City of Milwaukie

2021 Water System Master Plan
Volume 1 of 2

TETRA TECH

November 2021

2021 Water System Master Plan

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PREPARED FOR

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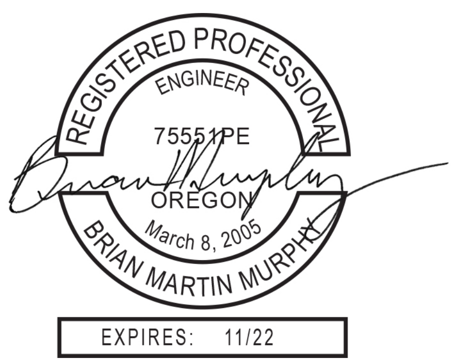

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ABBREVIATIONS

Abbreviation	Definition
4PX	4-plex residential housing
ACI	American Concrete Institute
ADD	average-day demand
AISC	American Institute of Steel Construction
ASCE	American Society of Civil Engineers
AWWA	American Water Works Association
ccf	100 cubic feet
CCFD	Clackamas County Fire District #1
CIP	capital improvement program
COM	Commercial property
CRW	Clackamas River Water
DMU	Downtown Mixed Use
DUP	Duplex residential housing
EPA	U.S. Environmental Protection Agency
ERU	equivalent residential unit
fps	feet per second
FRP	fiberglass reinforced plastic
GIS	geographic information system
gpd	gallons per day
gpm	gallons per minute
GR	groundwater registrations
HAA	halogenic acetic acids
HDPE	high-density polyethylene
HMI	human-machine interface
IBC	International Building Code
IOC	inorganic contaminant
LCR	Lead and Copper Rule
MCC	motor control center
MCL	maximum contaminant level
MDD	maximum-day demand
MDW	Multiple-unit residential housing
MG	million gallons
mgd	million gallons per day
NMU	Neighborhood Mixed Use
O&M	operation and maintenance
OAR	Oregon Administrative Rule
OHA	Oregon Health Authority
OLWSD	Oak Lodge Water Services District
ORS	Oregon Revised Statute
OWRD	Oregon Water Resources Department

Abbreviation	Definition
PHD	peak-hour demand
PRV	pressure-reducing valve
psi	pounds per square inch
PSUPRC	Portland State University Population Research Center
PVC	polyvinyl chloride
PWB	Portland Water Bureau
RES	Single-family residential housing
RLF	revolving loan fund
RTCR	Revised Total Coliform Rule
RWPC	Regional Water Providers Consortium
SCADA	supervisory control and data acquisition
SDC	system development charge
SOC	synthetic organic contaminant
SRF	State Revolving Fund
TGA	Troutdale Gravel Aquifer
THM	trihalomethane
TMS	The Masonry Society
TP235	treatment plant for Wells 2, 3, and 5
TP47	treatment plant for Wells 4 and 7
TRI	Triplex residential housing
UGMA	Urban Growth Management Agreement
USDA	U.S. Department of Agriculture
VOC	volatile organic compound
WIFIA	Water Infrastructure Finance and Innovation Act of 2014
WMCP	Water Management and Conservation Plan
WMP	Water Master Plan

EXECUTIVE SUMMARY

This 2021 Water Master Plan (2021 WMP) updates the City of Milwaukie's 2010 Water Master Plan. The 2021 WMP describes current conditions of the City's water system and addresses projected future needs. Information in the 2021 WMP will enable City staff to respond effectively to new water system demand for future development. It includes a capital improvement program (CIP) designed to meet current and future demand and to replace aging and seismically non-resilient assets.

PLANNING AREA

The City of Milwaukie is mostly within Clackamas County; a small portion extends into Multnomah County. The city limits generally follow the Willamette River on the west, Johnson Creek Boulevard on the north, Linwood Avenue and 71st Avenue on the east, and Kellogg Road and Lake Road on the south, encompassing 3,169 acres. The current water system serves a population of 20,291 through 7,870 metered connections. The water system service area corresponds approximately to the city limits, as shown in Figure ES-1.

The City's 1990 Urban Growth Management Agreement (UGMA) with Clackamas County designates 7,400 acres adjacent to the City as the City's future urban service area. The UGMA and the City's Comprehensive Plan policies address ultimate City expansion to include the area between its current boundary and I-205, but no mechanism has been outlined to enable city annexation of this area. Under the UGMA, the *North Clackamas Urban Area Public Facilities Plan* guides public facility improvements for the area, and Clackamas County has planning authority for the area.

The land within the UGMA includes two "dual interest areas" adjacent to the City, however, it has been assumed they will not be included in the City's Water Service area anytime during the planning period. The areas are currently served by Clackamas River Water.

WATER SYSTEM DESCRIPTION

The City's water normally consists entirely of groundwater from the Troutdale Gravel Aquifer. The City has access to secondary water sources via interties with Clackamas River Water and the Portland Water Bureau, both of which use surface water for their water supply. These secondary sources are used by the City only during emergency or high-level maintenance situations. A previous intertie with the Oak Lodge Water Services District is no longer in service, although the City is exploring alternatives for a new intertie with that district.

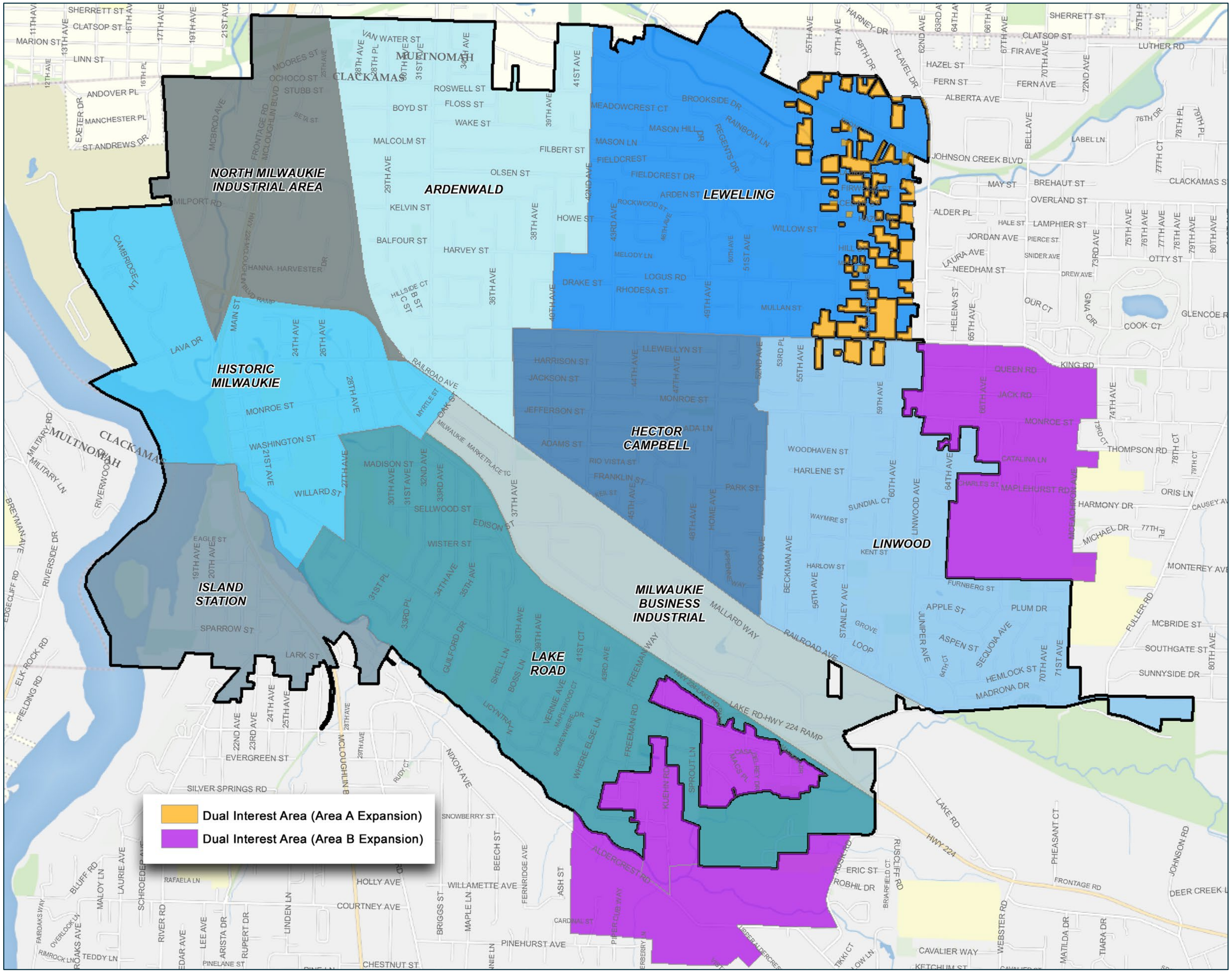


Figure ES-1. Water Service Area

The water system is made up of four pressure zones and provides water through the following water system assets (see Figure ES-2):

- 6,900 service meters
- 100 miles of pipeline
- seven groundwater wells
- two treatment facilities
- two transfer pump stations
- two booster pump stations
- three reservoirs
- 794 hydrants
- 36 pumps
- 19 PRVs
- 6 reduced pressure assemblies
- 4 reduced pressure detectors
- 4 pressure regulators
- 3,001 operational valves
- 2 interties

A December 2019 condition assessment of essential assets found them to be in generally good condition; some deferred maintenance issues were identified.

WATER SYSTEM DEMAND AND PRODUCTION, AND POPULATION

Water demand in the City's system is metered and recorded monthly for each customer. The City does not meter or record daily demand. Demand data in the 2021 WMP is presented by the City's fiscal year—July 1 through June 30. The City also meters and bills Clackamas River Water customers located within the city limits; those accounts are not included in the data presented in the 2021 WMP.

Figure ES-3 shows water demand by account classification for the past five years as residential (RES), duplexes, tri-plexes, four-plexes and multi units (MDW), commercial (COM), and total. Figure ES-4 shows annual production for the same period. The difference between recorded water production and demand is defined as water loss, which consists of two components:

- Non-revenue losses represent water that can be tracked and quantified but is not billed, such as operational, flushing, and construction use.
- Unaccounted-for water represents unbilled water that cannot be tracked, such as firefighting, leaks, main breaks, metering inaccuracies, illegal connections, and other types of unmetered water use.

Figure ES-5 compares production, demand, and water loss for the past five years.

SERVICE AREA POPULATION

Water system planning requires reliable growth estimates. The City contracted with Angelo Planning Group to develop five growth scenarios and evaluate their potential impacts on infrastructure. For this WMP update, the City selected Scenario 4 ("Hubs and Corridors") as the most likely to occur. Scenario 4 represents more growth than the other scenarios, with significant changes to land abutting high-frequency transit corridors and specific hubs where those corridors intersect. Scenario 4 includes growth outside the city limits, but that growth is not included in the planning assumptions and criteria used in this report.

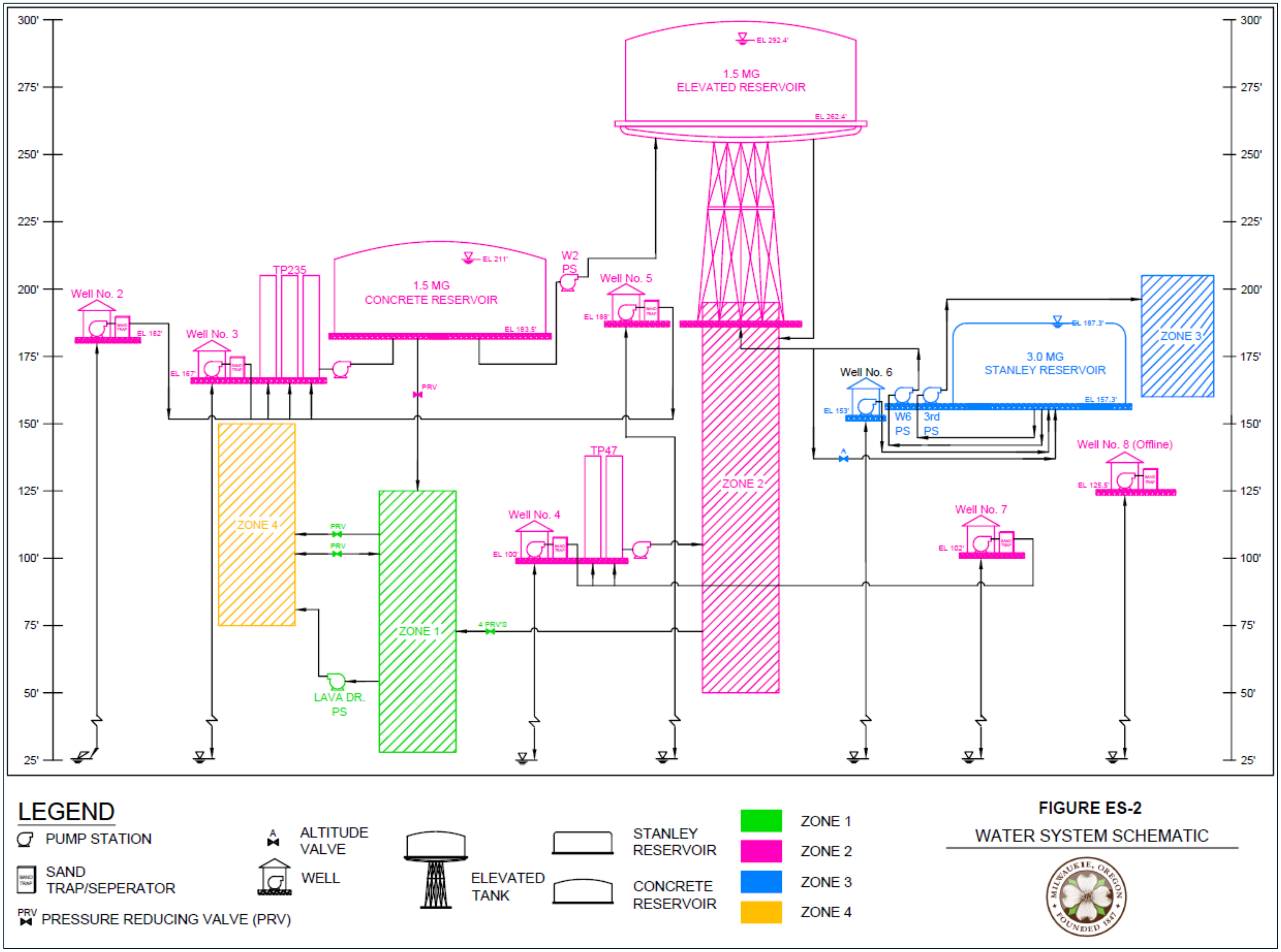


Figure ES-2. Water System Schematic

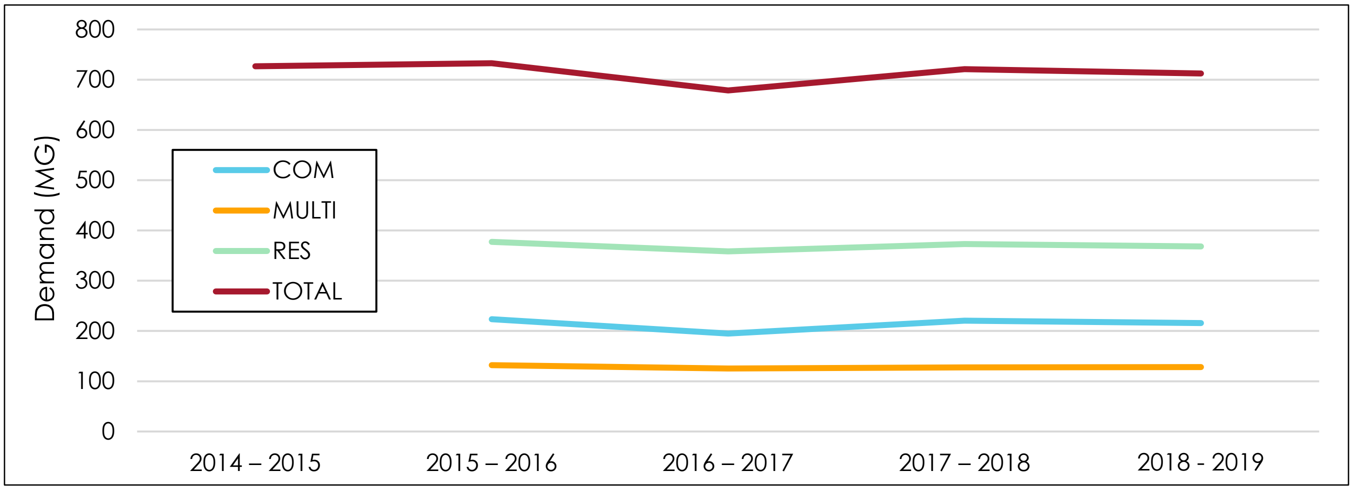


Figure ES-3. Annual Water Demand, 2014-15 Through 2018-19

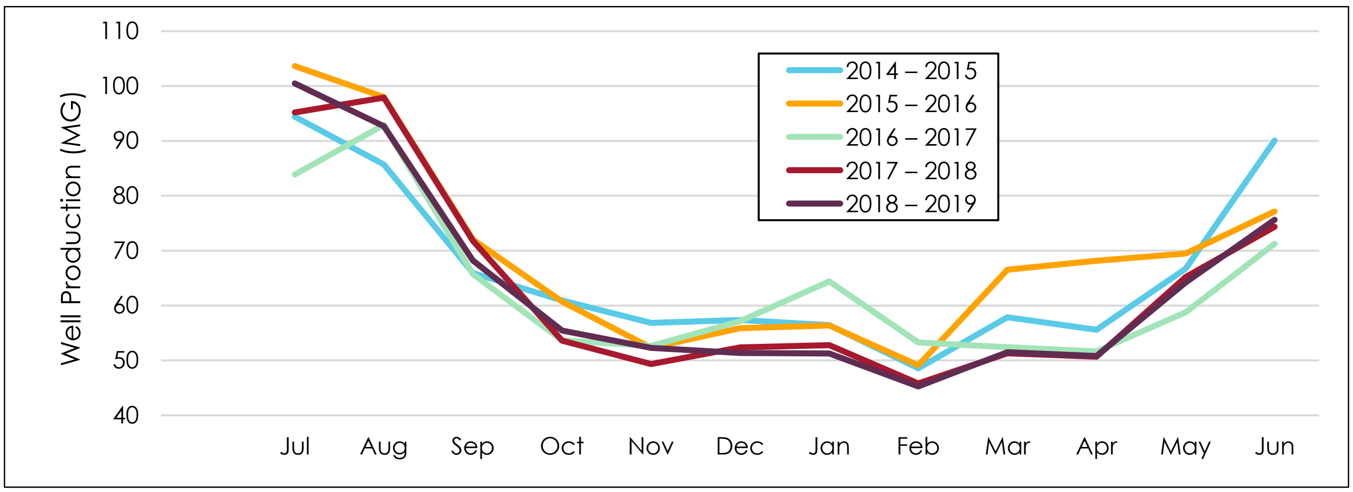


Figure ES-4. Monthly Well Production, 2014-15 Through 2018-19

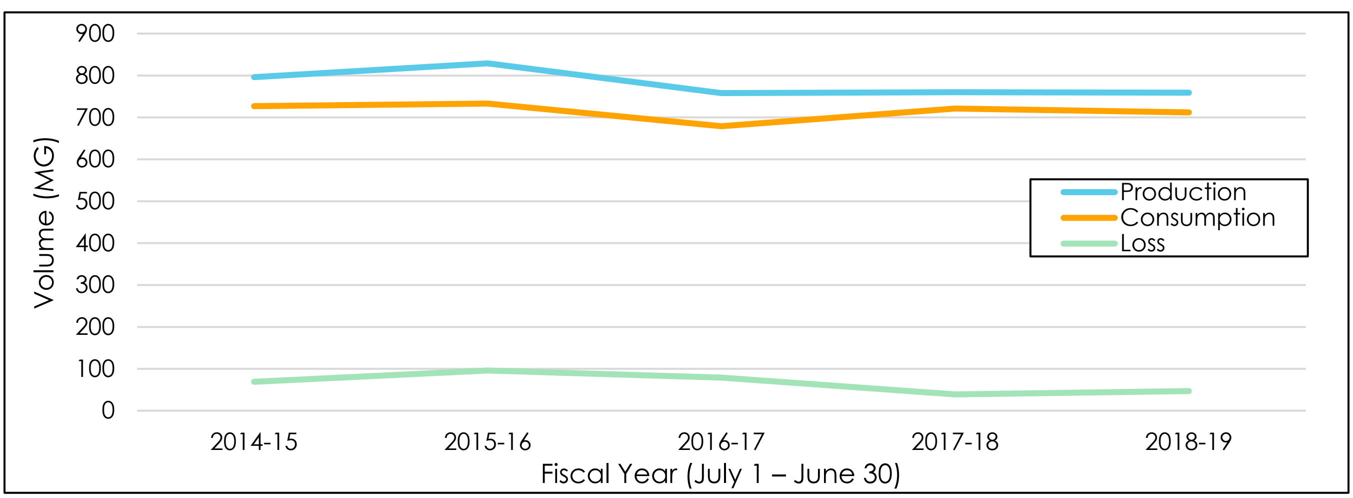


Figure ES-5. Annual Water Demand, Production and Water Loss

Scenario 4 predicted an additional 10,704 residential units in the City at full buildout—6,062 within the city limits and 4,642 in the City's planning area outside the city limits. It is assumed that development outside the city limits will be served by other water providers. This WMP assumes that 80 percent of the Scenario 4 full buildout within the city limits—4,850 units—will be developed within the planning period (by 2039-40). It also assumes that all this development will be residential, with each unit equivalent to 2.3 people.

Based on these assumptions, the planning area population growth will be 11,154 by 2039-40, for a total of 31,445 at the end of the planning period. This equates to an annual average growth rate of 1.02 percent. Figure ES-6 illustrates the resulting planning period projections for population and ERUs.

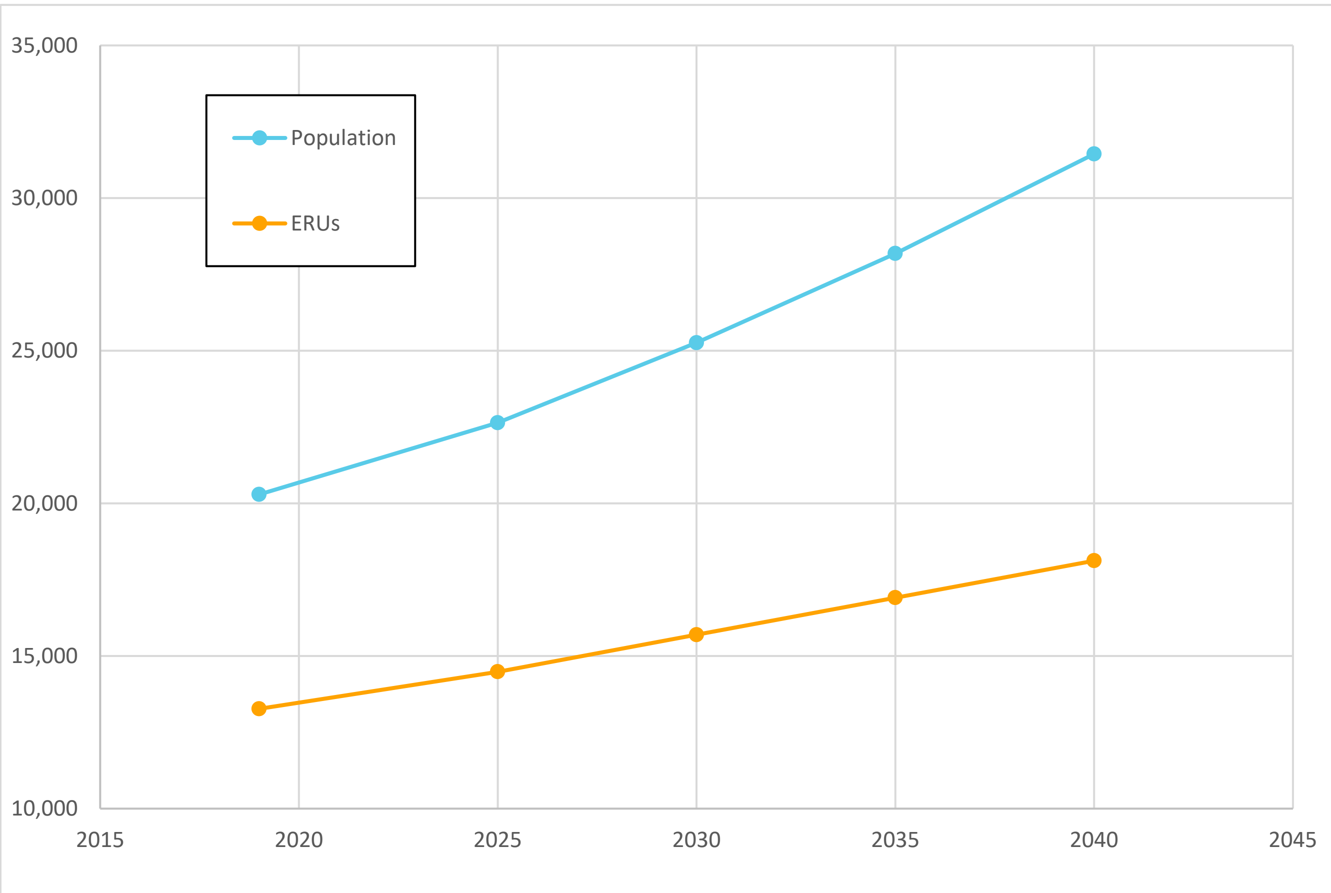


Figure ES-6. Projected Planning Period Population and ERUs

Future system-wide water demand was estimated by applying the ratio of future to present ERUs to the following existing demand values:

- The 2019 average-day demand of 2.0 million gallons (MG)
- The 2019 maximum-day demand of 4.1 MG

The resulting projections are shown on Figure ES-7.

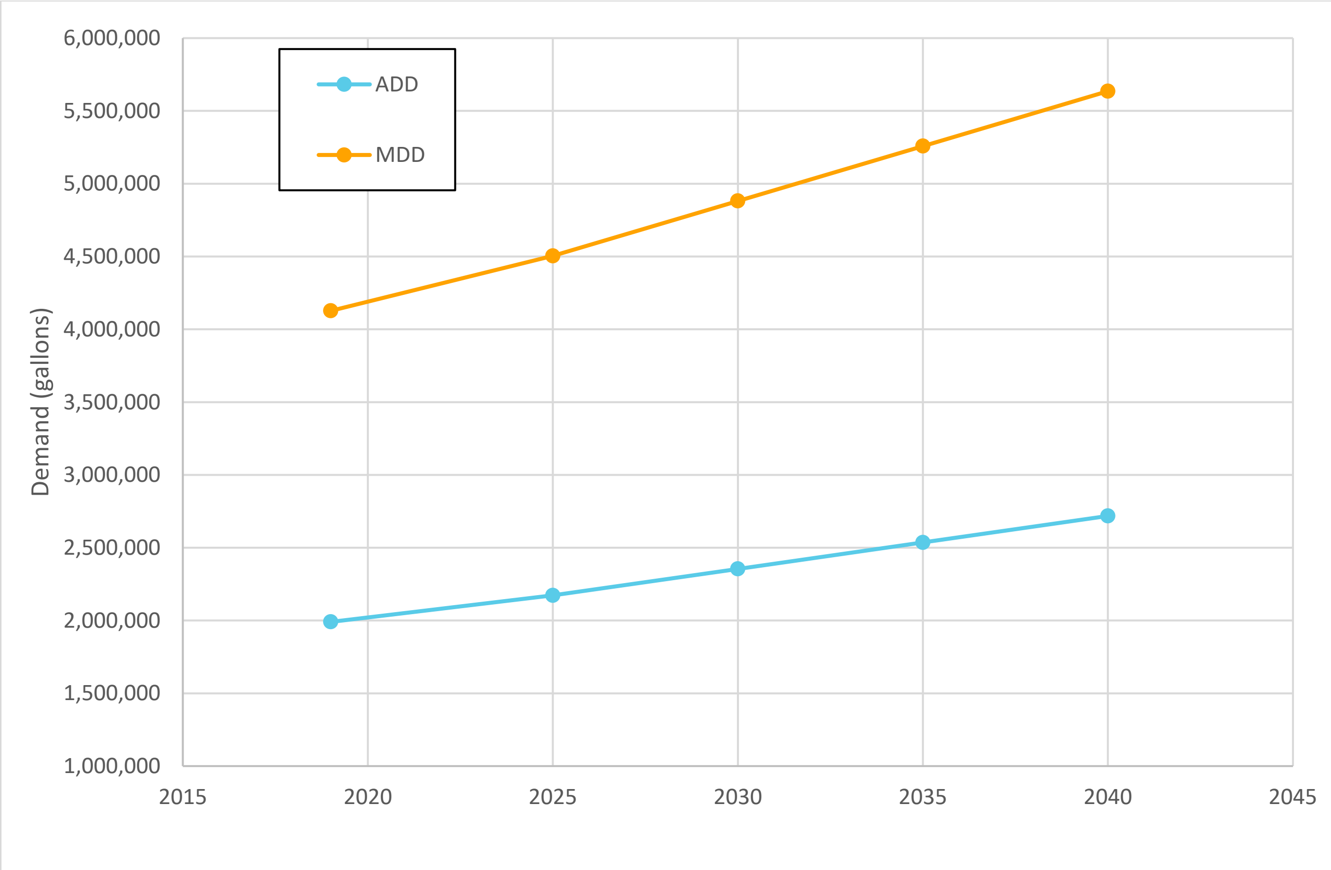


Figure ES-7. Projected Average-Day and Maximum-Day Demand

SYSTEM ANALYSIS

Innovyze's InfoWater software (version 12.4) was used for the hydraulic analysis of the water distribution system. The City maintains a hydraulic model of its water distribution network. The City's model, last calibrated in 2010, was the starting point for the analysis. For this update, the pipe network and calibration were reviewed and updated.

The 2021 WMP used modeling to evaluate the ability of the water distribution system to meet service-pressure standards and to provide required water flows for firefighting. The modeling evaluated the hydraulic capacity of the existing system and identified system improvements to increase capacity as needed.

Findings

Model scenarios were run for the existing system to evaluate the following:

- **Minimum pressure at peak-hour demand (PHD)**—Pressure deficiencies were assessed by modeling PHD with tanks two-thirds full and looking for system operating pressures below 40 psi, the City's minimum service pressure target. Areas that exhibited low pressures typically

were in the immediate vicinity of reservoirs and pumps. All deficiencies fall within 6 psi of the pressure requirements, except for those in Zone 4.
- **Maximum pressure at average-day demand (ADD)**—Excessive pressure were assessed by modeling ADD and looking for system operating pressures above 105 psi, the City's maximum service pressure target. The area of Zone 2 southwest of Kellogg Lake has areas of low elevation, resulting in some junctions exceeding 105 psi.
- **Fire flow at maximum-day demand (MDD)**—Under MDD conditions with reservoirs two-thirds full, analysis revealed that the distribution system has some areas that do not achieve required fire flow of 1,500 gallons per minute (gpm) for residential or 3,000 gpm for industrial/commercial. All hydrants in institutional zones meet required flows. Most fire flow deficiencies identified are on mains smaller than 8 inches or dead-end mains. In industrial/commercial areas, deficiencies are the result of insufficient looping and transmission.
- **Pipe flow velocity at PHD**—No pipes were identified with velocities exceeding the 7-foot-per-second maximum at PHD.

Recommendations

A list of recommended distribution improvements that are required to meet residential, commercial, and institutional fire flow requirements was developed and prioritized. The recommended improvements are prioritized by the severity of fire flow deficit, the number of hydrants that are brought up to the required flow, and the replacement of existing 4-inch diameter pipes and older pipes. The recommended distribution improvements would increase transmission, eliminate dead ends in areas with low fire flow, and address identified deficiencies.

Evaluation of Potential Emergency Intertie Connections

Seven potential intertie locations were identified from a previous Oak Lodge Water Service District evaluation and from GIS information on neighboring utility pipes. Potential locations were evaluated based on pipe size, pumping requirements, and location. Interties on larger mains are more desirable for conveyance. Based on the data collected, the existing City of Portland, Clackamas River Water and Oak Lodge Aldercrest interties should be considered for future development, due to their adequate pipe size, lack of additional pumping, and connection to Zone 2.

SOURCE OF SUPPLY

The City's primary water source, the Troutdale Gravel Aquifer, covers 300 square miles under the greater Portland metropolitan area. The aquifer is a deep system of gravels and sandstone with large unconsolidated areas that is well-confined by low-permeability layers. These qualities make a good municipal source of water. The City operates six groundwater wells. Wells 2, 3, and 5 are part of a wellfield in near Water Tower Park. Wells 4, 6, and 7 are in the southern part of the City. Well 8 was taken offline in 2013 due to high iron content in the water and steadily decreasing capacity. Rehabilitation of Well 8 is currently being reviewed as part of a project to develop a new Well 2.

Ability to Meet Current and Projected Demand

The adequacy of the source of supply was assessed based on projected population, ERUs and a 10 percent loss factor. The 2019 maximum-day demand with 10 percent water loss—3,184 gpm—is well within the total supply of 5,094 gpm authorized by the City's water rights. By 2040, maximum-day demand with a 10 percent allowance for system loss is expected to reach 4,304 gpm, which is also within the City's authorized rate. Given that the City's water rights capacity exceeds demand over the planning period, it is not necessary to apply for a new water right at this time. The City should continue to evaluate demand and revisit projections over the next few years to determine whether a new water right or additional source of supply is needed.

Operational Constraints on Source of Supply

The City's water rights currently exceed operational and treatment capacities and the City could more fully use its water rights by addressing those limitations. Operational limitations are primarily associated with treatment tower capacities. The City's future groundwater pumping capacity could be increased to utilize full water rights through construction of additional wells or reinstatement of existing wells that are currently offline. The City's future treatment capacity also could be increased.

Source of Supply Management

It is in the City's interest to maximize the resource through conservation practices. It is recommended that consideration be given to increasing proactive conservation activities to include the following:

- Indoor appliance rebate program
- Landscape irrigation management tool rebates
- Landscape modification rebates
- Landscape water audits
- Demonstration garden
- Indoor leak kit distribution
- Water use data billing inserts

The Oregon Water Resources Department currently requires a Water Management and Conservation Plan (WMCP) as a condition for new municipal water rights or for permit extensions. However, the City received its most recent permit in 1986 and has never had to extend a permit, so the WMCP requirement has not been triggered. When the City next applies for a new water right, a WMCP will be required. In the interim, there is a great deal of overlap between the WMP and WMCP and the City may choose to include WMCP analysis in subsequent WMP updates to track its conservation activities and to identify those that are most cost effective.

OPERATIONS AND MAINTENANCE

Operation and Maintenance and Staffing

The 2021 WMP describes the current operational control capabilities of the water system and basic operational procedures. The City meets the following Oregon Administrative Rule (OAR) 333-061-0065 requirements for operation and maintenance of key water system components:

- Service continuity must be maintained to ensure continuous production and delivery of potable water.

- Personnel responsible for operations must be competent, knowledgeable, and appropriately trained and certified.
- Operating manuals must be maintained and reviewed at least every five years and updated when new equipment or systems are installed.
- Documents and records must be retained by the water supplier and available upon request.

Figure ES-8 shows the relevant organizational structure.

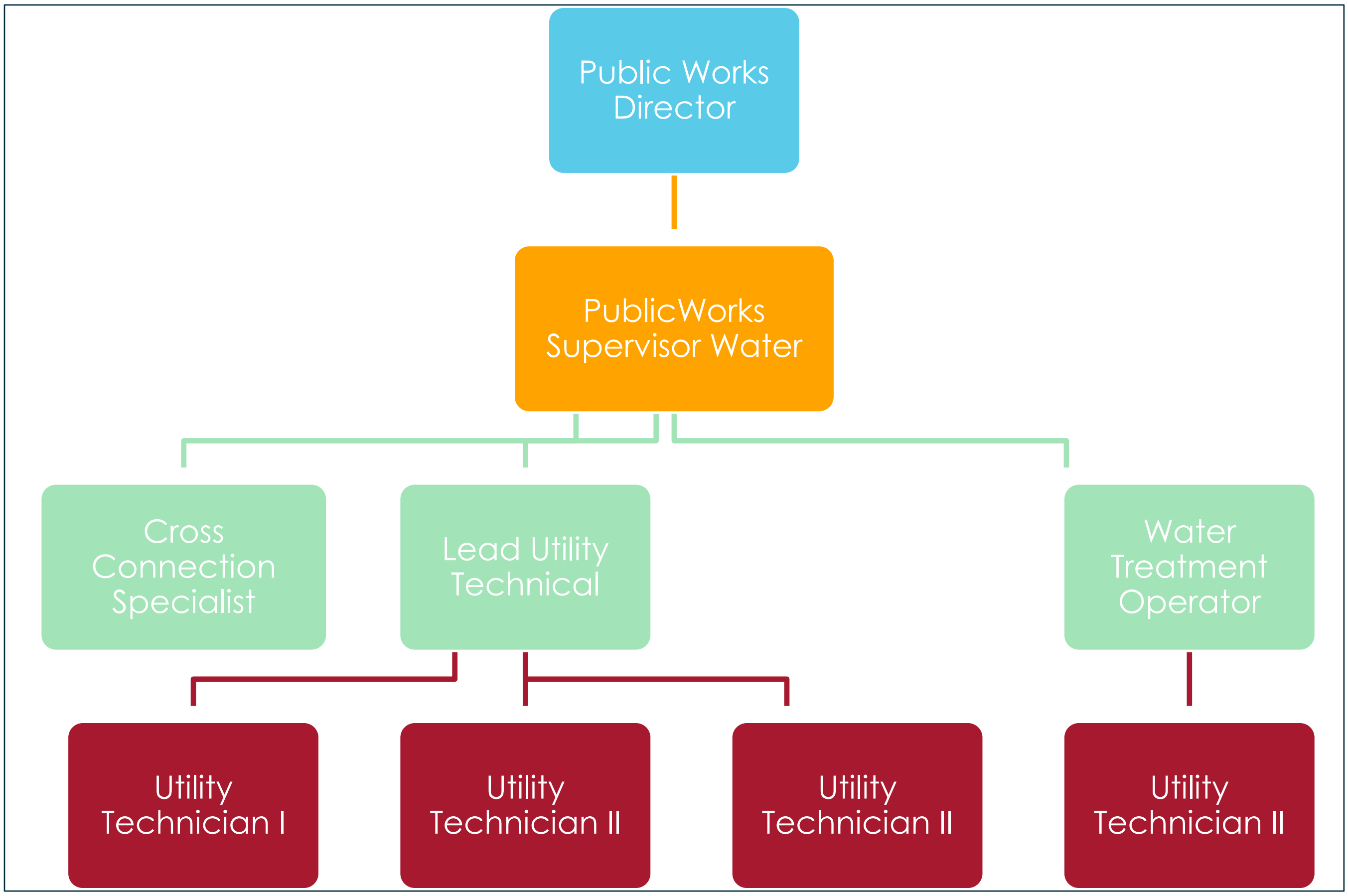


Figure ES-8. Organizational Structure

Supervisory Control and Data Acquisition

City staff control and monitor the water pumping, treatment and storage facilities through a proprietary supervisory control and data acquisition (SCADA) system. The SCADA computers enable operators to monitor system conditions, gather data on system processes and send control commands to the remote pumping facilities. The system alerts operators by text about such issues as well malfunction, low water levels and chlorine issues.

