulations and create a “best fit” at all locations; therefore, some error between the field tests and model simulations is expected. However, the allowable error is limited to ensure the calibrated model is a reasonably accurate representation of the actual water distribution system.

While there are no universal calibration standards for water distribution system model calibration, the goal of calibration, and therefore the accuracy criteria, should be guided by the intended use of the hydraulic model. A model that is sufficiently calibrated for master planning, for instance, may not be sufficiently calibrated for water quality analysis.

For this analysis, the steady-state model calibration accuracy goal is ± 5 psi of the recorded pressure drop and ± 5 psi of the recorded static pressure prior to each flow test.

The steady-state model calibration simulations were performed to replicate results from the hydrant flow test data collected in June 2020. The following summarizes the field tests performed and modifications made during model calibration.

Initial roughness coefficients were assigned to water mains based on diameter, material, and installation date. Initial model results showed much higher system pressure during hydrant flow tests than was observed during field tests. This could be indicative of unknown closed or partially closed gate valves causing higher than expected system head loss. City operation staff have noted high amounts of tuberculation within some pipes resulting in a reduced capacity in those pipe sections. This was apparent in some flow tests, which indicate lower than expected roughness values for cast iron pipe. Roughness factors were adjusted, as needed, to account for this reduced capacity and improve the calibration of the model.

Most modeled flow tests are within calibration goals criteria for this project. However, discrepancies remain. Predicted results for some flow tests do not correlate well to observed data. The areas around these tests are heavily influenced by old cast iron pipe and could potentially have closed or partially closed gate valves on the nearby distribution mains. Additionally, some flow tests are influenced by the nearby PRV stations where PRV settings could have drifted from reported values and real losses through the PRV pit are unknown. Further data collection will be required to determine the exact cause of this discrepancy.

Hydrant flow test data and model calibration results are included in Appendix E.

4.3 Summary and Recommendations

The unknown conditions of the PRV stations (actual PRV set points and head losses through the pit during high flow conditions), known severe tuberculation within cast iron pipes, and potential for unknown closed or partially closed gate valves are heavily influencing the remaining discrepancies between the model and observed field data. Conservative adjustments to the modeled roughness values and PRV settings have been made for the model to be used for this master plan.

Further refinement of the model is recommended to provide continual improvement of model results. These refinements would include:

- Implement a valve exercising program that would provide many benefits including knowing the condition and status (closed/partially closed/broken) of gate valves throughout the water system. Valve turn records can also be correlated to pipe sizing.
- Verify PRV settings and conduct hydrant flow testing across each PRV station to capture headloss that occurs through each PRV station at varying flow conditions. With hydrant monitoring and SCADA during each PRV test, model input can be greatly improved.
- Investigate large water user patterns and update diurnal patterns as needed.
- Investigate typical operation of reservoirs and influence they have on the Skyline Tank.
- Once the above has been completed, perform additional system-wide hydrant flow tests and re-validate the hydraulic model.

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Chapter 5. Distribution System Analysis

Chapter 5 summarizes the findings from the evaluation and deficiency analysis of the existing City of Astoria water system. Water systems are analyzed, planned, and designed primarily by applying basic hydraulic and water quality principles and include:

- Location, capacity, and water quality of supply facilities
- Location, sizing, and elevation of storage facilities
- Location, magnitude, and variability of customer demands
- Water system geometry and geographic topography
- Minimum and maximum pressure requirements, both regulatory and level of service
- Land use characteristics with respect to fire protection needs
- Operation criteria that define the manner in which the system can be operated most efficiently

For this study, the evaluation determined the adequacy of the system to supply existing water needs and to supply water for fire protection purposes. The system was evaluated based on the following:

- Pressure
- Fire flow capacity
- Headloss and Velocity

The water system evaluation was based on compliance with Oregon Health Authority guidelines, City of Astoria Public Works Department Engineering Design Standards, and standard water industry engineering practice (AWWA 2008).

5.1 Water System Pressures

The City of Astoria water system hydraulic model was used to evaluate existing water distribution system characteristics and identify deficiencies with respect to water system pressures. Water system pressure varies greatly throughout the City due to differences in topographic elevations, user demands, and supply rates. In general, as water demand increases, water system pressure decreases. Areas higher in topographic elevation tend to exhibit lower water system pressures relative to lower topographic elevation areas within the same pressure zone.

Water distribution systems must be designed to provide pressure within a range of minimum and maximum allowable conditions. When system pressures are too low, water users may complain of inadequate water supply, and fire protection would be limited. Pressures that are too high can cause problems with system operation and maintenance and will tend to cause higher rates of water usage. High water system pressures have also been attributed to an increase in water loss, as leakage rates increase with increases in water system pressure.

AWWA's *Manual 32 – Computer Modeling of Water Distribution Systems, Fourth Edition* generally recommends a minimum system pressure of 35 psi during peak hour demand conditions (AWWA 2018). This value refers to the minimum pressure customers experience during normal system operation and ensures adequate pressure available for two-story buildings.

After reviewing historical SCADA data provided by the City and historical billing records, water system pressures vary depending on the operation of the Port of Astoria (Port), located in the Low Pressure Zone. Based on hourly SCADA data from June 2020, the Port typically operates during daytime hours using approximately 1,300 gpm. Billing records indicate an annual average day usage of approximately 170 gpm. When comparing these values to the average day demand of the rest of the water system (approximately 1.62 million gallons per day (MGD), or 1,120 gpm), the Port operation greatly influences system operations.

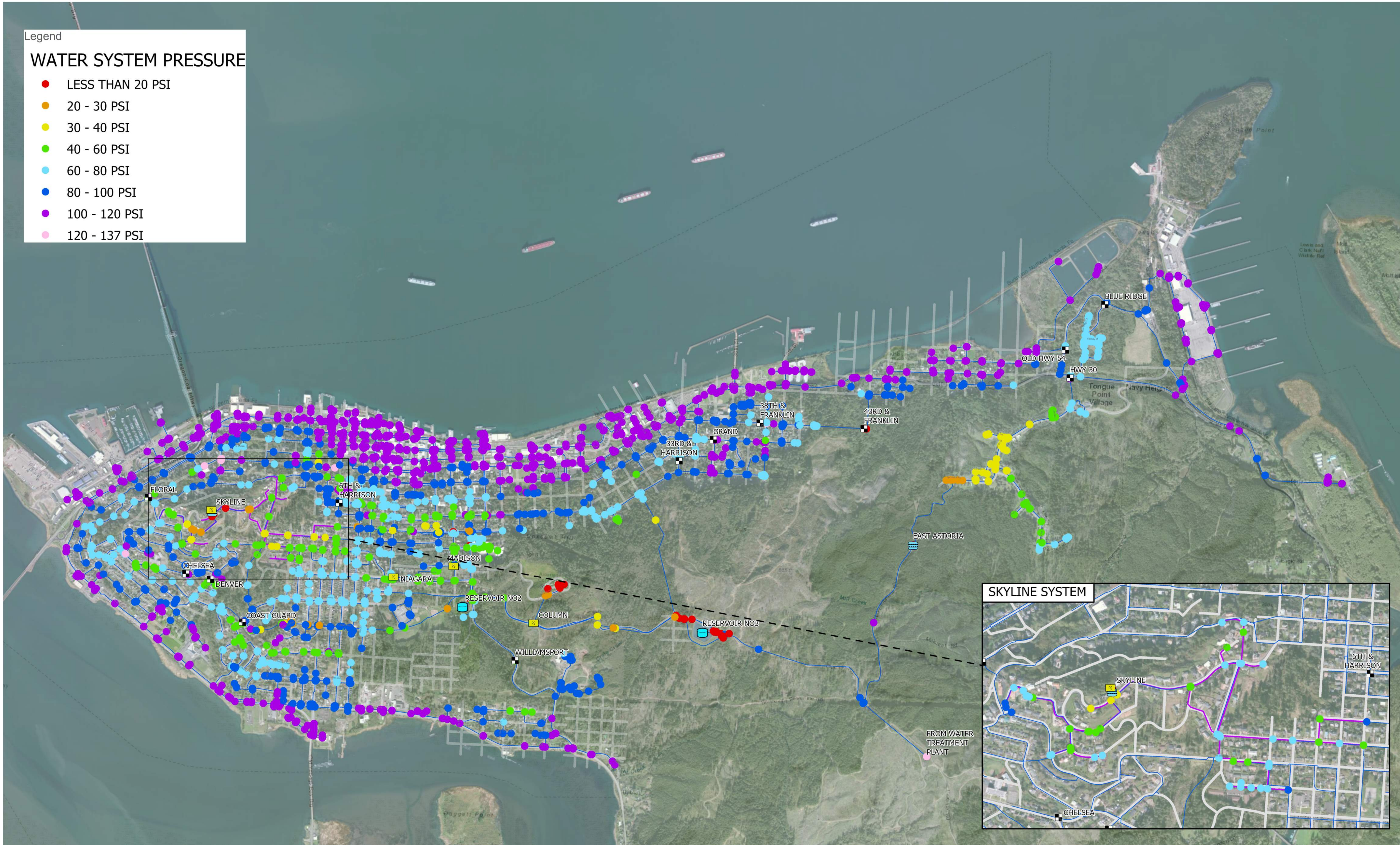
For the pressure evaluation, HDR reviewed three scenarios:

- Scenario 1: ADD without Port operating (Figure 5-1)
- Scenario 2: ADD with Port operating (Figure 5-2)
- Scenario 3: Peak hour demand with Port operating (Figure 5-3)

Table 5-1 provides a summary of the minimum and maximum pressures calculated by the model within each pressure zone.

Table 5-1. Summary of Pressure Evaluation

Pressure Zone	Scenario 1 Average Day Demand - Port of Astoria Not Operational	Scenario 2 Average Day Demand - With Port of Astoria	Scenario 3 Peak Hour Demand - With Port of Astoria
	Pressure Range (psi)		
Low	< 20 - 120	< 20 - 118	< 20 - 114
High	< 20 - 137	< 20 - 137	< 20 - 135
Skyline	32 - 87	32 - 87	32 - 87
Emerald Heights	< 20 - 109	< 20 - 109	< 20 - 109
Blue Ridge	66 - 113	66 - 113	66 - 113
Chelsea	66 - 71	66 - 71	66 - 71
Column	< 20 - 135	< 20 - 135	< 20 - 135
Floral	49 - 75	49 - 75	49 - 75
Madison	64 - 87	64 - 87	64 - 87
Niagara	71 - 72	71 - 72	71 - 72
Harrison	58 - 72	58 - 72	58 - 72



EXISTING WATER DISTRIBUTION SYSTEM - PRESSURE UNDER AVERAGE DAY DEMAND

Figure 5-1

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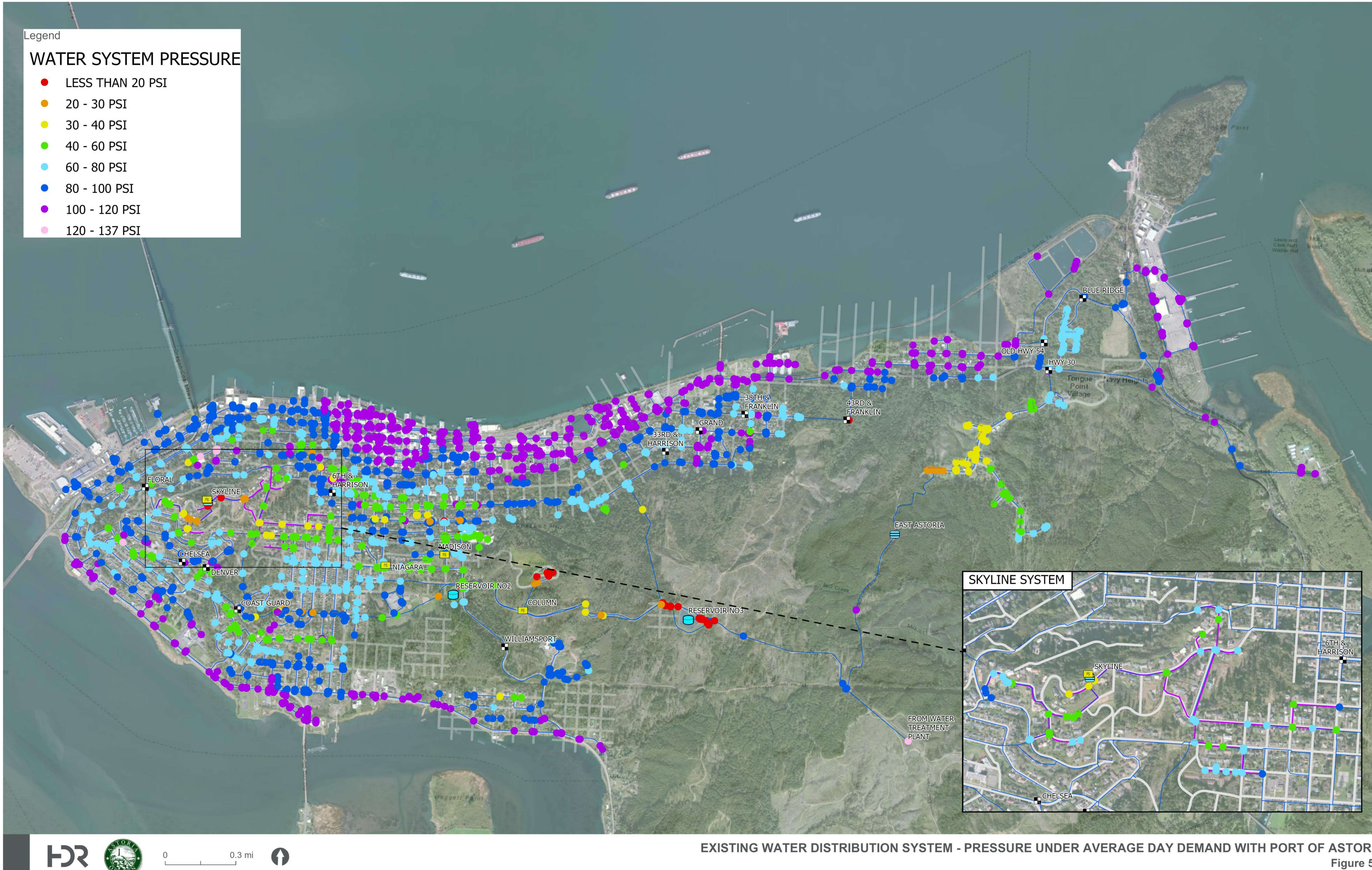

EXISTING WATER DISTRIBUTION SYSTEM - PRESSURE UNDER AVERAGE DAY DEMAND WITH PORT OF ASTORIA

Figure 5-2

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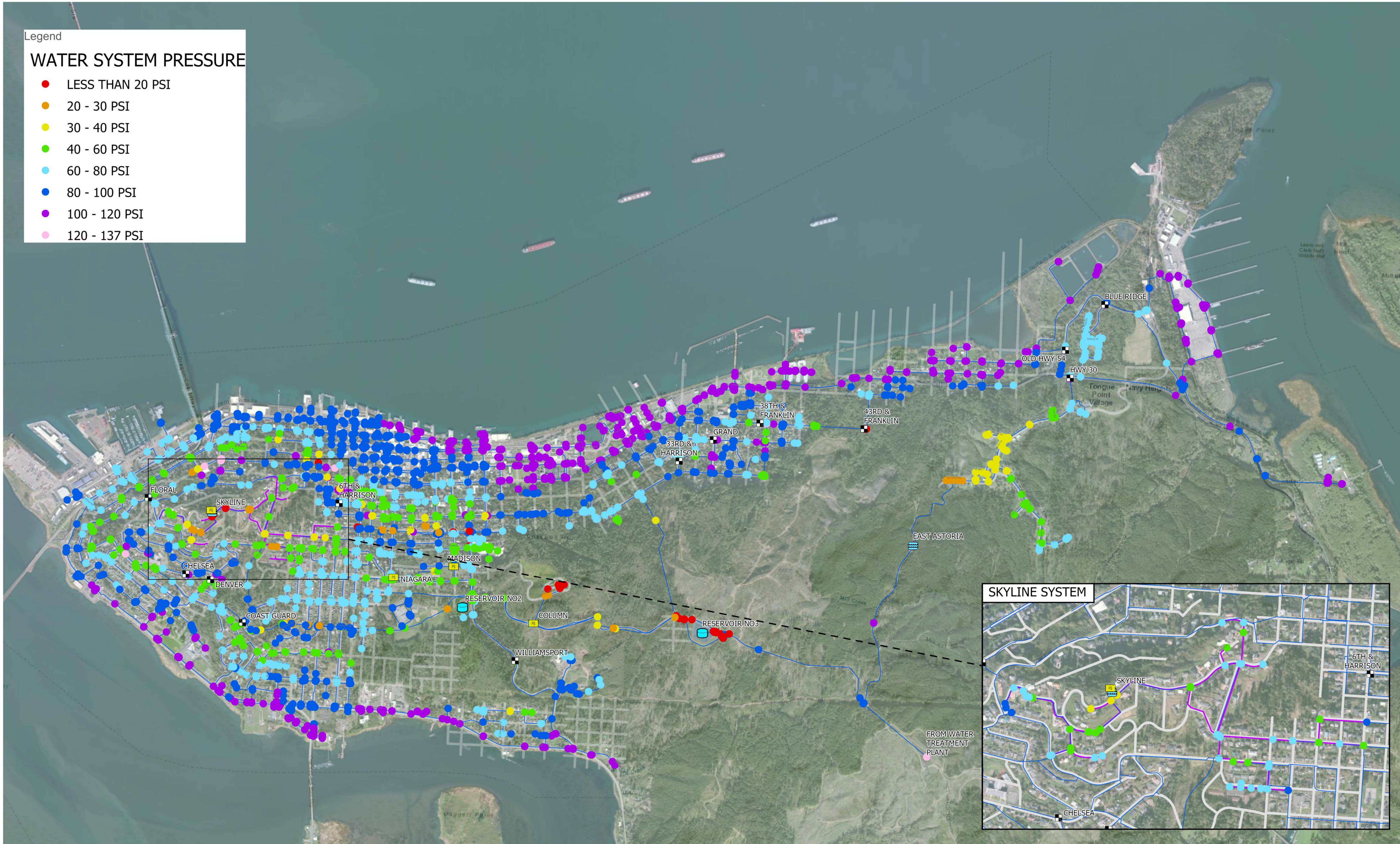

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EXISTING WATER DISTRIBUTION SYSTEM - PRESSURE UNDER PEAK HOUR DEMAND WITH PORT OF ASTORIA

Figure 5-3

System pressures within the Low Pressure Zone range from less than 20 psi to as high as 120 psi. The high pressures are observed near the waterfront as elevations drop to sea level. The low pressures under ADD conditions are observed along the transmission main that extends from Reservoir 2 down into the Low Pressure Zone. Under peak hour demand conditions, additional higher elevation areas near the pressure zone boundary experience pressures less than 20 psi. The model predicts there may be areas in the Low Pressure Zone near the pressure zone boundary with the High Pressure Zone where pressures may periodically fall to or below 20 psi. There are limited residential water service lines in these areas.

Due to the relatively large Port demands, in conjunction with the relatively low assigned C values for pipes within the Astoria water system, model-predicted pressure in the Low Pressure Zone near the Port drops by as much as 20 to 40 psi when the Port is operating.

System pressures within the High Pressure Zone range from less than 20 psi to as high as 137 psi. The high pressures are observed near the boundary with the Low Pressure Zone, where High Pressure Zone elevations are the lowest. The low pressures are observed along the Skyline ridge in the middle of the system where the Skyline Pressure Zone provides domestic service.

The Emerald Heights Pressure Zone regularly experiences pressures near 20 psi at the first service lateral off the transmission main.

In general, because the pressure zones supplied solely by pump stations or PRV stations maintain a steady system pressure under all three scenarios (e.g., the Skyline Pump Station maintains a steady 32 psi discharge under all three scenarios), the minimum and maximum pressures within those pressure zones will remain constant under all three scenarios.

5.2 Fire Flow Capacities

Water system planning for fire protection is an important consideration. In most instances, water main sizes are designed specifically to supply desired fire flows.

Fire protection needs vary with the physical characteristics of each building to be protected. For example, needed fire flows for a specific building can vary from 500 gpm to as high as 12,000 gpm, depending on habitual classifications, separation distances between buildings, height, construction materials, size of the building, and the presence or absence of building sprinklers. Municipal fire insurance ratings are partially based on the City’s ability to provide needed fire flows, up to a maximum of 3,500 gpm in most cases. If a specific building needs fire flows greater than this amount, the community’s fire insurance rating will only be based on the water system’s ability to provide 3,500 gpm.

For the City of Astoria, the 2019 Oregon Fire Code dictates fire flow requirements of 1,000 gpm for residential properties and 3,000 gpm for non-residential.

These fire flow requirements were used as the basis for evaluating the City of Astoria water system. While actual fire flow needed for specific buildings can be highly variable, the requirements illustrated herein are guidelines for evaluation purposes only.

Figure 5-4 illustrates the estimated fire flow requirements throughout the water system as determined by land use classification.

To evaluate the water system capacity to provide fire protection, the available fire flow throughout the water system was estimated using the hydraulic model.

Figure 5-5 and Figure 5-6 illustrate the available fire flow at each hydrant under maximum day demand while maintaining a residual system pressure of 20 psi throughout the water system when the Port is not in operation and when the Port is in operation, respectively.

Note that the illustrated available fire flow is not necessarily the amount of flow that can be obtained through a single hydrant, but rather the estimated flow that the distribution main can provide near the hydrant. One or more hydrants may need to be opened to obtain the available flow shown.

Figure 5-5 and Figure 5-6 also show the hydrant locations where fire flow requirements are anticipated to be met based on the requirements shown in Figure 5-4.

Table 5-2 shows the breakdown of modeled hydrant locations evaluated for each pressure zone containing hydrants.

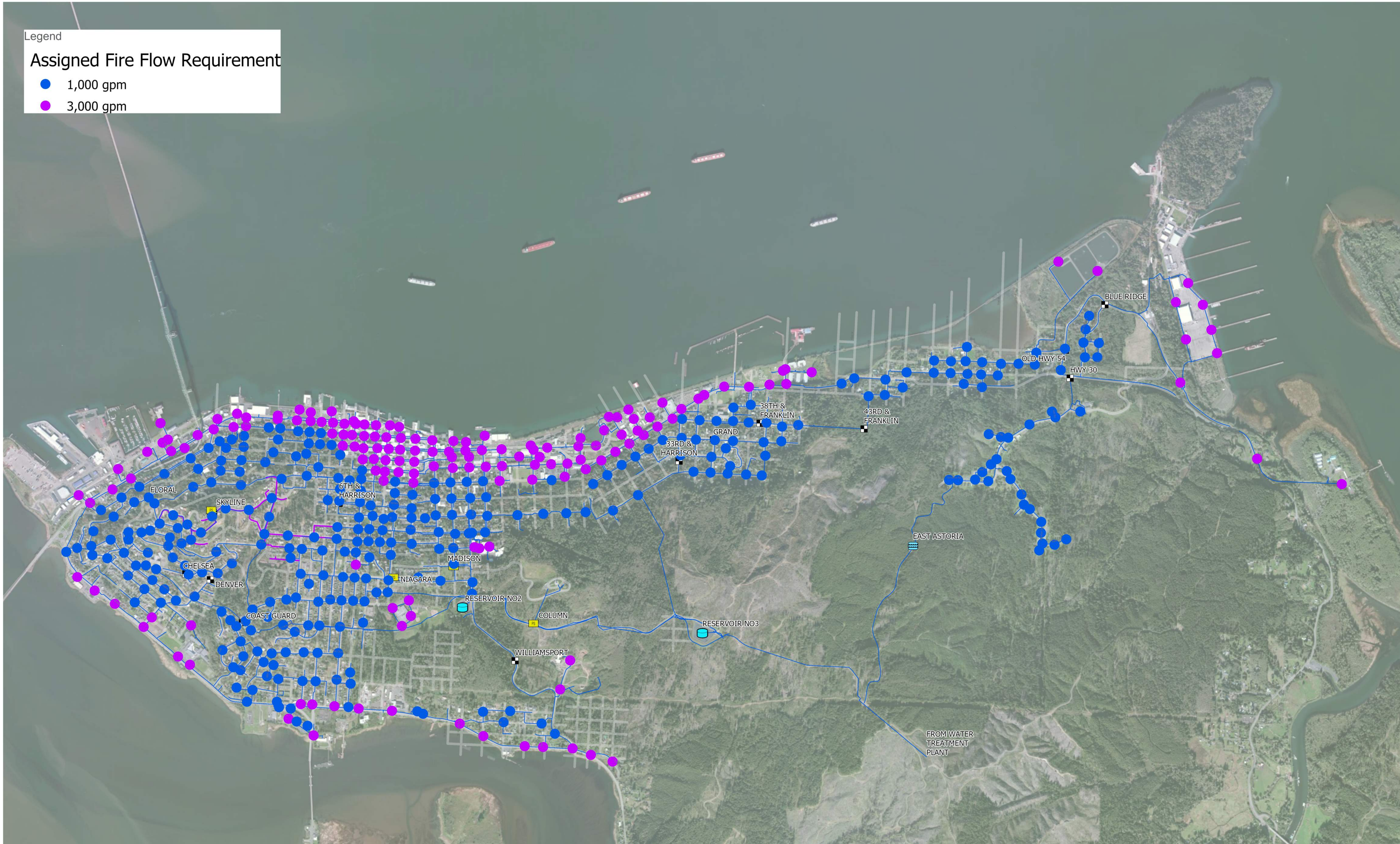
Table 5-2. Hydrants Evaluated for Available Fire Flow

Pressure Zone	Pass	Fail	Total	Pass Rate
High	71	55	126	56%
Low	109	203	312	35%

5.2.1 High Zone Discussion

Hydrants within the High Pressure Zone fail to meet the required available fire flow primarily due to dead end water mains, undersized water mains, high headloss water mains (low assigned C values), and a lack of a strong distribution backbone that is well-looped.

Multiple hydrants located in the West Grand region of the High Pressure Zone are limited in available fire flow due to the relatively high elevations near Hydrant 10-WG-H, located at West Grand and 1st Street. This hydrant is at a relatively high elevation within the High Pressure Zone with low static pressures which leaves minimal room for pressures to drop during fire flow conditions. Many hydrants near Hydrant 10-WG-H may provide more than the illustrated flow on Figure 5-5 if tested in the field. However, Hydrant 10-WG-H and more importantly the surrounding buildings, would experience pressures below 20 psi.



EXISTING WATER DISTRIBUTION SYSTEM - FIRE FLOW REQUIREMENTS BASED ON LAND USE

Figure 5-4

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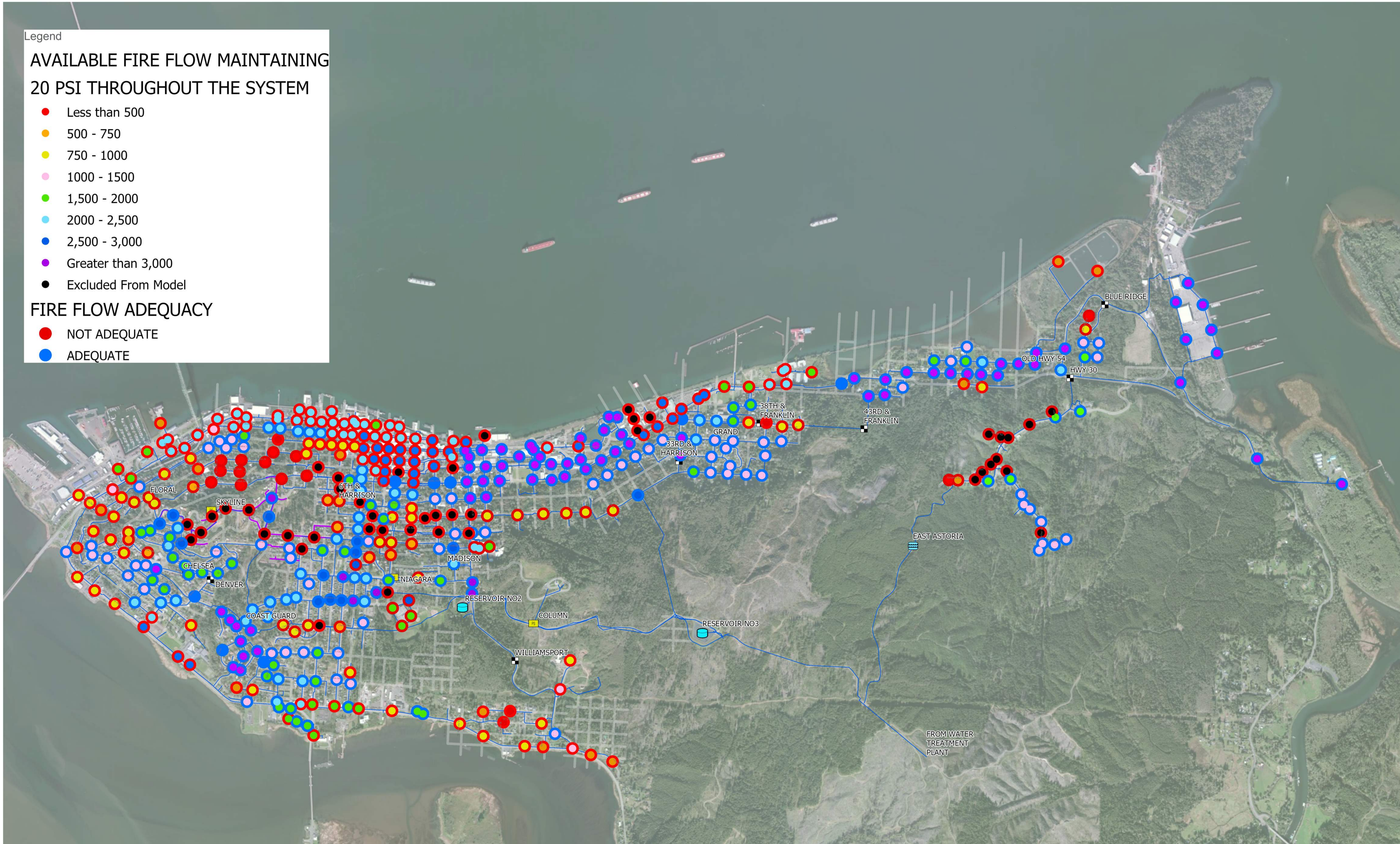

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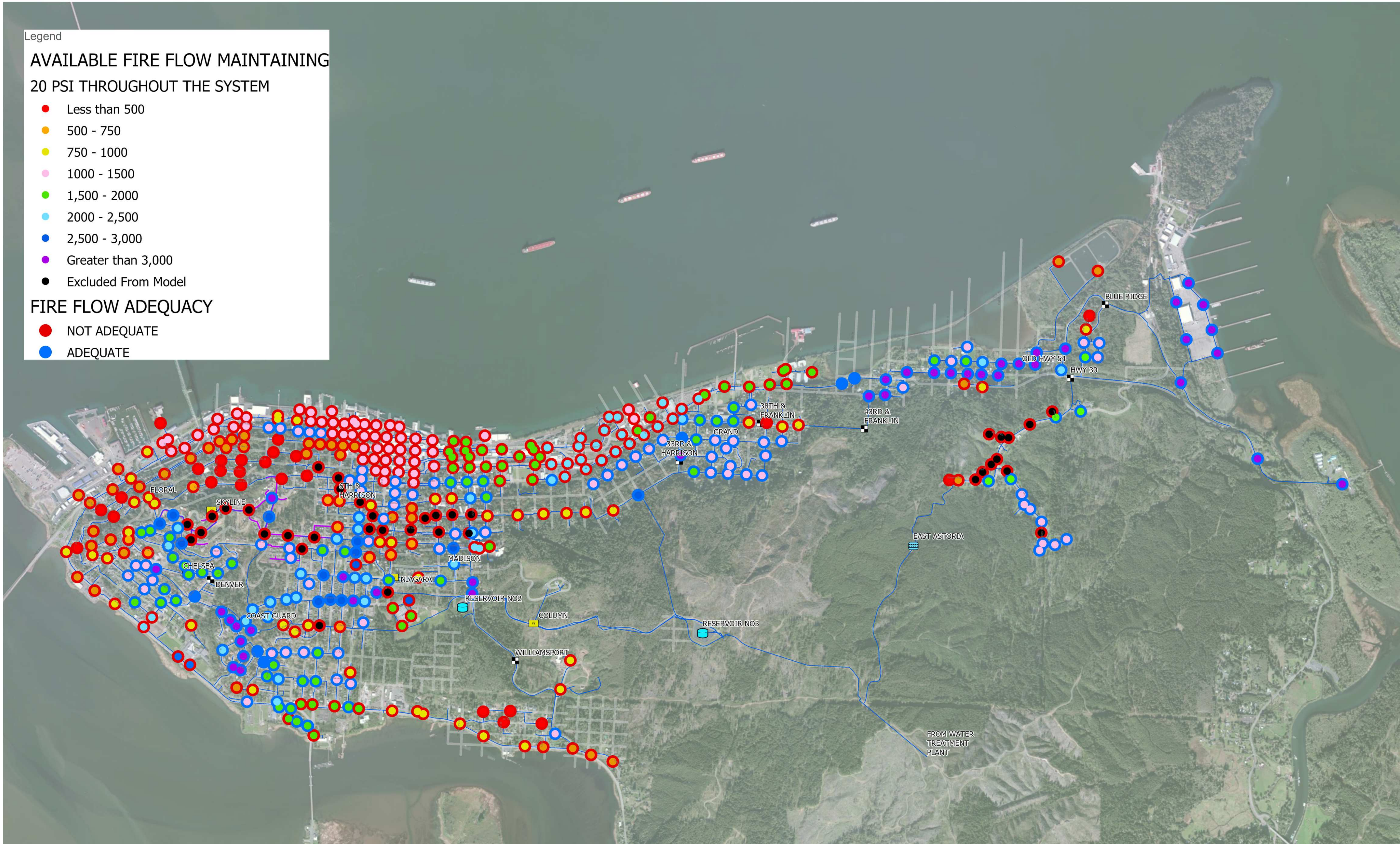
EXISTING WATER DISTRIBUTION SYSTEM - AVAILABLE FIRE FLOW UNDER MAXIMUM DAY DEMAND WITHOUT PORT OPERATION AND ADEQUACY

Figure 5-5



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EXISTING WATER DISTRIBUTION SYSTEM - AVAILABLE FIRE FLOW UNDER MAXIMUM DAY DEMAND AND ADEQUACY

Figure 5-6

Another area of the High Pressure Zone predicted to have less than the required available fire flow is the area including hydrants east of the 33rd & Harrison PRV Station, and west of the 43rd & Franklin PRV Station. The hydrants in this area are restricted for multiple reasons. First, the 18-inch tunnel transmission main and associated 14-inch and 12-inch distribution mains convey most of the water in this area connecting to the 43rd & Franklin PRV Station with minimal looping. These distribution mains were installed in the early 1900s and the model predicts high headloss through these pipe segments during fire flows resulting from low assigned C values. The low C values were assigned as a result of assumed high levels of tuberculation. Second, the 12-inch cast iron water main running from Hydrant 3994-FR-H east to the 43rd & Franklin PRV Station passes through elevations higher than the surrounding area which results in a small area of low static pressures. During fire flow conditions, this area becomes the critical point for all hydrants in the area, dropping to 20 psi fairly quickly in conjunction with the first point of high headloss. Additionally, areas west of the 18-inch tunnel transmission main are unable to meet the required fire flow due to the undersized 6-inch distribution main in this area.

This analysis excluded water mains near the Skyline Pumped Pressure Zone. Hydrants in this area are not part of the pumped zone and the model indicates that hydrants near the pumped zone have static pressures near 20 psi due to the relatively high elevations in this area. The low static pressures in this area cause artificially low available fire flow estimates in the rest of the High Pressure Zone and therefore were excluded from the analysis.

5.2.2 Low Zone Discussion

The model predicts that a number of areas within the Low Pressure Zone are unable to meet the available fire flow requirements. These areas create distinct regions of the water system and are discussed individually below.

In general, the hydrants along the western waterfront within the Low Pressure Zone are unable to provide the required fire flows due to multiple interrelated factors. First, a hydraulically well-connected backbone distribution main along the waterfront does not currently exist. Although there are areas fed by a 12-inch water main, most pipe in this area is six inches or less in diameter. Second, the distribution mains in this area likely have a relatively low assigned C value which creates higher than anticipated headloss during high flow conditions. Third, many dead end water mains exist due to the topography of the area. Any one of these three issues could create cause for concern in isolated areas of any water system, but together these issues are causing a majority of hydrants along the waterfront to be unable to meet needed fire flows.

A similar but somewhat different issue occurs on the northern waterfront area. A stretch of water main near Jerome Street between 8th Street and 16th Street connecting to the 18-inch transmission main from Reservoir 2 is limiting the available fire flow to the northern waterfront area. Low static pressures in this area result in many of the hydrants along the northern waterfront providing lower than anticipated fire flows. The model predicts that high headloss through the18-inch and 14-inch transmission mains supplying water to the Low Pressure Zone from Reservoir 2 is contributing to the low static pressure in the area.

The area south of the Williamsport PRV Station is unable to meet fire flow requirements due to the high elevation served along SE 3rd Street. Relatively low static pressures combined with the linear nature of water supply to this area result in low available fire flow while maintaining 20 psi. Even if service along SE 3rd Street in this area was excluded, hydrants would remain unable to meet the required fire flow indicating another challenge in this area. The 6-inch cast iron pipe along Highway 202 to the west of this area was identified as a significant bottleneck for flow to this area from 11th Street and Olney to 7th Street and Clatsop. City staff investigated the Williamsport PRV station in early 2021 and determined the pressure gauge was out of calibration. The gauge was replaced, however exact flow and pressure available through the Williamsport PRV Station is unavailable at this time.

Finally, another existing 6-inch water main connected to the 12-inch water main at the intersection of Clatsop and 7th Street extending south approximately 600 feet to the intersection of McClure and 7th Street was identified as a bottleneck. This is due to the limited looping connecting this area to the 12-inch water main connecting to Reservoir 2 which forces most of the flow down this 6-inch water main. Additionally, the model predicts excessive headloss in this water main.

5.2.3 All Other Zones Discussion

The model predicts that hydrants within the Emerald Heights Pressure Zone do not meet the 1,000 gpm residential fire flow requirement due to the long dead end water mains and low static pressures in the area. For example, the first hydrant on the transmission main coming down from the East Astoria Tanks is estimated to have a static pressure of just below 30 psi. Note: a number of the inadequate hydrant flows in this area are on private water mains.

In the Floral Pressure Zone, the model predicts that a few hydrants cannot provide the needed fire flow without pressure dropping below 20 psi at Hydrant 10-WG-H, located at West Grand and 1st Street. This hydrant is at a higher elevation within the High Pressure Zone with low static pressures resulting in limited available fire flow to the area.

5.3 Headloss and Velocity

The hydraulic system analysis also evaluated the distribution system network for water mains that are at or near capacity. High velocities or high headlosses are indicators of potential capacity problems. American Water Works Association *Manual 32 – Computer Modeling of Water Distribution Systems*, *Fourth Edition* provides the following guidelines for maximum recommended limits of pipe headloss and velocity:

- All pipe velocities should be less than 4 to 6 feet per second (fps) during normal operation.
- All pipes less than 16 inches in diameter should experience less than 5 to 7 feet per 1,000 feet of headloss during normal operation, and pipes greater than or equal to 16 inches in diameter should not exceed 2 to 3 feet per 1,000 feet of headloss.

Excessively high headloss and velocity could contribute to low system pressure, low available hydrant flows, or increased energy costs on a water system. Pipes with high velocities could also be more vulnerable to transient flows.

Model results show that multiple pipes within the water system do not meet the headloss guidance stated above. In general, these pipes are undersized and/or have low assigned C values (i.e., heavily tuberculated), resulting in excess headloss. While most pipes had modeled velocities below the velocity guideline, some of the pipes with high headlosses also experienced velocities that exceed the guideline.

Figure 5-7 illustrates system areas where the model predicts high headloss under peak hour conditions.

5.4 Analysis of Water System Improvements

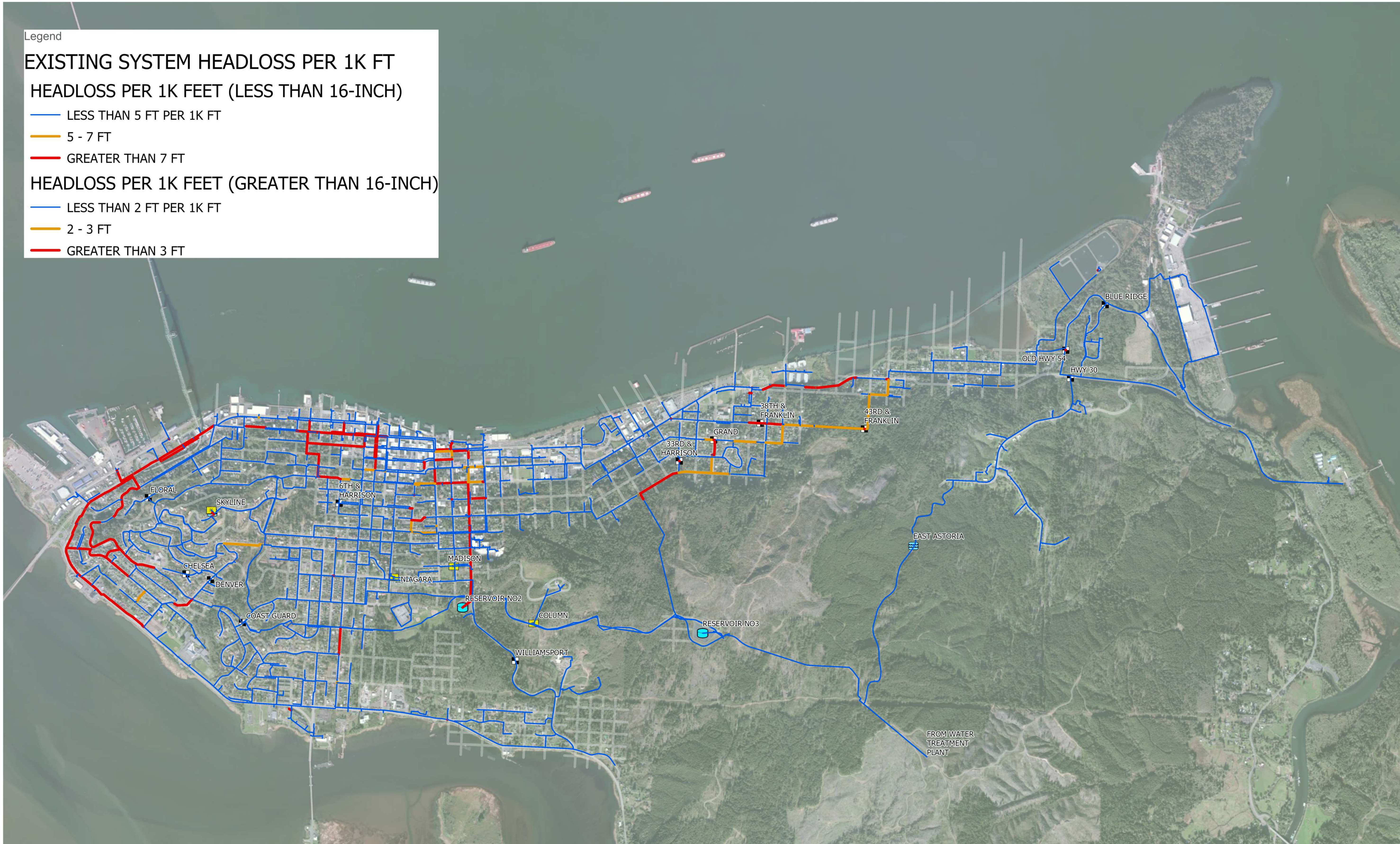
Proposed improvements were evaluated to address the existing system deficiencies and increase overall water system operation. The recommended Capital Improvement Plan (CIP) has been developed as a tool to guide the City in the siting and sizing of future system improvements. Because the proposed plan serves as a snapshot in time and represents the current knowledge, future changes in land use, water demands, or customer characteristics could substantially alter implementation of the plan. For this reason, it is recommended that the plan be periodically reviewed and updated using City planning information to reflect the most current projections. As Port operation greatly influences system performance, their usage should continue to be monitored, evaluated, and updated in the hydraulic model as appropriate.

This improvement plan should be used as guidance that details existing conditions and recommendations for the future. The plan is based on future conditions as perceived in 2020 based on available information. As time progresses and proposed improvements are implemented, new information and events will shape development of the water system. Therefore, the plan must be dynamic; it should be studied and used but also adjusted to address future changes and knowledge that will come with time.

The improvement plan presented in this section focuses on the main components listed below:

- Pipe Rehabilitation
- PRV Station Optimization
- Pipe Replacement
- Pressure Zone Realignment

The improvement plan was created to address deficiencies noted in the existing system evaluations.



EXISTING WATER DISTRIBUTION SYSTEM - HEADLOSS PER 1K FEET
Figure 5-7

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5.4.1 Pipe Rehabilitation

During the calibration process, many of the pipes throughout the water system were assessed as heavily tuberculated resulting in lower than anticipated C values. This tuberculation can negatively affect a water distribution system by creating lower system pressures, excessive headloss within pipes, lower than expected fire flows, and potential water quality issues.

One suggested pipe rehabilitation effort is to implement a Unidirectional Flushing (UDF) Plan. Unidirectional Flushing is the process for cleaning water distribution system pipelines by flowing relatively cleaner water in one direction through mains starting from a source and moving systematically through the water system. A properly constructed UDF plan increases the velocity of water in the mains, which increases the shear stress near the pipe wall and has been shown to improve water quality and restore pipe capacity. By strategically closing valves and flushing certain hydrants, scouring velocities greater than five feet per second within pipe segments can be achieved. It is also known that a proper UDF plan uses less water than a conventional flushing plan, and actively removes sediment, tuberculation, and biofilm from the system as opposed to moving these products from one pipe segment to another.

A holistic pipe rehabilitation/cleaning program created and implemented by the City of Astoria is recommended. A properly implemented UDF plan can restore system disinfectant residual, reduce bacterial regrowth, dislodge biofilm, remove sediment and deposits, and restore system capacity, all of which potentially prolong the water system's life expectancy. Regular flushing also helps by routinely assessing and field testing the water system assets. Data collected during these efforts can support further calibration of the model and lead to a better understanding of system dynamics.

5.4.2 PRV Station Optimization

The area south of the Williamsport PRV Station was identified as deficient in fire flow for two main reasons: undersized water main to the west along Youngs Bay, and low static pressures along SE 3rd Street. Based on the available data at the time of this project, the HGL setting for the Williamsport 8-inch PRV is approximately 240 feet HGL, which is approximately 40 feet HGL lower than the Reservoir 2 HGL. Due to this, the model predicts that the Williamsport PRV Station is only operational during periods of high flow in the area south of the Williamsport PRV Station. The model predicts that fire flows south of the Williamsport PRV Station could improve if the setting of the dual PRVs was raised. However, extensive flow testing across each PRV Station was not conducted as part of this project. Field verification of this model prediction should occur prior to changing any PRV set points. Additional capital projects may be required depending on field findings. A brief preliminary investigation by the City found the pressure gauges within the Williamsport PRV Station to be out of calibration.

Comprehensive testing at each PRV Station by the City is recommended to confirm available flow and pressure, as well as existing set points, and determine future set points for each PRV Station to optimize fire flows and static pressures in that area. Additionally, PRV stations with little added value can be identified and taken offline to reduce continued maintenance costs. The City has already begun assessing PRV stations, starting with the Williamsport PRV mentioned previously in this chapter.

5.4.3 Pipe Replacement – Short-Term

Short-term water distribution system improvements have been identified that would improve the available flows throughout the system, provide reliability, and efficiently convey flow from the reservoirs into the system.

Figure 5-8 illustrates the short-term recommended water distribution system improvements while Table 5-3 provides a summary of the improvements. As of January 2021, the City has proactively started to investigate Segment B.

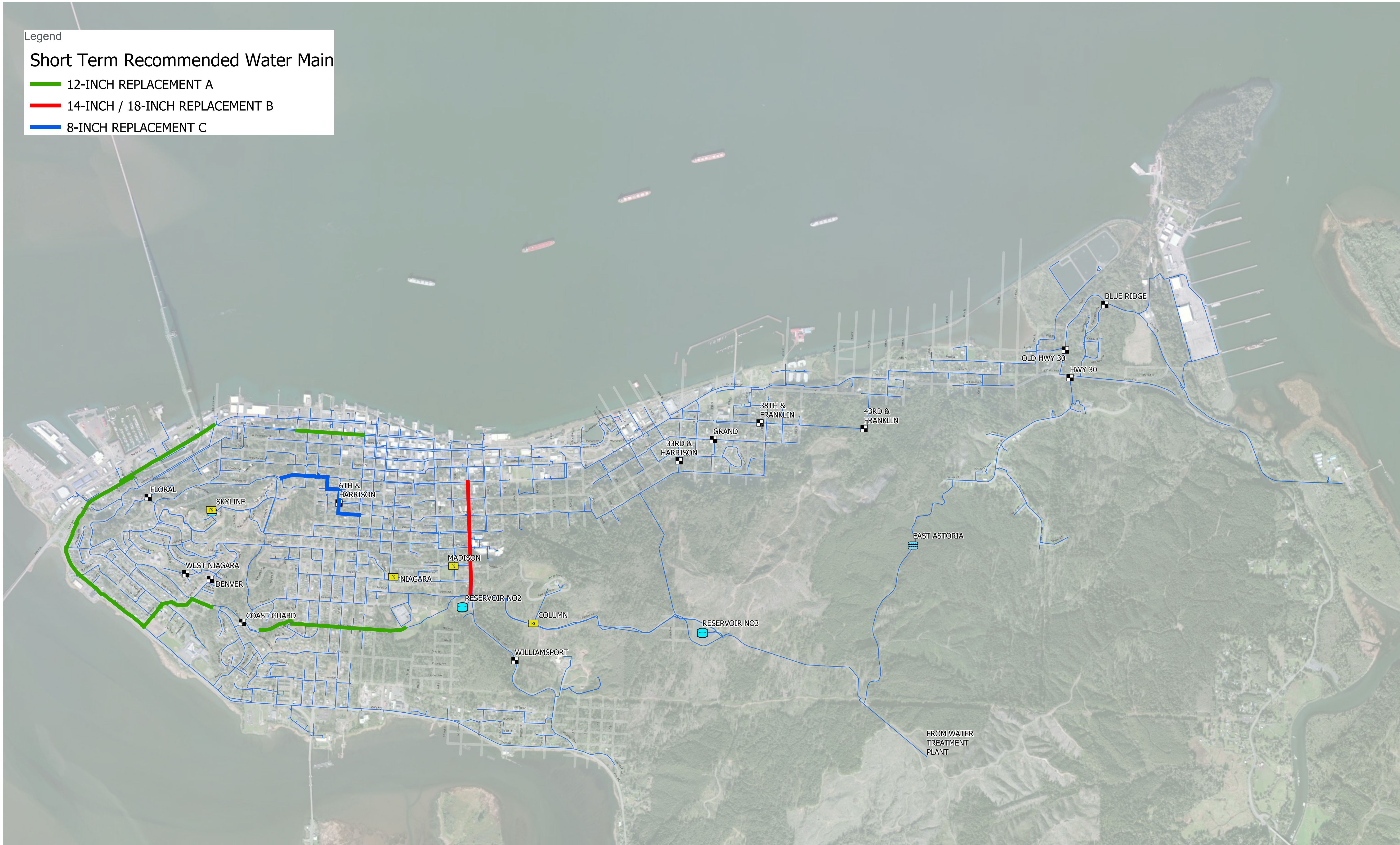
Table 5-3. Summary of Short Term Recommended Water Distribution System Improvements

Replacement Segment	Diameter	Approximate Length	Pressure Zone	Recommendation	Reason for Improvement
A	12-inch	13,750 feet	Low	Replace undersized and old segments of water main along the west waterfront to complete a looped transmission main in the Low Pressure Zone.	Improve available fire flow to a large portion of the Low Pressure Zone along the west waterfront.
B	14-inch/ 18-inch	1,100 feet/ 1,400 feet	Low	Replace the 18-inch and 14-inch transmission main segments from Reservoir 2 extending north to the 8-inch water main at Franklin and 16th Street.	Address excessive headloss during high flow conditions. Existing water main is beyond reasonable useful life expectancy.
C	8-inch	2,600 feet	High	Replace undersized water main extending from the intersection of Irving and 8th Street west to the intersection of West Grand and 1st Street.	Improve fire flow and static pressures to an area that is hydraulically isolated due to undersized/old water main.

5.4.3.1 Evaluation of Short-Term Improvements

Evaluation of the water distribution system for fire protection was repeated with the short-term recommended water distribution system improvements to confirm their effectiveness for the future flow conditions.

Figure 5-9 illustrates future fire flow adequacy with the recommended short-term improvements. The percentage of hydrants that are able to meet the required flow improves to approximately 75 percent from the originally predicted 35 percent in the Low Pressure Zone and improves to 86 percent from the originally predicted 56 percent in the High Pressure Zone. The remaining hydrants that cannot meet the required flow should be evaluated on an individual basis for long-term improvement.



RECOMMENDED SHORT TERM IMPROVEMENTS
Figure 5-8

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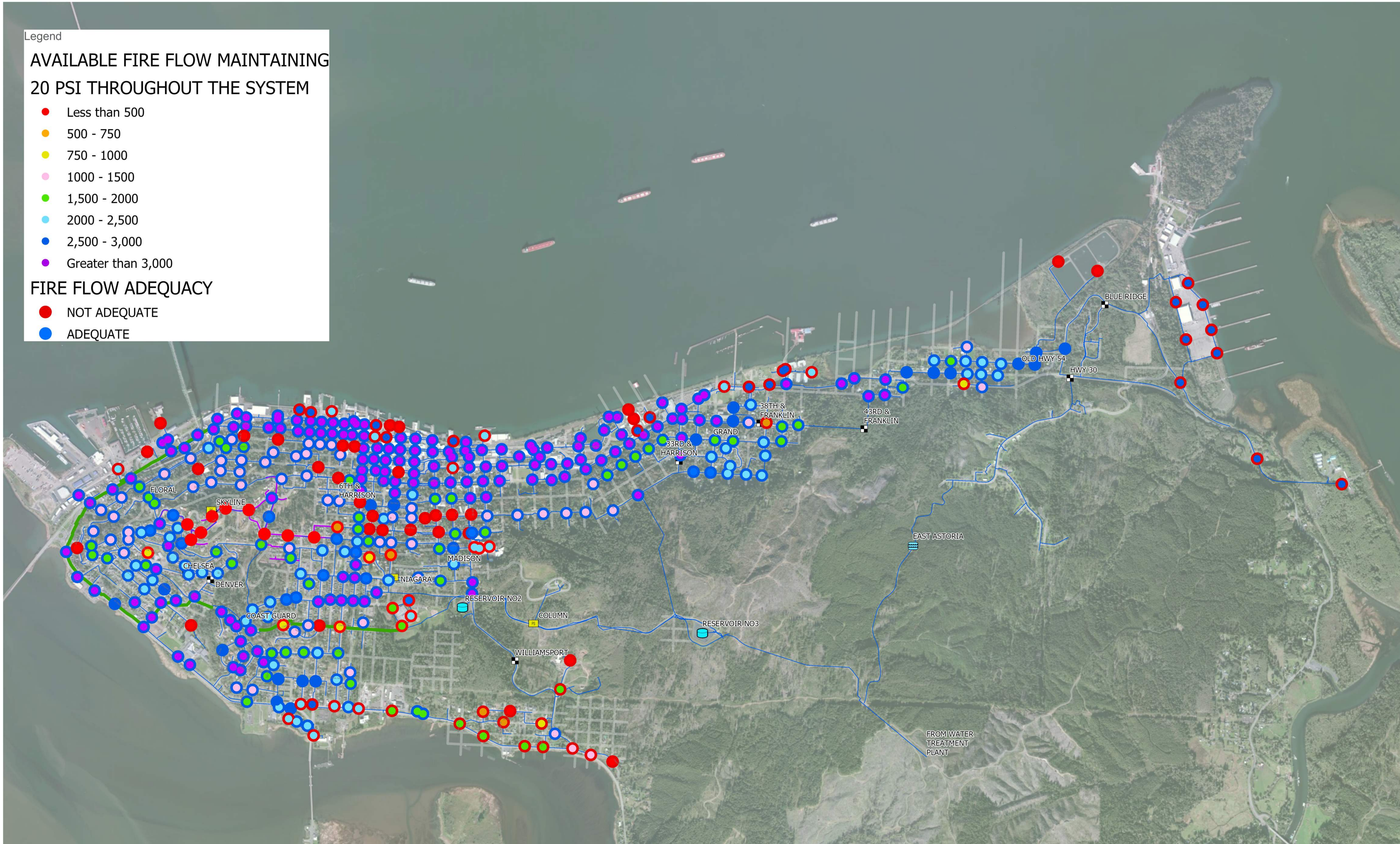

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FUTURE WATER DISTRIBUTION SYSTEM - AVAILABLE FIRE FLOW UNDER 2040 MAXIMUM DAY DEMAND AND ADEQUACY - SHORT TERM IMPROVEMENTS

Figure 5-9

5.4.4 Pipe Replacement – Long-Term

As the water system continues to age and degrade, consideration should be made for those pipes which are older and have reached their reasonable useful life expectancy.

A priority list of the long-term improvements for the local distribution mains was not included in this analysis as the City should consider the cost, complexity, practicality, and feasibility of these improvements on a case by case basis before implementation. To make progress in achieving these long-term goals, instituting a water main replacement program is recommended for the City to effectively replace approximately one percent of the water distribution system per year.

5.4.5 Pressure Zone Realignment

The possibility of shifting the pressure zone boundary in the Low Pressure Zone to incorporate areas of relatively high elevation back into the High Pressure Zone was reviewed. At this time, the newer 10-inch water main located on Jerome Street was found to convey a good portion of the flow to that area of the Low Pressure Zone. Any shifting of pressure zone under current conditions in this area would reduce the overall fire flow to the north waterfront area as much of the remaining pipe network is undersized or thought to be severely corroded.

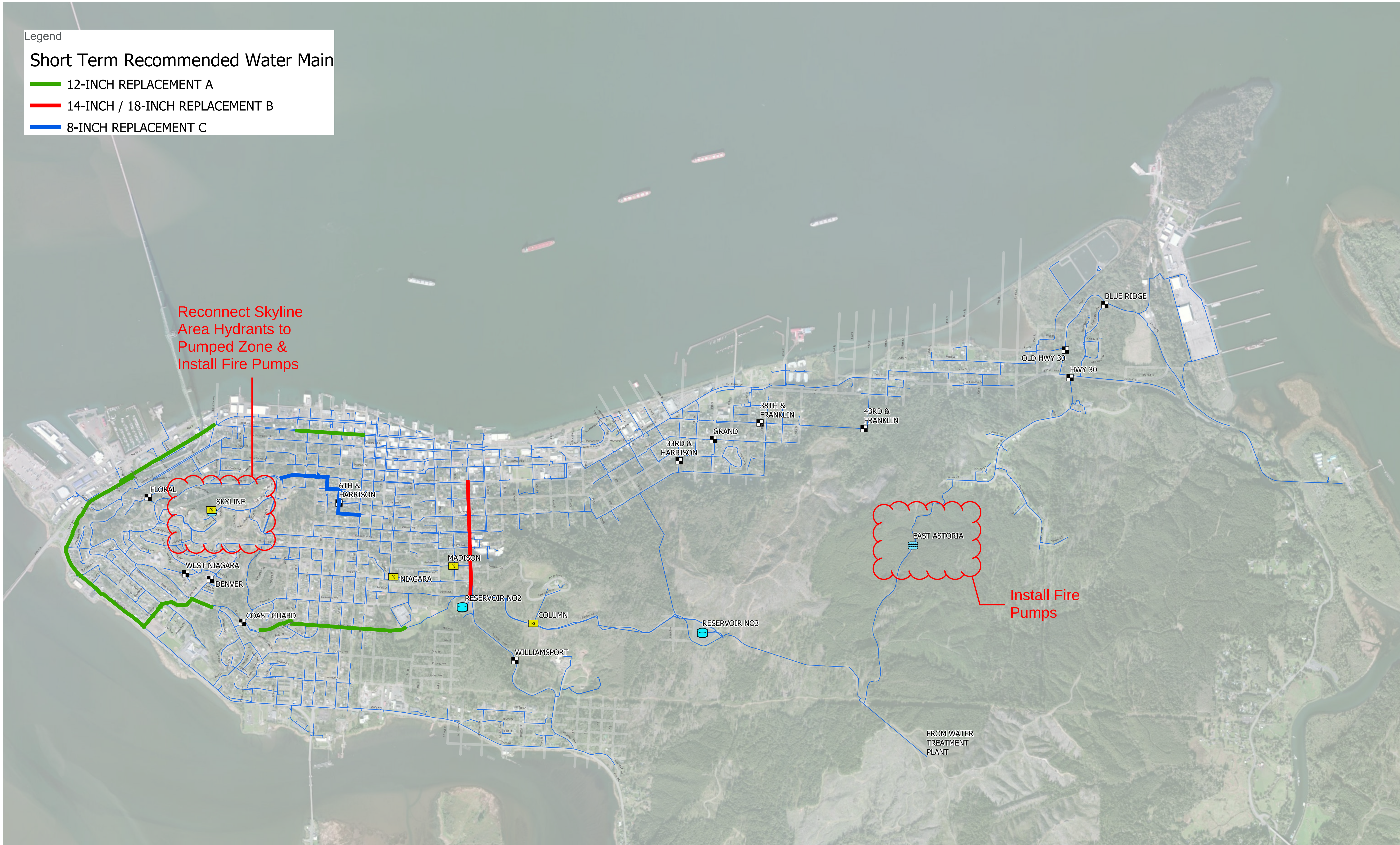
As the CIP is implemented and the north waterfront area pipes are replaced/rehabbed, pressure zone realignment should be considered and areas of higher elevation (low pressure) within the Low Pressure Zone should be transferred to the High Pressure Zone where possible.

5.5 Recommended Distribution System Improvements

The proposed distribution system CIP, as illustrated in Table ES 3, has been formulated based on the information presented in this study. The listed improvements have been developed and prioritized based on the deficiencies identified in the water system analysis. Figure 5-10 illustrates the recommended CIP for the City of Astoria water distribution system.

Table 5-4. Recommended Distribution System Improvements

Recommended Improvement	Timeframe
Project to improve fire flow at Skyline	Short-term
Replace 12-inch west waterfront	Short-term
Replace 8-inch in High Pressure Zone near Skyline	Short-term
Install fire pump at East Astoria Tanks	Short-term
Replace approximately 1,100 feet of 14-inch and approximately 1,400 feet of 18-inch transmission main from Reservoir 2 to Low Pressure Zone	Short-term
Water Main Replacement Annually 1 percent (approximately 4,200 feet per year)	Long-term



Water Distribution System - Capital Improvement Plan

Figure 5-10

To improve overall system efficiency, longevity, and operational ease, the following operation and maintenance recommendations are suggested:

- Unidirectional Flushing Plan:
    - The City of Astoria should create and implement a holistic pipe rehabilitation/cleaning program. A properly implemented UDF plan can restore system disinfectant residual, reduce bacterial regrowth, dislodge biofilm, remove sediment and deposits, and restore system capacity, all of which potentially prolong the water system's life expectancy.
- PRV Station Optimization:
    - The City should conduct comprehensive testing at each PRV Station to confirm available flow and pressure, as well as existing set points, and determine future set points for each PRV Station that would optimize fire flows and static pressures in that area. Additionally, PRV stations with little added value can be identified and brought offline to reduce continued maintenance costs.
- Pressure Zone Realignment:
    - As the CIP is implemented and the north waterfront area pipes are replaced/rehabilitated, pressure zone realignment should be considered and areas of higher elevation (low pressure) within the Low Pressure Zone should be transferred to the High Pressure Zone where possible.

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Chapter 6. Finished Water Storage

6.1 Existing Storage Facilities

The City's present system includes five storage facilities located in the City (Table 6-1). All water entering the City's distribution system from the transmission pipeline is directed into Reservoir No. 3, a large, covered, Hypalon-lined reservoir. Reservoir No. 3 can store 20 MG with a surface area of approximately 130,000 square feet. Water from this reservoir serves customers in the High Pressure Zone but is also able to serve the Low Pressure Zone through various PRV stations.

Some Reservoir No. 3 water is directed to the lower elevation Reservoir No. 2. Reservoir No. 2 is also a covered, Hypalon-lined reservoir that can store 5.5 MG with a surface area of approximately 70,000 square feet. Water from this reservoir serves customers in the Low Pressure Zone.

The third storage facility is the Skyline Tank and Booster Station. The Skyline Tank, installed in 2006, is a 130,000-gallon (nominal) cylindrical tank that serves a small residential area that is too high to be served by Reservoir No. 3. Water is pumped from the Skyline Tank to serve customers in the Skyline Pressure Zone. This factory-coated bolted steel tank (AWWA D103) is approximately 28 feet wide and 29 feet tall (plus an additional 6 feet for the sloped roof). The tank was designed and manufactured by Engineered Storage Products Company/Aquastore and provided with a glass-fused-to-steel coating.

The Skyline Booster Station is located on the same site as the Skyline Tank. The SCADA system that supports operation of the tank is located in the booster station. Emergency power for the SCADA system is provided by a generator located in the booster station. The booster station contains three 5 horsepower pumps that each have a pump rate of 140 gpm. Fire hydrants in the Skyline Pressure Zone are not connected to the pumped Skyline Tank system but to the distribution network fed by Reservoir No. 3.

Finally, the East Astoria Tanks consist of two 150,000-gallon (nominal) cylindrical tanks that were constructed in 1998. The tanks support the Emerald Heights area on the east side of the City of Astoria's service area and enhance the City's ability to provide water for fire suppression near the tanks. These conventionally reinforced concrete tanks have an interior diameter and height of 30 feet. The overflow elevation limits the maximum height of retained water to 29 feet, leaving 1 foot of freeboard. However, the City indicated they typically operate the tanks with a maximum height of retained water between 27 and 28 feet.

Table 6-1. Astoria Storage Facilities

Facility	Volume (MG)	Primary Pressure Zone Served
Reservoir No. 3	20.0	High Zone [a]
Reservoir No. 2	5.5	Low Zone
Skyline Tank	0.13	Skyline Zone
East Astoria Tanks	0.30	Emerald Heights

[a] Reservoir No. 3 serves the Low Pressure Zone through PRVs

6.2 Storage Criteria

Each pressure zone should have water storage facilities to provide operating storage, fire storage, and emergency storage. The total storage required is the sum of these three elements. A brief discussion of each element is provided below.

6.2.1 Operating Storage

Operating storage is required to meet water system demands in excess of delivery capacity from the supply source(s). For the Low and High Pressure Zones, and the reduced pressure zones (Chelsea, Floral, and Harrison), required operating storage is a function of supply available from the City’s water treatment system. Similarly, for the Skyline, Emerald Heights, and Blue Ridge Pressure Zones, operating storage is a function of the transmission capacity of the system supplying zone storage facilities and demand characteristics.

6.2.2 Fire Storage

Standard engineering practice assumes that a critical fire situation may occur during maximum day demand conditions. Under this scenario, fire storage should be provided to meet the single most severe fire flow demand, based on zoning, within the area (pressure zone) served by the storage facility. The fire storage volume required is determined by multiplying the fire flow rate by the duration of that flow. Specific fire flow quantity and duration recommendations by land use type are as follows:

- Residential properties: 1,000 gpm for 2 hours
- Non-residential properties: 3,000 gpm for 3 hours

6.2.3 Emergency Storage

In addition to the above described storage components, emergency storage is often provided to supply water from storage during emergencies such as pipeline failures, equipment failures, power outages, or natural disasters. The amount of emergency storage provided can be highly variable depending on an assessment of risk and the desired degree of system reliability. Some communities with single source systems and no emergency back-up have adopted an emergency storage goal equal to up to three average days of demand. Other systems that benefit from multiple emergency back-up capabilities, may include no emergency storage component in their storage requirement calculation methodology.

6.2.4 Summary of Storage Criteria

Based on a review and comparison of the planning criteria used in the City of Astoria's 2000 Water Distribution Plan, and accepted water industry practice and guidelines, the following storage criteria will be followed:

- Total Storage Volume (for each pressure zone):
  - Operating storage = 25% of maximum day demand
  - Fire suppression storage = most severe fire flow demand (volume) within the area served by the storage facility
  - Emergency Storage = 100% of the average day demand

6.3 Storage Analysis

The results of the storage analysis are presented in Table 6-2. Demands used for the storage analysis include residential demands, the demand from the Port, and unaccounted for water projections.

The Low Pressure Zone is comprised primarily of the commercial area around the waterfront and includes operations from the Port of Astoria. This area is primarily served from Reservoir No. 2 (5.5 MG) but can also be served through PRV connections by Reservoir No. 3 (20 MG). Both operating and emergency storage needs are based on the system demands including Port operations. Operating storage in 2070 is projected at 1.3 MG, while emergency storage is projected at 3.8 MG. Fire storage needed in this area is determined by the required commercial land use fire flow of 3,000 gpm for 3 hours (540,000 gallons). The total storage requirement in 2070 is projected at 5.6 MG. Well below the combined available storage in Reservoir No. 2 and Reservoir No. 3.

Result: No additional storage is projected to be needed for the Low Pressure Zone.

The High Pressure Zone in comprised primarily of residential land use and includes the Column, Madison, Niagara, Chelsea, Floral, and Harrison minor pressure zones. These areas are served primarily from Reservoir No. 3 (20.0 MG). By 2070, operating storage in this zone is projected at 0.2 MG and emergency storage at 0.4 MG. For residential land use, fire storage is calculated using a required fire flow of 1,000 gpm for 2 hours (120,000 gallons). Fire storage in the High Pressure Zone is projected at 0.1 MG. The total storage requirement for this zone is about 0.7 MG, well below the available storage volume in Reservoir No. 3.

Result: No additional storage is projected to be needed for the High Pressure Zone.

Water to the Skyline Pressure Zone is provided through the Skyline Tank and Booster Station. The zone is comprised primarily of residential land use and the pumped network provides service to all residential connections. However, hydrants in this zone are not connected to the pumped network. Hydrants are connected to a pipe network supplied by Reservoir No. 3. With this configuration fire storage will not be provided from the Skyline Tank, but rather Reservoir No. 3. Thus, only operating and emergency storage is required in the Skyline Tank. By 2070, operational storage and emergency storage are projected to be 0.02 MG and 0.04 MG, respectively. The total storage required for the Skyline Pressure Zone is 0.06 MG, below the available storage of 0.13 MG. As indicated in the System Analysis chapter (Section 5.2), limited fire flow is available from hydrants in the Skyline Pressure Zone due to low static pressure. Connecting hydrants to the pumped Skyline system is recommended to improve static pressure and meet fire flow requirements. If this is completed, as with the High Pressure Zone, fire storage is projected at 0.1 MG for residential land use. The total storage requirement for this zone would then be 0.18 MG and result in a storage deficiency of 0.05 MG.

Result: Projected deficiency for the Skyline Pressure Zone if hydrants are connected to Skyline system.

The Emerald Heights and Blue Ridge Pressure Zones are fed through the East Astoria Tanks with areas comprised of primarily residential land use. The available storage in the East Astoria Tanks is 0.3 MG with 2070 required Operational and Emergency storage of 0.05 and 0.15 MG, respectively. Fire storage based on residential land use is 0.12 MG. The total storage required for these areas is 0.32 MG, a storage deficiency of 0.02 MG.

Result: Projected deficiency for the Emerald Heights and Blue Ridge Pressure Zones is 0.02 MG.

Table 6-2. Storage Requirements

Pressure Zone and Planning Period	ADD (MGD)	MDD (MGD)	Operating Storage (MG)	Fire Storage (MG)	Emergency Storage (MG)	Total Storage Required (MG)	Total Storage Deficiency (MG)
Low Pressure Zone							
2020	3.43	4.40	1.10	0.54	3.43	5.07	N/A
2040	3.76	4.95	1.24	0.54	3.76	5.54	N/A
2070	3.76	4.95	1.24	0.54	3.76	5.54	N/A
High Pressure Zone [a]							
2020	0.40	0.51	0.13	0.12	0.40	0.65	N/A
2040	0.44	0.58	0.14	0.12	0.44	0.70	N/A
2070	0.44	0.58	0.14	0.12	0.44	0.70	N/A
Skyline Pressure Zone							
2020	0.04	0.05	0.01	0.12	0.04	0.17	N/A; 0.04 [b]
2040	0.04	0.06	0.02	0.12	0.04	0.18	N/A; 0.05 [b]
2070	0.04	0.06	0.02	0.12	0.04	0.18	N/A; 0.05 [b]
Emerald Heights & Blue Ridge Pressure Zones							
2020	0.14	0.18	0.04	0.12	0.14	0.30	0.01
2040	0.15	0.20	0.05	0.12	0.15	0.32	0.02
2070	0.15	0.20	0.05	0.12	0.15	0.32	0.02

MGD = million gallons per day
[a] High Pressure Zone demands include demands from the Column, Madison, Niagara, Chelsea, Floral and Harrison minor zones
[b] The first value indicates no storage deficiency assuming hydrants in this zone are fed from Reservoir No. 3. The second value is the storage deficiency assuming hydrants in this zone are connected to the pumped system.

6.4 Summary and Recommendations

Existing available storage is projected to be sufficient within the Low and High Pressure Zones under existing conditions and future demand projections. A relatively small storage deficiency is projected for the Emerald Heights and Blue Ridge Pressure Zones. A small storage deficiency is projected within the Skyline Pressure Zone if hydrants are connected to the Skyline system. Unaccounted for water plays an important role in the storage analysis results. Because it is unknown where in the system unaccounted for water is occurring, it is possible that the analysis is skewed in local areas like Emerald Heights and Skyline. Demand in areas with projected storage deficiencies should be confirmed to validate the necessity of additional storage.

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Chapter 7. Seismic Resilience

The State of Oregon, Department of Geology and Mineral Industries (DOGAMI), published the Map of Earthquake and Tsunami Damage Potential for a Simulated Magnitude 9 Cascadia Earthquake (Open File Report 0-13-06, Plate 7) in 2012. OHA requires water systems fully or partially located in areas identified as VII to X, inclusive, for moderate to heavy damage potential, to develop a seismic risk assessment and mitigation plan. The City of Astoria is located in this designated area, and therefore has prepared the required risk assessment and mitigation plan.

This chapter contains excerpts from three technical memorandums:

1. Level of Service Goals, Performance Objectives, and Water System Backbone, SEFT (Appendix F).
2. Geotechnical Seismic Data Summary, Cornforth (Appendix G).
3. Seismic Vulnerability Assessment of Select Structures, SEFT (Appendix H).

7.1 Seismic Risk Assessment

The City conducted a water system seismic resilience assessment to:

- define water system level of service (LOS) goals for the City water system following a Magnitude 9.0 Cascadia Subduction Zone (M9.0 CSZ) earthquake and its ensuing tsunami,
- identify key backbone system components that are required to achieve these LOS goals,
- define performance criteria for individual system components that are required to achieve these LOS goals,
- conduct a limited geotechnical seismic hazards evaluation for the City water system,
- conduct a limited structural/nonstructural vulnerability assessment of key facilities selected by the City to determine estimated system performance following a M9.0 CSZ earthquake,
- identify gaps between the LOS goals and current performance estimates, and
- develop preliminary mitigation recommendations to close these gaps.

7.1.1 Study Event Description

Consistent with OHA requirements, the City selected a M9.0 CSZ scenario earthquake and associated tsunami as the hazard to be explicitly considered for this seismic resilience study. In addition to the strong ground shaking, the tsunami that will be generated by a CSZ earthquake will significantly impact Astoria and surrounding coastal communities. Based on post-tsunami observations from the 2010 Tohoku tsunami in Japan, it is assumed that above-grade building-like facilities in the tsunami inundation zone will likely lose their functionality for months if not years or even be a total loss. Another major tsunami hazard is associated with the debris (timber logs, vehicles, boats/ships, etc.) that is transported by tsunami waters. This debris can cause impact damage to buildings and can create a significant logistical challenge for the transportation system and for debris removal after the event. Additionally, when tsunami waters recede, they can cause scour that damages building and bridge foundations, buried pipelines, and roadways. Despite the significant damage that is anticipated in the tsunami inundation zone, a study by the USGS estimated that less than 20% of developed land in the City of Astoria is within the tsunami inundation zone and less than 5% of City residents live in the tsunami inundation zone.

7.1.2 Post-Event Recovery Approach

Given that it would be cost prohibitive to eliminate all earthquake and tsunami damage, it is necessary to prioritize that a fundamental short-term community need will be to provide water for fire suppression and for use by hospitals, emergency shelters, and other similar facilities. It will be essential that the City is able to provide water to these critical community facilities to help care for residents and visitors that are injured or displaced as a result of the tsunami or as a result of earthquake-induced building damage. DOGAMI and OHA have collaborated with 11 coastal hospitals (including Columbia Memorial Hospital in Astoria) to develop a consistent coastal region response and recovery approach (DOGAMI 2019). Significant damage to the transportation system and other lifeline infrastructure systems will likely results in coastal communities being isolated for an extended period of time. The DOGAMI/OHA plan anticipates that coastal communities will need to rely on their onsite emergency supplies and replenishment from prearranged local sources for up to three weeks after the earthquake, before outside assistance is able to be provided to coastal areas.

The Oregon Resilience Plan recommended a three-tiered level of service (LOS) goal approach to implement a phased restoration of services and help define the speed of recovery for a community’s infrastructure systems. The first-tier goals are focused on ensuring the water system is restored to a minimal LOS to support emergency response activities. The second-tier goals are focused on restoring the water system to a functional LOS (up to about 50 percent capacity) that is sufficient to get the economy moving again. The third-tier goals are focused on restoring an operational LOS (up to about 90 percent capacity), but still may rely on temporary fixes. The LOS goals proposed for adoption by the City of Astoria generally align with those presented in the Oregon Resilience Plan and DOGAMI/OHA planning for coastal hospitals and are augmented by additional considerations suggested by the National Institute of Standards and Technology Community Resilience Planning Guide for Buildings and Infrastructure Systems. The goals for the City of Astoria water system are broken down in terms of specific goals for source, transmission, control systems, and distribution. All goals are based on providing water meeting minimum regulatory requirements, although a boil water notice will most likely be in effect due to damage throughout the distribution system. Note that the proposed LOS goals are for infrastructure located outside the tsunami inundation zone.

7.1.3 Water System Backbone

The HDR team has collaborated with the City of Astoria to identify the proposed backbone for the City water system (Figure 7-1). This backbone system provides water distribution system connections between the water source reservoirs, raw water transmission pipelines, water treatment plant, finished water reservoirs, and distribution system pipelines that serve facilities that are required to meet short- and intermediate-term community needs. Note that the backbone identified to serve critical community facilities has overlapping assets with but is not necessarily the same as a hydraulic (transmission main) backbone. The backbone systems proposed for the City of Astoria water system is consistent with that envisioned during the development of the Oregon Resilience Plan. Note that facilities and buried utilities in the tsunami inundation zone are expected to experience significant damage due to tsunami inundation and scouring. Therefore, it is recommended that they not be connected to the water system backbone. However, it is recommended that the City develop and implement plans to install isolation valves near the boundary of the tsunami inundation zone. This will permit the City to preserve their stored water supply by isolating areas with significant tsunami-induced pipeline damage.

Since it would be challenging to implement any significant repairs to the backbone system in the initial days and weeks after an earthquake, the elements of the backbone system should be designed or retrofit such that they experience only minor or no geotechnical, structural, and nonstructural (piping, valves, chemical feed equipment, electrical components, etc.) related damage during a major earthquake. This may require that the design of new water system structures or retrofit of existing structures consider elevated structural and nonstructural performance objectives. Also, since geotechnical hazards (e.g., landslide, liquefaction, and lateral spreading) can significantly impact the performance of water system structures following a major earthquake, it is recommended that site-specific geotechnical investigations and analysis be conducted to characterize these potential hazards. Water system structure designs should include appropriate measures to mitigate these potential site-specific geotechnical hazards. Piping entering or exiting water system structures should be designed to accommodate the anticipated earthquake-induced relative movement between the structure and surrounding soil (such as with the use of flexible joints or connections).

7.1.4 Summary and Recommendations

Several next steps were identified that, if implemented, will continue to help improve the seismic resilience of the City's water system in the event of a major earthquake and tsunami.

- Due to the fact that many critical community facilities are currently located in or in close proximity to the tsunami inundation zone, it is suggested that Astoria community stakeholders develop a comprehensive City-wide seismic resilience plan that holistically addresses the risk associated with a CSZ earthquake and associated tsunami, and other potential natural hazards (landslide, winter storm, etc.) If a facility that is critical to supporting community short- and intermediate-term social and/or economic needs is relocated, site selection criteria for the new location should consider proximity to the water system backbone or the water system backbone should be appropriately modified to include the location of the new facility. The backbone should also be routinely updated to incorporate future water system modifications that will be implemented by the City (e.g., future plans to upgrade/replace in-town storage reservoirs, future plans to provide water storage tanks at various locations around the City, etc.)
- Community facilities and the surrounding area (including buried utilities) in the tsunami inundation zone are likely to experience significant damage due to tsunami

inundation and scouring, and may take many months, if not years, to recover. It is recommended that the City develop and implement plans to install isolation valves near the boundary of the tsunami inundation zone. This will permit the City to preserve their stored water supply by isolating areas with significant tsunami-induced pipeline damage and facilitate functional recovery of the water system above the tsunami inundation zone within the timeframe indicated.

- The City has previously conducted: 1) a seismic stability evaluation of Bear Creek Dam (Cornforth 2016), and 2) a seismic resilience assessment of the 12-mile-long water transmission main between Bear Creek Dam and Reservoirs 2 and 3 (Hart Crowser 2019). As part of this water master plan update project, a limited structural/nonstructural seismic vulnerability assessment of four additional key facilities was conducted to determine their estimated performance following a M9.0 CSZ earthquake (Section 7.2). It is recommended that the City also conduct a seismic and tsunami assessment (as appropriate) of the remaining water system components. This will provide the City with a holistic view of the expected seismic performance of the water system that can be leveraged in developing a comprehensive long-term plan for implementing water system seismic and tsunami resilience improvements.
- In order to continue to advance the City’s water system resilience planning process, we recommend that a follow-up study be conducted that includes consideration of dependency relationships. Planning for and addressing issues such as where the City will get fuel for trucks and generators, how suppliers and contractors will be rapidly engaged and compensated, etc. will help improve resilience and speed the return to normalcy after a major disaster. Additionally, some equipment used in booster stations and treatment plants is not available from manufacturer’s stock and has a long lead time for production. Special consideration must be given to this difficult-to-source equipment to ensure that it is either not damaged during an earthquake, a predetermined work-around has been established, or the equipment manufacturing lead time aligns with restoration timeline goals. Note that these recommendations will be taken into consideration during the risk and resilience assessment required by America’s Water Infrastructure Act, scheduled for completion in 2021.

7.2 Vulnerability Assessment of Select Structures

The City of Astoria selected four critical water system structures to evaluate as part of this project: Reservoir 2 Gate House, Reservoir 3 Gate House, East Astoria Tanks, and Skyline Tank (Table 7-1).

Table 7-1. Description of Evaluated Structures

Water System Component	Structure Type	Year of Original Construction
Reservoir 2 Gate House	Stone Masonry (above-grade) and Plain Concrete (below-grade gate well)	1895
Reservoir 3 Gate House	Reinforced Concrete (above-grade) and Plain Concrete (below-grade gate well)	1919
East Astoria Tanks	Reinforced Concrete	1998
Skyline Tank	Factory-Coated Bolted Carbon Steel	2006

7.2.1 Structural Assessment Approach

As part of the preliminary seismic structural/nonstructural vulnerability assessment, SEFT reviewed available existing drawings, performed site visits to observe the existing structures, and completed seismic evaluation checklists and quick-check calculations, based on a variety of national standards and guidelines including ASCE 41-17 Seismic Evaluation and Retrofit of Existing Buildings Tier 1 Screening Procedure and ASCE TCLEE Monograph 22 Seismic Screening Checklists for Water and Wastewater Facilities, to identify potential seismic deficiencies that have commonly been observed in past earthquakes.

7.2.2 Geotechnical Seismic Hazard Assessment

Cornforth Consultants conducted a geotechnical seismic hazard assessment as part of this project and provided estimates of the spectral acceleration and permanent ground deformation (PGD) for liquefaction-induced lateral spreading and earthquake-induced landslide associated with a M9.0 CSZ scenario earthquake. It is estimated that the earthquake-induced landslide PGD at the four critical water system structures evaluated as part of this project could potentially range from 1.5 to 12.5 feet (Table 7-2).

Table 7-2. Geotechnical Seismic Hazard Data

Water System Component	Short Period Spectral Acceleration (g)	One-Second Spectral Acceleration (g)	Liquefaction/ Lateral Spreading PGD	Landslide PGD
Reservoir 2 Gate House	0.76	0.41	<1 cm	50-375 cm (20-150 in)
Reservoir 3 Gate House	0.76	0.40	<1 cm	50-300 cm (20-120 in)
East Astoria Tanks	0.75	0.40	<1 cm	50-375 cm (20-150 in)
Skyline Tank	0.76	0.41	<1 cm	50-75 cm (20-30 in)

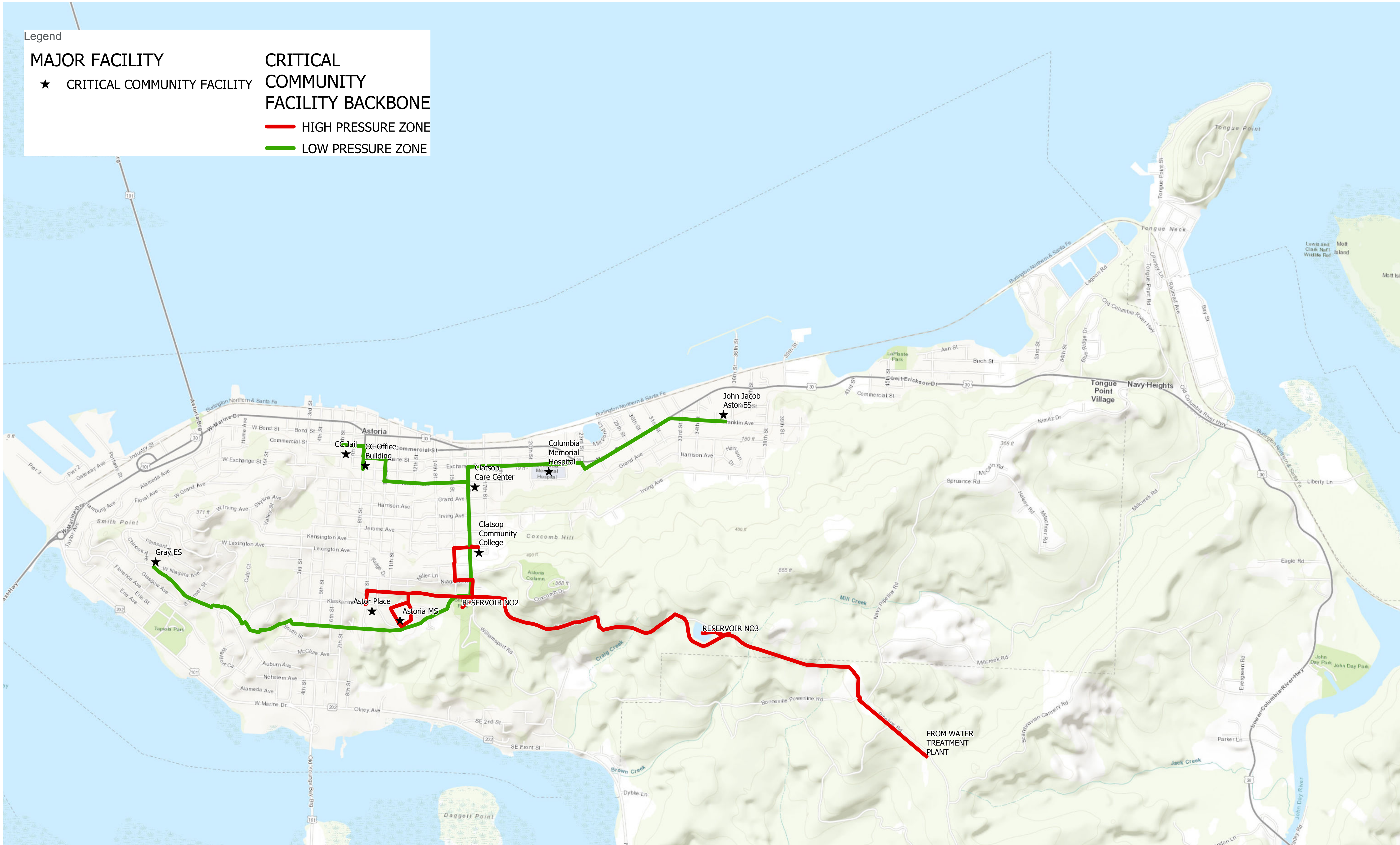
7.2.3 Findings

Based on the potential deficiencies identified in this vulnerability assessment, none of the evaluated structures are currently expected to achieve the performance objectives that are required to meet water system post-earthquake level of service goals (i.e., Immediate Occupancy structural performance or Operational nonstructural performance) for a M9.0 CSZ earthquake. Additionally, based on the potential deficiencies identified in this assessment, the Reservoir 2 and Reservoir 3 Gate Houses are not currently expected to achieve Life Safety performance and represents a potential safety hazard to City staff and contractors.

7.2.4 Summary and Recommendations

The findings of this seismic evaluation should be integrated with the findings of previous seismic studies of other water system components and future seismic and tsunami assessments (as appropriate) of the remaining water system components to develop a holistic view of the expected seismic performance of the water system. This knowledge can be leveraged in developing a comprehensive long-term plan for implementing water system seismic and tsunami resilience improvements. In the near-term, the City is strongly encouraged to implement a seismic retrofit program to address Life Safety seismic deficiencies for water system structures that are frequently accessed by City staff and contractors.

If replacement of existing or construction of new water system structures is considered in the future to meet water demand or operational goals, then this would provide an opportunity to build more seismically resilient structures and associated support infrastructure that are capable of achieving the City's post-earthquake LOS goals. The location and foundation design for any new water system structures should include appropriate consideration of potential earthquake-induced permanent ground deformation.



WATER DISTRIBUTION SYSTEM SEISMIC BACKBONE
Figure 7-1

Chapter 8. Operations and Maintenance

HDR met with City staff and reviewed relevant documents to assess the current state of Astoria's Operations and Maintenance (O&M) practices. The information gathered was compared to the requirements of OHA's *Plan Review requirements for Master Plans at existing or new public water systems* and Oregon Administrative Rule 333-061-0060 *Plan Submission and Review Requirements*.

This chapter contains excerpts from the *Operations Training and O&M Management Plan Review Technical Memorandum* (Appendix I).

8.1 Review of Operations and Management Plan

According to an OHA Fact Sheet, a water system's O&M manual is meant to be a comprehensive "how-to" guidance document that pertains to all physical aspects of a water system's daily O&M. Specifically, it includes O&M activities performed at the City's facilities, including source water, treatment, finished water storage, transmission, and distribution systems.

Additionally, for systems with certified operators in direct responsible charge (DRC) that also employ non-certified operators, the system is required to establish written protocols for each of these other operators that:

- Describes the operational decisions the operator(s) are allowed to make.
- Details the condition under which operator(s) must consult with DRCs, including when and how contact is made.
- Review operator(s) certification level, knowledge, skills, and abilities, and the range of expected operating conditions of the water system.
- Is signed and dated by the DRC and the other operator(s).

Water system staff would then be instructed and trained in the use of the manual.

The creation and implementation of the manual provides a detailed resource that can be used in the event the system suddenly loses its DRC and has to employ or contract new operators unfamiliar with the system. Additionally, it serves as a good training tool for new employees.

HDR reviewed the City's operations document titled *Operations Manual, City of Astoria Drinking Water System* for conformance with OHA guidance pertaining to developing and maintaining an O&M manual.

Specific comments based on this review are:

- The manual should specify a version number or revision date.
- The document should have page numbers.
- The organizational chart appears out of date and should be updated.
- The manual contains several procedures that use valve numbers in the description. A diagram showing the numbered valves would be helpful for these procedures.

- The manual should include a comprehensive list of record keeping requirements, including what records are kept, where they are stored, and how long they are retained.
- The manual should include a list of routine tasks that are required to maintain compliance with regulatory requirements, including a list of the rules (Lead & Copper Rule, Revised Total Coliform Rule, etc.).
- The manual should include a list of required reports for submittal to regulatory authorities along with contact information for the regulatory agency.
- The reviewer was provided with several documents that described utility operations but were not included in the O&M Manual (e.g., "Quality Control Sampling Plan," "Water Treatment Operator Checklists," and a document describing operator tasks responding to customer complaints). These documents and any Standard Operating Procedures used in utility operation can be referenced with a description of what they are and where they are located rather than being included in the O&M Manual.
- The Emergency Transmission Main Dewatering procedure includes a list of contact information for customers along the pipeline. Creating a contact information table is suggested to make it easier to find within the document and update when necessary.
- Chapters IV and V are in reverse order in the document.
- The Process Hazard What-If Analysis table does not display properly.
- The Instrumentation section of the Water Treatment Chapter appears to need updating. The section on nephelometric turbidity unit (NTU) sensors does not include the Hach TU5300 NTU sensor observed in the field.
- In the Reservoirs and Storage Tanks chapters there are several references to drawings or procedures that are to be included at the end of the section. The referenced documents are not included.

8.2 Current Operation and Maintenance Gaps

The City has a spreadsheet-based maintenance management program in place to address routine and recurring preventive and corrective maintenance. The scope of work for this project did not include an audit of the program, but it appears that City staff feels the program is effective for the tasks being managed. However, City staff also expressed concern that they do not have adequate resources to maintain all utility assets, notably the water distribution system valves and hydrants. In its Tech Brief, Valve Exercising, Summer 2007, Issue 2, the University of West Virginia's National Environmental Services Center experts recommend exercising distribution valves annually if possible. AWWA recommends all hydrants be inspected regularly, at least once a year – twice a year (spring and fall) for dry barrel hydrants in areas that experience freezing weather.

City staff is justifiably concerned that distribution system valves, because they have not been exercised regularly, may already be broken or will break or leak when they are operated. For this reason, implementation of a valve exercising program may require a phased approach where the first phase includes repair and replacement of valves and valve boxes in a multi-year program until all system valves are known to be operable. After this first phase, maintenance would include regular valve exercising.

8.3 Summary and Recommendations

This section provides recommendations for improvements to the City's O&M program.

O&M manual improvement recommendations include:

- Address specific comments provided in Section 8.1.
- Provide training on the use of the O&M manual to operations staff and others that need to use the document. Document the training and provide regular refresher training. This recommendation also applies to any Standard Operating Procedures related to the O&M manual.
- Review the O&M manual at least annually and update as required. Implement a program to ensure access to the most recent version of the document for required personnel.

The City's water utility's maintenance program should address all utility assets, including distribution system valves and hydrants. The current maintenance management system can utilize reliability centered maintenance (RCM) concepts to realize efficiencies in the maintenance management program. Detailed instructions to implement an RCM program are provided in Appendix I. If, after identifying maintenance requirements, prioritizing duties, and assessing staff capabilities, the City determines that current staff resources are insufficient to provide the required maintenance, the City should assess options to either reduce maintenance requirements by replacing maintenance intensive equipment, contract some maintenance activities to a third party, or increase staffing.

The City should also consider technologies that reduce manpower requirements for certain activities, in order to reallocate staff resources to address other needs. Automated meter reading is an example of a technology that promises to reduce manpower requirements while improving accuracy and providing other benefits to the utility and its customers (features such as excess flow and backflow notifications vary by manufacturer). The City utilizes a meter reading contractor but could still expect to regain some staff time and reduce operating costs incurred from the water meter contract. The reduction in manpower and cost for this function can result in increased staff and financial resources applied to deferred maintenance tasks.

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Chapter 9. Capital Improvement Plan

The proposed CIP (Table 9-1, Figure 9-1) was developed based on information presented in this study and additional City-provided projects based on known operational needs. Improvements were prioritized into four categories (high, medium, low, and aspirational) based on need and feasibility. Projects are not further prioritized within the four categories.

Planning-level (AACE Class 4) cost estimates have been developed for the capital projects included in the CIP. Generally, each project cost includes the following components:

- **Base construction cost.** Includes labor and material costs needed to construct a project. For pipeline projects, construction costs were estimated based on unit construction costs derived from bid tabulations for recent City projects and bid results for recent similar projects in western Oregon and southwest Washington.
- **Construction contingency.** Considers the uncertainties associated with estimating project costs at this planning level.
- **Design engineering.** Includes City and consultant design and other related cost items, such as permitting and construction administration.

The elements are summed to determine the total project-level cost estimate for a project, as expressed in 2020 dollars.

Actual costs for the recommended improvements may vary from the costs developed for this plan, depending on when facilities are constructed and unforeseen conditions that may be encountered during design or construction of the improvements. Because this plan was prepared during the COVID-19 pandemic, it is unknown how construction material and labor costs may be affected in future years. To prioritize these improvements, it will be necessary to evaluate City financial resources and local needs to assure that the recommended improvements are implemented in an orderly, coordinated, and economical fashion.

Table 9-1. Capital Improvement Plan

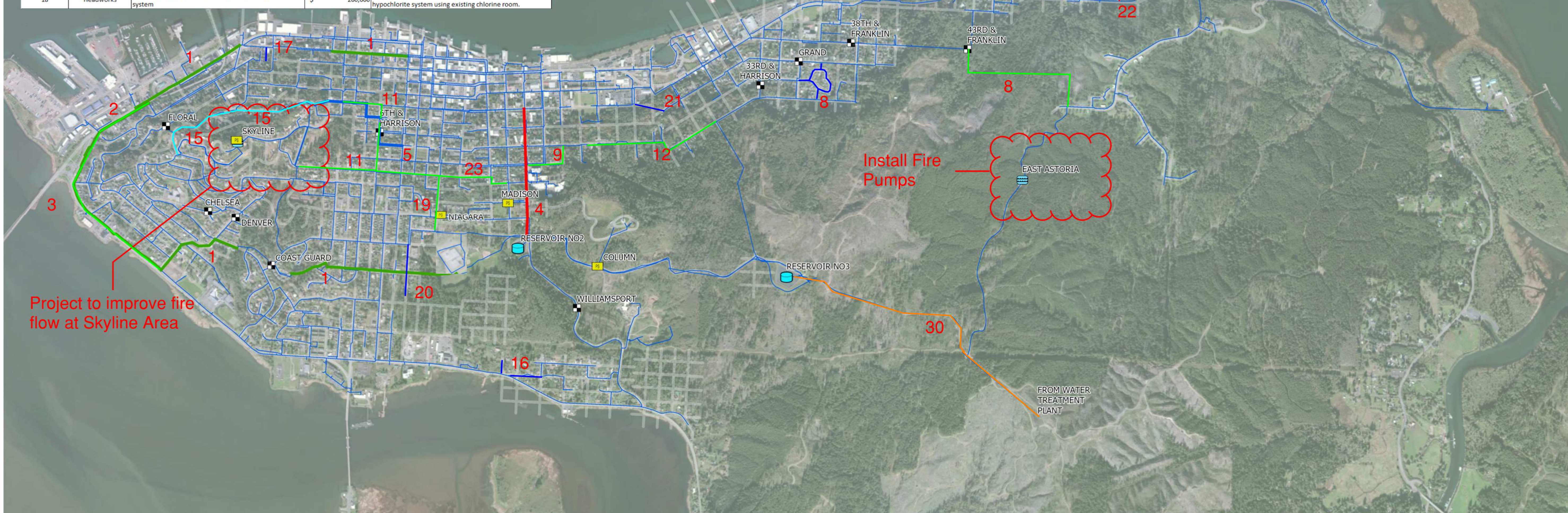
Project #	Category	Description	Estimated Capital Cost (2020$)	Notes
Priority: High				
1	Distribution System	Install 10,350 LF 12" main to complete waterfront looped backbone. A portion of this project is part of the identified seismic backbone.	$4,310,000	Improve available fire flow to a large portion of the Low Pressure Zone along the west waterfront.
2	Distribution System	Install 900 LF 12" main from Portway St/Industry St to Hamburg St/Industry St	$370,000	Improve fire flows and provide for future growth at Port and on west end of City.
3	Distribution System	Install 2,500 LF 12" main from the Port to W Marine View/Denver St	$1,040,000	--

Project #	Category	Description	Estimated Capital Cost (2020$)	Notes
4	Distribution System	Install 1,100 LF 14", 1400 LF 18" transmission main from Reservoir 2 to Low Pressure Zone. This project is part of the identified seismic backbone.	$1,280,000	Address excessive headloss during high flow conditions. Existing water main is beyond reasonable useful life expectancy.
5	Distribution System	Install 2,600 LF 8" main from 8th St/Irving Ave to 1st St/W Grand Ave	$850,000	Improve fire flow and static pressures to an area that is hydraulically isolated due to undersized/old water main.
6	Distribution System	Project to improve fire flow at Skyline	$580,000	--
7	Distribution System	Install fire pump at East Astoria Tanks	$350,000	--
8	Distribution System	a. Upgrade existing main from 35th St/Irving Ave to 36th St/Grand Ave (1,200 LF) b. Install new main from East Astoria pipeline (Emerald Heights) to 43rd St/Franklin Ave (2,500 LF)"	$1,430,000	--
9	Distribution System	Install 1,100 LF 12" main from 16th St/Jerome Ave to 18th St/Irving Ave	$460,000	Increase volume to central part of town. Backup for 21" from Res 3 to Res 2.
10	Distribution System	Replace existing water meters with AMR system	$1,500,000	4277 meters, budgetary cost $350 per service connection
11	Distribution System	Install 430 LF 8" main to 2nd St/Franklin Ave, 2,500 LF 12" main from 1st St/Kensington Ave to 6th St/Grand Ave, 1,200 LF 12" main from 6th St/Grand Ave to 3rd St/Franklin Ave	$1,680,000	Improve fire flows at W Exchange and Duane St near 1st St. Located in an active slide area.
12	Distribution System	Install 2,800 LF 12" main from 20th St/Irving Ave to 28th St/Irving Ave	$1,170,000	Increase volume to central part of town. Backup for 21" from Res 3 to Res 2. Located in an active slide area.
13	Headworks	Install 600,000-gallon clearwell tank at WTP	$700,000	--
Priority: Medium				
14	Distribution System	In downtown area: loop existing 4" dead-ends to existing 10" and 12" mains where possible or relocate services to existing 10" and 12" mains where possible.	$100,000	Improve circulation and increase pressure and fire flows in downtown area.
15	Distribution System	Install 2,100 LF 10" main from 2nd St/Franklin Ave to Lincoln St/W Grand Ave, 2,430 LF 10" main from Lincoln St/W Grand Ave to W Lexington St/W Grand Ave	$1,680,000	Replace line that has excessive repairs on W Grand Ave.
16	Distribution System	Install 900 LF 8" main from Wall St and SE 2nd St to Howard St	$290,000	Replace lines that require excessive repairs in south Astoria.

Project #	Category	Description	Estimated Capital Cost (2020$)	Notes
17	Distribution System	Install 300 LF 8" main on Washington St from W Bond St to Alameda Ave	$100,000	Existing line crosses private property. No easement found.
18	Headworks	Replace gas chlorination system with liquid hypochlorite system	$260,000	Wait until required at the WWTP. Assume liquid hypochlorite system using existing chlorine room.
Priority: Low				
19	Distribution System	Install 800 LF 12" main from 11th St/James Ave to 11th St/Kensington Ave	$330,000	Replace line that has excessive repairs and improve fire flows on 11th St.
20	Distribution System	Install 900 LF 8" main from 9th St/Klaskanine Ave to 9th St/McClure Ave	$290,000	Very old pipe in poor condition
21	Distribution System	Install 370 LF 8" main from Franklin Ave to Grand Ave (along 26th St or 27th St)	$120,000	Improve flows on Grand Ave
22	Distribution System	Install 350 LF 6" main from 51st St/Cedar St to 51st St/Lief Erikson Dr, 50 LF 2" main to extend dead-end service on Lief Erikson Dr	$110,000	Improve circulation on small dead end line on Lief Erikson Dr
23	Distribution System	Install 2,750 LF 12" main from 6th St/Kensington Ave to 15th St/Lexington Ave	$1,140,000	--
24	Distribution System	Replace Navy Hospital Swamp Line	$500,000	--
25	Reservoirs	Replace 21" meters (2) for Reservoir No. 3	$100,000	Improve flow monitoring accuracy.
26	Reservoirs	Replace 10" meter and 12" meter for Reservoir No. 2	$100,000	Improve flow monitoring accuracy.
27	Watershed	Replace Cedar Creek culvert with bridge	$350,000	--
28	Watershed	Install new slide gates on Bear Creek and Cedar Creek diversion structures	$100,000	--
Priority: Aspirational				
29	Reservoirs	Replace or retrofit in-town reservoirs	$15,000,000	Replace aging infrastructure while increasing seismic resilience
30	Transmission	Install 12 miles 24" transmission main	$43,330,000	Replace aging infrastructure while increasing seismic resilience

Project #	Category	Description	Estimated Capital Cost (2020$)	Notes
Priority: High				
1	Distribution System	Install 10350 LF 12" main to complete waterfront looped backbone	$ 4,310,000	Improve available fire flow to a large portion of the Low Pressure Zone along the west waterfront.
2	Distribution System	Install 900 LF 12" main from Portway St/Industry St to Hamburg St/Industry St	$ 370,000	Improve fire flows and provide for future growth at Port and on west end of City.
3	Distribution System	Install 2500 LF 12" main from the Port to W Marine View/Denver St	$ 1,040,000	
4	Distribution System	Install 1100 LF 14", 1400 LF 18" transmission main from Reservoir 2 to Low Pressure Zone	$ 1,280,000	Address excessive headloss during high flow conditions. Existing water main is beyond reasonable useful life expectancy.
5	Distribution System	Install 2600 LF 8" main from 8th St/Irving Ave to 1st St/W Grand Ave	$ 850,000	Improve fire flow and static pressures to an area that is hydraulically isolated due to undersized/old water main.
6	Distribution System	Project to improve fire flow at Skyline	$ 580,000	
7	Distribution System	Install fire pump at East Astoria Tanks	$ 350,000	
8	Distribution System	a. Upgrade existing main from 35th St/Irving Ave to 36th St/Grand Ave (1200 LF) b. Install new main from East Astoria pipeline (Emerald Heights) to 43rd St/Franklin Ave (2500 LF)	$ 1,430,000	
9	Distribution System	Install 1100 LF 12" main from 16th St/Jerome Ave to 18th St/Irving Ave	$ 460,000	Increase volume to central part of town. Backup for 21" from Res 3 to Res 2.
10	Distribution System	Replace existing water meters with AMR system	$ 1,500,000	4277 meters, budgetary cost $350 per service connection
11	Distribution System	Install 430 LF 8" main to 2nd St/Franklin Ave, 2500 LF 12" main from 1st St/Kensington Ave to 6th St/Grand Ave, 1200 LF 12" main from 6th St/Grand Ave to 3rd St/Franklin Ave	$ 1,680,000	Improve fire flows at W Exchange and Duane St near 1st St. Located in an active slide area.
12	Distribution System	Install 2800 LF 12" main from 20th St/Irving Ave to 28th St/Irving Ave	$ 1,170,000	Increase volume to central part of town. Backup for 21" from Res 3 to Res 2. Located in an active slide area.
13	Headworks	Install 600,000 gallon clearwell tank at WTP	$ 700,000	
Priority: Medium				
14	Distribution System	In downtown area: loop existing 4" dead-ends to existing 10" and 12" mains where possible or relocate services to existing 10" and 12" mains where possible.	$ 100,000	Improve circulation and increase pressure and fire flows in downtown area.
15	Distribution System	Install 2100 LF 10" main from 2nd St/Franklin Ave to Lincoln St/W Grand Ave, 2430 LF 10" main from Lincoln St/W Grand Ave to W Lexington St/W Grand Ave	$ 1,680,000	Replace line that has excessive repairs on W Grand Ave.
16	Distribution System	Install 900 LF 8" main from Wall St and SE 2nd St to Howard St	$ 290,000	Replace lines that require excessive repairs in south Astoria.
17	Distribution System	Install 300 LF 8" main on Washington St from W Bond St to Alameda Ave	$ 100,000	Existing line crosses private property. No easement found.
18	Headworks	Replace gas chlorination system with liquid hypochlorite system	$ 260,000	Wait until required at the WWTP. Assume liquid hypochlorite system using existing chlorine room.

Project #	Category	Description	Estimated Capital Cost (2020$)	Notes
Priority: Low				
19	Distribution System	Install 800 LF 12" main from 11th St/James Ave to 11th St/Kensington Ave	$ 330,000	Replace line that has excessive repairs and improve fire flows on 11th St.
20	Distribution System	Install 900 LF 8" main from 9th St/Klaskanine Ave to 9th St/McClure Ave	$ 290,000	Very old pipe in poor condition
21	Distribution System	Install 370 LF 8" main from Franklin Ave to Grand Ave (along 26th St or 27th St)	$ 120,000	Improve flows on Grand Ave
22	Distribution System	Install 350 LF 6" main from 51st St/Cedar St to 51st St/Lief Erikson Dr, 50 LF 2" main to extend dead-end service on Lief Erikson Dr	$ 110,000	Improve circulation on small dead end line on Lief Erikson Dr
23	Distribution System	Install 2750 LF 12" main from 6th St/Kensington Ave to 15th St/Lexington Ave	$ 1,140,000	
24	Distribution System	Replace Navy Hospital Swamp Line	$ 500,000	
25	Reservoirs	Replace 21" meters (2) for Reservoir No. 3	$ 100,000	Improve flow monitoring accuracy.
26	Reservoirs	Replace 10" meter and 12" meter for Reservoir No. 2	$ 100,000	Improve flow monitoring accuracy.
27	Watershed	Replace Cedar Creek culvert with bridge	$ 350,000	
28	Watershed	Install new slide gates on Bear Creek and Cedar Creek diversion structures	$ 100,000	
Priority: Aspirational				
29	Reservoirs	Replace or retrofit in-town reservoirs	$ 15,000,000	
30	Transmission	Install 12 miles 24" transmission main	$ 43,330,000	



Water Distribution System - Capital Improvement Plan
Figure 9-1

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Chapter 10. Financial Planning

A key element of effectively implementing the projects and system improvements identified in this plan is the development of a financial analysis to review revenue needs over a multi-year period. This chapter provides insight into the financial aspects of the master plan. OHA requires water system master plans to provide descriptions of alternatives for financing system improvements. There are several alternatives for financing needed capital projects which generally includes a combination of outside capital funding (loans, grants, etc.) and local financing from rates and charges collected from water customers. An important consideration when planning capital improvements is how to pay for those improvements. This plan provides several needed water system improvements the City should implement in the future to improve system operation efficiency and safety.

10.1 Historical Financial Summary

Reviewing historical financial results begins the financial analysis. Based on a review of historical financial results and recent budgets, the City's water system revenue appears to closely match its expenses. Table 10-1 provides a summary of historical and budgeted revenue and expenditures.

Table 10-1. Historical Financial Results

	Actual		Budget	
	2018	2019	2020	2021
	($1,000s)			
Revenue				
Water Meter Charge	$2,892	$3,599	$3,650	$3,763
Meter Installation Charge	19	31	20	20
Miscellaneous Revenue	71	64	55	55
Total Water Revenue	**$2,982**	**$3,693**	**$3,725**	**$3,838**
Expenditures				
Personnel Services	$896	$945	$1,054	$1,081
Materials and Services	407	435	614	621
Capital Equipment Outlay	9	32	49	31
Shared Expenses	928	1,001	1,178	1,199
Transfer to Other Funds	249	881	881	806
Total Expenditures	**$2,489**	**$3,294**	**$3,776**	**$3,738**
Results				
Revenue less Expenditures	$493	$399	($52)	$100
Balance/Deficiency of Funds (as % of Revenue)	-17.0%	-11.1%	1.4%	-2.6%
Debt Service Coverage Ratio	1.84	3.88	2.71	2.90

It should be noted a review of financial results is limited in the overall insights that can be gained. Operating a utility within its means cannot solely indicate if the water system is being adequately maintained. A high-level review of several key elements of the financial plan, such as total annual debt service and capital outlays can give some insight into how much reinvestment into the system the utility is making on an annual basis. However, when reviewing those items, it is important to do so in the context of the age and condition of the system. An older system with deteriorating condition coupled with low capital expenditures and declining or flat operating costs may be indicative of a system that is not being properly maintained. Conversely a system that is relatively new may not require significant maintenance or renewal and replacement capital expenditures. One way to determine if maintenance and capital are sufficiently maintained is to monitor the rate of system failures. High or increasing levels of system failures may indicate a need for additional maintenance and renewal and replacement activities.

10.2 Capital Financing

Water utilities may have several sources of funding available for financing capital improvement projects. Each of these funding sources have advantages and disadvantages. Which funding sources a utility draws upon is dependent on several factors including long-term strategy and planning as well as written and unwritten polices. A utility may have policies that limit the amount of borrowing that can be issued relative to revenue or expenditure while other utilities may have policies to not issue debt at all. A brief description of common, capital project funding sources is provided in this section.

10.2.1 Grants

Grants are sought after by water utilities because the funds do not have to be repaid, however grants can be difficult to secure. Grants are usually competitive and needs-based or for a specific purpose such as bringing the water system into compliance with regulation. Grant funds are often limited and require an application for consideration. Some programs that offer grants also offer low interest loans or a combination of grants and loans.

One example is the Community Development Block Grant program, which is a federal grant for public works projects provided based on community need. It specifically provides funds up to $2,500,000 for water and wastewater improvements in low-moderate income communities as defined by Housing and Urban Development. The City is not currently eligible based on current median household income; however the data is updated annually.

10.2.2 Debt Financing

Debt financing is a common source of funding for capital projects. Debt financing is well suited to funding capital as it allows the utility to spread the cost of the improvements over extended periods of time. Extending the cost over several years can help accomplish two things:

- reducing large rate increases in the initial years
- providing intergenerational equity among water system customers

Intergenerational equity is the spreading of costs over the life of the asset so that new customers help pay for that asset which they also utilize as a customer when they connect to the system.

10.2.3 Low Interest Loan Programs

Low interest loans are highly sought after, usually limited in available funds, and thus are more difficult to obtain. As the name suggests, low interest loans offer a low interest rate when compared to higher bond, revenue or general obligation, interest rates. There are several different low interest rate loan programs often from state and federal sources. Low interest loan programs have limited funds and usually require completing an application process.

The 1974 Safe Drinking Water Act Revolving Loan fund is a low interest loan program established to help water systems achieve compliance with the Safe Drinking Water Act requirements. The program is funded by the federal government but managed by state government and administered by Business Oregon. The program offers forgivable loans for a variety of planning projects including sustainability projects and source water protection. Loan funding and principal forgiveness is available for projects that help provide for the collection, treatment, and delivery of safe drinking water and is not limited to those projects necessary to achieve compliance. The City has utilized this funding source for its most recent debt issues with rates ranging from 1 percent to 4.62 percent.

The Water Wastewater Fund provides loans to municipalities up to $10 million for construction or $60,000 for technical assistance. Interest rates are variable and can be repaid over a period up to 30 years. This fund also provides subsidized interest rates and grants up to $750,000 for construction and $20,000 for technical assistance for eligible communities.

Water Infrastructure Finance and Innovation Act is a program administered by the EPA. The program is eligible for a broad range of water and wastewater infrastructure projects. Interest rates are set at U.S. Treasury rates and can be financed over a maximum of 35 years from substantial completion of the project. The program is limited to a minimum of $20 million for large communities and $5 million for communities with a population less than 25,000. A key limitation to the program is that the loan amount cannot exceed 49 percent of the total project costs and the project cannot exceed 80 percent of federal funding.

10.2.4 Bond Financing

Bond financing is usually the least desirable as bond interest rates are often higher than low interest loan programs. When bonds are issued, there are generally several requirements in the bond documents such as debt service coverage requirements and bond reserve requirements. There are two types of bond issues, general obligation bonds and revenue bonds. General obligation bonds are issued with the municipality's full faith and credit and often for general government purposes. Revenue bonds are issued as a pledge of revenue and generally the most utilized by utilities.

10.2.5 Urban Renewal District

Each Oregon City by default has an Urban Renewal Agency (URA) which is dormant unless it has been activated through a City ordinance. A URA is a legal entity separate from the City with a governing body which may or may not be the City Council. An active URA can create an Urban Renewal District (URD) to address specific blighted areas within the City. There are administrative costs associated with the activation of an URA as well as ongoing administrative requirements. The Astoria Development Commission is the City's urban renewal agency and was formed in 1979. Astoria has two existing URDs, Astor-East Urban Renewal District and Astor-West Urban Renewal District. The main source of revenue for a URD is through Tax Increment Financing utilizing property tax revenue. Tax Increment Financing works by freezing the tax collections from overlapping taxing authorities and diverts future increases to the URD. The revenue collected by the URD may be used to pay debt service on debt issued to fund the projects identified in the urban renewal plan. The URD exists for a defined period of time, and when it expires, the overlapping taxing authorities commence collecting their total allotted amount. URDs are required to cover a geographically defined area that is limited to 15 percent for cities with population greater than 50,000 or 25 percent for cities with populations less than 50,000.

10.2.6 Rates and Charges

Water utilities, including Astoria, utilize user rates to fund the utility. The City charges customers bi-monthly based on the size of the meter and volume of water consumed. Table 10-2 provides the current water service rates charged by the City.

Table 10-2. Water Rates for Service

Meter Size	Charge
5/8" x 3/4"	$37.58
1" Residential Sprinkler	40.68
1"	113.10
1.5"	261.07
2"	426.92
3"	945.38
4"	1,710.98
6"	3,797.26
8"	6,504.86
10"	10,024.21
Consumption Charge (1,000 gal)	$4.03

Based on the current rate structure, the meter charge comprises approximately 30 percent of total rate revenue leaving approximately 70 percent coming from the consumption charge. The proportion of fixed revenue versus variable consumption revenue indicates that the water utility's water rate revenue can vary significantly over the year with most revenue collections occurring during summer months when there is higher outside water use.

10.3 Generally Accepted Rate Setting Principles

Utilities should consider setting rates around generally accepted principles and guidelines including:

- Cost-based, equitable, and set at a level that meets the utility's full revenue requirement
- Easy to understand and administer
- Designed to conform with generally accepted rate setting techniques
- Stable in their ability to provide adequate revenues to meet the utility's financial, operating, and regulatory requirements
- Established at a level that is stable from year-to-year from a customer's perspective

The rate setting process, while similar to the budgeting process, differs because there are slightly different goals. Budgeting centers around funds while the rate setting process focuses specifically on the utility revenues generated and costs to provide service. Rates are intended to fund the entire utility on a stand-alone basis. Some utilities may be spread across several funds (i.e., debt service fund and capital fund operating fund). Municipal utilities like Astoria's water utility often use a method of setting rates called the cash basis. The cash basis revenue requirement sums all the utilities' costs, including:

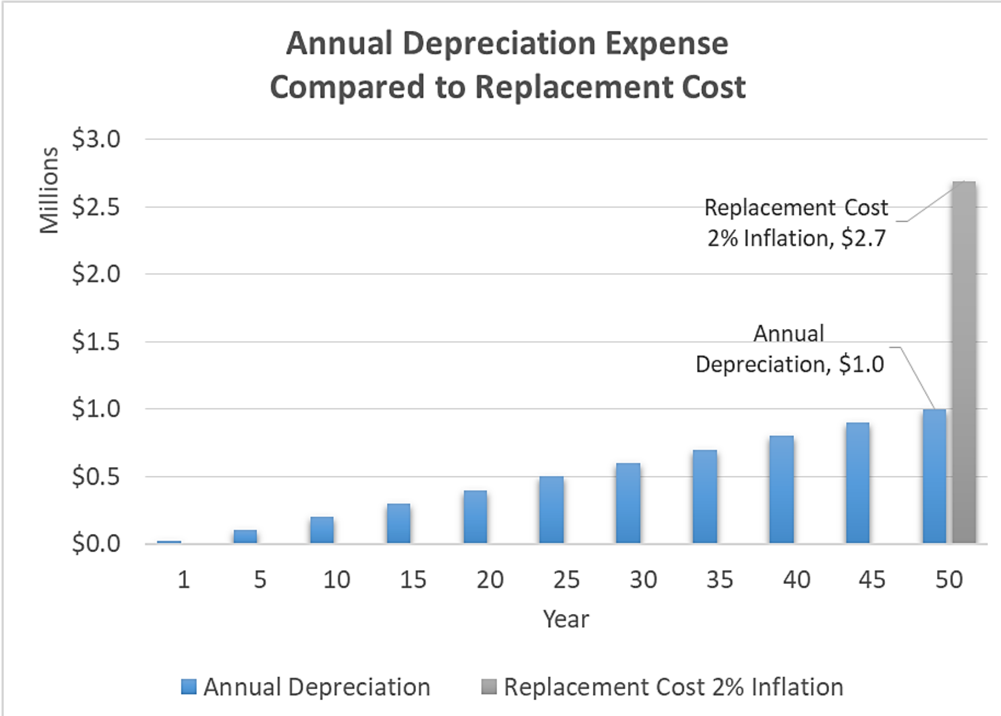
- Operations and Maintenance (O&M)
- Taxes and Transfers
- Capital Improvements Funded through Rates
- Debt Service (principal and interest)

These combined utility components are summed to equal what is referred to as the revenue requirement, which is the amount of revenue needed to fund the utility.

O&M consists of the day-to-day operations of the utility and should be set at a level sufficient to maintain the utility in a safe manner and meet regulatory requirements.

Taxes and transfers are state or local taxes charged to the utility on revenue or other transfers to funds outside the water utility.

Figure 10-1. Annual Depreciation Expense Compared to Replacement Cost



Capital funded through rates is the amount of rate revenue intended to fund capital on an annual basis (e.g., "pay as you go"). The amount of capital that a utility should fund with current rate revenue depends on several factors and is not the same for every utility. At a minimum, a utility should fund annual capital at a level at least equal to annual depreciation expense. While annual depreciation expense does not equal the cost of asset replacement, as it is intended to recover the capital cost not the cost to replace the asset, it does provide a benchmark for minimum reinvestment in the system on an annual basis. As an example, if an asset when built was $1 million and had a 50-year expected life, the replacement cost of the asset at the end of the useful life would be $2.7 million assuming 2 percent cost inflation. If the utility assumed annual depreciation at the time of replacement, the utility would be approximately $1.7 million short of the replacement cost. Several factors should be considered when assessing the prudent level of annual capital funding including the current age and condition of the water system and future capital project costs.

Deferred maintenance is another factor that should be considered when determining the appropriate level of capital funding for the water system. Deferred maintenance is when a utility opts not to conduct maintenance activities that would otherwise extend the useful life of a system component. The result of deferring maintenance activities is in effect delaying the cost of a failing asset to a later time and usually at a higher cost. For example, the cost of repairing or replacing a water main is higher when the main is allowed to fail as compared to before it fails in addition to possibly interrupting water service to customers. Utilities often face hard decisions for how to spend their limited funds especially during tough economic times, which often lead to deferring maintenance. The important thing about deferred maintenance is to not defer until failure but rather plan on catching up in the near future.

10.3.1 Affordability

Water rates have been increasing over the last four decades due to general cost inflation and increased regulations such as the 1974 Safe Drinking Water Act. The increased water rates have raised concerns of affordability of such an essential service. While affordability is a critical aspect of reviewing overall funding needs, it should not, on its own, drive the reduction in costs or additional deferral of capital. Rather, the utility should review its approach to assisting low income customers. This can be through a rate discount program, or through utility funded assistance programs. Additional local assistance may also be available through other community programs like Oregon's Housing and community services or other community service centers.

10.3.2 System Development Charges

System Development charges (SDC) are known by many names (i.e., connection charges, capacity charges, system facility charges), but the principle is the same, SDCs are intended to provide equity between existing and new water customers. SDCs are not charges related to the cost of physically connecting a customer to the water system. Rather they are a form of reimbursement to the system for investments made so that capacity (i.e., service) is available to new customers. Generally accepted methods for calculating SDCs are usually dependent on two things, the amount of available capacity in the existing system and the level of future projects necessary that will expand capacity to meet the needs of new customers. SDCs can be contentious among some groups such as builders' or development associations with the concern that SDCs increase the cost of housing. However, absent SDCs, existing customers will be funding the costs of capacity for new customers connecting to the system. Prior to implementing an SDC the utility should assess if conditions exist that would necessitate the charge. Obviously if little or no development is expected in the future, and expansion of the existing capacity is not necessary, an SDC may not be necessary. Alternatively, if the City is seeing significant development, or redevelopment, and the need to expand system capacity, it could produce revenue that would otherwise require increases in rates and place the financial burden on existing customers.

10.3.3 Recommendations

Generally, grants are the most sought-after and desirable funding source since it does not have to be repaid, but they are not widely available. Aside from grants, there are many factors that should be considered when considering how a utility funds it's capital program. A few of these factors are, keeping rates low now, keeping rates lower in the future, equity among customers, and the utilities financial health. A utility that is highly leveraged may not be capable of issuing additional debt or may have a policy that prevents it from issuing debt. Another consideration is the type of projects that need to be funded.

10.4 Projected Financials

Projected financials were prepared to show if current revenues are sufficient to fund projected expenditures (operating and capital) over a period of time into the future. Cities where their customer base is not growing at a rate that exceeds at an inflationary rate will over time see an erosion in the funds available to fund the operation of the utility. Rarely do utilities have an increasing customer base significant enough to overcome the increasing cost of operating the utility over the course of several years. Failure to keep revenue equal to or greater than cost inflation leads to cuts in costs and commonly capital costs.

The wide range of system improvement projects identified in this plan include projects to increase the water system's resiliency, fire flow and capacity, as well as renewal and replacement of existing assets. These projects have been prioritized into four categories: high, medium, low, and aspirational. The projects with prioritization from high to low are regarded as necessary to maintain the system over the next 20 years. Aspirational projects are projects that go beyond simply meeting the system's needs over the 20-year period but rather are intended to be meet longer term needs.

The total current value of the projects identified in this plan is $79.62 million. $58.3 million of those project costs are prioritized as aspirational while the remaining $21.29 million are within the low, medium, and high priorities. Funding the low, medium, and high priority projects spread over 20 years equals $1.065 million per year in 2020 dollars. Funding the aspirational projects is cost-prohibitive because, if funded over 20 years, would require annual capital expenditures of $4.0 million per year which is equal to 100 percent of the City's current rate revenue.

Table 10-3 provides a projection of the revenue, expenses and capital improvements (System Improvements). Rate revenue was projected to increase at a rate of 0.5 percent per year (due to assumed customer growth) and expenses were escalated by 3.2 percent per year which were the growth rates used in the previous FCS Group rate study (City of Astoria 2009). Expenditures and capital costs exceed revenue beginning in 2022 indicating rates need to be increased by 27.7 percent in 2022 with annual adjustments growing to 49.5 percent by the end of the analysis period to fully fund the utility. After a one-time increase of 27.7 percent, annual increases of 2 to 3 percent would be required thereafter. The capital plan is the primary driver for these rate increases; prior to adding the capital plan, revenue roughly equaled expenditures.

Table 10-3. Projected Financial Results including Low, Medium, and High Priority Projects

	Forecast									
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Revenue										
Water Meter Charge	$3,782	$3,801	$3,820	$3,839	$3,858	$3,877	$3,897	$3,916	$3,936	$3,955
Meter Installation Charge	20	20	20	20	21	21	21	21	21	21
Miscellaneous Revenue	55	56	56	56	56	57	57	57	58	58
Total Water Revenue	**$3,857**	**$3,876**	**$3,896**	**$3,915**	**$3,935**	**$3,954**	**$3,974**	**$3,994**	**$4,014**	**$4,034**
Expenditures										
Personnel Services	$1,115	$1,151	$1,188	$1,226	$1,265	$1,306	$1,347	$1,391	$1,435	$1,481
Materials and Services	641	662	683	705	727	750	774	799	825	851
Capital Equipment Outlay	32	33	34	35	36	37	38	39	41	42
System Improvements	1,065	1,086	1,108	1,130	1,152	1,175	1,199	1,223	1,247	1,272
Shared Expenses	1,238	1,277	1,318	1,360	1,404	1,449	1,495	1,543	1,592	1,643
Transfer to Other Funds[1]	815	830	846	863	880	803	822	841	681	702
Total Expenditures	**$4,905**	**$5,039**	**$5,176**	**$5,318**	**$5,465**	**$5,520**	**$5,676**	**$5,835**	**$5,822**	**$5,991**
Results										
Revenue less Expenditures	($1,048)	($1,162)	($1,281)	($1,403)	($1,530)	($1,566)	($1,701)	($1,841)	($1,807)	($1,957)
Balance/Deficiency of Funds (as % of Revenue)	27.7%	30.6%	33.5%	36.6%	39.7%	40.4%	43.7%	47.0%	45.9%	49.5%
Debt Service Coverage Ratio	2.67	2.43	2.19	1.93	1.66	1.97	1.56	1.14	3.25	1.18

[1] Line includes Emergency Communications Fund, Public Works Improvement Fund, and General Fund transfers. Transfers are variable and decrease in years when debt is scheduled to expire.

Table 10-4 provides financial projections when aspirational projects are added. Over the analysis period water rates would need to be increased by over 104.8 percent initially and ultimately 137.6 percent by the end of the 10-year period to fully fund the utility plus all of the capital projects including aspirational projects. After a one-time increase of 104.8 percent, annual increases of 4 to 5 percent would be required thereafter.

Table 10-4. Projected Financial Results including All Identified Projects

	Forecast									
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Revenue										
Water Meter Charge	$3,782	$3,801	$3,820	$3,839	$3,858	$3,877	$3,897	$3,916	$3,936	$3,955
Meter Installation Charge	20	20	20	20	21	21	21	21	21	21
Miscellaneous Revenue	55	56	56	56	56	57	57	57	58	58
Total Water Revenue	**$3,857**	**$3,876**	**$3,896**	**$3,915**	**$3,935**	**$3,954**	**$3,974**	**$3,994**	**$4,014**	**$4,034**
Expenditures										
Personnel Services	$1,115	$1,151	$1,188	$1,226	$1,265	$1,306	$1,347	$1,391	$1,435	$1,481
Materials and Services	641	662	683	705	727	750	774	799	825	851
Capital Equipment Outlay	32	33	34	35	36	37	38	39	41	42
System Improvements	3,981	4,061	4,142	4,225	4,309	4,395	4,483	4,573	4,664	4,758
Shared Expenses	1,238	1,277	1,318	1,360	1,404	1,449	1,495	1,543	1,592	1,643
Transfer to Other Funds[1]	815	830	846	863	880	803	822	841	681	702
Total Expenditures	$7,821	$8,013	$8,211	$8,413	$8,622	$8,740	$8,960	$9,186	$9,239	$9,477
Results										
Revenue less Expenditures	($3,964)	($4,137)	($4,315)	($4,498)	($4,687)	($4,786)	($4,986)	($5,191)	($5,225)	($5,443)
Balance/Deficiency of Funds as % of Revenue	104.8%	108.9%	113.0%	117.2%	121.5%	123.4%	128.0%	132.6%	132.8%	137.6%
Debt Service Coverage Ratio	2.67	2.43	2.19	1.93	1.66	1.97	1.56	1.14	3.25	1.18

[1] Line includes Emergency Communications Fund, Public Works Improvement Fund, and General Fund transfers. Transfers are variable and decrease in years when debt is scheduled to expire.

Table 10-3 and Table 10-4 provide financial projections for two vastly different capital plans. A large portion of the aspirational projects is a 12-mile-long transmission main replacement that could potentially be completed on a piecemeal basis as funds are available rather than increasing rates to fund the entire project. It should be noted that the above financial projections were provided to give a potential impact of implementing the desired capital plan and the City should consider conducting a more in-depth analysis before making decision on how to adjust water rates. The City should also consider conducting an SDC analysis to determine the amount of funding that could be collected to fund a portion of the capital plan to reduce the impact on rates.