The City is developing designs to expand the SCADA system. The recently completed SCADA Master Plan identifies requirements for operations, maintenance, engineering, IT, and enterprise users. The improvements will enhance the City's SCADA organization, methodology, technology, and cybersecurity, modernize the system to current industry standards, develop processes to maintain these standards, and ensure system reliability.

Preventive Maintenance

The City does not have a formal preventive maintenance program. It is generally recommended that public works departments conduct an annual operation and maintenance review to critique plan operation, review operating costs and make recommendations for more efficient plan operation. The City is in the process of identifying and addressing deferred maintenance issues. The City uses CityWorks Asset Management software to manage maintenance needs.

Emergency Response Plan

The City completed an updated Water Emergency Response Plan in 2021 addressing water system vulnerabilities and response to water emergencies, as required by the federal Public Health and Security Bioterrorism Preparedness and Response Act of 2002 and OAR 333-061-0064. That plan contains procedures and contacts for the following:

- Communication and authority
- Water system security
- Water system hazard review
- Emergency equipment and water supplies
- Emergency contacts
- Emergency resources
- Public notices
- Drinking water hauling
- Isolating water facility
- Emergency disinfection
- Water rationing plan

Water Rationing Plan

The City has developed a water rationing plan to address local, system-wide, and regional service interruptions. The plan, presented in Municipal Code Chapter 13.06 (Drought and Emergency Water Regulation), describes actions implemented under Level 1 (Critical) and Level 2 (Emergency) rationing. Upon implementation of a water rationing declaration, the water operations supervisor will coordinate with the City's public information officer to notify water system users through the media regarding the rationing requirements.

Recordkeeping

The City maintains water system records in compliance with OAR 333-061-0040 as well as additional records.

STANDARDS

The City has established standards for water system asset design, construction, and performance covering the following:

- **Performance standards:**
  - Service pressure and pressure zones
  - Valves and hydrants
  - Fire flow
  - Water storage
  - Pumping capacity
  - Emergency power generation
  - Pressure reduction
- **Design Standards:**
  - Standard drawings and specifications supplemental to Oregon Administrative Rules (OARs) and American Water Works Association Standards
- **Construction Standards:**
  - Pipe material and size
  - Looped system and dead-end mains
  - Restrained joints
  - Right of way location
  - Minimum cover
  - Separation with sewer lines
  - Easements
  - Watercourse crossings
  - Underwater crossings
  - Valves
  - Fire hydrants
  - Pressure reducing and air release valves
  - Railway and freeway crossings
  - Appurtenances
  - Backflow prevention
  - Water service lines
  - Fire service
  - Fire vaults
  - System testing
  - Water quality sampling stations

The City's criteria are within industry standards as recommended by the American Water Works Association.

SYSTEM RESILIENCY

Seismic Resiliency

The 2021 WMP includes an assessment of seismic resiliency of public water system assets in compliance with Oregon Health Authority requirements. Table ES-1 summarizes key findings.

Natural Hazard and Malevolent Acts

The 2021 WMP identifies water system risks associated with natural hazards and malevolent act based on the U.S. Environmental Protection Agency's comprehensive list of water system threats. The following were identified as hazards that pose a threat to City water system assets:

- Earthquake
- Flood
- Utilities dependency
- Key supplier dependency
- Key employee dependency
- Transportation dependency
- Contamination by chemicals, radionuclides, biotoxins, or pathogens
- Contaminant weaponization
- Physical or cyber sabotage or theft by an insider or outsider
- Car-borne explosive
- Assault by a single assailant
- Ice storm
- Wind

This list serves as the set of risks evaluated for the separate completion of the City's risk and resilience assessment.

Table ES-1. Summary of Points of Seismic Risk and Recommended Actions

Asset	Priority	Potential Point of Failure	Recommendation
Storage Assets			
Elevated Tank	Low	• Area of concern at the column base plates. The anchor bolts appear to be too small.	• Verify the capacity of the base plate anchorage. • Regularly monitor the interior and exterior of the structure for rust and touch up painting where necessary. • Regularly monitor foundation for settlement or cracks.
Stanley Reservoir	High	• Insufficient freeboard • Anchorage may not meet standards. • Piping connections may not allow for required displacements. • Uncontrolled loss of tank contents could cause significant damage	• Perform a seismic evaluation. Based on results, do one of the following: o Decrease water storage height to a maximum allowed, or o Retrofit tank
Concrete Reservoir	Medium	• Hoop tension is insufficient • Circumferential prestressing is likely undersized. • Inadequate shear transfer between the wall and foundation. • Seismic load will create excess stress.	• Add galvanized steel seismic cables at the wall base and foundation. • Add circumferential steel strand prestressing and shotcrete to the outside face of the concrete wall, or • Add FRP jacketing to one or both faces of the concrete and a reinforced concrete curb around the perimeter of the base.
Source Water Assets			
Well No. 2 Pumphouse	Low	• Discontinuity in the lateral force load resisting path could occur.	• Conduct a field investigation for discontinuities. • As needed, add bracing; repair rusted or broken frame members; repair or replace damaged connectors and/or anchor bolts.
Well No. 3, 4, 5, 6 and 7 Pumphouses	Low	• Certain seismic force mitigation features were not commonly incorporated in the construction of buildings of this era.	• Conduct a seismic evaluation • As needed, anchor the tops of the walls to the roof; add steel cross ties as part of the seismic wall anchorage; add roof diaphragm boundary nailing; add seismic shear transfer clips; verify anchorage capacities for onsite equipment
Water Treatment Assets			
TP47, TP235	Medium	• Certain seismic force mitigation features were not commonly incorporated in the construction of buildings of this era.	• Conduct a seismic evaluation o As needed, anchor the tops of the walls to the roof; add steel cross ties as part of the seismic wall anchorage; add roof diaphragm boundary nailing; add seismic shear transfer clips; verify anchorage capacities for onsite equipment
Air Stripping Towers	Low	• Anchors may no longer meet code requirements.	• Monitor the FRP shell and components for deterioration. • Perform a detailed evaluation of the anchor bolts and lugs. • Conduct post-earthquake evaluations of anchoring and foundation.

Asset	Priority	Potential Point of Failure	Recommendation
Distribution Operational Assets			
Lava Drive Pump Station	Low	• The weight of the structure could cause cracking during ground shaking. • Improperly anchored equipment may be displaced in earthquake.	• Evaluate anchorage and replaced inadequate systems. • Conduct and document post-earthquake examinations for diagonal cracking in the roof deck and walls.
3rd Pressure Zone Building	Low	• Certain seismic force mitigation features were not commonly incorporated in the construction of buildings of this era.	• Conduct a seismic evaluation • As needed, anchor the tops of the walls to the roof; add steel cross ties as part of the seismic wall anchorage; add roof diaphragm boundary nailing; add seismic shear transfer clips; verify anchorage capacities for onsite equipment

Climate Change Vulnerabilities

In the Pacific Northwest, climate change models project an increase in air temperatures, an increase in fall and winter precipitation, a decrease in summer precipitation, an increase in the severity and frequency of storm events, and a decrease in winter snowpack. The City's 100 percent groundwater source of supply should not be influenced by climate change year to year as surface water sources could be. However, long-term changes in precipitation patterns may lead to a diminishing supply due to diminished replenishment and increased demand on the aquifer. The following recommendations will help the City evaluate the impacts of climate change on its groundwater supply and plan for changes that will be needed in order to respond:

- Employ a groundwater monitoring program focused on identifying long-term trends
- Maintain redundant/emergency water supply agreements; periodically assess capability and reliability of redundant sources
- Implement a proactive water conservation program
- Integrate climate related design standards into facility design

CAPITAL IMPROVEMENT PLAN

Table ES-2 lists capital improvements that are recommended based on the analyses performed for the 2021 WMP and water system projects previously identified in the City's 2022-2026 Capital Improvement Plan (CIP), with a schedule of expenditures for each. Projects not included in the first 10 years are long-range projects that may be included in subsequent 10-year plans depending on need.

Table ES-2. Capital Improvement Program

Number of Projects		Annual Expenditures											
Water Master Plan	2022-2026 CIP	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033-2038	2039-2042
Source Improvements													
12	11	$250,000	$537,000	$230,000	$265,000	$130,000	$265,000	$30,000	$105,000	$30,000	$205,000	$0	$0
Treatment Improvements													
2	0	$0	$0	$0	$1,600,000	$1,600,000	$0	$0	$0	$0	$0	$0	$0
Storage Improvements													
3	0	$1,935,000	$1,335,000	$0	$0	$0	$0	$1,000,000	$5,500,000	$0	$0	$0	$0
Pumping Improvements													
5	0	$30,000	$30,000	$1,627,000	$30,000	$1,230,000	$30,000	$30,000	$30,000	$30,000	$1,230,000	$0	$0
Distribution Improvements													
67	12	$667,000	$1,631,750	$1,380,000	$1,141,850	$3,453,950	$5,087,000	$1,947,750	$0	$2,175,800	$283,150	$1,470,860	$5,089,325
SCADA Upgrades and Maintenance													
3	2	$50,000	$90,000	$90,000	$90,000	$90,000	$90,000	$50,000	$50,000	$50,000	$50,000	$250,000	$500,000
Planning and Evaluation Studies													
5	3	$125,000	$0	$25,000	$225,000	$25,000	$25,000	$550,000	$0	$0	$0	$0	$0
Total		$3,057,000	$3,623,750	$3,352,000	$3,315,850	$6,528,950	$5,497,000	$3,607,750	$5,685,000	$2,285,800	$1,768,150	$1,720,860	$5,589,325

CAPITAL FUNDING OPPORTUNITIES

Capital improvements addressing new and replaced facilities are often addressed through a combination of rates, system development charges, loans, grants, and municipal bonds. The City employs a base rate/usage rate structure that charges customers a fixed rate based on meter size plus a consumption rate. It is recommended that the City review its unit rates, rate structure and system development charges to meet projected capital improvements.

- Fixed rate based on meter size:
  - 5/8” - 3/4” meter—$8.69
  - 1” meter—$13.08
  - 1 ½” meter—$22.34
  - 2” meter—$33.90
  - 3” meter—$93.72
  - 4” meter—$164.62
  - 6” meter—$281.84
- Consumption charge:
  - Single-family Residential
    - $3.94/ccf for < 3 ccf/month
    - $4.07/ccf for >3 ccf/month
  - Single family low use discount
    - ($5.00) < 3 ccf/month
  - Multi-family/Commercial
    - $4.07/ccf

In addition to cash financing through water rates, the City may use the following sources to fund water capital improvements; each has specific requirements and limitations:

- Special Public Works Fund
- Drinking Water Revolving Fund Loan Program
- Drinking Water Source Protection Fund Program
- Rural Economic Development Loan & Grant Program
- Community Development Block Grant Program
- The Water Infrastructure Finance and Innovation Program
- Bond Financing
- System Development Charges

1. INTRODUCTION AND SYSTEM DESCRIPTION

1.1 PLAN PURPOSE AND ORGANIZATION

This 2021 Water Master Plan (2021 WMP) updates the City of Milwaukie's 2010 Water Master Plan. The 2021 WMP reflects the current conditions of the City's water system and addresses projected future development. It describes the City's water system structure, management, operation, supply, projected needs, and capital improvements. The 2021 WMP includes an inventory of assets, an updated water system hydraulic model, and system demand projections based on projected population growth. It also sets forth an initial step in seismic resiliency planning. Information in the 2021 WMP will enable City staff to respond effectively to new water system demand and to determine appropriate requirements or fees for future development.

The outcome of the 2021 WMP is a capital improvement program (CIP) designed to grow the system to meet current and future demand and replace old and seismically non-resilient assets in an efficient, cost-effective manner. The CIP addresses improvements on an annual basis for the first 10 years and then in five-year increments for the remaining 10 years. Projects beyond the 20-year planning horizon are categorized as "long-term" and not described in detail.

The 2021 WMP is designed to meet the needs of the City and the planning requirements of Oregon Administrative Rule (OAR) 333-061-0060 (5). It is organized into the following chapters:

- Executive Summary
- Chapter 1—Water System Description
- Chapter 2—Asset Condition Assessment
- Chapter 3—Basic Planning Data
- Chapter 4—System Analysis
- Chapter 5—Source-of Supply Analysis and Emergency Supply
- Chapter 6—Operations and Maintenance Program
- Chapter 7—Performance Standards
- Chapter 8—Capital Improvement Program
- Chapter 9—System Financing

1.2 WATER SOURCES

1.2.1 Source of Supply

The City normally receives all of its water supply from groundwater via the Troutdale Gravel Aquifer. This aquifer reaches more than 200 feet below ground and covers approximately 300 square miles. It extends from northern Clark County in Washington State to south of Milwaukie, and from the Willamette River to Troutdale. The water levels of the aquifer are maintained by the mass of land above it and the prehistoric paleo-channel of the Columbia River. Within Milwaukie, most of the groundwater flows from the northeast to the southwest.

The City maintains secondary water sources via interties with Clackamas River Water (CRW) and the Portland Water Bureau (PWB). Both secondary sources are surface water systems. They are used by the City only during emergency or high-level maintenance situations. Both interties are equipped with bi-directional meters, allowing operation in either direction. The CRW intertie is located at 7001 SE Harmony Road and is equipped with a dedicated 700-gallon-per-minute (gpm) pump station in Zone 2 of the City's water system. The intertie is bidirectionally metered and serves as an emergency intertie for both utilities. The PWB Intertie is located at Johnson Creek Boulevard and SE 45th Place and is equipped with backflow prevention devices. A remotely actuated valve is opened when PWB water is required to supplement the City's groundwater source. The pressure differential of approximately 30 psi between Portland and the City allows the City to receive water without pumping. Manual bypass pumping is required, however, to transfer water from the City to PWB's system.

In the past, the City had an intertie with the Oak Lodge Water Services District (OLWSD); however, that intertie has been disconnected. The City is currently exploring alternatives for a new intertie with the OLWDS. Due to the differences in elevation between the Milwaukie and Oak Lodge water systems, a pump station would be necessary to transfer water into the OLWSD distribution system and reservoirs. A portable trailer-mounted pump station may be suitable for this purpose.

1.2.2 Source Characteristics

Water systems that use groundwater as a source are concerned with water hardness. Milwaukie's groundwater source is classified as moderately hard, with a calcium carbonate concentration in the range of 40 to 120 mg per liter. Although not a health risk, water that is high in dissolved minerals can be considered a nuisance due to mineral buildup on fixtures over time and poor soap and/or detergent performance.

1.3 SERVICE AREA

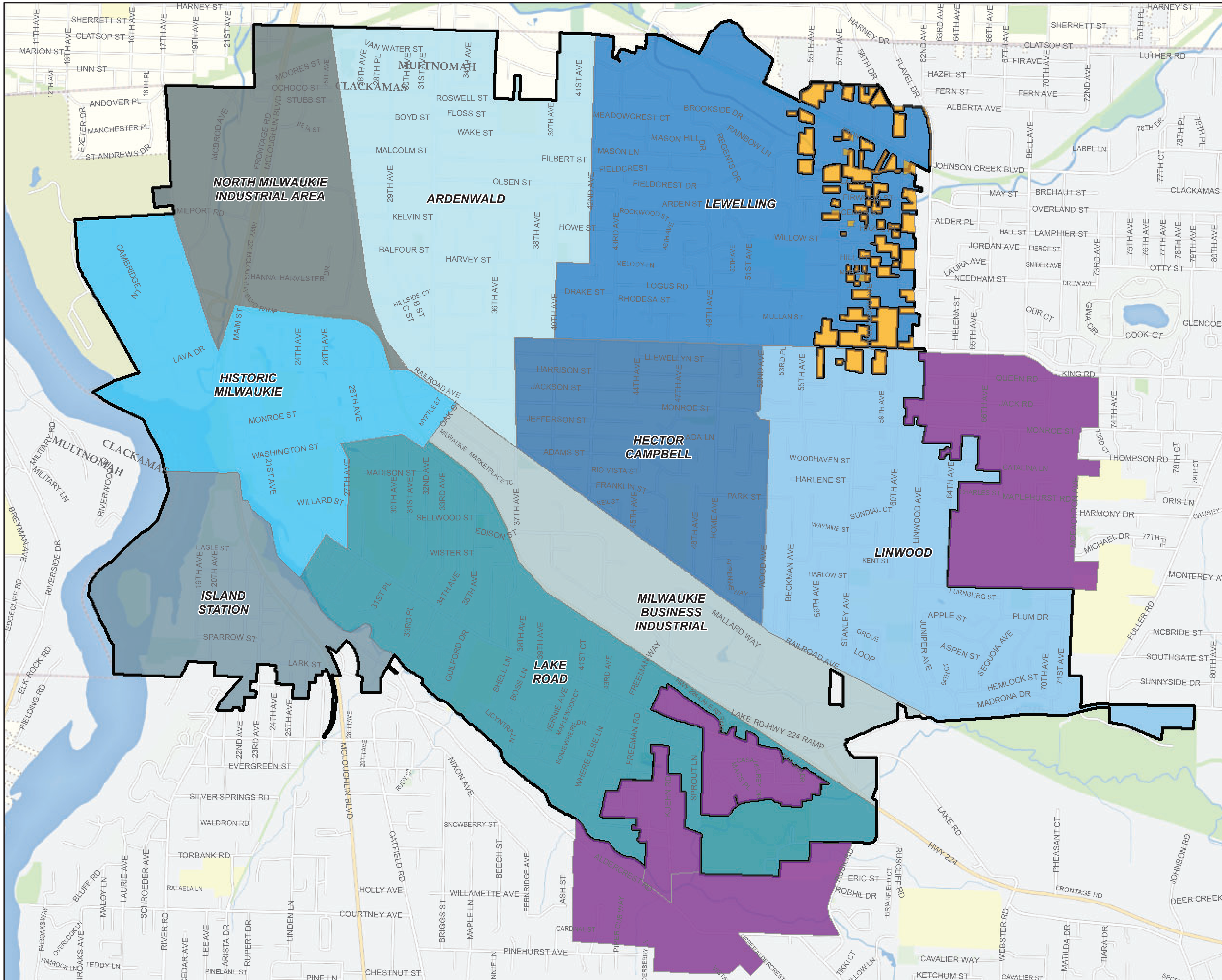
1.3.1 City Limits and Existing Service Area

The City of Milwaukie is located mostly within Clackamas County, 7 miles south of the downtown Portland; a small portion extends into Multnomah County. The city limits, generally bounded by the Willamette River (west) Johnson Creek Boulevard (north), Linwood Avenue and 71st Avenue (east) and Kellogg Road and Lake Road (south), encompass 3,169 acres. The city is divided into seven neighborhoods and two industrial areas (see Figure 1-1).

CITY OF MILWAUKIE

Figure 1-1.
Milwaukie Neighborhood Districts and Dual Interest Areas

- Milwaukie City Limits
- Ardenwald
- Hector Campbell
- Historic Milwaukie
- Island Station
- Lake Road
- Lewelling
- Linwood
- Milwaukie Business Industrial
- North Milwaukie Industrial Area
- Area A Expansion (dual interest area)
- Area B Expansion (dual interest area)



Data Sources: City of Milwaukie GIS, Clackamas County GIS, Metro Data Resource Center

Date: Monday, September 13, 2021

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0 0.25 0.5 Miles

The current water system serves a population of 20,291 (Portland State University Certified Population, July 2019) through 7,870 metered connections. The water system service area corresponds approximately to the city limits, as illustrated in Figure 1-2. Some residents, however, receive water from CRW (see the discussion of dual interest areas in Section 1.3.3).

1.3.2 Land Use and Zoning

The City consists of residential, commercial, mixed use and industrial zones. The City's Land Use Ordinance was revised in April 2019. The current land use and zoning designations are shown in Figure 1-3 and Figure 1-4. Total developed and vacant acreage are listed in Table 1-1.

Table 1-1. Total, Developed and Vacant (Buildable) Land by Zone

Zone	Description	Area (acres)[c]		
		Total [a]	Developed [b]	Vacant [b]
Low Density Residential Zones				
R-5	Medium Density: 8.8 to 21.1 units per net acre	350.9	225.7	9.2
R-7	Low Density: up to 6.2 units per net acre	1,335.9	1075.0	27.6
R-7PD	Low Density Planned Development: up to 6.2 units per net acre	17.0	13.2	0
R-10	Low Density: up to 6.2 units per net acre	297.5	222.0	9.1
R-10PD	Low Density Planned Development: up to 6.2 units per net acre	17.0	9.1	0.1
Medium and High-Density Residential Zones				
R-1	Medium and High Density Residential	27.9	14.0	0
R-1-B	High Density: 21.1 to 24.0 units per net acre	34.6	27.5	0
R-2	Medium Density: 6.3 to 8.7 units per net acre	183.3	141.0	7.7
R-2.5	Medium Density: 6.3 to 8.7 units per net acre	2.0	0.5	0
R-3	Medium Density: 6.3 to 8.7 units per net acre	144.4	128.2	1.0
Mixed Use				
DMU	Downtown Mixed Use: 10 – 40+ Units per net acre	63.7	45.0	0.8
GMU	General Mixed Use (outside downtown center): 25 – 50 units per net acre	39.8	14.5	13.8
NMU	Neighborhood Mixed Use	17.0	12.8	0
Commercial (CG and CN)				
C-CS	Community Shopping Commercial	25.1	20.6	0
C-G	General Commercial	9.3	6.4	0
C-L	Limited Commercial	21.8	2.1	0.1
C-N	Neighborhood Commercial	1.2	0.7	0
Industrial				
BI, M, MUTSA, NME	Business Industrial, Manufacturing, Heavy Industrial, North Milwaukie Employment Zone	582.3	414.2	9.7

a. Total area was obtained from the City's GIS, which is based on bulk area.
b. Developed and vacant areas were obtained from Angelo Planning data, which is based on parcels.
c. Discrepancies between total area and developed/vacant area include areas that are associated with right-of-way and other undevelopable land

1.3.3 Areas of Potential Growth

Urban Growth Management Agreement

The City entered into an Urban Growth Management Agreement (UGMA) with Clackamas County in 1990 that describes land use planning and facility provision for properties just outside the city limits. Approximately 7,400 acres of land adjacent to the City was designated under the UGMA as the City's future urban service area, as shown on Figure 1-5. The area extends east to about I-205 and south to just beyond SE Thiessen Road. The UGMA and the city's Comprehensive Plan policies address ultimate city expansion to include the area between its current boundary and I-205, however, no mechanism was outlined to encourage or enable the city to annex these properties.

The 1990 UGMA includes two provisions that inhibit city annexation and expansion into the area. The first acknowledges that the North Clackamas Urban Area Public Facilities Plan would guide public facility improvements for the area. This could limit the areas that could be served by City water and sewer service, keeping much of it served by County special service districts. The second provision gave Clackamas County planning authority for areas outside the city limits but inside the areas governed by the UGMA. In addition to these provisions, a vacant land inventory identified the UGMA future urban service area as highly developed, with only 5 percent (395 acres) of it currently vacant.

Currently, there are no plans in place to annex additional properties into the City's water service area. However, the City remains aware of potential impacts if policies change and future annexations do occur. No changes in the water service area are anticipated during the planning period.

Dual Interest Areas

The land within the UGMA includes two "dual interest areas" adjacent to but outside the Milwaukie city limits, as shown in Figure 1-1 and Figure 1-3:

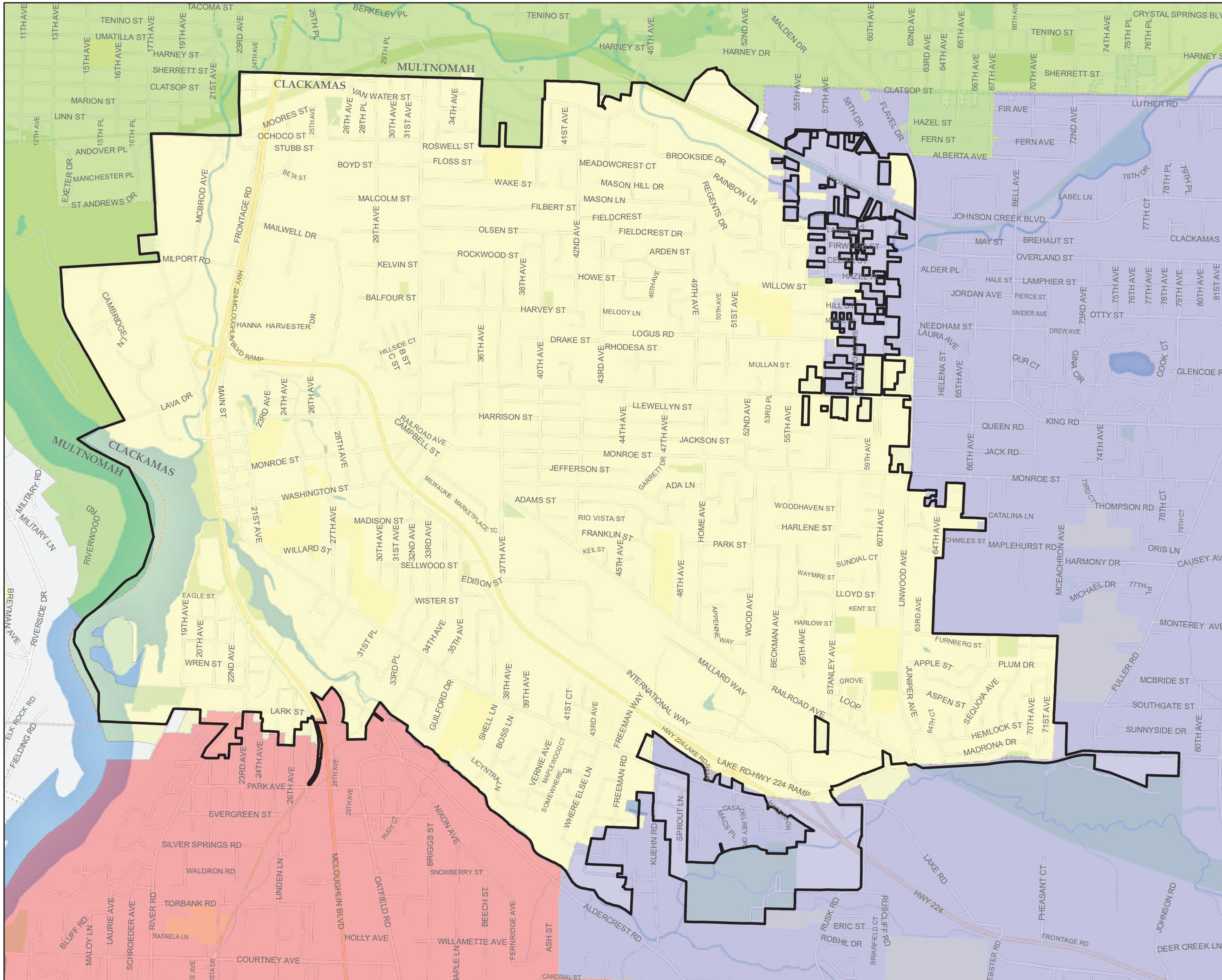
- **Dual Interest Area A**—Located in the northeast part of the city. This was the only area in the 1990 UGMA future urban service area where annexation was required for redevelopment and where the City of Milwaukie was identified as the provider of sewer service. In 2010, the City annexed all the rights-of-way within Area A and began installing new sewer lines. From 2010 through 2012, the City annexed approximately 100 properties into Milwaukie from this area through its Annexation Assistance Program. The City has continued to annex properties that are redeveloping or need to connect to sewer service, but numerous islands of unincorporated properties surrounded by city limits remain in this area. The City has taken a passive approach to annexation of these properties and has not forcibly annexed any islands in recent years.
- **Dual Interest Area B**—Located in the southeast corner of the City, bounded by Highway 224 on the north and intersected by Kuehn Road. This area is currently developed, so it is less likely to be annexed into the City anytime soon. A large City development in an adjacent location, however, could force an annexation.

Areas that are designated as dual interest areas and are currently outside the city limits are not expected to fall under the City's water service area in the future. Both dual interest areas currently receive water from CRW. For informational purposes only, Table 1-2 summarizes vacant land within the two dual interest areas.

CITY OF MILWAUKIE

Figure 1-2.
Water Service Areas

- City of Milwaukie
- City of Milwaukie Water
- City of Portland Water Bureau
- Clackamas River Water
- Oak Lodge Water District



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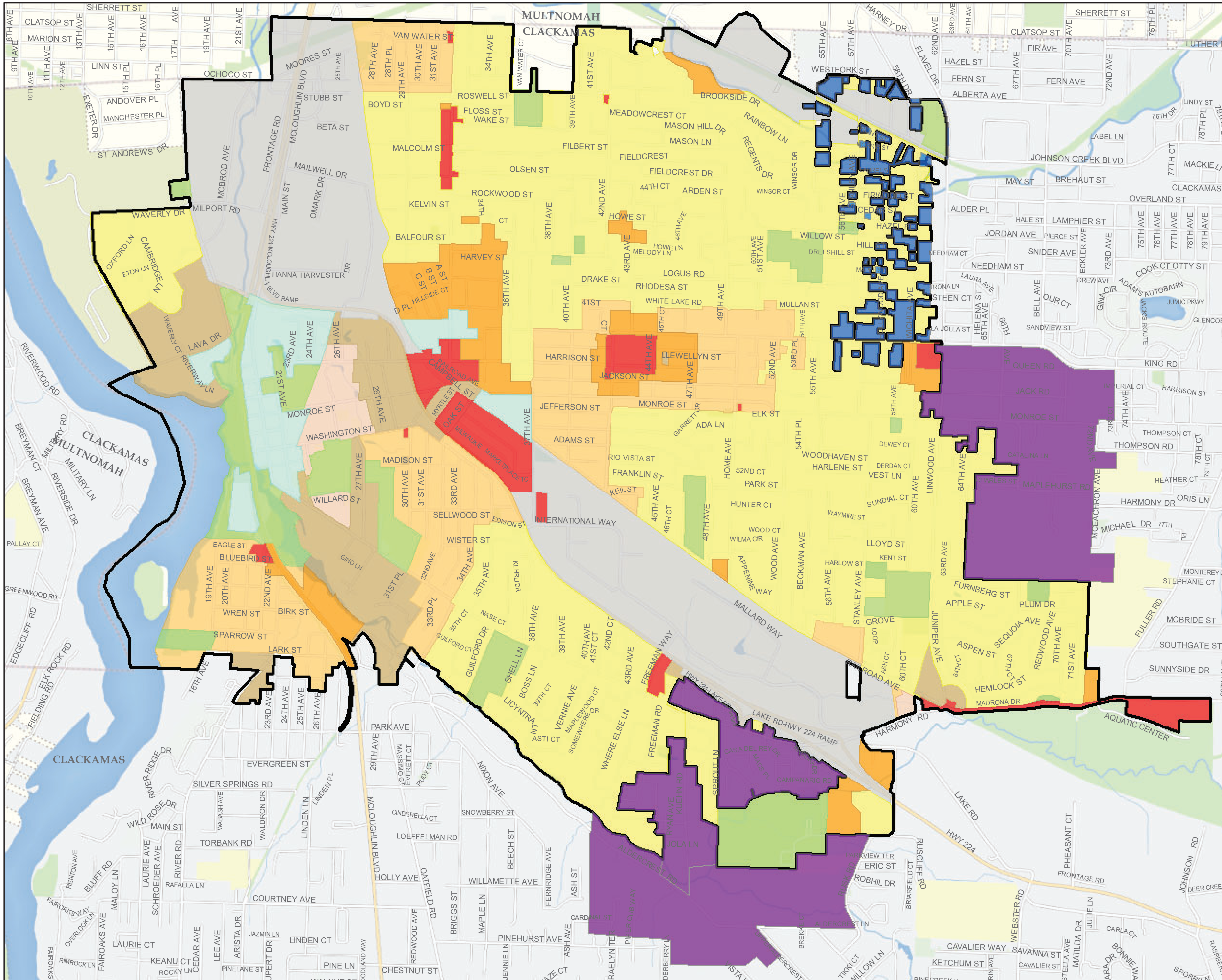
CITY OF MILWAUKIE

Figure 1-3.
Land Use and Dual Interest Areas

- Milwaukie City Limits
- LD - Low Density
- MD - Moderate Density
- MED. D - Medium Density
- HD - High Density
- C - Commercial
- C/HD - Mixed Use
- I - Industrial
- P - Public
- TC - Town Center
- Area A Expansion (Dual interest area)
- Area B Expansion (Dual interest area)



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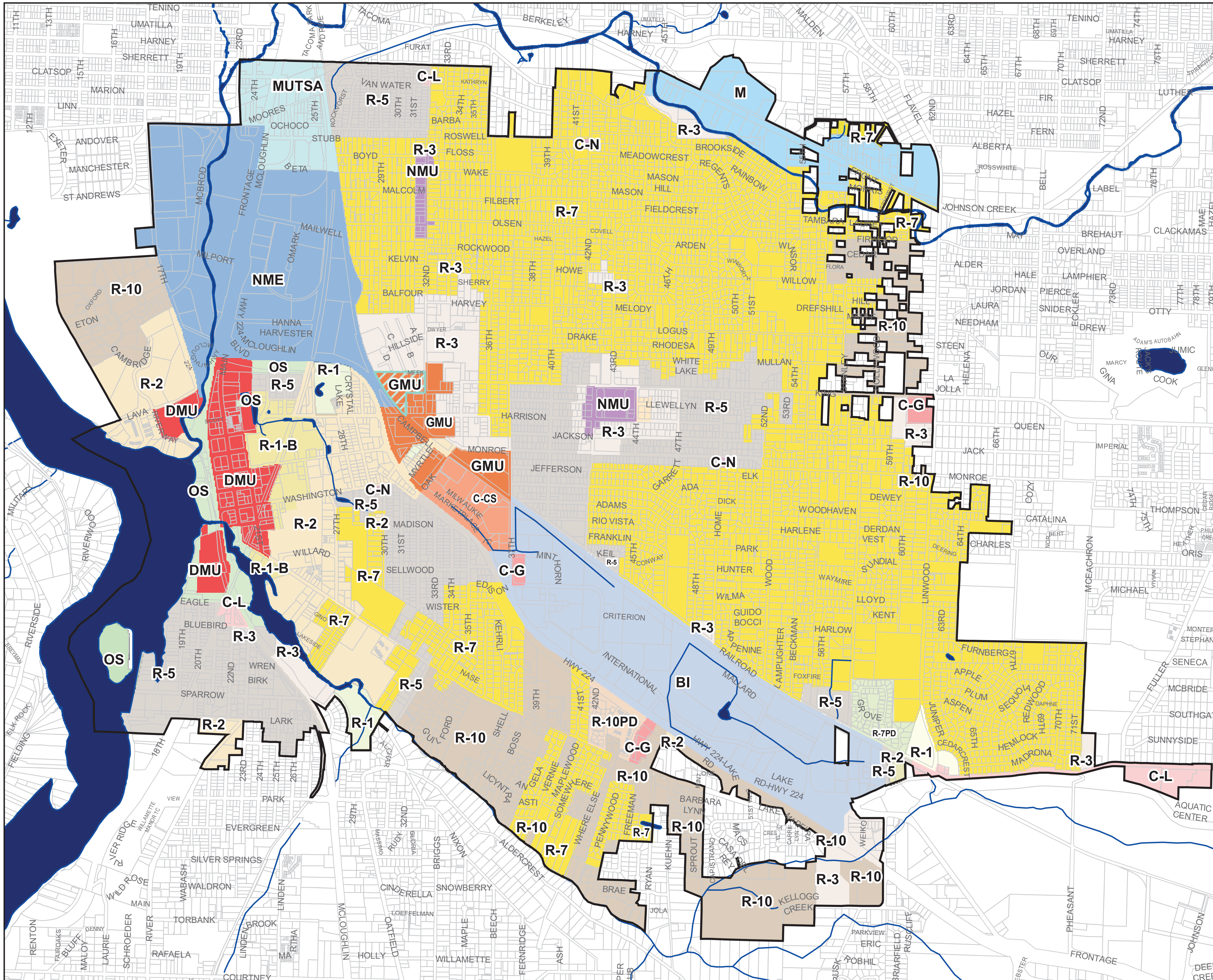


Figure 1-4.
Zoning

Industrial
- BI
- M
- MUTSA
- NME

Commercial and Mixed Use
- NMU
- C-N
- C-L
- C-G
- C-CS
- GMU

Residential
- R-1
- R-1-B
- R-2
- R-2.5
- R-3
- R-5
- R-7
- R-7PD
- R-10
- R-10PD

Downtown
- DMU
- OS

- Flex Space Overlay
- City Boundary
- Water Body

Adopted by Ord. #1438, effective Dec. 5, 1979
Rev. as of Ord. #2194 , effective August 28th, 2020

Data Sources: City of Milwaukie GIS, Metro Data Resource Center
9/10/2020

Please check with Planning Department for most up-to-date information.
503-786-7630
planning@milwaukieoregon.gov

CITY OF MILWAUKIE

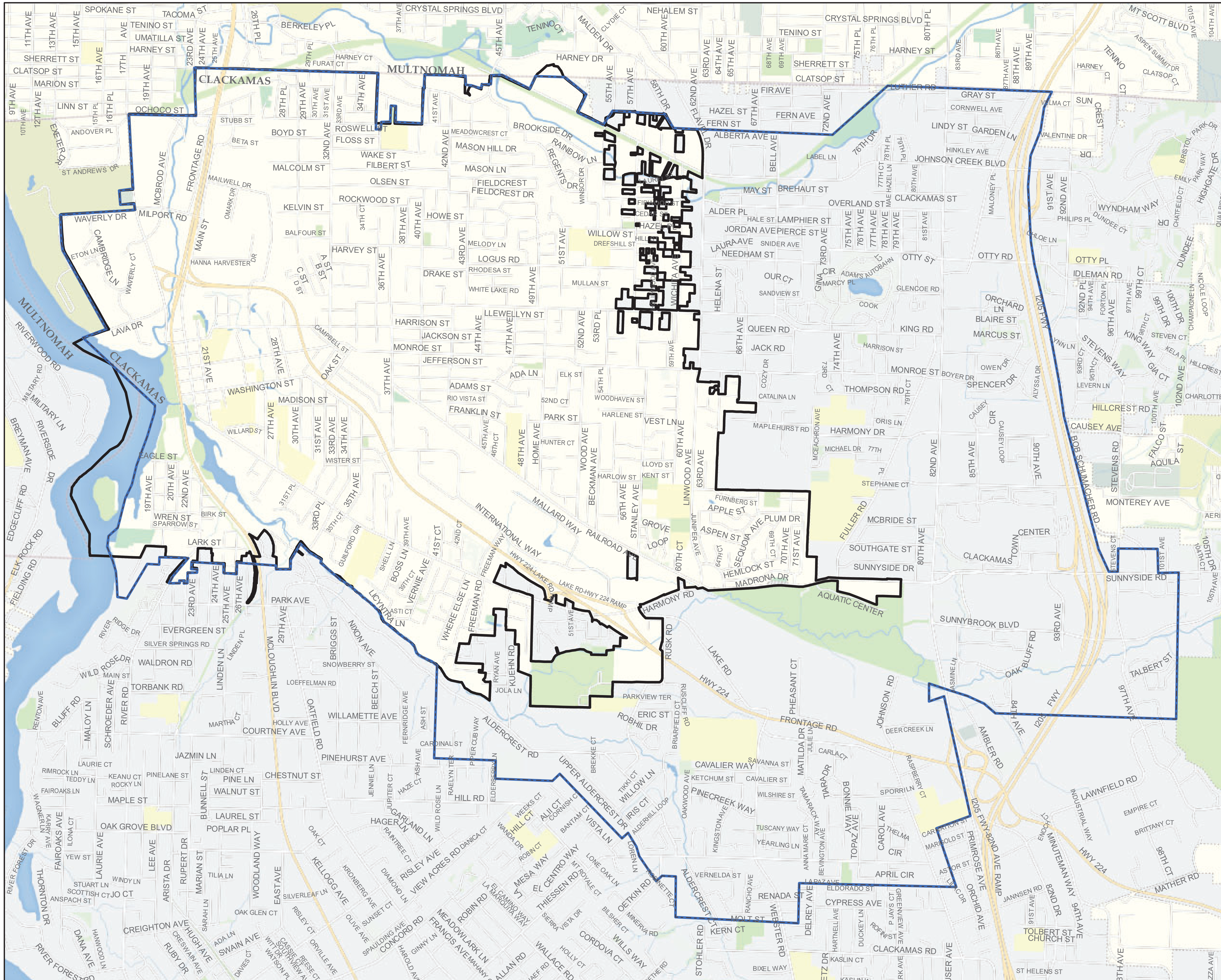
0 0.25 0.5 Miles

CITY OF MILWAUKIE

Figure 1-5. City Limits and UGMA Boundary

Milwaukie City Limits

Milwaukie UGMA



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0 0.5 1 Miles

Table 1-2. Dual Interest Area Vacant Land

County Land Use Category	Acres
Dual Interest Area A	
General Industrial	0.2
(M) Industrial	1.3
Urban Low Density Residential (R7)	1.5
Urban Low Density Residential (R10)	15.0
Dual Interest Area A Vacant Land Total	**18.0**
Dual Interest Area A Land Total	110.0
Dual Interest Areas A Percentage of Vacant Land	***16%***
Dual Interest Area B	
Heavy Industrial	2.4
Light Industrial	1.1
Multi-Family Residential	5.2
Multi-Unit Residential	6.3
Urban Low Density Residential (R5 and R7)	67.3
Urban Low Density Residential (R10)	35.3
Dual Interest Area B Vacant Land Total	**117.6**
Dual Interest Area B Land Total	2,237
Dual Interest Area B Percentage of Vacant Land	***5%***

1.3.4 Buildable Land Inventory

The City worked with a consultant in 2019 to develop a new buildable lands inventory for identified infrastructure scenarios. The results were published in a memorandum, which is included in Appendix A.

Five growth scenarios were explored, and the City selected the most conservative (highest growth rate) scenario for infrastructure planning purposes. This scenario assumes full buildout, but with higher density in areas the City identified as hubs and corridors. Partial redevelopment of existing single-family properties into duplexes was also factored into the projections. Vacant land was assumed to be developed at the full allowable density. Developed land was examined for potential infill development. Vacant land is a small fraction of the developable land, therefore most development will be achieved through infill and redevelopment.

The selected growth scenario projected a potential 10,704 additional housing units: 6,062 units within the city limits and 4,642 units within the dual interest areas. Only the 6,062 units within the city limits are used in the analyses for this WMP. It is assumed that the potential 4,462 units outside the city limits will be serviced by other water providers.

The selected growth scenario identified the distribution of the additional units by pressure zone. For that analysis, a discrepancy of 116 units between units outside existing pressure zones and outside the city limits was resolved by proportionally distributing those units across the existing pressure zones. The resulting projected distribution by pressure zone is described in Table 1-3.

Table 1-3. Full Build Out Projections—Additional Units by Pressure Zone

	Projected Additional Units
Pressure Zone 1	1,481
Pressure Zone 2	3,495
Pressure Zone 3	590
Pressure Zone 4	496
Total	**6,062**

1.4 WATER SYSTEM DESCRIPTION

1.4.1 System History and Ownership

The City of Milwaukie was incorporated in 1903, and the City Council issued a franchise to build water storage tanks, lay water mains and provide water in 1904. The City owns all water sources, equipment, systems, and facilities associated with the purveyance of water within its service area.

1.4.2 System Assets

The City maintains all of the following water system components:

- 6,900 service meters
- 100 miles of transmission and distribution pipeline
- seven groundwater wells (six are in operation)
- two treatment facilities
- two transfer pump stations
- two booster pump stations
- three reservoirs
- 794 hydrants
- 36 pumps
- 19 pressure-regulating valves (PRVs)
- 6 reduced pressure assemblies
- 4 reduced pressure detector assemblies
- 4 pressure regulators
- 3,001 operational valves
- 2 interties

Figure 1-6 shows the location of major water system assets.

1.4.3 Service Pressure Zones

The water system is made up of four pressure zones, as identified in Figure 1-7 and Table 1-4. Table 1-5 tabulates the water system's pipe inventory by pressure zone as described in the city's geographic information system (GIS).

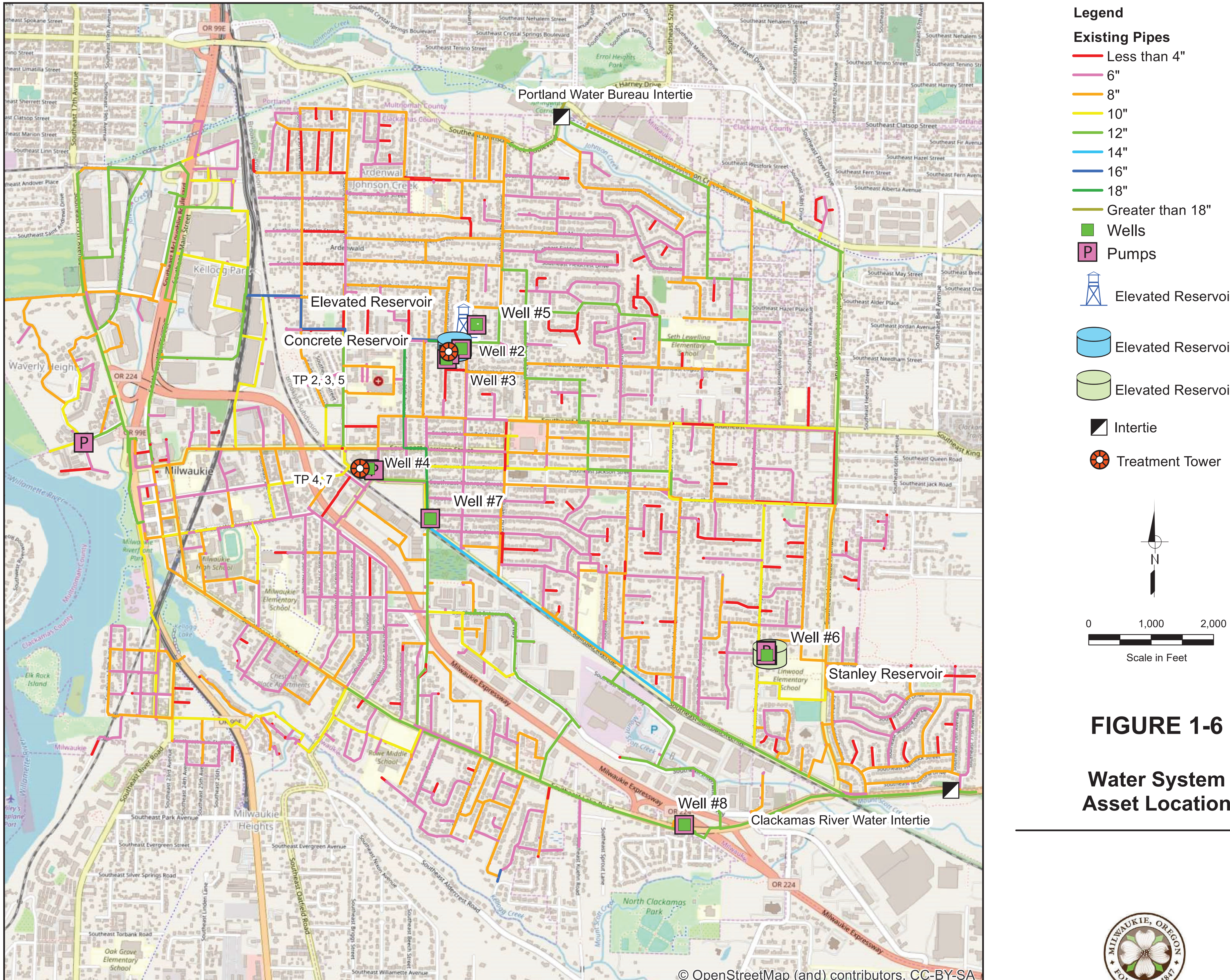


FIGURE 1-6

Water System Asset Location

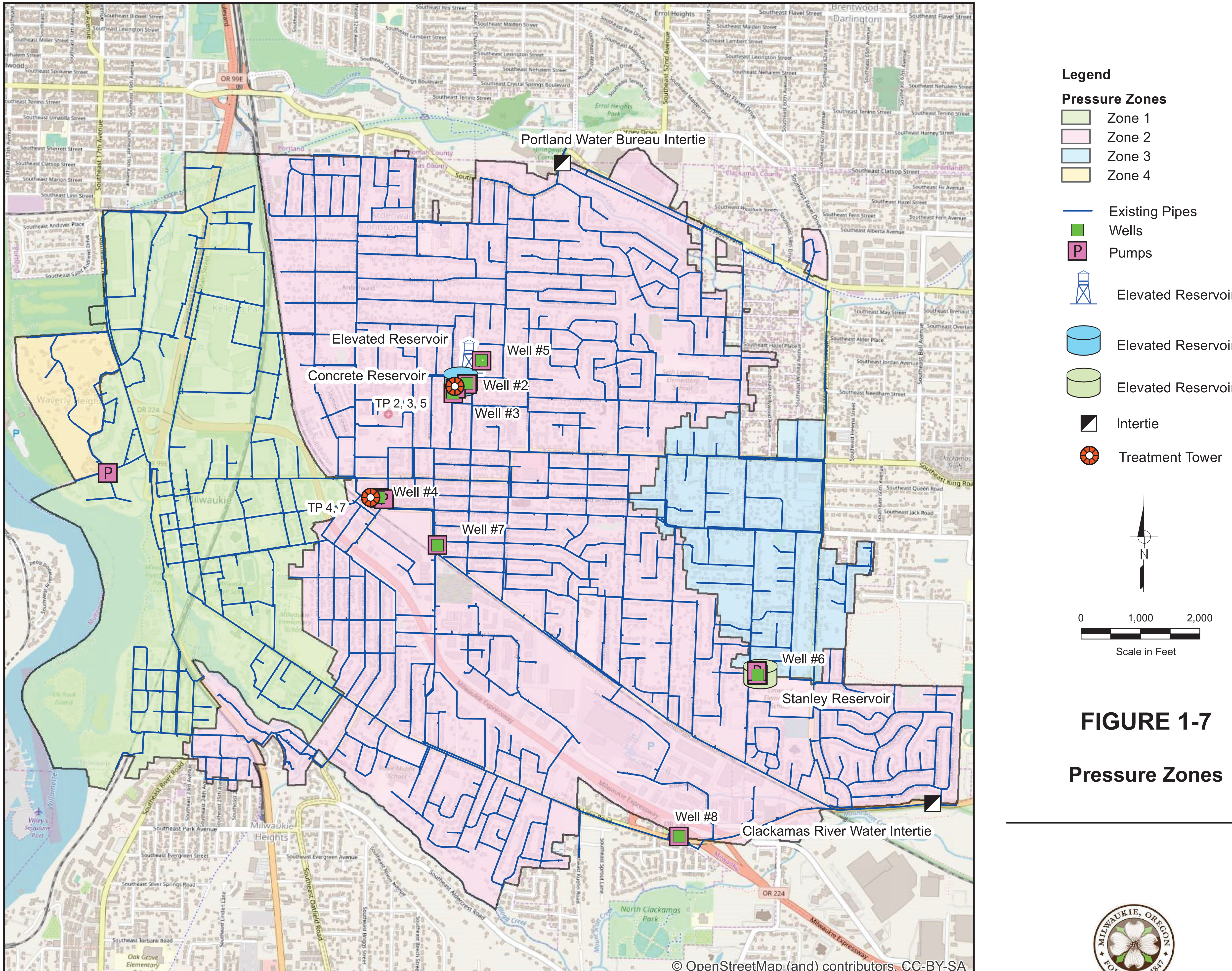


FIGURE 1-7

Pressure Zones

Table 1-4. Pressure Zones

Pressure Zone	Elevation (feet)	Type	Facilities in the Pressure Zone: Well	Reservoirs	Booster Stations	PRVs	Treatment Plants
1	28 - 125	Gravity fed by Concrete Reservoir, Zone 2 and Zone 4			Lava Drive Pump Station	5	
2	50 - 195	Gravity fed by Elevated Reservoir, Pumped by Well 8, Pumped by TP47	Well 2 Well 3 Well 4 Well 5 Well 7 Well 8	Elevated 1.5 MG Reservoir Concrete 1.5 MG Reservoir	W2 PS TP235 Booster TP47 Booster		TP235 TP47
3	160 - 205	Pumped by Well 6 Booster	Well 6	Stanley Reservoir	W6 Booster 3rd PS		
4	75 - 150	Lava Drive Pump Station and Gravity Fed by Zone 1					

Table 1-5. Pipe Inventory by Pressure Zone (2020)

Pressure Zone	Pipe Quantity (feet)	Percent of Total (%)
1	100,581	19%
2	375,700	71%
3	43,242	8%
4	6,957	1%
Total	**526,480**	**100%**

1.4.4 Groundwater Wells

The City operates seven wells. Characteristics of the wells are summarized in Table 1-6. Well 8 is out of operation. Well 6 pumps directly to a storage reservoir. All other wells pump to a facility for treatment prior to distribution.

1.4.5 Treatment

Water from Wells 2, 3, 4, 5 and 7 has historically contained elevated volatile organic carbons (VOCs). The City water systems includes two facilities providing packed tower aeration treatment to reduce effluent VOC concentrations. Both treatment facilities have the same configuration and operating procedures. Water is pumped directly to an air stripping tower for the removal of VOCs. Chlorine gas is injected into the flow stream prior to the treatment towers and a polishing dose is added after aeration. Treated water enters a clearwell from where it is pumped by vertical turbine booster pumps to the distribution system or storage. A typical schematic of this system is shown in Figure 1-8. The treatment towers are designed to achieve the effluent concentration limits under the conditions described in Table 1-7.

Table 1-6. Well Characteristics

Well Number	Location	Year of Well Construction	Total Depth (feet)	Year of Pump Installation	Flow Capacity (gpm)[a]	Horsepower/ Motor Speed	Total Dynamic Head (feet)[a]
2	9951 SE 40th Avenue	1936	290	1993	800 [c]	50/1800	257
3	3800 SE Harvey St. & SE 40th Ave.	1946	290	1980	510	60/1800	264
4	9829 SE Railroad Avenue	1960	304	2004	605	75/1800	290
5	9870 SE 40th Avenue	1963	383	1980	950 [d]	75/1800	234
6	11806 SE Stanley Avenue	1978	336	2007	670	60/1800	204
7	11022 SE 37th Avenue	1984	325	2000	1,120	125/1800	195
8[b]	5393 SE Lake Road	2008	481	2009	700		400

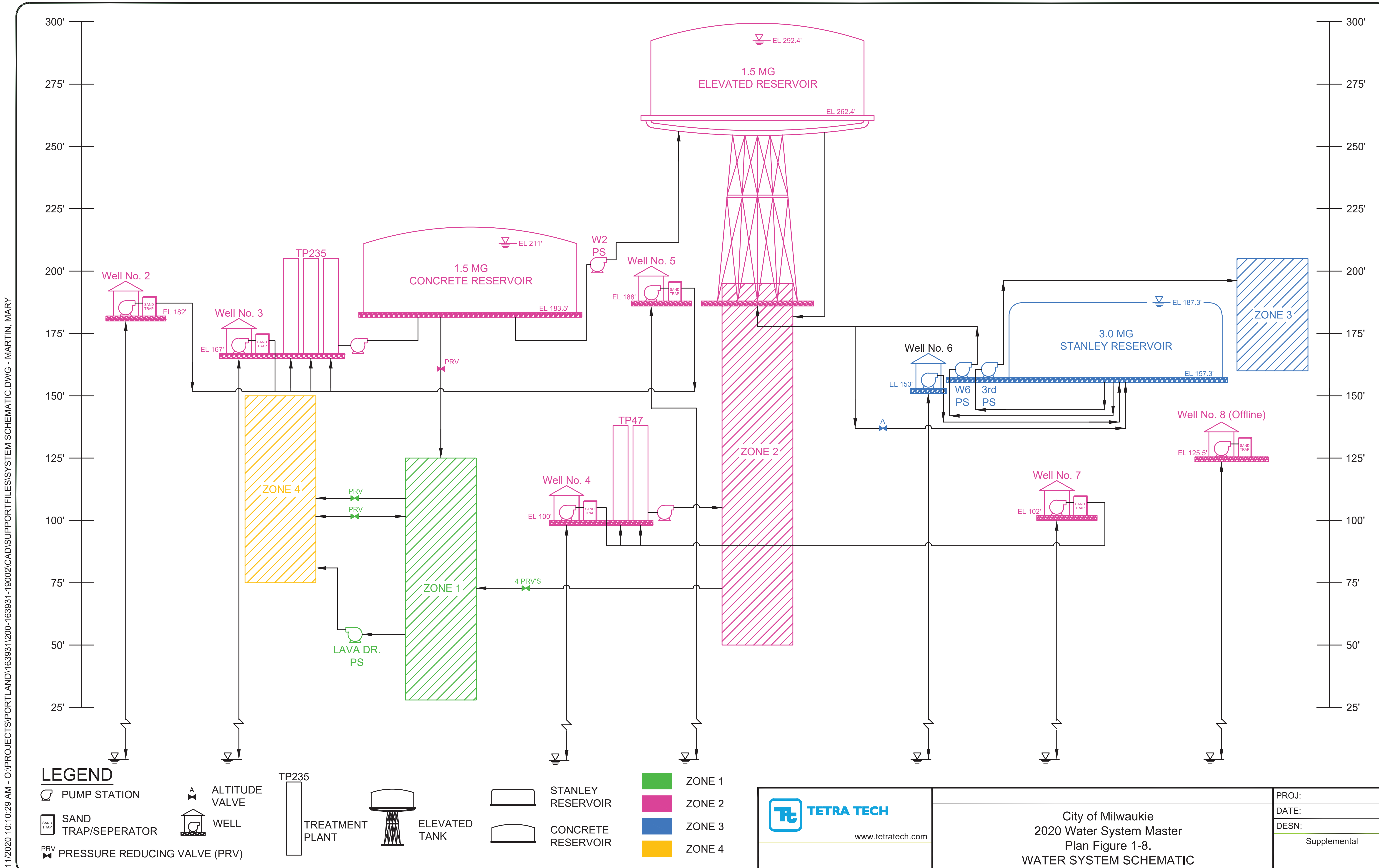
a. Data based on pump performance analysis performed by BacGen.
b. Well 8 is not in operation due to issues with biofouling.
c. Well 2 is jointly limited with Wells 3 and 5 to 1,800 gpm by capacity of the water treatment towers. During normal operation, Well 2 operates at approximately 605 gpm. Well 2 can produce up to 800 gpm when operating alone, however.
d. Well 5 is jointly limited with Wells 2 and 3 to 1,800 gpm by capacity of the water treatment towers. During normal operation, Well No. 5 operates at approximately 605 gpm. Well 5 can produce up to 950 gpm when operating alone, however.

Table 1-7. Treatment Facilities

Facility Name	Well Source	Description	Design Criteria				
			Flow Rate	Packing Depth	Minimum Air/ Water Ratio	Tower Diameter	Tower Material
TP235	Wells 2, 3 & 5	Treatment Towers 2, 3 and 5	600 gpm (each tower)	19 feet	40:1	6 feet	fiber reinforced plastic
TP47	Wells 4 and 7	Treatment Towers 4 and 7	600 gpm	19 feet	40:1	6 feet	fiber reinforced plastic
			1000 gpm	19 feet	40:1	8 feet	fiber reinforced plastic

Wells 4 and 7 pump to treatment facility TP47. TP47 is equipped with two towers, each dedicated to a specific well source. The piping configuration provides for operational flexibility if a tower is out of service for maintenance. Treated water from TP47 is pumped directly into the distribution system.

Under normal operating conditions, Wells 2, 3, and 5 pump to treatment facility TP235. TP235 is equipped with three towers, each dedicated to a specific well. The piping configuration provides for operational flexibility if a tower is out of service for maintenance. Treated water from Wells 2, 3, and 5 is pumped to the Concrete Storage Reservoir. A photo of TP235 is shown in Figure 1-9.



City of Milwaukie
2020 Water System Master
Plan Figure 1-8.
WATER SYSTEM SCHEMATIC

Bar Measures 1 inch

Figure 1-9. TP235 Towers

1.4.6 Storage

The City operates three distribution system storage reservoirs whose characteristics are summarized in Table 1-8.

Table 1-8. Storage Facilities

Facility Name	Storage Type	Material	Year Built	Overflow Height (feet)	Storage Capacity (MG)	Zone	Reservoir Supply
Elevated Reservoir	Elevated Tank	Welded Steel	1963	292.4	1.5	2	TP235
Concrete Reservoir	Ground Level	Concrete	1923	211.0	1.5	2	TP235
Stanley Reservoir	Ground Level	Welded Steel	1970	187.3	3.0	3	Well 6
Total Capacity (MG)					**6.0**		

1.4.7 Pump Stations

The City manages and operates two transfer pump stations and two booster stations, as described in Table 1-9.

Table 1-9. Transfer and Booster Pump Stations

Pump Station Name	Location	Pumping From	Pumping To	Number of Pumps	Motor Size/ Speed (hp/rpm)	Capacity Each Pump (gpm) [c]	Ground Elevation (feet)	Rated Discharge Head (feet)
W6 Transfer Pump Station	Stanley Reservoir Site, 11800 SE Stanley	Stanley Reservoir	Zone 2	2	50/1,800 50/1,800	850 940	158	118 118
W2 Transfer Pump Station	TP235 and Concrete Reservoir Site	Concrete Reservoir	Elevated Reservoir	2	20/1,800 20/1,800	430 601	188	90 90
Lave Drive Booster Pump Station[a]	Lava Drive	Zone 1	Zone 4	2 duty 2 fire	15/3,525 15/3,525 100/1,780 100/1,780	300 300 1,750 1,750	51	116 116 176 176
3rd Pressure Zone Booster Pump Station[b]	Stanley Reservoir Site	Stanley Reservoir	Zone 3	4	20/1,800 20/1,800 100/3,600 100/3,600	200 200 600 600	158	168 168 380 380

a. Fire pumps are rarely used and must be manually operated.
b. Fire pumps are activated when the two smaller pumps cannot maintain system pressure
c. Based on pump performance analysis performed by BacGen.

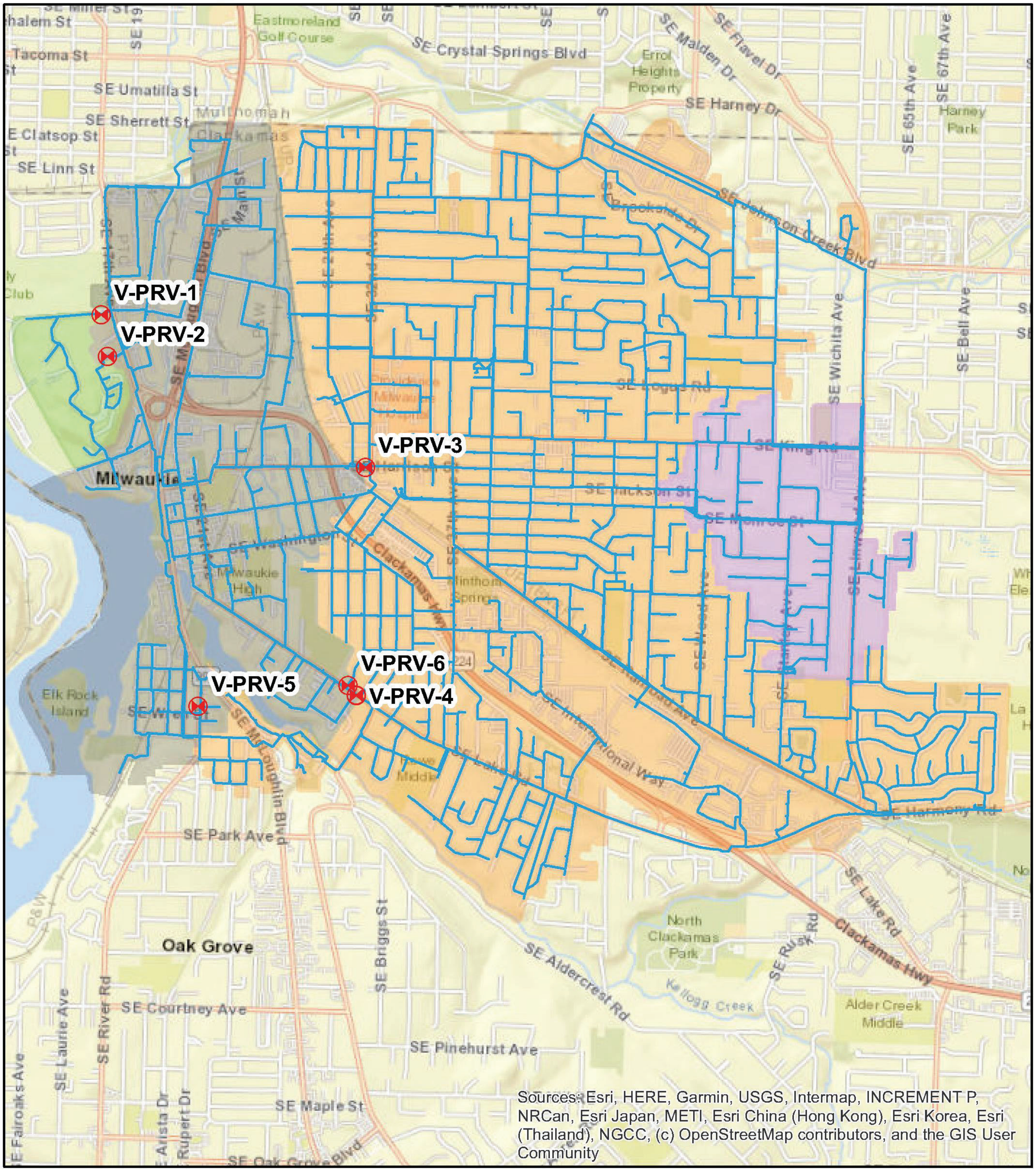
1.4.8 Pressure-Regulating Valves

Water system pressures are managed through six PRVs as described in Table 1-10. Figure 1-10 shows the PRV locations.

Table 1-10. Pressure-Regulating Valves

PRV Zone	Zone From/To	Size (inches)	Elevation	Location	PRV Setting or Control Used in Hydraulic Model (psi)
V-PRV-1[a]	1 / 4	8	92	SE Waverly & 17th	Opens on lower Zone 4 Pressure
	4 / 1	2	92		Open
V-PRV-2[b]	1 / 4	8	110	SE McBrod & 17th	Opens on Lower Zone 4 pressure
V-PRV-3[c]	2 / 1	8	102	Harrison & 32nd	43
V-PRV-4[c]	2 / 1	8	110	Lake & 33rd	40
V-PRV-5[c]	2 / 1	8	132	Wren & River	30
V-PRV-6[c]	2 / 1	8	109	32nd & Lake	40

a. Operates as a check valve. Set to pass about 20 gpm.
b. Operates as a check valve.
c. Opens on Zone 1 pressure lower than Elev. 202 in Concrete Reservoir.



Legend

- PRV
- Pressure Zone 1
- Pressure Zone 2
- Pressure Zone 3
- Pressure Zone 4

0 1,000 2,000

Scale in Feet

FIGURE 1-10

City of Milwaukie
Milwaukie Water Master Plan

PRV Locations

1.4.9 Pipe Inventory

Accurate records correlating pipe material and age are incomplete, and GIS data does not include pipe material for every pipe segment. Approximately 64 percent of the pipe is of unknown material, and the date of installation is unknown for approximately 7 percent of the pipe. Based on standard industry practices, all pipe installed prior to 1969 can be assumed to be cast iron, and pipe installed during the 1970s and 1980s can be assumed to be ductile iron. Construction in the 1990s continued the use of ductile iron but also started to introduce C900 PVC pipe.

Based on those assumptions, nearly half of the distribution system could be made of cast iron pipe. Cast iron can have a long structural life, but it is prone to internal corrosion and tubercle formation, which can significantly reduce internal diameters over time. As the City conducts pipe repairs, it would be valuable to collect cast iron pipe samples to assess system-wide condition.

2. ASSET CONDITION ASSESSMENT

The condition of the City's water system assets—reservoirs, treatment plants, wells, pump stations and associated equipment—was assessed in December 2019. This chapter summarizes the findings of the assessment; detailed evaluation forms and photos are included in Appendix B.

2.1 GROUNDWATER WELLS

The City has six operational groundwater wells, designated as Wells No. 2, No. 3, No. 4, No. 5, No. 6, and No. 7. An additional well (Well No. 8) is non-operational. Well No. 1 was decommissioned and its water right reallocated to Wells No. 2, No. 3, and No. 5.

2.1.1 Operational Wells

Well No. 2

The original Well No. 2 was installed in 1936. It supplies water to the City's concrete reservoir, from which the water is sent to the distribution system. A 2018 video inspection revealed a split in the well casing, with 6-inch gaps at depth of about 220 feet in the 290-foot-deep well. The well remains in use at a reduced capacity. City staff determined that it cannot be repaired and must be replaced. At the time of this WMP, a replacement well in the immediate vicinity is under construction but not yet in operation. The replacement well will generally operate in the same manner as the existing Well No. 2.

The building that houses the current Well No. 2 is also used by Public Works for equipment storage and contains the TP235 emergency generator. The building is a World War II era warehouse with a chronic leaking roof, no ventilation system and other maintenance needs.

Well No. 3

Well No. 3 experienced issues with shutting down after a few hours of operation. Maintenance was performed just prior to the December 2019 condition assessment. The signal conditioning unit is obsolete, with no parts or replacement available. The building in which Well No. 3 is located has no major condition issues, but it is not constructed to the current seismic code.

Well No. 4

The 2019 condition assessment did not reveal any issues with the condition of Well No. 4. However, the signal conditioning unit is obsolete, with no parts or replacement available, and the static level well probe is not operational. The Well No. 4 building has no major condition issues, but it is not constructed to the current seismic code.

Well No. 5

Just prior to the December 2019 condition assessment, Well No. 5 experienced a water leak, high vibration, and an oil leak. Maintenance was performed on the leaks, but vibration continues to be a concern. The signal conditioning unit is obsolete, with no parts or replacement available. The pump is capable of operating at 900 gpm, but its operation is limited by the treatment tower capacity of 600 gpm. The building in which Well No. 5 is located has maintenance problems—such as damage to insulation, a gutter downspout, and a vent screen—and is not constructed to the current seismic code.

Well No. 6

There were no apparent issues with Well No. 6 at the time of the 2019 condition assessment; however, the static level probe is inoperable. The building in which Well No. 6 is located has no major condition issues, but it is not constructed to the current seismic code.

Well No. 7

At time of the 2019 condition assessment, Well No. 7 appeared to have an oil leak, but no other condition issues were apparent at that time. The building in which Well No. 7 is located has no major condition issues, but it is not constructed to the current seismic code. The Well No. 7 flow control system should be upgraded to more closely match the well pump and booster pump operation.

Summary

Table 2-1 summarizes assessed conditions of the operational wells.

Table 2-1. Well Assessment Summary

	Pumps	Building
Well No. 2	Damaged casing. Replacement well has been drilled. Currently pumping at reduced capacity.	WW II era building, with leaking roof and other issues. Not built to current seismic code.
Well No. 3	Ongoing issues. The pump was recently failing after a few hours of use. Packing recently replaced.	Good condition Not built to current seismic code.
Well No. 4	Good condition. No known issues.	Good condition Concrete masonry unit construction Not built to current seismic code.
Well No. 5	High vibration, oil leak, packing gland leak Pump has a much higher capacity than that of the corresponding Treatment Tower 5 (900 gpm vs. 600 gpm)	Maintenance needed Inoperable ceiling fan Not built to current seismic code. Currently planned for replacement.
Well No. 6	Good condition. No known issues.	Maintenance needed Not built to current seismic code.
Well No. 7	Good condition. Evidence of oil leak. No other known conditions. Flow control is not optimal.	Good condition Not built to current seismic code.

2.1.2 Non-Operational Wells

Well No. 1 is decommissioned, and its capacity is used by Wells No. 2, No. 3, and No. 5. No condition assessment was made of Well No. 1 for this WMP.

Well No. 8, has been offline since 2013 due to iron-related bacteria fouling that resulted in reduced capacity and control issues. The fouling caused frequent well pump overheating. Well No. 8 was taken out of service, rather than decommissioned, so that it would be available for emergency purposes. However, while the pump, sand filter and generator are still in place, Well No. 8 is currently not considered operational. A 2021 technical memorandum prepared by GSI described potential rehabilitation and replacement scenarios. Based on previous rehabilitation efforts in the former Well No. 8, it is unlikely that rehabilitation would restore Well No. 8 to its original pumping capacity. GSI estimated that the cost to rehabilitate Well No. 8 would be $250,000 to $260,000. A routine maintenance program for the rehabilitated well is estimated to be an additional $65,000 per incident. The estimated cost to replace Well No. 8 is approximately $2million. Appendix C provides GSI technical memorandums from 2013 and 2021.

2.2 STORAGE

The City operates and maintains three potable water storage facilities, designated as the Elevated Reservoir, the Stanley Reservoir, and the Concrete Reservoir.

2.2.1 Elevated Reservoir

The Elevated Reservoir was built in 1963 and has a capacity of 1.5 MG. It was upgraded in 2004 to the current seismic code at that time. The interior and exterior coatings were replaced in 2017.

2.2.2 Stanley Reservoir

The Stanley Reservoir was built in 1970 and has a capacity of 3.0 MG. It was not constructed with seismic considerations, nor has it been upgraded to seismic code. A 2018 condition assessment indicated that the tank is adequate for hydrostatic and gravity loads, but there are concerns with seismic loads and wave action that could damage the roof. Therefore, until seismic upgrades are made, the operating level has been adjusted to 24.5 feet (the design operating level is 30 feet). This equates to a 17 percent reduction in storage—approximately a 250,000-gallon reduction in volume.

The 2018 condition survey of the Stanley Reservoir indicated several minor deficiencies. The most prevalent issues were the exterior coating (see Figure 2-1) and the operability of the tank mixer. The date of the most recent coating application to the reservoir is unknown. The City pressure-washed a portion of the exterior in 2019 in preparation of a new coating system, but the task not completed. It was determined that the original exterior coating is lead-based.