Chapter 11. References

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Appendix A. Water Rights Summary Technical Memorandum

TECHNICAL MEMORANDUM

City of Astoria Water Rights Summary

To: Kathryn Maschmann, HDR
Verena Winter, HDR

From: Kimberly Grigsby, GSI Water Solutions, Inc.
Ronan Igloria, GSI Water Solutions, Inc.
Leah Cogan, GSI Water Solutions, Inc.

Attachments: City of Astoria Water Rights Table
City of Astoria Water Rights Certificates and Permits (13)

Date: July 13, 2020

At your request, GSI Water Solutions (GSI) has developed this brief summary of the water rights held by the City of Astoria (City). This memorandum was developed as part of the development of the City's Water System Master Plan.

This water rights summary includes an inventory of water rights held by the City and describes the status of each water right. A table summarizing the water rights and current status is attached. A draft of the water rights table was discussed with the City during a meeting on June 19, 2020, and information provided during that meeting has been incorporated into the memorandum.

Introduction to Water Rights

Under Oregon water law, with a few exceptions, the use of public water requires a water right from the Oregon Water Resources Department (OWRD). The right to use water is typically first granted in the form of a water use permit. The permit describes the priority date, amount of water that can be used, point of diversion, type of water use, and place of use. The permit allows the water user to develop the infrastructure needed to put the water to full beneficial use.

Permits also describe the timeline for making full beneficial use of the water. If the water right holder completes its development of the water by this deadline, it can complete a claim of beneficial use and request a certificate. If a water right holder needs more time to develop the water right, it may request an "extension of time" from OWRD. For the holders of certain "municipal use permits," an extension of time may limit the amount of water accessible under the "extended permit." In order to access additional water, the municipal permit holder may need to submit a Water Management and Conservation Plan (WMCP) to OWRD and receive OWRD approval of the WMCP. As part of the permit extension process for some municipal permits, the Oregon Department of Fish and Wildlife (ODFW) may recommend conditions to maintain the persistence of fish listed under the endangered species acts. These "fish persistence conditions" are only imposed as part of the municipal permit extension process, and would not affect existing certificated water rights.

Typically, if the holder of a water right certificate does not use water for five consecutive years, a presumption of forfeiture is established and OWRD can initiate a proceeding to cancel the water right. However, OWRD does not consider municipal use certificates to be subject to forfeiture for non-use.

City of Astoria's Water Rights

The City holds 13 water rights, which are summarized in the table in Attachment 1. In addition, copies of the water rights are provided in Attachment 2. All of the water rights are held in the City's name in OWRD's records.

Five of the water rights are evidenced by water right certificates and provide the City's current water supply. Four certificates authorize the storage of water from Bear Creek in three reservoirs, and the use of stored water from the reservoirs and natural flow from Bear Creek. One certificate authorizes the use of water from Cedar Creek. GSI understands that the City also diverts water at Spur 14, and that OWRD considers this water use to be consistent with the City's existing water right certificates. An additional water right certificate authorizes the use of water from Bear Creek for hydroelectric power production.

In addition, the City holds four water use permits. Three permits authorize the storage of water from Youngs River, and the use of water from the reservoir and the Youngs River watershed. A fourth permit authorizes the use of water from Big Creek. GSI understands that the City does not currently use water under these permits.

Finally, the City holds three water rights certificates for the storage and use of stored water for irrigation of Ocean View Cemetery. GSI understands that although water continues to be stored in Smith Lake Reservoir, the stored water is not currently being used for irrigation.

Bear Creek Water Rights

Certificates 19542 and 19543

Certificate 19543 authorizes storage of up to 498 acre-feet of water from Bear Creek in Middle Lake and Wickiup Lake Reservoirs. Certificate 19542 authorizes use of up to 3.0 cfs from Bear Creek, Middle Lake, and Wickiup Lake Reservoirs for municipal use. These rights have a priority date of October 14, 1938.

Certificates 82234, 82236, and 89004

Certificate 82234 authorizes storage of up to 675 acre-feet of water from Bear Creek in Bear Creek Reservoir, and Certificate 82236 authorizes use of up to 12.0 cfs from Bear Creek and Bear Creek Reservoir for municipal use. These rights have a priority date of August 17, 1966. Certificate 89004 authorizes the use of up to 6.0 cfs for hydroelectric power generation in conjunction with Certificate 82236. Use of water is limited to periods when the water right under Certificate 82236 is being put to beneficial use. Certificate 89004 does not have its own priority date.

Cedar Creek Water Right

Certificate 82237

Certificate 82237 authorizes use of up to 2.0 cfs from Cedar Creek for municipal use. This certificate has a priority date of August 17, 1966.

Youngs River Water Rights

Permits R-2568 and S-27092

Permit R-2568 authorizes storage of up to 12,000 acre-feet from Youngs River in Youngs River Reservoir for municipal use. Permit S-27092 authorizes the use of up to 26.0 cfs from Youngs River Reservoir and the Youngs River for municipal use. These permits have a priority date of January 17, 1961. The City has not used water under these permits to date. The current development deadline for these permits is October 1, 1995. The City filed extension of time applications in December 2005. These applications are being processed by OWRD and are still awaiting ODFW fish persistence condition reviews. Draft fish persistence conditions indicate that the conditions may significantly limit the amount of water that will be available under the permits.

Permit S-7257

Permit S-7257 authorizes the use of up to 23.0 cfs from Youngs River for municipal use. This permit has a priority date of June 8, 1925. The City has not used water under this permit to date. The development deadline for this permit is October 1, 1995. The City filed an extension of time application in December 2005. This application is being processed by OWRD and is still awaiting an ODFW fish persistence condition review. Draft fish persistence conditions indicate that the conditions may significantly limit the amount of water that will be available under the permit.

Big Creek Water Right

Permit S-3945

Permit S-3945 authorizes the use of up to 16.0 cfs from Big Creek for domestic supplies. This permit has a priority date of November 6, 1918. The City has not used water under this permit to date. The development deadline for this permit is October 1, 1995. The City of Astoria filed an extension of time application in June 2006. This application is being processed by OWRD and is still awaiting an ODFW fish persistence condition review. Draft fish persistence conditions indicate that the conditions may significantly limit the amount of water that will be available under the permit.

Irrigation Water Rights (Smith Lake Reservoir)

Certificates 28405, 28406, and 28407

Certificate 28407 authorizes storage of up to 11,000,000 gallons (33.77 acre-feet) in Smith Lake Reservoir for irrigation. Certificate 28405 authorizes the use of up to 0.30 cfs from Smith Lake Reservoir for irrigation of Ocean View Cemetery (24.3 acres), and Certificate 28406 authorizes the use of up to 11,000,000 gallons from Smith Lake Reservoir for supplemental irrigation of Ocean View Cemetery.

Conclusion

The City's current water supply is obtained under water rights from the Bear Creek and Cedar Creek watersheds. These water rights authorize the use of water from Bear Creek, Cedar Creek, and three reservoirs that are filled with water from Bear Creek. The City has certificates for all of these water rights, and no further action is required to protect them. One certificate authorizes the use of water for hydroelectric production in conjunction with a certificate for municipal use of water from Bear Creek. The City also holds water use permits that it does not currently use. These water use permits authorize the use of water from the Big Creek and Youngs River watersheds, including authorizing a new reservoir that would be filled with water from Youngs River. The development deadlines on these permits expired several years ago. To preserve these permits, the City filed extension of time applications. The applications are currently pending with OWRD and awaiting fish persistence condition reviews by ODFW. Finally, the City has water right certificates for the storage and use of stored water in Smith Lake Reservoir for irrigation of Ocean View Cemetery. Water is being stored in Smith Lake Reservoir; however, stored water has not been used for irrigation of the cemetery in several years. Nonetheless, as water right certificates held by a city, OWRD would not consider these rights to be subject to forfeiture for non-use.

Attachment 1

Water Rights Table

City of Astoria Water Rights Summary

City of Astoria 7/13/2020

Application	Permit	Certificate	Source	Priority Date	Development Deadlines	Type of Beneficial Use	Max Rate/Volume (cfs/af)	Period Of Use	Status	Comments/ Recommendations
S-17632	S-13424	19542	Bear Creek, Middle Lake Reservoir, Wickiup Lake Reservoir	10/14/1938	---	Municipal	3.00 cfs	Year-round	• Water Right is Certificated so it is relatively secure	• *City's water source*
R-17631	R-724	19543	Bear Creek	10/14/1938	---	Storage for municipal use in Middle Lake & Wickiup Lake Reservoirs	498 af	Year-round	• Water Right is Certificated so it is relatively secure • Max use reported to OWRD in the past 5 years was 416.96 af	• *City's water source*
R-42655	R-4842	82234	Bear Creek	8/17/1966	---	Storage for municipal use in Bear Creek Reservoir	675 af	Year-round	• Water Right is Certificated so it is relatively secure • Max use reported to OWRD in the past 5 years was 713.78 af	• *City's water source*
S-42656	S-31880	82236	Bear Creek, Bear Creek Reservoir	8/17/1966	---	Municipal	12.0 cfs	Year-round	• Water Right is Certificated so it is relatively secure	• *City's water source*
PC 898	---	89004	Bear Creek	---	---	Hydroelectric production	6.0 cfs	Year-round	• Water Right is Certificated so it is relatively secure • Can only be used in conjunction with Certificate 82236	• Measure and report the quantity of water diverted
S-42657	S-31881	82237	Cedar Creek	8/17/1966	---	Municipal	2.0 cfs	Year-round	• Water Right is Certificated so it is relatively secure • Max use reported to OWRD in the past 5 years was 2.12 cfs	• *City's water source*
R-25855	R-2568	---	Youngs River	1/17/1961	10/1/1995	Storage for municipal use in Youngs River Reservoir	12,000 af	Year-round	• Extension application submitted to OWRD in December 2005. Application is being processed by OWRD and is awaiting ODFW fish persistence review.	• *No water use to date* • Extension PFO Protest Period Ends 3/16/2012
S-25856	S-27092	---	Youngs River, Youngs River Reservoir	1/17/1961	10/1/1995	Municipal	26.0 cfs	Year-round	• Extension application submitted to OWRD in December 2005. Application is being processed by OWRD and is awaiting ODFW fish persistence review	• *No water use to date* • Extension Comment Period Ends 1/10/2006
S-10226	S-7257	---	Youngs River	6/8/1925	10/1/1995	Municipal	23.0 cfs	Year-round	• Extension application submitted to OWRD in December 2005. Application is being processed by OWRD and is awaiting ODFW fish persistence review	• *No water use to date* • Extension Comment Period Ends 1/10/2006
S-6320	S-3945	---	Big Creek	11/6/1918	10/1/1995	Domestic supplies	16.0 cfs	Year-round	• Extension application submitted to OWRD in June 2006. Application is being processed by OWRD and is awaiting ODFW fish persistence review	• *No water use to date* • Extension Comment Period Ends 7/11/2006
R-18269	R-735	28407	"Seepage water"	7/13/1939	---	Storage for irrigation	11,000,000 gallons (33.77 af)	Year-round	• Water Right is Certificated so it is relatively secure	• Water continues to be stored in reservoir
S-11632	S-8096	28405	Smith Lake Reservoir	7/16/1927	---	Irrigation of Ocean View Cemetery – 24.3 Ac	0.30 cfs*	Year-round	• Water Right is Certificated so it is relatively secure	• Stored water is not currently being used to irrigate the cemetery
S-18336	S-13969	28406	Smith Lake Reservoir	8/12/1939	---	Supplemental Irrigation of 24.3 Ac	11,000,000 gallons* (33.77 af)	Year-round	• Water Right is Certificated so it is relatively secure • The volume of water stored should be reported for Certificate 28407, and the report for this right should show no use of water • Annual water use reported to OWRD is consistently 405 af (33.75 af/month)	• Stored water is not currently being used to irrigate the cemetery

cfs = cubic feet per second **af** = acre-feet **g** = gallons
* Limited to 1/80 cfs/ac and 2.5 af/ac

Attachment 2
City of Astoria Water Rights
City of Astoria Water Rights Summary

STATE OF OREGON

COUNTY OF CLATSOP

CERTIFICATE OF WATER RIGHT

This Is to Certify, *That* CITY OF ASTORIA

of Astoria *, State of* Oregon *, has made proof to the satisfaction of the STATE ENGINEER of Oregon, of a right to the use of the waters of* Bear Creek & 2 reservoirs (Middle Lake Res. & Wickiup Lake Res.) constructed under Application No. 17631, Permit No. R-724 *a tributary of* Columbia River *for the purpose of* Municipal *under Permit No.* 13424 *of the State Engineer, and that said right to the use of said waters has been perfected in accordance with the laws of Oregon; that the priority of the right hereby confirmed dates from* October 14, 1938 ;

that the amount of water to which such right is entitled and hereby confirmed, for the purposes aforesaid, is limited to an amount actually beneficially used for said purposes, and shall not exceed 3.0 cubic feet per second,

or its equivalent in case of rotation, measured at the point of diversion from the stream. The point of diversion is located in the SW¼ NE¼, Sec. 13, T. 7 N., R. 8 W., W.M.; & SW¼ SW¼, Sec. 18, T. 7 N., R. 7 W., W.M.

The amount of water used for irrigation, together with the amount secured under any other right existing for the same lands, shall be limited to — — — — *of one cubic foot per second per acre,*

and shall conform to such reasonable rotation system as may be ordered by the proper state officer.

A description of the place of use under the right hereby confirmed, and to which such right is appurtenant, is as follows:

Municipal use in Sections 2, 3, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 20, 21, 28, Township 8 North, Range 9 West, W. M.

The right to the use of the water for the purposes aforesaid is restricted to the lands or place of use herein described.

WITNESS the signature of the State Engineer, affixed

this 30th *day of* April *,* 1951 .

CHAS. E. STRICKLIN
State Engineer

Recorded in State Record of Water Right Certificates, Volume 14 *, page* 19542.

Reservoir—100—8-39

STATE OF OREGON

COUNTY OF CLATSOP

CERTIFICATE OF WATER RIGHT

This Is to Certify, *That* CITY OF ASTORIA

of Astoria *, State of* Oregon *, has made proof*

to the satisfaction of the STATE ENGINEER of Oregon, of a right to store the waters of

Bear Creek, a tributary of Columbia River, to be appropriated under Application No. 17632, Permit No. 13424,

for the purposes of

Municipal supply

under Reservoir Permit No. R-724 *of the State Engineer, and that said right to store said waters has been perfected in accordance with the laws of Oregon; that the priority of the right hereby confirmed dates from* October 14, 1938,

that the amount of water entitled to be stored each year under such right, for the purposes aforesaid, shall not exceed 498 *acre-feet.*

The reservoir is located in Section (See Below) *, Tp. , R. , W. M.*

Middle Lake Res. located in $E\frac{1}{2}$ $SW\frac{1}{4}$ $NE\frac{1}{4}$, Sec. 13, T. 7 N., R. 8 W., W.M.

Wickiup Lake Res. located in $NE\frac{1}{4}$ $SW\frac{1}{4}$, $SW\frac{1}{4}$ $SW\frac{1}{4}$, $SE\frac{1}{4}$ $SW\frac{1}{4}$, Sec. 18, T. 7 N, R. 7 W., W. M.

WITNESS the signature of the State Engineer,

affixed this 30th *day*

of April *, 19* 51

CHAS. E. STRICKLIN
State Engineer.

Recorded in State Record of Water Right Certificates, Volume 14 *, page* 19543 .

STATE OF OREGON

COUNTY OF CLATSOP

CERTIFICATE OF WATER RIGHT

THIS CERTIFICATE ISSUED TO

CITY OF ASTORIA
1095 DUANE ST
ASTORIA OR 97103

confirms the right to store water perfected under the terms of Permit R-4842. The amount of water used to which this right is entitled is limited to the amount used beneficially, and shall not exceed the amount specified, or its equivalent in the case of rotation, measured at the point of diversion from the source. The specific limits and conditions of the use are listed below.

APPLICATION NUMBER: R-42655
SOURCE: BEAR CREEK
STORAGE FACILITY: BEAR CREEK RESERVOIR
PURPOSE or USE: STORAGE FOR MUNICIPAL USE
MAXIMUM STORAGE VOLUME: 675.0 ACRE FEET EACH YEAR
DATE OF PRIORITY: AUGUST 17, 1966
DAM LOCATION:

The point of diversion is located as follows:

Twp	Rng	Mer	Sec	Q-Q
7 N	8 W	WM	2	NW SE

The area submerged by this reservoir is as follows:

Twp	Rng	Mer	Sec	Q-Q
7 N	8 W	WM	2	NE SE
7 N	8 W	WM	2	NW SE
7 N	8 W	WM	2	SW SE
7 N	8 W	WM	2	SE SE

NOTICE OF RIGHT TO PETITION FOR RECONSIDERATION OR JUDICIAL REVIEW

This is an order in other than a contested case. This order is subject to judicial review under ORS 183.484. Any petition for judicial review must be filed within the 60-day time period specified by ORS 183.484(2). Pursuant to ORS 536.075 and OAR 137-004-0080, you may either petition for judicial review or petition the Director for reconsideration of this order. A petition for reconsideration may be granted or denied by the Director, and if no action is taken within 60 days following the date the petition was filed, the petition shall be deemed denied. In addition, under ORS 537.260 any person with an application, permit or water right certificate subsequent in priority may jointly or severally contest the issuance of the certificate at any time before it has issued, and after the time has expired for the completion of the appropriation under the permit, or within three months after issuance of the certificate.

CONDITIONS OF USE

1. The right to store and use the water for the above purpose is restricted to beneficial use at the place of use described.

WITNESS the signature of the Water Resources Director, affixed SEP 29 2006

Dwight Ford for
Phillip C. Ward, Director
Water Resources Department

STATE OF OREGON

COUNTY OF CLATSOP

CERTIFICATE OF WATER RIGHT

THIS CERTIFICATE ISSUED TO

CITY OF ASTORIA
1095 DUANE ST
ASTORIA OR 97103

confirms the right to use the waters of BEAR CREEK and BEAR CREEK RESERVOIR for MUNICIPAL USES.

This right was perfected under Permit S-31880. The date of priority is AUGUST 17, 1966. The amount of water to which this right is entitled is limited to an amount actually used beneficially, and shall not exceed 12.0 CUBIC FEET PER SECOND or its equivalent in case of rotation, measured at the point of diversion.

The point of diversion is located as follows:

Twp	Rng	Mer	Sec	Q-Q	Survey Coordinates
7 N	8 W	WM	2	SW SE	1160 FEET NORTH AND 2340 FEET WEST FROM SE CORNER, SECTION 2

A description of the place of use to which this right is appurtenant is as follows:

Twp	Rng	Mer	Sec	Q-Q
8 N	9 W	WM	2	NE NE
8 N	9 W	WM	2	NW NE
8 N	9 W	WM	2	SW NE
8 N	9 W	WM	2	SE NE
8 N	9 W	WM	2	NE NW
8 N	9 W	WM	2	NW NW
8 N	9 W	WM	2	SW NW
8 N	9 W	WM	2	SE NW
8 N	9 W	WM	2	NE SW
8 N	9 W	WM	2	NW SW
8 N	9 W	WM	2	SW SW
8 N	9 W	WM	2	SE SW
8 N	9 W	WM	2	NE SE
8 N	9 W	WM	2	NW SE

NOTICE OF RIGHT TO PETITION FOR RECONSIDERATION OR JUDICIAL REVIEW

This is an order in other than a contested case. This order is subject to judicial review under ORS 183.484. Any petition for judicial review must be filed within the 60-day time period specified by ORS 183.484(2). Pursuant to ORS 536.075 and OAR 137-004-0080, you may either petition for judicial review or petition the Director for reconsideration of this order. A petition for reconsideration may be granted or denied by the Director, and if no action is taken within 60 days following the date the petition was filed, the petition shall be deemed denied. In addition, under ORS 537.260 any person with an application, permit or water right certificate subsequent in priority may jointly or severally contest the issuance of the certificate at any time before it has issued, and after the time has expired for the completion of the appropriation under the permit, or within three months after issuance of the certificate.

Twp	Rng	Mer	Sec	Q-Q
8 N	9 W	WM	2	SW SE
8 N	9 W	WM	2	SE SE
8 N	9 W	WM	3	NE NE
8 N	9 W	WM	3	NW NE
8 N	9 W	WM	3	SW NE
8 N	9 W	WM	3	SE NE
8 N	9 W	WM	3	NE NW
8 N	9 W	WM	3	NW NW
8 N	9 W	WM	3	SW NW
8 N	9 W	WM	3	SE NW
8 N	9 W	WM	3	NE SW
8 N	9 W	WM	3	NW SW
8 N	9 W	WM	3	SW SW
8 N	9 W	WM	3	SE SW
8 N	9 W	WM	3	NE SE
8 N	9 W	WM	3	NW SE
8 N	9 W	WM	3	SW SE
8 N	9 W	WM	3	SE SE
8 N	9 W	WM	7	NE NE
8 N	9 W	WM	7	NW NE
8 N	9 W	WM	7	SW NE
8 N	9 W	WM	7	SE NE
8 N	9 W	WM	7	NE NW
8 N	9 W	WM	7	NW NW
8 N	9 W	WM	7	SW NW
8 N	9 W	WM	7	SE NW
8 N	9 W	WM	7	NE SW
8 N	9 W	WM	7	NW SW
8 N	9 W	WM	7	SW SW
8 N	9 W	WM	7	SE SW
8 N	9 W	WM	7	NE SE
8 N	9 W	WM	7	NW SE
8 N	9 W	WM	7	SW SE
8 N	9 W	WM	7	SE SE
8 N	9 W	WM	8	NE NE
8 N	9 W	WM	8	NW NE
8 N	9 W	WM	8	SW NE
8 N	9 W	WM	8	SE NE
8 N	9 W	WM	8	NE NW
8 N	9 W	WM	8	NW NW
8 N	9 W	WM	8	SW NW
8 N	9 W	WM	8	SE NW
8 N	9 W	WM	8	NE SW
8 N	9 W	WM	8	NW SW
8 N	9 W	WM	8	SW SW
8 N	9 W	WM	8	SE SW
8 N	9 W	WM	8	NE SE
8 N	9 W	WM	8	NW SE
8 N	9 W	WM	8	SW SE

Twp	Rng	Mer	Sec	Q-Q
8 N	9 W	WM	8	SE SE
8 N	9 W	WM	9	NE NE
8 N	9 W	WM	9	NW NE
8 N	9 W	WM	9	SW NE
8 N	9 W	WM	9	SE NE
8 N	9 W	WM	9	NE NW
8 N	9 W	WM	9	NW NW
8 N	9 W	WM	9	SW NW
8 N	9 W	WM	9	SE NW
8 N	9 W	WM	9	NE SW
8 N	9 W	WM	9	NW SW
8 N	9 W	WM	9	SW SW
8 N	9 W	WM	9	SE SW
8 N	9 W	WM	9	NE SE
8 N	9 W	WM	9	NW SE
8 N	9 W	WM	9	SW SE
8 N	9 W	WM	9	SE SE
8 N	9 W	WM	10	NE NE
8 N	9 W	WM	10	NW NE
8 N	9 W	WM	10	SW NE
8 N	9 W	WM	10	SE NE
8 N	9 W	WM	10	NE NW
8 N	9 W	WM	10	NW NW
8 N	9 W	WM	10	SW NW
8 N	9 W	WM	10	SE NW
8 N	9 W	WM	10	NE SW
8 N	9 W	WM	10	NW SW
8 N	9 W	WM	10	SW SW
8 N	9 W	WM	10	SE SW
8 N	9 W	WM	10	NE SE
8 N	9 W	WM	10	NW SE
8 N	9 W	WM	10	SW SE
8 N	9 W	WM	10	SE SE
8 N	9 W	WM	11	NE NE
8 N	9 W	WM	11	NW NE
8 N	9 W	WM	11	SW NE
8 N	9 W	WM	11	SE NE
8 N	9 W	WM	11	NE NW
8 N	9 W	WM	11	NW NW
8 N	9 W	WM	11	SW NW
8 N	9 W	WM	11	SE NW
8 N	9 W	WM	11	NE SW
8 N	9 W	WM	11	NW SW
8 N	9 W	WM	11	SW SW
8 N	9 W	WM	11	SE SW
8 N	9 W	WM	11	NE SE
8 N	9 W	WM	11	NW SE
8 N	9 W	WM	11	SW SE
8 N	9 W	WM	11	SE SE

Twp	Rng	Mer	Sec	Q-Q
8 N	9 W	WM	12	NE NE
8 N	9 W	WM	12	NW NE
8 N	9 W	WM	12	SW NE
8 N	9 W	WM	12	SE NE
8 N	9 W	WM	12	NE NW
8 N	9 W	WM	12	NW NW
8 N	9 W	WM	12	SW NW
8 N	9 W	WM	12	SE NW
8 N	9 W	WM	12	NE SW
8 N	9 W	WM	12	NW SW
8 N	9 W	WM	12	SW SW
8 N	9 W	WM	12	SE SW
8 N	9 W	WM	12	NE SE
8 N	9 W	WM	12	NW SE
8 N	9 W	WM	12	SW SE
8 N	9 W	WM	12	SE SE
8 N	9 W	WM	13	NE NE
8 N	9 W	WM	13	NW NE
8 N	9 W	WM	13	SW NE
8 N	9 W	WM	13	SE NE
8 N	9 W	WM	13	NE NW
8 N	9 W	WM	13	NW NW
8 N	9 W	WM	13	SW NW
8 N	9 W	WM	13	SE NW
8 N	9 W	WM	13	NE SW
8 N	9 W	WM	13	NW SW
8 N	9 W	WM	13	SW SW
8 N	9 W	WM	13	SE SW
8 N	9 W	WM	13	NE SE
8 N	9 W	WM	13	NW SE
8 N	9 W	WM	13	SW SE
8 N	9 W	WM	13	SE SE
8 N	9 W	WM	14	NE NE
8 N	9 W	WM	14	NW NE
8 N	9 W	WM	14	SW NE
8 N	9 W	WM	14	SE NE
8 N	9 W	WM	14	NE NW
8 N	9 W	WM	14	NW NW
8 N	9 W	WM	14	SW NW
8 N	9 W	WM	14	SE NW
8 N	9 W	WM	14	NE SW
8 N	9 W	WM	14	NW SW
8 N	9 W	WM	14	SW SW
8 N	9 W	WM	14	SE SW
8 N	9 W	WM	14	NE SE
8 N	9 W	WM	14	NW SE
8 N	9 W	WM	14	SW SE
8 N	9 W	WM	14	SE SE
8 N	9 W	WM	15	NE NE

Twp	Rng	Mer	Sec	Q-Q
8 N	9 W	WM	15	NW NE
8 N	9 W	WM	15	SW NE
8 N	9 W	WM	15	SE NE
8 N	9 W	WM	15	NE NW
8 N	9 W	WM	15	NW NW
8 N	9 W	WM	15	SW NW
8 N	9 W	WM	15	SE NW
8 N	9 W	WM	15	NE SW
8 N	9 W	WM	15	NW SW
8 N	9 W	WM	15	SW SW
8 N	9 W	WM	15	SE SW
8 N	9 W	WM	15	NE SE
8 N	9 W	WM	15	NW SE
8 N	9 W	WM	15	SW SE
8 N	9 W	WM	15	SE SE
8 N	9 W	WM	16	NE NE
8 N	9 W	WM	16	NW NE
8 N	9 W	WM	16	SW NE
8 N	9 W	WM	16	SE NE
8 N	9 W	WM	16	NE NW
8 N	9 W	WM	16	NW NW
8 N	9 W	WM	16	SW NW
8 N	9 W	WM	16	SE NW
8 N	9 W	WM	16	NE SW
8 N	9 W	WM	16	NW SW
8 N	9 W	WM	16	SW SW
8 N	9 W	WM	16	SE SW
8 N	9 W	WM	16	NE SE
8 N	9 W	WM	16	NW SE
8 N	9 W	WM	16	SW SE
8 N	9 W	WM	16	SE SE
8 N	9 W	WM	17	NE NE
8 N	9 W	WM	17	NW NE
8 N	9 W	WM	17	SW NE
8 N	9 W	WM	17	SE NE
8 N	9 W	WM	17	NE NW
8 N	9 W	WM	17	NW NW
8 N	9 W	WM	17	SW NW
8 N	9 W	WM	17	SE NW
8 N	9 W	WM	17	NE SW
8 N	9 W	WM	17	NW SW
8 N	9 W	WM	17	SW SW
8 N	9 W	WM	17	SE SW
8 N	9 W	WM	17	NE SE
8 N	9 W	WM	17	NW SE
8 N	9 W	WM	17	SW SE
8 N	9 W	WM	17	SE SE
8 N	9 W	WM	18	NE NE
8 N	9 W	WM	18	NW NE

Twp	Rng	Mer	Sec	Q-Q
8 N	9 W	WM	18	SW NE
8 N	9 W	WM	18	SE NE
8 N	9 W	WM	18	NE NW
8 N	9 W	WM	18	NW NW
8 N	9 W	WM	18	SW NW
8 N	9 W	WM	18	SE NW
8 N	9 W	WM	18	NE SW
8 N	9 W	WM	18	NW SW
8 N	9 W	WM	18	SW SW
8 N	9 W	WM	18	SE SW
8 N	9 W	WM	18	NE SE
8 N	9 W	WM	18	NW SE
8 N	9 W	WM	18	SW SE
8 N	9 W	WM	18	SE SE
8 N	10 W	WM	12	NE NE
8 N	10 W	WM	12	NW NE
8 N	10 W	WM	12	SW NE
8 N	10 W	WM	12	SE NE
8 N	10 W	WM	12	NE NW
8 N	10 W	WM	12	NW NW
8 N	10 W	WM	12	SW NW
8 N	10 W	WM	12	SE NW
8 N	10 W	WM	12	NE SW
8 N	10 W	WM	12	NW SW
8 N	10 W	WM	12	SW SW
8 N	10 W	WM	12	SE SW
8 N	10 W	WM	12	NE SE
8 N	10 W	WM	12	NW SE
8 N	10 W	WM	12	SW SE
8 N	10 W	WM	12	SE SE
8 N	10 W	WM	13	NE NE
8 N	10 W	WM	13	NW NE
8 N	10 W	WM	13	SW NE
8 N	10 W	WM	13	SE NE
8 N	10 W	WM	13	NE NW
8 N	10 W	WM	13	NW NW
8 N	10 W	WM	13	SW NW
8 N	10 W	WM	13	SE NW
8 N	10 W	WM	13	NE SW
8 N	10 W	WM	13	NW SW
8 N	10 W	WM	13	SW SW
8 N	10 W	WM	13	SE SW
8 N	10 W	WM	13	NE SE
8 N	10 W	WM	13	NW SE
8 N	10 W	WM	13	SW SE
8 N	10 W	WM	13	SE SE

This use may be regulated if analysis of data available discloses that the appropriation will measurably reduce the surface water flows necessary to maintain the free-flowing character of a scenic waterway in quantities necessary for recreation, fish and wildlife in effect as of the priority date of this right or as those quantities may be subsequently reduced.

WITNESS the signature of the Water Resources Director, affixed SEP 2 9 2006

Phillip C. Ward, Director
Water Resources Department

STATE OF OREGON
COUNTY OF CLATPSOP
CERTIFICATE OF WATER RIGHT

THIS CERTIFICATE ISSUED TO:

CITY OF ASTORIA
1095 DUANE STREET
ASTORIA, OR 97103

confirms the right to use up to 6.0 CUBIC FEET PER SECOND (cfs) of the waters of BEAR CREEK and BEAR CREEK RESERVOIR for HYDROELECTRIC PRODUCTION of 68.2 THEORETICAL HORSEPOWER (THP).

The use of water for hydroelectric purposes shall be in conjunction with water used under the right of the City of Astoria for municipal purposes, as evidenced by Certificate 82236. Use of water shall be limited to periods when the water user's water right under Certificate 82236 is put to beneficial use without waste. The amount of water used shall not be greater than the quantity of water diverted to satisfy the authorized specific use under Certificate 82236. The use of water shall be limited by rate, duty, season and any other limitations of Certificate 82236. ORS 543.765(5)(b) and (c).

The applicant shall measure and report the quantity of water diverted. ORS 543.765(5)(d).

This right was filed under application PC 898.

The point of diversion is located: 1160 FEET NORTH AND 2340 FEET WEST FROM SE CORNER OF SECTION 2, being within the SW¼ SE¼, SECTION 2, TOWNSHIP 7 NORTH, RANGE 8 WEST, W.M.

NOTICE OF RIGHT TO PETITION FOR RECONSIDERATION OR JUDICIAL REVIEW

This is an order in other than a contested case. This order is subject to judicial review under ORS 183.484 and ORS 536.075. Any petition for judicial review must be filed within the 60-day time period specified by ORS 183.484(2). Pursuant to ORS 183.484, ORS 536.075 and OAR 137-004-0080, you may petition for judicial review and petition the Director for reconsideration of this order. A petition for reconsideration may be granted or denied by the Director, and if no action is taken within 60 days following the date the petition was filed, the petition shall be deemed denied. In addition, under ORS 537.260 any person with an application, permit or water right certificate subsequent in priority may jointly or severally contest the issuance of the certificate within three months after issuance of the certificate.

This statement of judicial review rights does not create a right to judicial review of this order if judicial review is otherwise precluded by law.

The authorized place of use is located: Tax Lot 200, SW¼ SE¼, SECTION 2, TOWNSHIP 7 NORTH, RANGE 8 WEST, W.M.

PROJECT DESCRIPTION

Water diverted from the Bear Creek Watershed travels to the water treatment plant. After treatment, the water is discharged into a 21 inch diameter steel pipe at the top of the Bear Creek Dam and descends approximately 100 feet in elevation to where a hydroelectric turbine is housed. Having passed through the turbine the water continues to the City of Astoria for distribution. The hydroelectric works, located on the downstream face of the dam include: a vault to house the turbine, an alternator, a power conversion system, and other accessory equipment.

WATER RIGHT CONDITIONS

Upon review of the application, the Oregon Water Resources Department (Department or OWRD) finds that the Bear Creek Watershed Hydroelectric Project (Project), with the conditions set forth below is consistent with the public interest. The Project is well adapted to the development and utilization of the water power involved.

1. The water right holder shall comply with all statutes and rules applicable to the Project.

2. The water right holder shall construct and build the Project according to the maps, plans and specifications filed with the application within five years of issuance of this water right certificate or by any lawful extension thereof. ORS 543.765 (10)

3. The water right holder shall construct, operate and maintain all fish screens, bypass devices and fish passages as required by the Oregon Department of Fish and Wildlife (ODFW). ORS 543.765(5)(a). The City has chosen to pay the annual Fish Passage Restoration fee identified in Oregon Laws 2013, Chapter 674 in lieu of providing fish passage.

4. The water right holder shall allow the OWRD Director and authorized agents and employees of the Oregon Department of Environmental Quality (ODEQ), ODFW, and OWRD free and unrestricted access in, through, and across the Project in the performance of their official duties, and shall allow free access to all reports, accounts, records, and other data relating to said Project.

5. This certificate shall be invalidated upon a change in the point of diversion authorized under Certificate 82236. ORS 543.765(5)(g).

6. The Oregon Water Resources Department shall conduct a review of this certificate upon approval of any changes or adjustments made to the water user's existing water right to determine if a revised certificate should be issued. ORS 543.765(5) (h).

7. The right to use water under this certificate is invalidated if the Federal Energy Regulatory Commission exemption related to the certificate is canceled or invalidated. ORS 543.765 (i).

8. This certificate does not have its own priority date. The Department shall not regulate for or against this certificate. This certificate does not grant a right to divert water for hydroelectric purposes other than in conjunction with the water right as used under Certificate 82236. ORS 543.765 (6) and (7).

9. This certificate is subject to review by the Department 50 years after the date of issuance pursuant to ORS 543.765(9).

10. The water right holder shall pay, upon receiving an invoice from OWRD, an annual fee to OWRD under ORS 543.078. This amount shall be due by the date specified on the invoice. ORS 543.765 (11) and (12).

11. The water right holder shall pay, upon receiving an invoice from OWRD, an annual Fish Passage Restoration fee to OWRD under Oregon Laws 2013, Chapter 674. This amount shall be due by the date specified on the invoice. ORS 543.765 (11) and (12). Pursuant to Oregon Laws 2013, Chapter 674, this annual Fish Passage Restoration fee may be terminated after the project commences operation if the project provides fish passages, or there is an agreement between the water right holder and ODFW providing for fish passages associated with the project, or a waiver or exemption has been issued under ORS 509.585 for the project.

12. If at any time, unanticipated circumstances or emergency situations arise in which fish or wildlife are being killed, harmed or endangered by any of the project facilities the City of Astoria shall immediately take appropriate action to prevent further loss. The City of Astoria shall notify the nearest ODFW office within 24 hours and shall comply with measures required by ODFW to prevent additional injury or mortality.

13. Failure to comply with any of the provisions of this water right may result in action including, but not limited to, restrictions on the use, civil penalties, or cancellation of the water right.

Issued December 11, 2013

Dwight W. French, Administrator
Water Right Services Division, *for*
Phillip C. Ward, Director
Oregon Water Resources Department

Recorded in State Record of Water Right Certificates numbered 89004

STATE OF OREGON

COUNTY OF CLATSOP

CERTIFICATE OF WATER RIGHT

THIS CERTIFICATE ISSUED TO

CITY OF ASTORIA
1095 DUANE ST
ASTORIA OR 97103

confirms the right to use the waters of CEDAR CREEK for MUNICIPAL USES.

This right was perfected under Permit S-31881. The date of priority is AUGUST 17, 1966. The amount of water to which this right is entitled is limited to an amount actually used beneficially, and shall not exceed 2.0 CUBIC FEET PER SECOND or its equivalent in case of rotation, measured at the point of diversion.

The point of diversion is located as follows:

Twp	Rng	Mer	Sec	Q-Q	Survey Coordinates
7 N	8 W	WM	1	SW SW	150 FEET NORTH AND 540 FEET EAST FROM SW CORNER, SECTION 1

A description of the place of use to which this right is appurtenant is as follows:

Twp	Rng	Mer	Sec	Q-Q
8 N	9 W	WM	2	NE NE
8 N	9 W	WM	2	NW NE
8 N	9 W	WM	2	SW NE
8 N	9 W	WM	2	SE NE
8 N	9 W	WM	2	NE NW
8 N	9 W	WM	2	NW NW
8 N	9 W	WM	2	SW NW
8 N	9 W	WM	2	SE NW
8 N	9 W	WM	2	NE SW
8 N	9 W	WM	2	NW SW
8 N	9 W	WM	2	SW SW
8 N	9 W	WM	2	SE SW
8 N	9 W	WM	2	NE SE
8 N	9 W	WM	2	NW SE

NOTICE OF RIGHT TO PETITION FOR RECONSIDERATION OR JUDICIAL REVIEW

This is an order in other than a contested case. This order is subject to judicial review under ORS 183.484. Any petition for judicial review must be filed within the 60-day time period specified by ORS 183.484(2). Pursuant to ORS 536.075 and OAR 137-004-0080, you may either petition for judicial review or petition the Director for reconsideration of this order. A petition for reconsideration may be granted or denied by the Director, and if no action is taken within 60 days following the date the petition was filed, the petition shall be deemed denied. In addition, under ORS 537.260 any person with an application, permit or water right certificate subsequent in priority may jointly or severally contest the issuance of the certificate at any time before it has issued, and after the time has expired for the completion of the appropriation under the permit, or within three months after issuance of the certificate.

Twp	Rng	Mer	Sec	Q-Q
8 N	9 W	WM	2	SW SE
8 N	9 W	WM	2	SE SE
8 N	9 W	WM	3	NE NE
8 N	9 W	WM	3	NW NE
8 N	9 W	WM	3	SW NE
8 N	9 W	WM	3	SE NE
8 N	9 W	WM	3	NE NW
8 N	9 W	WM	3	NW NW
8 N	9 W	WM	3	SW NW
8 N	9 W	WM	3	SE NW
8 N	9 W	WM	3	NE SW
8 N	9 W	WM	3	NW SW
8 N	9 W	WM	3	SW SW
8 N	9 W	WM	3	SE SW
8 N	9 W	WM	3	NE SE
8 N	9 W	WM	3	NW SE
8 N	9 W	WM	3	SW SE
8 N	9 W	WM	3	SE SE
8 N	9 W	WM	7	NE NE
8 N	9 W	WM	7	NW NE
8 N	9 W	WM	7	SW NE
8 N	9 W	WM	7	SE NE
8 N	9 W	WM	7	NE NW
8 N	9 W	WM	7	NW NW
8 N	9 W	WM	7	SW NW
8 N	9 W	WM	7	SE NW
8 N	9 W	WM	7	NE SW
8 N	9 W	WM	7	NW SW
8 N	9 W	WM	7	SW SW
8 N	9 W	WM	7	SE SW
8 N	9 W	WM	7	NE SE
8 N	9 W	WM	7	NW SE
8 N	9 W	WM	7	SW SE
8 N	9 W	WM	7	SE SE
8 N	9 W	WM	8	NE NE
8 N	9 W	WM	8	NW NE
8 N	9 W	WM	8	SW NE
8 N	9 W	WM	8	SE NE
8 N	9 W	WM	8	NE NW
8 N	9 W	WM	8	NW NW
8 N	9 W	WM	8	SW NW
8 N	9 W	WM	8	SE NW
8 N	9 W	WM	8	NE SW
8 N	9 W	WM	8	NW SW
8 N	9 W	WM	8	SW SW
8 N	9 W	WM	8	SE SW
8 N	9 W	WM	8	NE SE
8 N	9 W	WM	8	NW SE
8 N	9 W	WM	8	SW SE

Twp	Rng	Mer	Sec	Q-Q
8 N	9 W	WM	8	SE SE
8 N	9 W	WM	9	NE NE
8 N	9 W	WM	9	NW NE
8 N	9 W	WM	9	SW NE
8 N	9 W	WM	9	SE NE
8 N	9 W	WM	9	NE NW
8 N	9 W	WM	9	NW NW
8 N	9 W	WM	9	SW NW
8 N	9 W	WM	9	SE NW
8 N	9 W	WM	9	NE SW
8 N	9 W	WM	9	NW SW
8 N	9 W	WM	9	SW SW
8 N	9 W	WM	9	SE SW
8 N	9 W	WM	9	NE SE
8 N	9 W	WM	9	NW SE
8 N	9 W	WM	9	SW SE
8 N	9 W	WM	9	SE SE
8 N	9 W	WM	10	NE NE
8 N	9 W	WM	10	NW NE
8 N	9 W	WM	10	SW NE
8 N	9 W	WM	10	SE NE
8 N	9 W	WM	10	NE NW
8 N	9 W	WM	10	NW NW
8 N	9 W	WM	10	SW NW
8 N	9 W	WM	10	SE NW
8 N	9 W	WM	10	NE SW
8 N	9 W	WM	10	NW SW
8 N	9 W	WM	10	SW SW
8 N	9 W	WM	10	SE SW
8 N	9 W	WM	10	NE SE
8 N	9 W	WM	10	NW SE
8 N	9 W	WM	10	SW SE
8 N	9 W	WM	10	SE SE
8 N	9 W	WM	11	NE NE
8 N	9 W	WM	11	NW NE
8 N	9 W	WM	11	SW NE
8 N	9 W	WM	11	SE NE
8 N	9 W	WM	11	NE NW
8 N	9 W	WM	11	NW NW
8 N	9 W	WM	11	SW NW
8 N	9 W	WM	11	SE NW
8 N	9 W	WM	11	NE SW
8 N	9 W	WM	11	NW SW
8 N	9 W	WM	11	SW SW
8 N	9 W	WM	11	SE SW
8 N	9 W	WM	11	NE SE
8 N	9 W	WM	11	NW SE
8 N	9 W	WM	11	SW SE
8 N	9 W	WM	11	SE SE

Twp	Rng	Mer	Sec	Q-Q
8 N	9 W	WM	12	NE NE
8 N	9 W	WM	12	NW NE
8 N	9 W	WM	12	SW NE
8 N	9 W	WM	12	SE NE
8 N	9 W	WM	12	NE NW
8 N	9 W	WM	12	NW NW
8 N	9 W	WM	12	SW NW
8 N	9 W	WM	12	SE NW
8 N	9 W	WM	12	NE SW
8 N	9 W	WM	12	NW SW
8 N	9 W	WM	12	SW SW
8 N	9 W	WM	12	SE SW
8 N	9 W	WM	12	NE SE
8 N	9 W	WM	12	NW SE
8 N	9 W	WM	12	SW SE
8 N	9 W	WM	12	SE SE
8 N	9 W	WM	13	NE NE
8 N	9 W	WM	13	NW NE
8 N	9 W	WM	13	SW NE
8 N	9 W	WM	13	SE NE
8 N	9 W	WM	13	NE NW
8 N	9 W	WM	13	NW NW
8 N	9 W	WM	13	SW NW
8 N	9 W	WM	13	SE NW
8 N	9 W	WM	13	NE SW
8 N	9 W	WM	13	NW SW
8 N	9 W	WM	13	SW SW
8 N	9 W	WM	13	SE SW
8 N	9 W	WM	13	NE SE
8 N	9 W	WM	13	NW SE
8 N	9 W	WM	13	SW SE
8 N	9 W	WM	13	SE SE
8 N	9 W	WM	14	NE NE
8 N	9 W	WM	14	NW NE
8 N	9 W	WM	14	SW NE
8 N	9 W	WM	14	SE NE
8 N	9 W	WM	14	NE NW
8 N	9 W	WM	14	NW NW
8 N	9 W	WM	14	SW NW
8 N	9 W	WM	14	SE NW
8 N	9 W	WM	14	NE SW
8 N	9 W	WM	14	NW SW
8 N	9 W	WM	14	SW SW
8 N	9 W	WM	14	SE SW
8 N	9 W	WM	14	NE SE
8 N	9 W	WM	14	NW SE
8 N	9 W	WM	14	SW SE
8 N	9 W	WM	14	SE SE
8 N	9 W	WM	15	NE NE

Twp	Rng	Mer	Sec	Q-Q
8 N	9 W	WM	15	NW NE
8 N	9 W	WM	15	SW NE
8 N	9 W	WM	15	SE NE
8 N	9 W	WM	15	NE NW
8 N	9 W	WM	15	NW NW
8 N	9 W	WM	15	SW NW
8 N	9 W	WM	15	SE NW
8 N	9 W	WM	15	NE SW
8 N	9 W	WM	15	NW SW
8 N	9 W	WM	15	SW SW
8 N	9 W	WM	15	SE SW
8 N	9 W	WM	15	NE SE
8 N	9 W	WM	15	NW SE
8 N	9 W	WM	15	SW SE
8 N	9 W	WM	15	SE SE
8 N	9 W	WM	16	NE NE
8 N	9 W	WM	16	NW NE
8 N	9 W	WM	16	SW NE
8 N	9 W	WM	16	SE NE
8 N	9 W	WM	16	NE NW
8 N	9 W	WM	16	NW NW
8 N	9 W	WM	16	SW NW
8 N	9 W	WM	16	SE NW
8 N	9 W	WM	16	NE SW
8 N	9 W	WM	16	NW SW
8 N	9 W	WM	16	SW SW
8 N	9 W	WM	16	SE SW
8 N	9 W	WM	16	NE SE
8 N	9 W	WM	16	NW SE
8 N	9 W	WM	16	SW SE
8 N	9 W	WM	16	SE SE
8 N	9 W	WM	17	NE NE
8 N	9 W	WM	17	NW NE
8 N	9 W	WM	17	SW NE
8 N	9 W	WM	17	SE NE
8 N	9 W	WM	17	NE NW
8 N	9 W	WM	17	NW NW
8 N	9 W	WM	17	SW NW
8 N	9 W	WM	17	SE NW
8 N	9 W	WM	17	NE SW
8 N	9 W	WM	17	NW SW
8 N	9 W	WM	17	SW SW
8 N	9 W	WM	17	SE SW
8 N	9 W	WM	17	NE SE
8 N	9 W	WM	17	NW SE
8 N	9 W	WM	17	SW SE
8 N	9 W	WM	17	SE SE
8 N	9 W	WM	18	NE NE
8 N	9 W	WM	18	NW NE

Twp	Rng	Mer	Sec	Q-Q
8 N	9 W	WM	18	SW NE
8 N	9 W	WM	18	SE NE
8 N	9 W	WM	18	NE NW
8 N	9 W	WM	18	NW NW
8 N	9 W	WM	18	SW NW
8 N	9 W	WM	18	SE NW
8 N	9 W	WM	18	NE SW
8 N	9 W	WM	18	NW SW
8 N	9 W	WM	18	SW SW
8 N	9 W	WM	18	SE SW
8 N	9 W	WM	18	NE SE
8 N	9 W	WM	18	NW SE
8 N	9 W	WM	18	SW SE
8 N	9 W	WM	18	SE SE
8 N	10 W	WM	12	NE NE
8 N	10 W	WM	12	NW NE
8 N	10 W	WM	12	SW NE
8 N	10 W	WM	12	SE NE
8 N	10 W	WM	12	NE NW
8 N	10 W	WM	12	NW NW
8 N	10 W	WM	12	SW NW
8 N	10 W	WM	12	SE NW
8 N	10 W	WM	12	NE SW
8 N	10 W	WM	12	NW SW
8 N	10 W	WM	12	SW SW
8 N	10 W	WM	12	SE SW
8 N	10 W	WM	12	NE SE
8 N	10 W	WM	12	NW SE
8 N	10 W	WM	12	SW SE
8 N	10 W	WM	12	SE SE
8 N	10 W	WM	13	NE NE
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8 N	10 W	WM	13	SE NW
8 N	10 W	WM	13	NE SW
8 N	10 W	WM	13	NW SW
8 N	10 W	WM	13	SW SW
8 N	10 W	WM	13	SE SW
8 N	10 W	WM	13	NE SE
8 N	10 W	WM	13	NW SE
8 N	10 W	WM	13	SW SE
8 N	10 W	WM	13	SE SE

This use may be regulated if analysis of data available discloses that the appropriation will measurably reduce the surface water flows necessary to maintain the free-flowing character of a scenic waterway in quantities necessary for recreation, fish and wildlife in effect as of the priority date of this right or as those quantities may be subsequently reduced.

The use of water allowed herein may be made only at times when sufficient water is available to satisfy all prior rights, including prior rights for maintaining instream flows.

WITNESS the signature of the Water Resources Director, affixed SEP 29 2006

Phillip C. Ward, Director
Water Resources Department

 Recorded in State Record of Water Right Certificates numbered 82237.

2M-2-51

* Reservoir Permit No. [illegible]

Application for a Permit to Construct a Reservoir and to Store for Beneficial Use the Unappropriated Waters of the State of Oregon

I, THE CITY OF ASTORIA
(Name of Applicant)

of City Hall, 1095 Duane Stree, Astoria, Oregon,
(Mailing Address)

State of OREGON, do hereby make application for a permit to construct the following described reservoir and to store the unappropriated waters of the State of Oregon, subject to existing rights.

If the applicant is a corporation, give date and place of incorporation

Municipal Corporation

1. The name of the proposed reservoir is Youngs River Reservoir

2. The name of the stream from which the reservoir is to be filled and the appropriation made is

Youngs River

tributary of The Columbia River

3. The amount of water to be stored is 12,000 acre feet.

4. The use to be made of the impounded water is Municipal purposes
(Irrigation, power, domestic supply, etc.)

Refer to) Page 2) 5. The location of the proposed reservoir will be in Sec. 7, 16, 17, & 18, T 6 N.R.8 W. Sec. 12
(Give sections or townships to be submerged)

Tp. 6 N., R. 9 W., W. M., in the county of Clatsop

(a) State whether situated in channel of running stream and give character of material at outlet

In channel of Youngs River. Material at outlet clay over rock - Rock in stream bed.

(b) If not in channel of running stream, state how it is to be filled. If through a feed canal, give name and dimensions

6. The dam will be located in Lots 3 and 4, Sec. 7 T.6 N.R.8,W.W.M., & S.E.¼ of N.E.¼ Sec.12, ~~Sec~~ T6N.R.9 W.W.M.
(Smallest legal subdivision)

Tp. ...., R. ...., W. M. The maximum height will be 81 feet above stream bed or ground surface on center line of dam. The length on top will be 575 feet; length on bottom 45 feet; width on top 20 feet; slope of front or water side 3:1 (Feet horizontal to 1 vertical); slope on back 2:1 (Feet horizontal to 1 vertical); height of dam above water line when full 7.5 feet.

* A different form of application should be used for the appropriation of stored water to beneficial use. Such forms can be secured without charge, together with instructions, by addressing the State Engineer, Salem, Oregon.

7. The construction of dam, the material of which it is to be built, and method of protection from waves are as follows: Rock fill on lower slope, impervious clay in upper stream half, water face covered with three feet rock surface.

8. The location of wasteway with dimensions are as follows: Wasteway around dam of (State whether over or around the dam) concrete 80 feet wide with six foot high sidewalls, Crest of wasteway 10 feet below dam crest - 2.5' removable sections on spillway crest.

9. The location of outlet from the proposed reservoir, with character of construction and dimensions, are as follows: Outlet pipes through dam. (State whether through or around the proposed dam)

10. The area submerged by the proposed reservoir, when full, will be 440 acres, with a maximum depth of water of 68.5 feet; and approximate mean depth of water 45 feet.

11. The estimated cost of the proposed work is $ 550,000.00

12. Construction work will begin on or before January, 1962

13. Construction work will be completed on or before January, 1964

THE CITY OF ASTORIA, OREGON
(Name of applicant)

By:
William H. Cunningham
City Manager

STATE OF OREGON,
County of Marion, } ss.

This is to certify that I have examined the foregoing application, together with the accompanying maps and data, and return the same for correction or completion as follows: completion

In order to retain its priority, this application must be returned to the State Engineer, with corrections, on or before January 16, 1961.

WITNESS my hand this 14th day of October, 1960

LEWIS A. STANLEY
STATE ENGINEER

By
James W. Carver, Jr., Assistant
eh

Remarks: Additional borings of dam foundation, tests of soils and more topography around borders of flooded areas to be secured.

(Refer Page 1.) (Par. #5) The location of the proposed reservoir will be in ~~Sec.~~ $W\frac{1}{2}$ Sec. 7

SE $\frac{1}{4}$ NW$\frac{1}{4}$ Sec. 16: S$\frac{1}{2}$ NE$\frac{1}{4}$, S$\frac{1}{2}$ NW$\frac{1}{4}$; N$\frac{1}{2}$ NE$\frac{1}{4}$ SW$\frac{1}{4}$ Sec. 17;

N$\frac{1}{2}$ NW$\frac{1}{4}$; SE$\frac{1}{4}$ NW$\frac{1}{4}$; S$\frac{1}{2}$ NE$\frac{1}{4}$ Sec. 18.

STATE OF OREGON, }
County of Marion, } *ss.*

This is to certify that I have examined the foregoing application and do hereby grant the same, subject to the following limitations and conditions: The right herein granted is limited to the construction of Young's River Reservoir and storage of water from Young's River to be appropriated under application No. 25856, permit No. 27092 for municipal use, and plans and specifications shall be submitted to and approved by the State Engineer before beginning of construction work.

The right hereunder shall be limited to the storage of 12,000.0 *acre feet.*

The priority date of this permit is January 17, 1961

Actual construction work shall begin on or before February 15, 1965

and shall thereafter be prosecuted with reasonable diligence and be completed on or before October 1, 1965

WITNESS my hand this 15th *day of* February, 19 61

Lewis A. Stanley
STATE ENGINEER

Extended to October 1, 1989

A+B extended to 10-1-95

(5)

Application No. R-25855

Reservoir Permit No. R-2568

PERMIT

To construct a reservoir and store for beneficial use the unappropriated waters of the State of Oregon.

This instrument was first received in the office of the State Engineer at Salem, Oregon, on the 5th day of October, 1959, at 8:00 o'clock A M.

Approved:

February 15, 1961

Recorded in Book No. 9 of Reservoirs, on Page ....

LEWIS A. STANLEY
STATE ENGINEER

Drainage Basin No. 1 page 23

Fees Paid ....

State Printing Dept. 47156

5M—10-56

Permit No. [illegible]

*APPLICATION FOR PERMIT

To Appropriate the Public Waters of the State of Oregon

I, THE CITY OF ASTORIA
(Name of applicant)

of City Hall 1095 Duane Street, Astoria, Oregon,
(Mailing address)

State of OREGON, do hereby make application for a permit to appropriate the following described public waters of the State of Oregon, SUBJECT TO EXISTING RIGHTS:

If the applicant is a corporation, give date and place of incorporation MUNICIPAL CORPORATION

1. The source of the proposed appropriation is Youngs River and Youngs River Reservoir
(Name of stream)
, a tributary of the Columbia River

2. The amount of water which the applicant intends to apply to beneficial use is 26 cubic feet per second.
(If water is to be used from more than one source, give quantity from each)

**3. The use to which the water is to be applied is Municipal use
(Irrigation, power, mining, manufacturing, domestic supplies, etc.)

4. The point of diversion is located ...... ft. ...... (N. or S.) and ...... ft. ...... (E. or W.) from the ...... corner of ......
(Section or subdivision)

N. 48° 43' W 5300' from the ¼ Section Corner between sections 7 and 18

T. 6N. R.8 W

(If preferable, give distance and bearing to section corner)

(If there is more than one point of diversion, each must be described. Use separate sheet if necessary)

being within the Lots 3 and 4 (Give smallest legal subdivision) and SE ¼ N.E. ¼ Sec 12 T 6 N R 9 W of Sec. 7, Tp. 6N (N. or S.), R. 8 W. (E. or W.), W. M., in the county of Clatsop

5. The pipeline (Main ditch, canal or pipe line) to be 13.5 miles (Miles or feet) in length, terminating in the S.W. ¼ of S. W. ¼ (Smallest legal subdivision) of Sec. 17, Tp. 8N. (N. or S.), R. 9 W. (E. or W.), W. M., the proposed location being shown throughout on the accompanying map.

DESCRIPTION OF WORKS

Diversion Works—

6. (a) Height of dam 81 feet, length on top 575 feet, length at bottom ...... feet; material to be used and character of construction loose rock and impervious clay, wasteway around dam.
(Loose rock, concrete, masonry, rock and brush, timber crib, etc., wasteway over or around dam)

(b) Description of headgate Two 48" valve controlled pipes
(Timber, concrete, etc., number and size of openings)

(c) If water is to be pumped give general description
(Size and type of pump)

(Size and type of engine or motor to be used, total head water is to be lifted, etc.)

*A different form of application is provided where storage works are contemplated.

**Application for permits to appropriate water for the generation of electricity, with the exception of municipalities, must be made to the Hydroelectric Commission. Either of the above forms may be secured, without cost, together with instructions by addressing the State Engineer, Salem.

7. (a) Give dimensions at each point of canal where materially changed in size, stating miles from headgate. At headgate: width on top (at water line) .... feet; width on bottom .... feet; depth of water .... feet; grade .... feet fall per one thousand feet.

(b) At .... miles from headgate: width on top (at water line) .... feet; width on bottom .... feet; depth of water .... feet; grade .... feet fall per one thousand feet.

(c) Length of pipe, 13.5 miles ~~ft~~; size at intake, 48 in.; size at 500 ft. from intake 42 in.; size at place of use 42 in.; difference in elevation between intake and place of use, 165 ft. Is grade uniform? Yes Estimated capacity, ... sec. ft.

8. Location of area to be irrigated, or place of use City of Astoria, Oregon

Township North or South	Range E. or W. of Willamette Meridian	Section	Forty-acre Tract	Number Acres To Be Irrigated
T - 8N	R 9 W	7,8,9,10, ~~11,14,15,~~	All	Municipal
		~~16,~~17,18	All	
T 8 N	R 10 W	12 & 13	All	
8 N.	9 W.	11	SW¼ NW¼	
			NW¼ SW¼	
			SW¼ SW¼	
		14	NW¼ NW¼	
			SW¼ NW¼	
		15	N½	
		16	N½	
			SW¼	

(If more space required, attach separate sheet)

(a) Character of soil ....

(b) Kind of crops raised None

Power or Mining Purposes—

9. (a) Total amount of power to be developed None theoretical horsepower.

(b) Quantity of water to be used for power None sec. ft.

(c) Total fall to be utilized .... (Head) feet.

(d) The nature of the works by means of which the power is to be developed ....

(e) Such works to be located in .... (Legal subdivision) of Sec. ...., Tp. .... (No. N. or S.), R. .... (No. E. or W.), W. M.

(f) Is water to be returned to any stream? No (Yes or No)

(g) If so, name stream and locate point of return ...., Sec. ...., Tp. .... (No. N. or S.), R. .... (No. E. or W.), W. M.

(h) The use to which power is to be applied is ....

(i) The nature of the mines to be served ....

PERMIT

STATE OF OREGON,
County of Marion, } ss.

This is to certify that I have examined the foregoing application and do hereby grant the same, SUBJECT TO EXISTING RIGHTS and the following limitations and conditions:

The right herein granted is limited to the amount of water which can be applied to beneficial use and shall not exceed 26.0 *cubic feet per second measured at the point of diversion from the stream, or its equivalent in case of rotation with other water users, from* XXXXX Young's River and Young's River Reservoir to be constructed under application No. R-25855, permit No. R- 2568.

The use to which this water is to be applied is municipal

If for irrigation, this appropriation shall be limited to - - - *of one cubic foot per second or its equivalent for each acre irrigated*

and shall be subject to such reasonable rotation system as may be ordered by the proper state officer.

The priority date of this permit is January 17, 1961

Actual construction work shall begin on or before February 15, 1965 *and shall thereafter be prosecuted with reasonable diligence and be completed on or before October 1, 19*65.

Complete application of the water to the proposed use shall be made on or before October 1, 19 65.

WITNESS my hand this 15th *day of* February, 19 61.

Lewis A. Stanley
STATE ENGINEER

plication No. 25856
mit No. 27092

PERMIT

PPROPRIATE THE PUBLIC
ATERS OF THE STATE
OF OREGON

strument was first received in the
e State Engineer at Salem, Oregon,
th day of October,
8:00 o'clock A. M.

o applicant:

February 15, 1961
d in book No. 74 of
page 27092

LEWIS A. STANLEY
STATE ENGINEER

Basin No. 1 page 23

State Printing 98137

County, having a present population of
(Name of)

and an estimated population of 15,000 in 19 65

(b) If for domestic use state number of families to be supplied 3,500

(Answer questions 11, 12, 13, and 14 in all cases)

11. Estimated cost of proposed works, $ 1,500,000

12. Construction work will begin on or before January, 1962

13. Construction work will be completed on or before January, 1964

14. The water will be completely applied to the proposed use on or before January, 1966

CITY OF ASTORIA, OREGON
(Signature of applicant)

By: [signature]
William H. Cunningham
City Manager

Remarks:

STATE OF OREGON,
County of Marion, } ss.

This is to certify that I have examined the foregoing application, together with the accompanying maps and data, and return the same for completion

In order to retain its priority, this application must be returned to the State Engineer, with corrections on or before ~~December 7~~, ~~19 59~~ January 16, 1961.

~~WITNESS my hand this 7th day of October, 19 59~~ 14th day of October, 1960.

RECEIVED
DEC 1 1959
STATE ENGINEER
SALEM, OREGON

LEWIS A. STANLEY
STATE ENGINEER

By [signature] [signature]
Walter N. Perry, James W. Carver, Jr.
ASSISTANT

*Permit No. 7 2 5 7

APPLICATION FOR A PERMIT

To Appropriate the Public Waters of the State of Oregon

I, CITY OF ASTORIA, Oregon
(Name of applicant)

of Astoria (Postoffice), *County of* Clatsop,

State of Oregon, *do hereby make application for a permit to appropriate the following described public waters of the State of Oregon, subject to existing rights:*

If the applicant is a corporation, give date and place of incorporation

State of Oregon - 1865

1. *The source of the proposed appropriation is* Youngs River (Name of stream), *tributary of* Columbia River

2. *The amount of water which the applicant intends to apply to beneficial use is* 23 *cubic feet per second.*

3. *The use to which the water is to be applied is* (Irrigation, power, mining, manufacturing, domestic supplies, etc.) (Power and domestic supply) Municipal Purposes.

4. *The point of diversion is located* 372 feet - South 27 degrees, 43 minutes (Give distance and bearing to section corner) west from the one-quarter corner of Sections 22-27

being within the NE¼ of the NW¼ (Give smallest legal subdivision) *of Sec.* 27, *Tp.* 7 N (No. N. or S.),

R. 9 W (No. E. or W.), *W. M., in the county of* Clatsop

5. *The* pipeline (Main ditch, canal or pipe line) *to be* nine *miles in length, terminating in the* SW ¼ of the SW¼ (Smallest legal subdivision) *of Sec.* 16, *Tp.* 8 N (No. N. or S.),

R. 9 W (No. E. or W.), *W. M., the proposed location being shown throughout on the accompanying map.*

6. *The name of the ditch, canal or other works is*

DESCRIPTION OF WORKS

DIVERSION WORKS—

7. (a) *Height of dam* 50 *feet, length on top* 135 *feet, length at bottom* 20 *feet; material to be used and character of construction* (Loose rock, concrete, masonry, rock and brush, timber crib, etc., wasteway over or around dam)

Concrete, Wasteway over dam.

(b) *Description of headgate* (Timber, concrete, etc., number and size of openings)

* A different form of application is provided where storage works are contemplated. These forms can be secured without charge, together with instructions, by addressing the State Engineer, Salem, Oregon.

CANAL SYSTEM—

8. (a) *Give dimensions at each point of canal where materially changed in size, stating miles from headgate. At headgate: Width on top (at water line)* .... *feet; width on bottom* .... *feet; depth of water* .... *feet; grade* .... *feet fall per one thousand feet.*

(b) *At* .... *miles from headgate: Width on top (at water line)* .... *feet; width on bottom* .... *feet; depth of water* .... *feet; grade* .... *feet fall per one thousand feet.*

FILL IN THE FOLLOWING INFORMATION WHERE THE WATER IS USED FOR

IRRIGATION—

9. *The land to be irrigated has a total area of* .... *acres, located in each smallest legal subdivision, as follows:* ....
(Give area of land in each smallest legal subdivision which you intend to irrigate)

(If more space required, attach separate sheet)

POWER, MINING, MANUFACTURING, OR TRANSPORTATION PURPOSES—

10. (a) *Total amount of power to be developed* 200 *theoretical horsepower.*

(b) *Total fall to be utilized* 80 (Head) *feet.*

(c) *The nature of the works by means of which the power is to be developed* Turbine

(d) *Such works to be located in* NE¼ of the NW¼ (Legal subdivision) *of Sec.* 27, *Tp.* 7 N (No. N. or S.), *R.* 9 W (No. E. or W.), *W. M.*

(e) *Is water to be returned to any stream?* Yes (Yes or No)

(f) *If so, name stream and locate point of return* Youngs River NE¼ of the NW¼, *Sec.* 27, *Tp.* 7 N (No. N. or S.), *R.* 9 W (No. E. or W.), *W. M.*

(g) *The use to which power is to be applied is* Municipal purposes.