The 2019 condition survey indicated that the tank appeared structurally sound and the foundation was in good condition. The ladder appeared intact and functional; however, the roof was not accessed during the 2019 field condition assessment. The date of the most recent interior cleaning is unknown.

Figure 2-1. Stanley Reservoir Exterior Paint Condition

2.2.3 Concrete Reservoir

The Concrete Reservoir was built in 1923 and has a capacity of 1.5 MG. It was not constructed with seismic considerations, nor has it been upgraded to subsequent seismic code. The reservoir is in generally good condition. The locked ladder cover is warped and does not completely close. A new liner was installed in 1995. An inspection of the exterior and interior was performed in 2020 by Potable Divers, Inc. The resulting report is included in Appendix D.

2.2.4 Summary

Table 2-2 summarizes the condition of each reservoir.

2.3 TREATMENT FACILITIES

The City operates two treatment facilities, each using aeration towers to treat five of the City's six wells for volatile organic compounds (VOCs). The source water at Well No. 6 does not contain VOCs and is not treated. Treatment Plant (TP) 235 treats the water from Wells No. 2, No. 3, and No. 5, and TP47 treats the water from Wells No. 4 and No. 7. Figure 2-2 illustrates the typical VOC treatment system. The structures that house the treatment systems are not constructed to current seismic code.

Table 2-2. Reservoir Assessment Summary

	Interior	Exterior	Ladder & Appurtenances	Seismic	Comments
Elevated Reservoir	N/A	Excellent condition	Excellent condition	2004 seismic retrofit	The interior and exterior were recoated in 2016-2017.
Stanley Reservoir	N/A	Original exterior coating contains lead and is exposed due to subsequent coating failure.	Previous WMP indicated that mixer should be replaced	Not designed to current seismic code	Exterior has been partially pressure washed
Concrete Reservoir	Roof exhibits cracking, but no indication of leaching. Liner is in fair condition. Small hole in floor liner. Minor rust and corrosion on appurtenances. Supports on the overflow pipe are acting as a sacrificial anode. Rubber should be replaced between the metal surfaces.	The roof is in good condition with signs of previous repair cracks. Several cracks in exterior appear to be damp. Horizontal cracking 12 feet below the roof around circumference of tank. Foundation is in good condition.	Ladder is accessible from the ground level. The aluminum lid to the access hatch does not seal. The vents are not sealed.	Not designed to current seismic code.	New liner installed in 1995. Interior and exterior inspection performed in 2020.

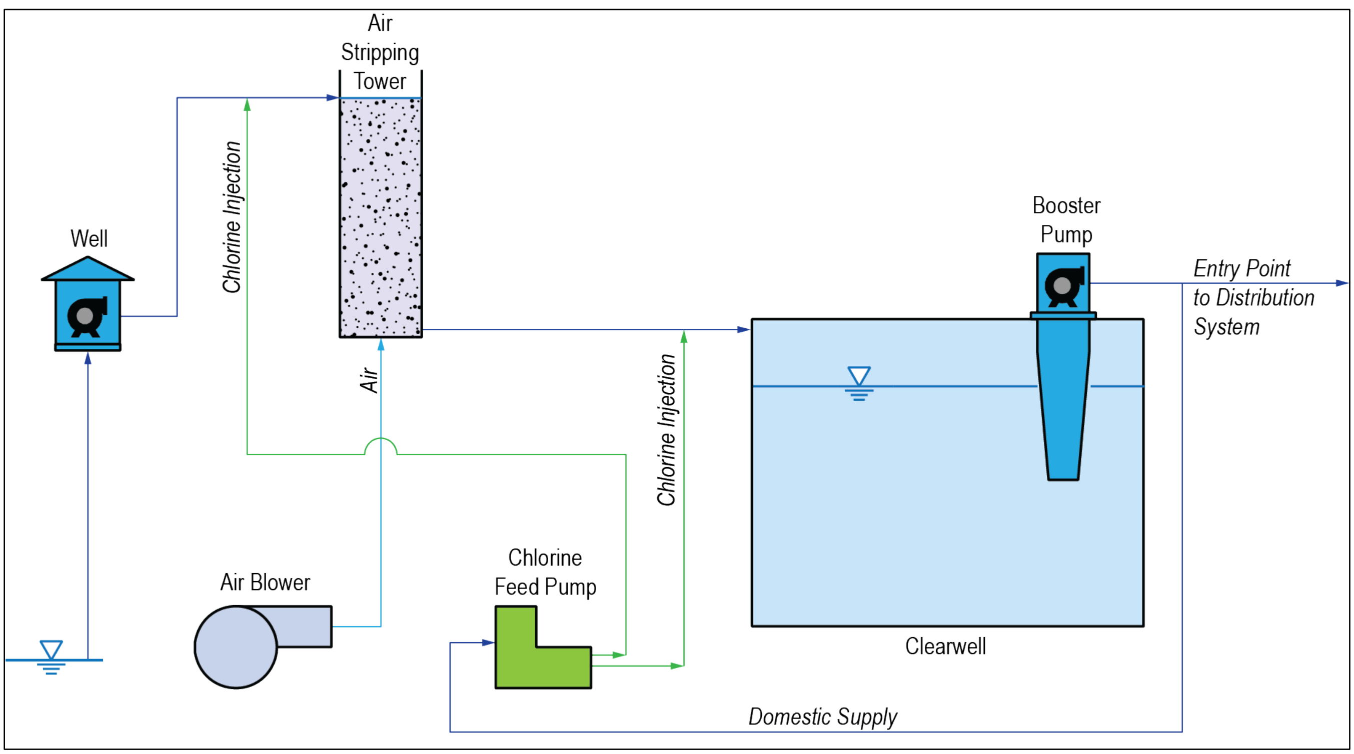


Figure 2-2. Typical VOC Treatment System

Each of the five treated wells has its own dedicated blowers, aeration towers and chlorine injection systems. However, the aeration and chemical feed equipment (Figure 2-3) can be cross-connected to other wells at the same treatment plant. Each source stream provides pretreatment addition of chlorine upstream of the tower and a final addition of chlorine downstream. Blowers at each treatment site provide forced air to the towers. Air filters are changed about every three months. No issues have been reported with the blowers or aeration system.

Figure 2-3. Chemical Feed Piping

The current control system at TP235 allows the well pumps to operate about 10 minutes longer than the chemical feed system after a system shutdown. This results in untreated water being pumped to the clear well and an exceedance in chlorine residual when the treatment system is restarted. If the clear well volume reaches the transfer pump setpoint before the well pumps shut down, untreated water could be pumped to the reservoir.

The eye washes at TP235 and TP47 do not have warm water. In order to meet code, they must be equipped with a hot water source and a tempering valve.

2.3.1 Chlorine Rooms

Chlorine gas cylinders, including spare cylinders, are stored in the same room as the chemical system piping and controls. This proximity has caused corrosion of the metal components and breakage in the plastic piping. The 150-pound cylinders should be relocated and stored in a separate and dedicated room. The treatment plants are located next to residential areas. The storage of chlorine gas near residential areas is considered a safety health issue. Therefore, the chemical storage rooms should be equipped with scrubbers.

The dedicated chemical storage rooms should be equipped with blower switches that can be accessed from outside the room. Currently, the blower switches are located inside the chemical storage/chemical system room. The existing chlorine-gas detection system is also currently located inside the chemical storage/chemical system room and should be moved to the exterior so Operations staff can monitor chlorine levels without entering the room. Operations staff have noted some safety incidents associated with the current conditions.

The chemical systems are also in need of improvements and upgrades to the piping, injectors, and feed pumps. Table 2-3 summarizes the condition of the treatment facilities.

2.4 TRANSFER AND BOOSTER STATIONS

The City operates two transfer pump stations—the W6 Transfer Pump Station and the W2 Transfer Pump Station—and two booster pump stations—the Pressure Zone 3 Booster Pump Station and the Lava Drive Pump Station.

2.4.1 W6 Transfer Pump Station

The W6 Transfer Pump Station is located at the Well No. 6/Stanley Reservoir site. The transfer station transfers water from the Stanley Reservoir to the Elevated Reservoir. Emergency power is provided by the Well No. 6 generator and automatic transfer switch. The generator's reliability is tested weekly. No condition-related issues were observed or reported during the field assessment. However, the pump station is equipped with obsolete mercury switches (see Figure 2-4).

Table 2-3. Treatment Plant Assessment Summary

	Aeration System	Chlorination System
TP235	Good condition Aged and inefficient blowers Unreliable controls	The aeration blowers are old and inefficient at TP235 and TP47. The control strategy is unreliable. The well pumps continue to operate after the disinfection and aeration systems have shut down. Control strategy should cause pumps to shut down first in the sequence. Untreated water could be pumped to the reservoir by the transfer pumps. The blower switch and chlorine gas detector need to be relocated to the exterior of the chemical room. Chlorine gas cylinders should be stored in a separate and dedicated room. Dedicated chemical storage rooms need to be equipped with scrubbers. This facility lacks a code-compliant eye-wash station, and there is evidence of chemical leaking creating a potential cross-contamination situation.
TP47	Good condition No known issues	Good condition, however, potential for corrosion and tubing blockage similar to TP235. The blower switch and chlorine gas detector need to be relocated to the exterior of the chemical room. Chlorine gas cylinders should be stored in a separate and dedicated room. Dedicated chemical storage rooms need to be equipped with scrubbers. This facility lacks a code-compliant eye-wash station, and there is evidence of chemical leaking creating a potential cross-contamination situation.

Figure 2-4. Mercury Switch

2.4.2 W2 Transfer Pump Station

The W2 Transfer Pump Station is located at the TP235 site and shares emergency power with that site. This transfer pump station transfers water from the Concrete Reservoir to the Elevated Reservoir. During the field assessment, staff reported that the pumps tend to overheat. The pumps typically run 2 to 3 hours. Pump starts and stops are controlled by a float switch in the clear well. The float was reported to become inoperable and prevent the pumps from starting. The pump room has historically flooded when the pumps were not started correctly.

2.4.3 Pressure Zone 3 Booster Pump Station

The 3rd Pressure Zone Booster Pump Station is located together with the W6 Transfer Pump Station at the Well No. 6/Stanley Reservoir site and relies on emergency power provided by the Well No. 6 generator and automatic transfer switch. This booster pump station provides service to Zone 3. No condition-related issues were observed or reported during the field assessment. However, the pump station is equipped with obsolete mercury switches.

The pumps must be run manually when switching from lead to lag or any other startup because of surges. This is most likely caused by the old mercury switches and a too small surge tank and the lack of any type of surge control. The existing pressure surge conditions create the potential for piping and plumbing damage.

2.4.4 Lava Drive Pump Station

The Lava Drive Pump Station is located at the edge of the Moda Insurance Building parking lot and serves Zone 4. The pumphouse is partially below grade. No condition-related issues were reported during the field assessment. This pump station relies on a portable generator for emergency backup power.

2.4.5 Summary

Table 2-4 summarizes the condition of the transfer and booster pump stations.

Table 2-4. Transfer and Booster Pump Station Assessment Summary

Pump Station	Pump(s)
W2 Transfer	• The pumps are in fair condition. They tend to run hot with a potential to overheat (they are too hot to touch). They run typically 2 to 3 hours. Last date that maintenance was performed is unknown. • Pumps are signaled to start by the float in the clearwell, but the float system can get stuck and the room floods because the booster pumps were not signaled to start.
W6 Transfer	• Fire pumps are not necessary anymore.
Zone 3 Booster	• The pumps are in good condition; however, they must be operated manually when switching from lead to lag or any other startup because of surges. This is likely caused by old mercury switches, a too-small surge tank. and a lack of surge control.
Lava Drive Booster	• Good condition internally

2.5 PIPELINES

Transmission pipeline conditions were not observed. There have been no indications of issues with the pipelines' integrity. Accurate records correlating pipe material and age are incomplete, and GIS data does not include pipe material for every pipe segment. Approximately 64 percent of the pipe is of unknown material, and the date of installation is unknown for approximately 7 percent of the pipe. General industry standards associated with pipe age and material result in the following assumptions:

- Pipe installed prior to 1969 could be assumed to be cast iron
- Pipe installed during the 1970s and 1980s could be assumed to be ductile iron.
- Pipe installed during the 1990s could be assumed to be ductile iron or C900 PVC.

Table 2-5 tabulates pipe inventory by diameter and age and Table 2-6 tabulates pipe inventory by material and age, as currently described in the City's GIS system. The discrepancy of 938 feet of total pipe between the two tables is due to rounding and data manipulation.

Table 2-5. Pipe Inventory by Diameter and Age

	Length by Pipe Age (feet)										
Diameter	1930-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2009	2010-2019	Unknown	Total	*Percent*
<3	190	2	255	15	207	233	26	20	3,832	**4,780**	*1%*
4	2,383	10638	7,864	1,735	1941	3,971	1,288	406	7,870	**38,096**	*7%*
6	20,679	36,500	30,133	13,914	24,826	24,636	11,036	2,912	10,364	**175,000**	*33%*
8	5,688	21,498	39,757	24,399	17,631	13,786	20,477	10,531	9,004	**162,771**	*31%*
10	255	3,429	14,696	11,130	7,351	6,466	659	1,979	254	**46,219**	*9%*
12	70	12,846	23,846	22,008	1,497	5,453	6,836	4,370	1,766	**78,692**	*15%*
14	0	0	1,340	3,440	0	63	6	12	9	**4,870**	*1%*
16	0	3776	1	0	0	66	2	0	120	**3,965**	*1%*
18	0	0	4415	183	105	74	0	25	91	**4,893**	*1%*
Unknown	3	411	1,013	2,500	749	493	1,134	274	1546	**8,123**	*2%*
Total	**29,268**	**89,100**	**123,320**	**79,324**	**54,307**	**55,241**	**41,464**	**20,529**	**34,856**	**527,409**	
Percent	***6%***	***17%***	***23%***	***15%***	***10%***	***10%***	***8%***	***4%***	***7%***		***100%***

Table 2-6. Pipe Inventory by Material and Age

	Length by Pipe Age (feet)										
Material[a]	1930-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2009	2010-2019	Unknown	Total	*Percent*
C900	0	63	1126	6	0	16588	5652	0	0	**23,435**	*4%*
Cast Iron	11,796	20,639	29419	4,376	587	666	551	104	1,172	**69,310**	*13%*
Ductile Iron	2,051	1,461	6,798	14,676	29,741	7,101	7,011	17,063	2,629	**88,531**	*17%*
Galvanized	0	2	42	8	10	30	5	15	1,123	**1,235**	*0%*
PVC	0	1	0	0	0	253	2,372	0	98	**2,724**	*1%*
HDPE	0	1	0	0	0	0	0	1,644	151	**1,796**	*0%*
Steel	0	713	0	0	0	0	0	0	0	**713**	*0%*
Unknown	15531	66513	85871	59949	24094	30617	24732	1694	29,726	**338,727**	*64%*
Total	**29,378**	**89,393**	**123,256**	**79,015**	**54,432**	**55,255**	**40,323**	**20,520**	**34,899**	**526,471**	
Percent	***6%***	***17%***	***23%***	***15%***	***10%***	***10%***	***8%***	***4%***	***7%***		***100%***

a. Piping Materials definitions: C900 = polyvinyl chloride pressure pipe; PVC = polyvinyl chloride; HDPE = high-density polyethylene

Based on the known age of distribution piping, nearly half of the distribution system could be made of cast iron pipe. Cast iron can have a long structural life, but it is prone to internal corrosion and tubercle formation, which can significantly reduce internal diameters over time. As the City conducts pipe repairs, it would be valuable to collect cast iron pipe samples to assess system-wide condition.

2.6 SECURITY

Unauthorized access incidents have historically been limited with regards to the water system assets. Typical security measures for the facilities include secured points of entry, perimeter control, security doors, padlocked chain link fencing at the site perimeter, surveillance, and security grade doors. The City will be conducting a full physical security assessment as part of the America's Water Infrastructure Act requirements.

2.7 EMERGENCY POWER CONDITION

The water system is equipped with backup diesel generators at all wells and treatment plants. At TP235 and Wells No. 2, No. 3, and No. 5, the generators are not equipped with an automatic transfer switch and are not routinely tested, and the volume and quality of diesel fuel in the tank are unknown. The generators at TP47 and Wells No. 4 and No. 7 are equipped with a generator and automatic transfer switch, but load testing, general maintenance and operability of the system are currently unknown.

The generator at Well No. 5 is load-tested annually, but the functionality of its automatic transfer switch is unknown as there is no record of an automatic transfer of power. The diesel tank is located outside the building, but the volume and quality of diesel fuel in the tank are unknown. The emergency power system at Well No. 6 is automatically load tested on a weekly basis and is routinely maintained.

A portable trailer-mounted generator is maintained at the W2 Warehouse to provide emergency power to the Lava Drive Pump. Since the Lava Drive Pump Station is located at the edge of a private parking lot (see Figure 2-5), access to the facility can be impacted and/or parked cars can be blocked by the presence of the trailer. Table 2-7 summarizes the condition of emergency power systems.

2.8 OPERATIONS CENTER

The City's Water Operations Center is situated in the Public Works Building at the Johnson Creek Facility at 6101 Johnson Creek Boulevard. The Operations Center houses the main SCADA system and operations and maintenance staff. It shares a two-story building with the City's Planning and Engineering Departments. A structural analysis of the building was not conducted as part of this master plan. The seismic resilience of the facility is addressed in Chapter 8. Generally, the building is in good condition and meets the needs of the City.

Figure 2-5. Lava Drive Pump Station Parking Lot

Table 2-7. Emergency Power System Assessment Summary

Facility	Equipment
Wells No. 2 and No. 3, TP235 and W2 Transfer Pumps	No automatic transfer switch, generator must be manually started and stopped. Generator is not routinely tested or maintained. Fuel level and age are unknown. Fill port is at building exterior and may not have a lock.
Well No. 4, 3rd Pressure Zone Booster Pumps and TP47	Standby generator and automatic transfer switch are onsite. Testing, maintenance, and operability are unknown. Fuel level and quality is unknown.
Well No. 5	Generator is only load tested on an annual basis. Unknown if automatic transfer switch works during an outage. No recent use. Fuel level and age are unknown. Diesel tank is located outside.
Well No. 6 and W6 Transfer Pumps	Generator and automatic transfer switch are tested weekly. Routine maintenance is performed.
Well No. 7	Standby generator and automatic transfer switch are onsite. Testing, maintenance, and operability are unknown. Fuel level and quality is unknown.
Lava Drive Pump Station	Emergency power is provided by portable trailer-mounted generator. Connection is located on building exterior. Portable generator is kept at the W2 Warehouse. Trailer-mounted generator must be moved to parking lot.

2.9 NEEDED MAINTENANCE AND EQUIPMENT REPLACEMENT

During the course of the condition assessment, it was noted that there are instruments and miscellaneous equipment that should be reviewed and considered for upgrading. The field condition assessment also noted several areas of needed maintenance. These items are summarized in Table 2-8.

Table 2-8. Summary of Needed Maintenance and Equipment Replacement

Equipment or System	Observed Condition
Wells No. 2, No. 3, No. 4, No. 5, and No. 7	• Obsolete signal conditioners
Well No. 4	• Inoperable static level probe • Unmaintained vegetation • Maintenance needed
Well No. 5	• Unmaintained vegetation • Pump vibration • Non-functioning ceiling fan • Abandoned natural gas connection at building exterior
Well No. 6	• Inoperable static level probe • Unmaintained vegetation • Deteriorated building siding, exterior light fixtures, damaged louvers, and gutters • Obsolete fire pumps and diesel tank
Stanley Reservoir	• Inoperable mixer • Unsecured hatches • Failing coating
Concrete Reservoir	• Damaged ladder cover
TP235 and TP47	• Need for digital readouts that display tank volume or level at clearwells • Need for additional SCADA signals for blower operation • Inefficient chemical feed system piping
W6 Transfer Pump Station	• Obsolete mercury switch
Zone 3 Booster Pump Station	• Obsolete mercury switches • Undersized surge tank
All pump stations and reservoirs	• Damaged perimeter fencing
W2 Warehouse	• Damaged roof • Lack of ventilation system • Unlocked diesel fill port cap
Emergency Power at TP235 and Wells No. 2, No. 3, and No. 5	• Lack of routine maintenance for generator • Unsecured diesel fill port cap
TP47 Emergency Power	• Maintenance needed

3. PLANNING DATA

Water demand projections are central to capital improvement planning and the evaluation of water resource needs. The basic planning information provided in this chapter is used throughout the WMP to assess current conditions and the future requirements of the water system.

3.1 WATER CONSUMPTION AND PRODUCTION RECORDS

Water demand is metered and recorded monthly for each water customer in the City. The City does not meter or record daily demand. The City maintains a database that includes the following information for each customer:

- Account number
- Meter number
- Bill date
- Billed consumption
- Customer name
- Address
- Account classification associated with the land use of the consumer's property (the City currently does not have an industrial account classification):
  - RES: Single-family residential housing
  - DUP: Duplex residential housing
  - TRI: Triplex residential housing
  - 4PX: 4-plex residential housing
  - MDW: Multiple-unit residential housing
  - COM: Commercial property
- Rate code description associated with the consumer's meter size and the account classification:
  - 3/4" MDW & COM
  - 5/8" x 3/4" MDW & COM
  - 1" METER MDW & COM
  - 1 1/2" METER MDW & COM
  - 2" METER MDW & COM
  - 3" METER MDW & COM
  - 4" METER MDW & COM
  - 3/4" METER
  - 5/8" X 3/4" METER
  - 1" RES
  - 1 1/2" RES
  - 2" RES
  - LOW INCOME WATER
  - 6" METER MDW & COM

The City defines a "consumption year" as October 1 through September 31; however, demand data in this chapter is presented by the City's fiscal year, July 1 through June 30. The City also meters and bills Clackamas River Water customers located within the city limits, but those accounts are not included in the data presented in this chapter because their source water is Clackamas River Water. Water production at each City well is metered and recorded on a daily basis by the City's SCADA system.

3.2 CURRENT AND HISTORICAL CONDITIONS

3.2.1 Water Demand

Table 3-1 and Figure 3-1 show the annual water demand by account classification for the past five years. Demand has been essentially flat over the previous five years, with residential demand at approximately half of the total demand. Figure 3-1 combines the demand volume for duplexes (DUP), tri-plexes (TRI), four-plexes (4PX) and multi units (MDW) are into one multi-unit classification (MULTI).

Table 3-1. Historical Demand by Customer Account Classification, 2014-15 Through 2018-19

	Demand (gallons)				
Account Class	2014-15	2015-16	2016-17	2017-18	2018-19
RES (residential)	a	377,337,600	358,411,886	373,019,844	368,373,693
COM (commercial)	a	223,458,078	194,878,753	220,633,434	215,819,719
DUP (duplex)	a	11,577,600	10,689,662	10,387,449	10,142,088
TRI (triplex)	a	1,657,683	1,674,140	1,695,834	1,462,442
4PX (four plex)	a	5,931,304	5,528,104	5,610,390	5,667,990
MDW (multi-dwelling)	a	112,821,943	107,461,403	109,738,473	110,842,597
Total	**726,610,535**	**732,784,208**	**678,643,948**	**721,085,507**	**712,308,310**

a. Records at the customer account classification level are not available for 2014-15.

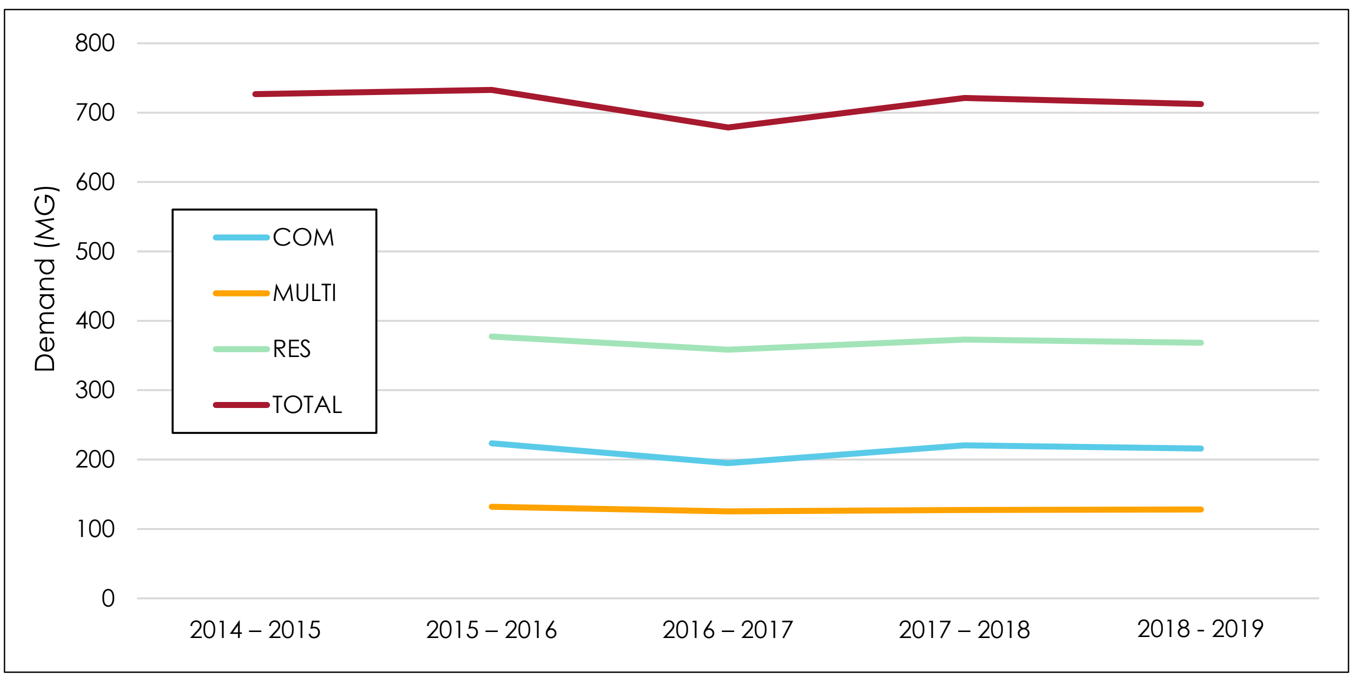


Figure 3-1. Historical Annual Demand by Customer Account Classification, 2014-15 Through 2018-19

3.2.2 Water Production

Table 3-2 and Figure 3-2 show the monthly production volume for each of the last five years. Table 3-2 also summarizes the total annual, average-day, and maximum-day production for each year in that time period. Total annual production rose about 5 percent between 2014-15 and 2015-16, dropped almost 9 percent between 2015-16 and 2016-17, then leveled off for the next three years. The maximum-month demand and maximum-day demand occur in June, July, or August.

Table 3-2. Well Production, 2014-15 Through 2018-19

	Well Production (gallons)				
	2014-15	**2015-16**	**2016-17**	**2017-18**	**2018-19**
July	94,419,000	103,633,000	83,855,000	95,182,000	100,470,000
August	85,690,000	97,990,000	92,923,000	97,882,000	92,689,000
September	65,906,000	72,018,000	65,701,000	71,793,000	68,181,000
October	60,922,000	60,710,000	53,667,000	53,606,000	55,435,000
November	56,833,000	52,315,000	52,641,000	49,321,000	52,279,000
December	57,365,000	55,859,000	57,168,000	52,383,000	51,344,000
January	56,439,000	56,355,000	64,401,000	52,783,000	51,251,000
February	48,557,000	49,102,000	53,270,000	45,801,000	45,256,000
March	57,868,000	66,517,000	52,387,000	51,283,000	51,509,000
April	55,568,000	68,150,000	51,642,000	50,671,000	50,789,000
May	66,694,000	69,483,000	58,764,000	65,182,000	64,199,000
June	90,081,000	77,136,000	71,241,000	74,344,000	75,624,000
Annual Total	**796,342,000**	**829,268,000**	**757,660,000**	**760,231,000**	**759,026,000**
Daily Average	***2,181,759***	***2,271,967***	***2,075,781***	***2,082,825***	***2,079,523***
Maximum-Day (Date)	**3,813,000 (7/20/14)**	**4,116,000 (7/2/15)**	**3,761,000 (6/4/16)**	**3,893,000 (8/5/17)**	**4,127,000 (7/25/18)**

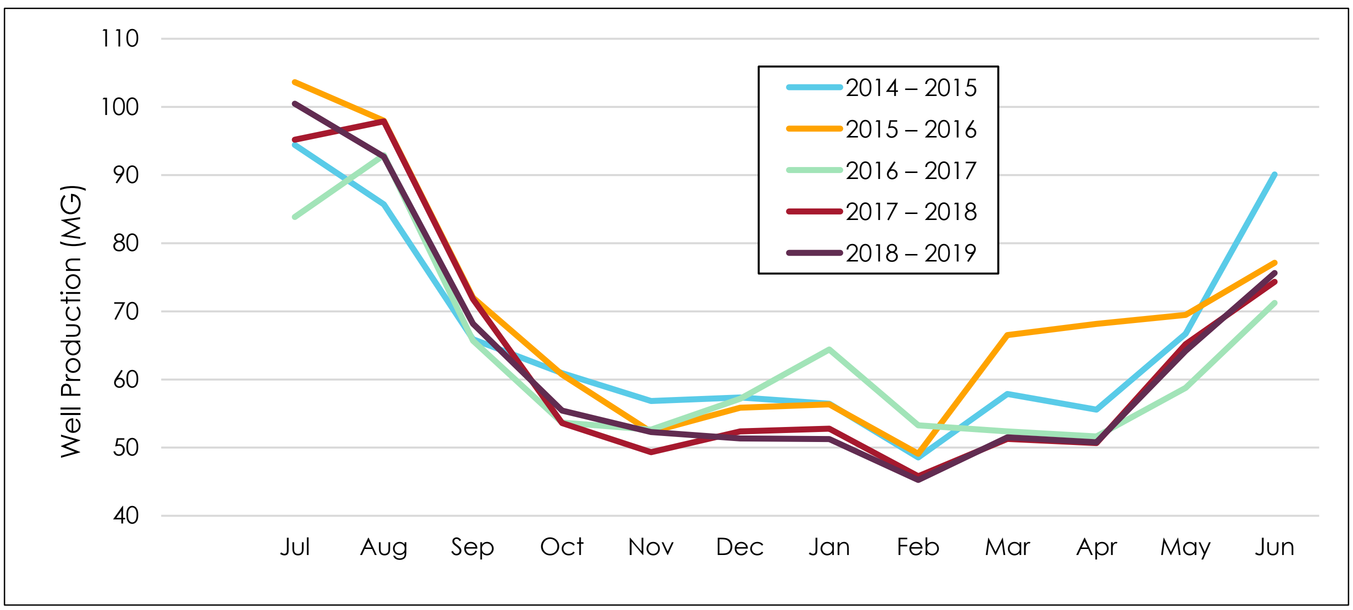


Figure 3-2. Monthly Well Production, 2014-15 Through 2018-19

3.2.3 Water Loss

Water loss—the difference between water production and demand—consists of two components:

- Non-revenue losses represent water that can be tracked and quantified but is not billed, such as operational, flushing, and construction use.
- Unaccounted-for water represents unbilled water that cannot be tracked, such as firefighting, leaks, main breaks, metering inaccuracies, illegal connections, and other types of unmetered water use.

Table 3-3 and Figure 3-3 show production, demand, and water loss for the past five years. The most recent total unaccounted-for water was 6.2 percent of production, which is below the accepted industry benchmark of 10 percent, per the American Water Works Association.

Table 3-3. Total Water Demand, Production and Water Loss

	Water Volume (MG)				
	2014-15	**2015-16**	**2016-17**	**2017-18**	**2018-19**
PRODUCTION					
Total Annual Production	796	829	758	760	759
Maximum-Day Production	3.8	4.1	3.8	3.9	4.1
Maximum-Month Production	3.0	3.3	3.0	3.1	3.2
DEMAND					
Total Annual Consumption	727	733	679	721	712
WATER LOSS					
Total Annual Loss Volume	69	96	79	39	47
Percentage of Produced Water	8.67%	11.58%	10.42%	5.13%	6.19%

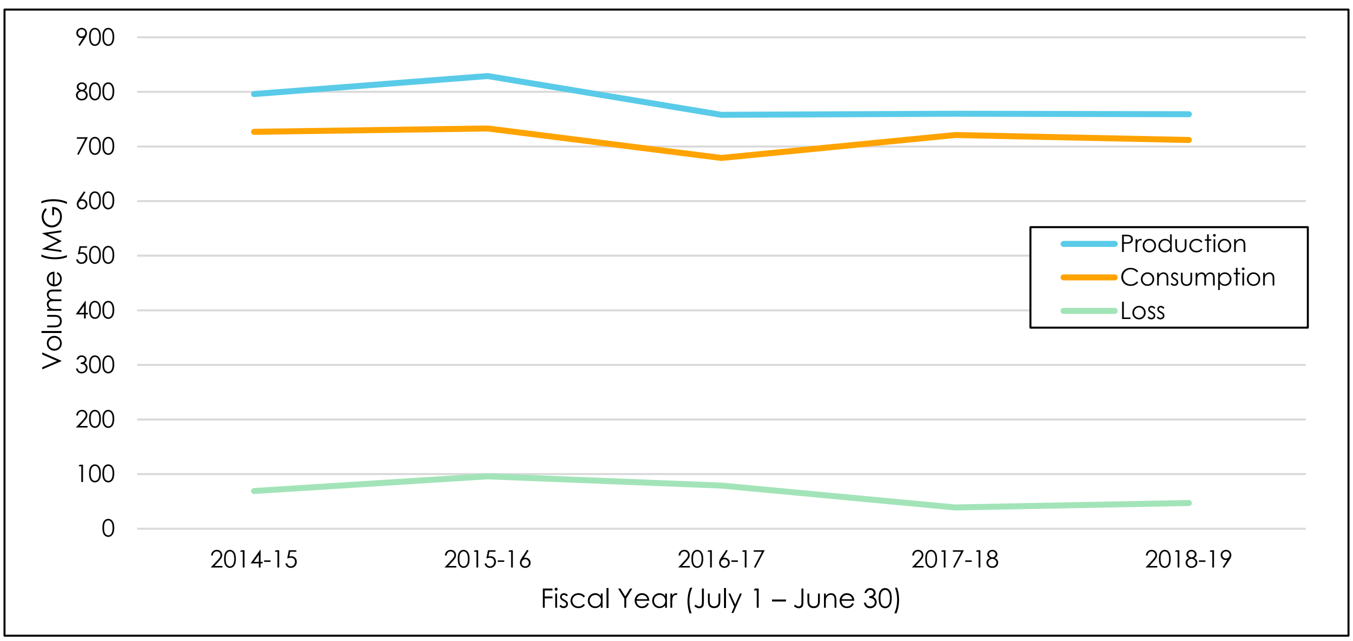


Figure 3-3. Annual Water Demand, Production and Water Loss

The City strives to be more efficient in non-revenue water uses and eliminate unaccounted-for-water when opportunities arise, but is not currently undertaking exceptional programs to identify and further reduce losses. When unaccounted-for water is below the 10 percent benchmark, the utility is considered to be performing well and further reduction is not considered to be cost effective.

3.2.4 Estimated Maximum-Day Demand

The City's production and demand directly correlate to each other. Because the City does not collect daily demand data, production data was used to estimate maximum-day demand. Table 3-4 summarizes the average-day and maximum-day production and peaking ratios for the maximum month from the last five years.

Table 3-4. Production Volume—Average to Maximum Ratio

	2014-15	2015-16	2016-17	2017-18	2018-19
Month of Maximum Production	July	July	August	August	July
Daily Average for the Maximum-Month Production (MG)	3.0	3.3	3.0	3.2	3.2
Maximum-Day Production (MG)	3.8	4.1	3.8	3.9	4.1
Peaking Factor Ratio	1.25	1.23	1.25	1.23	1.25

The maximum-day estimates were developed as follows:

- The daily average for the maximum-month production was determined by dividing the maximum-month production by the number of days in the month.
- The maximum-day production was identified as the single day with the highest production during the year.
- The maximum-day production volume was divided by the maximum-month daily average volume to obtain a peaking factor ratio.

The nearly identical peaking ratio for each year illustrates consistencies between average-day and maximum-day production volume for the City's water system. For this master plan, the maximum-day production values shown in this table are used as maximum-day demand (MDD).

3.2.5 Equivalent Residential Units

For water system planning, population has been normalized to units of equivalent residential units (ERUs). An ERU is equal to the average-day demand of one single-family residential connection. Based on the most recent water consumption records (for calendar year 2019), one ERU is equal to 150 gpd.

Table 3-5 shows number of services, total annual demand, and ERUs for residential (single-family), multi-unit residential (including duplex, 3-plex and 4-plex) and commercial accounts. Only accounts that had metered usage in the 2019 calendar year were used. Accounts with zero demand were excluded. Single-family residential users account for 89 percent of total metered connections, but only half of the City's ERUs. All residential customers account for 68 percent of ERUs, with commercial customers making up 32 percent.

Table 3-5. ERUs by Customer Account Classification for Calendar Year 2019

Customer Class	No. of Services (percentage)	2019 Data Period		
		Total Annual Demand (MG)	Equivalent ERUs[a]	Percentage of Total ERUs
Residential	6,603 (89%)	362	6,603	50%
Multi-Unit	345 (5%)	130	2,374	18%
Commercial	479 (6%)	235	4,292	32%
Total	**7,427 (100%)**	**727**	**13,270**	**100%**

Average-day demand per ERU = 150 gallons

3.2.6 Population

The Portland State University Population Research Center (PSUPRC) July 1, 2019, population estimate for Milwaukie was 20,535. The 2009 population used in the 2010 WMP was 20,920. Population in Milwaukie peaked in 2009, declined in 2010, and since then has grown at annual average rate of 0.38 percent.

3.3 PROJECTIONS FOR FUTURE GROWTH

3.3.1 Projected Population Growth

There are two local sources for population forecasting: PSUPRC, which state agencies consider to be the official source of population estimates; and Metro population forecasts. Neither source provides a direct forecast of Milwaukie's population. Annual PSUPRC projections are produced only at the county level. Metro's most recent forecast is for the entire Metro region and is current only as of 2016.

To get the best local population projection, the City contracted with Angelo Planning Group to develop five growth scenarios and evaluate their potential impacts on infrastructure. For this WMP update, the City selected Scenario 4 ("Hubs and Corridors") as the most likely to occur. Scenario 4 represents more growth than the other scenarios, much of it in the Milwaukie Planning Area outside city limits, where major corridors such as 82nd Avenue have significant capacity for residential development. Significant changes are assumed for land abutting high-frequency transit corridors and specific hubs where those corridors intersect. Figure 3-4 shows potential hub and corridor locations. A copy of the growth study is included in Appendix A. The findings provide the foundation for growth projections in this WMP update.

This scenario assumes the following:

- Infill will occur in hub or corridor areas with more than 0.25 acres of unconstrained land.
- Infill development in hubs will be a mix of 50 percent residential and 50 percent employment uses by area. Residential uses and densities will be those of the Neighborhood Mixed Use (NMU) zone.
- Infill development in corridors will be all residential, with R-3 zone uses and densities.
- Mixed use lots will have the same number of units as in the City's 2016 buildable lands inventory.
- Parcels in the Downtown Mixed Use (DMU) zone will be unchanged from the 2016 inventory.

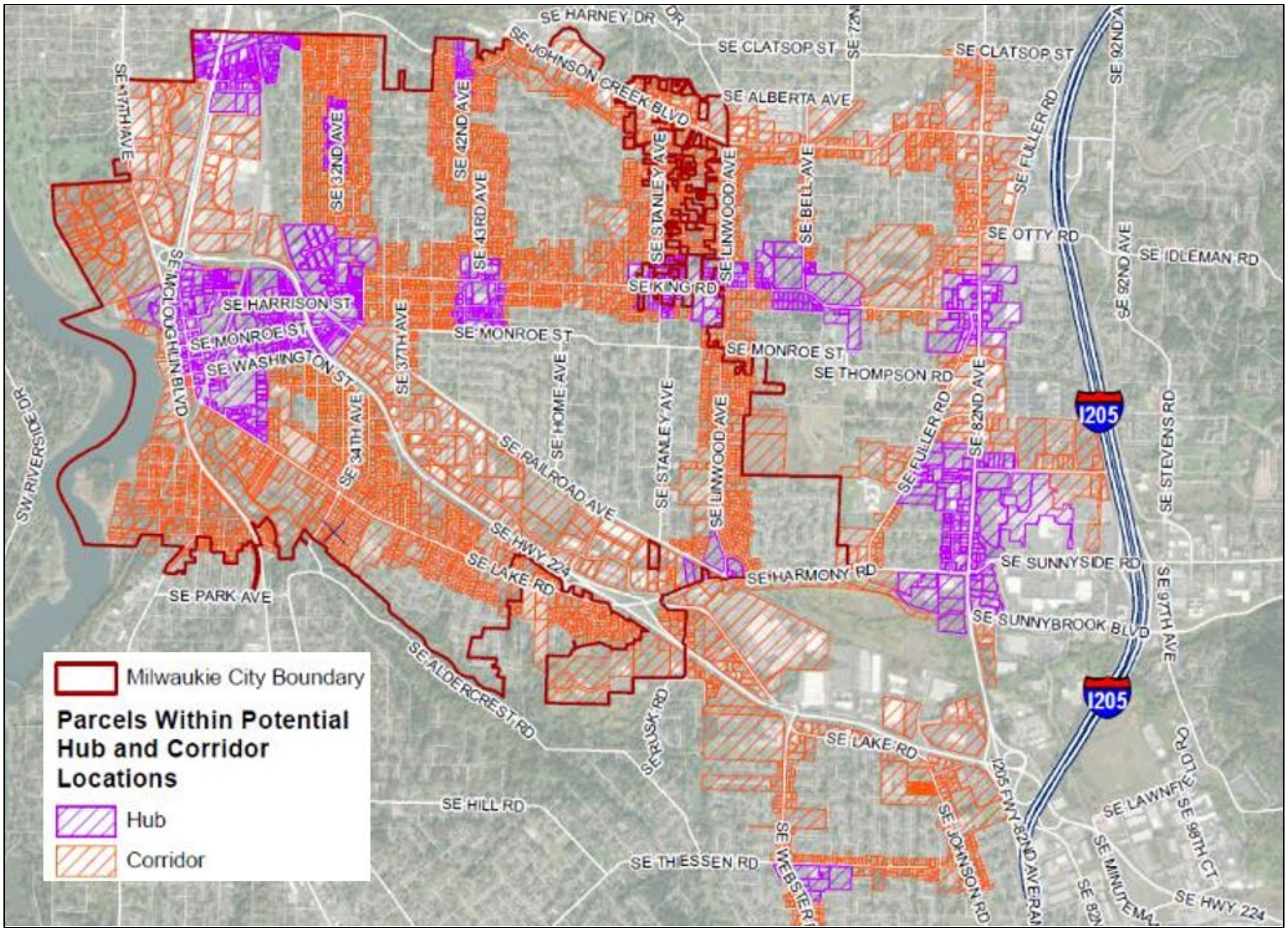


Figure 3-4. Potential Hubs and Corridors Under Selected Growth Scenario

Scenario 4 predicts an additional 10,704 residential units in the City at full buildout—6,062 within the city limits and 4,642 in the City's planning area outside the city limits. It has been assumed, however, that development outside the city limits will be served by other water providers. This WMP assumes that 80 percent of the Scenario 4 city limits full buildout, or 4,850 units, will be developed within the planning period (by 2039-40). It assumes that all this development will be residential, with each unit equivalent to 2.3 people. Based on these assumptions, planning area growth will be 11,154 additional population by 2039-40, for a total population of 31,445 at the end of the planning period. This equates to an annual average growth rate of 1.02 percent. the resulting planning period projections for population and ERUs are presented in Figure 3-5 and Table 3-6.

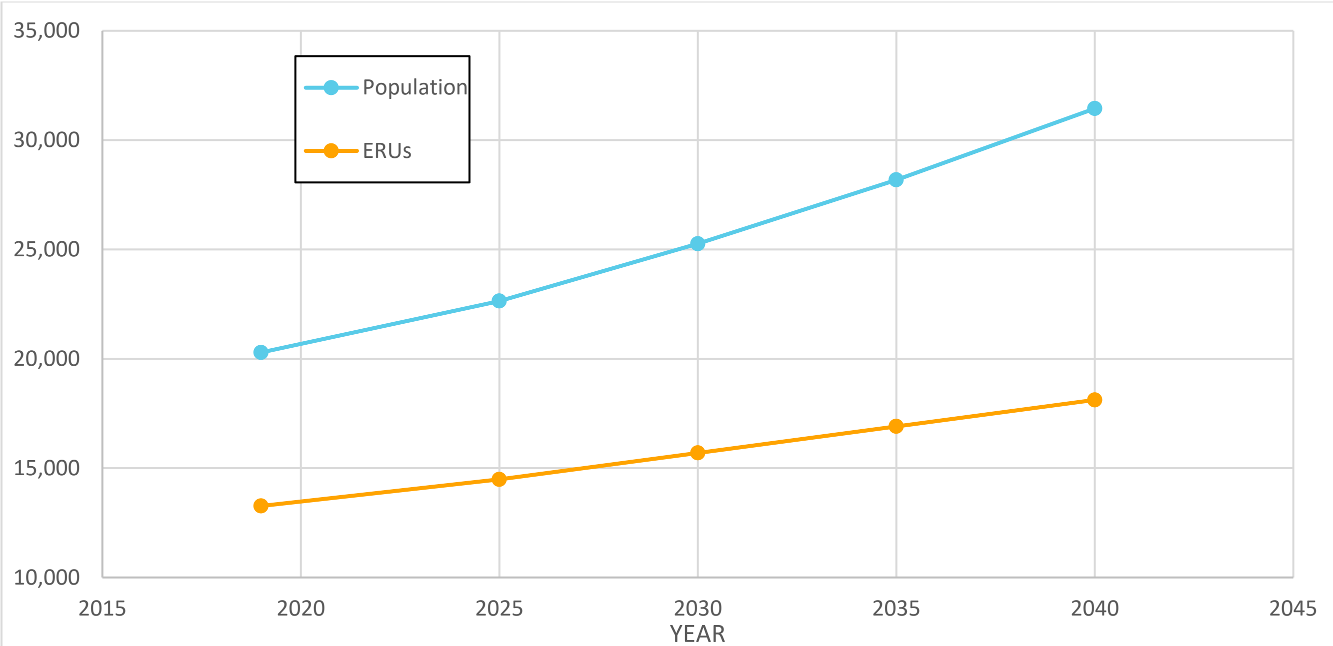


Figure 3-5. Projected Planning Period Population and ERUs

Table 3-6. Projected Planning Period Population and ERUs

Year	2019	2025	2030	2035	2040
Population	20,291	22,639	25,260	28,183	31,445
ERUs	13,270	14,483	15,695	16,908	18,120

3.3.2 Projected Total Annual, Average-Day, and Maximum-Day Demand

Future system-wide water demand was estimated based on the projected growth in ERUs. The ratio of projected ERUs to 2018-19 ERUs, as listed in Table 3-6, was applied to the following existing demand values:

- The 2019 total annual demand of 727 MG (as listed in Table 3-5)
- The 2019 average-day demand of 2.0 MG (calculated as 150 gallons per ERU multiplied by 13,270 ERUs)
- The 2019 maximum-day demand of 4.1 MG (as listed in Table 3-4)

The resulting projections are presented in Figure 3-6, Figure 3-7, and Table 3-7.

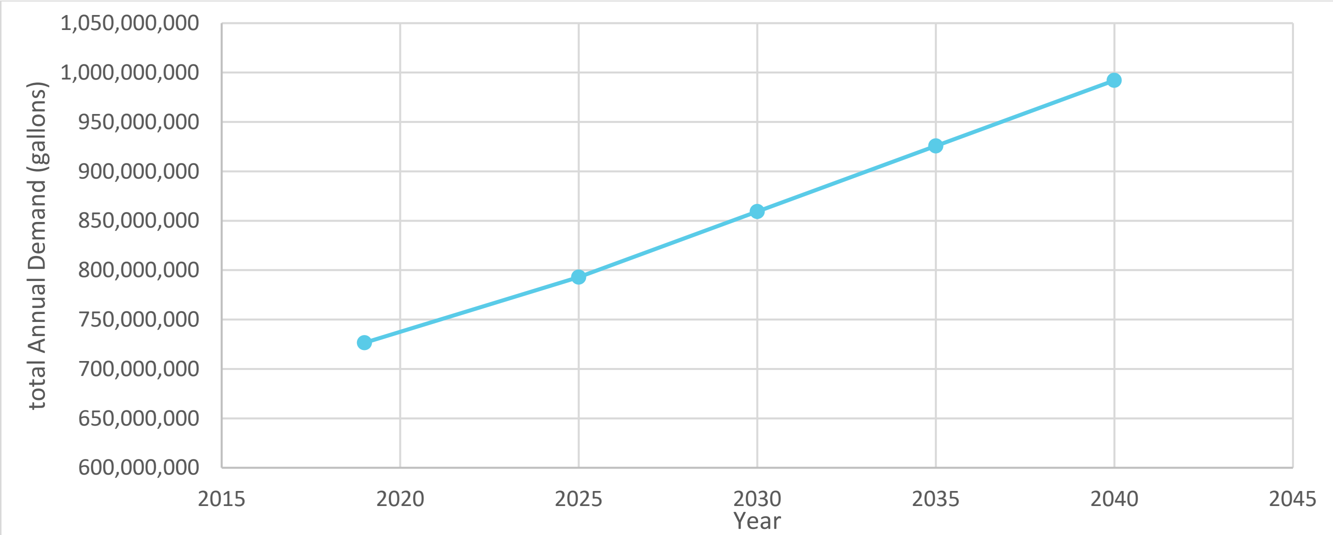


Figure 3-6. Projected Total Annual Demand

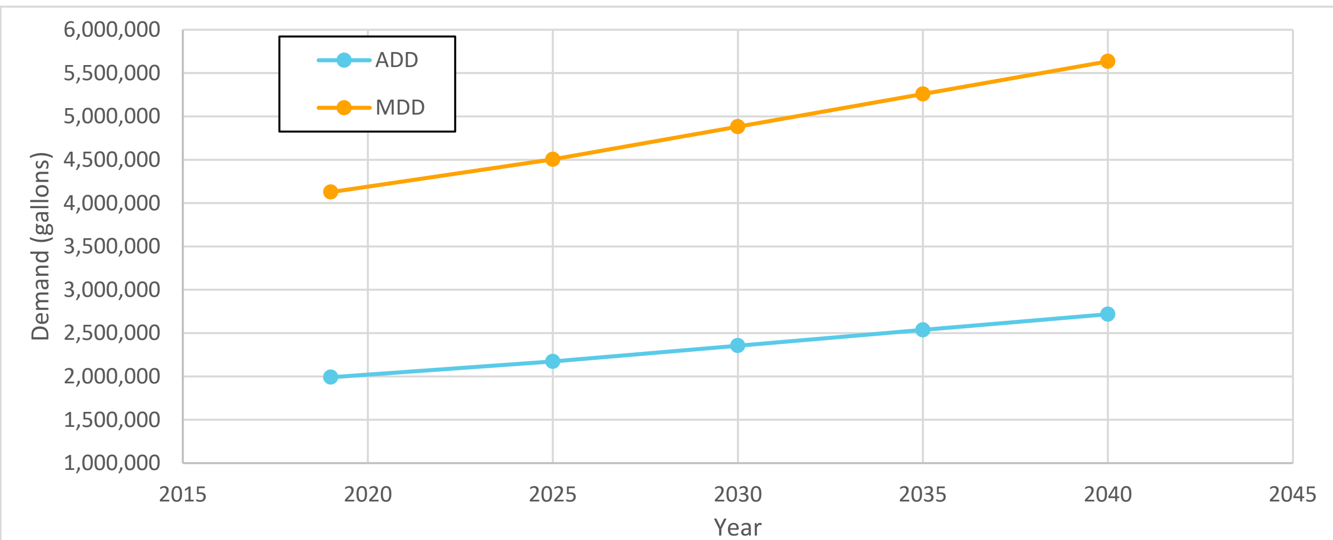


Figure 3-7. Projected Average-Day and Maximum-Day Demand

Table 3-7. Projected Average-Day Demand and Maximum-Day Demand

Year	ERUs	Demand (gallons)		
		Total Annual Demand	Average-Day Demand @ 150 gal/ERU	Maximum-Day Demand
2019	13,270	726,532,500	1,990,500	4,126,970
2025	14,483	792,916,875	2,172,375	4,504,058
2030	15,695	859,301,250	2,354,250	4,881,145
2035	16,908	925,685,625	2,536,125	5,258,233
2040	18,120	992,070,000	2,718,000	5,635,320

ADD and MDD volumes do not include unaccounted for water.

3.3.3 Projected Peak-Hour Demand

The peak-hour demand (PHD) is the maximum rate of water use, excluding fire flow, that can be expected to occur within a defined service area over a continuous 60-minute time period. Typically, the peak hour occurs during the evening and is 170 percent of the maximum demand for that day. The following equation is generally accepted engineering practice for calculating peak-hour demand:

$$PHD = (MDD/N/1{,}440) * (C * N + F) + 18$$

Where:

PHD	= Peak-hour demand (gpm)
C	= Coefficient associated with ranges of ERUs (C = 1.6 for ERU>500)
N	= Number of ERUs
F	= Factor associated with ranges of ERUs (F= 225 for ERU>500)
MDD	= MDD (gpd)

Based on this calculation the PHD for 2039-40 is projected to be 6,328 gallons per minute. Factoring in an MDD value that includes 10 percent water loss results in a PHD of 6,961 gallons per minute.

3.4 FIRE FLOW REQUIREMENTS

Fire flow demand is the rate of flow necessary to control fires within the service area. The City's level-of-service criteria require the system be able to provide a minimum pressure of 20 pounds per square inch (psi) at the point of fire flow delivery as well as throughout the system under MDD conditions.

Clackamas County Fire District #1 (CCFD) establishes the minimum requirements for firefighting in the City of Milwaukie. CCFD applies the 2019 Oregon Fire Code to determine minimum fire flows and durations (Fire Code Appendix B, Table B105.1). These requirements are based on the International Fire Code, with amendments authorized by the Oregon Revised Statute (ORS) 476.030 and in accordance with OAR Chapter 837, Division 40.

Table 3-8 summarizes fire flow requirements and standards for each customer classification. The fire flow requirements shown are used in the system hydraulic analysis of the distribution system.

Table 3-8. Fire Flow Requirements

Designation[a]	Non-Sprinklered			Sprinklered[b]		
	Fire Flow (gpm)	Duration (hours)	Recommended Storage (MG)	Fire Flow (gpm)	Duration (hours)	Recommended Storage (MG)[c]
Single-Family Residential	1,500	2	0.18	*d*	*d*	*d*
Multi-Family Residential	1,500	3	0.27	*d*	*d*	*d*
Institutional[e]	3,000	4	0.72	2,000[f]	4	0.36
Industrial/Commercial[g]	3,000	4	0.72	3,000[f]	4	0.60

a. Fire flow requirements in this table are based on previous estimates for listed land use types in similar communities. Individual development projects or projects with alternate materials may require higher fire flows and will be reviewed by the fire marshal on a case-by-case basis (e.g., proposed commercial/industrial areas and schools).
b. Sprinklered-building fire flows were determined from Table B105.1 of the 2019 Oregon Fire Code and depend on construction type and fire area. These fire flow requirements are based on buildings being fully sprinklered.
c. Recommended storage volumes do not include volume associated with 500 gpm sprinkler flow.
d. For a more conservative fire flow estimate, single family and multiple family buildings were considered non-sprinklered for this Water Master Plan Update.
e. Institutional includes parks & recreation and public and quasi-public land uses.
f. Fire flow includes a 500 gpm demand for on-site sprinkler flow.
g. Industrial/commercial includes commercial, mixed use corridor, mixed use downtown, mixed use employment, industrial and future urban land uses.

4. System Analysis

The hydraulic analysis for this water master plan included modeling to evaluate the ability of the water distribution system to provide required fire flows and service pressures. The modeling evaluated the hydraulic capacity of the existing system and identified system improvements to increase capacity as needed. This chapter outlines the approach, assumptions, and findings of the analysis.

4.1 MODEL CONFIGURATION

Innovyze's InfoWater (version 12.4) was used for the hydraulic analysis of the water distribution system. The City maintains a hydraulic model of its water distribution network. The City's model, last calibrated in 2010, was the starting point for the analysis. For this update, the pipe network and calibration were reviewed and updated.

In representing the water system, the hydraulic model uses assumptions and simplifications based on the availability of data. Actual system pressures and fire flows may vary from the model results, especially for conditions that are substantially different than those for which the model was calibrated.

4.1.1 Model Network

The existing pipe network was imported from an existing GIS pipe data provided by the City, which represents the current distribution network.

4.1.2 Model Demand

The aggregate magnitude of demand used in the model is presented in Chapter 3. The geographic distribution and magnitude are based on Milwaukie's September 2019 demand data by individual parcel. The MDD was multiplied by a peaking factor of 1.7 to approximate the peak-hour demand (PHD). The following values were used for modeling scenarios:

- 2019 Average-Day Demand—2.0 million gallons per day
- 2019 Maximum-Day Demand—4.1 million gallons per day
- 2019 Peak-Hour Demand—7.0 million gallons per day

4.1.3 System Settings

Pump settings and pump curves were provided by the City. The pressure reducing valves (PRVs) were defined by the settings presented in Chapter 1. Active pipes were determined based on GIS records indicating "In Service" pipes. Tank information was confirmed using GIS records.

4.1.4 Hydrant Testing and Model Calibration

Calibration of the updated model started with measurements of pressure and energy loss in the system. City utility staff collected hydrant flow and pressure data at 16 hydrant test locations as shown in Figure 4-1 (figures for this chapter are included at the end of the chapter). Hydrant testing at each location proceeded as follows:

- Crews measured the static pressure (pressure with no flow through the hydrant) at two closed hydrants.
- Crews opened one hydrant (the "flow hydrant") and recorded the flow at that hydrant and the pressure at the other hydrant (the "gauge hydrant"). The pressure at the gauge hydrant while the flow hydrant is open is called the residual pressure.
- During the tests, a pressure drop (the difference between the residual and static pressures at the gauge hydrant) of at least 10 psi was targeted to reduce uncertainty in the measurements.
- Crews recorded data on boundary conditions—such as well and booster station operation and reservoir levels—during the hydrant flow tests.

Modeled static pressures were calibrated using the static pressures measured at the gauge hydrant and the recorded boundary conditions. The static pressures were considered calibrated when 80 percent of the measured and modeled static pressures were within 2 psi.

Energy losses in the system were calibrated by matching the pressure drop at the gauge hydrant. Only tests with pressure drops greater than 5 psi were used for calibration. Measured flow at the flow hydrant was entered into the model and the roughness coefficient was adjusted until the measured and modeled pressure drops were similar. The energy loss scenario was considered calibrated when the modeled fire flow at 20 psi at 80 percent of the hydrants was within 15 percent of the observed fire flow adjusted to 20 psi.

There is good confidence in some input data, such as ground elevation and pipe diameter. Other data, such as pipe friction, have greater uncertainty and were adjusted as needed during calibration of the model. To complete the calibration, "C" factor adjustments were made within the range of 80 to 140, a minor loss was added at the Elevated Tank, and PRV settings were adjusted.

The hydrant test results are summarized in Table 4-1. Of the tests used for calibration, the modeled static pressure was within 2 psi of the measured static pressure for 85 percent of tests and the modeled fire flow at 20 psi was within 15 percent of the measured fire flow adjusted to 20 psi for 92 percent of tests. Both the static and flow calibration criteria exceed the goal of 80 percent of tests. Subsequent modeling was conducted with the calibrated model.

Table 4-1. Summary of Hydrant Calibration Results

Run No.	Pressure Zone	Test Location	Time	Date	Flow Hydrant: Hydrant No.	Flow Hydrant: Flow (gpm)	Residual Hydrant: Hydrant No.	Field Data: Static Pressure (psi)	Field Data: Residual Pressure (psi)	Field Data: Pressure Drop (psi)	Model Data: Static Pressure (psi)	Model Data: Residual Pressure (psi)	Model Data: Pressure Drop (psi)	Difference between Model & Field: Static Pressure (psi)	Difference between Model & Field: Residual Pressure (psi)	Difference between Model & Field: Pressure Drop (psi)
1	Zone 1	11275 27th	8:31	8/28/2020	1157	1062	1158	50	42	8	48	42	6	-2	0	-2
2	Zone 1	McBrod	8:58	8/27/2020	1025	1126	1767	72	64	8	72	63	9	-1	-1	+1
3	Zone 1	10466 Main St.	9:34	8/27/2020	1054	1245	1053	72	66	6	69	64	5	-3	-2	-1
4	Zone 1	11525 McLoughlin	10:00	8/27/2020	1072	1187	1068	74	68	6	77	72	5	+3	+4	-1
5a	Zone 1	9304 Main	9:16	8/27/2020	1116	1210	1117	70	68	2	-	-	-	-	-	-
6	Zone 2	5462 Willow	8:20	8/20/2020	1632	1245	1629	67	60	7	65	57	8	-2	-3	+1
7	Zone 2	3401 Guilford	8:53	8/20/2020	1186	1300	1187	88	78	10	89	80	9	+1	+2	-1
8a	Zone 2	10666 42nd	8:35	8/27/2020	1454	872	1453	48	48	0	-	-	-	-	-	-
9	Zone 2	3409 Filbert	9:32	8/20/2020	1297	1126	1298	56	47	9	56	48	7	0	+1	-2
10a	Zone 2	29th Elpuente School	8:04	8/28/2020	1324	949	1246	82	78	4	-	-	-	-	-	-
11b	Zone 2	4607 International Way	8:05	8/27/2020	1361	1353	1362	88	78	10	87	75	13	-1	-3	+3
12c	Zone 2	12045 Stanley	10:50	8/20/2020	1671	1126	1665	60	46	14	59	52	7	-1	+6	-7
13d	Zone 2	5106 Brookside	7:30	8/21/2020	1616	1151	1497	75	58	17	76	57	18	+1	-1	+1
14	Zone 3	11264 Linwood	7:46	8/18/2020	1715	1035	1729	70	52	18	71	54	17	+1	+2	-1
15	Zone 3	10523 52nd	8:06	8/18/2020	1826	1048	1846	67	44	23	67	40	27	0	-4	+4
16	Zone 4	9911 Cambridge	8:31	8/18/2020	1761	839	1077	76	30	46	75	29	46	-1	-1	-1

a. Tests with pressure drops lower than 5 psi not calibrated.
b. GIS confirmed closed valve at 3778 SE International Way.
c. No reasonable explanation for the discrepancy between modelled and measured results could be identified. Suspect testing or recording issue, test disregarded.
d. Suspect closed valve on SE Brookside Drive. Closed in model to simulate hydrant test results.

4.2 EVALUATION CRITERIA

Prior to analysis of the system, evaluation criteria were developed, as summarized in Table 4-2. A deficiency is defined as a hydrant that fails to meet statutory fire flow and level of service objectives.

Table 4-2. Evaluation Criteria

Criterion	Value
Residential Fire Flow Requirement at 20 psi Residual Pressure	1,500 gallons/minute
Institutional Fire Flow Requirement at 20 psi Residual Pressure	3,000 gallons/minute
Industrial/Commercial Sprinklered Fire Flow Requirement at 20 psi Residual Pressure	3,000 gallons/minute
Industrial/Commercial Non-Sprinklered Fire Flow Requirement at 20 psi Residual Pressure	3,000 gallons/minute
Maximum Flow Velocity @ Peak-Hour Demand	7.0 feet/second
Minimum Pressure @ Peak-Hour Demand	40 pounds/square inch
Minimum Pressure @ Maximum-Day Demand + Fire Flow	20 pounds/square inch
Maximum Pressure @ Average-Day Demand without PRVs for Individual Services	105 pounds/square inch

4.3 EVALUATION OF EXISTING SYSTEM

4.3.1 System Analysis

The existing system analysis included all pipes, pumps, tanks, and wells currently in the Milwaukie system. The system model was run in the static (steady-state) mode under appropriate scenarios to compare pressure, velocity, and available fire flow results against the design criteria. Tanks were set to two-thirds full to reflect the lower end of the normal operating range based on available data. Appendix E provides directions on how to access details on the assumptions pertaining to pump, pipe, reservoir, and valve settings. Model scenarios were run for the existing system to evaluate the following:

- Pressures at PHD
- Pressures at average-day demand (ADD)
- Fire flow at MDD
- Pipe flow velocity at PHD

4.3.2 Results

The results and deficiencies discussed below are independent of ongoing programs that may exist for annual replacement of undersized water lines (4 inches and smaller) or water lines made of undesirable materials (asbestos concrete, unlined cast iron, steel, etc.).

Minimum Pressure at PHD

Pressure deficiencies were assessed by modeling PHD conditions with tanks two-thirds full and looking for system operating pressures below 40 psi, the City's minimum level of service pressure target. Figure 4-2 shows existing low-pressure deficiencies:

- Low pressures were noted near PRVs between Zones 1 and 2, as these are high points in the zone.
- Junctions along the transmission line from the Concrete Reservoir to Zone 1 exhibit low pressures; however, these are disregarded as no services branch from this line.
- In Zone 2, the small industrial area south of King Road between 42nd and 44th Avenues exhibits low pressure due to the area's higher elevation.
- An additional high elevation area with low pressures exists north of King Road between 51st and 54th Avenue.
- The area of Zone 2 southwest of Kellogg Lake has areas of high elevation, resulting in some junctions failing to reach 40 psi.
- All junctions in the eastern portion of Zone 4 that is not fed by Lava Drive Booster exhibit low pressures, with a minimum of 21 psi.

Areas that exhibited low pressures typically were in the immediate vicinity of reservoirs and pumps. All deficiencies fall within 6 psi of the pressure requirements, excluding those in Zone 4. Appendix F provides directions on how to access detailed results.

Maximum Pressure at Average-Day Demand

Excessive pressures were assessed by modeling average-day demand conditions and looking for system operating pressures above 105 psi, the City's maximum level of service pressure target. Figure 4-3 shows existing high-pressure issues. The area of Zone 2 located southwest of Kellogg Lake has areas of low elevation, resulting in some junctions exceeding 105 psi. Appendix G provides directions on how to access detailed results.

Fire Flow at MDD

Under MDD conditions with two-thirds full reservoirs, analysis revealed that the distribution system has some areas that do not achieve required fire flow of 1,500 gpm for residential or 3,000 gpm for industrial/commercial, as shown in Figure 4-4. All hydrants in institutional zones meet required flows. Appendix H provides directions on how to access detailed results.

Most fire flow deficiencies identified are located on mains smaller than 8 inches or dead-end mains. In industrial/commercial areas, deficiencies are the result of insufficient looping and transmission.

Flow Velocity at PHD

No pipes were identified with velocities exceeding the 7-foot-per-second criterion at peak-hour demand.

4.3.3 Distribution Improvements

A list of recommended pipe improvements that are required to meet residential, commercial, and institutional fire flow requirements was developed and prioritized. Table 4-3 describes the methodology used for prioritization. In general, the recommended improvements are prioritized by the severity of fire flow deficit. Within each priority level, however, the pipes are prioritized by the number of hydrants that are brought up to the required flow.

Table 4-3. Prioritization Methodology (Fire Flow Requirements)

Priority Level	Existing Deficit (% of Required Fire Flow)[a]	Residential Fire Flow Requirement (gpm)	Industrial Fire Flow Requirement (gpm)
Priority 1	17 – 33%	500	1,000
Priority 2	33 – 50%	750	1,500
Priority 3	50 – 66%	1,000	2,000
Priority 4	66 – 83%	1,250	2,500
Priority 5	83 – 100%	1,500	3,000

a. Nothing falls below 17% of the required flow.

Priority was also given to the replacement of existing 4-inch diameter pipes and older pipes within each priority level. Further investigation may be necessary to refine the individual priority of each recommended improvement. Table 4-4 lists the recommended improvements in order of assumed priority and includes the location, existing length, existing diameter, approximate date of installation and the recommended replacement diameter for each recommended improvement.

Table 4-4. Distribution Improvements

Index	Number of Hydrants Corrected	Pressure Zone	Location	Length (feet)	Approximate Date of Installation	Existing Material	Existing Diameter (inches)	Proposed Diameter (inches)
PRIORITY 1								
D1[a]	5	4	Waverly Ct	340	1960s & 1970s	Unknown	Unknown	12
D2	5	1	Main St	470	1950s	Unknown	Unknown	12
			24th Ave	180		Unknown	10	12
			Ochoco St	890		Cast Iron	6	12
			Moores St	1,000		Unknown	10	12
			25th Ave	450		Cast Iron	6	12
D3	2	2	Firwood St	1,470	Unknown	Unknown	Unknown	12
D4	2	2	Flavel Dr	800	Unknown	Unknown	Unknown	12
D5	1	2	Winworth Ct	500	1950s	Unknown	4	8
D6	1	1	23rd Ave	750	1950s & 1970s	Unknown	Unknown	12
			Clatsop St	600		Unknown	6	12
			Loughlin Blvd	660		Cast Iron	6	12
PRIORITY 2								
D7	3	2	Elk St	240	1990s	PVC	4	8
			51st St	380		Unknown	Unknown	8
			52nd Ave	380		PVC	4	8
D8	1	2	44th Ave	260	1950s	Cast Iron	4	8
			Howe Ln	440		Cast Iron	4	8
			46th Ave	260		Cast Iron	4	8
D9	1	1	Drake St	360	1950s & 1960s	Cast Iron	4	8
			38th Ave	780		Unknown	4, 6	8
D10	1	2	Concrete Reservoir to Zone 2 Transmission Main	3,800	1940s	Cast Iron	16	18

Index	Number of Hydrants Corrected	Pressure Zone	Location	Length (feet)	Approximate Date of Installation	Existing Material	Existing Diameter (inches)	Proposed Diameter (inches)
PRIORITY 3								
D11	6	2	Adams St	1,550	1950s	Unknown	4	8
			47th Ave	300		Unknown	6	8
			Ada Ln	900		Unknown	4	8
			Rio Vista St	1,010		Unknown	4	8
			Washington	190			6	8
D12	6	2	Oak St	580	1980s	Unknown	6	8
			Campbell St	550		Unknown	6	16
			Industrial Area	220		Ductile Iron	6	12
			Industrial Area	1,820		Ductile Iron	6	16
			Oak St	240		Ductile Iron	6	12
			Myrtle St	800		Cast Iron	4	8
D13	3	2	Sparrow St	300	1960s & 1980s	Unknown	10	16
			Lakewood Dr	250		Unknown	Unknown	16
			Off Road	850		Unknown	Unknown	16
			PRV at Oatfield Rd and Guildford Ct	—		Unknown	Unknown	10
			Kellogg Lake Apartments	1,200		Unknown	Unknown	16
			Oatfield Rd	380		Unknown	10	16
			PRV at Lakewood Dr and McLoughlin Blvd	—				10
D14	2	2	Roswell St to Boyd St	450	1950s	Unknown	Unknown	8
D15	1	3	54th Ave	220	1960s	Cast Iron	4	12
			Woodhaven to Harlene St	340		Unknown	Unknown	12
			Woodhaven St	1,010		Unknown	4	12
D16	1	2	30th Ave	180	1990s	PVC	4	8
D17	1	2	31st Ave	180	1990s	PVC	4	8
D18	1	2	55th Ave	300	1990s	PVC	4	8
D19	1	2	41st Ct	470	1960s	Unknown	6	8
PRIORITY 4								
D20	9	2	Minthorn Springs	580	1970s & 1980s s	Ductile Iron	8	16
			International Way	3,600		Ductile Iron	10, 12	16
			Minthorn Loop	670		Unknown	Unknown	16
			Industrial Area, East of 37th	400		Unknown	Unknown	8
D21	3	2	47th Ave	250	1950s	Unknown	6	8
			Fieldcrest Dr	1,750		Unknown	4, 6	8
			Fieldcrest Ave	1,120		Unknown	6	8
D22	3	1	Llewellyn St	440	1990s	Unknown	Unknown	8
	2	2	King Rd	1,660		Unknown	8	12

Index	Number of Hydrants Corrected	Pressure Zone	Location	Length (feet)	Approximate Date of Installation	Existing Material	Existing Diameter (inches)	Proposed Diameter (inches)
D23[b]			Llewellyn St	1,300	1920s, 1930s & 1950s	Unknown	Unknown	12
			Harrison St	670		Unknown	8	12
			42nd Ave	270		Ductile Iron	8	12
D24	2	2	30th Ave	710	1960s, 1980s & 2000s	Ductile Iron	6	8
			Sellwood St	520		Ductile Iron	6	8
			32nd Ave	560		Unknown	6	8
			Wister St	250		Ductile Iron	6	8
D25	2	3	Reconnect King Rd Hydrants to 10 in Line	80	Unknown	Unknown	Unknown	8
D26	1	2	Grogran St	420	1960s, 1970s & 2000s	Unknown	8	12
			36th Ave	1,280		Cast Iron	4, 6	12
D27	1	2	36th Ave	330	1950s	Unknown	4	8
D28	1	2	Balfour St	700	Unknown	Cast Iron	4	8
D29	1	2	63rd to 64th Ave	240	Unknown	Unknown	Unknown	8
D30	1	2	Northridge Dr	430	1970s & 1980s	Unknown	6	8
			41st Ct	630		Unknown	6	8
D31	1	2	Hunter St	340	1960s, 1980s & 2000s	Cast Iron	6	8
D32	1	2	41st Ave to 42nd Ave, Extend SE Meadowcrest Ct	380	1990s	Unknown	Unknown	8
D33	1	2	32nd Ave	360	1940s	Cast Iron	12	12
D34	1	3	Wichita Ct to Woodhaven St	410	Unknown	Unknown	Unknown	12
D35[c]	0	1	26th Ave	600	1960s	Unknown	10	12
PRIORITY 5								
D36	2	2	Industrial Area to Railroad Ave	390	2000s	Unknown	Unknown	12
D37	1	2	30th Ave	630	1920s	Ductile Iron	6	8
			Madison St	400		Cast Iron	6	8
			Washington St	300		Unknown	6	8
D38	1	1	29th Ave	550	1920s	Unknown	6	8
			Washington St	270		Cast Iron	6	10
D39	1	1	Quail Ridge Apartments	352	1920s	Unknown	Unknown	8
D40	1	1	Hanna Harvester Dr	1,280	1940s	Cast Iron	12	12
D41	1	3	Waymire St	240	1950s	Unknown	4	8
D42	1	4	Oxford Ln	350	1950s	Unknown	6	8
D43	1	2	Brookside Apartments to Brookside Dr	310	1960s	Unknown	Unknown	8
D44	1	2	Se Furnberg St	500	1960s	Unknown	Unknown	8
D45	1	1	McLoughlin Blvd	90	1970s	Unknown	8	12
			Washington St	40		Unknown	8	12
D46	1	2	41st Ave	410	Unknown	Unknown	6	8

Index	Number of Hydrants Corrected	Pressure Zone	Location	Length (feet)	Approximate Date of Installation	Existing Material	Existing Diameter (inches)	Proposed Diameter (inches)
D47	1	1	29th Ave	350	1980s	Unknown	6	8
D48	1	2	Stanley Place	800	Unknown	Unknown	Unknown	12
D49	1	1	Riverway Ln to 17th Ave	850	Unknown	Unknown	Unknown	12
D50	1	3	Monroe St	960	Unknown	Unknown	Unknown	12
D51	1	2	White Lake Rd	460	Unknown	Unknown	6	8
D52	1	1	Clackamas Hwy	570	Unknown	Unknown	Unknown	12
D53c	0	1	Frontage Ave	550	1950s & 1960s	Unknown	8	12
			Milport Rd	210		Steel	8	12
D54c	0	1	23rd Ave	255	1950s, 1970s & 2000s	Cast Iron	8	12
			Adam St	340		HDPE	6	12
D55c	0	1	21st Ave to Main St	380	Unknown	Unknown	Unknown	8
D56c	0	2	56th Ave to Beckman Ave	340	Unknown	Unknown	Unknown	8
D57c	0	3	Deering Ct to Linwood Ave	330	1980s	Unknown	Unknown	12
D58c	0	3	60th Ave to Linwood Ave	450	Unknown	Unknown	Unknown	12

a. Project D1 was omitted from the capital improvement plan in this WMP because it was identified as included in a separate City project.
b. Improves pressure.
c. Completes a loop in the system.