(h) *The nature of the mines to be served* ....

MUNICIPAL SUPPLY—

11. *To supply the city of* Astoria

Clatsop (Name of) *County, having a present population of* 12000,

and an estimated population of 35,000 *in* 1930

(Answer questions 12, 13, 14, and 15 in all cases)

12. *Estimated cost of proposed works, $* 200,000.00

13. *Construction work will begin on or before* 1930

14. *Construction work will be completed on or before* 1932

15. *The water will be completely applied to the proposed use on or before* 1932

Duplicate maps of the proposed ditch or other works, prepared in accordance with the rules of the State Engineer, accompany this application.

City of Astoria, Oregon
(Name of applicant)
by O. A. Kratz,
City Manager,

Signed in the presence of us as witnesses:

(1) Agnes Cook (Name), Astoria, Ore. (Address of witness)

(2) J. S. Parks, (Name), Astoria, Ore. (Address of witness)

Remarks:

STATE OF OREGON,
County of Marion, } ss.

This is to certify that I have examined the foregoing application, together with the accompanying maps and data, and return the same for correction or completion, as follows:

For completion

In order to retain its priority, this application must be returned to the State Engineer, with corrections, on or before April 23, 1926

WITNESS *my hand this* 23rd *day of* March, 1926.

RHEA LUPER
STATE ENGINEER.
CH.

7257(c)

1

Application No. 10226

Permit No. 7257

PERMIT

TO APPROPRIATE THE PUBLIC WATERS OF THE STATE OF OREGON

District No. ....

This instrument was first received in the office of the State Engineer at Salem, Oregon, on the 8 *day of* June, *192*5, *at* 8:30 *o'clock* A. *M.*

Returned to applicant for correction:

March 23rd, 1926.

Corrected application received:

March 27th, 1926.

Approved:

April 9th, 1926.

Recorded in Book No. 24 *of Permits, on page* 7257.

RHEA LUPER

STATE ENGINEER.

1 map ACFP

$8.00

STATE OF OREGON, }
County of Marion, } *ss.*

This is to certify that I have examined the foregoing application and do hereby grant the same, subject to the following limitations and conditions: If for irrigation, this appropriation shall be limited to one-eightieth of one cubic foot per second, or its equivalent, for each acre irrigated, and shall be subject to such reasonable rotation system as may be ordered by the proper state officer.

The right herein granted is limited to the appropriation of water from Youngs River for municipal purposes.

The amount of water appropriated shall be limited to the amount which can be applied to beneficial use and not to exceed 23.0 *cubic feet per second, or its equivalent in case of rotation. The priority date of this permit is* June 8, 1925.

Actual construction work shall begin on or before April 9, 1921 *and shall thereafter be prosecuted with reasonable diligence and be completed on or before* April 9, 1931 EXTENDED TO Apr. 9, 1936 10/1/41 Extended to Oct. 1, 1946 Extended to Oct. 1, 1951

Complete application of the water to the proposed use shall be made on or before October 1, 1932 EXTENDED TO Apr. 9, 1937 10/1/41 Extended to Oct. 1, 1946 Extended to Oct. 1, 1952 Extended to Oct. 1, 1958

Apr. 9, 1963
Extended to Oct. 1, 1950
Extended to Oct. 1946
EXTENDED TO Apr. 9, 1932
10/1/41
Extended to Oct. 1, 1956
Extended to Oct. 1, 1957

Extended to Oct. 1, 1963

ABC Extended to Oct. 1, 1969, ABC 10-1-95

WITNESS my hand this 9th *day of* April, *192*6.

Rhea Luper,

STATE ENGINEER.

Permits for power development are subject to the limitation of franchise as provided in Section 5728, Oregon Laws, and the payment of annual fees as provided in Section 5803, Oregon Laws.

This form approved by the State Water Board, March 11, 1909.

*Permit No. 3945

APPLICATION FOR A PERMIT

To Appropriate the Public Waters of the State of Oregon

I, THE WATER COMMISSION Astoria
(Name of Applicant)

of Astoria, County of Clatsop
(Postoffice)

State of Oregon, *do hereby make application for a permit to appropriate the following described public waters of the State of Oregon subject to existing rights:*

If the applicant is a corporation, give date and place of incorporation

1. The source of the proposed appropriation is Big Creek
(Name of stream)

, tributary of Columbia River

2. The amount of water which the applicant intends to apply to beneficial use is Sixteen (16) *cubic feet per second.*

3. The use to which the water is to be applied is (Irrigation, power, mining, manufacturing, domestic supplies, etc.)
Domestic supplies

4. The point of diversion is located 2245 feet S 85° 45' E of 1/4 Section Cor.
(Give distance and bearing to section corner)
between Sections 3 and 4, T 7 N R 7 W.W.M

being within the SW1/4 *of Sec.* 3, *Tp.* 7 North
(Give smallest legal subdivision) (No. N. or S.)

R. 7 West, *W. M., in the county of* Clatsop
(No. E. or W.)

5. The pipe line *to be* 16.5
(Main ditch, canal or pipe line)

miles in length, terminating in the NE1/4 *of Sec.* 17, *Tp.* 8 North
(Smallest legal subdivision) (No. N. or S.)

R. 9 West *W. M., the proposed location being shown throughout on the accompanying map.*
(No. E. or W.)

6. The name of the ditch, canal or other works is Pipe line from headworks on Big Creek to City Reservoir, Astoria Water Works

DESCRIPTION OF WORKS

DIVERSION WORKS— No designs of plans have been made yet.

7. (a) Height of dam 10 *feet, length on top* *feet, length at bottom* *feet; material to be used and character of construction* Concrete
(Loose rock, concrete, masonry, rock and brush, timber crib, etc., wasteway over or around dam)

(b) Description of headgate No design of plans have been made yet.
(Timber, concrete, etc., number and size of openings)
30 inch riveted steel or wood stave pipe, with fall of 1.5' to 1000'

*A different form of application is provided where storage works are contemplated. These forms can be secured without charge, together with instructions, by addressing the State Engineer, Salem, Oregon.

CANAL SYSTEM—

8. (a) *Give dimensions at each point of canal where materially changed in size, stating miles from headgate. At headgate: Width on top (at water line)* .... *feet; width on bottom* .... *feet; depth of water* .... *feet; grade* .... *feet fall per one thousand feet.*

(b) *At* .... *miles from headgate. Width on top (at water line)* .... *feet; width on bottom* .... *feet; depth of water* .... *feet; grade* .... *feet fall per one thousand feet.*

Either riveted steel or wood stave pipe, with fall of 1.5 ft. per thousand feet, 30 inches in diameter.

FILL IN THE FOLLOWING INFORMATION WHERE THE WATER IS USED FOR:

IRRIGATION—

9. *The land to be irrigated has a total area of* .... *acres, located in each smallest legal subdivision, as follows:* ....
(Give area of land in each smallest legal subdivision which you intend to irrigate)

(If more space required, attach separate sheet)

POWER, MINING, MANUFACTURING, OR TRANSPORTATION PURPOSES—

10. (a) *Total amount of power to be developed* .... *theoretical horsepower.*

(b) *Total fall to be utilized* .... *feet.*
(Head)

(c) *The nature of the works by means of which the power is to be developed* ....

(d) *Such works to be located in* .... *of Sec.* ....
(Legal subdivision)

Tp. .... , *R.* .... , *W. M.*
(No. N. or S.) (No. E. or W.)

(e) *Is water to be returned to any stream?* ....
(Yes or No)

(f) *If so, name stream and locate point of return* ....
.... , *Sec.* .... , *Tp.* .... , *R.* .... , *W. M.*
(No. N. or S.) (No. E. or W.)

(g) *The use to which power is to be applied is* ....

(h) *The nature of the mines to be served* ....

MUNICIPAL SUPPLY—

11. To supply the city of Astoria

Clatsop *County, having a present population of* 20,000 *, and an*
(Name of)

estimated population of 50,000 *in 19*135

(Answer questions 12, 13, 14, and 15 in all cases)

12. Estimated cost of proposed works, $ 500,000.00

13. Construction work will begin on or before March 1st, 1933

14. Construction work will be completed on or before December 31st, 1935

15. The water will be completely applied to the proposed use on or before
December 31st, 1935

Duplicate maps of the proposed ditch or other works, prepared in accordance with the rules of the State Water Board, accompany this application.

THE ASTORIA WATER COMMISSION
(Name of applicant)
G W Lounsberry

Signed in the presence of us as witnesses:

(1) Lars Bergsvik (Name), Astoria, Oregon (Address of Witness)

(2) K Dempsie (Name), Astoria, Oregon (Address of Witness)

Remarks: The above application is to safeguard the City of Astoria from encroachment of private parties on the only available gravity water supply for domestic use adjacent to the City, at a head as shown on the accompanying map, and volume of water as applied for.

STATE OF OREGON,
County of Marion, } *ss.*

This is to certify that I have examined the foregoing application, together with the accompanying maps and data, and return the same for correction or completion, as follows:

In order to retain its priority, this application must be returned to the State Engineer, with corrections, on or before ..., 191...

WITNESS my hand this ... day of ..., 191...

State Engineer.

3945(c)

1

Application No. 6320

Permit No. 3945

PERMIT

TO APPROPRIATE THE PUBLIC WATERS OF THE STATE OF OREGON

Division No. 1 *District No.*

This instrument was first received in the office of the State Engineer at Salem, Oregon, on the 6 *day of* November *, 191*8 *at* 8:30 *o'clock* A *M.*

Returned to applicant for correction

Corrected application received

Approved:
Dec 7 1918

Recorded in Book No. 14 *of Permits, on Page* 3945

Percy A Cupper
State Engineer.

1 map RS $8.00

STATE OF OREGON,
County of Marion, } *ss.*

This is to certify that I have examined the foregoing application and do hereby grant the same, subject to the following limitations and conditions: If for irrigation, this appropriation shall be limited to one-eightieth of one cubic foot per second, or its equivalent, for each acre irrigated, and shall be subject to such reasonable rotation system as may be ordered by the proper State officer.

The right to the use of water herein granted is limited to domestic purposes.

The amount of water appropriated shall be limited to the amount which can be applied to beneficial use and not to exceed 16.0 *cubic feet per second, or its equivalent in case of rotation. The priority date of this permit is* Nov. 6, 1918

Actual construction work shall begin on or before December 7, 1923 - 10-1-36 10-1-41 Extended to Oct. 1, 1946 Extended to Oct. 1, 1950 10/1/60 Extended to 10/1/72 *and shall thereafter be prosecuted with reasonable diligence and be completed on or before* Extended to Oct. 1, 1 10/1/61 Dec. 7, 1923 extended to 10/1/35 " " 10/1/36 " " 10-1-41 Extended to Oct. 1, 1946 Extended to Oct. 1, 1951 Extended to 10/1/72

Complete application of the water to the proposed use shall be made on or before 10/1/62 Extended to 10/1/73 October 1, 1935 — 10-1-36 10-1-41 Extended to Oct. 1, 1946 Extended to Oct. 1, 1952

WITNESS my hand this 7th *day of* December, 1918

Percy A Cupper
State Engineer.

Permits for power development are subject to the limitation of franchise as provided in Section 6633, Lord's Oregon Laws, and the payment of annual fees as provided in Chapter 213, Session Laws of 1915.

This form approved by the State Water Board, March 11, 1909.

ABC extended to 10-1-95

STATE OF OREGON

COUNTY OF CLATSOP

CERTIFICATE OF WATER RIGHT

This Is to Certify, *That* CITY OF ASTORIA

of Astoria *, State of* Oregon *, has made proof to the satisfaction of the STATE ENGINEER of Oregon, of a right to store the waters of* seepage water, tributary of Smiths Lake, appropriated under Application No. 18336, Permit No. 13969

for the purposes of irrigation

under Reservoir Permit No. R-735 *of the State Engineer, and that said right to store said waters has been perfected in accordance with the laws of Oregon; that the priority of the right hereby confirmed dates from* July 13, 1939

that the amount of water entitled to be stored each year under such right, for the purposes aforesaid, shall not exceed 11,000,000 gallons

The reservoir is located in SE¼ SE¼, Section 20; NW¼ NW¼, SW¼ NW¼, NW¼ SW¼, as projected within Gray DLC 41, Section 28; NE¼ NE¼, Section 29, T. 8 N., R. 10 W., W.M.

WITNESS the signature of the State Engineer, affixed this date. APRIL 5 1961

LEWIS A. STANLEY
State Engineer

Recorded in State Record of Water Right Certificates, Volume 20 *, page* 28407

STATE OF OREGON

COUNTY OF CLATSOP

CERTIFICATE OF WATER RIGHT

This Is to Certify, *That* CITY OF ASTORIA

of Astoria *, State of* Oregon *, has made proof to the satisfaction of the STATE ENGINEER of Oregon, of a right to the use of the waters of* Smith's Lake *a tributary of* *for the purpose of* irrigation of Ocean View Cemetery

under Permit No. 8096 *of the State Engineer, and that said right to the use of said waters has been perfected in accordance with the laws of Oregon; that the priority of the right hereby confirmed dates from* July 16, 1927

that the amount of water to which such right is entitled and hereby confirmed, for the purposes aforesaid, is limited to an amount actually beneficially used for said purposes, and shall not exceed 0.3 cubic foot per second

or its equivalent in case of rotation, measured at the point of diversion from the stream. The point of diversion is located in the NW¼ NW¼, as projected within Gray DLC 41, Section 28, T. 8 N., R. 10 W., W.M.

The amount of water used for irrigation, together with the amount secured under any other right existing for the same lands, shall be limited to one-eightieth *of one cubic foot per second per acre,* or its equivalent for each acre irrigated and shall be further limited to a diversion of not to exceed 2½ acre feet per acre for each acre irrigated during the irrigation season of each year,

and shall conform to such reasonable rotation system as may be ordered by the proper state officer.

A description of the place of use under the right hereby confirmed, and to which such right is appurtenant, is as follows:

9.2 acres NW¼ NW¼, as projected within Gray DLC 41
14.4 acres SW¼ NW¼, as projected within Gray DLC 41
0.4 acre SE¼ NW¼, as projected within Gray DLC 41
0.2 acre SE¼ NW¼, as projected within Tuller DLC 43
0.1 acre NW¼ SW¼, as projected within Gray DLC 41
Section 28
T. 8 N., R. 10 W., W.M.

The right to the use of the water for the purposes aforesaid is restricted to the lands or place of use herein described.

WITNESS the signature of the State Engineer, affixed

this date. APRIL 5 1961

LEWIS A. STANLEY
State Engineer

Recorded in State Record of Water Right Certificates, Volume 20 *, page* 28105

Permit A—4M—3-59 State Printing 18605

STATE OF OREGON

COUNTY OF CLATSOP

CERTIFICATE OF WATER RIGHT

This Is to Certify, That CITY OF ASTORIA

of Astoria, State of Oregon, has made proof to the satisfaction of the STATE ENGINEER of Oregon, of a right to the use of the waters of Smith's Lake Reservoir constructed under Appl. #R-18269, Permit #R-735 a tributary of for the purpose of supplemental irrigation of 24.3 acres

under Permit No. 13969 of the State Engineer, and that said right to the use of said waters has been perfected in accordance with the laws of Oregon; that the priority of the right hereby confirmed dates from August 12, 1939

that the amount of water to which such right is entitled and hereby confirmed, for the purposes aforesaid, is limited to an amount actually beneficially used for said purposes, and shall not exceed 11,000,000 gallons stored water only

or its equivalent in case of rotation, measured at the point of diversion from the stream. The point of diversion is located in the SE¼ SE¼, as projected within Gray DLC 41, Section 20, T. 8 N., R. 10 W., W.M.

The amount of water used for irrigation, together with the amount secured under any other right existing for the same lands, shall be limited to one-eightieth of one cubic foot per second per acre, or its equivalent for each acre irrigated and shall be further limited to a diversion of not to exceed 2½ acre feet per acre for each acre irrigated during the irrigation season of each year,

and shall conform to such reasonable rotation system as may be ordered by the proper state officer.

A description of the place of use under the right hereby confirmed, and to which such right is appurtenant, is as follows:

9.2 acres NW¼ NW¼, as projected within Gray DLC 41
14.4 acres SW¼ NW¼, as projected within Gray DLC 41
0.4 acres SE¼ NW¼, as projected within Gray DLC 41
0.2 acres SE¼ NW¼, as projected within Tuller DLC 43
0.1 acres NW¼ SW¼, as projected within Gray DLC 41
Section 28
T. 8 N., R. 10 W., W.M.

The right to the use of the water for the purposes aforesaid is restricted to the lands or place of use herein described.

WITNESS the signature of the State Engineer, affixed

this date. APRIL 5 1961

LEWIS A. STANLEY
State Engineer

Recorded in State Record of Water Right Certificates, Volume 20, page 28406

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Appendix B. Summary of Water Quality Regulations and Monitoring Requirements

Table B-1. Regulations and Monitoring Requirements for Inorganic Chemicals (IOCs)

Contaminant	MCL / MCLG (mg/L unless noted)	Federal Monitoring Requirements / Comments	Current Monitoring for Astoria per OHA Requirements
Antimony	0.006 / 0.006	Once a year for surface waters. Monitoring reduced by using historical data, waivers, and/or composite samples.	1 sample, every 9 years
Asbestos (fiber length > 10 µm)	7 MFL / 7 MFL	Once every 9 years.	1 sample, every 9 years
Barium	2 / 2	Same as Antimony.	1 sample, every 9 years
Beryllium	0.004 / 0.004		
Cadmium	0.005 / 0.005		
Chromium (total)	0.1 / 0.1		
Copper (revisions and clarifications)	TT (AL = 1.3) / 1.3	ALs must be met in 90% of the samples. Monitoring every 6 months after corrosion controls initiated or optimized. Reduced monitoring for systems consistently meeting AL.	20 samples, every 3 years
Cyanide (as free cyanide)	0.2 / 0.2	Same as Antimony.	1 sample, every 9 years
Fluoride	4.0 / 4.0		
Lead (revisions & clarifications)	TT (AL = 0.015) / 0	Same as Copper.	20 samples, every 3 years
Mercury (inorganic)	0.002 / 0.002	Same as Antimony.	1 sample, every 9 years
Nitrate (as N)	10 / 10	Surface water: quarterly initially, then annually.	1 sample, yearly
Nitrite (as N)	1 / 1	One sample yearly during first 3-years. Repeat frequency determined by primacy agency.	1 sample, every 9 years
Selenium	0.05 / 0.05	Same as Antimony.	1 sample, every 9 years
Thallium	0.002 / 0.0005		
Arsenic Rule			
Arsenic	0.010 / 0	Same as IOCs (see Antimony).	1 sample, every 9 years
Radionuclides			
Combined Radium-226 and Radium-228	5 pCi/L / 0	Sample point is the distribution system entry point that is representative of all sources being used. Four consecutive quarterly samples must be taken at all sample points.	1 sample, every 9 years (6 years starting 2023)
Gross Alpha (excluding radon & uranium)	15 pCi/L / 0		1 sample, every 9 years
Beta Particles & Photon Emitters	4 mrem/year / 0	Primacy agency designates vulnerable systems.	N/A
Uranium	0.030 / 0	Same as Combined Radium and Gross Alpha.	1 sample, every 9 years

Table B-2. Regulations and Monitoring Requirements for Synthetic Organic Chemicals (SOCs)

Contaminant	MCL / MCLG (mg/L unless noted)	Federal Monitoring Requirements / Comments	Current Monitoring for Astoria per OHA Requirements
2,3,7,8-TCDD (Dioxin)	0.00000003 / 0	For SOCs: Compliance is based on annual average of quarterly samples. If no detections are found during initial round, two quarterly samples are required each year for systems serving > 3,300. With the completion of source water assessments, primacy agencies are allowed to develop alternative monitoring requirements.	2 samples, every 3 year (Except Alachlor and Epichlorohydrin, only reported if used in treatment; Dioxin also has a waiver and does not need to be monitored)
2,4,5-TP (Silvex)	0.05 / 0.05		
2,4-D	0.07 / 0.07		
Acrylamide	TT / 0		
Alachlor	0.002 / 0		
Atrazine	0.003 / 0.003		
Benzo(a)pyrene (PAHs)	0.0002 / 0		
Carbofuran	0.04 / 0.04		
Chlordane	0.002 / 0		
Dalapon	0.2 / 0.2		
Di(2-ethylhexyl) adipate	0.4 / 0.4		
1,2-Dibromo-3-chloropropane (DBCP)	0.0002 / 0		
Di(2-ethylhexyl) phthalate (DEHP)	0.006 / 0		
Dinoseb	0.007 / 0.007		
Diquat	0.02 / 0.02		
Endothall	0.1 / 0.1		
Endrin	0.002 / 0.002		
Epichlorohydrin	TT / 0		
Ethylene Dibromide (EDB)	0.00005 / 0		
Glyphosate	0.7 / 0.7		
Heptachlor	0.0004 / 0		
Heptachlor Epoxide	0.0002 / 0		
Hexachlorobenzene	0.001 / 0		
Hexachlorocyclopentadiene (HEX)	0.05 / 0.05		
Lindane	0.0002 / 0.0002		
Methoxychlor	0.04 / 0.04		
Oxamyl (Vydate)	0.2 / 0.2		

Contaminant	MCL / MCLG (mg/L unless noted)	Federal Monitoring Requirements / Comments	Current Monitoring for Astoria per OHA Requirements
Pentachlorophenol	0.001 / 0		
Picloram	0.5 / 0.5		
Polychlorinated Biphenyls (PCBs)	0.0005 / 0		
Simazine	0.004 / 0.004		
Toxaphene	0.003 / 0		

Table B-3. Regulations and Monitoring Requirements for Volatile Organic Chemicals (VOCs)

Contaminant	MCL / MCLG (mg/L unless noted)	Federal Monitoring Requirements / Comments	Current Monitoring for Astoria per OHA Requirements
1,1,1-Trichloroethane	0.2 / 0.2	For VOCs: Four consecutive quarterly samples during first compliance period. Compliance is based on annual average of quarterly samples. If no detections are found during initial round, two quarterly samples are required each year for systems serving > 3,300; one sample is required every 3 years for smaller systems. With the completion of source water assessments, primacy agencies are allowed to develop alternative monitoring requirements.	1 sample, Yearly
1,1,2-Trichloroethane	0.005 / 0.003		
1,1-Dichloroethylene	0.007 / 0.007		
1,2,4-Trichlorobenzene	0.07 / 0.07		
1,2-Dichloroethane	0.005 / 0		
1,2-Dichloropropane	0.005 / 0		
Benzene	0.005 / 0		
Carbon Tetrachloride	0.005 / 0		
Chlorobenzene	0.1 / 0.1		
Cis-1,2-Dichloroethylene	0.07 / 0.07		
Dichloromethane	0.005 / 0		
Ethylbenzene	0.7 / 0.7		
Ortho-Dichlorobenzene	0.6 / 0.6		
Para-Dichlorobenzene	0.075 / 0.075		
Styrene	0.1 / 0.1		
Tetrachloroethylene (PCE)	0.005 / 0		
Toluene	1 / 1		
Trans-1,2-Dichloroethylene	0.1 / 0.1		
Trichloroethylene (TCE)	0.005 / 0		
Vinyl Chloride	0.002 / 0		
Xylenes (total)	10 / 10		

Table B-4. Regulations and monitoring requirements for Disinfectants and Disinfection Byproducts (DBPs)

Contaminant	MCL / MCLG (mg/L unless noted)	Federal Monitoring Requirements / Comments	Current Monitoring for Astoria per OHA Requirements
Stage 1 Disinfectants/Disinfection Byproducts Rule (D/DBPR)			
Chlorine	4.0 (as Cl_2) MRDL / 4 MRDLG	Monitor at the same time/sample locations as the Total Coliform Rule. Compliance based on running annual arithmetic average of monthly averages. Daily sample at distribution system entry point.	Daily monitor in treatment and distribution
Chloramines	4.0 (as Cl_2) MRDL / 4 MRDLG		N/A
Chlorine Dioxide	0.8 (as Cl_2)MRDL /0.8 MRDLG	Four quarterly distribution system samples. Compliance based on running annual average of quarterly average.	N/A
Total Trihalomethanes (TTHMs)	0.08	See Stage 2 D/DBPR (below) for compliance.	2 samples, quarterly
Haloacetic Acids (HAA5)	0.06		
Chlorite	1.0 / 0.8	Systems that add chlorine dioxide.	N/A
Bromate	0.010 / 0	Systems that use ozone.	N/A
Total Organic Carbon (TOC)	TT	Source and treated water TOC sampled once a month. Compliance based on running annual average of TOC removal ratios.	N/A
Stage 2 Disinfectants/Disinfection Byproducts Rule (D/DBPR)			
Total Trihalomethanes (TTHMs)	**0.08**	Compliance Monitoring: Locational Running Annual Average (LRAA) of quarterly samples taken at locations determined by Initial Distribution System Evaluation (IDSE). Compliance sites are locations in the distribution system where TTHMs are high, HAA5s are high, and at average detention time sites. The number of sites is based on the type of source water and population served.	2 samples, quarterly
Chloroform	/ 0.07		
Bromodichloromethane (BDCM)	/ 0		
Bromoform	/ 0		
Dibromochloromethane (DBCM)	/ 0.06		
Haloacetic Acids (HAA5)	**0.06**		
Monochloroacetic Acid (MCAA)	/ 0.07		
Dichloroacetic Acid (DCAA)	/ 0		
Trichloroacetic Acid (TCAA)	/ 0.02		

Table B-5. Regulations and Monitoring Requirements for Microbial Contaminants

Contaminant	MCL / MCLG (mg/L unless noted)	Federal Monitoring Requirements / Comments	Current Monitoring for Astoria per OHA Requirements
Total Coliform Rule (TCR)			
Total Coliforms	MCL = See comments MCLG = 0	The total number and location of samples is based on the population served and a system-specific sampling plan. If less than 40 samples per month, no more than one positive for total coliforms.	10 Samples, Monthly
Fecal Coliforms			
E. coli			
Revised Total Coliform Rule (RTCR)			
E. coli	TT / 0	RTCR specifies frequency and timing of microbial testing based on the population served and a system-specific sampling plan for total coliform. Systems must conduct assessments (Level 1 or 2) based on treatment technique triggers. Level 1 TT triggers: if taking fewer than 40 samples per month, system has 2 or more total coliform-positive samples. Level 2 TT triggers: a) E.coli MCL violation; b) second Level 1 trigger in rolling 12 months; c) Level 1 trigger in 2 consecutive years.	10 Samples, Monthly
Total Coliforms	TT / 0		
Surface Water Treatment Rule (SWTR)			
Turbidity	TT	Grab samples every four hours or continuous monitoring for turbidity. Continuous chlorine residual required for systems > 3,300. Must maintain disinfectant residual ≥ 0.2 mg/L entering the distribution system. Performance requirements demonstrated through combination of removal via filtration and inactivation via disinfection. See IESWTR and LT1ESWTR for turbidity TT requirements.	Turbidity grab samples every 4 hours
Giardia lamblia	TT / 0	Minimum three-log removal/inactivation of Giardia (99.9%).	Credits for filtration and disinfection
Enteric Viruses	TT / 0	Minimum four-log removal/inactivation of viruses (99.99%).	
Legionella	TT / 0	No limit. Rule assumes if virus and Giardia limits are met, Legionella will be controlled.	See *Giardia* and viruses
Heterotrophic Plate Count (HPC)	TT	Filtration avoidance is allowed under certain circumstances (see Regulation). Lower bacteria concentration indicates better maintained water system.	N/A

Contaminant	MCL / MCLG (mg/L unless noted)	Federal Monitoring Requirements / Comments	Current Monitoring for Astoria per OHA Requirements
Interim Enhanced Surface Water Treatment Rule (IESWTR)			
Turbidity	TT	Must continue to comply with SWTR. Treatment effectiveness is demonstrated by combined effluent turbidity ≤ 0.3 NTU in 95% of measurements taken each month. Conventional and direct filtration systems must measure combined filter effluent turbidity at least every four hours and continuously monitor turbidity of each individual filter. The maximum turbidity limit is 1 NTU. If the PWS meets filtered water turbidity criteria, it is assumed to achieve the required 2-log *Cryptosporidium* removal. Performance triggers for individual filter turbidities lead to additional reporting and assessments if exceeded. IESWTR applies to systems ≥ 10,000; LT1ESWTR applies to systems < 10,000 people.	Turbidity grab samples every 4 hours
Cryptosporidium	TT / 0		
Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR)			
Turbidity	TT		
Cryptosporidium	TT / 0		
Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)			
Cryptosporidium	TT / 0	Monthly monitoring for *Cryptosporidium* for 2 years to characterize the source water. Small systems monitor for *E. Coli* in lieu. Calculated *Cryptosporidium* concentration defines require level of additional treatment.	LT2 monitoring in 2017/2018; MPN of *E. Coli* used as surrogate for *Crypto*
Filter Backwash Rule			
Cryptosporidium	TT / 0	No monitoring required, but PWS must collect and provide information on recycle flow for review by primacy agency (all conventional or direct filtration systems that recycle spent filter backwash water).	N/A
Ground Water Rule (GWR)			
Viruses	TT	Applies to ground water systems. Sanitary survey every 3 years (CWS) and 5 years (NCWS). Source water monitoring required for systems that do not treat to 4-log viral inactivation.	N/A

Appendix C. Summary of Water Quality Compliance Monitoring

Table C-1. Summary of Compliance Monitoring since 2014 for Inorganic Chemicals (IOCs)

Contaminant	MCL / MCLG (mg/L unless noted)	Frequency of Sampling over Past 6 Years	Summary of Results (mg/L unless noted)
Antimony	0.006 / 0.006	Once (2020)	ND
Asbestos (fiber length > 10 µm)	7 MFL / 7 MFL	Twice (2020), once (2015)	ND
Barium	2 / 2	Once (2020)	0.00652
Beryllium	0.004 / 0.004	Once (2020)	ND
Cadmium	0.005 / 0.005	Once (2020)	ND
Chromium (total)	0.1 / 0.1	Once (2020)	ND
Copper	TT (AL = 1.3) / 1.3	20 samples (2018), 20 samples (2015)	0.073 - 0.485; 90^{th} = 0.240 (2018) 0.157 - 0.713; 90^{th} = 0.374 (2015)
Cyanide (as free cyanide)	0.2 / 0.2	Once (2020)	ND
Fluoride	4.0 / 4.0	Daily	Highest yearly: 0.74 - 0.97
Lead	TT (AL = 0.015) / 0	20 samples (2018), 20 samples (2015)	ND – 0.026; 90^{th} = 0.003 (2018) ND – 0.007; 90^{th} = 0.006 (2015)
Mercury (inorganic)	0.002 / 0.002	Once (2020)	ND
Nitrate (as N)	10 / 10	Once, yearly	ND – 0.381
Nitrite (as N)	1 / 1	Once (2020)	ND
Selenium	0.05 / 0.05	Once (2020)	ND
Thallium	0.002 / 0.0005	Once (2020)	ND
Arsenic Rule			
Arsenic	0.010 / 0	Twice (2020)	ND
Radionuclides			
Combined Radium-226 and Radium-228	5 pCi/L / 0	Once (2020), once (2014)	ND (2020) 1.8 pCi/L (2014)
Gross Alpha (excluding radon & uranium)	15 pCi/L / 0	Once (2020), once (2014)	ND (2020) ND (2014)
Uranium	0.030 / 0	Once (2020), once (2014)	ND (2020) ND (2014)

Table C-2. Summary of Compliance Monitoring since 2014 for Synthetic Organic Chemicals (SOCs)

Contaminant	MCL / MCLG (mg/L unless noted)	Frequency of Sampling over Past 6 Years	Summary of Results (mg/L unless noted)
2,4,5-TP (Silvex)	0.05 / 0.05	Once (2020), Twice (2017 & 2014)	ND
2,4-D	0.07 / 0.07	Once (2020), Twice (2017 & 2014)	ND
Alachlor	0.002 / 0	Once (2020), Twice (2017 & 2014)	ND
Atrazine	0.003 / 0.003	Once (2020), Twice (2017 & 2014)	ND
Benzo(a)pyrene (PAHs)	0.0002 / 0	Once (2020), Twice (2017 & 2014)	ND
Carbofuran	0.04 / 0.04	Once (2020), Twice (2017 & 2014)	ND
Chlordane	0.002 / 0	Once (2020), Twice (2017 & 2014)	ND
Dalapon	0.2 / 0.2	Once (2020), Twice (2017 & 2014)	ND
Di(2-ethylhexyl) adipate	0.4 / 0.4	Once (2020), Twice (2017 & 2014)	ND
1,2-Dibromo-3-chloropropane (DBCP)	0.0002 / 0	Once (2020), Twice (2017 & 2014)	ND
Di(2-ethylhexyl) phthalate (DEHP)	0.006 / 0	Once (2020), Twice (2017 & 2014)	ND
Dinoseb	0.007 / 0.007	Once (2020), Twice (2017 & 2014)	ND
Diquat	0.02 / 0.02	Once (2020), Twice (2017 & 2014)	ND
Endothall	0.1 / 0.1	Once (2020), Twice (2017 & 2014)	ND
Endrin	0.002 / 0.002	Once (2020), Twice (2017 & 2014)	ND
Ethylene Dibromide (EDB)	0.00005 / 0	Once (2020), Twice (2017 & 2014)	ND
Glyphosate	0.7 / 0.7	Once (2020), Twice (2017 & 2014)	ND
Heptachlor	0.0004 / 0	Once (2020), Twice (2017 & 2014)	ND
Heptachlor Epoxide	0.0002 / 0	Once (2020), Twice (2017 & 2014)	ND
Hexachlorobenzene	0.001 / 0	Once (2020), Twice (2017 & 2014)	ND
Hexachlorocyclopentadiene (HEX)	0.05 / 0.05	Once (2020), Twice (2017 & 2014)	ND
Lindane	0.0002 / 0.0002	Once (2020), Twice (2017 & 2014)	ND
Methoxychlor	0.04 / 0.04	Once (2020), Twice (2017 & 2014)	ND
Oxamyl (Vydate)	0.2 / 0.2	Once (2020), Twice (2017 & 2014)	ND
Pentachlorophenol	0.001 / 0	Once (2020), Twice (2017 & 2014)	ND
Picloram	0.5 / 0.5	Once (2020), Twice (2017 & 2014)	ND
Polychlorinated Biphenyls (PCBs)	0.0005 / 0	Once (2020), Twice (2017 & 2014)	ND

Contaminant	MCL / MCLG (mg/L unless noted)	Frequency of Sampling over Past 6 Years	Summary of Results (mg/L unless noted)
Simazine	0.004 / 0.004	Once (2020), Twice (2017 & 2014)	ND
Toxaphene	0.003 / 0	Once (2020), Twice (2017 & 2014)	ND

Table C-3. Summary of Compliance Monitoring since 2014 for Volatile Organic Chemicals (VOCs)

Contaminant	MCL / MCLG (mg/L unless noted)	Frequency of Sampling over Past 6 Years	Summary of Results (mg/L unless noted)
1,1,1-Trichloroethane	0.2 / 0.2	Yearly	ND
1,1,2-Trichloroethane	0.005 / 0.003	Yearly	ND
1,1-Dichloroethylene	0.007 / 0.007	Yearly	ND
1,2,4-Trichlorobenzene	0.07 / 0.07	Yearly	ND
1,2-Dichloroethane	0.005 / 0	Yearly	ND
1,2-Dichloropropane	0.005 / 0	Yearly	ND
Benzene	0.005 / 0	Yearly	ND
Carbon Tetrachloride	0.005 / 0	Yearly	ND
Chlorobenzene	0.1 / 0.1	Yearly	ND
Cis-1,2-Dichloroethylene	0.07 / 0.07	Yearly	ND
Dichloromethane	0.005 / 0	Yearly	ND
Ethylbenzene	0.7 / 0.7	Yearly	ND
Ortho-Dichlorobenzene	0.6 / 0.6	Yearly	ND
Para-Dichlorobenzene	0.075 / 0.075	Yearly	ND
Styrene	0.1 / 0.1	Yearly	ND
Tetrachloroethylene (PCE)	0.005 / 0	Yearly	ND
Toluene	1 / 1	Yearly	ND
Trans-1,2-Dichloroethylene	0.1 / 0.1	Yearly	ND
Trichloroethylene (TCE)	0.005 / 0	Yearly	ND
Vinyl Chloride	0.002 / 0	Yearly	ND
Xylenes (total)	10 / 10	Yearly	ND

Table C-4. Summary of Compliance Monitoring since 2014 for Disinfectants and Disinfection Byproducts (DBPs)

Contaminant	MCL / MCLG (mg/L unless noted)	Frequency of Sampling over Past 6 Years	Summary of Results (mg/L unless noted)
Chlorine	4.0 (as Cl_2) MRDL / 4 MRDLG	Daily	Highest yearly: 1.80 - 2.85 (One incident below 0.2 entering distribution system)
Total Trihalomethanes (TTHMs)	0.08	2 samples, Quarterly	0.039-0.056 (Running Annual Average)
Haloacetic Acids (HAA5)	0.06	2 samples, Quarterly	0.037-0.062 (Running Annual Average)

Table C-5. Summary of Compliance Monitoring since 2014 for Microbial Contaminants

Contaminant	MCL / MCLG (mg/L unless noted)	Frequency of Sampling over Past 6 Years	Summary of Results (mg/L unless noted)
Total Coliforms	MCL = 1 MCLG = 0	10 samples, Monthly	1 positive (Aug 2017) 1 positive (Oct 2017)
Fecal Coliforms			0 positive
E. coli			0 positive
Turbidity	TT	Daily (grab samples every 4 hours)	Highest yearly: 0.260 - 0.790 (NTU)

Appendix D. Water Rights Strategy Technical Memorandum

TECHNICAL MEMORANDUM

City of Astoria: Water Rights Strategy

To: Jeff Harrington (City of Astoria)

From: Ronan Igloria, Kim Grigsby, Leah Cogan (GSI Water Solutions, Inc.)

CC: Verena Winter, Katie Maschmann (HDR)

Date: January 10, 2021

Attachments:
A. Water Rights Summary Table
B. Extension Applications (main body of application only; submitted in 2005)

GSI Water Solutions (GSI) is a subconsultant to HDR to prepare the City of Astoria Water System Master Plan (WSMP). GSI's task is to support the water supply plan component focusing on management of the City's water rights. As part of this effort, GSI prepared a summary of the water rights held by the City of Astoria (City) in a tech memo dated July 13, 2020.

This tech memo summarizes recommendations for managing the City water rights based on their current status, the updated water demand forecast prepared as part of the WSMP, and input from the City on their current needs and priorities for water supply. The focus of the memo is on the water use permits (i.e. not certificated water rights) that could be used for the City's potable supply in the future.

Water Rights Status

The City's current municipal water supply is provided by five water right certificates. The City also holds four municipal and domestic water use permits that are not yet developed, along with certificates authorizing the use of water for hydroelectric power production and irrigation. A copy of the water rights summary table from the July 2020 memo is included as **Attachment A.**

Certificated Status

The City's certificated municipal water rights authorize the use of water from Bear Creek, Cedar Creek, and three reservoirs that are filled with water from Bear Creek:

- **Certificates 19543 and 82234** authorize storage of up to 498 acre-feet (162.3 million gallons [MG]) in Middle Lake and Wickiup Lake, and up to 675 acre-feet (219.9 MG) in Bear Creek Reservoir, respectively, for a total storage volume of 1,173 acre-feet (382.2 MG) annually.
- **Certificate 19542** authorizes the use of up to 3.0 cubic feet per second (cfs) (1.94 million gallons per day [mgd]) from stored water in Middle Lake and Wickiup Lake along with live flow from Bear Creek.
- **Certificate 82236** authorizes the use of up to 12.0 cfs (7.76 mgd) from Bear Creek and stored water from Bear Creek Reservoir.
- **Certificate 82237** authorizes the use of up to 2.0 cfs (1.29 mgd) from Cedar Creek.

Collectively, the certificated water rights authorize a maximum instantaneous diversion rate of 17.0 cfs (11.0 mgd). Because these water rights are certificated, they are secure and require no further action from the City to protect them.

As noted, in the City of Astoria Water Rights Summary memo (GSI, July 13, 2020) the City also diverts water at Spur 14, and OWRD considers this water use to be consistent with the City's existing water right certificates. Spur 14 is a spring that empties into Middle Lake or flows past Middle Lake into drainages that eventually find their way to Cedar or Bear Creeks. The City had constructed a diversion to capture this spring flow. Based on communications in March 2015, OWRD indicated the diversions would be considered part water use from Wickiup Lake, and requested that the City meter the water diverted from Spur 14.

Permit Status

The City holds four water use permits that are undeveloped, meaning no water has been used under these rights to date:

- **Permit R-2568** authorizes storage of up to 12,000 acre-feet (3910.2 MG) in Youngs River Reservoir.
- **Permit S-27092** authorizes the use of up to 26.0 cfs (16.8 mgd) from Youngs River and stored water from Youngs River Reservoir.
- **Permit S-7257** authorizes the use of an additional 23.0 cfs (14.9 mgd) from Youngs River.
- **Permit S-3945** authorizes the use of up to 16.0 cfs (10.34 mgd) from Big Creek.

Combined, these four permits authorize a total maximum use of 65.0 cfs (42.0 mgd).

The development deadline for each of these permits is October 1, 1995. To preserve the permits, the City filed extension of time applications in 2005 and 2006, which are currently pending with the Oregon Water Resources Department (OWRD). The applications for extension of time (included in **Attachment B**) requested a development period to October 1, 2055. The extension applications identified factors influencing potential water demand growth that indicate that the City would need to use water under the Youngs River and Big Creek permits in the future. These factors included future needs for a non-potable water supply, industrial and commercial growth (particularly associated with the Port of Astoria), a redundant supply for fighting wildfire, and the potential need to supply water to unincorporated communities or a regional supply system.

The City's permits were issued between 1918 and 1961, and have been extended multiple times. In recent years, OWRD's review process for municipal extensions of time has become more complex, and now includes the Oregon Department of Fish and Wildlife (ODFW) determining the need for conditions to "maintain the persistence" of listed fish species in the municipal user's water sources. "Fish persistence" conditions recommended by ODFW are intended to protect streamflows and typically reduce the municipal water provider's access to water during times when identified flow targets are not met.

ODFW provided draft "fish persistence" conditions for the City's Youngs River and Big Creek permits consistent with the flows protected by instream water rights on Big Creek and Youngs River. Historical gage information from a Youngs River gage that operated from 1928 to 1958 suggests that the draft flow targets would significantly reduce the City's access to water from these permits. For example, based on the historical data, ODFW's draft flow targets would be met less than half of the time in the summer months. It should be noted, that conditions for the storage rights would likely be different than the permits for diversion.

Additional Water Rights

The City holds Certificate 89004, which authorizes the use of water from Bear Creek and Bear Creek Reservoir for hydroelectric power production in conjunction with the City's use of water for municipal purposes under Certificate 82236. The City also holds Certificates 28405, 28406, and 28407, which authorize the storage and use of stored water in Smith Lake Reservoir for irrigation of Ocean View Cemetery. As non-municipal water rights and because they require no further action by the City to protect them, these water rights are not considered further in this memo's evaluation of the City's municipal water supply.

Water Infrastructure Capacity

The storage capacities of the City's three reservoirs mirror the authorized volumes in the associated storage water rights: Bear Creek Reservoir holds approximately 200 MG, Wickiup Lake holds 110 MG (although it is rarely full), and Middle Lake holds 52 MG. Water diverted from Bear Creek, the reservoirs, and Cedar Creek is conveyed to a water treatment plant (WTP) with a capacity of 6.0 mgd. The City's water operators note that the capacity of the raw water supply is dependent on the water quality conditions of the supply sources. The City has been able to meet peak demands to the WTP, and thus is not a limiting capacity in the system. Finished water is then conveyed approximately 12 miles through a transmission main with a capacity of 6.9 mgd to Reservoir No. 3 where it enters the City's distribution system. Prior to reaching the finished water reservoir, some of the water in the transmission main is also sent to Tongue Point, Emerald Heights, and several outlying water districts. Based on the information above, the WTP capacity of 6.0 mgd is assumed to be the limiting supply capacity.

Water Demand Forecast

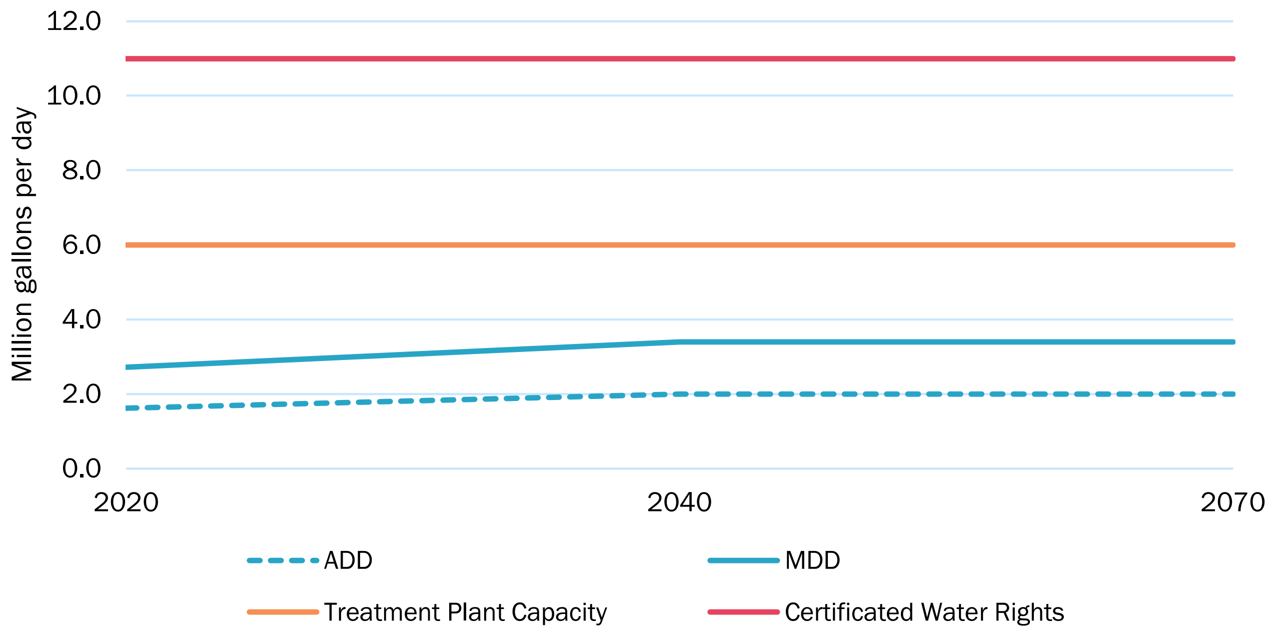
HDR prepared a water demand forecast as part of the City's WSMP process. The water demand forecast used available information about population forecasts, changes in housing patterns, land use changes, and future growth of large water users. Demand was projected for the 2040 and 2070 planning horizons in terms of the average daily demand (ADD), maximum daily demand (MDD), and peak hour demand (PHD, the maximum hourly demand on the maximum day, expressed as an equivalent mgd). The water demand forecast is summarized in **Table 1** below. The forecast shows water demand is expected to increase through 2040 and then remain relatively flat through 2070. (The increase from 2040 to 2070 is within the rounding difference in the calculations.)

Table 1. Water Demand Projections (million gallons per day)

	ADD	MDD	PHD
2020	1.62	2.72	3.76
2040	2.00	3.40	4.60
2070	2.00	3.40	4.60

Figure 1 compares the demand forecast with the maximum capacity of the City's water system (based on the water treatment plant capacity) and the total rate of use authorized by the City's certificated municipal water rights. This graph shows that future demands through 2070 are projected to be within the capacity of the treatment plant and the total maximum authorized rate of the City's certificated water rights.

Figure 1. Demand Projection Comparisons.



City of Astoria's Future Water Service Objectives

As described above, the City holds four water use permits that authorize the storage and use of water from Youngs River and Youngs River Reservoir, as well as Big Creek. To date, the City has not used water under any of these water rights. GSI identified the following water service objectives as key drivers for the City's plans for its water use permits.

- **Water Service Area:** The City's priority is to ensure water supply is available for their existing customers throughout the year. As noted above, the City's water rights for its existing Bear Creek source and infrastructure capacity are sufficient to meet needs for the next 50 years. The City does not currently have plans to serve new wholesale customers or residential communities with new intertie connections from its Bear Creek source.
- **Regional Supply:** The Northwest Coastal Water Supply Task Force completed a study in 2009 regarding the opportunity to develop a regional water supply source. The study considered the opportunity to use the City's water use permit(s) to provide a new source of supply for the region However, since the study, the Task Force and other parties in the region have not coalesced to move a coordinated regional supply forward.
- **Supply Resiliency:** Supply resiliency is an important consideration for City of Astoria, because it has a single source of supply (the Bear Creek watershed), and is vulnerable in particular to loss of water supply due to seismic events along with neighboring communities. As part of the WSMP, the City will finalize level-of-service goals related to its supply resiliency. The draft recommendations from the study by SEFT (subconsultant to HDR for the WSMP) focus on seismic hardening of its existing water system backbone infrastructure and critical facilities. However, the recommendations do not preclude developing interties with neighboring communities, or investments in new supply development in Big Creek or Youngs River to address resiliency goals over the long-term.

Management Options for City's Water Use Permits

GSI has identified four options for the Big Creek and Youngs River water rights. Key considerations for each option are described below.

1. **Monitor the on-going application for extension of time.** The City filed extension applications for its permits in 2005 and 2006, and it is unclear when OWRD will complete processing of the applications. No action by the City is required for OWRD to complete its review of the City's extensions, and having the permit extension applications pending essentially provides the City with a base level of "protection" for the permits without having to actively manage or incur additional costs. The permits will not be cancelled while the applications are pending, and OWRD would not expect the City to develop the permits during this time. The drawback to just waiting for the extensions to be processed without communicating with the agencies is that the City will not have an opportunity to potentially improve the outcome of the process, and ODFW's "fish persistence" conditions will likely significantly diminish the City's access to water under its permits.

2. **Actively engage with ODFW.** Engaging with ODFW is an opportunity for the City to potentially retain access to more water under its permits. The City can take a range of steps to engage with ODFW, including providing information or working cooperatively on creative conditions in the extension order. This option provides the City an opportunity to elevate engagement with the agencies (OWRD and ODFW) as concerns are identified:

    a. The City can communicate regularly (semi-annually or quarterly) with ODFW to understand their current timeline and any updates to their approach for fish persistence conditions. The City can increase to a higher level of engagement (e.g. moving on to option 2b below) if the City identifies a need or value.

    b. The City could be more proactive and hire a fisheries biologist to provide information that could improve the scientific basis for ODFW's "fish persistence" recommendations. The City could work with ODFW and develop an agreed upon approach to collect field data that would support developing flow targets using empirical data. This study could take on the order of one year to complete. As part of this option, the City could ask potential partners (other water districts) in the area to assist financially with these studies to support the extension process.

3. **Cancel the permits.** The City could indicate that it does not intend to develop the permits and OWRD could cancel the permits in response. GSI does not recommend this option.

4. **Sell or lease water user permits.** The City could attempt to sell the water use permits, but the market may be non-existent due to the uncertainty of the use of the permits and difficulty establishing their value. The City could lease the rights through a contractual agreement and then consider selling them after the extension is complete, and after a water right certificate is issued when the water has been put to beneficial use.

Recommendation

At this stage, GSI recommends option 2a to actively monitor and assess the extension process by communicating regularly with OWRD and ODFW. This allows the City an opportunity to check-in with the agencies and determine if more active engagement is needed should opportunities for regional partnership or demands change for the permits.

Attachment A

City of Astoria 7/13/2020

Application	Permit	Certificate	Source	Priority Date	Development Deadlines	Type of Beneficial Use	Max Rate/Volume (cfs/af)	Period Of Use	Status	Comments/ Recommendations
S-17632	S-13424	19542	Bear Creek, Middle Lake Reservoir, Wickiup Lake Reservoir	10/14/1938	---	Municipal	3.00 cfs	Year-round	• Water Right is Certificated so it is relatively secure	• *City's water source*
R-17631	R-724	19543	Bear Creek	10/14/1938	---	Storage for municipal use in Middle Lake & Wickiup Lake Reservoirs	498 af	Year-round	• Water Right is Certificated so it is relatively secure • Max use reported to OWRD in the past 5 years was 416.96 af	• *City's water source*
R-42655	R-4842	82234	Bear Creek	8/17/1966	---	Storage for municipal use in Bear Creek Reservoir	675 af	Year-round	• Water Right is Certificated so it is relatively secure • Max use reported to OWRD in the past 5 years was 713.78 af	• *City's water source*
S-42656	S-31880	82236	Bear Creek, Bear Creek Reservoir	8/17/1966	---	Municipal	12.0 cfs	Year-round	• Water Right is Certificated so it is relatively secure	• *City's water source*
PC 898	---	89004	Bear Creek	---	---	Hydroelectric production	6.0 cfs	Year-round	• Water Right is Certificated so it is relatively secure • Can only be used in conjunction with Certificate 82236	• Measure and report the quantity of water diverted
S-42657	S-31881	82237	Cedar Creek	8/17/1966	---	Municipal	2.0 cfs	Year-round	• Water Right is Certificated so it is relatively secure • Max use reported to OWRD in the past 5 years was 2.12 cfs	• *City's water source*
R-25855	R-2568	---	Youngs River	1/17/1961	10/1/1995	Storage for municipal use in Youngs River Reservoir	12,000 af	Year-round	• Extension application submitted to OWRD in December 2005. Application is being processed by OWRD and is awaiting ODFW fish persistence review.	• *No water use to date* • Extension PFO Protest Period Ends 3/16/2012
S-25856	S-27092	---	Youngs River, Youngs River Reservoir	1/17/1961	10/1/1995	Municipal	26.0 cfs	Year-round	• Extension application submitted to OWRD in December 2005. Application is being processed by OWRD and is awaiting ODFW fish persistence review	• *No water use to date* • Extension Comment Period Ends 1/10/2006
S-10226	S-7257	---	Youngs River	6/8/1925	10/1/1995	Municipal	23.0 cfs	Year-round	• Extension application submitted to OWRD in December 2005. Application is being processed by OWRD and is awaiting ODFW fish persistence review	• *No water use to date* • Extension Comment Period Ends 1/10/2006
S-6320	S-3945	---	Big Creek	11/6/1918	10/1/1995	Domestic supplies	16.0 cfs	Year-round	• Extension application submitted to OWRD in June 2006. Application is being processed by OWRD and is awaiting ODFW fish persistence review	• *No water use to date* • Extension Comment Period Ends 7/11/2006
R-18269	R-735	28407	"Seepage water"	7/13/1939	---	Storage for irrigation	11,000,000 gallons (33.77 af)	Year-round	• Water Right is Certificated so it is relatively secure	• Water continues to be stored in reservoir
S-11632	S-8096	28405	Smith Lake Reservoir	7/16/1927	---	Irrigation of Ocean View Cemetery – 24.3 Ac	0.30 cfs*	Year-round	• Water Right is Certificated so it is relatively secure	• Stored water is not currently being used to irrigate the cemetery
S-18336	S-13969	28406	Smith Lake Reservoir	8/12/1939	---	Supplemental Irrigation of 24.3 Ac	11,000,000 gallons* (33.77 af)	Year-round	• Water Right is Certificated so it is relatively secure • The volume of water stored should be reported for Certificate 28407, and the report for this right should show no use of water • Annual water use reported to OWRD is consistently 405 af (33.75 af/month)	• Stored water is not currently being used to irrigate the cemetery

cfs = cubic feet per second **af** = acre-feet **g** = gallons
* Limited to 1/80 cfs/ac and 2.5 af/ac

Attachment B

City of Astoria
Application for Extension of Time for Water Right Permit S-27092

City of Astoria
Application #: S-25856
Permit #: S-27092

Maximum Rate:	26 cubic feet per second (cfs)
Priority Date:	January 17, 1961
Purpose of Use:	Municipal Use
Period of Use:	Year Round

The City of Astoria (City) is seeking an extension of time for the development of Permit S-27092 until October 1, 2055. This permit is one of three permits (S-7257, S-27092, and R-2568) the City of Astoria has in the Youngs River watershed for the development of this source. Permit S-27092 is for withdrawal of water from the Youngs River, R-2568 is for storage of water in a reservoir on the Youngs River, and S-27092 is for the use of water released from storage. The point of diversion for this permit is located southwest of the City, upstream of a waterfall on Youngs River. Individual extension of time applications will be submitted for the three permits, however, the information presented in each application will be identical.

Information in support of the City of Astoria's extension of time application is provided below.

1. **Submit the appropriate extension of time fee ($250), as specified under ORS 536.050.**

   The required fee of $250.00 is attached.

2. **Provide evidence of the actions taken to begin actual construction on the project as required under the applicable statute.** All Quasi-Municipal permits and Municipal ground water permits issued prior to October 23, 1999, are generally required to begin actual construction within one (1) year.

   Historical records indicate that in 1927 the City completed engineering plans and specifications and obtained bids for construction of a dam, transmission main, and storage reservoir, and purchased additional surrounding land at the dam and reservoir site in the Youngs River watershed to develop Permits S-7257, S-27092, and R-2568. Additional engineering plans were completed in 1951. In 1966, site plans and geologic cross-sections were completed and in 1965, an industrial and municipal water supply engineering report was completed. **We believe that the City did not move forward with the project at the completion of these studies because of the high cost relative to other supply alternatives they developed.**

In 1995, the Lewis & Clark Water District constructed a pipeline that passes by the City's Young's River diversion point. An additional turnout was constructed so that an intake on the Young's River could be constructed at a later date in order to utilize the City of Astoria's water rights on the Young's River. This diversion point has not been constructed to date because there is insufficient demand at this time to justify its construction. However, the District has requested that this permit be preserved for future use by the District as demand increases in the future (see attached letter from the District – Attachment 7).

3. Describe and supply documentation of actions taken to develop the water right permit:

A. If this is the first extension request for this permit; ***or***

B. If a prior extension was granted for this permit, identify the last authorized dates for completion of construction and/or full beneficial use of water under the permit and provide evidence that includes dates of work that occurred within the time period of the most recently authorized (extended) dates for completion of construction and/or beneficial use of water.

The City of Astoria has applied for, and received, permit extensions for its three Youngs River permits–S-7257, S-27092, and R-2568–as required by the rules since issuance of the permits. The last extension application was submitted in 1995 and approved on April 9, 1996. The City has until December 31, 2005, to submit new extension applications in accordance with the revised extension rules (see Attachment 1). The City has not yet begun physical construction of the infrastructure necessary to use Permits S-7257, S-27092, and R-2568 because of its focus on maximizing the use of existing treatment and infrastructure investments in the Bear Creek and Cedar Creek watersheds located on the east side of Astoria. However, the City intends to take actions to maintain and develop this water right as a source for future development needs.

Historical records indicate that in 1927 the City completed engineering plans and specifications and obtained bids for construction of a dam, transmission main, and storage reservoir, and purchased additional surrounding land at the dam and reservoir site in the Youngs River watershed to develop Permits S-7257, S-27092, and R-2568. In 1951, the City completed a preliminary engineering design, survey, and topographic investigation for construction of a dam. An engineering report on industrial and municipal water supply system at Youngs River Falls, site plans, and geologic sections were completed in 1965 and 1966. **We believe that the City did not move forward with the project at the completion of these studies because of the high cost relative to other supply alternatives.**

In 1995, the Lewis & Clark Water District constructed a pipeline that passes by the City's Young's River diversion point. An additional turnout was constructed so that an intake on the Young's River could be constructed at a later date in order to utilize the City of Astoria's water rights on the Young's River. This diversion point has not been constructed to date because there is insufficient demand at this time to justify its construction.

<u>The City commissioned a Water Supply Study evaluating the historical water use and future water supply options in the fall of 1996</u>. The study completed by CH2M Hill (see Attachment 2) evaluated all of Astoria's current demands and options for addressing its near future supply issues. Part of this study examined using the City's permits along the Youngs River for development of additional water storage and supply through treatment at Astoria's existing treatment facilities. The study determined this option to be infeasible at the time of the study because of the substantial construction cost required to provide water to the City; however, the study identifies the Youngs River source as a future municipal water source for meeting future demands for the City and surrounding areas west of the City. The study also concluded that because of the very large capital cost of establishing a new municipal water source at Youngs River, the City needs to focus its limited financial resources on repairing and maximizing its existing supply sources and treatment facilities at this time. Future

population growth in the Youngs River area and the potential for development of a regional water source will be additional catalysts for the future development of the Youngs River water source.

Water Use Demand Study, 1996. This study was completed as one of 11 separate technical components of Astoria's 1996 larger Water Supply Study. Astoria's water supply demands are discussed further in Section 10 of this application. A copy of the memorandum is presented in Attachment 3.

Discussion with Lewis & Clark Water District (LCWD) – Water Requirement Study. The City has engaged in discussions with the LCWD, which serves the unincorporated communities of Jeffers Garden and Miles Crossing located southwest of Astoria, about the possible use of Astoria's Youngs River source to meet growing future water demands. In anticipation of reaching an agreement with Astoria, LCWD has installed a stub-out on its system main line at the point of diversion for Astoria's Permit S-7257. Water demand in this area southwest of Astoria is increasing and possible use of the City's Youngs River water rights are discussed in the LCWD Water Master Plan (see Attachment 4). The attached letter from Bill Mitchell, Superintendent of the Youngs River Lewis & Clark Water District, clearly demonstrates the future need for this water (see Attachment 7).

Clatsop Plains Regional Water Supply Source. In the late 1990's, the Oregon Department of Conservation and Development commissioned the study of regional problem solving strategies for the Clatsop Plains, which include the cities of Warrenton, Gearhart, Seaside and adjacent unincorporated areas. A key aspect of this study focused on the development of a regional water resource plan. Use of Astoria's undeveloped water rights on Youngs River was identified by the study as a potential water source to meet future water demand for the region (see page 5-7, McKeever/Morris, 1997 – Attachment 5). As water demands increase in the Clatsop Plain, regionalization of water supply may be required to increase supply. Because of limited surface and groundwater sources in this area, the Youngs River permits held by the City of Astoria are a potential regional water supply source.

4. Provide evidence of compliance with conditions contained in the original permit, as well as any conditions added by previous extensions. If any conditions have not been satisfied, please explain the reason(s) why.

The original permit and last extension of time did not contain conditions. The City is requesting an extension of time to develop the full amount of water under the permits. Copies of the permit and last extension of time are in Attachment 1.

5. Document evidence of the maximum instantaneous rate of water diverted to the date of this application, if any, for beneficial Quasi-Municipal or Municipal purposes.

No water has been diverted to date under Permits S-7257, S-27092, and R-2568. The City has been expending its limited financial resources in developing its existing facilities to the maximum extent possible before turning its attention to assessing and developing a new municipal supply source and/or power generation at Youngs River. The City is relying on the Youngs River permits as a water source for meeting future demands in the City and surrounding areas to the west. Discussions have been initiated to develop the Youngs River water right.

6. Provide an estimate of the population served under this permit and a description of the methodology(ies) used to make this estimate.

The City currently serves a population of approximately 9,880 inside the City limits (*Certified July 1, 2004 Estimates - Oregon, Its Counties and Incorporated Cities*, Population Research Center, Portland State University). The City serves an additional 3,000 individuals that reside between the City's headworks in the Bear Creek watershed and the eastern side of the City (see page 1, Tech. Memo. 1, Attachment 3 – Water Demand Study, CH2M HILL, 1996). The total population currently served by the City is approximately 12,880.

7. Provide a description of the financial expenditures made toward completion of the water development under this permit.

The City has conducted several engineering studies regarding the development of a dam, transmission main, storage reservoir, water treatment, and intake and pump station on Youngs River since receiving the permit in 1925. The City has purchased property at the future reservoir site and the intake facility.

<u>Project Cost to Date.</u>

Preliminary Engineering Design and Survey (1927)	$45,000
Additional Engineering Design and Survey (1951)	$75,000
Engineering Report for Municipal And Industrial Water Supply (1965)	$10,000
Site Plans and Geologic Sections (1966)	$20,000
1996 Water Supply Study	$15,000

(costs are estimated by the City and are presented as equivalent costs in 2005 dollars)

It is estimated the City has invested approximately $165,000 relating to the development of Permits S-7257, S-27092, and R-2568.

8. Provide an estimate of the cost necessary to complete the water development.

To fully develop Permits S-7257, S-27092, and R-2568, the City will need to construct a dam, water transmission lines, a water treatment facility, and two water intake facilities. The total cost of the infrastructure needed to fully develop the permits is estimated at 8 – 10 million dollars.

9. List and describe all events that delayed completion of the water development or application of water to full beneficial use, including other governmental requirements (if any), relating to the project that have significantly delayed completion of construction or perfection of the right.

The City of Astoria has been focusing its limited financial resources on completing development of its Bear Creek and Cedar Creek storage and water treatment facilities to the maximum extent possible. This includes conducting studies to evaluate repairs to the dam and reservoirs in the Bear Creek watershed that have been required by the state engineer. The completion of the repairs and upgrades at the Bear Creek source will be completed in 2020. The City intends to rely on its Youngs River permits for meeting anticipated increasing future demand originating both in town and from unincorporated areas to the west.

In addition, the delay in water development of the City's Youngs River permit also is attributable to the downturn in the regional and international economy and the corresponding reduction in population growth and water demands. This has significantly slowed both the industrial and commercial development activities within the City limits, and slowed development of neighboring unincorporated areas southwest of town (see Figure 1 attached, graph showing decline in total tonnage shipped to and from the Port of Astoria).