The distribution improvements are projected to affect system performance as follows:

- Reduce the number of low-pressure junctions in Zone 4 and Zone 2; however, low pressure junctions in Zone 1 will not be changed due to issues with elevation.
- The high-pressure area in Zone 2 would be exacerbated by increased transmission to the area.
- All fire flow deficiencies in residential zones (excluding those near tanks or pumps) would be eliminated by the improvements.
- All but one hydrant at a high elevation would meet the sprinklered fire flow for industrial and commercial zones.

Figure 4-5 shows the location of these distribution improvements. The resulting low pressures, high pressures, and fire flow are shown in Figure 4-6, Figure 4-7, and Figure 4-8, respectively.

The low-pressure issues remaining after the distribution improvements are the result of high elevation areas. For Zone 1, all low-pressure deficiencies are eliminated when the Concrete Tank is 98 percent full. A taller tank or pumps at the Concrete Reservoir would resolve these issues. For Zone 2, all low-pressure deficiencies are eliminated when the Elevated Reservoir is 75 percent full; however, any increase in the level of the Elevated Reservoir would exacerbate the high-pressure deficiencies near Kellogg Creek. At Kellogg Creek, the proposed pipe in Table 4-4 (D-13) would run parallel to the existing pipe, and PRVs would be placed on the existing pipe. The PRVs would address the high pressures of the existing services and the new main would address the low pressures southwest of this area. Remaining high pressure areas can be addressed with individual service PRVs.

4.4 EVALUATION OF EXISTING PRESSURE ZONE BREAKS

Table 4-5 catalogs the zone crossings and their valve settings. No deficiencies were detected between zone breaks.

Table 4-5. Zone Break Structure

Location	Main Diameter	Zones Connected	Valve Type	Valve ID	Valve Status
SE River Rd & SE Wren St	8 inches	2/1	PRV	V-PRV-5	30 psi
Lake & 33rd	8 inches	2/1	PRV	V-PRV-4	40 psi
Lake & 33rd	8 inches	2/1	Gate	13135	Closed
32nd & Lake	6 inches	2/1	PRV	V-PRV-6	40 psi
Washington & 30th	6 inches	2/1	Gate	ZB10805	Closed
Monroe & Penzance	10 inches	2/1	PRG	PRG006	Presumed 40 psi setting
2700 Kevin	16 inches	Concrete Tank to Zone 2	None		
Harrison & 32nd	8 inches	2/1	PRV	V-PRV-3	43
Lava Drive & Riverway	12 inches	1/4	Lava Drive Pump Station		
1600 McBrod	8 inches	1/4	PRV	V-PRV-2	Open
Waverly & 17th	8 inches	1/4	PRV	V-PRV-1	20 gpm
Waverly & 17th	2 inches	4/1	PRV	13291	20 gpm
Stanley & Harlow	10 inches	2/3	Check Valve	13222	Closed in Normal Operation
Linwood & Furnberg	8 inches	2/3	Check Valve	12461	Closed in Normal Operation
Stanley & Lloyd	8 inches	2/3	Check Valve	12347	Closed in Normal Operation
5600 Waymire	4 inches	2/3	Check Valve	12208	Closed in Normal Operation
11000 Wood	6 inches	2/3	Check Valve	13226	Closed in Normal Operation
Wood & Monroe	8 inches	2/3	Gate Valve	12159	Closed in Normal Operation
52nd & Monroe	8 inches	2/3	Gate Valve	12150	Closed in Normal Operation
52nd & Monroe	8 inches	2/3	Swing Check	13307	Closed in Normal Operation
Jackson & Home	12 inches	2/3	Check Valve	13403	Closed in Normal Operation
King & 52nd	8 inches	2/3	Check Valve	CHV-002	Closed in Normal Operation
Stanley & Logus	6 inches	2/3	Check Valve	13180	Closed in Normal Operation
1700 Linwood	12 inches	2/3	Check Valve	CHV-001	Closed in Normal Operation

4.5 IDENTIFICATION OF DUPLICATE WATER MAINS

Duplicate parallel pipes with connected flows are identified in Figure 4-9, and their characteristics and service connections are listed in Table 4-6. The objective of this WMP was the identification of the duplicate pipes. It is recommended that more detailed modeling be conducted to determine if removal or abandonment of one pipe would adversely affect level of service characteristics. The duplicate pipes are not addressed in the CIP for this WMP.

Table 4-6. Duplicate Pipes

#	Figure	Location of Duplicate Pipes	Pipe Extent	Pressure Zone	Length (feet)	Parallel Pipe 1				Parallel Pipe 2			
						Pipe Size (in)	Year	Material	Services	Pipe Size (in)	Year	Material	Services
X1	Figure 4-10	SE Sparrow St & SE 22nd Ave	River Rd & McLoughlin Blvd	1	280	6	1934	Unk	Yes	10	1998	Unk	Yes
X2	Figure 4-11	SE Washington St	23rd St & 28th Ave	1	1,300	10	1969	DI	Yes	6	1985	CI	No
X3	Figure 4-12	SE Main St	Scott St & Harrison St	1	330	6	1930	CI	No	12	1968	CI	Yes
X4	Figure 4-13	SE Roswell St	29th Ave& 32nd Ave	2	700	8	1969	Unk	No	4	Unk	Unk	No
X5	Figure 4-14	SE 32nd Ave	Harvey St & Llewellyn St	2	1,410	6	1930	CI	Yes	12	1952	CI	Yes
X6	Figure 4-15	SE Harvey St	40th Ave & 42nd Ave	2	510	4	1954	CI	Yes	12	1969	CI	No
X7	Figure 4-15	SE 42nd Ave	Mason Ln & Harvey St	2	1,780	4	1954	CI	Yes	12	1969	Unk	Yes
X8	Figure 4-14	SE 40th Ave	Harvey St & King Rd	2	1,320	6	1954	CI	Yes	8	1954	Unk	Yes
X9	Figure 4-16	SE Railroad Ave	45th Ave & Home St	2	1,570	8	1954	Unk	Yes	14	1970	Unk	No
X10	Figure 4-16	SE 47th Ave	Franklin St & Railroad Ave	2	900	6	1954	Unk	Yes	10	1980	Unk	No
X11	Figure 4-17	SE Wood Ave	Park St & Apennine Way	2	1,470	4	Unk	Unk	Yes	8	1970	DI	Yes
X12	Figure 4-18	SE Monroe St	55th Ave & Linwood Ave	3	1,900	4	Unk	Unk	Yes	10	1987	Unk	Yes
X13	Figure 4-18	SE Linwood Ave	Monroe St & Beverly Ln	3	1,470	6	1954	Unk	Yes	12	1970	DIP	Yes
X14	Figure 4-19	SE 52nd Ave	Jackson St & Monroe St	3	370	12	1957	Unk	Yes	10	1970	Unk	Yes
X15	Figure 4-18	SE King Rd	52nd Ave & Stanley Ave	3	1,210	4	1937	Unk	Yes	10	1970	Unk	Yes
X16	Figure 4-18	SE King Rd	Stanley Ave & Linwood Ave	3	1,420	6	1954	Unk	Yes	10	1970	Unk	Yes

4.6 EVALUATION OF POTENTIAL EMERGENCY INTERTIE CONNECTIONS

The City is interested in establishing functioning intertie connections with neighboring utilities. The City of Milwaukie has two existing emergency interties: with the City of Portland and Clackamas River Water. Clackamas River Water's Milwaukie Pump Station would facilitate the emergency flow of water to Milwaukie. Neither intertie is currently in use. Seven potential intertie locations were identified from a previous Oak Lodge Water Service evaluation and from GIS information regarding neighboring utility pipes. Figure 4-20 shows the location of existing and potential interties; summary information is provided in Table 4-7.

Potential and existing emergency intertie connections with the City of Portland, Clackamas River Water, and Oak Lodge Water Services were evaluated based on pipe size, pumping requirements, and location. Interties on larger mains are more desirable for conveyance. For interties with transmission through mains with existing diameters 10 inches and smaller, the mains should be upsized to a minimum diameter of 12 inches. Where the neighboring utility's hydraulic gradeline is equal to or lower than Milwaukie's, pumping would likely be required to provide emergency flow. Interties that do not require the construction of new pump stations are preferred. Connections to Zone 2 are more desirable, as all zones in the City can be fed by Zone 2. Connections to Zone 1 would serve only Zone 1 and Zone 3.

Based on the data collected for Table 4-7, the existing City of Portland, existing Clackamas River Water and Oak Lodge Aldercrest interties are or would be most beneficial to Milwaukie and should be considered for future development due to their adequate pipe size, lack of additional pumping, and connection to Zone 2.

4.7 SUMMARY OF DEFICIENCIES AND IMPROVEMENTS

Small-diameter pipes and dead ends are causing fire flow deficiencies. Pressure deficiencies are caused by high and low elevations in the system. The following tasks were identified to address these issues:

- Complete the Phase 1 improvements to the existing system outlined and prioritized in Table 4-4.
- Address high pressure areas with PRVs on individual services or reconnecting service to a pipe with a PRV.

Table 4-7. Emergency Intertie Connections

#	Utility	Location	Elevation (feet)	Milwaukie Zone	Neighboring Utility Zone	Difference in Hydraulic Gradeline	Pumping	Milwaukie Pipe Sizes	Neighboring Utility Pipe Size	Milwaukie Upsizing
EXISTING										
C1	Clackamas River Water	Harmony Rd & 71st Ave	140	Zone 2 (292 feet)	Mather (292 feet)	0 feet	Existing Milwaukie Pump Station	12"	12"	None
C2	Portland	Johnson Creek & 45th Pl	104	Zone 2 (292 feet)	Unavailable	Unavailable	Pumping not required	12"	20"	None
PROPOSED										
C3	Clackamas River Water	Lake Rd & Kuehn Rd	~137	Zone 2 (292 feet)	Mather (292 feet)	0 feet	Pumping likely required	12"	8"	None
C4	Clackamas River Water	Johnson Creek Blvd & Wichita Ave	~140	Zone 2 (292 feet)	Otty (382 feet)	90 feet	Pumping not required	12"	8"	None
C5	Oak Lodge	(A) 12381 Oatfield Rd	~86	Zone 2 (292 feet)	OLWSD Lower Zone (353 feet)	61 feet	Pumping not required	10"	Unknown	Upsize Oatfield to 12"
C6	Oak Lodge	(C) 23rd Ave & Lark St	~130	Zone 2 (292 feet)	OLWSD Lower Zone (353 feet)	61 feet	Pumping not required	10"	Unknown	Upsize Oatfield & Kellogg Lake to 12"
C7	Oak Lodge	(D) River Rd & Sparrow St	~127	Zone 1 (211 feet)	OLWSD Lower Zone (353 feet)	142 feet	Pumping not required	10"	Unknown	Upsize McLoughlin Blvd, 22nd Ave, River Rd 8" & 10" pipe to 12"
C8	Oak Lodge	(E) Aldercrest Rd	~45	Zone 2 (292 feet)	OLWSD Lower Zone (353 feet)	61 feet	Pumping not required	12", 16"	Unknown	None
C9	Portland	McBrod Ave & Ochoco St	67	Zone 1 (211 feet)	Unavailable	Unavailable	Pumping likely not required	12"	8"	None

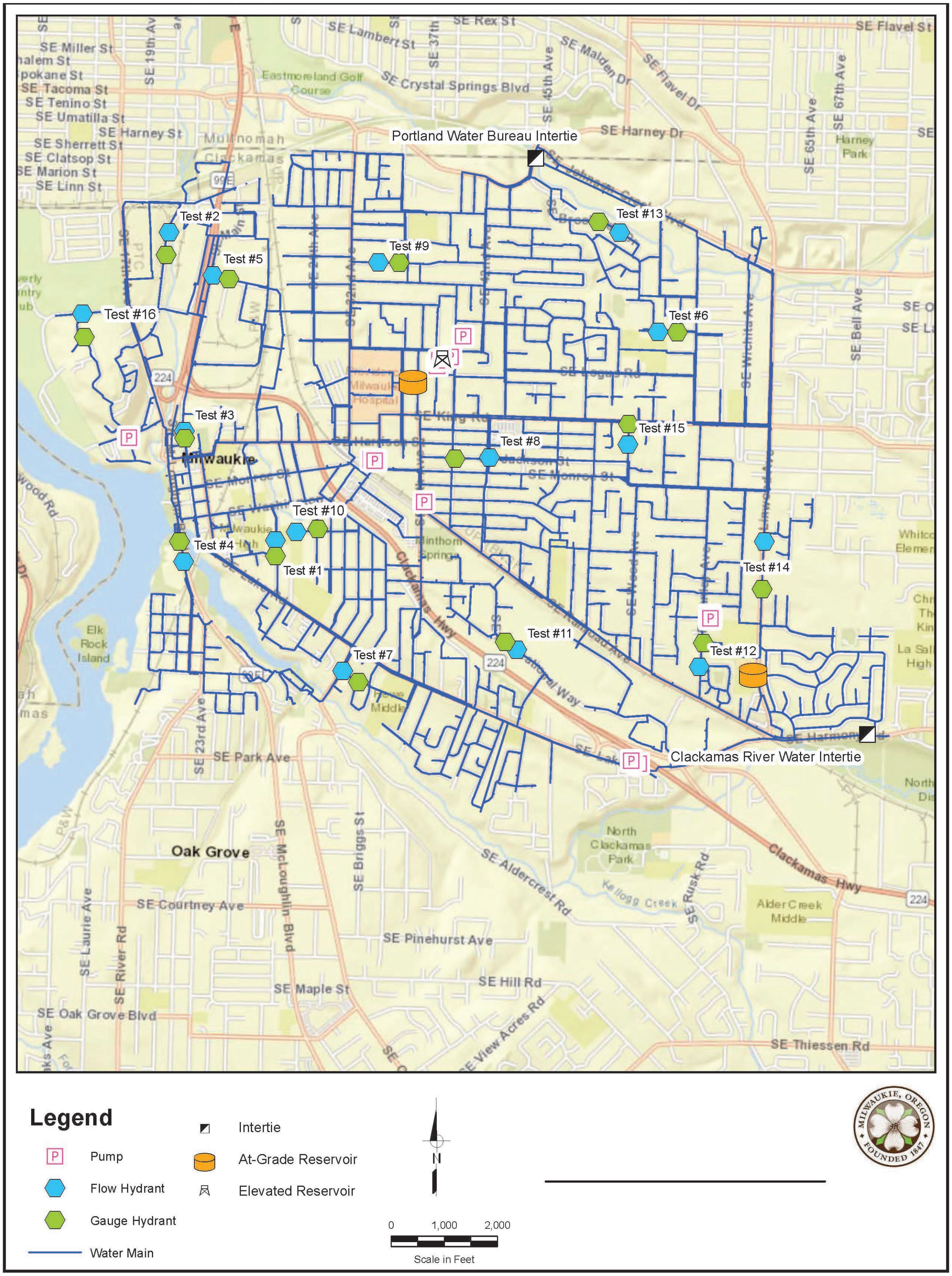


Figure 4-1. Hydrant Test Locations

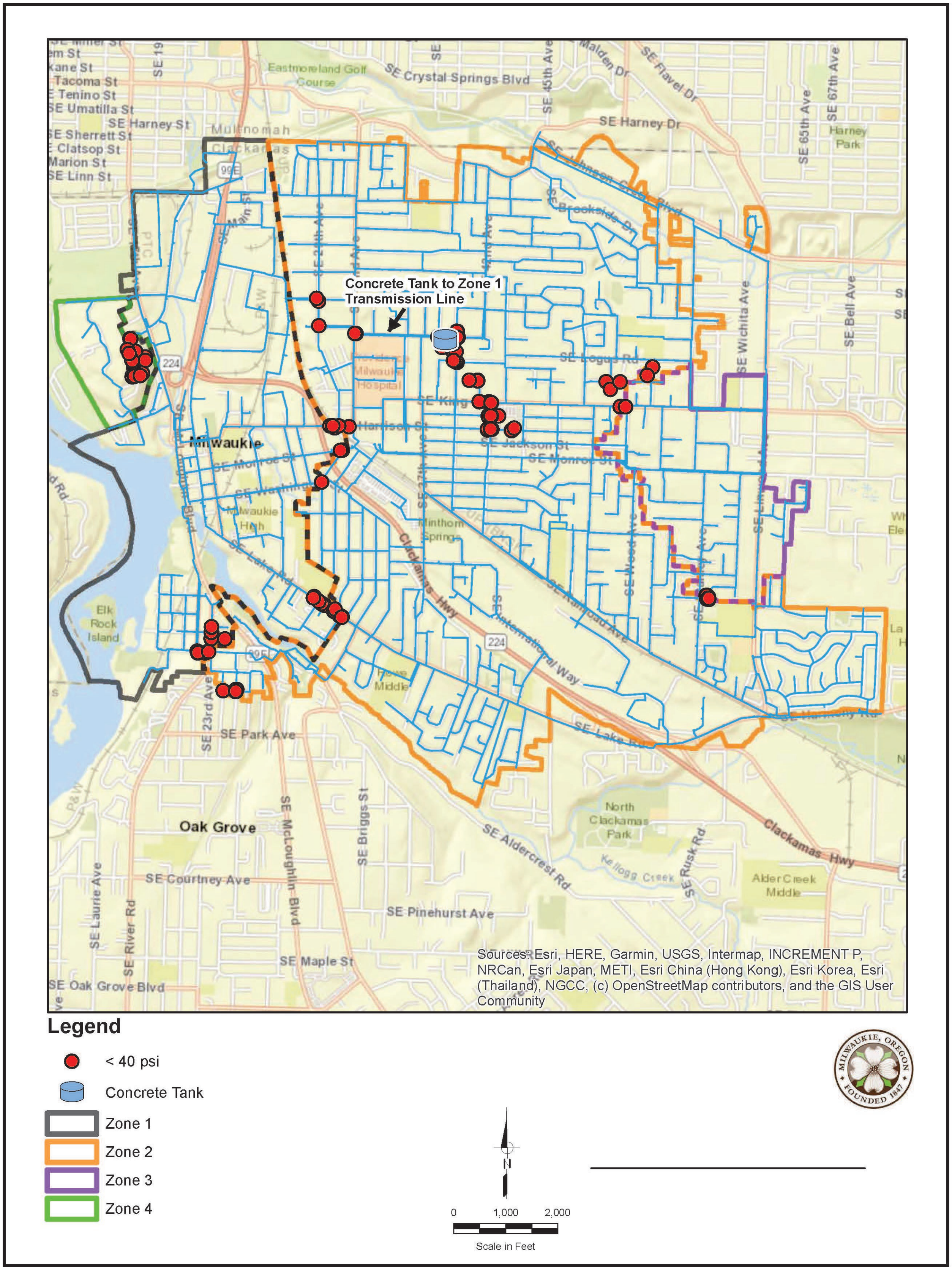


Figure 4-2. Existing Low-Pressure Locations Under Peak-Hour Demand Conditions

Figure 4-3. Existing High-Pressure Locations Under Average-Day Demand Conditions

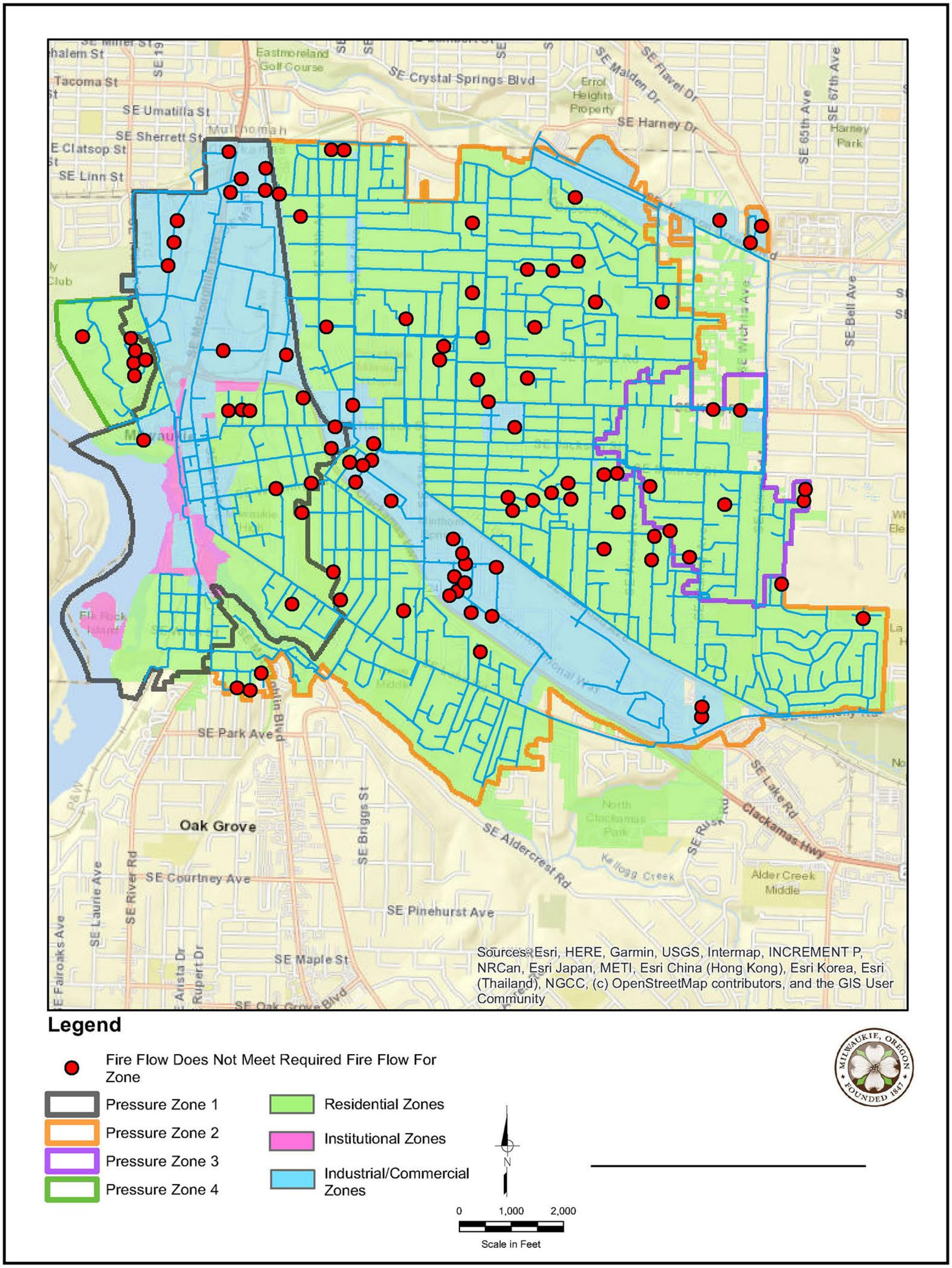


Figure 4-4. Existing Low Fire Flow Hydrants Under Maximum-Day Demand Conditions

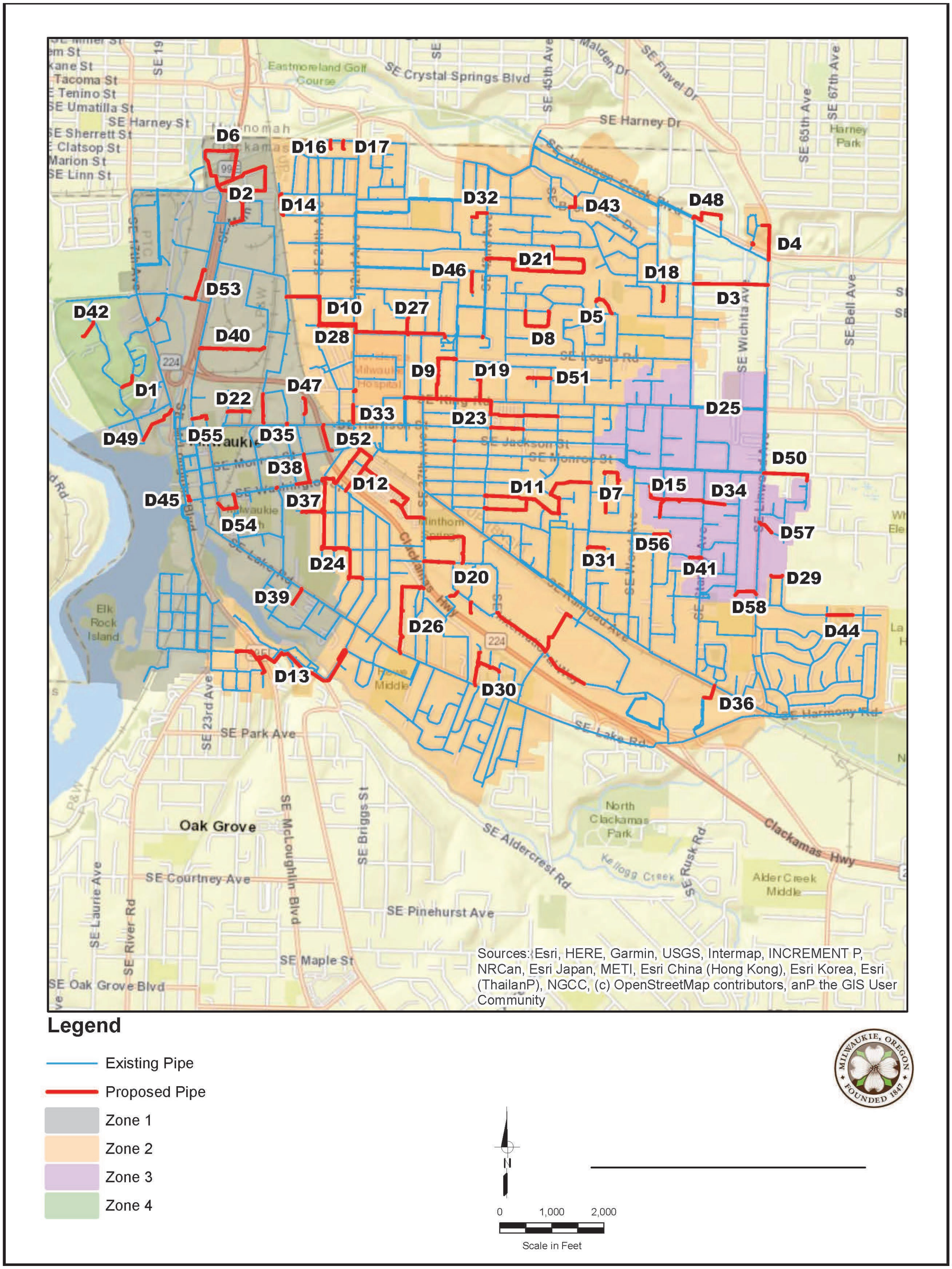


Figure 4-5. Distribution System Improvements

Figure 4-6. Low Pressure Locations Under Peak-Hour Demand Conditions with Improvements

Figure 4-7. High Pressure Locations Under Average-Day Demand Conditions with Improvements

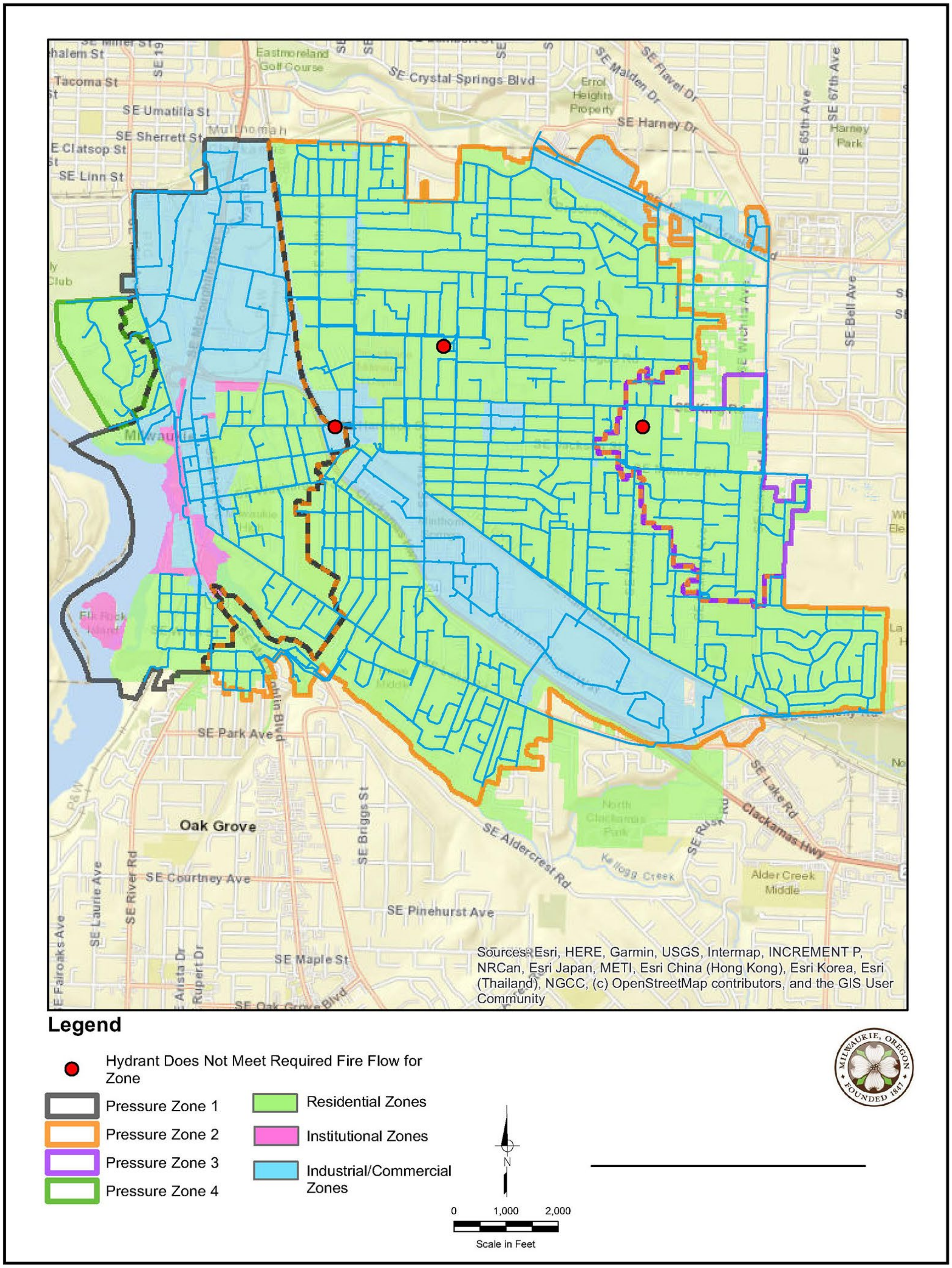


Figure 4-8. Low Fire Flow Hydrants Under Maximum-Day Demand Conditions with Improvements