The local economy currently shows only minimal signs of recovery to date, however, the City continues to aggressively pursue increasing the industrial, commercial, and Port business base. Increased development of industrial/commercial shipping is critically linked to numerous outside factors, such as the status of the Columbia River dredging project that has been continually delayed.

10. A. Provide an estimated demand projection and a description of the methodology(ies) used for the subject water right permit, considering the other water rights and contracts held by the municipal or quasi-municipal water use permit holder, and a date by which the water development is anticipated to be completed and water put to full beneficial use.

Current and Projected Peak Demand and Population. The City of Astoria's recent Water Supply Study completed in 1996 developed demand projection for within the City limits of Astoria based on existing demand, peaking factors, water conservation impacts, and unaccounted for water (see Attachment 3, Table 6). The Water Supply Study used a growth rate of 1 percent for its water demand estimates up to a full City population build-out of 15,000 and a maximum daily demand of 10.1 cubic feet per second (cfs) or 6.5 million gallons per day (mgd). The following demand projection (Table 10-1) through the year 2050 has been based on an average annual growth rate of 1 percent, which includes additional demand from water users between the City's headworks in Bear Creek and the eastern limits of Astoria. The maximum daily demands were projected using peaking factors. The peaking factor used in the demand projections was 1.7 and was based on historical water usage data (see Tech. Memo. 1, Attachment 3). These demand projections assume no increased industrial or commercial growth occurs beyond the existing demand levels.

Table 10-1 – City of Astoria Future Demand Projections

	2005	2020	2030	2040	2050
Average Day Demand, cfs	4.6	5.4	5.9	6.0	6.0
Max. Daily Demand, cfs	7.7	9.0	9.9	10.1	10.1

Potential Water Supply Demand Growth. The demand projection completed in 1996 did not include potential future water demand growth in several areas of the City because these demands are difficult to accurately quantify. Additional water demands associated with the Youngs River area east of town are listed below. The City recognizes these future demands are in various stages of development and consequently cannot be accurately estimated. The City considers preservation of the Youngs River permit critical to satisfying these developing future water demands should they come to fruition in the future.

- Non-potable water uses. Astoria is exploring the future water needs for non-potable water options in this area of the City and unincorporated areas. An example is a golf course being constructed along Youngs River outside of town.

- Industrial commercial development within the City. The recent downturn in the regional economy has reduced the number of industries moving to the City, with only minimal signs of recovery to date. The future economic forecast indicates the regional economy eventually will rebound. The industrial and commercial base is closely linked to the Port of Astoria (Port) and harbor issues. The City is closely monitoring the Columbia River dredging project and evaluating possible economic changes to the industrial and commercial base and water needs if the Port expands in the future.

- Expansion of the Port. Substantial growth of the Port of Astoria is likely if dredging projects on the Columbia River proceed as scheduled, which could shift some fraction of the water-use intensive shipping and industrial facilities from Portland to Astoria. Quantifying the impact of industrial and shipping facilities on water demand is difficult, but an increase in activity and water demand potentially could be substantial.

- Unincorporated community supply needs. Several unincorporated communities are growing rapidly west and south (along the coast) of Astoria. The City is also continuing discussions with the Lewis & Clark Water District about a possible intertie to serve the community of Miles Crossing.

- Regional water supply system for coastal communities. A report commissioned by the Oregon Department of Conservation and Development (see McKeever/Morris, 1997 – Attachment 5) identified the City's undeveloped permits on the Youngs River as a potential regional water source for the Clatsop Plain. Seaside is completing a Water Master Plan that identifies the regionalization concept as one of its future water supply options. This regional water supply concept may include Astoria.

Inventory of Water Rights Held. A table listing the City of Astoria's water rights is presented in Attachment 6. Astoria's existing water supply facilities are located east of the City in the Bear Creek/Cedar Creek watershed (Permits S-31880, S-31881, S-13424, and R-724). The City maintains water supply facilities in the Bear Creek watershed capable of meeting the City's current water demands. During the summer, flow in Bear and Cedar Creeks falls below water demand and the City must use stored water from its three reservoirs in the watershed to meet peak demands. The City has sufficient water rights to meet current demands. However, the City recognizes that these sources are vulnerable to a fire in the watershed and so a redundant source is needed. Astoria currently is not using the Big Creek or the Youngs River water rights.

Astoria evaluated the capability of its water rights to meet future water demands projections by comparing yields for the Bear Creek/Cedar Creek watershed to the calculated demands to determine the amount of storage needed to make up the difference between the low summer flows in Bear and Cedar Creeks and the high summer demand. Based on the projected growth calculated in the 1996 Water Supply Study, the storage need will be 360 million gallons by 2050. The existing water storage rights in the Bear and Cedar Creek watershed is approximately equal to the projected need. However, this capacity calculation does not include any of the unquantifiable potential water demand growth (described above).

Therefore, if growth of industrial facilities near the Port of Astoria occurs, the development of a regional water system moves forward, or realization of the other identified water supply

demands to the west of Astoria develops, the increased demand will tax the City's current water supply system and require the City to develop alternative water supply options to meet summer peak demands.

The City expects these future increases in water demand to be the catalyst for development and beneficial use of the Youngs River permits and expects full beneficial use of the water to be accomplished by October 1, 2055.

10 - B. Extension requests for greater than 50 years must include documentation that the demand projection is consistent with the amount and types of lands and uses proposed to be served by the permit holder.

Not Applicable.

11. Provide a summary of the future plan and schedule to complete construction and/or perfect the water right.

Because the timing of the need for additional water is not clear at this time, it is not possible to provide a plan and schedule to complete construction at this time. The following is a general plan and schedule for developing the Youngs River water rights.

<u>Phased Approach</u>

Phase I	-	2025	Refine future water demand projections and secure funding source
Phase II	-	2030-2035	Design/construct necessary facilities (allowing for multiple expansions)
Phase III	-	2040	Facility expansion (as necessary)
Phase IV	-	2050	Facility expansion (as necessary)

12. Justify the time requested to complete the project and/or apply the water to full beneficial use.

The City maintains water supply facilities in the Bear Creek watershed capable of meeting the City's current water demands. During the summer, flow in Bear and Cedar Creeks falls below water demand and the City must use stored water at its three reservoirs in the watershed to meet peak demands. Projected regional growth will tax the City's current water system and require the City to develop alternative water supply options to meet summer peak demands. Additionally, if growth of industrial facilities near the Port of Astoria occurs or a regional water system moves forward, the City will need Permits S-7257, S-27092, and R-2568 to meet the water demand.

Additional time is needed to fully develop the permits because the City and the surrounding areas are relying on the additional water to meet their increasing water demands for the next 30 to 50 years. Therefore, it is critical that the City extend the permits through the year 2055 to ensure that the total available quantity of water on Permits S-7257, S-27092, and R-2568 is available to meet the future needs of the City and its customers.

13. Any other information you wish the Department to consider while evaluating the extension of time application.

A fish protection agreement with ODFW is not necessary because there are no sensitive, threatened, or endangered fish species in this segment of the Young's river. The City's point of diversion is located upstream of a 50 foot high water fall.

Figure 1	Reduction in Shipping Tonnage at the Port of Astoria Terminals from 1968 through 1994
Attachment 1	Permit and Latest Extension of Time
Attachment 2	City of Astoria Water Supply Study, CH2M HILL, 1996
Attachment 3	City of Astoria Water Supply Study, Technical Supplement, Water Demand Study CH2M HILL, 1996
Attachment 4	Lewis & Clark Water District (LCWD) Technical Memorandum (September 30, 2004)
Attachment 5	Regional Problem Solving Strategies for the Clatsop Plains, McKeever/Morris, inc. (November 5, 1997)
Attachment 6	City of Astoria Water Rights Summary
Attachment 7	Letter from Bill Mitchell, Superintendent of the Youngs River Lewis & Clark Water District

City of Astoria
Application for Extension of Time for Water Right Permit S-7257

City of Astoria
Application #: S-10226
Permit #: S-7257

Maximum Rate:	23 cubic feet per second (cfs)
Priority Date:	June 8, 1925
Purpose of Use:	Municipal Use and HydroPower Supply
Period of Use:	Year Round

The City of Astoria (City) is seeking an extension of time for the development of Permit S-7257 until October 1, 2055. This permit is one of three permits (S-7257, S-27092, and R-2568) the City of Astoria has in the Youngs River watershed for the development of this source. Permit S-7257 is for withdrawal of water from the Youngs River, R-2568 is for storage of water in a reservoir on the Youngs River, and S-27092 is for the use of water released from storage. The point of diversion for this permit is located southwest of the City, upstream of a waterfall on Youngs River. Individual extension of time applications will be submitted for the three permits, however, the information presented in each application will be identical.

Information in support of the City of Astoria's extension of time application is provided below.

1. **Submit the appropriate extension of time fee ($250), as specified under ORS 536.050.**

   The required fee of $250.00 is attached.

2. **Provide evidence of the actions taken to begin actual construction on the project as required under the applicable statute.** All Quasi-Municipal permits and Municipal ground water permits issued prior to October 23, 1999, are generally required to begin actual construction within one (1) year.

   Historical records indicate that in 1927 the City completed engineering plans and specifications and obtained bids for construction of a dam, transmission main, and storage reservoir, and purchased additional surrounding land at the dam and reservoir site in the Youngs River watershed to develop Permits S-7257, S-27092, and R-2568. Additional engineering plans were completed in 1951. In 1966, site plans and geologic cross-sections were completed and in 1965, an industrial and municipal water supply engineering report was completed. **We believe that the City did not move forward with the project at the completion of these studies because of the high cost relative to other supply alternatives they developed.**

In 1995, the Lewis & Clark Water District constructed a pipeline that passes by the City's Young's River diversion point. An additional turnout was constructed so that an intake on the Young's River could be constructed at a later date in order to utilize the City of Astoria's water rights on the Young's River. This diversion point has not been constructed to date because there is insufficient demand at this time to justify its construction. However, the District has requested that this permit be preserved for future use by the District as demand increases in the future (see attached letter from the District – Attachment 7).

3. Describe and supply documentation of actions taken to develop the water right permit:

A. If this is the first extension request for this permit; ***or***

B. If a prior extension was granted for this permit, identify the last authorized dates for completion of construction and/or full beneficial use of water under the permit and provide evidence that includes dates of work that occurred within the time period of the most recently authorized (extended) dates for completion of construction and/or beneficial use of water.

The City of Astoria has applied for, and received, permit extensions for its three Youngs River permits–S-7257, S-27092, and R-2568–as required by the rules since issuance of the permits. The last extension application was submitted in 1995 and approved on April 9, 1996. The City has until December 31, 2005, to submit new extension applications in accordance with the revised extension rules (see Attachment 1). The City has not yet begun physical construction of the infrastructure necessary to use Permits S-7257, S-27092, and R-2568 because of its focus on maximizing the use of existing treatment and infrastructure investments in the Bear Creek and Cedar Creek watersheds located on the east side of Astoria. However, the City intends to take actions to maintain and develop this water right as a source for future development needs.

Historical records indicate that in 1927 the City completed engineering plans and specifications and obtained bids for construction of a dam, transmission main, and storage reservoir, and purchased additional surrounding land at the dam and reservoir site in the Youngs River watershed to develop Permits S-7257, S-27092, and R-2568. In 1951, the City completed a preliminary engineering design, survey, and topographic investigation for construction of a dam. An engineering report on industrial and municipal water supply system at Youngs River Falls, site plans, and geologic sections were completed in 1965 and 1966. **We believe that the City did not move forward with the project at the completion of these studies because of the high cost relative to other supply alternatives.**

In 1995, the Lewis & Clark Water District constructed a pipeline that passes by the City's Young's River diversion point. An additional turnout was constructed so that an intake on the Young's River could be constructed at a later date in order to utilize the City of Astoria's water rights on the Young's River. This diversion point has not been constructed to date because there is insufficient demand at this time to justify its construction.

<u>The City commissioned a Water Supply Study evaluating the historical water use and future water supply options in the fall of 1996</u>. The study completed by CH2M Hill (see Attachment 2) evaluated all of Astoria's current demands and options for addressing its near future supply issues. Part of this study examined using the City's permits along the Youngs River for development of additional water storage and supply through treatment at Astoria's existing treatment facilities. The study determined this option to be infeasible at the time of the study because of the substantial construction cost required to provide water to the City; however, the study identifies the Youngs River source as a future municipal water source for meeting future demands for the City and surrounding areas west of the City. The study also concluded that because of the very large capital cost of establishing a new municipal water source at Youngs River, the City needs to focus its limited financial resources on repairing and maximizing its existing supply sources and treatment facilities at this time. Future

population growth in the Youngs River area and the potential for development of a regional water source will be additional catalysts for the future development of the Youngs River water source.

Water Use Demand Study, 1996. This study was completed as one of 11 separate technical components of Astoria's 1996 larger Water Supply Study. Astoria's water supply demands are discussed further in Section 10 of this application. A copy of the memorandum is presented in Attachment 3.

Discussion with Lewis & Clark Water District (LCWD) – Water Requirement Study. The City has engaged in discussions with the LCWD, which serves the unincorporated communities of Jeffers Garden and Miles Crossing located southwest of Astoria, about the possible use of Astoria's Youngs River source to meet growing future water demands. In anticipation of reaching an agreement with Astoria, LCWD has installed a stub-out on its system main line at the point of diversion for Astoria's Permit S-7257. Water demand in this area southwest of Astoria is increasing and possible use of the City's Youngs River water rights are discussed in the LCWD Water Master Plan (see Attachment 4). The attached letter from Bill Mitchell, Superintendent of the Youngs River Lewis & Clark Water District, clearly demonstrates the future need for this water (see Attachment 7).

Clatsop Plains Regional Water Supply Source. In the late 1990's, the Oregon Department of Conservation and Development commissioned the study of regional problem solving strategies for the Clatsop Plains, which include the cities of Warrenton, Gearhart, Seaside and adjacent unincorporated areas. A key aspect of this study focused on the development of a regional water resource plan. Use of Astoria's undeveloped water rights on Youngs River was identified by the study as a potential water source to meet future water demand for the region (see page 5-7, McKeever/Morris, 1997 – Attachment 5). As water demands increase in the Clatsop Plain, regionalization of water supply may be required to increase supply. Because of limited surface and groundwater sources in this area, the Youngs River permits held by the City of Astoria are a potential regional water supply source.

4. Provide evidence of compliance with conditions contained in the original permit, as well as any conditions added by previous extensions. If any conditions have not been satisfied, please explain the reason(s) why.

The original permit and last extension of time did not contain conditions. The City is requesting an extension of time to develop the full amount of water under the permits. Copies of the permit and last extension of time are in Attachment 1.

5. Document evidence of the maximum instantaneous rate of water diverted to the date of this application, if any, for beneficial Quasi-Municipal or Municipal purposes.

No water has been diverted to date under Permits S-7257, S-27092, and R-2568. The City has been expending its limited financial resources in developing its existing facilities to the maximum extent possible before turning its attention to assessing and developing a new municipal supply source and/or power generation at Youngs River. The City is relying on the Youngs River permits as a water source for meeting future demands in the City and surrounding areas to the west. Discussions have been initiated to develop the Youngs River water right.

6. Provide an estimate of the population served under this permit and a description of the methodology(ies) used to make this estimate.

The City currently serves a population of approximately 9,880 inside the City limits (*Certified July 1, 2004 Estimates - Oregon, Its Counties and Incorporated Cities*, Population Research Center, Portland State University). The City serves an additional 3,000 individuals that reside between the City's headworks in the Bear Creek watershed and the eastern side of the City (see page 1, Tech. Memo. 1, Attachment 3 – Water Demand Study, CH2M HILL, 1996). The total population currently served by the City is approximately 12,880.

7. Provide a description of the financial expenditures made toward completion of the water development under this permit.

The City has conducted several engineering studies regarding the development of a dam, transmission main, storage reservoir, water treatment, and intake and pump station on Youngs River since receiving the permit in 1925. The City has purchased property at the future reservoir site and the intake facility.

<u>Project Cost to Date.</u>

Preliminary Engineering Design and Survey (1927)	$45,000
Additional Engineering Design and Survey (1951)	$75,000
Engineering Report for Municipal And Industrial Water Supply (1965)	$10,000
Site Plans and Geologic Sections (1966)	$20,000
1996 Water Supply Study	$15,000

(costs are estimated by the City and are presented as equivalent costs in 2005 dollars)

It is estimated the City has invested approximately $165,000 relating to the development of Permits S-7257, S-27092, and R-2568.

8. Provide an estimate of the cost necessary to complete the water development.

To fully develop Permits S-7257, S-27092, and R-2568, the City will need to construct a dam, water transmission lines, a water treatment facility, and two water intake facilities. The total cost of the infrastructure needed to fully develop the permits is estimated at 8 – 10 million dollars.

9. List and describe all events that delayed completion of the water development or application of water to full beneficial use, including other governmental requirements (if any), relating to the project that have significantly delayed completion of construction or perfection of the right.

The City of Astoria has been focusing its limited financial resources on completing development of its Bear Creek and Cedar Creek storage and water treatment facilities to the maximum extent possible. This includes conducting studies to evaluate repairs to the dam and reservoirs in the Bear Creek watershed that have been required by the state engineer. The completion of the repairs and upgrades at the Bear Creek source will be completed in 2020. The City intends to rely on its Youngs River permits for meeting anticipated increasing future demand originating both in town and from unincorporated areas to the west.

In addition, the delay in water development of the City's Youngs River permit also is attributable to the downturn in the regional and international economy and the corresponding reduction in population growth and water demands. This has significantly slowed both the industrial and commercial development activities within the City limits, and slowed development of neighboring unincorporated areas southwest of town (see Figure 1 attached, graph showing decline in total tonnage shipped to and from the Port of Astoria).

The local economy currently shows only minimal signs of recovery to date, however, the City continues to aggressively pursue increasing the industrial, commercial, and Port business base. Increased development of industrial/commercial shipping is critically linked to numerous outside factors, such as the status of the Columbia River dredging project that has been continually delayed.

10. A. Provide an estimated demand projection and a description of the methodology(ies) used for the subject water right permit, considering the other water rights and contracts held by the municipal or quasi-municipal water use permit holder, and a date by which the water development is anticipated to be completed and water put to full beneficial use.

Current and Projected Peak Demand and Population. The City of Astoria's recent Water Supply Study completed in 1996 developed demand projection for within the City limits of Astoria based on existing demand, peaking factors, water conservation impacts, and unaccounted for water (see Attachment 3, Table 6). The Water Supply Study used a growth rate of 1 percent for its water demand estimates up to a full City population build-out of 15,000 and a maximum daily demand of 10.1 cubic feet per second (cfs) or 6.5 million gallons per day (mgd). The following demand projection (Table 10-1) through the year 2050 has been based on an average annual growth rate of 1 percent, which includes additional demand from water users between the City's headworks in Bear Creek and the eastern limits of Astoria. The maximum daily demands were projected using peaking factors. The peaking factor used in the demand projections was 1.7 and was based on historical water usage data (see Tech. Memo. 1, Attachment 3). These demand projections assume no increased industrial or commercial growth occurs beyond the existing demand levels.

Table 10-1 – City of Astoria Future Demand Projections

	2005	2020	2030	2040	2050
Average Day Demand, cfs	4.6	5.4	5.9	6.0	6.0
Max. Daily Demand, cfs	7.7	9.0	9.9	10.1	10.1

Potential Water Supply Demand Growth. The demand projection completed in 1996 did not include potential future water demand growth in several areas of the City because these demands are difficult to accurately quantify. Additional water demands associated with the Youngs River area east of town are listed below. The City recognizes these future demands are in various stages of development and consequently cannot be accurately estimated. The City considers preservation of the Youngs River permit critical to satisfying these developing future water demands should they come to fruition in the future.

- Non-potable water uses. Astoria is exploring the future water needs for non-potable water options in this area of the City and unincorporated areas. An example is a golf course being constructed along Youngs River outside of town.

- Industrial commercial development within the City. The recent downturn in the regional economy has reduced the number of industries moving to the City, with only minimal signs of recovery to date. The future economic forecast indicates the regional economy eventually will rebound. The industrial and commercial base is closely linked to the Port of Astoria (Port) and harbor issues. The City is closely monitoring the Columbia River dredging project and evaluating possible economic changes to the industrial and commercial base and water needs if the Port expands in the future.

- Expansion of the Port. Substantial growth of the Port of Astoria is likely if dredging projects on the Columbia River proceed as scheduled, which could shift some fraction of the water-use intensive shipping and industrial facilities from Portland to Astoria. Quantifying the impact of industrial and shipping facilities on water demand is difficult, but an increase in activity and water demand potentially could be substantial.

- Unincorporated community supply needs. Several unincorporated communities are growing rapidly west and south (along the coast) of Astoria. The City is also continuing discussions with the Lewis & Clark Water District about a possible intertie to serve the community of Miles Crossing.

- Regional water supply system for coastal communities. A report commissioned by the Oregon Department of Conservation and Development (see McKeever/Morris, 1997 – Attachment 5) identified the City's undeveloped permits on the Youngs River as a potential regional water source for the Clatsop Plain. Seaside is completing a Water Master Plan that identifies the regionalization concept as one of its future water supply options. This regional water supply concept may include Astoria.

Inventory of Water Rights Held. A table listing the City of Astoria's water rights is presented in Attachment 6. Astoria's existing water supply facilities are located east of the City in the Bear Creek/Cedar Creek watershed (Permits S-31880, S-31881, S-13424, and R-724). The City maintains water supply facilities in the Bear Creek watershed capable of meeting the City's current water demands. During the summer, flow in Bear and Cedar Creeks falls below water demand and the City must use stored water from its three reservoirs in the watershed to meet peak demands. The City has sufficient water rights to meet current demands. However, the City recognizes that these sources are vulnerable to a fire in the watershed and so a redundant source is needed. Astoria currently is not using the Big Creek or the Youngs River water rights.

Astoria evaluated the capability of its water rights to meet future water demands projections by comparing yields for the Bear Creek/Cedar Creek watershed to the calculated demands to determine the amount of storage needed to make up the difference between the low summer flows in Bear and Cedar Creeks and the high summer demand. Based on the projected growth calculated in the 1996 Water Supply Study, the storage need will be 360 million gallons by 2050. The existing water storage rights in the Bear and Cedar Creek watershed is approximately equal to the projected need. However, this capacity calculation does not include any of the unquantifiable potential water demand growth (described above).

Therefore, if growth of industrial facilities near the Port of Astoria occurs, the development of a regional water system moves forward, or realization of the other identified water supply

demands to the west of Astoria develops, the increased demand will tax the City's current water supply system and require the City to develop alternative water supply options to meet summer peak demands.

The City expects these future increases in water demand to be the catalyst for development and beneficial use of the Youngs River permits and expects full beneficial use of the water to be accomplished by October 1, 2055.

10 - B. Extension requests for greater than 50 years must include documentation that the demand projection is consistent with the amount and types of lands and uses proposed to be served by the permit holder.

Not Applicable.

11. Provide a summary of the future plan and schedule to complete construction and/or perfect the water right.

Because the timing of the need for additional water is not clear at this time, it is not possible to provide a plan and schedule to complete construction at this time. The following is a general plan and schedule for developing the Youngs River water rights.

<u>Phased Approach</u>

Phase I	-	2025	Refine future water demand projections and secure funding source
Phase II	-	2030-2035	Design/construct necessary facilities (allowing for multiple expansions)
Phase III	-	2040	Facility expansion (as necessary)
Phase IV	-	2050	Facility expansion (as necessary)

12. Justify the time requested to complete the project and/or apply the water to full beneficial use.

The City maintains water supply facilities in the Bear Creek watershed capable of meeting the City's current water demands. During the summer, flow in Bear and Cedar Creeks falls below water demand and the City must use stored water at its three reservoirs in the watershed to meet peak demands. Projected regional growth will tax the City's current water system and require the City to develop alternative water supply options to meet summer peak demands. Additionally, if growth of industrial facilities near the Port of Astoria occurs or a regional water system moves forward, the City will need Permits S-7257, S-27092, and R-2568 to meet the water demand.

Additional time is needed to fully develop the permits because the City and the surrounding areas are relying on the additional water to meet their increasing water demands for the next 30 to 50 years. Therefore, it is critical that the City extend the permits through the year 2055 to ensure that the total available quantity of water on Permits S-7257, S-27092, and R-2568 is available to meet the future needs of the City and its customers.

13. Any other information you wish the Department to consider while evaluating the extension of time application.

A fish protection agreement with ODFW is not necessary because there are no sensitive, threatened, or endangered fish species in this segment of the Young's river. The City's point of diversion is located upstream of a 50 foot high water fall.

Figure 1	Reduction in Shipping Tonnage at the Port of Astoria Terminals from 1968 through 1994
Attachment 1	Permit and Latest Extension of Time
Attachment 2	City of Astoria Water Supply Study, CH2M HILL, 1996
Attachment 3	City of Astoria Water Supply Study, Technical Supplement, Water Demand Study CH2M HILL, 1996
Attachment 4	Lewis & Clark Water District (LCWD) Technical Memorandum (September 30, 2004)
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Attachment 6	City of Astoria Water Rights Summary
Attachment 7	Letter from Bill Mitchell, Superintendent of the Youngs River Lewis & Clark Water District

City of Astoria
Application for Extension of Time for Water Right Permit R-2568

City of Astoria
Application #: R-25855
Permit #: R-2568

Maximum Rate:	12,000 acre-feet
Priority Date:	January 17, 1961
Purpose of Use:	Municipal Use
Period of Use:	Year Round

The City of Astoria (City) is seeking an extension of time for the development of Permit R-2568 until October 1, 2055. This permit is one of three permits (S-7257, S-27092, and R-2568) the City of Astoria has in the Youngs River watershed for the development of this source. Permit S-27092 is for withdrawal of water from the Youngs River, R-2568 is for storage of water in a reservoir on the Youngs River, and S-27092 is for the use of water released from storage. The point of diversion for this permit is located southwest of the City, upstream of a waterfall on Youngs River. Individual extension of time applications will be submitted for the three permits, however, the information presented in each application will be identical.

Information in support of the City of Astoria's extension of time application is provided below.

1. **Submit the appropriate extension of time fee ($250), as specified under ORS 536.050.**

   The required fee of $250.00 is attached.

2. **Provide evidence of the actions taken to begin actual construction on the project as required under the applicable statute.** All Quasi-Municipal permits and Municipal ground water permits issued prior to October 23, 1999, are generally required to begin actual construction within one (1) year.

   Historical records indicate that in 1927 the City completed engineering plans and specifications and obtained bids for construction of a dam, transmission main, and storage reservoir, and purchased additional surrounding land at the dam and reservoir site in the Youngs River watershed to develop Permits S-7257, S-27092, and R-2568. Additional engineering plans were completed in 1951. In 1966, site plans and geologic cross-sections were completed and in 1965, an industrial and municipal water supply engineering report was completed. **We believe that the City did not move forward with the project at the completion of these studies because of the high cost relative to other supply alternatives they developed.**

In 1995, the Lewis & Clark Water District constructed a pipeline that passes by the City's Young's River diversion point. An additional turnout was constructed so that an intake on the Young's River could be constructed at a later date in order to utilize the City of Astoria's water rights on the Young's River. This diversion point has not been constructed to date because there is insufficient demand at this time to justify its construction. However, the District has requested that this permit be preserved for future use by the District as demand increases in the future (see attached letter from the District – Attachment 7).

3. Describe and supply documentation of actions taken to develop the water right permit:

A. If this is the first extension request for this permit; ***or***

B. If a prior extension was granted for this permit, identify the last authorized dates for completion of construction and/or full beneficial use of water under the permit and provide evidence that includes dates of work that occurred within the time period of the most recently authorized (extended) dates for completion of construction and/or beneficial use of water.

The City of Astoria has applied for, and received, permit extensions for its three Youngs River permits–S-7257, S-27092, and R-2568–as required by the rules since issuance of the permits. The last extension application was submitted in 1995 and approved on April 9, 1996. The City has until December 31, 2005, to submit new extension applications in accordance with the revised extension rules (see Attachment 1). The City has not yet begun physical construction of the infrastructure necessary to use Permits S-7257, S-27092, and R-2568 because of its focus on maximizing the use of existing treatment and infrastructure investments in the Bear Creek and Cedar Creek watersheds located on the east side of Astoria. However, the City intends to take actions to maintain and develop this water right as a source for future development needs.

Historical records indicate that in 1927 the City completed engineering plans and specifications and obtained bids for construction of a dam, transmission main, and storage reservoir, and purchased additional surrounding land at the dam and reservoir site in the Youngs River watershed to develop Permits S-7257, S-27092, and R-2568. In 1951, the City completed a preliminary engineering design, survey, and topographic investigation for construction of a dam. An engineering report on industrial and municipal water supply system at Youngs River Falls, site plans, and geologic sections were completed in 1965 and 1966. **We believe that the City did not move forward with the project at the completion of these studies because of the high cost relative to other supply alternatives.**

In 1995, the Lewis & Clark Water District constructed a pipeline that passes by the City's Young's River diversion point. An additional turnout was constructed so that an intake on the Young's River could be constructed at a later date in order to utilize the City of Astoria's water rights on the Young's River. This diversion point has not been constructed to date because there is insufficient demand at this time to justify its construction.

The City commissioned a Water Supply Study evaluating the historical water use and future water supply options in the fall of 1996. The study completed by CH2M Hill (see Attachment 2) evaluated all of Astoria's current demands and options for addressing its near future supply issues. Part of this study examined using the City's permits along the Youngs River for development of additional water storage and supply through treatment at Astoria's existing treatment facilities. The study determined this option to be infeasible at the time of the study because of the substantial construction cost required to provide water to the City; however, the study identifies the Youngs River source as a future municipal water source for meeting future demands for the City and surrounding areas west of the City. The study also concluded that because of the very large capital cost of establishing a new municipal water source at Youngs River, the City needs to focus its limited financial resources on repairing and maximizing its existing supply sources and treatment facilities at this time. Future

population growth in the Youngs River area and the potential for development of a regional water source will be additional catalysts for the future development of the Youngs River water source.

Water Use Demand Study, 1996. This study was completed as one of 11 separate technical components of Astoria's 1996 larger Water Supply Study. Astoria's water supply demands are discussed further in Section 10 of this application. A copy of the memorandum is presented in Attachment 3.

Discussion with Lewis & Clark Water District (LCWD) – Water Requirement Study. The City has engaged in discussions with the LCWD, which serves the unincorporated communities of Jeffers Garden and Miles Crossing located southwest of Astoria, about the possible use of Astoria's Youngs River source to meet growing future water demands. In anticipation of reaching an agreement with Astoria, LCWD has installed a stub-out on its system main line at the point of diversion for Astoria's Permit S-7257. Water demand in this area southwest of Astoria is increasing and possible use of the City's Youngs River water rights are discussed in the LCWD Water Master Plan (see Attachment 4). The attached letter from Bill Mitchell, Superintendent of the Youngs River Lewis & Clark Water District, clearly demonstrates the future need for this water (see Attachment 7).

Clatsop Plains Regional Water Supply Source. In the late 1990's, the Oregon Department of Conservation and Development commissioned the study of regional problem solving strategies for the Clatsop Plains, which include the cities of Warrenton, Gearhart, Seaside and adjacent unincorporated areas. A key aspect of this study focused on the development of a regional water resource plan. Use of Astoria's undeveloped water rights on Youngs River was identified by the study as a potential water source to meet future water demand for the region (see McKeever/Morris, 1997 – Attachment 5). As water demands increase in the Clatsop Plain, regionalization of water supply may be required to increase supply. Because of limited surface and groundwater sources in this area, the Youngs River permits held by the City of Astoria are a potential regional water supply source.

4. Provide evidence of compliance with conditions contained in the original permit, as well as any conditions added by previous extensions. If any conditions have not been satisfied, please explain the reason(s) why.

The original permit and last extension of time did not contain conditions. The City is requesting an extension of time to develop the full amount of water under the permits. Copies of the permit and last extension of time are in Attachment 1.

5. Document evidence of the maximum instantaneous rate of water diverted to the date of this application, if any, for beneficial Quasi-Municipal or Municipal purposes.

No water has been diverted to date under Permits S-7257, S-27092, and R-2568. The City has been expending its limited financial resources in developing its existing facilities to the maximum extent possible before turning its attention to assessing and developing a new municipal supply source and/or power generation at Youngs River. The City is relying on the Youngs River permits as a water source for meeting future demands in the City and surrounding areas to the west. Discussions have been initiated to develop the Youngs River water right.

6. Provide an estimate of the population served under this permit and a description of the methodology(ies) used to make this estimate.

The City currently serves a population of approximately 9,880 inside the City limits (*Certified July 1, 2004 Estimates - Oregon, Its Counties and Incorporated Cities*, Population Research Center, Portland State University). The City serves an additional 3,000 individuals that reside between the City's headworks in the Bear Creek watershed and the eastern side of the City (see page 1, Tech. Memo. 1, Attachment 3 – Water Demand Study, CH2M HILL, 1996). The total population currently served by the City is approximately 12,880.

7. Provide a description of the financial expenditures made toward completion of the water development under this permit.

The City has conducted several engineering studies regarding the development of a dam, transmission main, storage reservoir, water treatment, and intake and pump station on Youngs River since receiving the permit in 1925. The City has purchased property at the future reservoir site and the intake facility.

<u>Project Cost to Date.</u>

Preliminary Engineering Design and Survey (1927)	$45,000
Additional Engineering Design and Survey (1951)	$75,000
Engineering Report for Municipal And Industrial Water Supply (1965)	$10,000
Site Plans and Geologic Sections (1966)	$20,000
1996 Water Supply Study	$15,000

(costs are estimated by the City and are presented as equivalent costs in 2005 dollars)

It is estimated the City has invested approximately $165,000 relating to the development of Permits S-7257, S-27092, and R-2568.

8. Provide an estimate of the cost necessary to complete the water development.

To fully develop Permits S-7257, S-27092, and R-2568, the City will need to construct a dam, water transmission lines, a water treatment facility, and two water intake facilities. The total cost of the infrastructure needed to fully develop the permits is estimated at 8 – 10 million dollars.

9. List and describe all events that delayed completion of the water development or application of water to full beneficial use, including other governmental requirements (if any), relating to the project that have significantly delayed completion of construction or perfection of the right.

The City of Astoria has been focusing its limited financial resources on completing development of its Bear Creek and Cedar Creek storage and water treatment facilities to the maximum extent possible. This includes conducting studies to evaluate repairs to the dam and reservoirs in the Bear Creek watershed that have been required by the state engineer. The completion of the repairs and upgrades at the Bear Creek source will be completed in 2020. The City intends to rely on its Youngs River permits for meeting anticipated increasing future demand originating both in town and from unincorporated areas to the west.

In addition, the delay in water development of the City's Youngs River permit also is attributable to the downturn in the regional and international economy and the corresponding reduction in population growth and water demands. This has significantly slowed both the industrial and commercial development activities within the City limits, and slowed development of neighboring unincorporated areas southwest of town (see Figure 1 attached, graph showing decline in total tonnage shipped to and from the Port of Astoria).

The local economy currently shows only minimal signs of recovery to date, however, the City continues to aggressively pursue increasing the industrial, commercial, and Port business base. Increased development of industrial/commercial shipping is critically linked to numerous outside factors, such as the status of the Columbia River dredging project that has been continually delayed.

10. A. Provide an estimated demand projection and a description of the methodology(ies) used for the subject water right permit, considering the other water rights and contracts held by the municipal or quasi-municipal water use permit holder, and a date by which the water development is anticipated to be completed and water put to full beneficial use.

<u>Current and Projected Peak Demand and Population.</u> The City of Astoria's recent Water Supply Study completed in 1996 developed demand projection for within the City limits of Astoria based on existing demand, peaking factors, water conservation impacts, and unaccounted for water (see Attachment 3, Table 6). The Water Supply Study used a growth rate of 1 percent for its water demand estimates up to a full City population build-out of 15,000 and a maximum daily demand of 10.1 cubic feet per second (cfs) or 6.5 million gallons per day (mgd). The following demand projection (Table 10-1) through the year 2050 has been based on an average annual growth rate of 1 percent, which includes additional demand from water users between the City's headworks in Bear Creek and the eastern limits of Astoria. The maximum daily demands were projected using peaking factors. The peaking factor used in the demand projections was 1.7 and was based on historical water usage data (see Tech. Memo. 1, Attachment 3). These demand projections assume no increased industrial or commercial growth occurs beyond the existing demand levels.

Table 10-1 – City of Astoria Future Demand Projections

	2005	2020	2030	2040	2050
Average Day Demand, cfs	4.6	5.4	5.9	6.0	6.0
Max. Daily Demand, cfs	7.7	9.0	9.9	10.1	10.1

<u>Potential Water Supply Demand Growth.</u> The demand projection completed in 1996 did not include potential future water demand growth in several areas of the City because these demands are difficult to accurately quantify. Additional water demands associated with the Youngs River area east of town are listed below. The City recognizes these future demands are in various stages of development and consequently cannot be accurately estimated. The City considers preservation of the Youngs River permit critical to satisfying these developing future water demands should they come to fruition in the future.

- <u>Non-potable water uses.</u> Astoria is exploring the future water needs for non-potable water options in this area of the City and unincorporated areas. An example is a golf course being constructed along Youngs River outside of town.

- Industrial commercial development within the City. The recent downturn in the regional economy has reduced the number of industries moving to the City, with only minimal signs of recovery to date. The future economic forecast indicates the regional economy eventually will rebound. The industrial and commercial base is closely linked to the Port of Astoria (Port) and harbor issues. The City is closely monitoring the Columbia River dredging project and evaluating possible economic changes to the industrial and commercial base and water needs if the Port expands in the future.

- Expansion of the Port. Substantial growth of the Port of Astoria is likely if dredging projects on the Columbia River proceed as scheduled, which could shift some fraction of the water-use intensive shipping and industrial facilities from Portland to Astoria. Quantifying the impact of industrial and shipping facilities on water demand is difficult, but an increase in activity and water demand potentially could be substantial.

- Unincorporated community supply needs. Several unincorporated communities are growing rapidly west and south (along the coast) of Astoria. The City is also continuing discussions with the Lewis & Clark Water District about a possible intertie to serve the community of Miles Crossing.

- Regional water supply system for coastal communities. A report commissioned by the Oregon Department of Conservation and Development (see McKeever/Morris, 1997 – Attachment 5) identified the City's undeveloped permits on the Youngs River as a potential regional water source for the Clatsop Plain. Seaside is completing a Water Master Plan that identifies the regionalization concept as one of its future water supply options. This regional water supply concept may include Astoria.

Inventory of Water Rights Held. A table listing the City of Astoria's water rights is presented in Attachment 6. Astoria's existing water supply facilities are located east of the City in the Bear Creek/Cedar Creek watershed (Permits S-31880, S-31881, S-13424, and R-724). The City maintains water supply facilities in the Bear Creek watershed capable of meeting the City's current water demands. During the summer, flow in Bear and Cedar Creeks falls below water demand and the City must use stored water from its three reservoirs in the watershed to meet peak demands. The City has sufficient water rights to meet current demands. However, the City recognizes that these sources are vulnerable to a fire in the watershed and so a redundant source is needed. Astoria currently is not using the Big Creek or the Youngs River water rights.

Astoria evaluated the capability of its water rights to meet future water demands projections by comparing yields for the Bear Creek/Cedar Creek watershed to the calculated demands to determine the amount of storage needed to make up the difference between the low summer flows in Bear and Cedar Creeks and the high summer demand. Based on the projected growth calculated in the 1996 Water Supply Study, the storage need will be 360 million gallons by 2050. The existing water storage rights in the Bear and Cedar Creek watershed is approximately equal to the projected need. However, this capacity calculation does not include any of the unquantifiable potential water demand growth (described above).

Therefore, if growth of industrial facilities near the Port of Astoria occurs, the development of a regional water system moves forward, or realization of the other identified water supply

demands to the west of Astoria develops, the increased demand will tax the City's current water supply system and require the City to develop alternative water supply options to meet summer peak demands.

The City expects these future increases in water demand to be the catalyst for development and beneficial use of the Youngs River permits and expects full beneficial use of the water to be accomplished by October 1, 2055.

10 - B. Extension requests for greater than 50 years must include documentation that the demand projection is consistent with the amount and types of lands and uses proposed to be served by the permit holder.

Not Applicable.

11. Provide a summary of the future plan and schedule to complete construction and/or perfect the water right.

Because the timing of the need for additional water is not clear at this time, it is not possible to provide a plan and schedule to complete construction at this time. The following is a general plan and schedule for developing the Youngs River water rights.

Phased Approach

Phase I	-	2025	Refine future water demand projections and secure funding source
Phase II	-	2030-2035	Design/construct necessary facilities (allowing for multiple expansions)
Phase III	-	2040	Facility expansion (as necessary)
Phase IV	-	2050	Facility expansion (as necessary)

12. Justify the time requested to complete the project and/or apply the water to full beneficial use.

The City maintains water supply facilities in the Bear Creek watershed capable of meeting the City's current water demands. During the summer, flow in Bear and Cedar Creeks falls below water demand and the City must use stored water at its three reservoirs in the watershed to meet peak demands. Projected regional growth will tax the City's current water system and require the City to develop alternative water supply options to meet summer peak demands. Additionally, if growth of industrial facilities near the Port of Astoria occurs or a regional water system moves forward, the City will need Permits S-7257, S-27092, and R-2568 to meet the water demand.

Additional time is needed to fully develop the permits because the City and the surrounding areas are relying on the additional water to meet their increasing water demands for the next 30 to 50 years. Therefore, it is critical that the City extend the permits through the year 2055 to ensure that the total available quantity of water on Permits S-7257, S-27092, and R-2568 is available to meet the future needs of the City and its customers.

13. Any other information you wish the Department to consider while evaluating the extension of time application.

A fish protection agreement with ODFW is not necessary because there are no sensitive, threatened, or endangered fish species in this segment of the Young's river. The City's point of diversion is located upstream of a 50 foot high water fall.

Figure 1	Reduction in Shipping Tonnage at the Port of Astoria Terminals from 1968 through 1994
Attachment 1	Permit and Latest Extension of Time
Attachment 2	City of Astoria Water Supply Study, CH2M HILL, 1996
Attachment 3	City of Astoria Water Supply Study, Technical Supplement, Water Demand Study CH2M HILL, 1996
Attachment 4	Lewis & Clark Water District (LCWD) Technical Memorandum (September 30, 2004)
Attachment 5	Regional Problem Solving Strategies for the Clatsop Plains, McKeever/Morris, inc. (November 5, 1997)
Attachment 6	City of Astoria Water Rights Summary
Attachment 7	Letter from Bill Mitchell, Superintendent of the Youngs River Lewis & Clark Water District

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Appendix E. Hydraulic Model Development Technical Memorandum

HDR

Memo

Date:	Thursday, January 14, 2021
Project:	Astoria Water System Master Plan Project
To:	Jeff Harrington, Public Works Director
From:	Steve Muir, Hydraulic Modeler; Kathryn Maschmann, Project Engineer
Subject:	**Hydraulic Model Development**

1.0 Water System Hydraulic Model Development

The City of Astoria's water distribution system was modeled using Innovyze's InfoWater Pro distribution system hydraulic computer model. The hydraulic model was developed using City-provided GIS data for its water system. Required data for creation of the model included water main diameter and length, customer billing records, ground elevations, and general operating characteristics of water system facilities (i.e., pump curves, water storage tank gauging tables, PRV settings). In addition to the above data, the model also required pipe roughness coefficients, or Hazen-Williams' C-values, which represent the relative internal condition of the water main. The C-values are used in the hydraulic calculation to determine pressure losses within the modeled pipe network. Water main roughness coefficients were estimated based on diameter, material, and installation date. Field observations of severe tuberculation within cast iron pipe were also incorporated into the roughness coefficient estimate.

2.0 Water System Hydraulic Model Calibration

The hydraulic model was calibrated prior to using it to evaluate water system performance. Model calibration is the adjustment of model parameters so that the hydraulic model accurately simulates actual system performance. The calibration of the City of Astoria water system model was performed under steady-state simulations (micro-calibration). Without significant head loss, the hydraulic grade line of the entire water system can be relatively consistent which can result in an uncalibrated model appearing to closely represent observed system pressures. To effectively assess the level of accuracy of model predictions, it is important to stress the system and verify that the model will correctly represent these changes in hydraulic grade line at higher head loss. A stressed condition with high head loss, such as during a hydrant flow test, produces more meaningful comparisons between field measurements and model predictions.

Steady state model calibration data for the City of Astoria water system model used data obtained from 10 flow and pressure tests performed in June 2020. During each test, pressure data was collected at two hydrants near the flowing hydrant. City of Astoria water system operators performed the flow tests and provided SCADA data for the day of testing. Flow and pressure test results were used to verify the model simulates actual field conditions to a reasonable degree by comparing flows and pressures measured in the field with those simulated by the hydraulic model. During the model calibration process, pump status, PRV status, and reservoir water levels were set to match the field conditions. Pipe roughness coefficients were adjusted until the water system model adequately simulated field test data.

Precise duplication of the field test results at all locations within the water distribution system during steady state calibration of the computer model is unrealistic due to the many factors that influence field test results. Instead, the goal of steady-state calibration is to minimize the error between the field test data and the model simulations and create a “best fit” at all locations; therefore, some error between the field tests and model simulations is expected. However, the allowable error is limited to ensure the calibrated model is a reasonably accurate representation of the actual water distribution system.

While there are no universal calibration standards for water distribution system model calibration, the goal of calibration, and therefore the accuracy criteria, should be guided by the intended use of the hydraulic model. A model that is sufficiently calibrated for master planning, for instance, may not be sufficiently calibrated for water quality analysis.

For this analysis, the steady-state model calibration accuracy goal is ± 5 pounds per square inch (psi) of the recorded pressure drop and ± 5 psi of the recorded static pressure prior to each flow test.

The steady-state model calibration simulations were performed to replicate results from the hydrant flow test data collected in June 2020. The following summarizes the field tests performed and modifications made during model calibration.

Flow test data are shown in Table 1. Initial roughness coefficients were assigned to water mains based on diameter, material, and installation date. Initial model results showed much higher system pressure during hydrant flow tests than was observed during field tests. This could be indicative of unknown closed or partially closed gate valves causing higher than expected system head loss. City operation staff have noted high amounts of tuberculation within some pipes resulting in a reduced capacity in those pipe sections. This is apparent in both Flow Tests 1 and 3 which indicate lower than expected roughness values for cast iron pipe. Roughness factors were adjusted, as needed, to account for this reduced capacity and improve the calibration of the model.

Final model calibration results are shown in Table 2.

Table 1. Hydrant Flow Test Data

Flow Test	Flow 1			Flow 2		Residual 1			Residual 2		
	Hydrant Location	**Time**	**Flow**	**Hydrant Location**	**Flow**	**Hydrant Location**	**Static Initial**	**Residual**	**Hydrant Location**	**Static Initial**	**Residual**
1	Front & SE Grant	10:47	604	-	-	Front & SE Hancock	108.8	30.7	Front & SE Kearney	110.1	40.8
2	W Marine Drive & HS Track	10:20	825	-	-	W Marine Drive & Frankfort	104.8	66.5	W Marine Drive & Denver	104.8	68.0
3	W Grand - 300' E of W Lexington	11:21	170	-	-	W Grand & Chelmsford	78.5	17.3	W Grand & Hume	73.7	27.7
4	Marine Drive & 12th	9:07	825	-	-	Marine Drive & 14th	103.3	81.7	Marine Drive & 10th	101.1	81.4
5	Florence & Rivington	9:33	680	-	-	Alameda & Agate	58.8	35.2	Alameda & Chinook	50.1	43.4
6	Kensington & 8th	11:49	869			Lexington & 8th	62.3	59.0	Niagara & 8th	61.8	60.0
6	Kensington & 8th	12:07	795	Jerome & 8th	940	Lexington & 8th	61.8	51.6	Niagara & 8th	61.2	53.9
7	Leif Erikson, between 35th & 36th	1:45	896	-	-	Leif Erikson, 34th & 35th	107.8	88.7	Leif Erikson & 37th	102.2	87.7
8	Irving & 22nd	1:21	624	-	-	Irving between 20th & 21st	95.3	68.7	Irving & 28th	71.1	68.5
9	Ash & 53rd	2:05	923	-	-	Birch & 53rd	90.3	75.8	Ash & Old Highway (54th)	70.8	58.1
10	Nimitz & Lee	2:27	662	-	-	Nimitz & Kincaid	30.3	26.6	Spruance & 49th	28.4	25.7

Table 2. Calibration Results

Flow Test	Flowing Hydrant 1	Flowing Hydrant 2	Pressure Zone	Data Source	Residual 1				Residual 2			
					Static	Residual	Pressure Drop	Model vs Field	Static	Residual	Pressure Drop	Model vs Field
1	604	-	Low	Field	108.8	30.7	78.1	--	110.1	40.8	69.3	--
				Model	111.5	49.9	61.6	-17	112.4	64.8	47.6	-22
2	825	-	Low	Field	104.8	66.5	38.3	--	104.8	68.0	36.8	--
				Model	108.4	60.9	47.5	9	108.4	67.1	41.3	5
3	170	-	High	Field	78.5	17.3	61.2	--	73.7	27.7	46.0	--
				Model	79.5	46.2	33.3	-28	76.1	47.9	28.1	-18
4	825	-	Low	Field	103.3	81.7	21.6	--	101.1	81.4	19.7	--
				Model	102.2	88.4	13.9	-8	100.6	83.8	16.8	-3
5	680	-	Low	Field	58.8	35.2	23.6	--	50.1	43.4	6.7	--
				Model	59.0	33.0	25.9	2	51.9	48.8	3.1	-4
6	795	940	High	Field	61.8	51.6	10.2	--	61.2	53.9	7.3	--
				Model	62.1	48.2	13.9	4	62.0	52.3	9.7	2
7	896	-	Low	Field	107.8	88.7	19.1	--	102.2	87.7	14.5	--
				Model	104.9	90.5	14.4	-5	102.1	89.2	13.0	-2
8	624	-	High	Field	95.3	68.7	26.6	--	71.1	68.5	2.6	--
				Model	94.6	68.0	26.6	0	69.6	68.1	1.5	-1
9	923	-	Low	Field	90.3	75.8	14.5	--	70.8	58.1	12.7	--
				Model	94.4	85.0	9.5	-5	75.3	66.2	9.1	-4
10	662	-	Emerald Heights	Field	30.3	26.6	3.7	--	28.4	25.7	2.7	--
				Model	32.0	29.1	2.8	-1	28.5	26.7	1.8	-1

Note: Green highlight denotes test location within calibration accuracy criteria.

An example of the tuberculation in a cast iron pipe section is shown in Figure 1.

Figure 1. Photo of Tuberculation

Most modeled flow tests are within calibration goals criteria for this project. However, discrepancies remain. Predicted results for Flow Tests 1 and 3 do not correlate well to observed data. The areas around these tests are heavily influenced by old cast iron pipe and could potentially have closed or partially closed gate valves on the nearby distribution mains. Additionally, Flow Tests 1 and 2 are influenced by the nearby PRV stations where PRV settings could have drifted from reported values and real losses through the PRV pit are unknown. Further data collection will be required to determine the exact cause of this discrepancy.

Overall model calibration accuracy is shown in Table 3.

Table 3. Calibration Accuracy

Calibration Accuracy Criteria	% Modeled Results within Accuracy Criteria
Static pressure within 5 psi of observed	100%
Static pressure within 2 psi of observed	60%
Residual pressure within 5 psi	55%
Pressure drop within 5 psi	65%
Total	**70%**

In conclusion, the unknown conditions of the PRV stations (actual PRV set points and head losses through the pit during high flow conditions), known severe tuberculation within cast iron pipes, and potential for unknown closed or partially closed gate valves are heavily influencing the remaining discrepancies between the model and observed field data. Conservative adjustments to the modeled roughness values and PRV settings have been made for the model to be used for this master plan.

Further refinement of the model is recommended to provide continual improvement of model results. These refinements would include:

- Implement a valve exercising program that would provide many benefits including knowing the condition and status (closed/partially closed/broken) of gate valves throughout the water system. Valve turn records can also be correlated to pipe sizing.
- Verify PRV settings and conduct hydrant flow testing across each PRV station to capture headloss that occurs through each PRV station at varying flow conditions. With hydrant monitoring and SCADA during each PRV test, model input can be greatly improved.
- Investigate large water user patterns and update diurnal patterns as needed.
- Investigate typical operation of reservoirs and influence they have on the Skyline Tank.
- Once the above has been completed, perform additional system-wide hydrant flow tests and re-validate the hydraulic model.

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Appendix F. Level of Service Goals, Performance Objectives, and Water System Backbone

WATER SYSTEM MASTER PLAN
SEISMIC AND TSUNAMI RESILIENCE ASSESSMENT

CITY OF ASTORIA PUBLIC WORKS DEPARTMENT
ASTORIA, OREGON

Final Technical Memorandum: Level of Service Goals, Performance Objectives, and Water System Backbone

October 16th, 2020
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SEFT Consulting Group
4800 SW Griffith Drive, Suite 100
Beaverton, OR 97005

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Executive Summary

Events like Hurricane Katrina in 2005, the Great East Japan M9.0 Earthquake and Tsunami in 2011, and Hurricane Sandy in 2012 have underscored the devastating impacts that natural disasters can inflict at a local, regional, state, and multi-state level. One strategy to mitigate the effects of such a disaster is to plan for and implement programs and strategies to improve disaster resilience at the local, regional, state, and national level. In February of 2013, the Oregon Seismic Safety Policy Advisory Commission submitted a report to the 77th Legislative Assembly entitled the *Oregon Resilience Plan: Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami* (OSSPAC, 2013). The report discussed the risk that is faced by the citizens of Oregon from an impending Cascadia Subduction Zone earthquake and accompanying tsunami, the gaps that exist between the current state of Oregon's infrastructure and where it needs to be, and provided over 100 recommendations on how to improve the resilience of the State of Oregon and its local communities.

As part of the water master plan update, the City of Astoria is conducting a water system seismic resilience assessment to: 1) define water system level of service (LOS) goals for the City water system following a Magnitude 9.0 Cascadia Subduction Zone (M9.0 CSZ) earthquake and its ensuing tsunami, 2) identify key backbone system components that are required to achieve these LOS goals, 3) define performance criteria for individual system components that are required to achieve these LOS goals, 4) conduct a limited geotechnical seismic hazards evaluation for the City water system, 5) conduct a limited structural/nonstructural vulnerability assessment of key facilities selected by the City to determine estimated system performance following a M9.0 CSZ earthquake, 6) identify gaps between the LOS goals and current performance estimates, and 7) develop preliminary mitigation recommendations to close these gaps. This Technical Memorandum presents the HDR team recommendations related to items 1 through 3.

Consistent with Oregon Health Authority requirements, the City of Astoria has selected a M9.0 CSZ scenario earthquake and associated tsunami as the hazard to be explicitly considered for this seismic resilience study. In addition to the strong ground shaking, the tsunami that will be generated by a CSZ earthquake will significantly impact Astoria and surrounding coastal communities. Based on post-tsunami observations from the 2010 Tohoku tsunami in Japan, it is assumed that above-grade building-like facilities in the tsunami inundation zone will likely lose their functionality for months if not years or even be a total loss. Another major tsunami hazard is associated with the debris (timber logs, vehicles, boats/ships, etc.) that is transported by tsunami waters. This debris can cause impact damage to buildings, and can create a significant logistical challenge for the transportation system and for debris removal after the event. Additionally, when tsunami waters recede, they can cause scour that damages building and bridge foundations, buried pipelines, and roadways. Despite the significant damage that is anticipated in the tsunami inundation zone, a study by the United States Geological Survey estimated that less than

20% of developed land in the City of Astoria is within the tsunami inundation zone and less than 5% of City residents live in the tsunami inundation zone (Wood, 2007).

Given that it would be cost prohibitive to eliminate all earthquake and tsunami damage, it is necessary to prioritize that a fundamental short-term community need will be to provide water for fire suppression and for use by hospitals, emergency shelters, and other similar facilities. It will be critical that the City is able to provide water to these critical facilities to help care for residents and visitors that are injured or displaced as a result of the tsunami or as a result of earthquake-induced building damage. DOGAMI and the Oregon Health Authority (OHA) have collaborated with 11 coastal hospitals (including Columbia Memorial Hospital in Astoria) to develop a consistent coastal region response and recovery approach (DOGAMI, 2019). Significant damage to the transportation system and other lifeline infrastructure systems will likely results in coastal communities being isolated for an extended period of time. The DOGAMI/OHA plan anticipates that coastal communities will need to rely on their onsite emergency supplies and replenishment from prearranged local sources for up to three weeks after the earthquake, before outside assistance is able to be provided to coastal areas.

The *Oregon Resilience Plan* (*ORP*) recommended a three-tiered level of service (LOS) goal approach to implement a phased restoration of services and help define the speed of recovery for a community's infrastructure systems. The first-tier goals are focused on ensuring the water system is restored to a minimal LOS to support emergency response activities. The second-tier goals are focused on restoring the water system to a functional LOS (up to about 50 percent capacity) that is sufficient to get the economy moving again. The third-tier goals are focused on restoring an operational LOS (up to about 90 percent capacity), but still may rely on temporary fixes. The LOS goals proposed in Section 3.8 for adoption by the City of Astoria generally align with those presented in the *ORP* and DOGAMI/OHA planning for coastal hospitals, and are augmented by additional considerations suggested by the NIST *Community Resilience Planning Guide for Buildings and Infrastructure Systems*. The goals for the City of Astoria water system are broken down in terms of specific goals for source, transmission, control systems, and distribution. All goals are based on providing water meeting minimum regulatory requirements, although a boil water notice will most likely be in effect due to damage throughout the distribution system. Note that the proposed LOS goals are for infrastructure located outside the tsunami inundation zone.

The HDR team has collaborated with the City of Astoria to identify the proposed backbone for the City water system, as described in Section 4. This backbone system provides water distribution system connections between the water source reservoirs, raw water transmission pipelines, water treatment plant, finished water reservoirs, and distribution system pipelines that serve facilities that are required to meet short- and intermediate-term community needs. The backbone systems proposed for the City of Astoria water system is consistent with that envisioned during the development of the *ORP*. Note that facilities and buried utilities in the tsunami inundation zone are expected to experience significant damage due to tsunami inundation and scouring. Therefore, it is recommended that they not be connected to the water system backbone described in Section 4. However, it is recommended that the City develop and implement plans to install isolation valves near the boundary of the tsunami inundation zone. This will permit the City to preserve their stored water supply by isolating areas with significant tsunami-induced pipeline damage.

Since it would be challenging to implement any significant repairs to the backbone system in the initial days and weeks after an earthquake, the elements of the backbone system should be designed or retrofit such that they experience only minor or no geotechnical, structural, and nonstructural (piping, valves, chemical feed equipment, electrical components, etc.) related damage during a major earthquake. This may require that the design of new water system structures or retrofit of existing structures consider elevated structural and nonstructural performance objectives. Also, since geotechnical hazards (e.g., landslide, liquefaction, and lateral spreading) can significantly impact the performance of water system structures following a major earthquake, it is recommended that site-specific geotechnical investigations and analysis be conducted to characterize these potential hazards. Water system structure designs should include appropriate measures to mitigate these potential site-specific geotechnical hazards. Piping entering or exiting water system structures should be designed to accommodate the anticipated earthquake-induced relative movement between the structure and surrounding soil (such as with the use of flexible joints or connections). Section 5 provides additional recommendations related to the proposed structural and nonstructural performance objectives for water system structures.

1.0 Introduction and Background

1.1 City of Astoria Water System Description

The City of Astoria relies on the City-owned Bear Creek Watershed to supply water for the City's approximately 10,000 residents and commercial customers, including the City's tourism-based businesses and seafood industries. In the watershed, Bear and Cedar Creeks feed three source water reservoirs (Bear Creek Reservoir, Middle Lake, and Wickiup Lake). Raw water from these reservoirs is treated by a slow sand filtration plant located near Bear Creek Reservoir (approximately 10 miles east of the City). Treated water is delivered to two in-town earthen reservoirs (Reservoir 2 and Reservoir 3) by a 21-inch diameter concrete cylinder pipe transmission main that is approximately 12 miles in length. The majority of the City's service area is supplied by one of two different pressure zones (either high or low). Certain higher elevation areas in the City are served by a combination of two in-town tanks (East Astoria and Skyline) and four booster pump stations. The City's distribution system consists of approximately 80 miles of pipelines up to 24 inches in diameter and constructed from multiple different materials (including cast iron, ductile iron, transite, galvanized steel, PVC, and HDPE). On average, more than 2.0 million gallons per day of water is produced and distributed to the community. More than 4.0 million gallons may be used per day during the peak summer season. The City of Astoria also provides drinking water to seven outlying water districts with a total of approximately 613 customer connections.

1.2 Seismic Resilience Assessment

Based on Oregon Health Authority requirements for water master plan updates, the City of Astoria is conducting a water system seismic resilience assessment. The City has previously conducted: 1) a seismic stability evaluation of Bear Creek Dam (Cornforth, 2016) and 2) a seismic resilience assessment of the 12-mile-long water transmission main between Bear Creek Dam and Reservoirs 2 and 3 (Hart Crowser, 2019). This current assessment will evaluate the expected performance of the City water system following a Magnitude 9.0 (M9.0) Cascadia Subduction Zone (CSZ) earthquake and associated tsunami, and identify preliminary recommendations for improvements that should be implemented to enable the City to more rapidly restore water service after a major earthquake, to meet community social and economic needs. The scope of this seismic resilience study includes:

1. Define water system level of service (LOS) goals for the City water system following a M9.0 Cascadia Subduction Zone Earthquake and its ensuing tsunami;
2. Identify key backbone system components that are required to achieve these LOS goals, including the locations of key supply points for water for fire suppression and community water distribution;
3. Define performance criteria for individual system components that are required to achieve these LOS goals;

4. Conduct a limited geotechnical seismic hazards evaluation for the City water system (Cornforth);
5. Conduct a preliminary structural/nonstructural vulnerability assessment of four key facilities selected by the City to determine estimated system performance following a M9.0 CSZ earthquake (SEFT);
6. Identify gaps between the LOS goals and current performance estimates; and
7. Develop preliminary mitigation recommendations (HDR) to close these gaps utilizing new or retrofit infrastructure, changes to design standards, enhancements in emergency response planning, and recommendations for further study.

This Technical Memorandum (TM) presents the HDR team recommendations related to scope items 1 through 3.

1.3 Resilience Planning by Other Oregon Water Agencies

The resilience planning effort being undertaken by the City of Astoria is similar to the planning activities undertaken by several Oregon water agencies and other cities. Additionally, numerous other agencies on the west coast of the United States and Canada are actively conducting resilience planning and resilience-based capital improvement projects.

Tualatin Valley Water District, City of Hillsboro Water Department, and Willamette Water Supply System

TVWD and the City of Hillsboro Water Department have each completed a water system resilience plan. They and the City of Beaverton are partnering to complete the 1.3 billion-dollar Willamette Water Supply System (WWSS) to provide an additional water supply for the region they serve. When complete, the WWSS will greatly enhance the ability of the partner agencies to deliver water to their customers immediately after a major earthquake by providing a resilient and reliable water supply for the region, designed to meet stringent seismic performance goals.

City of Portland

The Portland Water Bureau has completed a water system resilience planning project and is beginning to incorporate recommendations from the plan into their capital improvement projects. The Bureau of Environmental Services has completed a wastewater system seismic resilience master plan and has already begun to incorporate early action item recommendations into practice.

City of Gresham

The City of Gresham has completed resilience planning projects for both their water and wastewater systems and are beginning to incorporate recommendations from these plans into their capital improvement projects. They have successfully leveraged their water system resilience plan to obtain Federal Emergency Management Agency pre-disaster mitigation grant funding to implement seismic improvements at one of their water reservoirs.

City of Newberg

The City of Newberg has completed a water system resilience planning project and are beginning to incorporate preliminary seismic mitigation recommendations into their capital improvement planning process. The City views improving their seismic resilience as especially critical, since they anticipate that Newberg may receive an influx of people that may be temporarily displaced from coastal communities following a Cascadia Subduction Zone earthquake.

2.0 Community Resilience

Events like Hurricane Katrina in 2005, the Great East Japan M9.0 Earthquake and Tsunami in 2011, and Hurricane Sandy in 2012 have underscored the devastating impacts that natural disasters can inflict at a local, regional, state, and multi-state level. The Federal government has defined the National Preparedness Goal as: "A secure and resilient Nation with the capabilities required across the whole community to prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk" (FEMA, 2015).

One strategy to achieve this National Preparedness Goal is to plan for and implement programs and strategies to improve disaster resilience at the local, regional, state, and national level. In February of 2013, the Oregon Seismic Safety Policy Advisory Commission submitted a report to the 77th Legislative Assembly entitled the *Oregon Resilience Plan: Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami* (OSSPAC, 2013). The report discussed the risk that is faced by the citizens of Oregon from an impending Cascadia Subduction Zone earthquake and accompanying tsunami, and the gaps that exist between the current state of Oregon's infrastructure and where it needs to be. In addition to life safety impacts, the report also highlighted the economic vulnerabilities to individuals and communities from such an event. The *ORP* went on to outline steps that can be taken over the next 50 years to bring the state closer to resilient performance through a systematic program of vulnerability assessments, capital investments in public infrastructure, new incentives to engage the private sector, and policy changes that reflect current understanding of the Cascadia threat. While the *ORP* specifically addresses improving resilience in the aftermath of a major earthquake, implementation of the plan is also expected to improve resilience for other hazards.

A primary focus of the *ORP* goals is to minimize the long-term economic damage associated with the potential out-migration of businesses and population that would be expected to occur following a major disaster if basic services cannot be restored rapidly enough to meet the communities social and economic needs. Resilience of the water system will be key to the region's economic recovery. For example, the fundamental goal of quickly restoring the supply of safe drinking water to homes and businesses will help to enable residents to shelter-in-place and businesses to resume operation as quickly as possible after the event. Small businesses are particularly vulnerable to being closed for an unplanned amount of time and many may not be able to re-open if closed for more than a month. Each business closing negatively impacts employment, tax revenue, and the long-term economic and social viability of the City. The more rapidly that businesses are able to reopen, the quicker revenue will normalize, and money will circulate within the region's economy. At a fundamental level, the water system must be functioning at a certain level for service fees to be collected to provide revenue for the City of Astoria to sustain everyday functions and to help fund the recovery process.

2.1 Definition of Resilience

In the field of community disaster planning, a common definition of "resilience" has been put forth by Presidential Policy Directive (PPD). PPD-8 [2011] defines resilience as "the ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies." PPD-21 [2013] refined the definition to "…the ability to prepare for and adapt to changing conditions and to withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents."

2.2 Planning Process

While varied forms of community disaster preparedness planning have been taking place for decades, a specific focus on community resilience has developed over about the last 10 years. In 2015, the National Institute of Standards and Technology (NIST) published NIST Special Publication 1190, *Community Resilience Planning Guide for Buildings and Infrastructure Systems* (NIST, 2015). The *Guide* outlines a consistent framework for a six-step resilience planning process (see Figure 2.1) that is designed to be conducted at a community level, involving broad representation from local and regional government, building owners, infrastructure system owner/operators, and community representatives. The *Guide* process can also be adapted to resilience planning for a specific infrastructure system (e.g. water system), with some limitations. One of the main limitations of an individual infrastructure system planning approach is that it requires assumptions to be made that can't be tested with community stakeholders and other infrastructure system providers. For instance, operation of water booster stations requires commercial electrical power or emergency generators with adequate fuel supplies. The timeline for restoration of commercial electrical power or availability of fuel for generators is largely controlled by stakeholders that aren't involved in a water system only planning scenario.

2.3 Seismic Hazard

One of the initial steps in the resilience planning process involves determining the specific hazards to be safeguarded against. Consistent with Oregon Health Authority requirements, the City of Astoria has selected a M9.0 Cascadia Subduction Zone scenario earthquake and associated tsunami as the hazard to be explicitly considered for this seismic resilience study.

The geologic and seismologic information available for identifying the potential seismicity throughout the State of Oregon is continually evolving, and large uncertainties are associated with estimates of the probable magnitude, location, and frequency of occurrence of earthquakes. The available information indicates the potential seismic sources that may affect the state can be grouped into three categories:

- Subduction zone events related to sudden slip between the upper surface of the Juan de Fuca plate and the lower surface of the North American plate,
- Subcrustal events related to deformation and volume changes within the subducted mass of the Juan de Fuca plate, and
- Local crustal events associated with movement on shallow, local faults.

A major contributor to the seismic hazard in western Oregon is the Cascadia Subduction Zone (CSZ) that lies off the coast of Oregon, Washington, Northern California, and British Columbia. The CSZ is an active plate boundary along which the remnants of the Farallon Plate (the Gorda, Juan de Fuca and Explorer plates) are being subducted beneath the western edge of the North American continent. Figure 2.2 shows that the subduction zone off the coast of Oregon is a mirror image of the subduction zone off the coast of Northern Japan that produced the deadly Magnitude 9.0 Tohoku earthquake in 2011. Seismologists anticipate that the strong shaking from a CSZ earthquake will last from 3 to 5 minutes, much longer than the 30-second strong shaking experienced in a typical California earthquake.

Seismologists' understanding of the damaging earthquakes produced by the CSZ has steadily increased over the past 25 years. Research by the Oregon Department of Geology and Mineral Industries (DOGAMI), Oregon State University, and others has provided evidence of the timeline of historic great CSZ earthquakes. The timeline of these 41 earthquakes over the last 10,000 years is provided in Figure 2.3, showing that past earthquakes have occurred at highly variable intervals, and ranged widely in size and in which parts of the Pacific Northwest they affected. The rupture distance for these CSZ earthquakes varied from a short rupture along the Northern California and Southern Oregon Coast, to a rupture along the entire length of the subduction zone from Northern California to British Columbia. There is about a 37 percent chance in the next 50 years of a Magnitude 8+ earthquake originating on the southern portion of the CSZ and up to a 15 percent chance in the next 50 years of a great earthquake affecting the entire Pacific Northwest. The scenario involving rupture of the Northern Oregon portion would significantly impact all Western Oregon, including Astoria.

Figure 2.1 – Six-Step Process to Planning for Community Resilience (NIST, 2015)

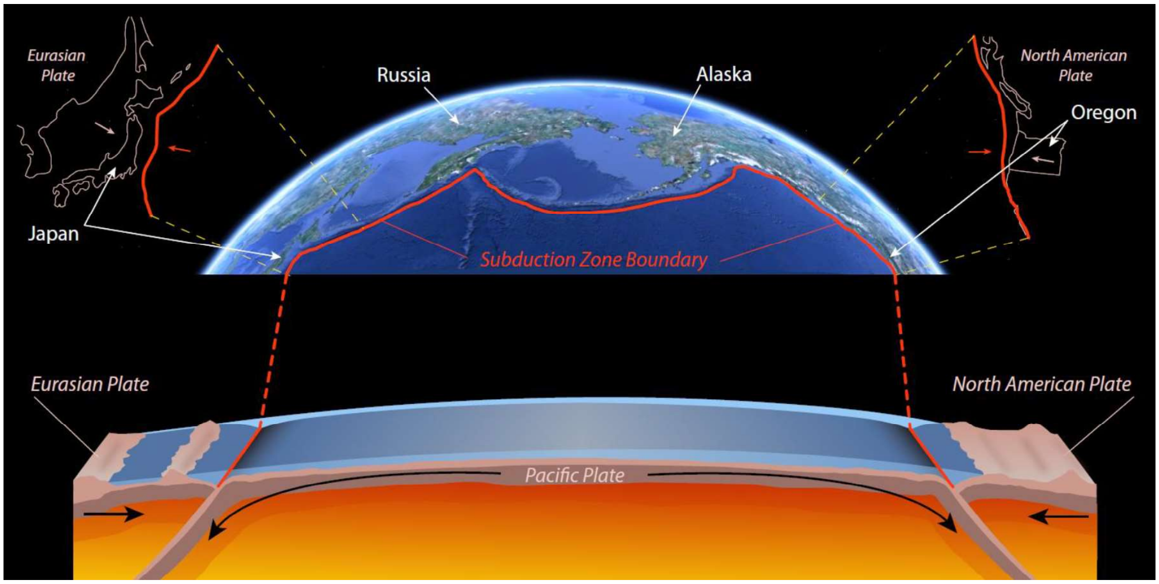


Figure 2.2 – Oregon and Northern Japan Mirror Image Subduction Zones (OSSPAC, 2013)

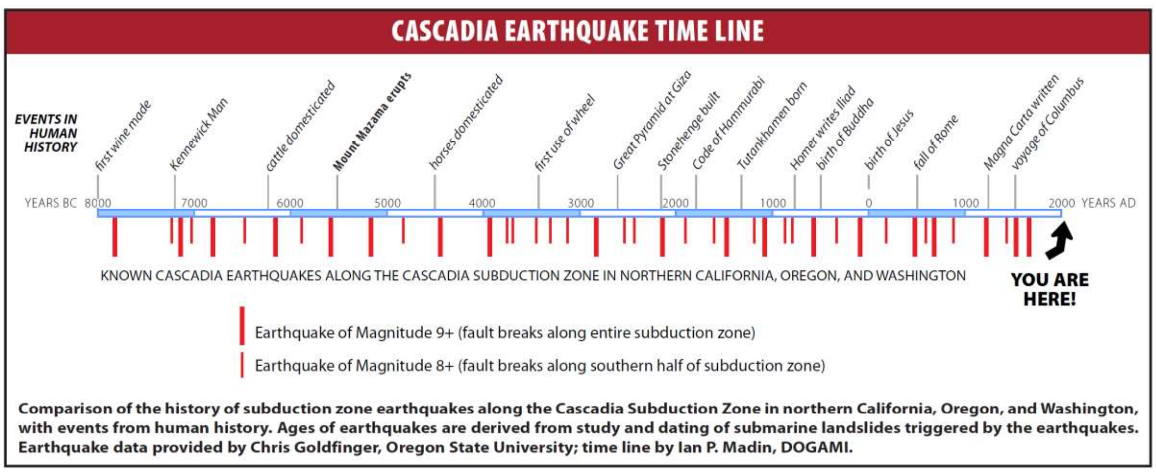


Figure 2.3 – Historic Cascadia Subduction Zone Earthquake Timeline (DOGAMI, 2010)

3.0 Level of Service Goals

Resilience planning involves establishing level of service (LOS) goals to define system performance expectations after being impacted by the hazard under consideration. These LOS goals could be simple, such as maintain service for 100 percent of customers during a routine winter storm that disrupts commercial electrical power for 24 hours, or they may be more complex for more damaging hazards like major earthquakes. This section presents examples of LOS goals included in major pioneering resilience plans, developed over about the last 10 years, for historical context and then describes the LOS goals proposed for adoption by the City of Astoria for their water system.

3.1 SPUR Resilient City

In one of the first studies of its kind, the San Francisco Planning + Urban Research Association (SPUR) developed a series of policy papers aimed at raising awareness of how San Francisco's buildings and lifeline infrastructure are likely to perform in an expected earthquake and identifying actions that could be implemented before an earthquake to improve the City's resilience. The report outlined the importance of how the restoration timeline for water, wastewater, electrical power, and other lifeline systems impacts the speed with which a community can return to normal after a major disruption (SPUR, 2009). The report established the goals of restoring lifeline services to: 1) 90 percent of customers within 72 hours, 2) 95 percent of customers within one month, and 3) 100 percent of customers within four months after an expected level earthquake. It is assumed that critical facilities (e.g., hospitals, emergency operations centers, etc.) would be included in the 90 percent of customers restored within 72 hours. For buildings, the SPUR report defines the expected level earthquake as one having a 10 percent probability of occurring in a 50-year period and compares it to a magnitude 7.2 earthquake on the peninsula segment of the San Andreas Fault. The SPUR report also indicated that for lifeline systems, that typically have a longer design life than buildings, a larger expected level earthquake should be considered.

3.2 Oregon Resilience Plan

The threat of a Cascadia earthquake is a significant enough physical, economic, and social risk in the Pacific Northwest that in 2012 and 2013, at the request of the State of Oregon Legislative Assembly, the Oregon Seismic Safety Policy Advisory Commission (OSSPAC) and a team of volunteer professionals developed the *Oregon Resilience Plan: Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami* (OSSPAC, 2013). The *ORP* outlines steps that can be taken over a 50-year period to bring the state closer to resilient performance through a systematic program of vulnerability assessments, capital investments in buildings and infrastructure systems, new incentives to engage the private sector, and policy changes that reflect current understanding of the Cascadia threat to our community and economy.

OSSPAC assembled eight task groups, comprising over 160 volunteer subject-matter experts from government, universities, the private sector, and the general public. Task Groups included: (1) Cascadia earthquake scenario, (2) business and workforce continuity, (3) coastal communities, (4) critical and essential buildings, (5) transportation, (6) energy, (7) information and communications, and (8) water and wastewater. Task Group activities were overseen by OSSPAC and an Advisory Group. Each Task Group was charged to:

- Determine the likely impacts of a Magnitude 9.0 Cascadia earthquake and tsunami on its assigned sector, and estimate the time required to restore functions in that sector if the earthquake were to strike under present conditions;
- Define acceptable timeframes to restore functions after a future Cascadia earthquake to fulfill expected resilient performance; and
- Recommend changes in practice and policies that, if implemented during the next 50 years, will allow Oregon to reach the desired resilience targets.

The various task groups used estimates of the seismic hazard and expected ground motions developed by the Cascadia Earthquake Scenario Task Group in combination with knowledge of the construction era and condition of existing infrastructure to estimate the expected performance and service restoration times if the scenario event were to occur at the time the *ORP* was being developed.

The *ORP* used the SPUR model as a starting point for developing LOS goals (target timelines for restoration of services) after a Cascadia earthquake. These restoration targets were established assuming system resilience enhancements would be implemented over the following 50 years. These targets were set for three levels of service:

- Minimal level of service restored for the use of emergency response;
- Functional level of service up to 50 percent of capacity that is sufficient to get the economy moving again, and an
- Operational level of service where restoration is up to 90 percent of capacity (which may still rely on temporary fixes).

Table 3.1 summarizes the *ORP's* goals for the restoration of water service for the Coastal (Non-Tsunami) Zone (after 50 years of resilience improvements) and compares it to the expected performance if the earthquake were to have occurred at the time the *ORP* was written. The time differences between the *ORP* restoration target (LOS) goal and expected performance illustrates the resilience gaps that require investment in infrastructure improvements, and public policy enhancements over the coming years.

Table 3.1 – ORP Water System Recovery Goals: Coastal (Non-Tsunami) Zone (adapted from OSSPAC 2013)

	0-24 hours	**1-3 days**	**3-7 days**	**1-2 weeks**	**2-4 weeks**	**1-3 months**	**3-6 months**	**6-12 months**	**1-3 years**	**3+ years**
Potable water available at supply source (WTP, wells, impoundment)			R		Y		G		X	
Main transmission facilities, pipes, pump stations, and reservoirs (backbone) operational		R	Y	G					X	
Water supply to critical facilities available			R		Y		G		X	
Water for fire suppression – at key supply points		R		Y			G		X	
Water for fire suppression – at fire hydrants					R	Y	G		X	
Water available at community distribution centers/points			R	Y	G	X				
Distribution system operational				R		Y	G			X

Key to Table

Target Timeframe for Recovery:

Desired time to restore components to 20-30% operational	R
Desired time to restore components to 50-60% operational	Y
Desired time to restore components to 80-90% operational	G
Current state (90% operational)	X

3.3 NIST Community Resilience Planning Guide

The authors of the NIST *Guide* built upon the framework established by SPUR and the *ORP* in developing recommendations for community resilience planning. The categories, for which restoration timeline goals should be set, were further expanded to consider additional system components and to clarify that restoration timelines will likely vary based on the building cluster that is being supported (critical facilities, emergency housing, housing/neighborhoods, etc.). The *Guide* does not make recommendations for recovery timelines but provides a framework that communities can use to collectively establish these recovery timeline goals. The expanded *Guide* performance goal table along with the restoration timeline goals established by the *ORP* have been used in developing level of service goals for this project. Further description of the recommended City of Astoria water system level of service goals developed as part of this project is provided in Section 3.8.

3.4 San Francisco Public Utilities Commission

The San Francisco Public Utilities Commission (SFPUC) outlines seismic design requirements in an agency specific engineering standard, *General Seismic Requirements for Design of New Facilities and Upgrade of Existing Facilities* (SFPUC, 2014). The purpose of the Standard is "to set forth consistent criteria for the seismic design and retrofit of San Francisco's water and wastewater infrastructures. These systems comprise buildings, aboveground and underground piping, retaining walls, underground structures, tanks and basins, dams and reservoirs, special structures, and equipment under the jurisdiction of the SFPUC."

The SFPUC Standard establishes that the water system basic level of service goal is to deliver winter day demand (WDD) within 24 hours after a major earthquake. For critical and non-redundant structures and components, this major earthquake is defined as having a 5% probability of exceedance in 50 years (975-year return period). The basic level of service goal also considers several supplemental criteria that include (SFPUC, 2014):

- Deliver WDD to at least 70% of SFPUC wholesale customers' turnouts within each of the three customer groups (Santa Clara/Alameda/South San Mateo County, Northern San Mateo County, and City of San Francisco);
- Achieve a 90% confidence level of meeting the above goal, given the occurrence of a major earthquake;
- To achieve the basic level of service, the SFPUC shall rely on the wholesale customer's own water systems and supply or other regional water purveyor's systems. SFPUC will work with customers to assess their ability to contribute to their own system reliability;
- The SFPUC shall consider a facility to have failed if it cannot be brought back to its intended purpose within 24 hours without secondary damage resulting; and
- To achieve the basic level of service, the SFPUC shall assume that power supplies are available, whether from the grid or from standby sources.

The SFPUC shall assume that no significant repairs are performed in the first 24 hours following a major earthquake. Possible operations that might occur during the first 24 hours include valve operations, temporary bypasses, and restoration of minor planned outages, if regional infrastructure remains intact.

3.5 Community Needs Following a Major Earthquake

To support the region's economic and community recovery after a major disaster, infrastructure services are required to be restored as the building clusters that rely on these services come back online (i.e., a building that will take six months to reopen due to repair of structural damage doesn't need water service until the end of that six months). In some cases, like that for smaller businesses, an outage of critical services like water for more than a few weeks may mean a business cannot return to a location. The current expectation of many Oregonians is that water service will be restored within one month after a major earthquake (City Club, 2017). The water system recovery goals suggested in the *ORP* are generally consistent with this public expectation in the Willamette Valley region, including the Portland metro region, where the target goal is to restore water service within two to four weeks. However, for coastal communities that will be impacted by stronger ground shaking due to their proximity to the CSZ and due to impacts of the associated tsunami, the *ORP* established a target goal of restoring water service within three to six months (for areas outside of the tsunami inundation zone). The *ORP* also sets goals for partial recovery in the initial days and weeks after a major earthquake with the aim of initially supporting earthquake/tsunami emergency response and then quickly transitioning to supporting rapid economic and social recovery.

The tsunami that will be generated by a CSZ earthquake will significantly impact Oregon's coastal communities. Cycles of significant tsunami wave inundation are likely to continue for several hours after a CSZ earthquake. Figure 3.1 shows a map of the extents of the tsunami inundation zone in the Astoria area associated with several different magnitude CSZ scenario earthquakes (DOGAMI, 2013). A M9.0 CSZ scenario earthquake is associated with earthquake size "L" shown in the DOGAMI map. Based on post-tsunami observations from the 2010 Tohoku tsunami in Japan, it is assumed that above-grade building-like facilities in the tsunami inundation zone will likely lose their functionality for months if not years or even be a total loss. Figure 3.2(a) shows an example of a building that collapsed due to tsunami wave-generated forces and Figure 3.2(b) shows an example of a building that overturned due to tsunami wave and buoyancy-generated forces.

Another major tsunami hazard is associated with the debris that is transported by tsunami waters. Figure 3.3 shows examples of timber log, vehicular, and boat/ship debris that can be carried by tsunami waters and result in impact damage to buildings, and can create a significant logistical challenge for the transportation system and for debris removal after the event. Additionally, when tsunami waters recede, they can cause scour that damages building and bridge foundations, buried pipelines, and roadways (see Figure 3.4). Despite the significant damage that is anticipated in the tsunami inundation zone, a study by the United States Geological Survey estimated that less than 20% of developed land in the City of Astoria is within the tsunami inundation zone and less than 5% of City residents live in the tsunami inundation zone (Wood, 2007).

Given that it would be cost prohibitive to eliminate all earthquake and tsunami damage, it is necessary to prioritize that a fundamental short-term community need will be to provide water for fire suppression and for use by hospitals, emergency shelters, and other similar facilities. It will be critical that the City is able to provide water to these critical facilities to help care for residents and visitors that are injured or displaced as a result of the tsunami or as a result of earthquake-induced building damage. Immediately after the event, it is anticipated that the City of Astoria will focus on repairing any damage to the water system supplying these critical customers and then quickly transition to restoring water service to other customers. This goal for rapid restoration of the water service will help support the Astoria Community's desire that residents will be able to remain in their homes immediately after a major earthquake and that they will be able to resume a semi-normal daily routine as quickly as possible by returning to school/work, shopping at their local grocery store, receiving medical care at their local clinic, etc. All these normal activities involve the use of water. At first, it is expected that temporary measures will be required to distribute water, but as the weeks progress more permanent fixes will be implemented and the temporary measures will slowly disappear.

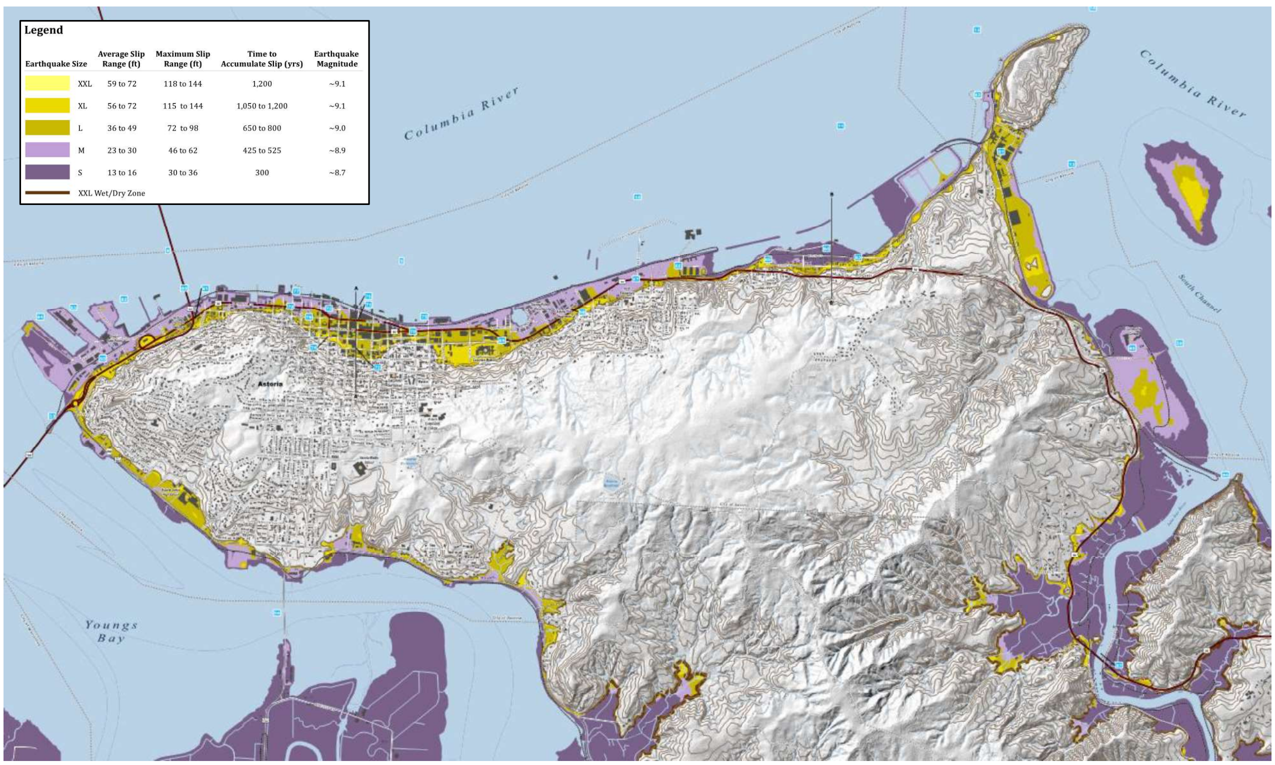


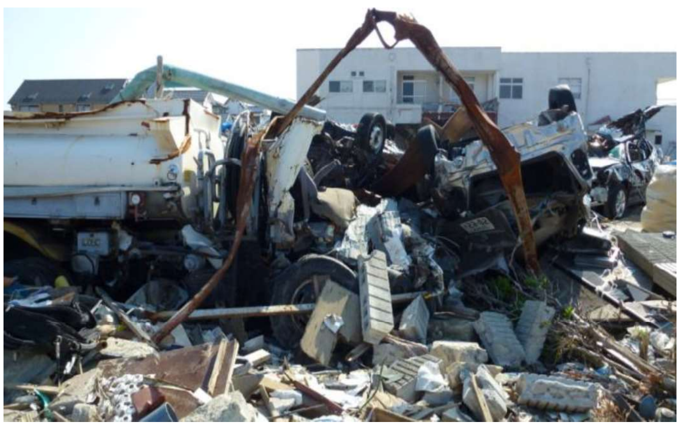
Figure 3.1 – Tsunami Inundation Map
(adapted from DOGAMI, 2013)

(a) Collapsed Building

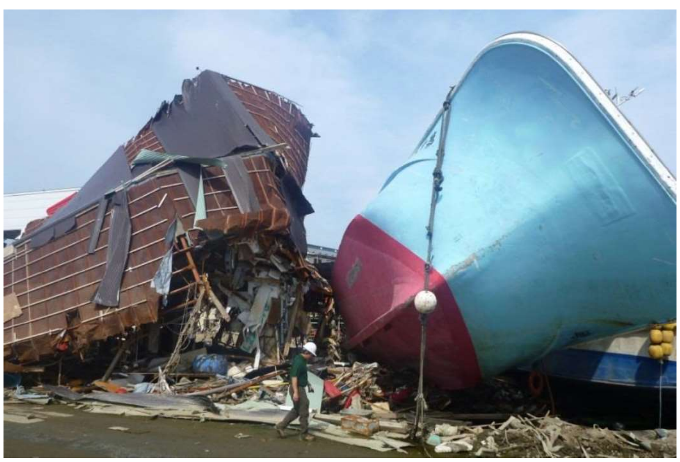
(b) Overturned Building

Figure 3.2 – Building Damage Due to Tsunami Inundation (Source: Degenkolb Engineers)

(a) Timber Log



(b) Vehicles



(c) Boats/Ships

Figure 3.3 – Tsunami Debris
(Source: Degenkolb Engineers)

(a) Foundation and Pipelines Exposed Adjacent to Building

(b) Pipelines Exposed Adjacent to Road

Figure 3.4 – Pipelines Exposed by Tsunami-induced Scour
(Source: Degenkolb Engineers)

Table 3.2 provides a breakdown of restoration priorities for City customers that was initially based on a partial listing of critical facilities indicated in the "Community Overview" section of the *City of Astoria Natural Hazard Mitigation Plan Addendum to the Clatsop County Natural Hazards Mitigation Plan* (City of Astoria, 2015) and further refined in a collaborative workshop conducted with the HDR team and City of Astoria staff. The table links social and economic needs to restoration timeline goals [short-term (days), intermediate-term (weeks), and long-term (months)]. The table also indicates which critical community facilities are currently located in the tsunami inundation zone associated with a M9.0 CSZ earthquake. Since these facilities and the surrounding area (including buried utilities) are likely to experience significant damage due to tsunami inundation and scouring (and may take many months, if not years, to recover), it is recommended that they not be connected to the water system backbone described in Section 4. However, it is recommended that the City develop and implement plans to install isolation valves near the boundary of the tsunami inundation zone. This will permit the City to preserve their stored water supply by isolating areas with significant tsunami-induced pipeline damage and facilitate functional recovery of the water system above the tsunami inundation zone within the timeframe established in Section 3.8.

For the remaining critical community facilities (outside the tsunami inundation zone), note that these restoration timeline goals have been established based on our current understanding of the community's needs, without knowledge of the expected seismic performance of these existing community facilities. In order to support community needs on a timeline that is consistent with the targeted states of recovery for critical and essential facilities in the coastal region as defined in the *ORP* , many of these community facilities may need to be seismically retrofit or replaced with new buildings designed with a higher structural and nonstructural performance objective. Due to the fact that many critical community facilities are currently located in or in close proximity to the tsunami inundation zone, it is suggested that Astoria community stakeholders develop a comprehensive City-wide seismic resilience plan that holistically addresses the risk associated with a CSZ earthquake and associated tsunami, and other potential natural hazards (landslide, winter storm, etc.) If a facility that is critical to supporting community short- and intermediate-term social and/or economic needs is relocated, site selection criteria for the new location should consider proximity to the water system backbone or the water system backbone should be appropriately modified to include the location of the new facility.

As an example, from a holistic community disaster resilience perspective, Columbia Memorial Hospital stakeholders may decide that it is appropriate to relocate the current hospital to a higher elevation site that would be less likely to be impacted by a tsunami. This could potentially reduce the impacts to hospital operation that the tsunami may cause at the current site (tsunami debris and scour damage causing transportation and site access challenges, scour damage to wastewater pipeline serving site, etc.). If community stakeholders choose to relocate the hospital, then the water system backbone (described in Section 4) will need to be appropriately modified to provide service to the new site.

Table 3.2 – City of Astoria Social/Economic Recovery Goals

Response/Recovery Phase	Social/Economic Needs

Short-Term (days)	• Water Supply Points for Fire Suppression
	  o Reservoir 2
	  o Reservoir 3
	  o Various locations for drafting water from Columbia River and/or Youngs Bay
	• Columbia Memorial Hospital
	• Urgent Care Centers
	  o UrgentCare NW[a]
	  o CMH Urgent Care[a]
	• Astoria Police Department[a]
	• Astoria Fire Department
	  o Headquarters Station[a]
	  o Station 2[a]
	• Astoria City Hall[a]
	• Astoria Public Works Operations/Shops[a]
	• Astoria Wastewater Treatment Facility[a] (pump seal water)
	• Clatsop County Jail
	• Clatsop County Office Building
	• Clatsop County Public Works[a]
	• Emergency Shelters
	  o Gray Elementary School
	  o John Jacob Astor Elementary School
	  o Astoria Middle School
	  o Astoria High School[a]
	  o Clatsop Community College
	• Senior Care Facilities
	  o Astor Place
	  o Clatsop Care Center
	  o Clatsop Retirement Village[a]
	  o Winterlite Adult Foster Care[a]

Intermediate-Term (weeks)	• Community Water Distribution Points
	  o Gray Elementary School
	  o John Jacob Astor Elementary School
	  o Astoria Middle School
	  o Clatsop Community College
	• Water District Customers

Long-Term (months)	• Remaining City of Astoria facilities • Port of Astoria Maritime Operations facilities • Medical office buildings • 90% of customer connections • 90% of fire hydrants
Long-Term (beyond 6 months)	• Remaining 10% of customer connections • Remaining 10% of fire hydrants

[a] Indicates that the critical community facility is currently located in the tsunami inundation zone associated with a M9.0 CSZ earthquake and therefore will not be connected to the water system backbone.

3.6 Water Supply Points for Fire Suppression

Table 3.2 and Figure 3.5 identify the potential location of two key supply points where tanker trucks could obtain water for fire suppression if the hydrant system is down following a major earthquake. At the two reservoir sites, it may be necessary to install seismic shutoff valves to preserve water storage and install segments of hardened pipe with hydrant connections to enable easy filling of tanker trucks. This piping and hydrant connection should be designed to accommodate any expected permanent ground deformation. It should be noted that the accessibility of these two reservoir sites could be compromised by earthquake-induced landslides or other earthquake-induced damage. The City has discussed future plans to provide water storage tanks at various locations around the City. This distributed storage approach may help provide more easily accessible and/or redundant supply points where tanker trucks could obtain water for fire suppression if the hydrant system is down. In addition to the two current reservoir sites, there are numerous potential alternative sites around the City where fire trucks could draft water from the Columbia River and/or Youngs Bay, assuming that required removal of tsunami debris can be completed shortly after the event.

3.7 Community Water Distribution Points

Table 3.2 and Figure 3.6 identify the potential location of four community water distribution points throughout the City where residents could obtain potable water following a major earthquake. It is recommended that hydrants be installed at these community water distribution points that are connected to the hardened backbone system and are designed to accommodate any expected permanent ground deformation.

Figure 3.5 – Potential Water Supply Points for Fire Suppression

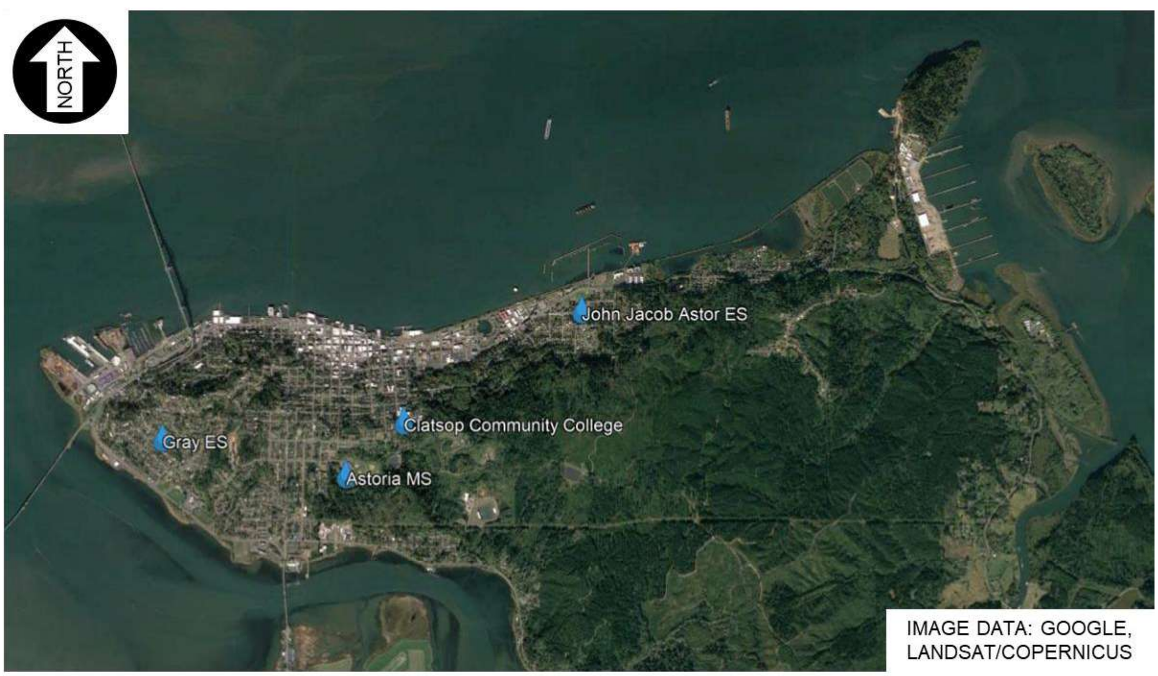


Figure 3.6 – Potential Community Water Distribution Points

3.8 City of Astoria Water System Level of Service Goals

The *ORP* was developed assuming a three-tiered LOS goal approach to implement a phased restoration of services and help define the speed of recovery for a community's infrastructure systems. The *ORP* recommended a timeline for these three-tiered LOS goals but provided the flexibility for an individual utility to define how the levels of functional restoration are to be achieved for their specific system. Subsequent to publishing the *ORP*, DOGAMI and the Oregon Health Authority (OHA) collaborated with 11 coastal hospitals (including Columbia Memorial Hospital in Astoria) to develop a consistent coastal region response and recovery approach (DOGAMI, 2019). Coastal communities are expected to be severely impacted by strong ground shaking from a CSZ earthquake and the associated devastation of low-lying areas that are inundated by the tsunami accompanying the earthquake. Significant damage to the transportation system and other lifeline infrastructure systems will likely result in coastal communities being isolated for an extended period of time.

DOGAMI and OHA have recommended a three-stage approach to address post-earthquake/tsunami needs for potable water and liquid fuel for emergency generators. In Stage 1, hospitals will rely on conservation efforts and their own onsite emergency supplies. In Stage 2, hospitals will replenish their onsite supplies from prearranged local sources. Stages 1 and 2 are expected to last for up to three weeks after the earthquake. Hospitals are strongly encouraged to coordinate with their water provider now to develop a plan that will satisfy their post-earthquake/tsunami potable water needs from local sources, so that they can continue to provide critical healthcare services to the community during Stages 1 and 2. In Stage 3, hospitals will continue to rely on local supplies, but they will be supplemented by state resources. This approach is illustrated in Figure 3.7.

The LOS (i.e., restoration timeline) goals proposed for adoption by the City of Astoria generally align with those presented in the *ORP* and DOGAMI/OHA planning for coastal hospitals, and are augmented by additional considerations suggested by the NIST *Guide*. Table 3.3 summarizes these goals for the City of Astoria water system broken down in terms of specific goals for source, transmission, control systems, and distribution. All goals are based on providing water meeting minimum regulatory requirements, although a boil water notice may be in effect due to damage throughout the distribution system. Table 3.3 provides additional information about the recommended definition of 30%, 60%, and 90% operational for City of Astoria water system infrastructure. For example, the 90% operational goal for hospital facilities has been defined to mean that the City of Astoria water system is capable of delivering 90% of their average winter day demand of water meeting minimum regulatory requirements to hospital facilities within the City of Astoria service area.

The City and Clatsop County have recently received a joint grant to purchase a portable water filtration system that is intended to be used to help provide potable water for area residents after a major disaster. The LOS goals described in Table 3.3 assume that this portable water filtration system may be used to augment the available in-town stored water supply in the initial days after an earthquake, prior to 30% restoration of the City's water filtration plant and water transmission main between the plant and Reservoirs 2 and 3. It is suggested that the City coordinate with the County Emergency Manager on the logistics associated with operation of this portable water filtration system, including an appropriate plan for staffing and to provide liquid fuel to operate the system.

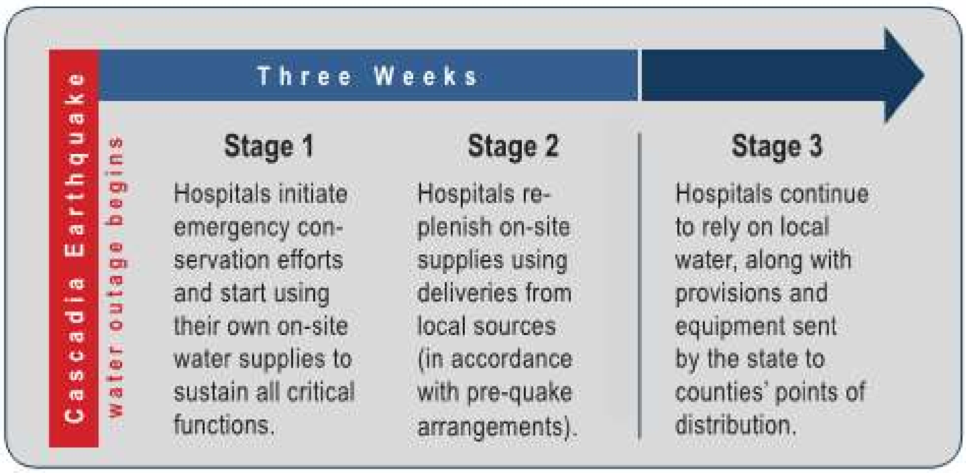


Figure 3.7 – Coastal Region Hospital Response/Recovery Approach – Water (Source: DOGAMI, 2019)

Table 3.3 – City of Astoria Water System Recovery Goals (Non-Tsunami Zone)
(adapted from OSSPAC 2013 and NIST 2015)

Water Systems	Target Timeframe for Recovery							
	Phase 1: Short-Term			Phase 2: Intermediate			Phase 3: Long-Term	
	Days			Weeks			Months	
	0-1	1-3	3-7	1-2	2-4	4-12	3-6	6-12
Source								
Raw or source water and terminal reservoirs			30% AWDD[a]		60% AWDD		90% AWDD	
Raw water conveyance (pump stations and piping to WTP)			30% AWDD		60% AWDD		90% AWDD	
Water Production			30% AWDD		60% AWDD		90% AWDD	
Well and/or Treatment operations functional			30% AWDD		60% AWDD		90% AWDD	
Transmission								
Backbone transmission facilities (pipelines, pump station, and tanks)			30% AWDD		60% AWDD	90% AWDD		
Water for fire suppression at key supply points (to promote redundancy)		30% of required fire flow and duration available[b]		60% of required fire flow and duration available			90% of required fire flow and duration available	
Control Systems								
SCADA and other control systems		30% of components required for normal operation are functional	60% of components required for normal operation are functional	90% of components required for normal operation are functional				
Distribution								
Critical Facilities								
Wholesale Users (other communities, rural water districts)				30% AWDD		60% AWDD	90% AWDD	
Hospitals		30% AWDD[c]	60% AWDD[c]	90% AWDD				
EOC, Police Stations, Fire Stations, Public Works Buildings		30% AWDD[c]	60% AWDD[c]	90% AWDD				
Emergency Housing								
Emergency Shelters		30% of emergency water for drinking/sanitation[c]	60% of emergency water for drinking/sanitation[c]	90% of emergency water for drinking/sanitation				
Housing/Neighborhoods								
Potable water available at community distribution centers			30% of emergency water for drinking/sanitation[c]	60% of emergency water for drinking/sanitation	90% of emergency water for drinking/sanitation			
Water for fire suppression at fire hydrants					30% of hydrants restored	60% of hydrants restored	90% of hydrants restored	
Community Recovery Infrastructure								
All other clusters				30% of customer connections restored		60% of customer connections restored	90% of customer connections restored	

[a] AWDD = Average Winter Day Demand
[b] Relies on in-town storage capacity and/or drafting water from Columbia River and/or Youngs Bay
[c] Relies on or partially relies on in-town storage capacity and/or portable treatment

Key to Table

Desired time to restore components to 30% operational	R
Desired time to restore components to 60% operational	Y
Desired time to restore components to 90% operational	G

4.0 City of Astoria Backbone System Supporting Short- and Intermediate-Term Community Needs

Satisfying short- and intermediate-term LOS restoration timeline goals requires critical components of the water production, treatment, transmission, and distribution system to remain operational or experience only minor damage after a major earthquake. These critical system components usually include: small diameter distribution pipelines and associated reservoirs/pump stations that connect to critical and essential facilities (hospitals, emergency shelters, etc.), large diameter transmission pipelines and associated pump stations, treatment plant structures, and certain support facilities (laboratories, maintenance shops, etc.). If an assessment of these critical system components reveals any gaps between the expected performance and the performance required to achieve the LOS goals, then these deficient components should be seismically retrofit or replaced, as appropriate.

The HDR team has collaborated with the City of Astoria to identify the proposed backbone for the City water system shown in Figure 4.1. The backbone system provides water distribution system connections between the water source reservoirs, raw water transmission pipelines, water treatment plant, finished water reservoirs, and distribution system pipelines that serve facilities that are required to meet short- and intermediate-term community needs (see Table 3.2). The backbone systems proposed for the City of Astoria water system is consistent with that envisioned during the development of the *ORP*. The backbone includes elements of the water system that are required to meet short- and intermediate-term LOS restoration timeframe goals in the initial days and weeks after a major earthquake. Since it would be challenging to implement any significant repairs to the backbone system in the initial days and weeks after an earthquake, the elements of the backbone system should be designed or retrofit such that they experience only minor or no geotechnical, structural, and nonstructural related damage during a major earthquake.

Two potential routes were identified for the backbone pipeline located to the west of Columbia Memorial Hospital that serves John Jacob Astor Elementary School (see Figure 4.2). Option A is to locate this segment of backbone pipe along Highway 30. However, this route is located in the tsunami inundation zone associated with a M9.0 CSZ earthquake. Option B is to locate this segment of backbone pipe along Grand Ave. However, this route is located in close proximity to a recently active landslide zone. Both options were discussed with the City, who selected Option A as the preferred route for this backbone pipeline segment. Since this pipeline segment is located in the tsunami inundation zone and will likely be subjected to tsunami-induced scour, it is recommended that this pipeline segment be constructed using a pipe material and joint type that has the capacity to accommodate large permanent ground deformation (e.g. earthquake resistant ductile iron pipe or welded joint high density polyethylene).

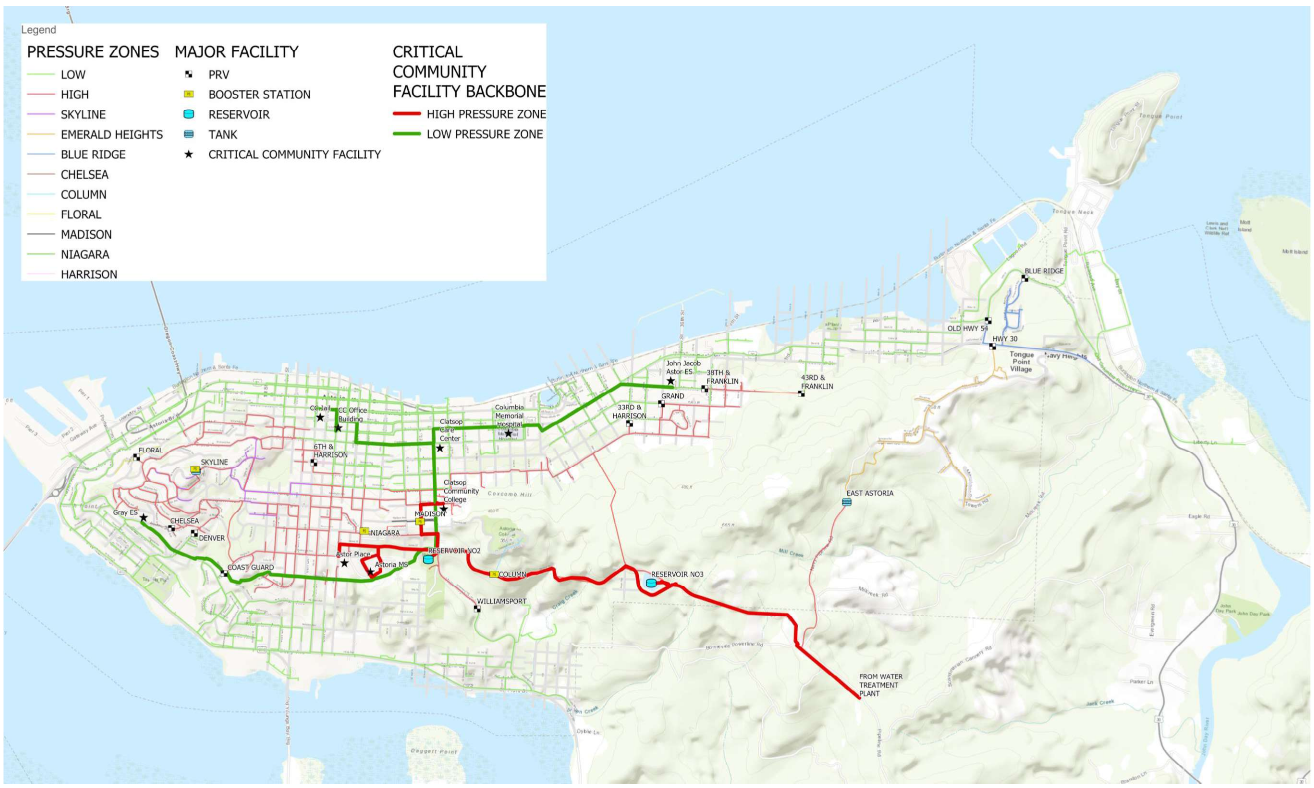


Figure 4.1 – City of Astoria Water System Backbone

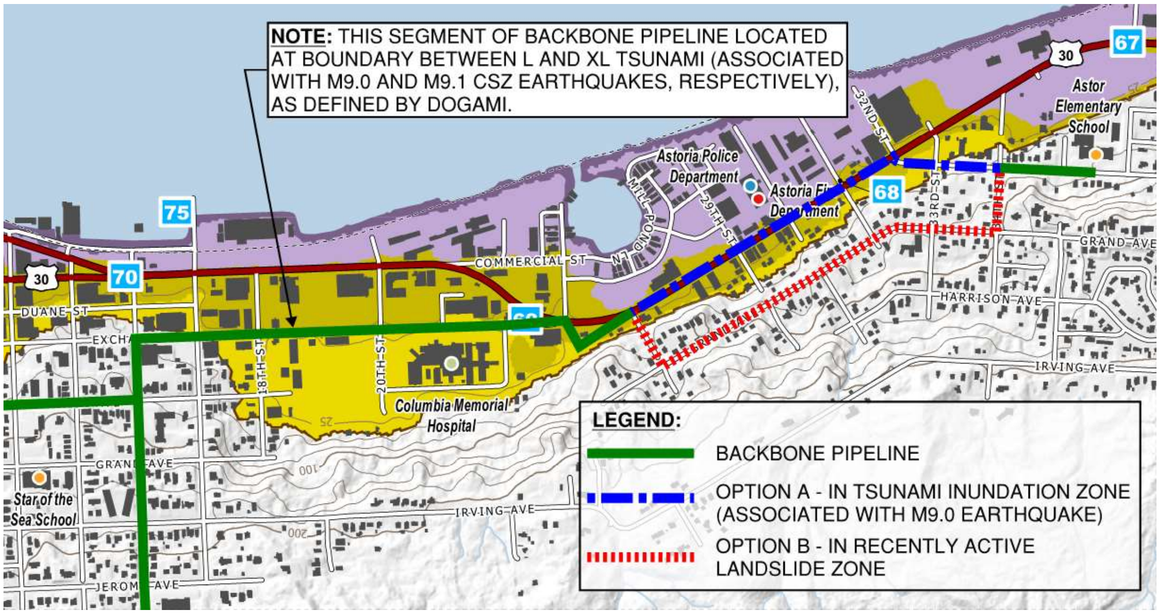


Figure 4.2 – Backbone Pipeline Options Serving John Jacob Astor Elementary School (adapted from DOGAMI, 2013)

5.0 Translation of Level of Service Goals into System Performance Requirements

Several factors need to be taken into consideration when translating the City of Astoria LOS goals into performance requirements for the seismic design or retrofit of water system components. Section 5.1 describes several of the factors that have been considered in developing the recommended general performance requirements detailed in Section 5.2.

5.1 Considerations

The following subsections describe factors considered in developing performance requirements for the various components of the City of Astoria water system. For future water system projects, these factors should also be evaluated on a project-specific basis to determine if there are any unique features of the project that require modification of the general seismic resilience-based performance requirements.

5.1.1 Geotechnical Hazards

Observations from past earthquakes have indicated that geotechnical hazards are a major contributing factor to the expected post-earthquake performance of water systems. Infrastructure that is exposed to liquefaction, lateral spreading, or landslide geotechnical hazards requires special design considerations that include either mitigation measures to address the geotechnical hazard or predetermined work-arounds to bypass components that may fail during an earthquake. Water treatment plants can be particularly vulnerable to damage from earthquake-induced liquefaction and lateral spreading because these facilities are often constructed in low-lying areas near water sources. These areas correspond with those at high risk for liquefaction and lateral spreading. Transmission and distribution piping that crosses creeks or other low-lying areas are also particularly vulnerable to damage from earthquake-induced liquefaction and lateral spreading.

5.1.2 Effects of Aftershocks

Major earthquakes are often accompanied by numerous aftershocks. In the 2011 Tohoku Japan earthquake, two major aftershocks caused additional damage to infrastructure systems, resulting in relapses in the number of customer outages (Nojima, 2012). It may be necessary to reevaluate system components or perform additional repairs after major aftershocks.

5.1.3 Repair Difficulty

Certain water system components (like large diameter transmission mains) may be very difficult to repair after an earthquake. If a component is anticipated to be difficult to repair and it is also important to system performance, then it should be designed to minimize any potential earthquake damage that would impact the functionality of the component. Other assets of this type could include pipes under railroad tracks or highways.

5.1.4 Availability of Public Works Department Staff

The first priority for many City of Astoria Public Works Department staff in the initial hours and days following a major earthquake will be to ensure the health and safety of their families. Once those critical needs are addressed, City of Astoria Public Works Department staff will, ideally, be available to report to work. However, even after they return to work, it is possible that the City Emergency Manager may assign Public Works Department staff to work on non-water system related tasks that are deemed more critical to the City's disaster response activities. This scenario suggests that Public Works Department staff may have limited ability to perform repairs or implement predetermined work-arounds in the initial hours and days after an earthquake. Critical components of the water system that are required to be operational within the first 3-7 days after an earthquake should be designed or seismically retrofitted to remain operational during and immediately after a major earthquake.

5.1.5 Availability of Design Professionals and Contractors

The restoration timeline goals and required repairs must be in line with the anticipated availability of qualified design professionals and contractors to design and implement the repairs. It is anticipated that the design and construction of major repairs to a reservoir or treatment plant structure would take between 6-12 months, or longer. It is anticipated that the design and construction to replace a reservoir or treatment plant structure would take a minimum of 18 months. These timeframes may increase if the City decides to rebuild to a higher standard of performance, i.e., a resilient design, which may require more planning and design time.

5.1.6 Availability of Repair Materials or Replacement Equipment

The City of Astoria maintains limited supplies of emergency repair materials, but these supplies are not anticipated to be adequate for the number of repairs that may be necessary after a major earthquake. For disasters that impact a relatively small geographic region, it is possible that other nearby utilities could lend repair supplies. However, a CSZ earthquake will impact the entire Pacific Northwest (from Northern California to British Columbia) and relying on neighboring utilities as a potential source for repair materials is likely impractical.

Additionally, some equipment used in booster stations and treatment plants is not available from manufacturer's stock and has a long lead time for production. Special consideration must be given to this difficult-to-source equipment to ensure that it is either not damaged during an earthquake, a predetermined work-around has been established, or the equipment manufacturing lead time aligns with restoration timeline goals.

5.1.7 Infrastructure Dependencies

The restoration of water system infrastructure is highly dependent on other infrastructure systems. Examples of these dependencies include:

- Co-location with and damage to other lifeline systems (roads, bridges, wastewater pipes, etc.);
- Liquid fuel availability for trucks, generators, and equipment;
- Commercial electrical power;
- Transportation system for delivery of repair materials and mutual aid assistance crews; and
- Cellular communications system for coordination of City of Astoria staff and contractors.

The level of service goals and performance requirements suggested in this report assume that all lifeline service providers will be making significant investments in the earthquake resilience of their systems in the next 50 years. If one or more lifeline sectors do not make these system improvements, then the speed of community recovery could be greatly impacted because of the dependencies between all infrastructure systems. Figure 5.1 shows an example of the complicated dependency relationships among lifelines in the San Francisco Bay Area (City and County of San Francisco Lifelines Council, 2014). Heavy and light lines widths depict the relative level of dependencies anticipated to occur between the various lifelines systems following a scenario M7.9 earthquake on the San Andreas fault.

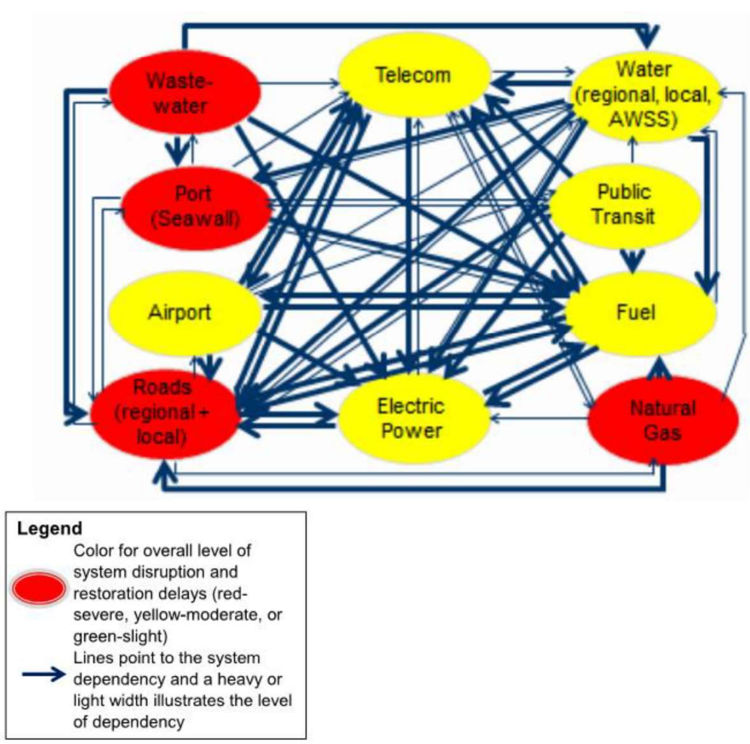


Figure 5.1 – Lifeline Interdependencies in the San Francisco Bay Area (City and County of San Francisco Lifelines Council, 2014)

5.2 Water System Structures

Water system structures (reservoirs, booster pump stations, etc.) required to maintain water pressure for fire suppression are designated as Risk Category IV structures and water system structures not required to maintain water pressure for fire suppression are designated as Risk Category III structures according to the requirements of the latest edition of the *Oregon Structural Specialty Code* (OSSC, 2019). For new structures, the construction cost increase associated with elevating the design standard from Risk Category III to Risk Category IV is typically relatively minor. Therefore, it is recommended that all new water system structures should be designed per the more stringent *Oregon Structural Specialty Code* seismic design requirements for Risk Category IV structures.

Also, since geotechnical hazards (e.g., liquefaction and lateral spreading, etc.) can significantly impact the performance of water system structures following a major earthquake, it is recommended that site-specific geotechnical investigations and analysis be conducted to characterize these potential hazards. Water system structure designs should include appropriate measures to mitigate these potential site-specific geotechnical hazards. Equipment associated with water system structures should be adequately braced and seismically certified, per the requirements of the latest edition of ASCE 7*, Minimum Design Loads for Buildings and Other Structures* (ASCE, 2017a), so that it could remain operational after a design level earthquake, as long as dependent systems are also functional [e.g., electrical power (emergency generator or commercial), etc.]. Piping entering or exiting water system structures should be designed to accommodate the anticipated earthquake-induced relative movement between the structure and surrounding soil.

In order to meet the target LOS goals, water system structures need to meet or exceed defined levels of structural and nonstructural seismic performance. ASCE 41-17, *Seismic Evaluation and Retrofit of Existing Buildings* (ASCE, 2017b), presents several structural and nonstructural seismic performance objectives and describes the expected level of earthquake damage associated with each performance objective. Also included are expectations about the operability and reparability of earthquake damage for these various performance objectives. The ASCE 41-17 descriptions of these performance objectives are provided below and summarized in Figure 5.2. Table 5.1 provides a comparison between these performance objectives and the intended performance associated with *Oregon Structural Specialty Code* Risk Categories.

Table 5.1 – Comparison of Seismic Performance Objectives with OSSC Risk Categories

Risk Category	Performance Objective[a]	
	Structural	Nonstructural
IV	Immediate Occupancy	Operational
III	Damage Control	Position Retention
I & II	Life Safety	Position Retention

[a] For the BSE-1N seismic hazard level as defined by ASCE 41-17

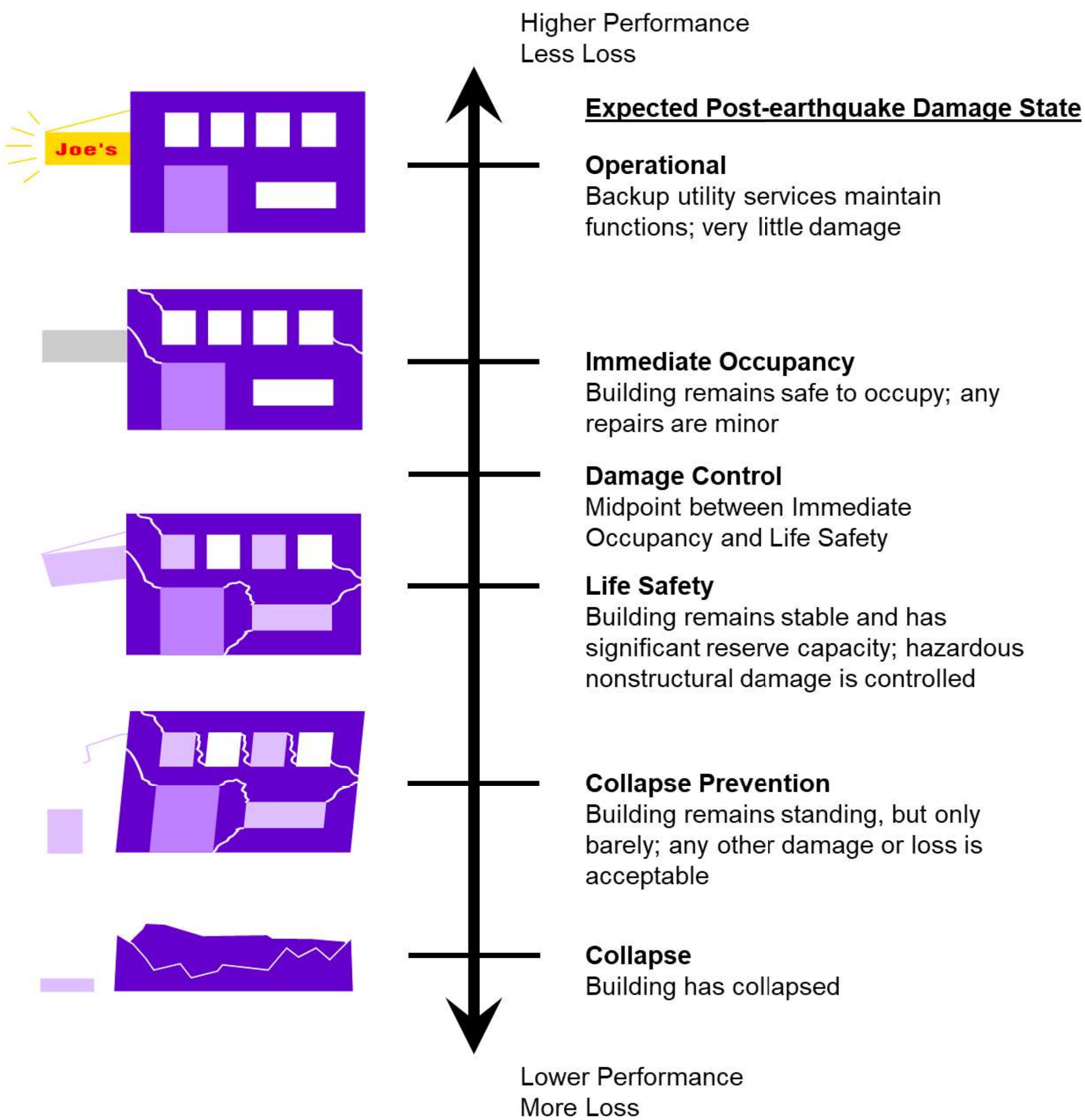


Figure 5.2 – Building Performance Objectives (adapted from ASCE, 2017b)

Structural Performance Objectives

Immediate Occupancy: "Immediate Occupancy" refers to the post-earthquake damage state in which only very limited structural damage has occurred. The basic vertical- and lateral-force-resisting systems of the building retain almost all their pre-earthquake strength and stiffness. The risk of life-threatening injury from structural damage is very low, and although some minor structural repairs might be appropriate, these repairs would generally not be required before re-occupancy. Continued use of the building is not limited by its structural condition but might be limited by damage or disruption to nonstructural elements of the building, furnishings, or equipment and availability of external utility services.

Damage Control: "Damage Control" refers to a midway point between Life Safety (see next description) and Immediate Occupancy (see previous description). This performance objective is intended to provide a structure with a greater reliability of resisting collapse and being less damaged than a typical structure, but not to the extent required of a structure designed to meet the Immediate Occupancy Performance Level. Although this level is a numerically intermediate level between Life Safety and Immediate Occupancy, the two performance objectives are essentially different from each other. The primary consideration for Immediate Occupancy is that the damage is limited in such a manner as to permit reoccupation of the building, with limited repair work occurring while the building is occupied. The primary consideration for Life Safety is that a margin of safety against collapse be maintained and that consideration for occupants to return to the building is a secondary impact to the Life Safety objective being achieved. The Damage Control Performance Level provides for a greater margin of safety against collapse than the Life Safety Performance Level would. The level might control damage in such a manner as to permit return to function more quickly than the Life Safety Performance Level, but not as quickly as the Immediate Occupancy Performance Level does.

Life Safety: "Life Safety" refers to the post-earthquake damage state in which significant damage to the structure has occurred but some margin against either partial or total structural collapse remains. Some structural elements and components are severely damaged, but this damage has not resulted in large falling debris hazards, either inside or outside the building. Injuries might occur during the earthquake; however, the overall risk of life-threatening injury from structural damage is expected to be low. It should be possible to repair the structure; however, for economic reasons, this repair might not be practical. Although the damaged structure is not an imminent collapse risk, it would be prudent to implement structural repairs or install temporary bracing before re-occupancy.

Nonstructural Performance Objectives

Operational: "Operational" refers to the performance level where most nonstructural systems required for normal use of the building are functional, although minor cleanup and repair of some items might be required. Achieving the Operational nonstructural performance level requires considerations of many elements beyond those that are normally within the sole province of the structural engineer's responsibilities. For Operational nonstructural performance, in addition to ensuring that nonstructural components are properly mounted and braced within the structure, it is often necessary to provide emergency standby equipment to provide utility services from external sources that might be disrupted. It might also be necessary to perform seismic qualification testing to ensure that all necessary equipment will continue to function during and after strong shaking.

Position Retention: "Position Retention" refers to the nonstructural condition of a building after an event where, presuming that the building is structurally safe, occupants can occupy the building safely, with some limitations: normal use might be impaired, some cleanup might be needed, and some inspection might be warranted. In general, building equipment is secured in place and might be able to function if the necessary utility service is available. However, some components might experience misalignments or internal damage and be inoperable. Power, water, natural gas, communications lines, and other utilities required for normal building use might not be available. Cladding, glazing, ceilings, and partitions might be damaged but would not present safety hazards or un-occupiable conditions. For this performance level, the risk of life-threatening injury caused by nonstructural damage is very low.

Detailed geotechnical and structural seismic evaluations should be conducted for existing water system structures to determine if their anticipated seismic performance will enable LOS goals to be achieved. To satisfy the target water system restoration timeline, structures that must be operational soon after a major earthquake should be evaluated and if required, seismically retrofit to a more stringent structural and nonstructural performance level than those that are not required until later in the recovery phase. Table 5.2 provides the seismic retrofit criteria proposed for adoption by the City of Astoria for water system infrastructure in terms of the structural and nonstructural performance objectives presented in ASCE 41. These performance objectives are for the Basic Safety Earthquake-1 for use with the Basic Performance Objective Equivalent to New Building Standards (BSE-1N). This BSE-1N seismic hazard level is consistent with that used to design new structures per the *Oregon Structural Specialty Code*. Note that the proposed LOS goals require that the water system has essentially been restored to a 90% operational level within 3-6 months after a M9.0 CSZ earthquake. This would suggest that the majority of system components are capable of achieving Immediate Occupancy structural performance and Operational or position retention nonstructural performance. Table 5.2 also includes alternative (less stringent) retrofit performance objectives for system components that might not be required to be returned to service until 6-12 months after the earthquake. For example, the City of Astoria may decide that one of the booster stations is not required to achieve 90% LOS goals and may elect to relax the restoration timeline goals for that particular water system structure.

Table 5.2 – Water System Seismic Retrofit Performance Objectives

Restoration Timeline	**Retrofit Performance Objective**[a]	
	Structural	**Nonstructural**
0-1 months	Immediate Occupancy	Operational
1-6 months	Immediate Occupancy	Position Retention[b]
6-12 months	Damage Control[c]	Position Retention[b]

[a] For the BSE-1N seismic hazard level as defined by ASCE 41-17.
[b] Assumes lead time for delivery and installation of damaged equipment falls within restoration timeline goals, otherwise equipment should be seismically certified per the requirements of the latest edition of ASCE 7.
[c] Assumes that the structural damage can be repaired within restoration timeline goals. For earthquake damage that may be especially difficult to repair within the target timeline, structure should be retrofit to satisfy the Immediate Occupancy performance objective.