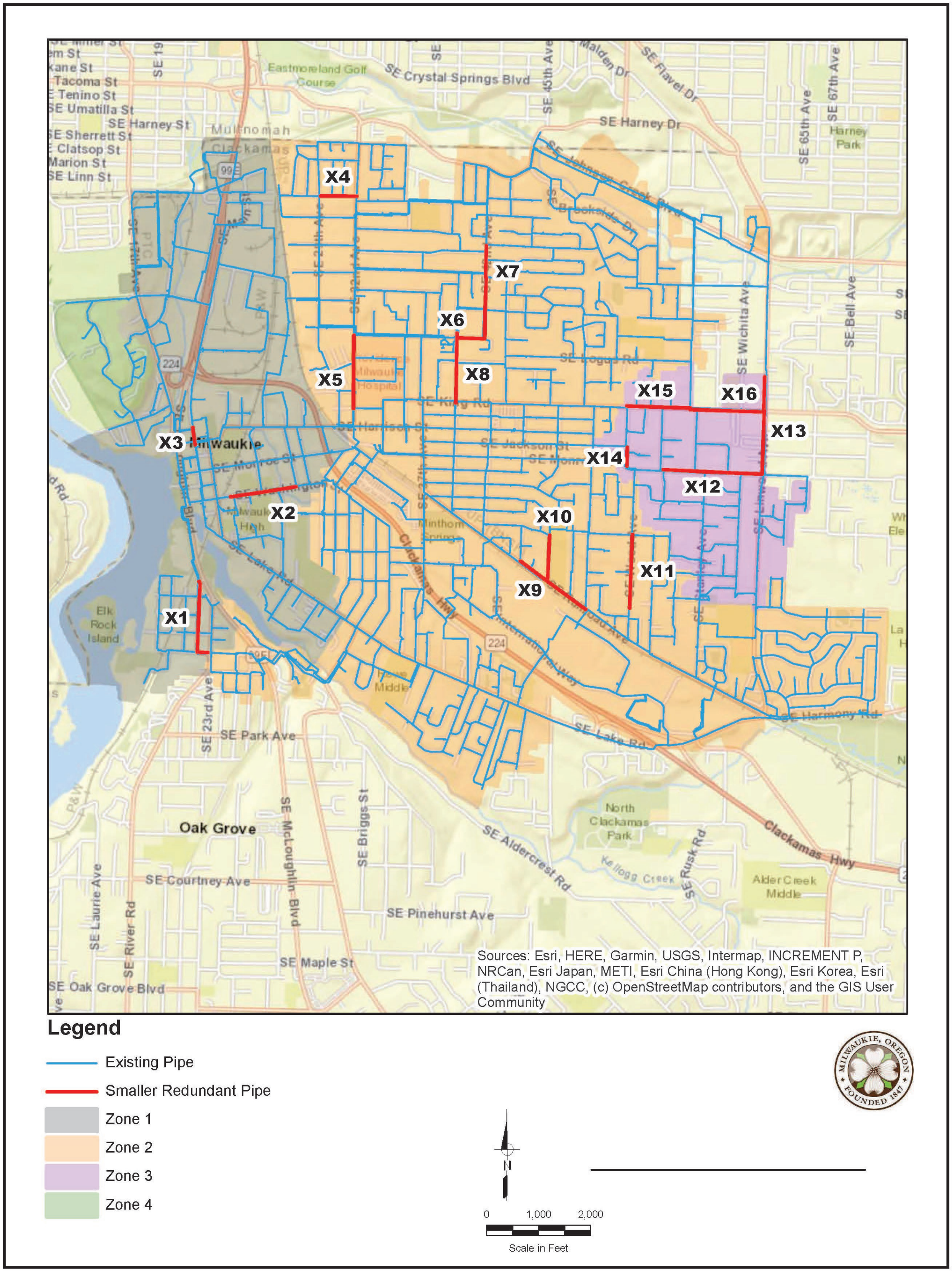


Figure 4-9. Duplicate Pipe Overview

Figure 4-10. Duplicate Main X1

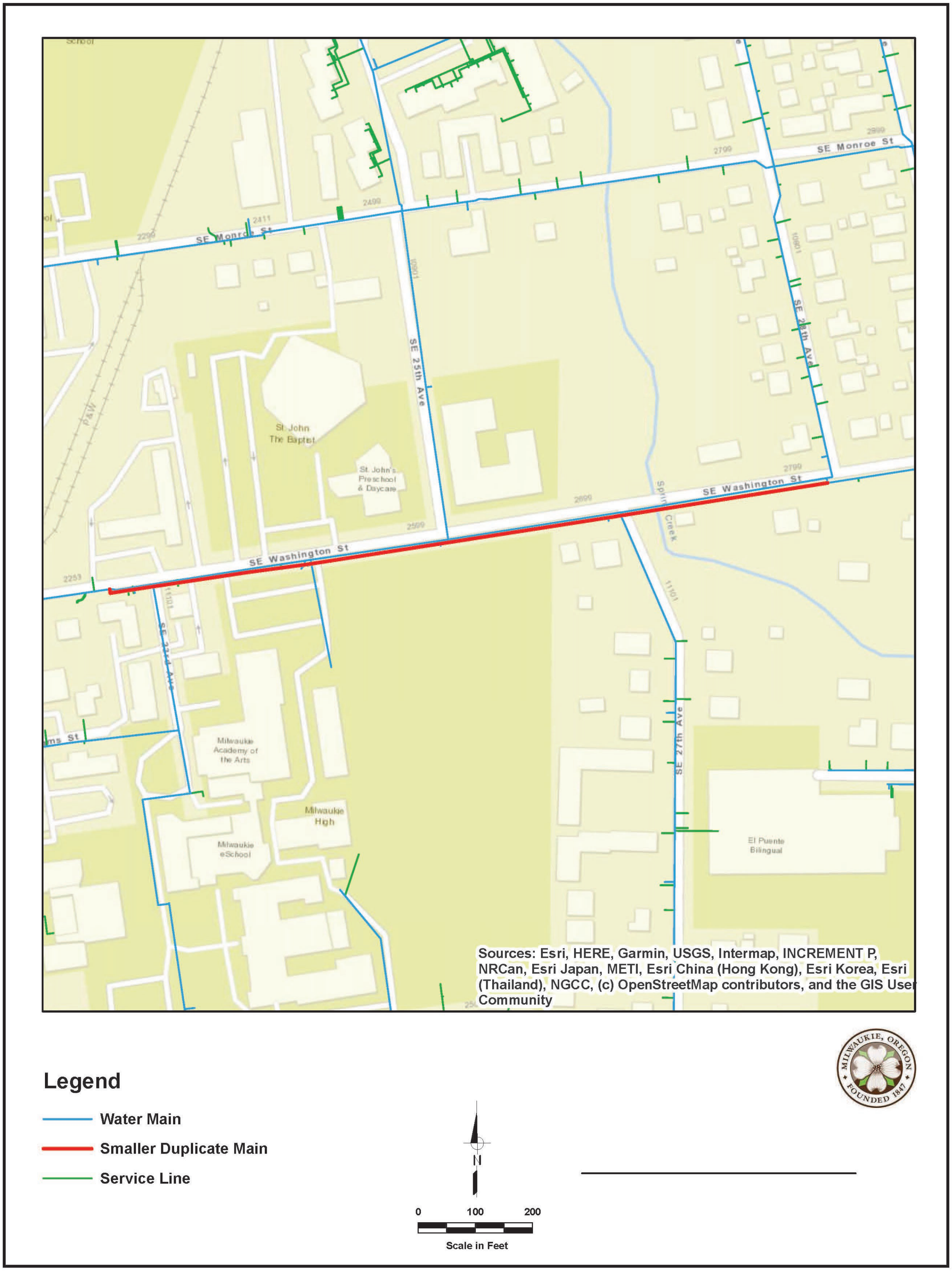


Figure 4-11. Duplicate Main X2

Figure 4-12. Duplicate Main X3

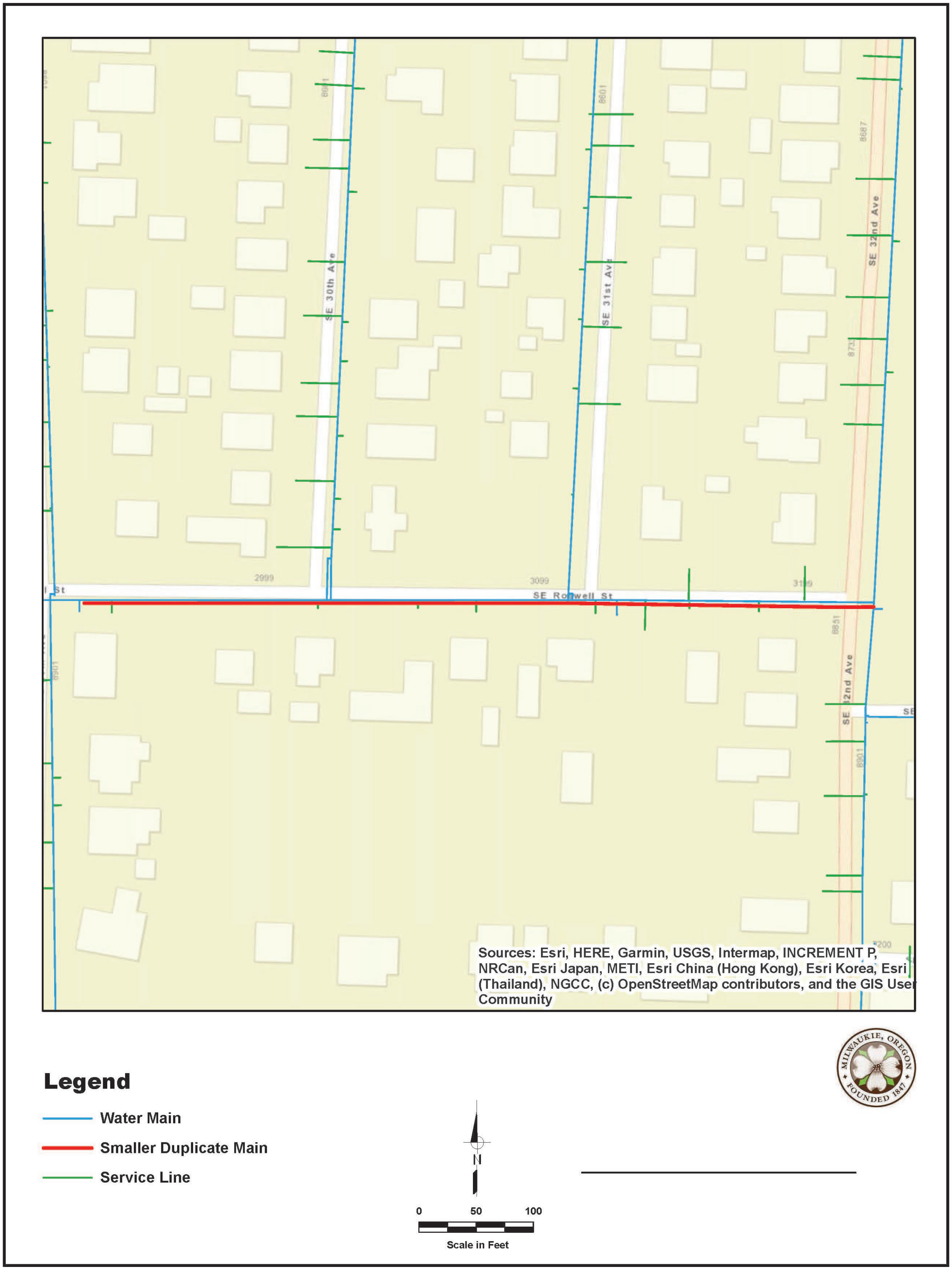


Figure 4-13. Duplicate Main X4

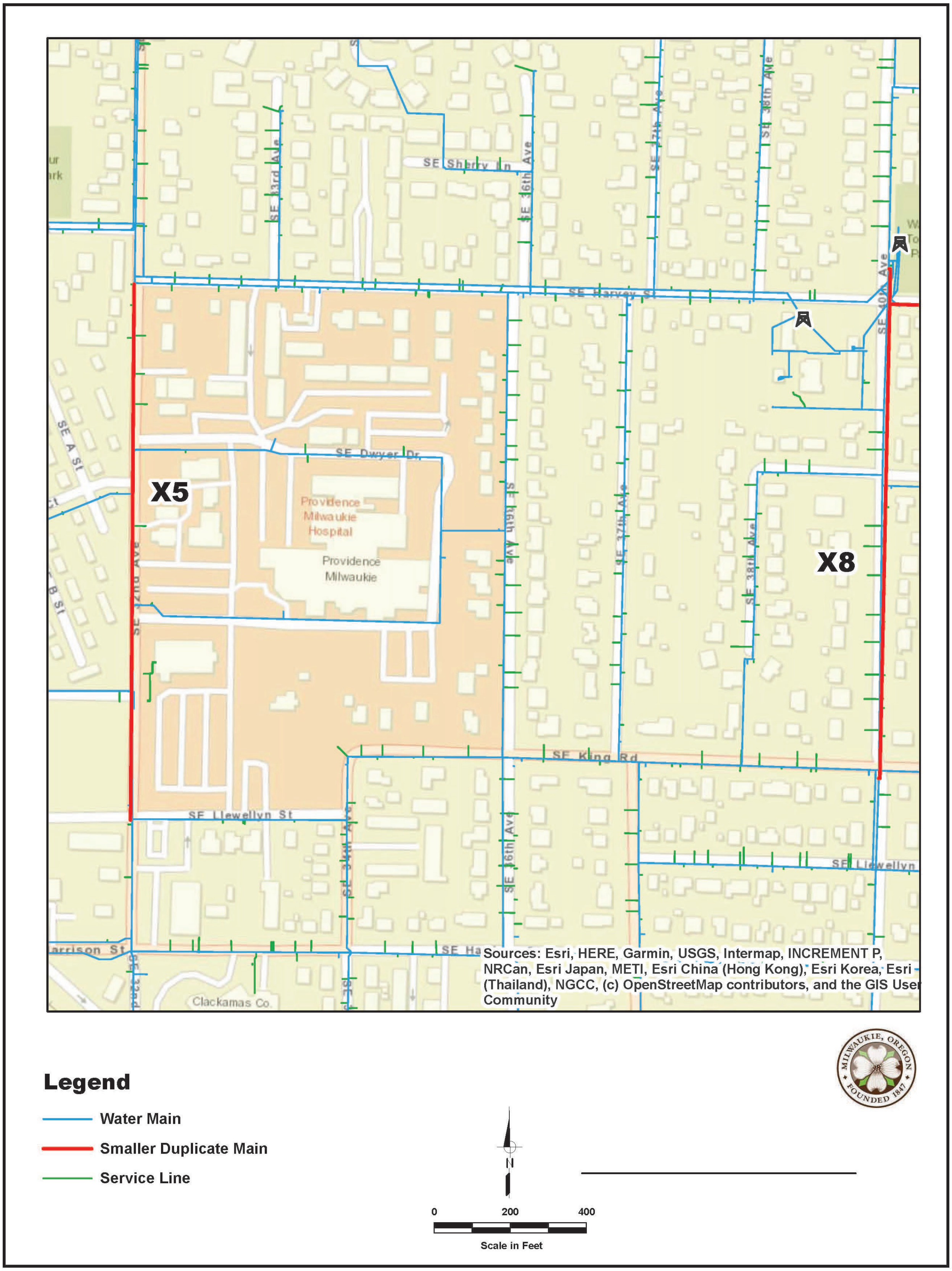


Figure 4-14. Duplicate Mains X5 and X8

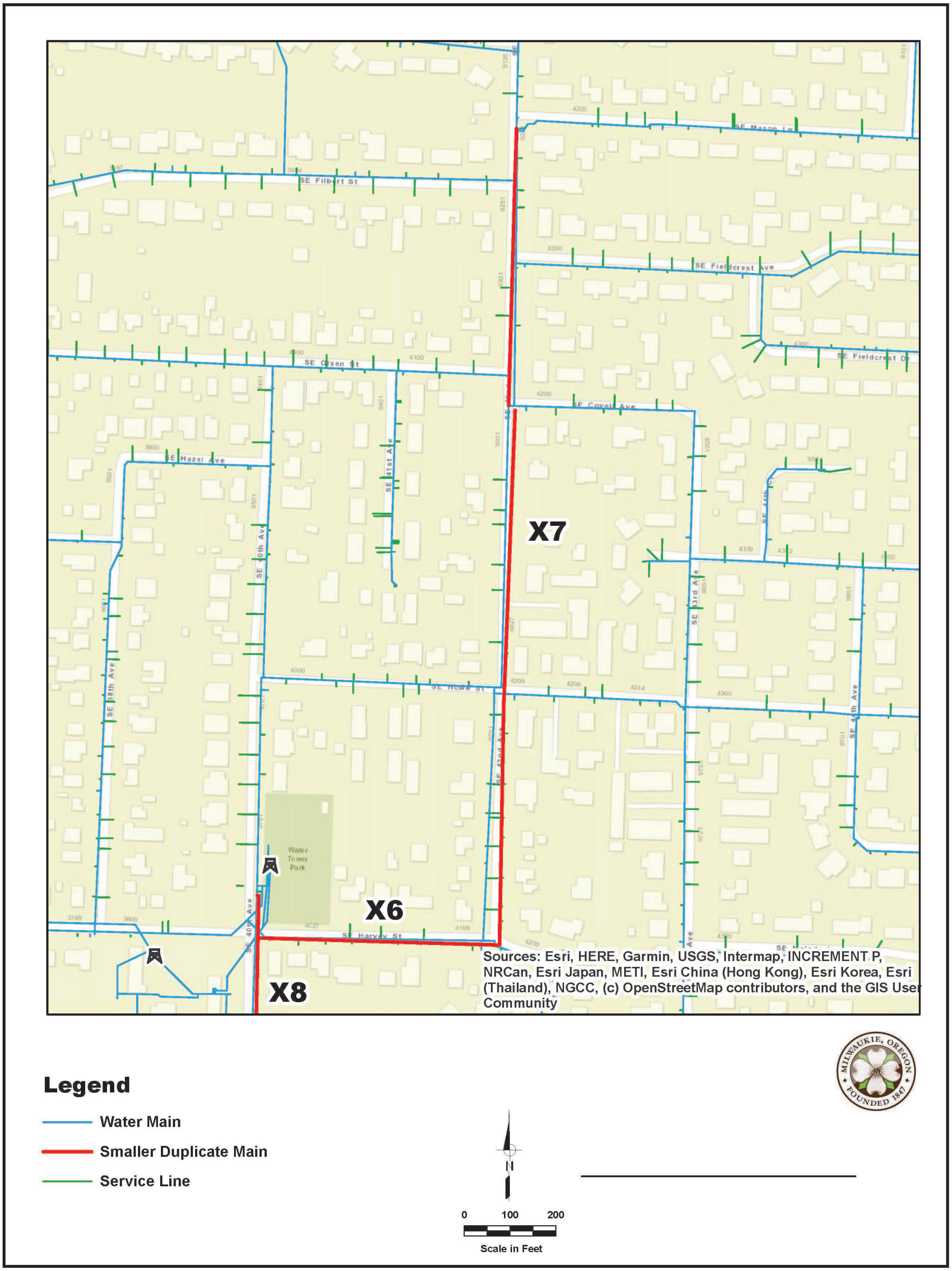


Figure 4-15. Duplicate Mains X6, X7, and X8

Figure 4-16. Duplicate Main X9 and X10

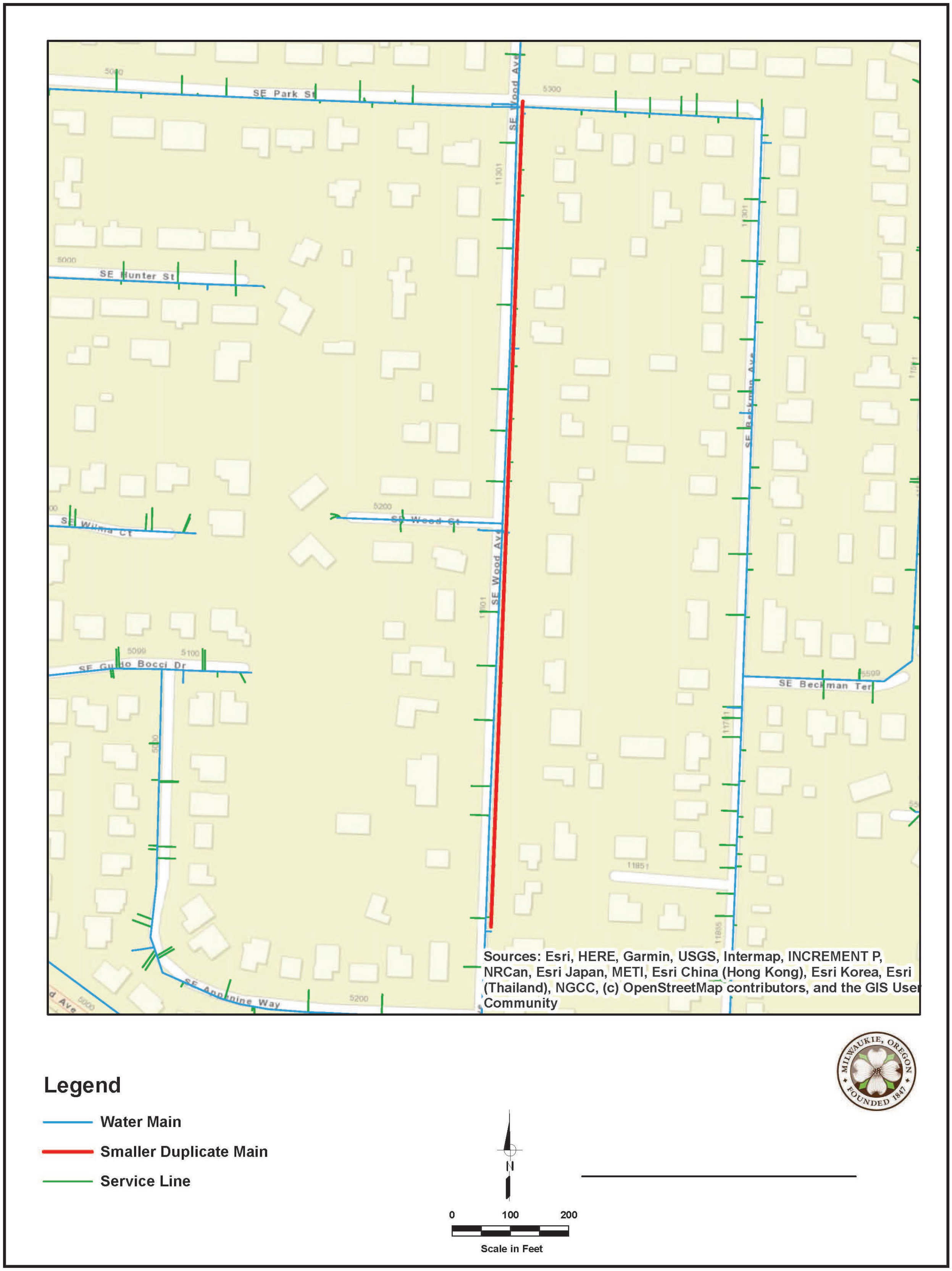


Figure 4-17. Duplicate Main X11

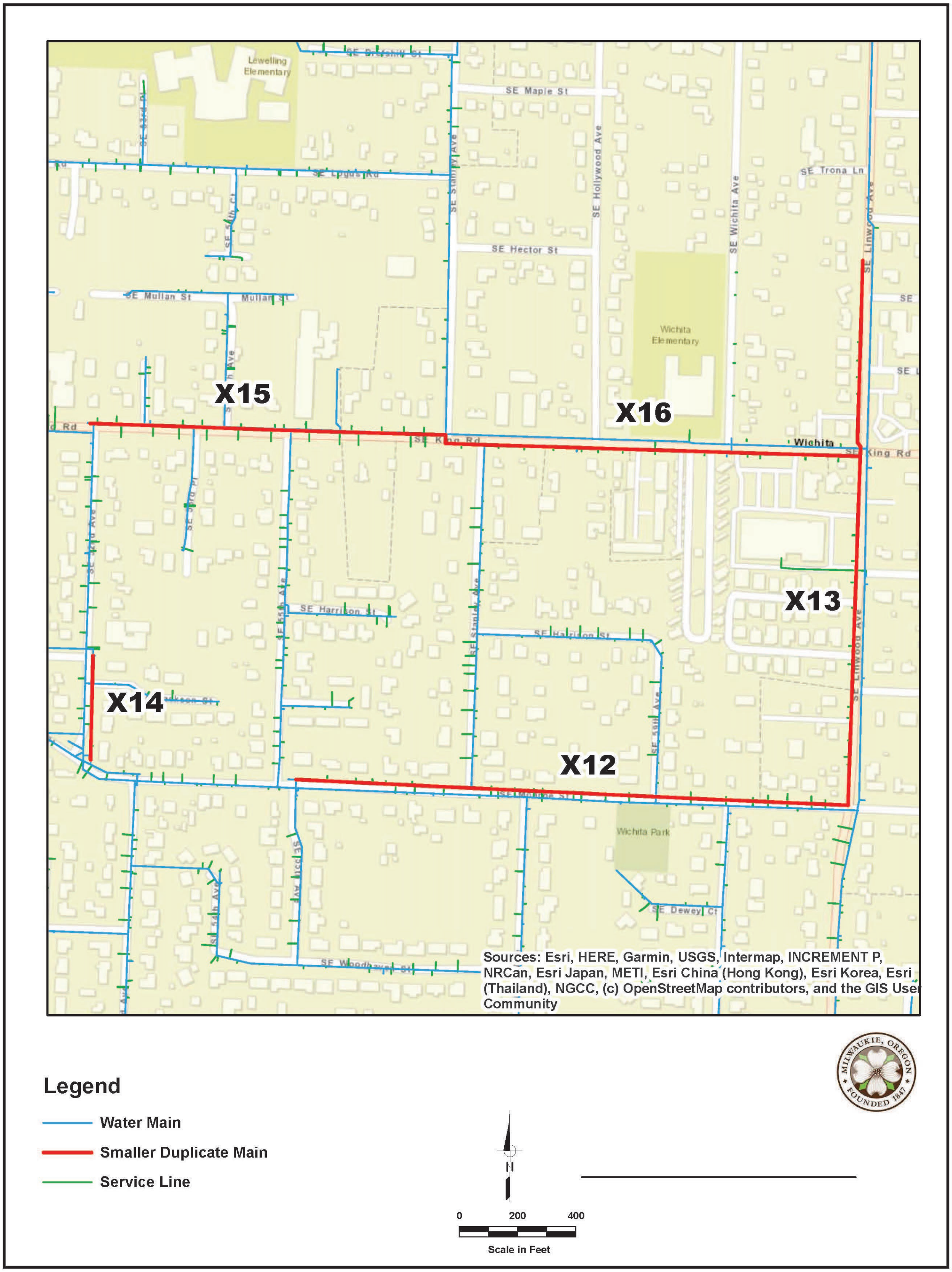


Figure 4-18. Duplicate Mains X12, X13, X14, X15, and X16

Figure 4-19. Duplicate Main X14

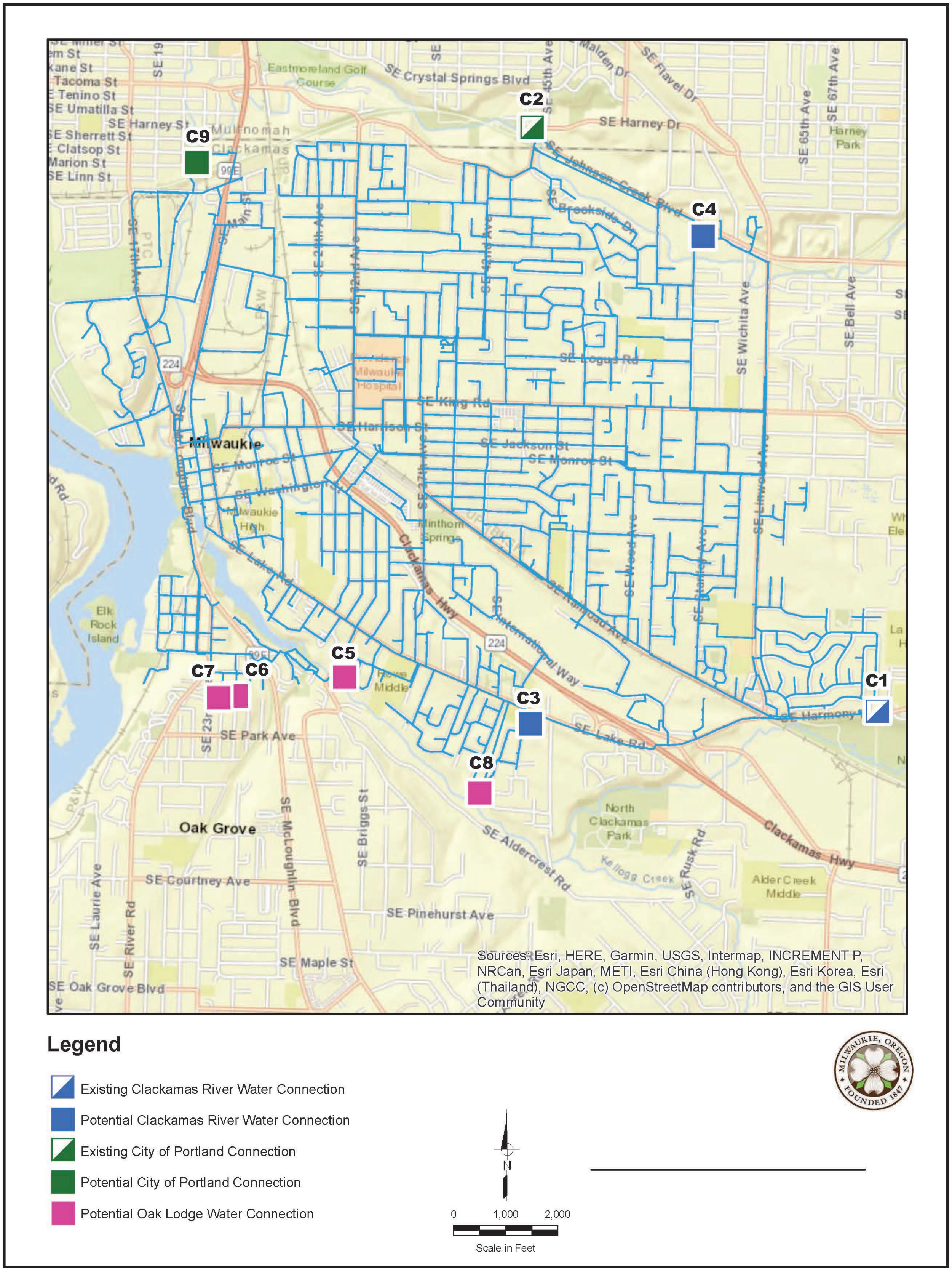


Figure 4-20. Existing and Potential Emergency Intertie Connections

5. SOURCE OF SUPPLY

5.1 SOURCE RELIABILITY

The City of Milwaukie receives 100 percent of its water supply from groundwater. The source of that groundwater is the Troutdale Aquifer, which covers approximately 300 square miles under the greater Portland metropolitan area. The aquifer is a deep system of gravels and sandstone with large unconsolidated areas that is well-confined by low-permeability layers. These qualities make a good municipal source of water.

The City does not have a wellhead protection plan, but it performed a source water assessment in 2004. The City is a member of the Regional Water Providers Consortium, which is made up of 20 water providers in a collaborative organization to improve planning and management of municipal water supplies in the Portland metropolitan area.

5.2 WELL CHARACTERISTICS

The City operates six groundwater wells distributed throughout the water service area, as listed in Table 5-1. Table 5-1 also summarizes pumping capacities associated with the authorized water rights. Wells 2, 3, and 5 are part of a wellfield in the vicinity of Water Tower Park. Wells 4, 6, and 7 are in the southern part of the City service area.

In 2014, it was discovered that the casing for Well 2 was damaged. At the time of this WMP, a replacement Well 2R is under construction. A 2020 technical memorandum that describes a screening-level assessment of the new Well 2R site is included as Appendix I.

Well 8 was taken offline in 2013 due to high iron content in the source water that caused screen fouling and pump overheating. When Well 8 was in operation, pumping rates ranged between 300 and 700 gpm.

Table 5-1. Well Characteristics Summary

Well	Well Log ID	Year Drilled	Year Pump Installed	Depth Drilled (feet)	Casing Size (inches)	Current Pumping Capacity[a] (gpm)
Active Wells						
2[b]	CLAC 307	1936	1993	290	12	800
2R[c]	CLAC 75329	2019	2020	392	12	700
3[d]	CLAC 308	1946	1980	290	10	510
4[e]	CLAC 319	1960	2004	304	16	605
5[f]	CLAC 305	1963	1980	383	12	950
6	CLAC 363	1978	2007	336	14	670
7[g]	CLAC 315	1984	2000	325	16	1,120
Inactive Wells						
8A[h]	CLAC 3990/CLAC 64868					--
8[i]	CLAC 64690	2008	2009	481	N/A	--

a. Capacities for Wells 3, 4, 6 and 7 are based on pump performance analysis performed by BacGen. Well capacities for Wells 2 and 5 are from GSI (2019).
b. The maximum pumping capacity of Well 2 is 800 gpm. Combined groundwater registrations for Wells 2 and 3 limit the draw from Well 2 to 630 gpm. Operational limitations at Treatment Towers 2, 3, and 5 limit operational capacity of Well 2 to 600 gpm. At the time of this WMP, Well 2 is still in operation, but it will be decommissioned after Well 2R is online.
c. Construction of Well 2R will be completed in 2020. Its maximum pumping capacity will be 700 gpm. Combined groundwater registrations for Wells 2R and 3 will limit the draw from Well 2R to 630 gpm. Operational limitations at Treatment Towers 2, 3, and 5 will limit operational capacity of Well 2R to 600 gpm.
d. Well 3 is currently jointly limited with Wells 2 and 5 to 1,800 gpm by the capacity of Treatment Towers 2, 3, and 5. Well 3 is currently jointly limited with Well 2/2R by groundwater registrations of 1,140 gpm.
e. Current capacity of Well 4 is limited to 600 gpm by capacity of Treatment Tower 4
f. The maximum pumping capacity of Well 5 is 950 gpm. Operational limitations at Treatment Towers 2, 3, and 5 limit operational capacity of Well 5 to 660 gpm. Well 5 typically operates at 605 gpm. Water rights are limited to 718 gpm.
g. Current capacity of Well 7 is limited to 1,000 gpm by capacity of Treatment Tower 7.
h. Well 8A was abandoned in 2007. CLAC 3990 is the log for Well 8A when it was drilled. CLAC 64868 is the log for the abandonment of Well 8A.
i. Well 8 is Inactive due to biofouling

In 2013 GSI Water Solutions prepared a technical memorandum addressing rehabilitation for the well that included mechanical and chemical redevelopment (Appendix C). Rehabilitation of Well 8 was planned as part of a project to develop Well 2. However, staff at that time decided to abandon the rehabilitation of Well 8 in favor of identifying new well locations for the following reasons:

- The original Well 8 at the same site being abandoned decreased production capacity
- The existing Well 8 began exhibiting the same capacity issues as the original well
- Attempts to rehabilitate the original Well 8 had not been successful
- Continued efforts to rehabilitate Well 8 at its existing location were not proving to be a sound long-term investment
- The well would require rehabilitation every 2 to 5 years
- The well is in accelerated decline and rehabilitation would be a significant commitment.

A permanent water right is valid as long as the water is used at least once every five years in accordance with the water right. Certificated groundwater rights are those for which the Oregon Water Resources Department (OWRD) has approved a claim of beneficial use for a water use permit. Groundwater registrations are claims for the use of groundwater initiated before the enactment of Oregon's groundwater code in 1955.

5.3 WATER RIGHTS

The process of securing water rights in Oregon requires the user to obtain a permit from OWRD that authorizes initial beneficial use of the water. After a permitted water right has been fully developed and shown to have been put to beneficial use, OWRD issues a water right certificate as a permanent water right.

5.3.1 Water Rights Documentation

The City's water supply wells are authorized by three groundwater registrations and five certificated groundwater rights for municipal use. The City's groundwater registrations and certificated groundwater rights and associated pumping rates are summarized in Table 5-2. The City's certificate water rights and groundwater registrations authorize use up to 5,094 gpm (7.33 million gallons per day (mgd)).

Table 5-2. City of Milwaukie Municipal Authorized Water Rights and Pumping Rates

	Groundwater Registrations			Certificated Water Rights					Total
Authorized Source	**Well 1**	**Well 2/2R**	**Well 3**	**Well 4**	**Well 5**	**Well 6**	**Well 7**	**Well 8**	
Permit or Claim Information									
Permit or Claim No.	GR-1479	GR-1478	GR-1480	G-1609	G-2542	G-9953	G-9954	G-10582	
Application No.	—	—	—	G-1779	G-2531	G-10760	G-10762	G-11464	
Certificate or GR Modification	T-13144	T-13143	T-13145	32158	34010	56403	56404	82571	
Priority Date	1935	1936	1946	6/29/1960	11/6/1963	6/28/1982	6/28/1982	12/13/1985	
Authorized Pumping Rates									
(gpm)		1,140		503	718	808	1,198	727	**5,094**
(mgd)		1.64		0.72	1.03	1.16	1.73	1.05	**7.33**
(cubic feet/second)		2.54		1.12	1.6	1.8	2.67	1.62	**11.35**

GR = groundwater registration
Source: OWRD records of applications, permits and certificates of water rights.

No groundwater adjudication for this area has been initiated, and it is unclear when OWRD may initiate a groundwater adjudication—it may be many years in the future.

Groundwater Registrations

As shown in Table 5-2, the City holds three groundwater registrations (GR) for a combined 1,140 gpm (1.64 mgd) for Wells 1, 2/2R, and 3. In March 2019, the City submitted applications to modify all three of the City's groundwater registrations to enable the City to use this total rate flexibly across Wells 2R and 3. OWRD issued final orders approving the groundwater registration modifications in March 2020. The capacity of both Well 2 and Well 3 previously exceeded the authorized rate under any individual GR but did not exceed the authorized rate under all three GRs combined. The City is now authorized to pump up to a combined 1,140 gpm (1.64 mgd) from Well 2/2R and Well 3.

The new Well 2R will have a pumping capacity of 700 gpm when it is the only well in operation at that wellfield. The City plans to equip Well 2R with a variable frequency drive that will limit the pumping rate of Well 2R while Well 3 or Well 5 is pumping, in order to limit interference with the other wells and remain within the existing treatment tower capacity. Well 2R will be capable of pumping up to an estimated 650 gpm when Well 3 and 5 are in operation. With Well 2R pumping at 650 gpm, and assuming no reduction in the pumping rate of Well 3, the two wells could pump at a combined rate of 1,160 gpm, which is approximately equal to the rate authorized by the City's groundwater registrations (Table 5-2).

Water Right Certificates

The City holds five water right certificates authorizing the use of up to 3,954 gpm (5.69 mgd) from Wells 4 through 8. Table 5-2 shows the authorized water rights and pumping rates for Wells 4 through 8. The pumping capacity of Wells 6 and 7 are slightly below the rates authorized by the City's water rights. The pumping capacity of Wells 4 and 5 are approximately 100 and 230 gpm above the rate authorized by the associated water right certificates, respectively. Well 8 is currently not in use.

The City's groundwater registrations and the Well 5 certificate together authorize the use of the City's three wells in the vicinity of Water Tower Park (Well 2/2R, 3 and 5) at up to 1,858 gpm. Individually, the pumping capacity of Well 5 exceeds the authorized rate of Certificate 34010 (with Well 2/2R and 3 not pumping). If Well 2/2R, 3 and 5 are pumping simultaneously, their combined pumping rate is currently limited to 1,800 gpm by the capacity of the corresponding treatment towers. If this constraint were lifted, the wells may be able to pump at a rate of up to 2,110 gpm, which would exceed the authorized rate of the wellfield water rights by a combined 250 gpm.

Non-Municipal Water Rights

In addition to its municipal use water rights, the City holds two pond registrations, two surface water claim registrations, and a water right certificate for pond maintenance in natural areas throughout the City. These water rights are listed in Table 5-3. Because the City does not plan to use these surface water rights for municipal water supply purposes, they are not discussed further in this water system master plan.

Table 5-3. City of Milwaukie Non-Municipal Use Water Rights

Application Number	Permit/ Claim Number	Certificate	Authorized Source	Use	Priority Date	Rate (cubic feet/second)	Volume (acre-feet)
P-80990[a]			Various creeks/ runoff	Storage in various ponds	2/26/1996	N/A	11.07
P-80991[b]			A spring	Storage in Furnburg Pond	2/26/1996	N/A	0.78
	SW-216[c]		Spring Creek	Duck Ponds - Wildlife Habitat	1883	0.013	1.05
	SW-217[d]		Kellogg Creek	Kellogg Lake - Wildlife Habitat	1852	0.51	45
R-84738[e]	R-13529	93312	Minthorne Creek	Multi-purpose Storage	1/28/2002		5.45

a. Pond registration for US Bank, Roswell, Police Station, Shana Park, and Scott Park ponds.
b. Pond registration for Furnburg Park pond.
c. Surface water claim registration for storage of water in ponds on lower Spring Creek and use for evapotranspiration and pond maintenance.
d. Surface water claim registration for storage of water in Kellogg Lake and use for evapotranspiration and pond maintenance.
e. For storage at Minthorne Spring natural area.
N/A = Pond registrations authorize a volume of water for storage rather than a rate of appropriation.

5.3.2 Comparison of Current Water Rights Authorizations to 2040 Demand

Table 5-4 shows current population, 20-year projected population, equivalent residential units (ERUs), and demand. The values for demand have also assumed a 10 percent loss factor. With that assumption, the 2019 maximum-day demand of 4.13 mgd (2,866 gpm) represents a demand of 4.59 mgd (3,184 gpm) on the groundwater source (i.e., what is pumped from the City's groundwater wells). This is within the total rate authorized by the City's water rights (5,094 gpm). By 2040, maximum-day demand with a 10 percent allowance for system loss is expected to reach 6.2 mgd 4,304 gpm). This is also within the total rate authorized by the City's water rights of 5,094 gpm.

Table 5-4. Current and 20-Year Projected City Population, ERUs, and Demand (with 10% Loss Factor)

Year	Population	Equivalent Residential Units	Total Annual Demand (million gallons)	Average Day Demand (mgd)	Maximum-Day Demand (mgd)	Maximum-Day Demand (gpm)
2019	20,291	13,270	807	2.21	4.59	3,184
2040	31,445	18,120	1,091	3.00	6.2	4,304

Although the current authorized rate cannot meet the estimated demand in 2040, it is not necessary to apply for a new water right at this time, given the uncertainties associated with estimating maximum-day demand for 2040. The City needs to continue to evaluate maximum-day demand and revisit projected 10- and 20-year demand over the next few years to determine whether a new water right is needed.

5.3.3 Comparison of Actual and Authorized Appropriation Rates

Pumping at full capacity at one or more of the City's wells may exceed the rate the authorized water rights. Well 5 can pump at a rate 232 gpm greater than the rate authorized by Certificate 34010 (with Wells 2/2R and 3 idle). Well 4 pumps at 102 gpm greater than the rate authorized by Certificate 32158. Fluctuations in the production rate of groundwater wells is expected due to seasonal or long-term changes in water levels and well maintenance considerations. When there is a small difference between the rate of pumping and the rate authorized by a water right, OWRD generally takes enforcement action only if there are observed impacts on other water users or water bodies, or if complaints are made by affected parties or the general public.

Options for the City to consider in order to address differences between pumping capacity and authorized pumping rates are as follows:

- Complete a groundwater registration modification to add Well 5 to one of the groundwater registrations authorizing the use of Wells 1, 2/2R, and 3.
- Obtain a new water right for use of water from one or more of the City's existing wells.
- Transfer (change) one or more of the City's existing, underutilized groundwater water rights to add additional authorized points of appropriation (wells).
- Purchase an existing non-municipal water right and submit a water right transfer application to change the character of use to municipal and authorize use from one or more of the City's wells.

Groundwater Registration Modification to Add Well 5 to GR-1478, GR-1479, or GR-1480

The City completed groundwater registration modifications that provided flexibility to use the combined rate of GR-1478, GR-1479, and GR-1480 at Wells 2/2R and 3. The City can complete a groundwater registration to add Well 5 to one of these groundwater registrations. The 232 gpm overage from Well 5 pumping would then be authorized under that specific groundwater registration.