6.0 Next Steps

This technical memorandum summarizes SEFT's recommendations to the City related to: 1) water system LOS goals following a M9.0 CSZ scenario earthquake and associated tsunami, 2) structural and nonstructural performance objectives required to ensure water system structures will be able to achieve the target LOS goals, and 3) a water system backbone that is intended to help support community short- and intermediate-term social and/or economic needs following a major earthquake. In the process of developing these recommendations, several next steps were identified that, if implemented, will continue to help improve the seismic resilience of the City's water system in the event of a major earthquake and tsunami.

- Due to the fact that many critical community facilities are currently located in or in close proximity to the tsunami inundation zone, it is suggested that Astoria community stakeholders develop a comprehensive City-wide seismic resilience plan that holistically addresses the risk associated with a CSZ earthquake and associated tsunami, and other potential natural hazards (landslide, winter storm, etc.) If a facility that is critical to supporting community short- and intermediate-term social and/or economic needs is relocated, site selection criteria for the new location should consider proximity to the water system backbone or the water system backbone should be appropriately modified to include the location of the new facility. The backbone should also be routinely updated to incorporate future water system modifications that will be implemented by the City (e.g., future plans to upgrade/replace in-town storage reservoirs, future plans to provide water storage tanks at various locations around the City, etc.)
- Community facilities and the surrounding area (including buried utilities) in the tsunami inundation zone are likely to experience significant damage due to tsunami inundation and scouring, and may take many months, if not years, to recover. It is recommended that the City develop and implement plans to install isolation valves near the boundary of the tsunami inundation zone. This will permit the City to preserve their stored water supply by isolating areas with significant tsunami-induced pipeline damage and facilitate functional recovery of the water system above the tsunami inundation zone within the timeframe indicated in Table 3-3.
- The City has previously conducted: 1) a seismic stability evaluation of Bear Creek Dam (Cornforth, 2016), and 2) a seismic resilience assessment of the 12-mile-long water transmission main between Bear Creek Dam and Reservoirs 2 and 3 (Hart Crowser, 2019). As part of this water master plan update project, a limited structural/nonstructural seismic vulnerability assessment of four (4) additional key facilities will be conducted to determine their estimated performance following a M9.0 CSZ earthquake. It is recommended that the City also conduct a seismic and tsunami assessment (as appropriate) of the remaining water system components. This will provide the City with a holistic view of the expected seismic performance of the water system that can be leveraged in developing a

comprehensive long-term plan for implementing water system seismic and tsunami resilience improvements.

- In order to continue to advance the City's water system resilience planning process, we recommend that a follow up study be conducted that includes consideration of dependency relationships. Planning for and addressing issues such as where the City will get fuel for trucks and generators, how suppliers and contractors will be rapidly engaged and compensated, etc. will help improve resilience and speed the return to normalcy after a major disaster. Additionally, some equipment used in booster stations and treatment plants is not available from manufacturer's stock and has a long lead time for production. Special consideration must be given to this difficult-to-source equipment to ensure that it is either not damaged during an earthquake, a predetermined work-around has been established, or the equipment manufacturing lead time aligns with restoration timeline goals.

7.0 Limitations

The opinions and recommendations presented in this technical memorandum were developed with the care commonly used as the state of practice of the profession. No other warranties are included, either expressed or implied, as to the professional advice included in this technical memorandum. This technical memorandum has been prepared for the City of Astoria to be used solely in its evaluation of the seismic safety of the water system referenced. This technical memorandum has not been prepared for use by other parties and may not contain sufficient information for purposes of other parties or uses.

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Appendix G. Geotechnical Seismic Data Summary Technical Memorandum

CORNFORTH CONSULTANTS

January 6, 2021 2865

Katie Maschmann, P.E.
HDR, Inc.
1050 SW 6th Avenue, Suite 1800
Portland, Oregon 97204

Geotechnical Seismic Data Summary
Astoria Water System Master Plan
City of Astoria, Oregon

Dear Katie,

In accordance with your authorization, we have completed geotechnical services for the above referenced project. This letter report summarizes geotechnical data for the development of the Astoria Water System Master Plan.

INTRODUCTION

In 2011, the Oregon Legislature charged the Oregon State Seismic Safety Policy Advisory Commission (OSSPAC) with the preparation of a statewide seismic resilience plan. The focus of this plan was to identify vulnerabilities and provide recommended policies to improve the State of Oregon's resilience following a Cascadia Subduction Zone interface event earthquake. This mandate culminated in the release of the 2013 Oregon Seismic Resilience Plan with the goal of increasing the State's seismic resiliency over the next 50 years.

The City of Astoria is following through with development of a city-wide Water System Master Plan to address the recommendations of the Oregon Resilience Plan and subsequent Oregon Health Authority requirements for seismic resilience planning. A significant component of the master plan is an evaluation of potential impacts on the water system from a M9.0 Cascadia Subduction Zone (CSZ) earthquake. Objectives of the master plan include performing a seismic resilience assessment of the system so that long-term capital improvement plans can be developed. Seismic impacts on the "back-bone" components of the water supply and distribution system are an element of the overall system evaluation. The Site Plan on Figure 1 shows an aerial view of the City of Astoria overlaid with waterlines. Geotechnical elements of this work involve estimating ground motions, estimating the deformations that impact the system resulting from liquefaction and lateral spreading, and earthquake induced landslide movement.

SCOPE OF WORK

The Oregon Department of Geology and Mineral Industries (DOGAMI) compiled seismic hazard maps for a CSZ earthquake as part of the 2013 Oregon Resilience Plan. To support HDR's civil and structural evaluation of the water system, Cornforth Consultants, Inc. (CCI) utilized existing maps and geologic databases to develop refined maps for the City of Astoria showing seismic hazard contours relative to existing infrastructure. Seismic characteristics of concern include:

- Site Classification
- Peak ground acceleration (PGA)
- Short period spectral acceleration (SA0.2)
- 1.0-second spectral acceleration (SA1.0)
- Liquefaction and lateral spread probability and permanent ground deformation
- Earthquake induced landslide probability and permanent ground deformation

GEOLOGIC SETTING

The regional tectonic setting of the city of Astoria in western Oregon is a zone of active convergence between the Juan de Fuca and the North American lithospheric plates. The city of Astoria is located within the Northern Oregon Coast Range physiographic province. The geology of the region consists predominately of Astoria Formation that contains weak siltstones, mudstones, and fine-grained sandstone interbeds, interfingered with intrusions and displacement by volcanic rocks of the Columbia River Basalt Group.

The convergence of the Juan de Fuca and North American plates controls the seismicity in the region. These plate tectonics generate three principal earthquake sources. These sources consist of crustal earthquakes along local faults, deep intraslab or Benioff zone source earthquakes and the large magnitude subduction zone interface source earthquakes. Contributions from each of these sources make up the overall seismic hazard for the City, however the Subduction Zone interface source is the dominant hazard for the immediate vicinity.

The subduction zone sources are a result of the interaction between the subducting Juan de Fuca Plate and the overriding North American Plate. Locking and stress development occurs along the plate boundaries as the Juan de Fuca plate subducts beneath the North American plate. This stress builds up along the interface, releasing energy as earthquake movement occurs. Geologic evidence from observations in Japan, explorations along the Oregon Coast and offshore core drilling indicate potential recurrence intervals of large magnitude events is on the order of every 350 to 700 years for the subduction zone interface.

Stresses can also develop deep within the subducting Juan de Fuca plate as bending and breaking of the plate occurs at deep depths. Intraslab earthquakes are relatively common in the Seattle Basin, however there is increasing evidence that the likelihood of intraslab events in Western Oregon is low. Historical earthquake records indicate that intraslab events in Western Oregon are rare and no events have been documented at this time. The lack of intraslab earthquakes in Western Oregon has been attributed to either higher temperatures in the subducting slab or low deviatoric stress in the slab.

Local crustal faults also contribute to the seismic hazard. However, given the recurrence interval and proximity to the interpreted zone of interface locking, the Cascadia Subduction Zone interface source dominates the seismic hazard.

GEOTECHNICAL SEISMIC DATA

Geotechnical seismic data has been compiled to support HDR's water system evaluation. Geotechnical data included seismic site classification, seismic ground motions (spectral accelerations and velocities), liquefaction and lateral spread probability and deformation estimates, earthquake induced landslide probability and deformation estimates.

Data Sources

Geotechnical data maps were developed from three primary sources. These sources include the City of Astoria geographic information system (GIS) database, the City's geotechnical reports and the 2013 State of Oregon Department of Geology and Mineral Industries (DOGAMI) report on Ground Motion, Ground Deformation, Tsunami Inundation, Coseismic Subsidence, and Damage Potential Maps for the 2013 Oregon Resilience Plan for Cascadia Subduction Zone Earthquakes.

The City's GIS database includes City infrastructure, water lines, as well as City maintained maps of historic and mapped landslide terrain.

Geotechnical reports for the stability evaluation of Bear Creek Dam, water line replacement at Bear Creek Dam, and Resilience Study on the Pipeline Road Water Transmission Main were also reviewed for this work.

The 2013 DOGAMI Seismic Maps were reviewed and incorporated into data development for the Astoria WSMP. Data included in the DOGAMI maps included site classification, peak ground acceleration (on bedrock and site adjusted), 1.0-second spectral acceleration, liquefaction hazard characterization and landslide deformation estimates.

The following sections describe the geotechnical data developed for the Astoria WSMP project.

Site Classification

Site classification is used to develop site ground response adjusted for local site conditions, such as hard rock, stiff soil, soft soil or soils susceptible to seismic failure. Typically the bedrock seismic motions are modified by a site classification factor to account for the response as motions propagate through the anticipated subsurface soil profile. Site classifications by DOGAMI were developed based on updated shear wave velocity maps using a combination of statewide geologic map data and a catalog of shear wave velocity measurements. Shear wave velocity measurements were correlated to NEHRP site classification ratings. For the Astoria Region, mapping performed by Madin and Wang, 1999, provided preliminary basis for amplification factors with shear wave velocities measurements of 70 to 95 meters/second, 133 to 210 m/sec, and 523 m/sec for estuarine clay and silt, sand, and Astoria

Formation bedrock, respectively. Additionally, mapped landslide, talus/colluvium and alluvial and debris deposits mapped by DOGAMI were incorporated into the updated site classification.

The compiled NEHRP site classification maps for the City of Astoria are shown on Figure 2. This maps shows the four primary ground conditions within the area, consisting of silt and clay sediments along Youngs Bay (Site Class E), alluvial sediment along the river and bay (Site Class D), dense soil and soft rock in the slopes above the river (Site Class C), and mapped landslide zones (Site Class F).

Site Spectral Accelerations

Site spectral accelerations were developed to provide ground response for structural and waterline analyses. Spectral accelerations developed included peak ground acceleration, short periods spectral acceleration (0.2-second period) and 1.0-second period spectral acceleration. Ground motions on bedrock were developed for a Cascadia Subduction Zone event utilizing the USGS Cascadia M 9.0 scenario ShakeMap and presented in the 2013 DOGAMI Seismic database (PGA_{rock} and 1.0-spectral acceleration $SA1.0_{rock}$). The bedrock ground motions were then adjusted for site classification using site-amplification coefficients provided by Boore and Atkinson (2008). The adjusted spectral acceleration, PGA_{site} and $SA1.0_{site}$, were calculated using DOGAMI derived amplification factors and are presented in Figures 3 and 5, respectively.

Bedrock ground motions for the 0.2-second period spectral acceleration ($SA0.2_{rock}$) were developed by adjusting the PGA_{rock} by a factor of 2.25, based on current ratios of SA0.2/PGA from USGS probabilistic seismic hazard mapping response spectra for the Astoria vicinity. Site amplification factors for the 0.2-second period were determined using the Boore and Atkinson (2008) procedures with amplification factors ranging from 0.87 to 1.07 depending on site class. The spectral accelerations ($SA0.2_{site}$) are presented on Figure 4.

Liquefaction and Lateral Spread

Liquefaction and lateral spread evaluations were performed to quantify anticipated deformations that could impact the water system. Liquefaction susceptibility estimates were developed based on new statewide mapping efforts by DOGAMI for the 2013 seismic database. These maps utilized recently published LiDAR-based surface geology maps, combined with data from other published hazard studies. Based on geologic data, DOGAMI assigned liquefaction susceptibility rankings from none to very high. Figure 6 shows the liquefaction probability for the City of Astoria. Generally, the probability of liquefaction ranges from 10 to 23% along both Youngs Bay and the Columbia River and is negligible (<5%) in the higher ground areas.

Deformation estimates for liquefaction induced settlement and lateral spread permanent ground deformation (PGD) utilized methods presented in the FEMA guidance documents, HAZUS-MH, (2011). Peak ground deformations utilize a susceptibility category that is derived from the liquefaction probability, adjusted by ground water and magnitude correction factors. Using the susceptibility category, site peak ground acceleration, displacement correction factor, the permanent ground deformation was calculated and is presented in Figure 7. Ground deformations from liquefaction and lateral spread at the lowland areas along Columbia River and Young's Bay are estimated to be between 5 and 8 feet (150 to 250 cm).

Earthquake-Induced Landslides

Landslide deformation induced by earthquakes is likely to occur on steep slopes or existing landslide terrain in the City of Astoria. The City has an extensive history of landslide movement and maintains a landslide map to document locations of known landslides. Additionally, DOGAMI has conducted landslide mapping within the region and at locations of existing and potential landslide terrain. The 2013 Seismic database by DOGAMI utilized several factors in developing earthquake probability maps. These factors included slope classification, geologic maps, landslide susceptibility maps, and site peak ground acceleration. Critical acceleration values from the FEMA (2012) HAZUS-MH document were correlated to landslide susceptibility category to determine likelihood of landslide. The likelihood of landslides for the City are shown in Figure 8.

Landslide deformation estimates have been developed to provide an estimate of the stresses that may be induced on waterlines within the City's system. Seismic deformations developed by DOGAMI for the Oregon Resilience Plan geodatabase utilized the HAZUS-MH methodology by FEMA to estimate landslide deformations. This method utilizes a displacement factor determined as a function of critical acceleration and induced acceleration to correlate landslide deformation with peak ground acceleration and landslide probability. Earthquake-induced landslide deformation estimates are shown on Figure 9. These landslide deformation estimates indicate permanent ground deformation on the order of 5 to 10+ feet in mapped landslide locations. The most critical areas of distress are on the limits of the landslides and this is evident in the map, as the margins of the landslides show greater amount of displacement than interior portions of the landslide.

GEOTECHNICAL DATA ASSESSMENT

Geotechnical hazard data presented above represents estimated seismic response of the ground to a large magnitude subduction zone earthquake. Impacts of ground motions and deformations on the City of Astoria's water systems are being performed in conjunction with HDR and subconsultant SEFT Consulting Group. Table 1 below provides geotechnical parameters for four critical infrastructure locations identified by SEFT Consulting Group (Reservoir 2 Gatehouse, Reservoir 3 Gatehouse, Skyline Tank, and East Astoria Tanks). Discussion below focuses on several key geotechnical aspects of the hazard data as they apply to the City's water system.

Table 1 – Seismic Parameters at Select Locations

Location	Short Period Spectral Acceleration (SA 0.2)	1.0-Sec Spectral Acceleration (SA1.0)	Liquefaction /Lateral Spread Probability and Deformation	Landslide Probability and Deformation
Reservoir 2 Gatehouse	0.76g	0.41g	<1% <1cm	15-25% 50-375cm
Reservoir 3 Gatehouse	0.76g	0.40g	<1% <1cm	15-25% 50-300cm
Skyline Tank	0.76g	0.41g	<1% <1cm	15-20% 50-75cm
East Astoria Tanks	0.75g	0.40g	<1% <1cm	15-25% 50-375cm

Liquefaction, Lateral Spread and Landslide Deformations

Liquefaction, lateral spread and landslide deformation can take a variety of forms. Liquefaction deformation often manifests as settlement of ground in areas where liquefaction has occurred. This may result in separation of pipes or valves connected to hardened infrastructure such as buildings or tanks. Lateral spreading, such as may be expected along the Columbia River or Youngs Bay may result in lateral deformation and spreading of ground where depressions in topography or a free face (such as the river) exist. This deformation can cause damage to pipelines and the spreading soils cause tensile stresses along the pipe at joints or bends. Earthquake-induced landslide deformation in Astoria is anticipated to consist of large landslide masses translating as a cohesive block. This results in greatest stresses along the water infrastructure at the margins of the landslide (scarps, cracks and toe).

Reservoirs 2 and 3

Seismic performance of embankment dams for Reservoirs 2 and 3 have not specifically been evaluated as part of this study. General seismic parameters prepared for this report can be used for a general understanding of seismic response. It is our understanding that there have not been seismic stability analyses performed on these embankment dams at this time. A review of past information from construction indicates that designers of Reservoir 2 recognized landslide terrain on the north facing slopes and elected to move the reservoirs to a more favorable location on the south facing slope. The 2019 Pipeline Road Water Transmission Main Resilience Study identified and mapped landslide deposits in the area downslope of Reservoir 3. Mapped landslide deposits also are identified north of and across a drainage from Reservoir 2. The 2019 pipeline report shows the locations and limits of these landslide areas. Additional analyses would help to further characterize the seismic performance of these structures.

CONCLUSION

Seismic response of ground conditions within the City of Astoria are critical to the performance of the water system. Potential for liquefaction and lateral spread along Youngs Bay and the Columbia River as well as mapped landslide terrain on the slope areas of the City result in potential deformation throughout the water system.

Developing and delineating the seismic hazards involves merging and displaying data developed by others and herein to provide planners with data to visualize seismic hazard at a coarse scale. Planning level data is typically supplemented by site-specific studies for critical system elements or locations, such as has previous been done for Bear Creek Dam and the Pipeline Road Transmission Main. The regions delineated on Figures 1 through 9 should be used for informing design rather than as absolute values.

We appreciate the opportunity to assist HDR with this project. If you have any questions, please call us at (503) 452-1100.

Sincerely,

CORNFORTH CONSULTANTS, INC.

Christopher I Carpenter, P.E.
Senior Associate Engineer

LIMITATIONS IN THE USE AND INTERPRETATION OF THIS GEOTECHNICAL REPORT

Our professional services were performed, our findings obtained, and our recommendations prepared in accordance with generally accepted engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

The geotechnical report was prepared for the use of the Owner in the design of the subject facility and should be made available to potential contractors and/or the Contractor for information on factual data only. This report should not be used for contractual purposes as a warranty of interpreted subsurface conditions such as those indicated by the interpretive boring and test pit logs, cross-sections, or discussion of subsurface conditions contained herein.

The analyses, conclusions and recommendations contained in the report are based on site conditions as they presently exist and assume that the exploratory borings, test pits, and/or probes are representative of the subsurface conditions of the site. If, during construction, subsurface conditions are found which are significantly different from those observed in the exploratory borings and test pits, or assumed to exist in the excavations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. If there is a substantial lapse of time between the submission of this report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, this report should be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions and time lapse.

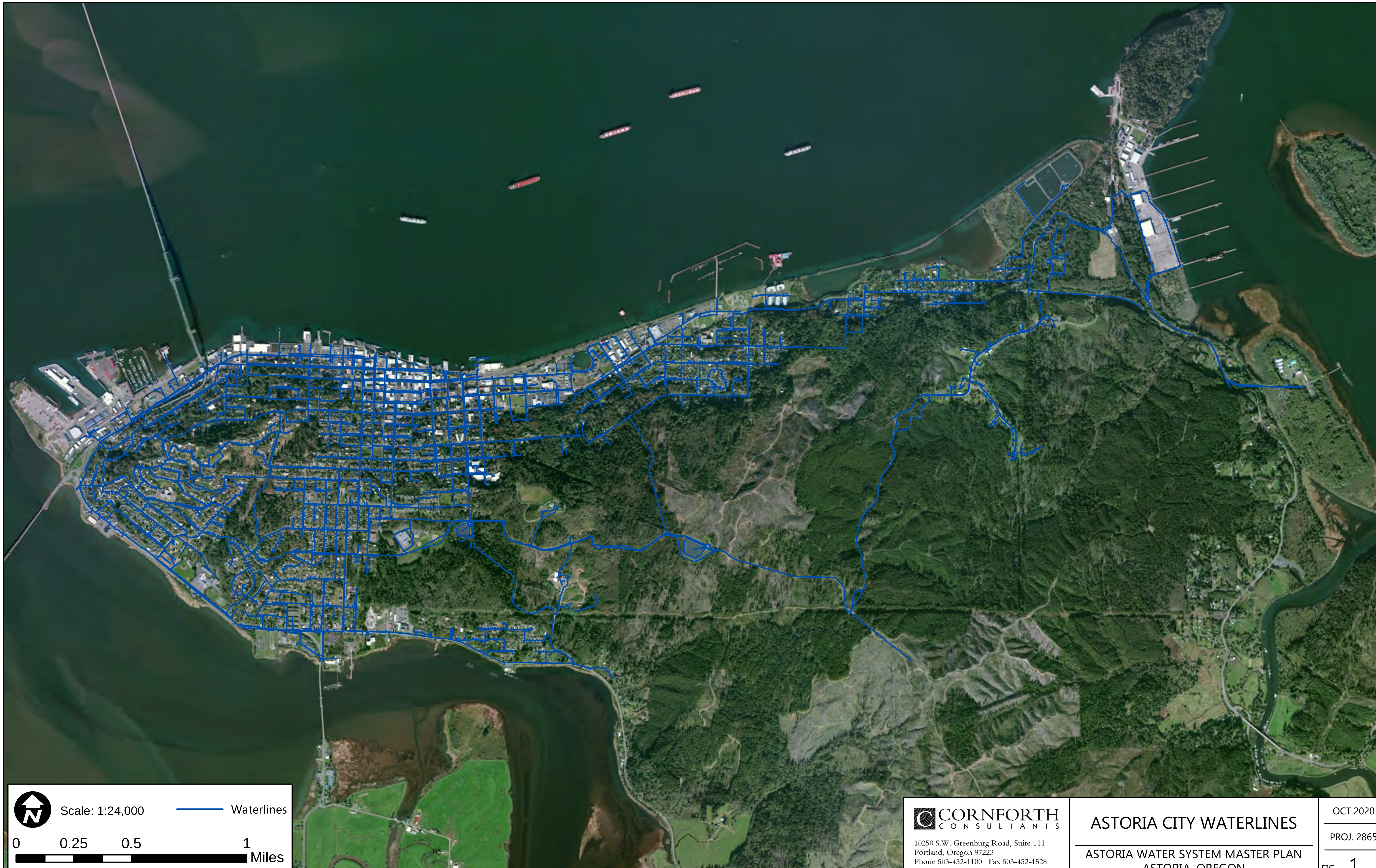
The Summary Boring Logs are our opinion of the subsurface conditions revealed by periodic sampling of the ground as the borings progressed. The soil descriptions and interfaces between strata are interpretive and actual changes may be gradual.

The boring logs and related information depict subsurface conditions only at these specific locations and at the particular time designated on the logs. Soil conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the soil conditions at these boring locations.

Groundwater levels often vary seasonally. Groundwater levels reported on the boring logs or in the body of the report are factual data only for the dates shown.

Unanticipated soil conditions are commonly encountered on construction sites and cannot be fully anticipated by merely taking soil samples, borings or test pits. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. It is recommended that the Owner consider providing a contingency fund to accommodate such potential extra costs.

This firm cannot be responsible for any deviation from the intent of this report including, but not restricted to, any changes to the scheduled time of construction, the nature of the project or the specific construction methods or means indicated in this report; nor can our firm be responsible for any construction activity on sites other than the specific site referred to in this report.



CORNFORTH CONSULTANTS
10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1100 Fax 503-452-1528

ASTORIA CITY WATERLINES

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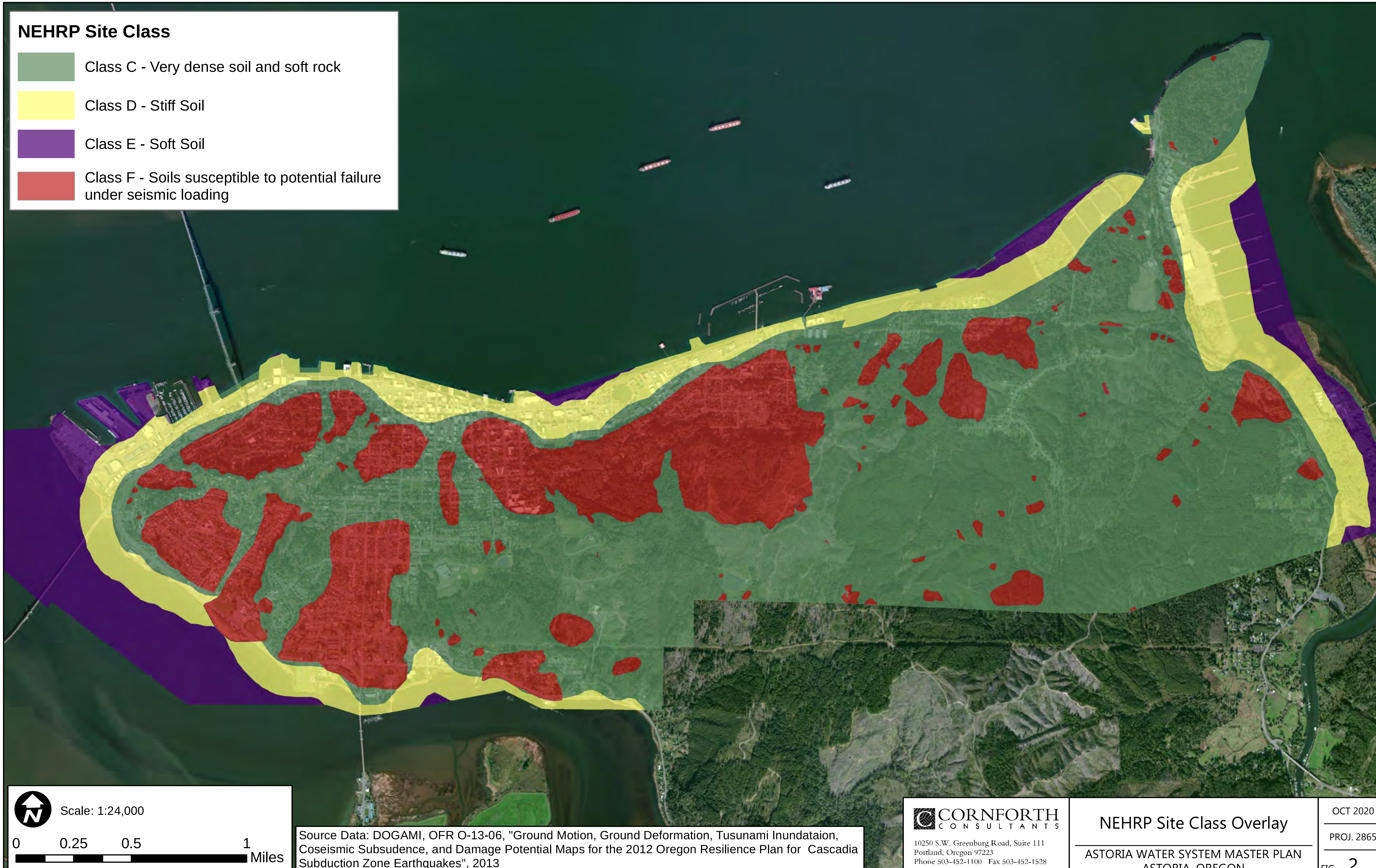
FIG. 1



Source Data: DOGAMI, OFR O-13-06, "Ground Motion, Ground Deformation, Tusunami Inundataion, Coseismic Subsudence, and Damage Potential Maps for the 2012 Oregon Resilience Plan for Cascadia Subduction Zone Earthquakes", 2013

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NEHRP Site Class Overlay

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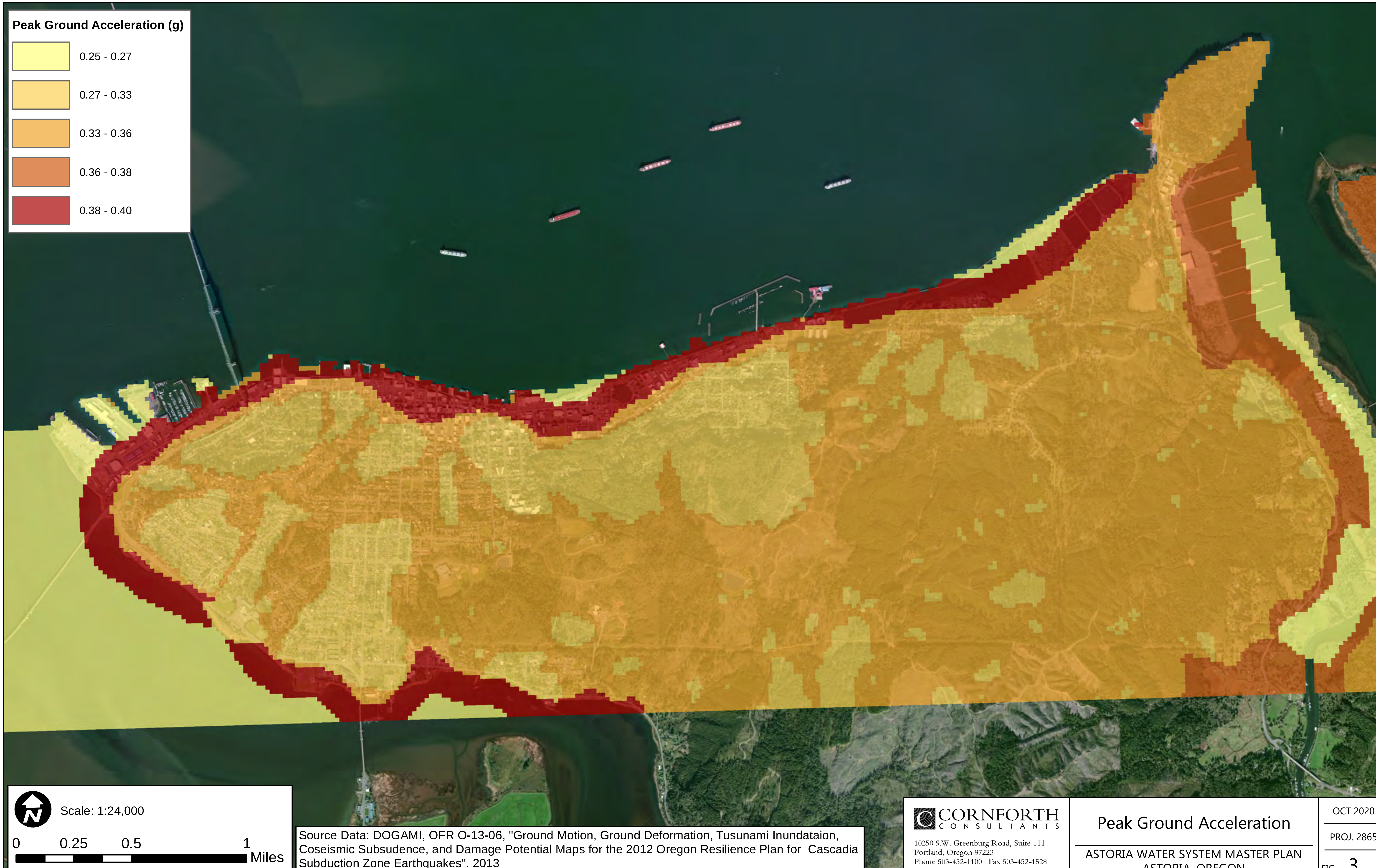
FIG. 2


Peak Ground Acceleration (g)
0.25 - 0.27
0.27 - 0.33
0.33 - 0.36
0.36 - 0.38
0.38 - 0.40
Scale: 1:24,000
0 0.25 0.5 1 Miles
Source Data: DOGAMI, OFR O-13-06, "Ground Motion, Ground Deformation, Tusunami Inundataion, Coseismic Subsudence, and Damage Potential Maps for the 2012 Oregon Resilience Plan for Cascadia Subduction Zone Earthquakes", 2013
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Peak Ground Acceleration
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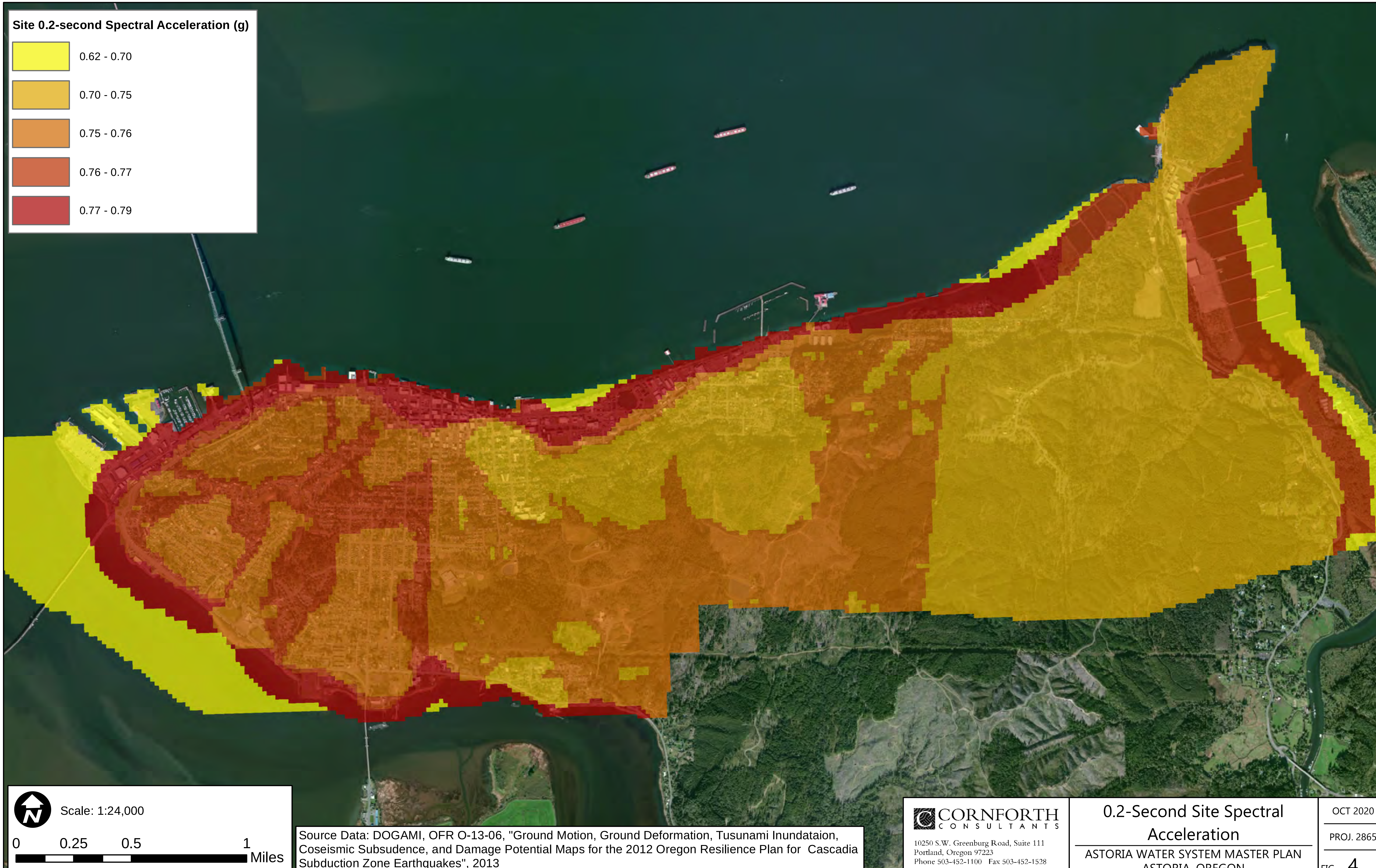
FIG. 3



Source Data: DOGAMI, OFR O-13-06, "Ground Motion, Ground Deformation, Tusunami Inundataion, Coseismic Subsudence, and Damage Potential Maps for the 2012 Oregon Resilience Plan for Cascadia Subduction Zone Earthquakes", 2013

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0.2-Second Site Spectral Acceleration

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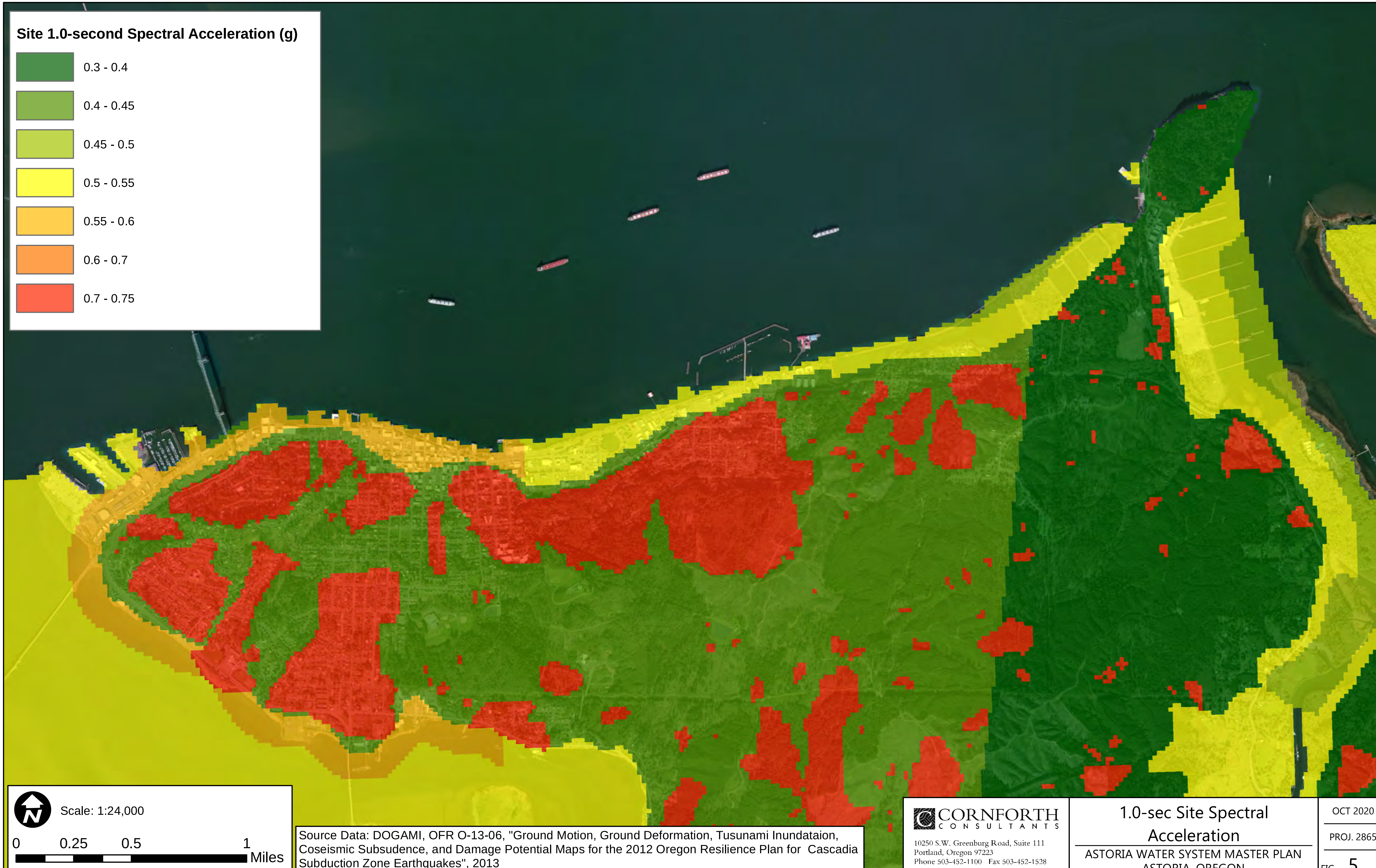
FIG. 4



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1.0-sec Site Spectral Acceleration

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FIG. 5


Liquefaction/Lateral Spread Probability
0 - 5%
5% - 10%
10% - 14%
14% - 18%
18% - 23%
Scale: 1:24,000
0 0.25 0.5 1 Miles
Source Data: DOGAMI, OFR O-13-06, "Ground Motion, Ground Deformation, Tusunami Inundataion, Coseismic Subsudence, and Damage Potential Maps for the 2012 Oregon Resilience Plan for Cascadia Subduction Zone Earthquakes", 2013
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Liquefaction/Lateral Spread Probability
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FIG. 6

Source Data: DOGAMI, OFR O-13-06, "Ground Motion, Ground Deformation, Tusunami Inundataion, Coseismic Subsidence, and Damage Potential Maps for the 2012 Oregon Resilience Plan for Cascadia Subduction Zone Earthquakes", 2013

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Portland, Oregon 97223
Phone 503-452-1100 Fax 503-452-1528

Liquefaction Displacement

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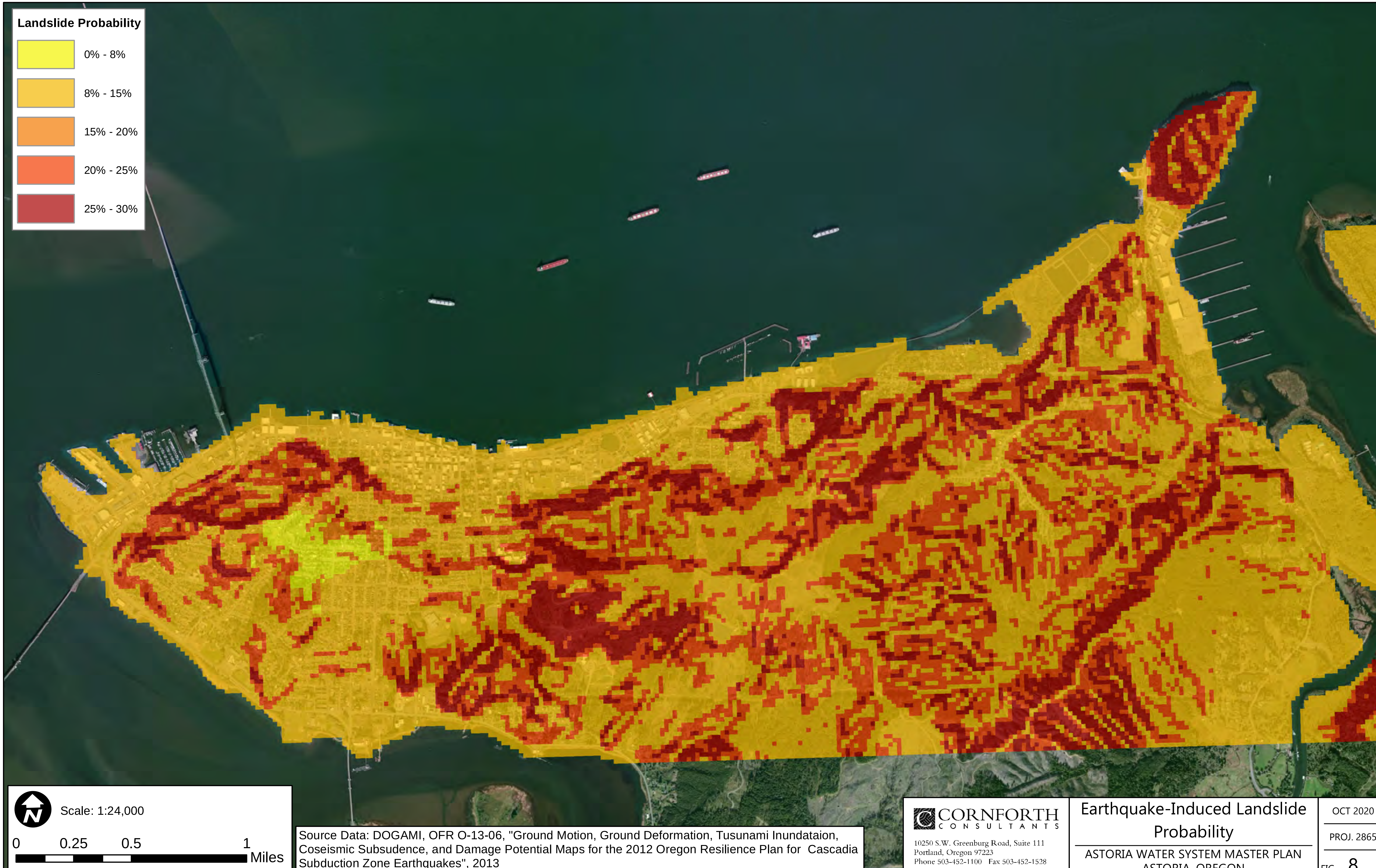
FIG. 7



Landslide Probability
0% - 8%
8% - 15%
15% - 20%
20% - 25%
25% - 30%
Scale: 1:24,000
0 0.25 0.5 1 Miles
Source Data: DOGAMI, OFR O-13-06, "Ground Motion, Ground Deformation, Tusunami Inundataion, Coseismic Subsudence, and Damage Potential Maps for the 2012 Oregon Resilience Plan for Cascadia Subduction Zone Earthquakes", 2013
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Portland, Oregon 97223
Phone 503-452-1100 Fax 503-452-1528
Earthquake-Induced Landslide Probability
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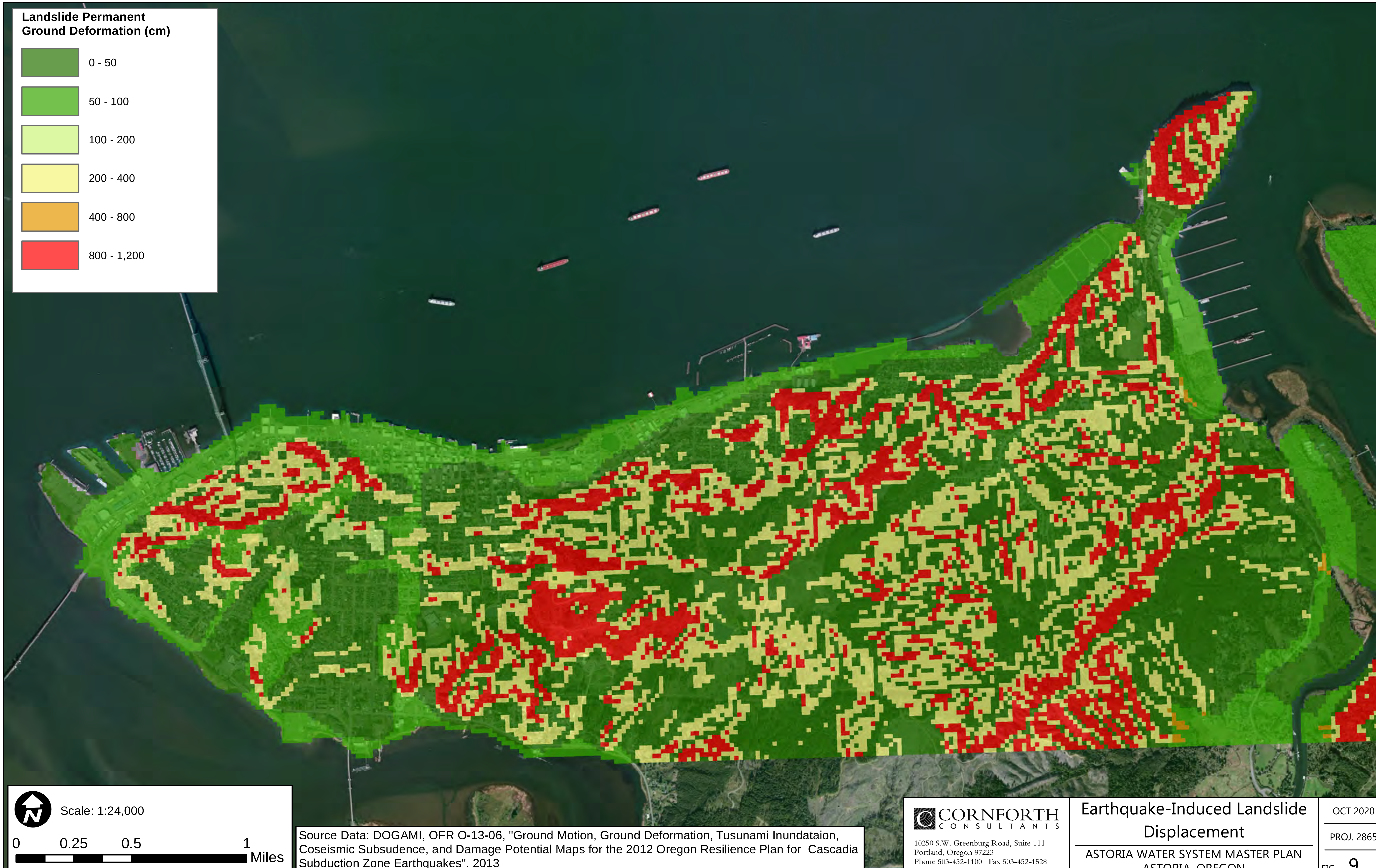
FIG. 8



Source Data: DOGAMI, OFR O-13-06, "Ground Motion, Ground Deformation, Tusunami Inundataion, Coseismic Subsudence, and Damage Potential Maps for the 2012 Oregon Resilience Plan for Cascadia Subduction Zone Earthquakes", 2013

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Phone 503-452-1100 Fax 503-452-1528

Earthquake-Induced Landslide Displacement

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FIG. 9

Appendix H. Seismic Vulnerability Assessment of Select Structures Technical Memorandum

WATER SYSTEM MASTER PLAN
SEISMIC AND TSUNAMI RESILIENCE ASSESSMENT

CITY OF ASTORIA PUBLIC WORKS DEPARTMENT
ASTORIA, OREGON

Final Technical Memorandum: Seismic Vulnerability Assessment of Select Structures

January 13th, 2021
SEFT Project Number: B20001.00

SEFT Consulting Group
4800 SW Griffith Drive, Suite 100
Beaverton, OR 97005

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Executive Summary

Events like Hurricane Katrina in 2005, the Great East Japan M9.0 Earthquake and Tsunami in 2011, and Hurricane Sandy in 2012 have underscored the devastating impacts that natural disasters can inflict at a local, regional, state, and multi-state level. One strategy to mitigate the effects of such a disaster is to plan for and implement programs and strategies to improve disaster resilience at the local, regional, state, and national level. In February of 2013, the Oregon Seismic Safety Policy Advisory Commission submitted a report to the 77th Legislative Assembly entitled the *Oregon Resilience Plan: Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami* (OSSPAC, 2013). The report discussed the risk that is faced by the citizens of Oregon from an impending Cascadia Subduction Zone earthquake and accompanying tsunami, the gaps that exist between the current state of Oregon's infrastructure and where it needs to be, and provided over 100 recommendations on how to improve the resilience of the State of Oregon and its local communities.

As part of the water master plan update, the City of Astoria is conducting a water system seismic resilience assessment to: 1) define water system level of service (LOS) goals for the City water system following a Magnitude 9.0 Cascadia Subduction Zone (M9.0 CSZ) earthquake and its ensuing tsunami, 2) identify key backbone system components that are required to achieve these LOS goals, 3) define performance criteria for individual system components that are required to achieve these LOS goals, 4) conduct a limited geotechnical seismic hazards evaluation for the City water system, 5) conduct a limited structural/nonstructural vulnerability assessment of key facilities selected by the City to determine estimated system performance following a M9.0 CSZ earthquake, 6) identify gaps between the LOS goals and current performance estimates, and 7) develop preliminary mitigation recommendations to close these gaps. This Technical Memorandum presents the HDR team findings and observations related to item 5.

The City of Astoria selected four (4) critical water system structures to evaluate as part of this project (Reservoir 2 Gate House, Reservoir 3 Gate House, East Astoria Tanks, and Skyline Tank). As part of the preliminary seismic structural/nonstructural vulnerability assessment, SEFT reviewed available existing drawings, performed site visits to observe the existing structures, and completed seismic evaluation checklists and quick-check calculations, based on a variety of national standards and guidelines including ASCE 41-17 *Seismic Evaluation and Retrofit of Existing Buildings* Tier 1 Screening Procedure and ASCE TCLEE Monograph 22 *Seismic Screening Checklists for Water and Wastewater Facilities,* to identify potential seismic deficiencies that have commonly been observed in past earthquakes.

Cornforth Consultants conducted a geotechnical seismic hazard assessment as part of this project and provided estimates of the spectral acceleration and permanent ground deformation (PGD) for liquefaction-induced lateral spreading and earthquake-induced landslide associated with a M9.0 CSZ scenario earthquake. They have estimated that the earthquake-induced landslide PGD at the four critical water system structures evaluated as part of this project could potentially range from 1.5 to 12.5 feet.

Based on the potential deficiencies identified in this vulnerability assessment, none of the evaluated structures are currently expected to achieve the performance objectives that are required to meet water system post-earthquake level of service goals (i.e., Immediate Occupancy structural performance or Operational nonstructural performance) for a M9.0 CSZ earthquake. Additionally, based on the potential deficiencies identified in this assessment, the Reservoir 2 and Reservoir 3 Gate Houses are not currently expected to achieve Life Safety performance and represents a potential safety hazard to City staff and contractors during and after an earthquake.

The findings of this seismic evaluation should be integrated with the findings of previous seismic studies of other water system components and future seismic and tsunami assessments (as appropriate) of the remaining water system components to develop a holistic view of the expected seismic performance of the water system. This knowledge can be leveraged in developing a comprehensive long-term plan for implementing water system seismic and tsunami resilience improvements. In the near-term, the City is strongly encouraged to implement a seismic retrofit program to address Life Safety seismic deficiencies for water system structures that are frequently accessed by City staff and contractors.

1.0 Introduction and Background

1.1 City of Astoria Water System Description

The City of Astoria relies on the City-owned Bear Creek Watershed to supply water for the City's approximately 10,000 residents and commercial customers, including the City's tourism-based businesses and seafood industries. In the watershed, Bear and Cedar Creeks feed three source water reservoirs (Bear Creek Reservoir, Middle Lake, and Wickiup Lake). Raw water from these reservoirs is treated by a slow sand filtration plant located near Bear Creek Reservoir (approximately 10 miles east of the City). Treated water is delivered to two in-town earthen reservoirs (Reservoir 2 and Reservoir 3) by a 21-inch diameter concrete cylinder pipe transmission main that is approximately 12 miles in length. The majority of the City's service area is supplied by one of two different pressure zones (either high or low). Certain higher elevation areas in the City are served by a combination of two in-town tanks (East Astoria and Skyline) and four booster pump stations. The City's distribution system consists of approximately 80 miles of pipelines up to 24 inches in diameter and constructed from multiple different materials (including cast iron, ductile iron, transite, galvanized steel, PVC, and HDPE). On average, more than 2.0 million gallons per day of water is produced and distributed to the community. More than 4.0 million gallons may be used per day during the peak summer season. The City of Astoria also provides drinking water to seven outlying water districts with a total of approximately 613 customer connections.

1.2 Seismic Resilience Assessment

Based on Oregon Health Authority requirements for water master plan updates, the City of Astoria is conducting a water system seismic resilience assessment. The City has previously conducted: 1) a seismic stability evaluation of Bear Creek Dam (Cornforth, 2016) and 2) a seismic resilience assessment of the 12-mile-long water transmission main between Bear Creek Dam and Reservoirs 2 and 3 (Hart Crowser, 2019). This current assessment will evaluate the expected performance of the City water system following a Magnitude 9.0 (M9.0) Cascadia Subduction Zone (CSZ) earthquake and associated tsunami, and identify preliminary recommendations for improvements that should be implemented to enable the City to more rapidly restore water service after a major earthquake, to meet community social and economic needs. The scope of this seismic resilience study includes:

1. Define water system level of service (LOS) goals for the City water system following a M9.0 Cascadia Subduction Zone Earthquake and its ensuing tsunami;
2. Identify key backbone system components that are required to achieve these LOS goals, including the locations of key supply points for water for fire suppression and community water distribution;
3. Define performance criteria for individual system components that are required to achieve these LOS goals;

4. Conduct a limited geotechnical seismic hazards evaluation for the City water system (Cornforth);
5. Conduct a preliminary structural/nonstructural vulnerability assessment of four key facilities selected by the City to determine estimated system performance following a M9.0 CSZ earthquake (SEFT);
6. Identify gaps between the LOS goals and current performance estimates; and
7. Develop preliminary mitigation recommendations (HDR) to close these gaps utilizing new or retrofit infrastructure, changes to design standards, enhancements in emergency response planning, and recommendations for further study.

This Technical Memorandum (TM) presents SEFT's findings related to scope item 5. The components of the water system that have been evaluated by SEFT as part of this effort are summarized in Table 1.1. The locations of these components are illustrated in Figure 1.1. To complete this scope of work, SEFT utilized the Final TM: Level of Service Goals, Performance Objectives, and Water System Backbone (SEFT, 2020) completed as part of this project, and the as-built drawings indicated in Table 1.2.

Table 1.1 – Summary of Water System Components Evaluated by SEFT

Water System Component	Structure Type	Year of Original Construction
Reservoir 2 Gate House	Stone Masonry (above-grade) and Plain Concrete (below-grade gate well)	1895
Reservoir 3 Gate House	Reinforced Concrete (above-grade) and Plain Concrete (below-grade gate well)	1919
East Astoria Tanks	Reinforced Concrete	1998
Skyline Tank	Factory-Coated Bolted Carbon Steel	2006

Table 1.2 – Evaluation Documents

Water System Component	As Built Drawing
Reservoir 2 Gate House	"Plan of Astoria Power & Gate House," dated August 1938
Reservoir 3 Gate House	"Astoria Water Works – Gate House for the High Service Reservoir: Reservoir No. 3," dated March 1917
East Astoria Tanks	"Construction Drawings for East Astoria Water Storage tanks for the City of Astoria" by KCM, Inc, dated September 1998 and requested changes from Mike Caccavano, Astoria City Engineer, dated October 1998
	"Structural Plans and Details for 30 foot diameter Water Reservoir" by Dibble Engineering, dated March 1998
Skyline Tank	"Skyline Reservoir & Water System Improvements" by Erwin Consultant Engineering, dated May 2004

Figure 1.1 – Location Map for Water System Components Evaluated by SEFT

2.0 Evaluation Methodology and Seismic Performance Objectives

2.1 Seismic Hazard

This evaluation considered a single seismic hazard level associated with a M9.0 scenario earthquake originating on the Cascadia Subduction Zone (CSZ). As part of this project, Cornforth Consultants conducted a geotechnical seismic hazard assessment (Cornforth, 2020). In their report, Cornforth Consultants provided estimates of the spectral acceleration and permanent ground deformation (PGD) for liquefaction-induced lateral spreading and earthquake-induced landslide associated with a M9.0 CSZ scenario earthquake. This geotechnical data is summarized in Table 2.1 and was used to inform SEFT's structural and nonstructural evaluation.

2.2 Seismic Performance Objectives

In the initial phase of this project, the HDR/SEFT team worked with the City of Astoria to establish proposed level of service (LOS) goals for the City of Astoria water system following a major earthquake, as described in SEFT (2020). The structural and nonstructural performance objectives used for evaluation of water system components for a M9.0 CSZ scenario earthquake were based on these LOS goals and are described in Sections 2.2.1 and 2.2.2.

2.2.1 Structural Performance Objective

Immediate Occupancy: "Immediate Occupancy" refers to the post-earthquake damage state in which only very limited structural damage has occurred. The basic vertical- and lateral-force-resisting systems of the building retain almost all their pre-earthquake strength and stiffness. The risk of life-threatening injury from structural damage is very low, and although some minor structural repairs might be appropriate, these repairs would generally not be required before re-occupancy. Continued use of the building is not limited by its structural condition but might be limited by damage or disruption to nonstructural elements of the building, furnishings, or equipment and availability of external utility services.

2.2.2 Nonstructural Performance Objectives

Operational: "Operational" refers to the performance level where most nonstructural systems required for normal use of the building are functional, although minor cleanup and repair of some items might be required. Achieving the Operational nonstructural performance level requires considerations of many elements beyond those that are normally within the sole province of the structural engineer's responsibilities. For Operational nonstructural performance, in addition to ensuring that nonstructural components are properly mounted and braced within the structure, it is often necessary to provide emergency standby equipment to provide utility services from external sources that might be disrupted. It might also be necessary to perform seismic qualification testing to ensure that all necessary equipment will continue to function during and after strong shaking.

2.3 Water System Evaluation Methodology

The preliminary seismic structural evaluations of the Reservoir 2 and 3 Gate House structures were completed using the Tier 1 Screening Procedure of ASCE 41-17 *Seismic Evaluation and Retrofit of Existing Buildings* (ASCE, 2017a). This Tier 1 evaluation procedure uses a checklist-based approach to identify potential seismic structural deficiencies that have been commonly observed in past earthquakes. The Tier 1 procedure also uses quick-check calculations to evaluate potential deficiencies in the primary components of the seismic load resisting system.

The seismic evaluation approach for the conventionally reinforced concrete water storage tanks (East Astoria Tanks) has been adapted from the Tier 1 Screening Procedure of ASCE 41-17. The ASCE 41 Tier 1 procedure uses a quick-check calculation approach with unreduced (i.e., response modification factor, R is set equal to 1.0) and non-amplified (i.e., importance factor, I is set equal to 1.0) seismic loads. The demand capacity ratio for seismic force resisting system elements is compared to ASCE 41 specified component modification factors (m-factors) to evaluate the acceptability of components of the structure for the Immediate Occupancy structural performance objective. Earthquake-induced hydrodynamic forces were calculated using the procedure outlined in American Concrete Institute (ACI) standard ACI 350.3-06 *Seismic Design of Liquid-Containing Concrete Structures and Commentary* (ACI, 2006) modified by ASCE 7-16 *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* ASCE, 2017b). Consistent with ACI 350.3, soil loads were neglected where they act to decrease the demand on buried portions of tank concrete walls.

For the Skyline Tank (factory-coated bolted carbon steel), a different evaluation approach was used because ASCE 41-17 does not include quick-check evaluations and acceptance criteria that are applicable to this type of tank. American Water Works Association (AWWA) standard design checks were evaluated for primary components of the seismic load path. Earthquake-induced hydrodynamic forces were calculated using the procedure outlined in AWWA D103-09 *Factory-Coated Bolted Carbon Steel Tanks for Water Storage* (AWWA, 2009), as modified by ASCE 7-16.

Freeboard calculations where completed based on both the applicable ACI/AWWA design standard and ASCE 7-16. The required freeboard calculated using ASCE 7-16 varies from that calculated using the ACI/AWWA standards. This study used the more conservative of the freeboard estimates calculated using both methods. The recommended freeboard calculations used a seismic importance factor equal to 1.0, as indicated in the applicable standards. In order to ensure Immediate Occupancy structural performance for the M9.0 CSZ event, we have increased the calculated freeboard values by a factor equal to 1.5.

The seismic nonstructural evaluation of components within the City of Astoria water system was completed using the nonstructural seismic evaluation checklists presented in ASCE 41-17 supplemented by TCLEE Monograph No. 22 *Seismic Screening Checklists for Water and Wastewater Facilities* (TCLEE, 2002). Similar to the ASCE 41 Tier 1 structural evaluation procedure, this checklist-based evaluation approach is used to identify potential seismic nonstructural deficiencies that have been commonly observed in past earthquakes.

Site visits to these four structures were conducted by SEFT on August 13th, 2020. Site observation was limited to those areas readily accessible to view, and did not include any areas concealed by existing finishes, such as ceilings, soffits, roofing, etc. Site observation did not include entry into any permit required confined spaces and did not include any entry or observation inside the tanks. A detailed structural condition assessment of these structures was not included in the scope of this project.

Table 2.1 – Summary of Geotechnical Seismic Hazard Data
(Source: Cornforth, 2020)

Water System Component	Short Period Spectral Acceleration (g)	One-Second Spectral Acceleration (g)	Liquefaction/ Lateral Spreading PGD	Landslide PGD
Reservoir 2 Gate House	0.76	0.41	<1 cm	50-375 cm (1.67-12.5 ft)
Reservoir 3 Gate House	0.76	0.40	<1 cm	50-300 cm (1.67-10 ft)
East Astoria Tanks	0.75	0.40	<1 cm	50-375 cm (1.67-12.5 ft)
Skyline Tank	0.76	0.41	<1 cm	50-75 cm (1.67-2.5 ft)

3.0 Expected Seismic Structural and Nonstructural Performance

The expected structural and nonstructural seismic performance of select City of Astoria water system components has been evaluated for a M9.0 CSZ scenario earthquake. Sections 3.1 through 3.4 provide a short narrative description of the water system component evaluated, followed by a table that summarizes the potential seismic structural and nonstructural deficiencies identified by the seismic evaluation procedures described in Section 2.3. Sections 3.1 through 3.4 also include images from the as-built drawings where structural deficiencies are identified, and selected photos taken during site visits conducted on August 13th, 2020.

3.1 Reservoir 2 Gate House

The Reservoir 2 Gate House (see Figure 3.1) was constructed in 1895 to support operation of Reservoir 2. Reservoir inlet piping passes through the gate house in a trench that is located at the east end of the building, and reservoir outlet piping, bypass piping, and a riveted steel tank (approximately 6,000 gallon capacity) are located in the gate well at the west end of the building. The gate house also contains chlorination equipment that is used to inject additional chlorine into the water system, as required.

The overall plan dimensions of the building are approximately 64 feet in the east-west direction by 28 feet in the north-south direction (see Figure 3.2). The floor to roof height is approximately 27 feet for the east (rectangular) portion of the building and 22 feet for the west (semicircular) portion of the building. At the west end of the building, the circular wall of the below-grade gate well (approximately 23 feet depth) is constructed from plain concrete. The above-grade walls of the building are constructed from stone masonry.

The main floor level for the east portion of the building consists of a concrete slab on grade with a T-shaped trench for reservoir inlet and bypass piping. The main floor level for the west portion of the building (over the gate well) consists of wood straight sheathing supported by wood joists. These wood joists are supported by both a short height of circular stone masonry wall (which is in turn supported by a circular plain concrete wall) and an east-west oriented wood beam at the middle of the gate well. This wood beam is supported by the circular stone masonry wall and supplemental posts (wood on one end and a steel tube section on the other end). The building was originally constructed with a wood-framed second floor level and pitched roof. The City indicated that sometime around the 1950's, the original roof system was removed and replaced with a flat roof, consisting of precast concrete planks. Additionally, the original wood-framing for the second floor of the building and associated stairs were removed, modifying the building from two stories to a single story (above-grade).

A wood-framed SCADA system enclosure and emergency generator (in a fenced enclosure) are located immediately to the south of the Reservoir 2 Gate House. The generator provides backup power for the chlorination system, SCADA system, and Reservoir 2 cover drain system pumps.

Table 3.1 presents a summary of potential seismic structural and nonstructural deficiencies identified by this evaluation. Based on the potential deficiencies identified in Table 3.1, the Reservoir 2 Gate House is not expected to achieve Immediate Occupancy structural performance or Operational nonstructural performance for a M9.0 CSZ earthquake. Additionally, based on the potential deficiencies identified in this assessment, the Reservoir 2 Gate House is also not expected to achieve Life Safety performance and represents a safety hazard to City staff and contractors during and after an earthquake.

Table 3.1 – Reservoir 2 Gate House Seismic Evaluation Summary

Potential Deficiencies	Description
Structural	• Per the Geotechnical Report, there is a possibility of earthquake-induced landslides resulting in a significant level (1.5 to 12.5 feet) of permanent ground deformation (PGD). This level of PGD will likely cause damage to the Reservoir 2 Gate House and associated buried piping. **Stone Masonry Building** • Figure 3.3 shows a horizontal band where the original second floor framing was previously pocketed into the stone masonry walls. The removal of the second floor resulted in stone masonry walls with a large height-to-thickness ratio. These bearing walls could potentially fall into or away from the building when subjected to out-of-plane loading during an earthquake, resulting in a partial or complete collapse of the building. • The exterior face of the building's masonry walls was constructed from rectangular cut stones. The interior face of the walls was constructed from more irregularly shaped stones. The walls are approximately 20 inches thick, but is uncertain if there are any significant voids between the exterior and interior wythes of stone, or if the walls are mortared solid. Even if the stone masonry walls are completely solid, they may not have adequate strength to resist the expected seismic forces. • Existing cracking in the interior stone masonry wall (above the doorway) may reduce the capacity of the wall to resist seismic forces. See Figure 3.4.

Table 3.1 – Reservoir 2 Gate House Seismic Evaluation Summary (cont.)

Potential Deficiencies	Description
Structural (cont.)	• Several window openings are missing a lintel beam on the interior face of the wall. Additional cracking of the masonry walls around these window openings may occur during an earthquake because of the missing portions of lintel. See Figure 3.5. • The current roof diaphragm consists of precast concrete planks (see Figure 3.6), spanning in the north-south direction, that replaced the original wood-framed pitched roof. There are no drawings available related to this roof replacement. Based on the construction vintage of this roof replacement (1950's), it is anticipated that an adequate shear connection was not provided between adjacent concrete planks to resist the expected seismic diaphragm forces. • Based on field observations, there was no visual indication of a positive connection between the precast concrete plank roof diaphragm and the stone masonry walls. See Figure 3.7. **Below-Grade Gate Well** • Based on field observation of an approximate 4 by 6 foot wall opening, which appears to have been constructed after the walls were originally cast, there is not a visible indication that the gate well concrete walls are reinforced (i.e., cut reinforcing bar ends). These plain concrete walls may not have adequate capacity to resist the expected seismic forces resulting from earthquake-induced landslide PGD. • The wood-framed floor over the gate well consists of straight sheathing that has a limited capacity to resist the expected seismic forces. See Figure 3.8. • The wood-framed floor over the gate well appears to lack adequate positive connections between the wood joists, wood beam, wood and steel posts, short height of stone masonry wall, and plain concrete wall to resist the expected seismic forces. See Figures 3.9 and 3.10.

Table 3.1 – Reservoir 2 Gate House Seismic Evaluation Summary (cont.)

Potential Deficiencies	Description
Nonstructural	• Some pipe, fittings, and valves associated with the gate house may be cast-iron, which is a brittle material that may crack when subjected to earthquake shaking-induced forces and/or ground deformation. • Piping that penetrates through the gate house walls or floors may not have adequate flexibility to accommodate potential differential movement between the gate house and the surrounding soil at the pipe penetration. See Figure 3.11. • The piping, flowmeter, and valves in the in-floor trench are supported on pipe stanchions that provide gravity support, but do not provide adequate bracing to resist seismic forces. See Figure 3.12. • The vertical segment of bypass piping and the valve operator stems in the gate well are approximately 20 feet tall and lack any mid-height bracing. See Figure 3.13. • The 1895 vintage rivetted steel tank located in the gate well (see Figure 3.14) likely does not have adequate capacity to resist the expected seismic loads. Also, based on site visit observations, there are no anchors connecting the tank to the concrete foundation (see Figure 3.15). • The chlorination system and spill containment skids are not adequately anchored to the concrete slab to resist the expected seismic forces. See Figure 3.16. • The backup battery associated with the chlorination system is restrained against toppling and transverse movement by a zip tie, but is unrestrained against sliding in the longitudinal direction. See Figure 3.17. • Details of the connections between the chlorination room partition wall to the concrete masonry unit (CMU) curb and CMU curb to concrete slab are unknown. The wall and/or curb connections may not have adequate capacity to resist the expected seismic forces. See Figure 3.18. • The crane rail system in the building may not have adequate capacity to resist the expected seismic forces. Since it is no longer in use, the City should consider removing the crane rail system. See Figure 3.19.

Table 3.1 – Reservoir 2 Gate House Seismic Evaluation Summary (cont.)

Potential Deficiencies	Description
Nonstructural (cont.)	• Stone masonry parapets may exceed height-to-thickness ratio limits and may present a falling hazard during an earthquake. • The wood-framed SCADA enclosure may not have adequate capacity to resist the expected seismic forces. See Figure 3.20. • The SCADA system backup battery is not adequately restrained. See Figure 3.21. • The roof was not accessed during the site visit. Therefore, the adequacy of the SCADA antenna anchorage/bracing could not be verified. • The emergency generator starter battery is not adequately restrained. See Figure 3.22.

(a) View from North

(b) View from South

Figure 3.1 – Reservoir 2 Gate House

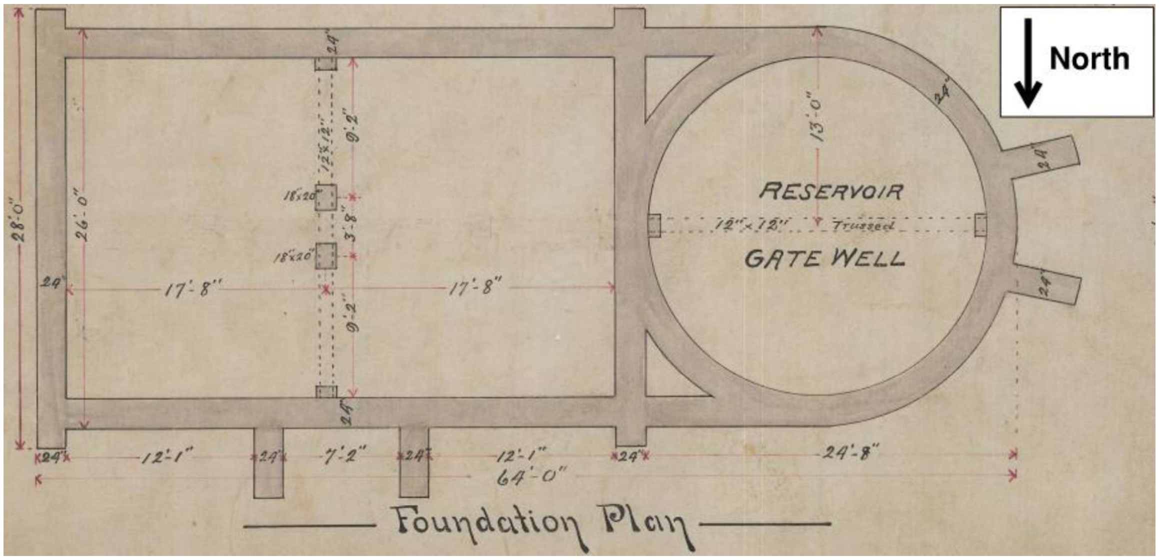


Figure 3.2 – Reservoir 2 Gate House Foundation Plan
(Source: Plan of Astoria Power & Gate House, dated August 1938)

Figure 3.3 – Horizontal Band on East Wall where Original 2nd Floor was Removed

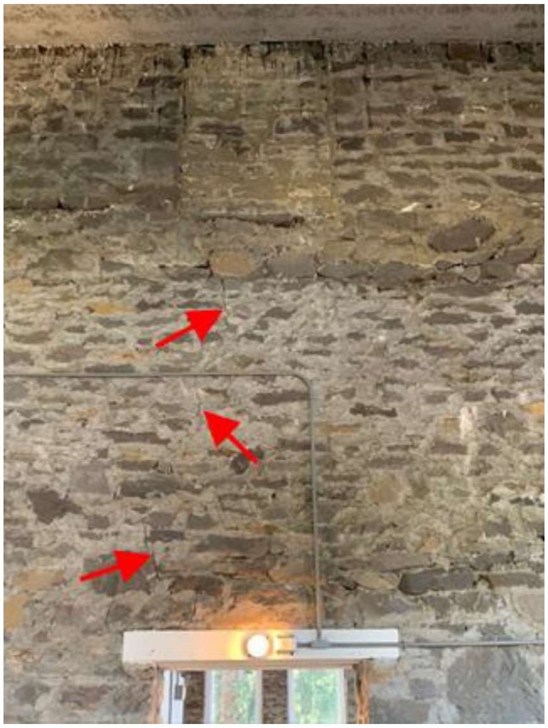


Figure 3.4 – Cracking of Interior Stone Masonry Wall Above Door Opening

Figure 3.5 – Missing Partial Thickness of Wood Lintel Beams Above Window Openings

Figure 3.6 – Diaphragm Built of Concrete Planks with Unclear Shear Transfer Mechanism Between Planks

Figure 3.7 – No Evidence of Positive Connection Between Concrete Roof Diaphragm and Stone Masonry Walls

Figure 3.8 – Straight-Sheathed Wood Diaphragm

(a) Joist-to-Beam

(b) Joist-to-Wall

Figure 3.9 – Joists Supporting Floor Above Gate Well Lack Positive Connections Between Framing Members

(a) Beam-to-Wall

(b) Post to Slab-on-Grade

Figure 3.10 – Beam and Post Supporting Floor Above Gate Well Lack Positive Connections Between Framing Members

Figure 3.11 – Reservoir Inlet Pipe Penetrating Gate House Stone Masonry Wall without Adequate Flexibility

Figure 3.12 – Piping, Valves and Flowmeter not Braced

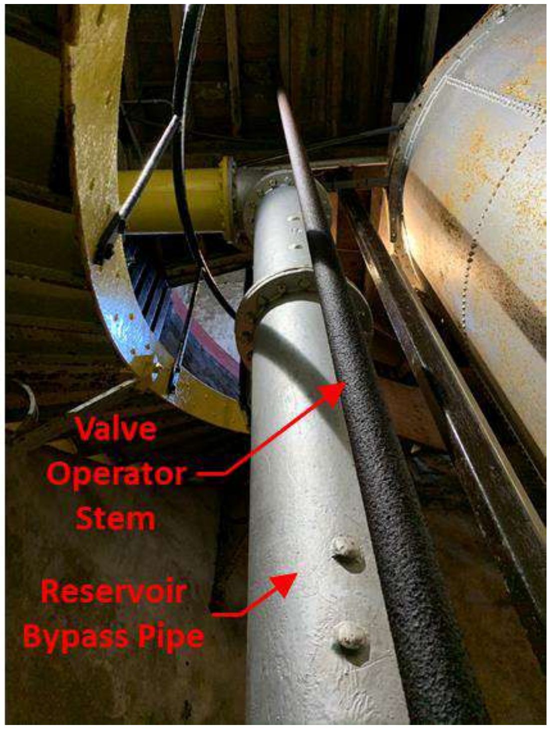


Figure 3.13 – Vertical Pipe and Valve Operator Stem not Braced

Figure 3.14 – Rivetted Steel Tank

Figure 3.15 – Steel Tank Lacks Anchorage to Resist Sliding and Overturning

Figure 3.16 – Chlorination System and Spill Containment Skids not Adequately Restrained

Figure 3.17 – Chlorination System Backup Battery not Adequately Restrained

Figure 3.18 – Connection Details Between Partition Wall to CMU Curb and CMU Curb to Concrete Slab are Unknown

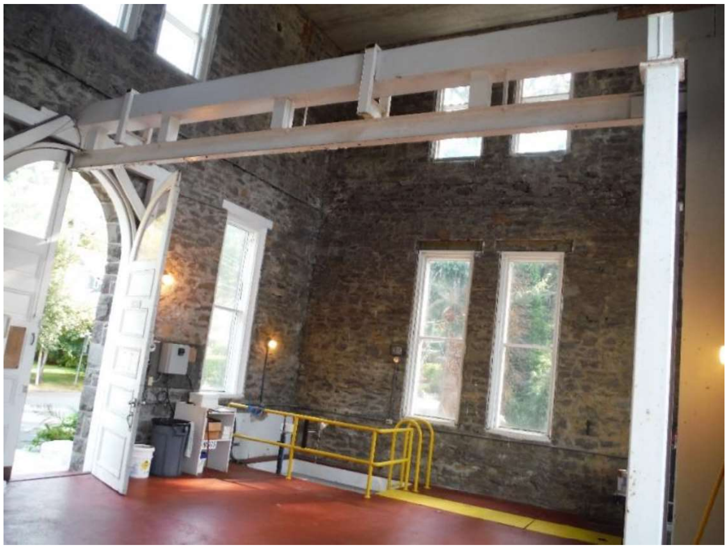


Figure* 3.19 *– Crane Rail System (no longer in use)

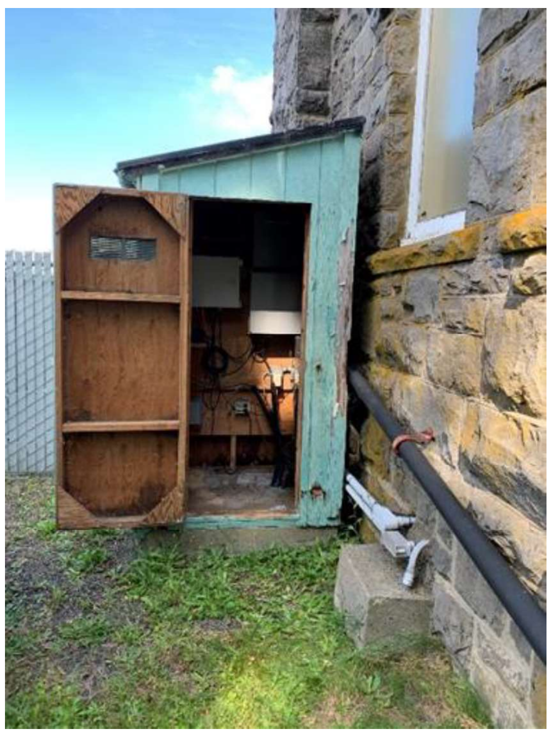


Figure 3.20 – Wood-Framed SCADA Enclosure with Limited Capacity to Resist Seismic Forces

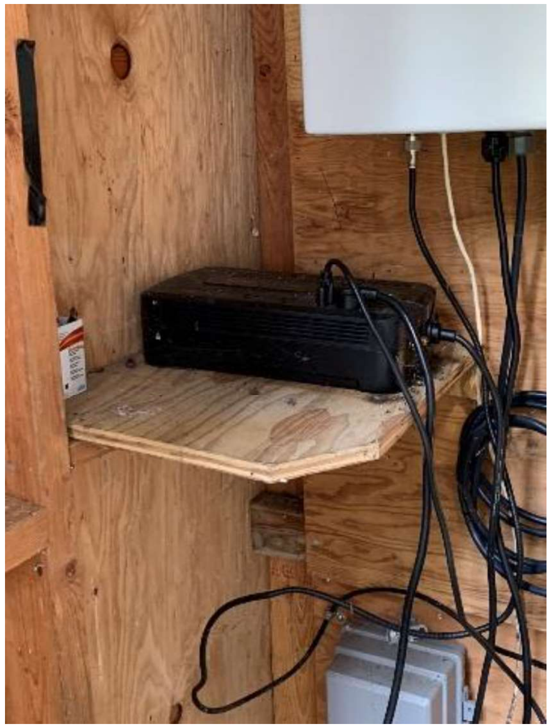


Figure 3.21 – SCADA Backup Battery not Restrained

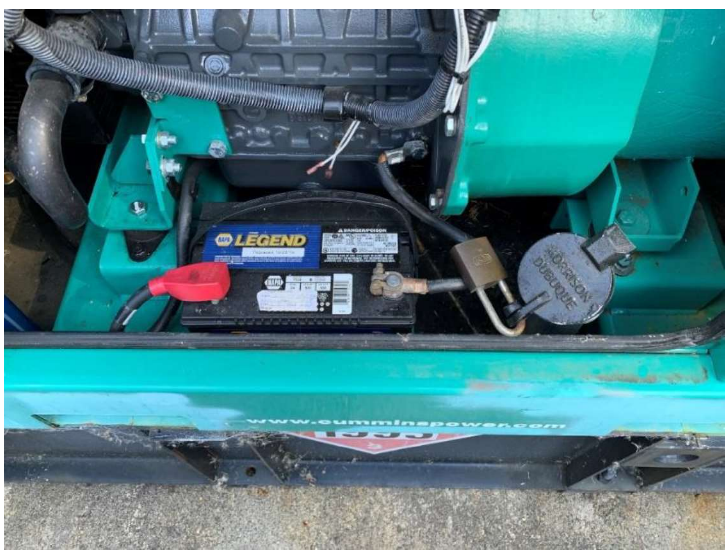


Figure 3.22 – Emergency Generator Starter Battery not Adequately Restrained

3.2 Reservoir 3 Gate House

The Reservoir 3 Gate House (see Figure 3.23) was constructed in 1919 to support operation of Reservoir 3. Reservoir inlet, outlet, and bypass piping passes through the gate well at the north end of the building. The gate well has a water storage capacity of approximately 63,000 gallons. The gate house also contains chlorination equipment that is used to inject additional chlorine into the water system, as required.

The overall plan dimensions of the building are approximately 36 feet in the north-south direction by 23 feet in the east-west direction (see Figure 3.24). The top of the building roof slab is approximately 17 feet above the main floor elevation. At the north end of the building, the below-grade gate well circular wall (approximately 32 feet depth) is constructed from plain concrete with walls that vary in thickness from 18 to 30 inches. The single-story, above-grade exterior walls of the building are constructed from reinforced concrete and are nominally 14 inches thick. An interior wall that divides the north and south portions of the building is constructed of plain concrete and is 8 inches thick.

The main floor level for the south portion of the building consists of a concrete slab on grade. The main floor level for the north portion of the building (over the gate well) consists of an elevated concrete slab (reinforced with triangular steel mesh) supported by concrete composite beams and girders (concrete encased steel I-beams). Similar to the floor above the gate well, the roof of the building consists of a concrete slab (reinforced with triangular steel mesh) supported by concrete composite beams and girders (concrete encased steel I-beams). An additional roof slab layer is provided over portions of the building to provide slope for roof drainage (see Figure 3.25).

A wood-framed SCADA system enclosure is located immediately to the south of the Reservoir 3 Gate House (see Figure 3.26). The SCADA system at the Reservoir 3 Gate House also currently functions as a repeater for SCADA communications between the slow sand filtration plant (located near Bear Creek Reservoir) and the City of Astoria Shops (located on 30th Street in downtown Astoria). However, the City already has a future plan to use an alternative location as the SCADA repeater between the plant and the City Shops. An emergency generator is located further to the south in a fenced enclosure and has a steel framed cover (see Figure 3.27). The generator provides backup power for the chlorination system, SCADA system, and Reservoir 3 cover drain system pumps.

Table 3.2 presents a summary of potential seismic structural and nonstructural deficiencies identified by this evaluation. Based on the potential deficiencies identified in Table 3.2, the Reservoir 3 Gate House is not expected to achieve Immediate Occupancy structural performance or Operational nonstructural performance for a M9.0 CSZ earthquake. Additionally, based on the potential deficiencies identified in this assessment, the Reservoir 3 Gate House is also not expected to achieve Life Safety performance and represents a safety hazard to City staff and contractors during and after an earthquake.

Table 3.2 – Reservoir 3 Gate House Seismic Evaluation Summary

Potential Deficiencies	Description
Structural	• Per the Geotechnical Report, there is a possibility of earthquake-induced landslides resulting in a significant level of PGD (1.5 to 10 feet). This level of PGD will likely cause damage to the Reservoir 3 Gate House and associated buried piping. **Concrete Building** • It is likely that the roof and floor diaphragm to shear wall connections do not have adequate capacity to develop the lesser of the shear strength of the walls or diaphragms. Drawings from original construction show that steel reinforcing mesh from the roof and floor slabs was extended into the walls, but this detail is unlikely to provide adequate capacity. See Figure 3.28. • Several potential deficiencies are likely that are associated with detailing requirements for reinforcing steel [reinforcing ratio, minimum spacing limits (see Figure 3.29), and reinforcing at openings, and foundation dowels]. • During the site visit, two areas of concrete spalling and steel corrosion were observed (see Figure 3.30). One area of concrete spalling and reinforcing steel corrosion was observed on the interior face of the north curved wall of the gate house. This spall is approximately 3 feet down from the underside of the roof. A second area of concrete spalling and corrosion on an embedded steel beam was observed to occur on the underside of the floor over the top of the gate well, just to the west of the gate well access hatch (as observed through the access hatch). This existing concrete and steel damage may reduce the capacity of the structure. **Below-Grade Gate Well** • The walls of the below-grade gate well are constructed of plain concrete. These plain concrete walls may not have adequate capacity to resist the combination of hydrostatic forces, hydrodynamic forces and/or the expected seismic forces resulting from earthquake-induced landslide PGD.

Table 3.2 – Reservoir 3 Gate House Seismic Evaluation Summary (cont.)

Potential Deficiencies	Description
Nonstructural	• Some pipe, fittings, and valves associated with the gate house may be cast-iron, which is a brittle material that may crack when subjected to earthquake shaking-induced forces and/or ground deformation. • Piping that penetrates through the gate house walls or floors may not have adequate flexibility to accommodate potential differential movement between the gate house and the surrounding soil at the pipe penetration. • The adequacy of the bracing of vertical overflow piping in the gate well (shown on the available construction drawings) is unknown. • The chlorination system and spill containment skid are not adequately anchored to the concrete slab to resist the expected seismic forces. See Figure 3.31. • The backup battery associated with the chlorination system is not adequately restrained. See Figure 3.32. • The adequacy of the bracing of the ceiling system in the south portion of the building (chlorination room) is unknown. (Note: the above ceiling space was not accessible during the site visit.) • There are storage shelves in the building that appear to be unanchored and the contents of the shelves are not restrained. See Figure 3.33. • The crane rail systems in the building may not have adequate capacity to resist the expected seismic forces. Since they are no longer in use, the City should consider removing the crane rail systems. See Figure 3.34. • A pumping system and associated valves in the gate house are not adequately anchored/braced (see Figure 3.35). However, it is acknowledged that this pumping system is currently only used to clean the reservoir cover, and may not be critical to the functionality of the gate house after an earthquake. • The valve operator stems in the gate well are approximately 30 feet tall and may not be adequately braced. • On the exterior of the building, conduits from below grade connect to electrical cabinets without apparent flexibility to accommodate potential relative movement between the structure and the surrounding soil in which the conduits are buried. See Figure 3.36.

Table 3.2 – Reservoir 3 Gate House Seismic Evaluation Summary (cont.)

Potential Deficiencies	Description
Nonstructural (cont.)	• The wood-framed SCADA enclosure may not have adequate capacity to resist the expected seismic forces. See Figure 3.37. • The SCADA backup battery is not adequately restrained. See Figure 3.38. • The edge distance is potentially not adequate for the anchors connecting the SCADA antenna to the roof concrete slab. See Figure 3.39. • The emergency generator starter battery is not adequately restrained. See Figure 3.40.

(a) View from North

(b) View from East

Figure 3.23 – Reservoir 3 Gate House

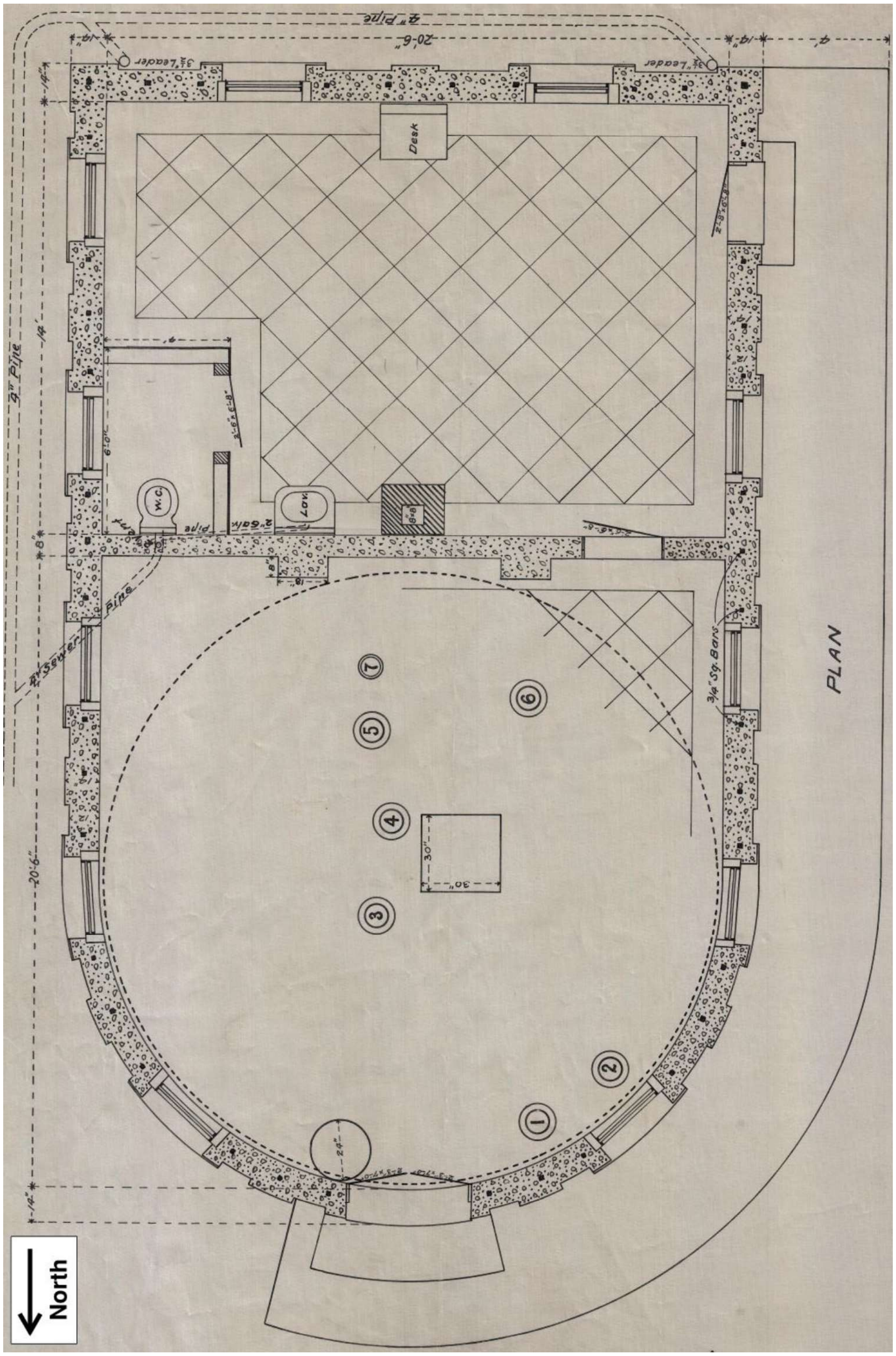


Figure 3.24 – Reservoir 3 Gate House Plan
(Source: Drawings of Astoria Water Works – Gate House for the High Service Reservoir: Reservoir No. 3)

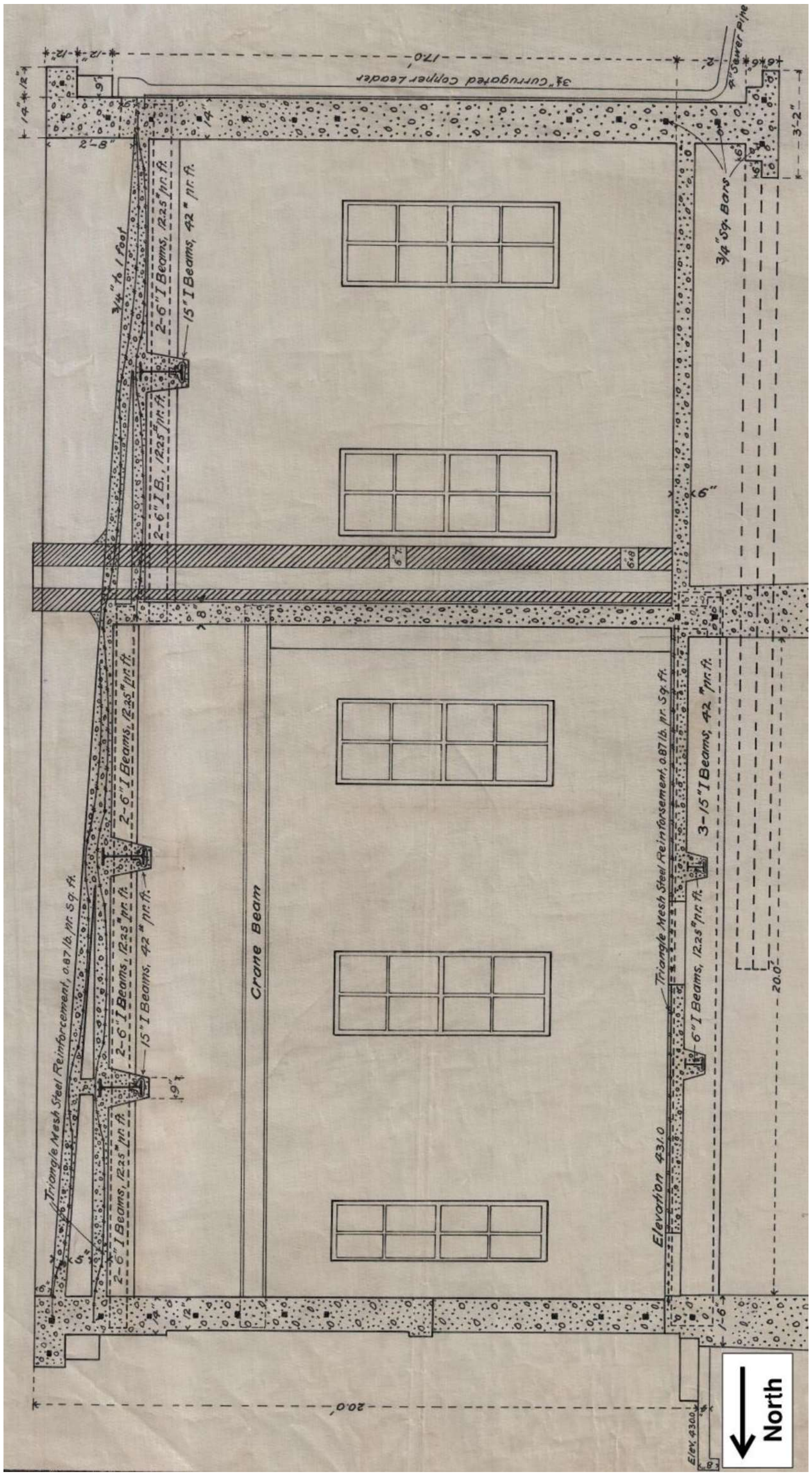


Figure 3.25 – Reservoir 3 Gate House Section
(Source: Drawings of Astoria Water Works – Gate House for the High Service Reservoir: Reservoir No. 3)

Figure 3.26 – Reservoir 3 Wood-Framed SCADA Enclosure

Figure 3.27 – Reservoir 3 Gate House Emergency Generator

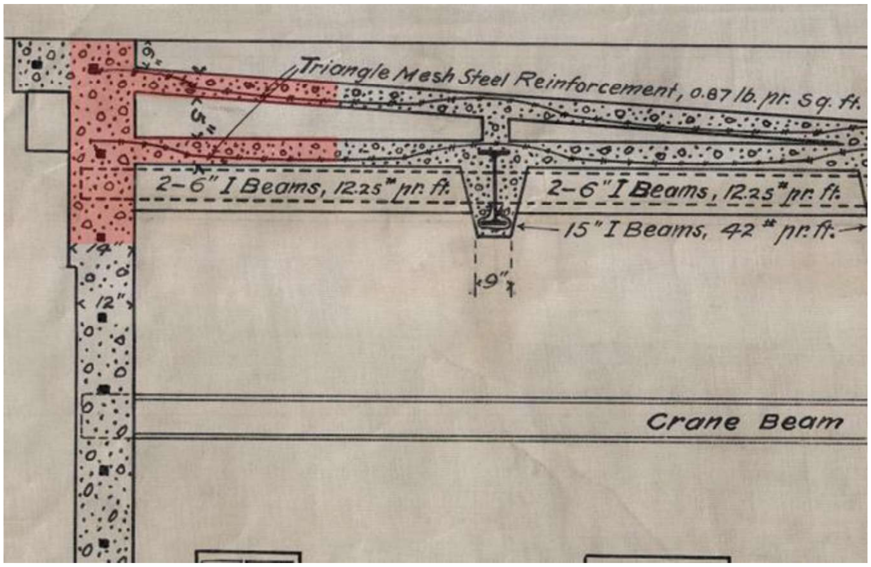


Figure 3.28 – Inadequate Roof Diaphragm To Shear Wall Connection
(Source: Drawings of Astoria Water Works – Gate House for the High Service Reservoir: Reservoir No. 3)

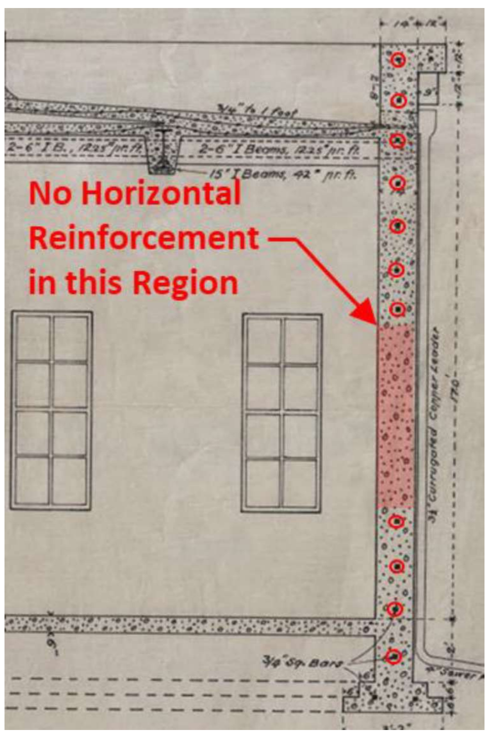


Figure 3.29 – Walls With Insufficient Reinforcing Steel to Resist Seismic Forces
(Source: Drawings of Astoria Water Works – Gate House for the High Service Reservoir: Reservoir No. 3)

(a) North Wall

(b) Composite Floor Beam in Gate Well

Figure 3.30 – Concrete Spalling and Steel Corrosion

Figure 3.31 – Chlorination System and Spill Containment Skid not Adequately Restrained

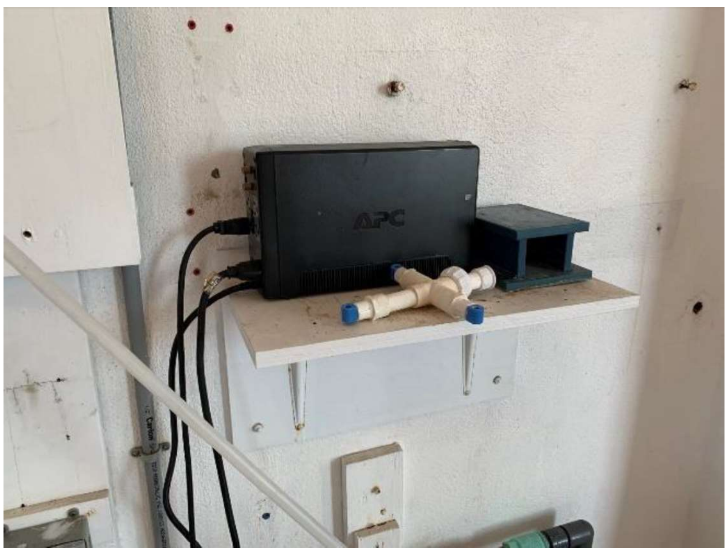


Figure 3.32 – Chlorination System Backup Battery not Adequately Restrained

Figure 3.33 – Unanchored Storage Rack and Unrestrained Contents

(a) East-West Rail System

(b) North-South Rail System

Figure 3.34 – Crane Rail Systems (no longer in use)

Figure 3.35 – Pumping System Used to Clean Reservoir Cover not Adequately Braced

Figure 3.36 –Conduits from Below Grade Connecting to Electrical Cabinets without Flexibility

Figure 3.37 – Wood-Framed SCADA Enclosure with Limited Capacity to Resist Seismic Forces

Figure 3.38 – SCADA Backup Battery not Adequately Restrained

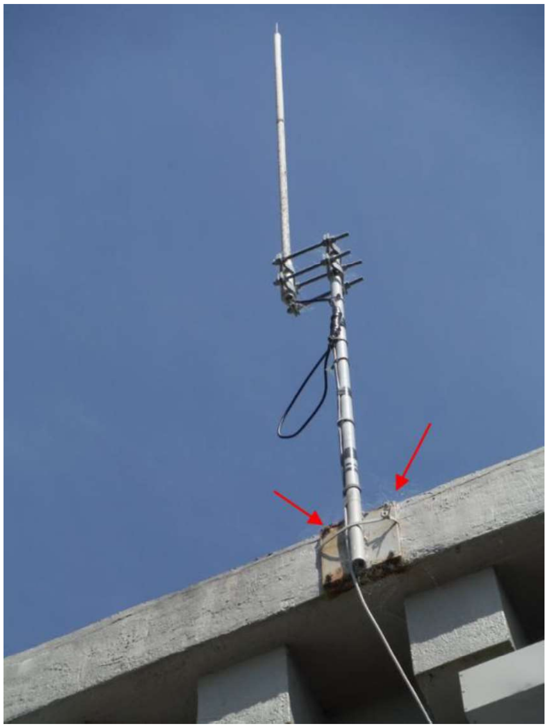


Figure 3.39 –SCADA Antenna to Roof Slab Connection with Potentially Inadequate Edge Distance for Concrete Anchors

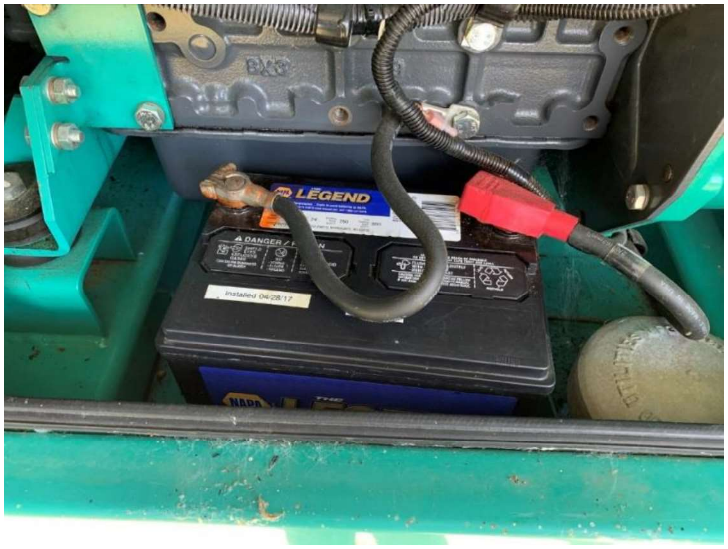


Figure 3.40 – Emergency Generator Starter Battery not Adequately Restrained

3.3 East Astoria Tanks

The East Astoria Tanks consist of two 150,000-gallon (nominal) circular tanks that were constructed in 1998 (see Figure 3.41). The tanks support the Emerald Heights area on the east side of the City of Astoria service area and enhance the City's ability to provide water for fire suppression in the vicinity of the tanks. These conventionally reinforced concrete tanks have an interior diameter and an interior height both equal to 30 feet. The overflow elevation limits the maximum height of retained water to 29 feet, leaving 1 foot of freeboard. However, the City has indicated that they typically operate the tanks with a maximum height of retained water between 27 to 28 feet.

A precast concrete valve vault associated with the tanks is located near the southeast corner of the tank site. The SCADA system that supports operation of the tanks is located on the roof of the Tank 2 (northern tank). Power for the SCADA system is provided by solar panels and a battery storage system.

Table 3.3 presents a summary of potential seismic structural and nonstructural deficiencies identified by this evaluation. Based on the potential deficiencies identified in Table 3.3, the East Astoria Tanks are not expected to achieve Immediate Occupancy structural performance or Operational nonstructural performance for a M9.0 CSZ earthquake.

Table 3.3 – East Astoria Tanks Seismic Evaluation Summary

Potential Deficiencies	Description
Structural	• Per the Geotechnical Report, there is a possibility of earthquake-induced landslides resulting in a significant level of PGD (1.5 to 12.5 feet). This level of PGD will likely cause damage to the tanks, valve vault, and associated buried piping. **Tanks** • The sloshing wave height exceeds the provided freeboard, and the roof slab does not have top reinforcement to resist the upward pressure resulting from the sloshing waves. See Figure 3.42. **Altitude Valve Vault** • The vault consists of multiple precast concrete segments. The joints of this stacked precast vault may separate and shift due to seismic lateral earth pressures on the face of the vault.
Nonstructural	**Tanks** • Piping that penetrates through the floor of the tanks may not have adequate flexibility to accommodate the potential differential movement between the tanks and the surrounding soil at the pipe penetration. • No overflow pipe bracing details are shown on the available construction drawings. Therefore, the adequacy of any bracing of the overflow pipe is unknown. • On the exterior of Tank 2, conduits from below grade connect to the chlorine analyzer cabinet without apparent flexibility to accommodate potential relative movement between the structure and the surrounding soil in which the conduits are buried. See Figure 3.43. • The SCADA system batteries are not adequately restrained. See Figure 3.44. **Altitude Valve Vault** • Valves in-line with the piping inside the vault are not independently braced. See Figure 3.45. • Piping that penetrates through the vault walls does not appear to have adequate flexibility to accommodate the potential differential movement between the vault and the surrounding soil at the pipe penetration. See Figure 3.45.

(a) View from North

(b) View from South

Figure 3.41 – East Astoria Tanks

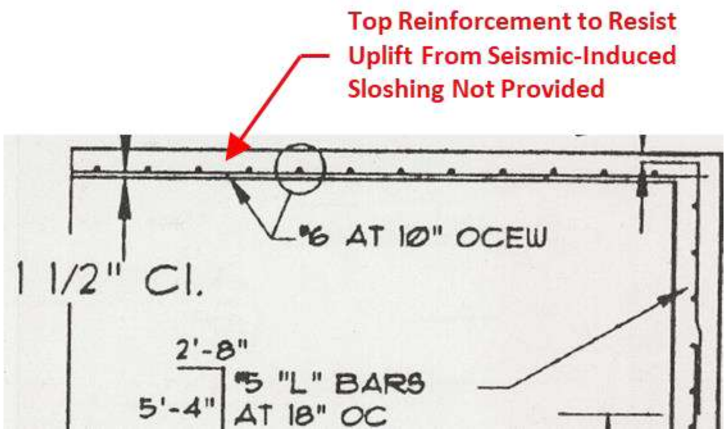
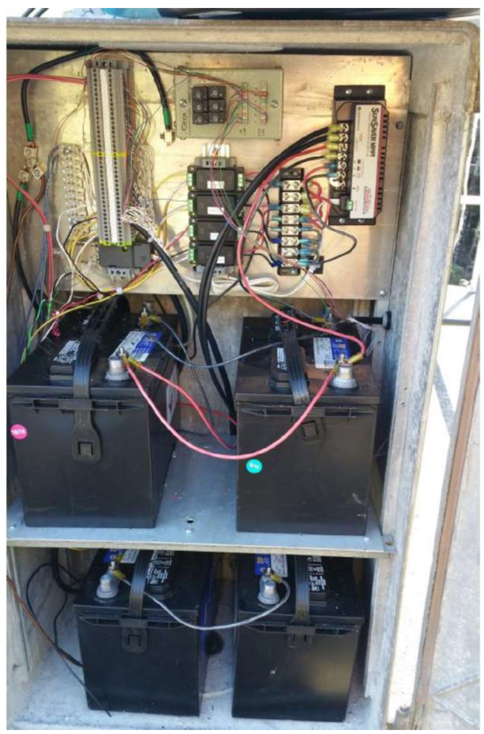


Figure 3.42 – Reinforcement of Tank Roof
(Source: Structural Plans and Details for 30 foot diameter Water Reservoir by Dibble Engineering, dated March 1998)

Figure 3.43 – Conduits from Below Grade Connecting to Chlorine Analyzer Cabinet without Flexibility

(a) Overall View



(b) SCADA Batteries not Adequately Restrained

Figure 3.44 – Solar Power System and SCADA Cabinet Located on Top of Tank 2
(Source: City of Astoria)

Figure 3.45 – No Flexibility at Pipe to Wall Interfaces and Valves Inside Altitude Valve Vault are not Independently Braced

3.4 Skyline Tank

The Skyline Tank is a 130,000-gallon (nominal) circular tank that was constructed in 2006 (see Figure 3.46). The tank supports the Skyline pressure zone in the higher elevation areas on the west side of the City of Astoria service area. This factory-coated bolted steel tank (AWWA D103) is approximately 28 feet in diameter and 29 feet tall (plus an additional 6 feet for the sloped roof). The tank was designed and manufactured by Engineered Storage Products Company/Aquastore and provided with a glass-fused-to-steel coating.

The Skyline Booster Station is located on the same site as the Skyline Tank, but was not evaluated as part of this project. The SCADA system that supports operation of the tank is located in the booster station. Emergency power for the SCADA system is provided by a generator located in the booster station. This generator also provides emergency power to support the City's police and fire emergency dispatch system infrastructure that is collocated at the site, including the antennas that are attached to the Skyline Tank [see Figure 3.46(b)].

Table 3.4 presents a summary of potential seismic structural and nonstructural deficiencies identified by this evaluation. Based on the potential deficiencies identified in Table 3.4, the Skyline Tank is not expected to achieve Immediate Occupancy structural performance or Operational nonstructural performance for a M9.0 CSZ earthquake.

Table 3.4 – Skyline Tank Seismic Evaluation Summary

Potential Deficiencies	Description
Structural	• Per the Geotechnical Report, there is possibility of earthquake-induced landslides resulting in a significant level of PGD (1.5 to 2.5 feet). This level of PGD will likely cause damage to the tank and associated buried piping. • The sloshing wave height exceeds the available freeboard (above the overflow elevation). The tank roof may potentially be damaged by the upward water pressure resulting from sloshing waves in the tank.
Nonstructural	• Piping that penetrates through the tank floor may not have adequate flexibility to accommodate the potential differential movement between the tank and the surrounding soil at the pipe penetration. • No overflow pipe bracing details are shown on the available construction drawings. Therefore, the adequacy of any bracing of the overflow pipe is unknown. • The SCADA antenna is mounted to a wood pole. The antenna support connections may not be adequate to prevent the antenna from being misaligned after an earthquake. See Figure 3.47. • The emergency generator starter battery is not adequately restrained. See Figure 3.48. (Note that the emergency generator is located in the Skyline Booster Station. This booster station was not evaluated as part of this project.) • The propane tank that provides fuel for the emergency generator is positioned on slightly sloping ground near top edge of a steeper slope (see Figure 3.49). Additionally, the buried gas line from the propane tank to the generator may not have adequate flexibility to accommodate potential relative movement between the concrete slab supporting the propane tank and the surrounding soil in which the gas line is buried.

(a) View from Southeast

(b) View from West

Figure 3.46 – Skyline Tank

Figure 3.47 – SCADA Antenna Attached to Wood Pole

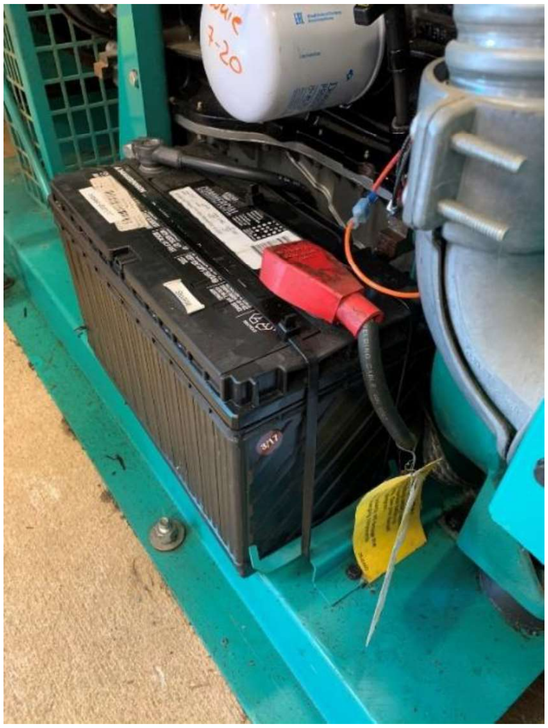


Figure 3.48 – Emergency Generator Starter Battery not Adequately Restrained

Figure 3.49 – Emergency Generator Propane Tank Near Top Edge of Slope

4.0 Next Steps

This technical memorandum summarizes the results of SEFT's preliminary seismic structural and nonstructural evaluation of the Reservoir 2 Gate House, Reservoir 3 Gate House, East Astoria Tanks, and Skyline Tank. Based on the potential structural and nonstructural deficiencies identified, none of the evaluated structures are expected to achieve either the Immediate Occupancy structural performance objective or the Operational nonstructural performance objective for a M9.0 CSZ scenario earthquake.

The findings of this seismic evaluation should be integrated with the findings of previous seismic studies of other water system components and future seismic and tsunami assessments (as appropriate) of the remaining water system components, to develop a holistic view of the expected seismic performance of the water system. This knowledge can be leveraged in developing a comprehensive long-term plan for implementing water system seismic and tsunami resilience improvements. In the near-term, the City is strongly encouraged to implement a seismic retrofit program to address Life Safety seismic deficiencies for water system structures that are frequently accessed by City staff and contractors.

If replacement of existing or construction of new water system structures is considered in the future to meet water demand or operational goals, then this would provide an opportunity to build more seismically resilient structures and associated support infrastructure that are capable of achieving the City's post-earthquake LOS goals. The location and foundation design for any new water system structures should include appropriate consideration of potential earthquake-induced permanent ground deformation.

In order to continue to advance the City of Astoria water system resilience planning process, we recommend that a follow-up study be conducted that includes consideration of dependency relationships. Planning for and addressing issues such as where the City will get fuel for trucks and generators, how suppliers and contractors will be rapidly engaged and compensated, etc. will help improve resilience and speed the return to normalcy after a major disaster. The City of Astoria should also continue to evaluate and implement alternative options to provide water to customers in the event that the water system is significantly damaged by a major earthquake and could take months to repair for more recently constructed structures to years to rebuild older structures.

5.0 Limitations

The opinions and recommendations presented in this technical memorandum were developed with the care commonly used as the state of practice of the profession. No other warranties are included, either expressed or implied, as to the professional advice included in this technical memorandum. This technical memorandum has been prepared for the City of Astoria to be used solely in its evaluation of the seismic safety and functional recovery of the water system components referenced. This technical memorandum has not been prepared for use by other parties and may not contain sufficient information for purposes of other parties or uses.

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Appendix I. Operations Training and O&M Management Plan Review Technical Memorandum

Technical Memorandum

Date:	Thursday, January 07, 2021
Project:	Astoria Waster System Master Plan Project
To:	Jeff Harrington, Public Works Director
From:	Mike Jacobson, Operations Specialist; Kathryn Maschmann, Project Engineer
Subject:	**Operations Training and O&M Management Plan Review**

1.0 Introduction and Purpose

The City of Astoria (City) contracted with HDR to develop a Water System Master Plan in accordance with Oregon Health Authority (OHA) requirements which includes assessing operations and maintenance (O&M) training and plan needs as follows:

- Review O&M Plan document to identify shortcomings and improvements.
- Visit key project facilities with City operations staff, including supply, pump, treatment, storage, and control facilities to identify gaps in maintenance best practices and record operational concerns and problems.
- Define O&M best practices, identify current O&M gaps, and provide recommendations for improvement in terms of O&M and operator safety.

HDR met with City staff and reviewed relevant documents to assess the current state of Astoria's O&M practices. The information gathered was compared to the requirements of OHA's *Plan Review requirements for Master Plans at existing or new public water systems* and Oregon Administrative Rule 333-061-0060 *Plan Submission and Review Requirements*.

2.0 Review of Operations and Management Plan

According to an OHA Fact Sheet, a water system's O&M manual is meant to be a comprehensive "how-to" guidance document that pertains to all physical aspects of a water system's daily O&M. Specifically, it includes O&M activities performed at the City's facilities, including source water, treatment, finished water storage, transmission, and distribution systems.

Additionally, for systems with certified operators in direct responsible charge (DRC) that also employ non-certified operators, the system is required to establish written protocols for each of these other operators that:

- Describes the operational decisions the operator(s) are allowed to make.
- Details the condition under which operator(s) must consult with DRCs, including when and how contact is made.

- Review operator(s) certification level, knowledge, skills, and abilities, and the range of expected operating conditions of the water system.
- Is signed and dated by the DRC and the other operator(s).

Water system staff would then be instructed and trained in the use of the manual.

The creation and implementation of the manual provides a detailed resource that can be used in the event the system suddenly loses its DRC and has to employ or contract new operators unfamiliar with the system. Additionally, it serves as a good training tool for new employees.

HDR reviewed the City's operations document titled *Operations Manual, City of Astoria Drinking Water System* for conformance with OHA guidance pertaining to developing and maintaining an O&M manual.

Specific comments based on this review are:

- The manual should specify a version number or revision date.
- The document should have page numbers.
- The organizational chart appears out of date and should be updated.
- The manual contains several procedures that use valve numbers in the description. A diagram showing the numbered valves would be helpful for these procedures.
- The manual should include a comprehensive list of record keeping requirements, including what records are kept, where they are stored, and how long they are retained.
- The manual should include a list of routine tasks that are required to maintain compliance with regulatory requirements, including a list of the rules (Lead & Copper Rule, Revised Total Coliform Rule, etc.).
- The manual should include a list of required reports for submittal to regulatory authorities along with contact information for the regulatory agency.
- The reviewer was provided with several documents that described utility operations but were not included in the O&M Manual (e.g., "Quality Control Sampling Plan," "Water Treatment Operator Checklists," and a document describing operator tasks responding to customer complaints). These documents and any Standard Operating Procedures used in utility operation can be referenced with a description of what they are and where they are located rather than being included in the O&M Manual.
- The Emergency Transmission Main Dewatering procedure includes a list of contact information for customers along the pipeline. Creating a contact information table is suggested to make it easier to find within the document and update when necessary.
- Chapters IV and V are in reverse order in the document.
- The Process Hazard What-If Analysis table does not display properly.
- The Instrumentation section of the Water Treatment Chapter appears to need updating. The section on nephelometric turbidity unit (NTU) sensors does not include the Hach TU5300 NTU sensor observed in the field.
- In the Reservoirs and Storage Tanks chapters there are several references to drawings or procedures that are to be included at the end of the section. The referenced documents are not included.

3.0 O&M Best Practices

The O&M Best Practices discussion is divided into three topics: measuring the quality of an O&M program, maintenance management, and asset management. To define O&M best practices, HDR looked to published guidance. Section 3.1, Measuring the Quality of an O&M Program, and Section 3.2, Maintenance Management, are adapted from the publication *Operations & Maintenance Best Practices*, USDOE Federal Energy Management Program Release 3.0 August 2010. Section 3.3, Asset Management is adapted from the publication *Reference Guide for Asset Management Tools*, EPA, June 2020.

3.1 Measuring the Quality of an O&M Program[i]

Traditional thinking in the O&M field has focused on a single metric for program evaluation: reliability. Every O&M manager wants a reliable facility; however, this metric alone is not enough to evaluate or build a successful O&M program.

Beyond reliability, O&M managers need to be responsible for controlling costs, evaluating and implementing new technologies, tracking and reporting on health and safety issues, and expanding their program. To support these activities, the O&M manager must be aware of the various indicators that can be used to measure the quality or effectiveness of the O&M program. These metrics are useful in assessing effectiveness, justifying equipment purchases, program modifications, and staff hiring.

Below are a number of metrics that can be used to evaluate an O&M program. Not all of these metrics can be used in all situations; however, a program should use as many metrics as possible to better define deficiencies and publicize successes.

- Capacity factor – Relates actual operation to the full-capacity operation of the plant or equipment. This is a measure of actual operation compared to fully-utilized operation.
- Work orders generated/closed out – Tracking generated and completed (closed out) work orders over time allows the manager to better understand workloads and schedule staff.
- Backlog of corrective maintenance – An indicator of workload issues and effectiveness of preventive/predictive maintenance programs.
- Safety record – Commonly tracked either by number of loss-of-time incidents or total number of reportable incidents. Useful in getting an overall safety picture.
- Energy use – A key indicator of equipment performance, level of efficiency achieved, and possible degradation.
- Inventory control – An accurate accounting of spare parts can be an important element in controlling costs. A monthly reconciliation of inventory "on the books" and "on the shelves" can provide a good measure of cost control practices.
- Overtime worked – Weekly or monthly hours of overtime worked has workload, scheduling, and economic implications.
- Environmental record – Tracking water quality measurements and non-compliance situations.
- Absentee rate – Because high or varying absentee rates can be a signal of low worker morale and have economic implications, it should be tracked.

- Staff turnover – High turnover rates are also a sign of low worker morale. Significant costs are incurred in the hiring and training of new staff. Other costs include those associated with errors made by newly hired personnel that normally would not have been made by experienced staff.

3.2 Maintenance Management

Maintenance programs can be divided into four types of maintenance[ii]:

- Reactive Maintenance: The "run-it-till-it-breaks" maintenance mode. No actions or efforts are taken to maintain the equipment to ensure design life is reached.
- Preventive Maintenance: Actions performed on a calendar time- or machine-run-hour-based schedule that detects, precludes, or mitigates degradation of a component or system with the aim of sustaining or extending its useful life by controlling degradation to an acceptable level.
- Predictive Maintenance: Measurements that detect the onset of system degradation, by identifying causes for deterioration of the component's physical state. Results of the measurements indicate current condition and predict future functional capability.
- Reliability Centered Maintenance (RCM): RCM is defined as "a process used to determine the maintenance requirements of any physical asset in its operating context."

RCM methodology handles some key issues not covered by other types of maintenance programs. It recognizes that all equipment in a facility is not of equal importance to either the process or facility safety. It recognizes that equipment design and operation differs and that certain equipment will have a higher probability to fail than other equipment due to exposure to different degradation mechanisms. It also approaches structuring a maintenance program recognizing that facilities do not have unlimited financial and personnel resources and maintenance should be prioritized and optimized. RCM is a systematic approach to evaluate a facility's equipment and resources to best couple the two and result in a high degree of facility reliability and cost-effectiveness. RCM is highly reliant on predictive maintenance, but recognizes that maintenance activities on equipment that is inexpensive and unimportant to facility reliability may best be left to a reactive maintenance approach.

3.3 Asset Management

Best practices for operation and maintenance of a utility's infrastructure revolve around the concept of asset management. Asset management is a systematic process of developing, operating, maintaining, upgrading, and disposing of assets in the most cost-effective manner (including consideration of costs, risks, and performance attributes).

The practice of asset management involves managing infrastructure capital assets to minimize the total cost of owning and operating them, while delivering the service level customers desire. Asset management is a framework widely adopted by the water sector as a means to pursue and achieve sustainable infrastructure. Asset management can open communications between drinking water system staff and decision makers, help move systems from crisis management to informed decision making, facilitate more efficient and focused system operations, and improve financial management to make the best use of a system's limited resources. An asset management plan serves as a tool to record a system's asset management practices and strategies.

Systems implementing asset management develop detailed asset inventories, perform operation and maintenance tasks, conduct long-range financial planning, and undertake other activities to build system capacity, which help move systems along the path to long-term sustainability. Asset management can have numerous benefits to a system including prolonging asset life, meeting customer demands, identifying sustainable rates, institutionalizing budget planning, meeting regulatory requirements, and improving emergency response times and methods.[iii]

4.0 Current Operation and Maintenance Gaps

The City has a spreadsheet-based maintenance management program in place to address routine and recurring preventive and corrective maintenance. The scope of work for this project did not include an audit of the program, but it appears that City staff feels the program is effective for the tasks being managed. However, City staff also expressed concern that they do not have adequate resources to maintain all utility assets, notably the water distribution system valves and hydrants. In its Tech Brief, *Valve Exercising*, Summer 2007, Issue 2, the University of West Virginia's National Environmental Services Center experts recommend exercising distribution valves annually if possible. The American Water Works Association (AWWA) recommends all hydrants be inspected regularly, at least once a year – twice a year (spring and fall) for dry barrel hydrants in areas that experience freezing weather.

City staff is justifiably concerned that distribution system valves, because they have not been exercised regularly, may already be broken or will break or leak when they are operated. For this reason, implementation of a valve exercising program may require a phased approach where the first phase includes repair and replacement of valves and valve boxes in a multi-year program until all system valves are known to be operable. After this first phase, maintenance would include regular valve exercising.

5.0 Recommendations

This section provides recommendations for improvements to the City's O&M program.

5.1 Review Operations and Management Plan

O&M manual improvement recommendations include:

- Address specific comments provided in Sections 2.0.
- Provide training on the use of the O&M manual to operations staff and others that need to use the document. Document the training and provide regular refresher training. This recommendation also applies to any Standard Operating Procedures related to the O&M manual.
- Review the O&M manual at least annually and update as required. Implement a program to ensure access to the most recent version of the document for required personnel.

5.2 Implement O&M Best Practices

Reliability Centered Maintenance: The City's current maintenance management program was not reviewed in detail, therefore HDR does not have specific recommendations for improvements. The publication referenced in Section 3.2 offers steps to implement an RCM program, should the City choose this path.

Basic steps to initiate an RCM program include:

1. Develop a Master equipment list identifying facility equipment.
2. Prioritize the listed components based on importance or criticality to operation, process, or mission, highlighting priority scheme.
3. Assign components into logical groupings.
4. Determine the type and number of maintenance activities required and frequency using:
   a. Manufacturer technical manuals
   b. Machinery history
   c. Root cause analysis findings - Why did it fail?
   d. Good engineering judgment
5. Assess the number of maintenance staff with maintenance requirements.
6. Identify tasks that may be performed by O&M personnel.
7. Analyze equipment failure modes and impacts on components and systems.
8. Identify effective maintenance tasks or mitigation strategies.

Asset Management: Develop an implementation plan for a comprehensive asset management program that builds on current efforts by City staff. Best Practices for implementing an asset management program include evaluating five core questions[iv]:

1. What is the current state of the system's assets?
   - Preparing an asset inventory and system map (City is currently preparing a spreadsheet-based asset inventory; making continual improvements and updates to GIS data).
   - Developing a condition assessment and rating system.
   - Assessing remaining useful life by consulting projected-useful-life tables or decay curves.
   - Determining asset values and replacement costs (City is currently tracking replacement costs within asset inventory).
2. What is the required sustainable level of service?
   - Analyzing current and anticipated customer demand and satisfaction with the system.
   - Understanding current and anticipated regulatory requirements.
   - Writing and communicating to the public a level of service agreement that describes the system's performance targets.
   - Using level of service standards to track system performance over time.
3. Which assets are critical to sustained performance?
   - Listing assets according to how critical they are to system operations.

- Conducting a failure analysis (root cause analysis, failure mode analysis).
- Listing assets by failure type and determining their probability of failure.
- Analyzing failure risk and consequences.
- Using asset decay curves.
- Reviewing and updating the system's vulnerability assessment.

4. What are the minimum life cycle costs?

- Moving from reactive maintenance to predictive maintenance.
- Knowing the costs and benefits of rehabilitation versus replacement.
- Looking at lifecycle costs, especially for critical assets.
- Deploying resources based on asset conditions.
- Analyzing the causes of asset failure to develop specific response plans.

5. What is my best long-term funding strategy?

- Revising the rate structure.
- Funding a dedicated reserve from current revenues (i.e., creating an asset annuity).
- Financing asset rehabilitation, repair, and replacement through borrowing or other financial assistance.

The five core questions framework for asset management are the starting point for asset management. Beyond planning, asset management should be implemented to achieve continual improvements through a series of plan, do, check, and act steps.

- Plan: Five core questions framework (short-term), revise asset management plan (long-term).
- Do: Implement asset management program.
- Check: Evaluate progress, evolving factors and new best practices.
- Act: Take action based on review results.

5.3 Address O&M Gaps

The City's water utility's maintenance program should address all utility assets, including distribution system valves and hydrants. Using the steps outlined in Section 5.2 above, the current maintenance management system can utilize RCM concepts to realize efficiencies in the maintenance management program. If, after identifying maintenance requirements, prioritizing duties, and assessing staff capabilities, the City determines that current staff resources are insufficient to provide the required maintenance, the City should assess options to either reduce maintenance requirements by replacing maintenance intensive equipment, contract some maintenance activities to a third party, or increase staffing.

5.4 Other Recommendations

The City should also consider technologies that reduce manpower requirements for certain activities, in order to reallocate staff resources to address other needs. Automated meter reading (AMR) is an example of a technology that promises to reduce manpower requirements while improving accuracy and providing other benefits to the utility and its customers (features such as excess flow and backflow notifications vary by manufacturer). The City uses a meter reading contractor but could regain some staff time and reduce operating costs incurred from the water meter contract. The reduction in manpower and cost for this function can result in increased staff and financial resources applied to deferred maintenance tasks.

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[i] Adapted from *Operations & Maintenance Best Practices*, USDOE Federal Energy Management Program Release 3.0 August 2010.

[ii] Ibid.

[iii] Adapted from *Reference Guide for Asset Management Tools*, EPA, June 2020.

[iv] Adapted from *Asset Management: A Best Practices Guide*, EPA Office of Water EPA 816-F-08-014, April 2008.

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