The authorized pumping rate of the City's groundwater registrations and Certificate 34010 for Well 5 is 1,858 gpm. Because the City is currently limited to a combined rate of 1,800 gpm from the wellfield wells by the capacity of the corresponding treatment towers, this would make the City's wellfield water rights consistent with the current operation of the wellfield wells. In the future, if the capacity of the water treatment towers increases and the City seeks to be able to use in excess of 1,858 gpm from the wellfield wells, the City would need to obtain a new water right or transfer an existing water right to the wellfield wells, which may not be possible, as discussed in greater detail below.

New Groundwater Right

When evaluating an application for a new water right, OWRD considers a number of factors, including the following:

- Whether water is available
- Whether the proposed use would cause injury to an existing water right (where injury is defined as precluding an existing water right from receiving the water to which it is entitled)
- Whether the proposed use would have impacts on nearby hydraulically connected surface water bodies.

Wells 2R, 3, and 5 are located within one mile of Johnson Creek, so OWRD may find that the wells are hydraulically connected to Johnson Creek. If a well were found to be hydraulically connected to Johnson Creek, an application for a water right for municipal use would be evaluated like a surface water application for the use of Johnson Creek. Because Johnson Creek is administratively closed to new appropriation, OWRD would not issue a new water right permit. However, in the area of the City's wells, the Troutdale Gravel Aquifer exhibits some evidence of confinement, and the source aquifer is sufficiently deep that OWRD may not find that any of Wells 2/2R, 3, or 5 are hydraulically connected.

Well 4 is also within one mile of Johnson Creek, but it is equally distant to the Willamette River, so OWRD may find that groundwater pumping impacts would affect the Willamette River. Because of the significant flow of the Lower Willamette River, it is unlikely that OWRD would find that the impacts of pumping from Well 4 would be enough for OWRD to evaluate a new groundwater application for Well 4 as a surface water application. Even if OWRD were to do so, the agency may still issue a permit, as surface water is available in the Lower Willamette River; however, the permit may be subject to conditions related to water quality or quantity. The only way to have certainty about the outcome of OWRD's review would be to submit an application and go through the review process.

Transfer of Existing City Water Rights

When evaluating the transfer of a groundwater right, OWRD considers whether the proposed transfer would do any of the following:

- Cause injury to other existing water rights
- Result in enlargement of the water right to be transferred (where enlargement is defined as an expansion of a water right permit, including, but not limited to, using a greater rate or duty of water per acre than allowed under a permit)
- Be from the same or a different water source (it appears that all of the City's wells develop the Troutdale Gravel Aquifer)

Because the City's transfer would involve the same aquifer (the Troutdale Gravel Aquifer) and would not enlarge the water right, OWRD's evaluation primarily would consider whether adding another well would cause injury, either by increasing impacts on other groundwater users or increasing impacts on water rights for nearby surface water bodies. If a transfer involves increasing the production rate at a well that is nearer to a surface water body than the original well, then OWRD may find the change would increase the impact on the surface water body (assuming the aquifer is hydraulically connected to the surface water).

An OWRD finding of potential injury to other users, or possible impacts on surface water bodies, would not necessarily mean that OWRD would deny the proposed transfer. Approval or denial of a proposed transfer would depend on the magnitude of the potential impacts, the assessment of which is done using fairly subjective criteria. In general, impacts on existing groundwater users are deemed injurious if the proposed new use will prevent existing users from receiving the water they are accustomed to receiving. Determining potential adverse impacts on surface water bodies is even less straightforward because of complex factors and criteria used to make that determination.

Based on past experiences and existing conditions, it may be possible for the City to add one or more of Wells 2R, 3, or 5 as authorized points of appropriation to the water right certificates for Wells 4 and 7 without triggering an injury or enlargement determination. Wells 4 and 7 are relatively close to one another (about 0.5 miles), and there are few nearby groundwater rights that might be adversely affected.

Another transfer opportunity would be to add Wells 2R, 3, and 5 to the water right certificates for Well 6 or Well 8. It is more difficult to make a preliminary assessment of the likelihood of OWRD approval of this potential change because of the relatively large distance between the two groups of wells (about 1.25 to 1.50 miles). The source aquifer is the same for all of the wells, and injury to nearby users is unlikely. However, compared to Wells 6 and 8, the wellfield wells are nearer to Johnson Creek. Thus, there is a moderate probability that OWRD would determine that the proposed transfer would result in a net adverse impact on Johnson Creek sufficient to deny the transfer request. However, the City should still consider this transfer option, given the amount of uncertainty.

Given the proximity of Well 7 to Well 4, it is likely that OWRD would approve a transfer application proposing to add Well 4 to the existing water right for Well 7. It may also be possible to add Well 4 to the water right for Well 8.

Purchase and Transfer of a Groundwater Right to Municipal Use

If the City wanted to acquire an existing groundwater right, and change it to allow use by the City, it would need to apply for a water right transfer to change the authorized well, place of use, and type of use (to municipal purposes). OWRD's criteria for evaluating such a transfer application would be whether the changes would cause injury and enlargement, as described above. If the City obtained an irrigation water right, its use would be limited to the irrigation season, which is March through October in the Willamette Basin.

5.3.4 Water Supply Analysis and Water Rights Implications

The City's current authorized water rights of 5,094 gpm is 145 gpm short of the projected 2040 maximum-day demand of 5,239 gpm. The City's current operational and treatment capacity of 4,070 gpm is 1,169 gpm short of the projected 2040 maximum-day demand of 5,239 gpm. To make up the deficit between current supply and future demand, the City will need to do one or more of the following:

- If additional aquifer capacity is available, secure additional rights, increase production and treatment capacity.
- Secure other sources of water supply (e.g., increased reliance on interties with Portland Water Bureau and Clackamas River Water).
- Implement some combination of groundwater expansion and alternative source of supply.

Any new well installations will require a water right transfer or a new water right. Areas to the south and east of the wellfield wells, which include much of the land within the City's water service area, are more than a mile from Johnson Creek. For any proposed well east of 40th Avenue and south of about Monroe Street—possibly as far north as King Road—OWRD would be more likely to find that the proposed use did not have the potential for substantial interference with surface water, and would therefore not evaluate the water right as a use of surface water (i.e., the City would be more likely to receive a water right).

Wells further to the south and east in this area may be hydraulically connected with Mount Scott or Kellogg Creeks. If OWRD finds that there is a hydraulic connection to Mount Scott or Kellogg Creeks, it still may not find that there is potential for substantial interference. If there is, then the Oregon Department of Fish and Wildlife and Department of Environmental Quality may request conditions in the permit to protect surface water resources.

5.3.5 Summary and Recommendation

The following are recommended actions for addressing the shortfall between current total well capacity and projected future maximum-day demand:

- Develop plans to increase water supply capacity to meet 2040 maximum-day demand over the next 20 years. A 2020 technical memorandum (GSI, 2020) provides an analysis of potential new well sites for the City to consider.
- Continue to evaluate current and projected future maximum-day demand in order to determine whether a new water source will be needed in the future. The City can request up to 20 years to develop and certificate a new water right. Obtaining a new water right can take well over a year, or longer if there are complications relating to potential for substantial interference.
- Align well pumping rates and authorized rates by transferring existing water rights (including groundwater registration modifications). OWRD review of water right transfer applications is limited to questions of injury and enlargement and does not provide a pathway for water rights to be burdened with onerous conditions. However, there is uncertainty about how OWRD would evaluate specific water right transfer applications, as discussed above. The City should evaluate in greater detail the opportunity to add or change the location of the points of appropriation authorized by its water rights.

5.4 OPERATIONAL CONSTRAINTS ON SOURCE-OF-SUPPLY

5.4.1 Pumping Capacity

Table 5-5 summarizes the authorized water rights and pumping capacities for each well. The City's water rights currently exceed operational and treatment capacities and the City could more fully utilize their water rights by addressing those limitations. As described above, operational limitations include shared water rights and treatment limitations include treatment tower capacities.

- The City's future groundwater pumping capacity could be increased by 1,001 gpm to utilize full water rights through the construction of additional wells or reinstatement of existing wells that are currently offline.
- Increasing the City treatment capacity by 876 gpm (1.26 mgd) would fully utilize the current water right.

Table 5-5. Water Rights and Pumping Capacity

Well Name	Permitted Water Rights (gpm)	Individual Pumping Capacity (gpm)	Operational Capacity (gpm)	Treatment Capacity (gpm)	Capacity Limitation
1	1,140				Treatment restricted by 60 gpm
2R		700	630	600	
3		510	510	600	
4	503	605	503	600	Water Rights restricted by 97 gpm
5	718	950	660	600	Treatment restricted by 118 gpm
6	808	670	670	No Treatment	Operational limited by 238 gpm
7	1,198	1,120	1,120	1000	Treatment limited by 198 gpm
8	727	0	N/A	N/A	Offline
Total	**5,094**	**4,555**	**4,093**	**3,400**	

5.5 APPLICABLE DRINKING WATER QUALITY REGULATIONS

Water quality standards address source water and water treatment as well as distribution system water quality. The City is responsible for monitoring requirements under the rules shown in Table 5-6. The City monitors regulated and unregulated potential contaminants based on a frequency ranging from daily to every nine years, as prescribed by regulatory requirements. A description of each rule is included below.

Table 5-6. Water Quality Rules Applicable to the City's Water System

Source Water	Distribution and Source Water	Distribution System
Chemical Contaminant Rule • Inorganics contaminants • Volatile Contaminants • Synthetic Organic Contaminants Arsenic Rule	Groundwater Rule	Revised Total Coliform Rule (RTCR) Lead and Copper Rule (LCR) Disinfectants and Disinfection Byproducts Rule

5.5.1 Chemical Contaminant Rule

The Chemical Contaminant Rule regulates over 65 contaminants in three contaminant groups:

- Inorganic Contaminants (IOCs) (including arsenic and nitrate)
- Volatile Organic Contaminants (VOCs)
- Synthetic Organic Contaminants (SOCs)

The rule applies to all public water systems. System type, size, and water source type determine which contaminants require monitoring for that system.

The U.S. Environmental Protection Agency (EPA) set a maximum contaminant level (MCL) goal for each contaminant. The MCL goal is the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, and which allows an adequate margin of safety. MCL goals are not enforceable. The MCL goal is not a legal limit set for public water systems. It is based solely on human health. For known cancer-causing contaminants the MCL goal is set at zero. This is because any chemical exposure could present a cancer risk.

The Chemical Contaminants Rule also sets MCL for each contaminant. EPA sets MCLs as close to the health goal as possible. The MCL weighs the technical and financial barriers with public health protection. Table 5-7 details the VOCs, SOCs, and IOCs that are regulated in each phase of the Phase II/V Rules.

Table 5-7. Compounds Regulated by the Chemical Contaminant Rule

Phases of the Phase II/V Rules	VOC	SOC	IOC
Phase I, July 7, 1987 **(52 FR 25690)** **Effective: 1989**	Benzene Carbon tetrachloride p-dichlorobenzene Trichloroethylene Vinyl chloride 1,1,1-trichloroethane 1,1-dichloroethylene 1,2-dichloroethane		
Phase II, January 1991 **(56 FR 3526)** **Effective: 1992**	cis-1,2-dichloroethylene Ethylbenzene Monochlorobenzene (chlorobenzene) o-dichlorobenzene Styrene Tetrachloroethylene Toluene Trans-1,2-Dichloroethylene Xylenes 1,2-dichloropropane	Alachlor Atrazine Carbofuran Chlordane Ethylene dibromide 1,2-dibromo-3-chloropropane Heptachlor Heptachlor epoxide Lindane Methoxychlor Toxaphene PCBs 2,4-D 2,4,5-TP	Asbestos Cadmium Chromium Fluoride Mercury Nitrate Nitrite Selenium
Phase IIB, July 1991 **(56 FR 30266)** **Effective: 1993**		Pentachlorophenol Aldicarb[a] Aldicarb sulfone[a] Aldicarb sulfoxide[a]	Barium
Phase V, July 1992 **(57 FR 31776)** **Effective: 1994**	Dichloromethane 1,1,2-trichloroethane 1,2,4-trichlorobenzene	Benzo(a)pyrene Dalapon Di(ethylhexyl)-adipate Di(ethylhexyl)-phthalate Dinoseb Diquat Endothall Endrin Glyphosate Hexachlorobenzene Hexachlorocyclo-pentadiene Oxamyl Picloram Simazine 2,3,7,8-TCDD (dioxin)	Antimony Beryllium Cyanide Nickel[b] Thallium

a. Aldicarb, aldicarb sulfone, and aldicarb sulfoxide are considered regulated chemicals. However, their MCLs are stayed and no monitoring is required (57 FR 22178, May 27, 1992).
b. The MCL for nickel was remanded in 1995 but public water systems are still required to monitor.

5.5.2 Arsenic Rule

Arsenic is a semi-metal element in the periodic table. It is odorless and tasteless. It can enter drinking water supplies from natural deposits in the earth or from agricultural and industrial practices. In 2001, EPA set the arsenic standard for drinking water at 10 ppb (or 0.010 parts per million). This protects consumers from the effects of long-term, chronic exposure to arsenic.

5.5.3 Groundwater Rule

Groundwater source monitoring required under the EPA Groundwater Rule applies to all public water systems that use groundwater sources or purchase groundwater. The purpose of the rule is to protect the public from fecal bacterial (indicated by E. coli) and viral pathogens.

If a groundwater source (well or spring) is found to be fecally contaminated, the public water supplier must take corrective action to assure that their consumers are adequately protected. The coliform monitoring required under this rule is different from the required coliform monitoring in the distribution system.

5.5.4 Revised Total Coliform Rule

The Revised Total Coliform Rule (RTCR) identifies provisions for monitoring for total coliform as an indicator of bacteriological quality. Under the rule, water systems must have a monitoring plan that identifies a prescribed number of monitoring locations based on population. Based on its current population, Milwaukie collects and analyzes 20 samples per month from a list of 87 maximum-residence-time locations. If a sample tests positive for total coliform, the RTCR outlines resampling procedures and public notification triggers. The City's *Coliform Monitoring Plan* is described in the Sampling Plan, included in Appendix J. Table 5-8 outlines the key provisions of the RTCR.

The City's sample sites for coliform and disinfection byproducts are maintained and kept current in the Sampling Plan, which is the responsibility of the senior treatment plant operator. Maps, drawings, and lists are updated once per compliance period (every 2 years).

5.5.5 Lead and Copper Rule

The Lead and Copper Rule reduces the risk of lead and copper in drinking water, which primarily originate in plumbing materials. Currently, the City conducts monitoring as prescribed on a three-year interval at 30 samples sites, as required for a system of its size, in homes most vulnerable to lead and copper corrosion—generally, homes built between 1982 and 1987 and using copper plumbing. The results of that monitoring determine if additional measures are required. Because historical samples have been below the LCR action level, no action beyond monitoring is required.

The Revised Lead and Copper Rule (RLCR) promulgated in January 2021 includes changes to many aspects of the original LCR. The revisions are designed to alter how utilities implement corrosion control treatment, conduct compliance sampling, manage lead service lines, and communicate with customers. The revisions will expand the City's responsibility associated with privately owned service lines, sampling protocol, service line inventory, and full lead service line replacement (LSLR) requirements. They will also expand public outreach and education needs through more frequent customer contact and annual service line notification letters.

Table 5-8. Revised Total Coliform Rule Key Provisions

Provision Category	Key Provisions
Contaminant Level	• Addresses the presence of total coliforms and E. coli in drinking water. • The maximum contaminant level (MCL) goal is zero for E. coli, The MCL is based on the occurrence of a condition that includes routine and repeat samples. • For total coliforms, public water systems must conduct a Level 1 or Level 2 assessment of their system when they exceed a specified frequency of total coliform occurrences. • An MCL violation or failure to take repeat samples following a routine total coliform-positive sample will trigger a Level 1 or Level 2 assessment. • Any sanitary defect identified during a Level 1 or Level 2 assessment is to be corrected by the public water system. These are the treatment technique requirements of the RTCR.
Monitoring	• Develop and follow a sampling plan that designates the public water system's collection schedule. This includes location of routine and repeat water samples. • Collect routine water samples on a regular basis (monthly, quarterly, annually). Have samples tested for the presence of total coliforms by a state certified laboratory. • Analyze all routine or repeat samples that are total coliform positive for E. coli. • Collect repeat samples (at least three) for each total coliform positive routine sample. • For public water systems on quarterly or annual sampling, collect additional routine samples (at least three) in the month after a total coliform routine or repeat sample. • Seasonal systems must monitor and certify completion of state-approved startup.
Level 1 & 2 Assessments and Corrective Actions	• Public water systems are required to conduct a Level 1 or Level 2 assessment if conditions indicate they might be vulnerable to contamination. Public water systems must fix any sanitary defects within a required timeframe.
Reporting and Recordkeeping	• Public water systems are required to report certain items to their states. The RTCR's reporting and recordkeeping requirements added Level 1 and Level 2 requirements to the original Total Coliform Rule.
Violations, Public Notification and Consumer Confidence Report	• Public water systems incur violations if they do not comply with the requirements of the RTCR. The biggest change in violation types under the RTCR compared to the original Total Coliform Rule is no acute or monthly MCL violation for total coliform positive samples only. • Public notification is required for violations incurred. Within required timeframes, the public water system must use the required health effects language and notify the public if it did not comply with certain requirements of the RTCR. The type of public notification depends on the severity of the violation. • Community water systems must use specific language in their consumer confidence reports when they must conduct an assessment or if they incur an E. coli MCL violation.

The revisions included in the RLCR address the following:

- Lead and Copper Tap Sampling Prioritizes LSLs
  - Redefinition of compliance site selection criteria that place a priority on sampling from sites containing actual and not potential lead service lines.
  - Reevaluation of LCR sample site selection to determine if compliance monitoring locations comply with the proposed tier requirements.
  - When lead service lines are present, compliance sampling will include first liter and fifth liter samples.
  - Utilities will be required to adopt new protocols for evaluating and mitigating lead release on a site-specific basis, increasing utility coordination and communication with customers.

  - ➢ Utilities will be required to sample from schools and childcare facilities an develop a sampling plan for these high-risk locations and develop procedures to communicate both the sampling results and potential actions the location can take to reduce lead in drinking water.

- Changes Further Protect Public Health Efforts
  - ➢ The RLCR strengthens corrosion control treatment requirements and establishes a new trigger level (TL) of 10 ppb.
- Corrosion Control Treatment Becomes High Priority
  - ➢ Requirement to conduct a corrosion control study if either the lead trigger level or action level is exceeded.
  - ➢ Required to conduct a corrosion control study prior to a source water or treatment change, or if the USEPA or state regulatory agency deems the utility's current corrosion control treatment not optimal.
  - ➢ When corrosion control testing is required, the RLCR requires the use of pipe loops with harvested lead service lines for evaluating corrosion control techniques. Systems without lead service lines can consider other types of corrosion testing including bench-scale immersion testing.
  - ➢ Systems will be required to evaluate specific orthophosphate doses (1 mg/L and 3 mg/L as PO4), which is expected to push systems to use higher orthophosphate doses than historical norms.
- Developing Service Line Inventories
  - ➢ The RLCR requires the development of a publicly available inventory of all publicly and privately-owned service lines in the distribution system. For large systems, the service line inventory must be posted to a publicly available website in electronic format. Interactive maps are recommended due to ease of use for customers.
  - ➢ The RLCR requires annual notification letters to all customers with lead service lines or service lines of unknown material. The RLCR now changes the presumption of service lines of unknown materials from non-lead to lead.
- Expansion of Lead Service Line Replacement
  - ➢ Systems with unknown or lead service lines are required to develop a LSLR Plan establishing how a utility intends to perform LSLRs within the system for voluntary replacements or mandatory replacements in response to a Trigger Level or Action Level exceedance.
  - ➢ A LSLR goal rate must be established and identify methods to fund the replacements as part of the LSLR Plan.
  - ➢ Systems exceeding the Trigger Level or Action Level at the 90th percentile are required to replace full LSLs, including privately-owned portions, at a specified rate.

The compliance date for the RLCR is October 16, 2024 providing the City with three years to make the necessary changes. It is recommended that the City take the following steps:

- Next 6 months
  - ➢ Review past monitoring data results to determine the new 10 ppb Trigger Level has been exceeded as exceedance will trigger treatment modifications.

- Develop an interactive map inventory of all known LSLs and service lines of unknown material

- 6 to 18 months
  - Determine if all current sample sites contain LSLs and develop a list of alternative sample sites with LSLs
  - For LSL sample sites develop first- and fifth-liter sampling protocols
  - Develop sampling plans for all schools and childcare facilities in the service area in addition to compliance sampling locations
- 18 to 24 months
  - Develop a LSLR Plan. If the Trigger Level of 10 ppb is not exceeded the replacement is voluntary, if the Trigger Level is exceeded replacement becomes mandatory
- Immediate, but contingent on Action Level and Trigger Level exceedance
  - Develop plan for treatment testing as exceedance level and LSLs materials prescribe

5.5.6 Disinfectants and Disinfection Byproducts Rule

The Disinfectants and Disinfection Byproducts Rule establishes monitoring requirements for the formation of trihalomethane and haloacetic acid compounds that can be byproducts of disinfection. The rule applies to all utilities that practice chemical or ozone disinfection and deliver water with a disinfectant residual. Because these byproducts change in concentration with time, sample sites are located to represent maximum water age in the distribution system.

The City collects five quarterly samples at the same time as the coliform samples. The list of 87 maximum-residence-time locations includes specific sites for disinfection byproduct sample collection and are based on the maximum residence time in the distribution system. The sampling sites were developed over time and are based on free chlorine, historical disinfection byproduct results, pressure zone influence over residence time. The locations of the sample sites are subject to change as treatment and supply parameters change.

5.5.7 Monitoring Frequency Requirements

The City's current Sampling Plan is included in Appendix J and the required monitoring frequency is summarized in Table 5-9. City staff examines water at each well and entry point where treated water enters the distribution system.

Records of bacteriological analysis are kept on file for at least 5 years and records of chemical analysis, secondary contaminants, turbidity, and radioactive substances are kept for at least 10 years. City staff is required to report the monthly average summary of disinfectant residual and microbiological results from coliform monitoring. The disinfectant residual summary is also sampled and reported quarterly, with the results for haloacetic acids and total trihalomethanes (disinfection byproducts).

Table 5-9. Regulatory Compliance Monitoring Frequencies

Constituent	Quantity	Frequency	Last Samples	Next Scheduled Monitoring
Analyte/Analyte Set				
Microbiological Bacteria[a]	20 Per Month 6/Week x 3 2 samples in week 4	6 per Week x 3 + 2 samples in week 4	Ongoing	Ongoing
Disinfection Byproducts[b] and Free Chlorine	2	Quarterly	Ongoing	Ongoing
Lead and Copper[c]	30	Every 3 years	June – Sept 2019	June – Sept 2022
All Operating Well Sample Points				
Microbiological Bacteria[a]	1 per site	Annually	Ongoing	Ongoing
Arsenic	1 per site	Every 9 years	6/10/2020	6/10/2029
Inorganic Compounds[d]	1 per site	Every 9 years	6/10/2020	6/10/2029
Nitrate	1 per site	Annually	2/14/2021	2/14/2022
Nitrite	1 per site	Every 9 years	5/27/2015	5/27/2024
Synthetic Organic Compounds[e]	1 per site X 2 events	Every 3 Years 2 consecutive Quarters	7/10/2019 - 11/2/2019	7/10/2022 - 11/2/2022
Volatile Organics[f]	1 per site	Sampling is only required every 3 years, however, Milwaukie samples on a quarterly basis due to known VOCs	11/30/2018	Ongoing
Entry Point Samples A, B and C				
Arsenic	1 per site	Every 9 years	6/10/2020	6/10/2029
Inorganic Compounds[d]	1 per site	Every 9 years	6/10/2020	6/10/2029
Nitrate	1 per site	Annually	2/18/2019	2/18/2020
Nitrite	1 per site	Every 9 years	5/27/2021	5/27/2030
RAD – Gross Alpha	1 per site	Every 9 years		6/14/2024
RAD – Radium 226/228	1 per site	Every 9 years		6/14/2024
RAD - Uranium	1 per site	Every 9 years		6/14/2024
Synthetic Organic Compounds[e]	1 per site X 2 events	Every 3 Years 2 consecutive Quarters	7/10/2019 - 11/2/2019	7/10/2022 - 11/2/2022
Volatile Organics[f]	1 per site	Every 3 years	11/30/2018	11/30/2021

a. Microbiological bacteria include total coliform, fecal coliform, and E. coli
b. Disinfection byproducts include haloacetic acids and total trihalomethanes
c. Lead and copper sample sites based on city and state list. Current rules are likely to be changed.
d. Inorganic compounds include barium, fluoride, strontium, chromium, vanadium, chlorine
e. Synthetic organic compounds Include 1.4-Dioxane
f. VOCs include: Hexavalent Chromium and Chromium 6

5.6 SOURCE WATER QUALITY

Water from Wells 2, 3, 4, 5 and 7 has historically contained elevated VOCs, which are removed using a packed tower aeration treatment. The treatment towers are designed to reduce effluent concentrations to levels below the MCL, as shown in Table 5-10. A comparison of the tower design criteria to the state health requirements shows a strong factor of safety. Treatment will remain sufficient even if influent contaminant levels increase or if the state decreases the MCLs.

Table 5-10. VOCs Concentrations

COMPOUND	Effluent Concentration Design Criteria (µg/l)	Maximum Contaminant Level (µg/l)
Trichloroethylene	<0.2	5.0
1, 1-Dichloroethylene	<0.2	7.0
1,1,1-Trichloroethane	<0.2	200.0
Tetrachloroethylene	<0.2	75.0

The State requires a free chlorine residual of 0.2 mg per liter under all flow conditions throughout the distribution system. The City achieves this concentration through continuous disinfection in two steps: chlorination of treatment tower influent to prevent bacterial growth on the media; and re-chlorination of treatment tower effluent prior to discharge into the City's distribution system.

The Milwaukie system has interties with surrounding systems for emergency purposes. In emergency situations, the short-term availability of water is the primary concern. However, as the City explores ways to expand or diversify its sources of supply, priorities shift, and water quality becomes the primary concern. The potable water served by the City and its neighbors all meets federal regulatory requirements. However, the neighboring systems all make use of treated surface water. Surface water and groundwater and the manner in which they treated can result in different chemical characteristics, which may be detrimental to Milwaukie's distribution system and delivered water quality. As the City investigates the potential for meeting future demand through direct intertie with its neighbors, a comprehensive analysis of water chemistry is imperative to determine the impacts of mixing, direct exposure of City infrastructure to a new water source, and the potential need for treatment at intertie locations.

5.7 COMPLIANCE MONITORING RESULTS (2015 – 2019)

For the period of 2015 - 2020, the City has not experienced any compliance monitoring or water quality violations. No regulatory exceedances occurred regarding regulated contaminants. Water quality reports are included in Appendix K.

5.8 EMERGENCY SOURCES OF SUPPLY

The City's emergency water supply comes from interties with the City of Portland and Clackamas River Water intertie, both of which are surface water systems. The supply source for the City of Portland Intertie is the Bull Run system and the supply source for the Clackamas River Water Intertie is the Clackamas River. Both interties are equipped with bidirectional meters and can operate in either direction. Both interties are connected to Pressure Zone 2. The Clackamas River Water intertie is a pump station with 700 gpm capacity (see Figure 5-1). The pressure differential at the City of Portland Intertie does not require pumping. A potential third intertie with the Oak Lodge Water System is in the early planning stages.

Figure 5-1. Clackamas River Water Intertie Pump Station

5.9 SOURCE OF SUPPLY MANAGEMENT

Climate change is occurring across the globe, but the changes differ regionally. In the pacific northwest climate models project the changes will result in:

- An increase in air temperatures, leading to warmer winters and hotter summers
- An increase in the amount of fall and winter precipitation and a decrease in summer precipitation
- An increase in the severity and frequency of storm event
- A decrease in winter snowpack

The City's source of supply is 100 percent groundwater availability of supply is not influenced by acute climatic changes that may impact surface water sources in a given year. This provides a stable supply from years to year. However, climate changes that may lead to long-term changes in precipitation patterns may lead to a diminishing supply due to diminished replenishment and increased demand on the aquifer. It is the City's interest to maximize the resource through conservation practices to maximize the source of supply.

As a member of the Regional Water Providers Consortium (RWPC), the City participates in the regional conservation education efforts. As the City evaluates its source management practices it is recommended that consideration be given to increasing City specific proactive conservation activities to extend beyond customer education. Elements that the City should consider that other RWCP utilities are practicing include:

- Indoor appliance rebate program
- Landscape irrigation management tool rebates
- Landscape modification rebates
- Landscape water audits
- Demonstration garden
- Indoor leak kit distribution
- Water use data billing inserts

The Oregon Water Resources Department (OWRD) began requiring Water Management and Conservation Plan (WMCP) as a condition for new municipal water rights or a condition for obtaining permit extensions. The WMCP is designed to help utilities plan, implement, and track conservation efforts as justification for additional water rights. However, the City's most recent permit was issued in 1986 and has never had to extend a permit and thus has not triggered the requirement for a WMCP. When the City next applies for a new municipal water right the requirement for a WMCP will be a condition to the water right that will require submittal of a WMCP every 10 years, and progress reports every intervening 5 years.

In the interim, there is a great deal of overlap between the WMP and WMCP and the City may choose to include WMCP analysis in subsequent WMP updates to track its conservation activities and impact of those activities to identify those that are most cost effective.

6. OPERATION AND MAINTENANCE PROGRAM

This chapter describes the current operational control capabilities of the water system and basic operational procedures for key asset groups. Some descriptions will be revised following implementation of the City's SCADA Master Plan recommendations, which is currently in progress. This chapter also addresses emergency response, curtailment, preventive maintenance schedules, and recordkeeping practices.

6.1 REGULATORY REQUIREMENTS

Oregon Administrative Rule (OAR) 333-061-0065 outlines the following requirements for operation and maintenance (O&M) of key water system components:

- **Service Continuity** must be maintained to ensure continuous production and delivery of potable water through:
  - Operation of all phases and components of the system in the manner for which they were designed
  - Prompt repair of leaks and broken or malfunctioning equipment
  - Maintenance of proper equipment, tools, and parts to make repairs to the system
  - Procedures to ensure safe drinking water during emergencies
- **Personnel** responsible for operations shall have:
  - Competence
  - Knowledge about all functions of the particular facility being addressed
  - The training and experience necessary to ensure continuous delivery of water
  - Certification as required
- **Operating Manuals** must be maintained and reviewed at least every five years and include:
  - Source operation and maintenance
  - Water treatment operation and maintenance
  - Reservoir operation and maintenance
  - Distribution system operation and maintenance
  - Written protocols describing the operational decisions on-site operators are allowed to make
- The following **Documents and Records** shall be retained by the water supplier and shall be available when the system is inspected or upon request by the Oregon Health Authority:
  - As-built plans and specifications of the entire system and other documents necessary for system maintenance and operation

- Current operating manuals
- A current master plan
- Data showing production capabilities
- Number, type, and location of service connections
- Raw water quality, both chemical and microbiological
- All chemicals and dosage rates used in the treatment of water
- Maintenance records
- Sampling and analysis for regulatory compliance with the maximum contaminant levels
- Residual disinfectant measurements
- Cross connection control and backflow prevention device testing
- Customer complaints pertaining to water quality and follow-up action
- Fluoridation records

6.2 SYSTEM ORGANIZATION

OAR Chapter 333 requires all personnel directly involved with the operation of a public water system to be certified by the state. All water department field personnel must be certified in one of the three categories listed below:

- Water Treatment Operator
- Water Distribution Operator
- Operator-in-Training

Certification level requirements should be developed in consultation with the Oregon Health Authority (OHA). Education and experience requirements for each operator grade are also determined by OHA

Figure 6-1 summarizes the City's organizational structure. Table 6-1 lists operations staff and their certifications.

6.3 SUPERVISORY CONTROL AND DATA ACQUISITION

City staff control and monitor the water pumping, treatment and storage facilities through a proprietary supervisory control and data acquisition (SCADA) system. The SCADA operational center is located at the Johnson Creek Public Works Building.

Upcoming SCADA Changes

The City is in the process of developing designs to expand the City's SCADA system, as outlined in its recently completed SCADA Master Plan. The SCADA Master Plan identified functional requirements for operations, maintenance, engineering, IT, and enterprise users. It recommended short- and long-term system improvements for managing SCADA and incorporating process data into the City's business applications. The improvements will enhance the City's SCADA organization, methodology, technology, and cybersecurity, modernize the system to current industry standards, and develop processes to maintain these standards. They also address the robustness of security controls and resilience to ensure system reliability.

The information provided in this section describes current SCADA capabilities as of February 2020, prior to implementation of the SCADA Master Plan recommendations.

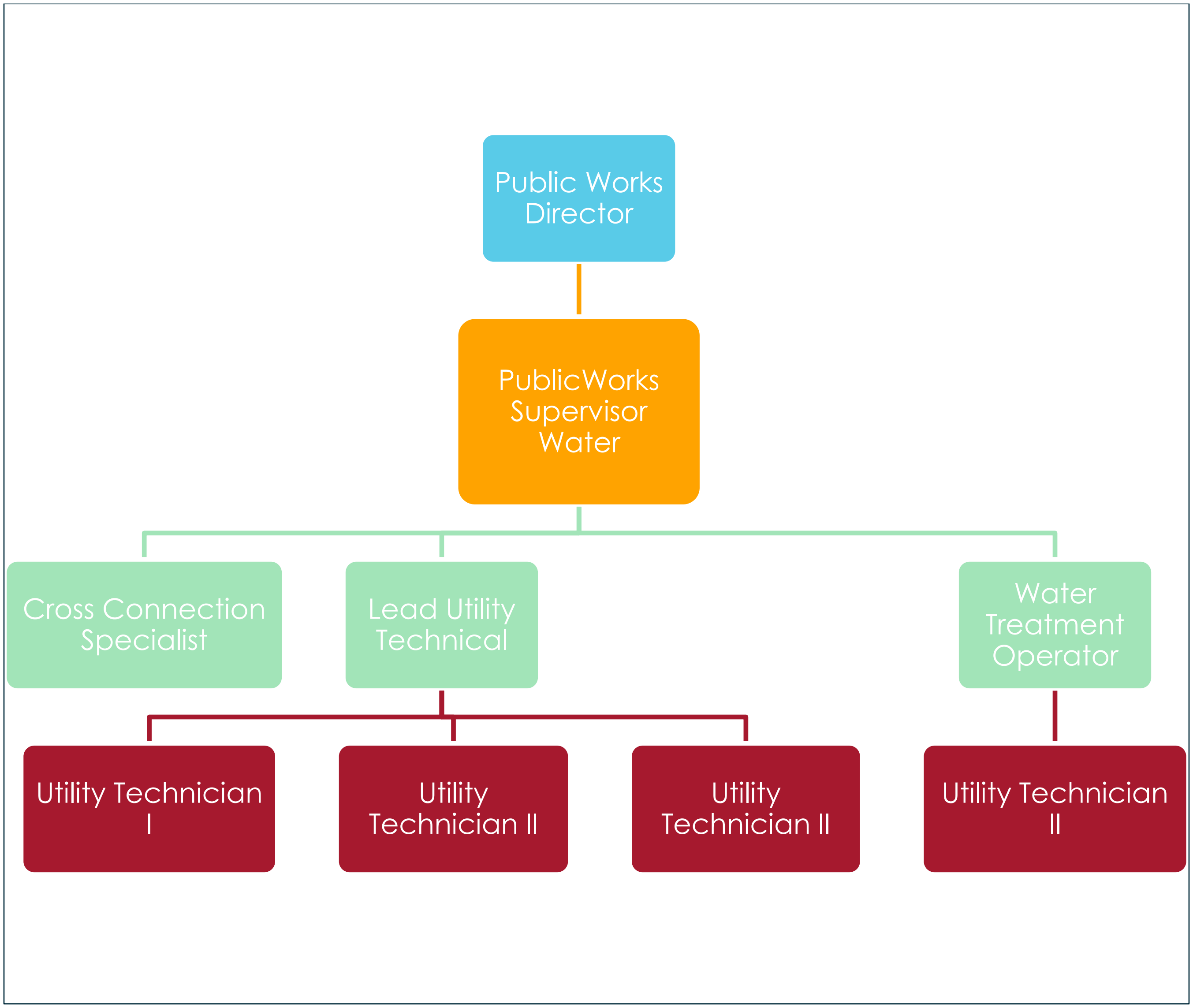


Figure 6-1. Organizational Structure

Table 6-1. Water System Operations Staff and Certifications

Staff	Operator Certification Grade/Type
Jamie Clark	Distribution Level III / CCS
Mark Odell	Treatment II and Distribution II
Chase Barnes	Distribution Level I
Oscar Cellabos	Distribution Level I
Riley Gill	Distribution Level I
Austin Mudra	Distribution Level 1
Jacob Hoesch	Distribution Level 1
Shawn Flye	Distribution Level II / CCS / Backflow

The SCADA communication infrastructure is a combination of radio and land line connections using proprietary software connecting the supervisory computers. The SCADA computers enable operators to monitor system conditions, gather data on system processes and send control commands to the remote pumping facilities.

The telemetry system is operated by the SCADA (supervisory control and data acquisition) system. The system alerts operators by text about such issues as well malfunction, low water levels and chlorine issues.

Remote telemetry units and programmable logic controllers are connected to pressure transducer sensors and motor controls actuators. Both units have embedded ladder logic control capabilities and are networked to the supervisory computer system through the communication infrastructure. The SCADA human-machine interface (HMI) at the operations center provides operators a real time graphical output of operational status of the pump stations, storage levels, and system pressures. The HMI is linked to the supervisory computers to provide live data to drive system diagrams, alarm displays and trending graphs. The HMI also gives the operator the ability to switch a pump on or off or alter sequencing.

6.4 TYPICAL SYSTEM OPERATION CONTROL

Summary control descriptions provided below are described in detail in the 1991 TP235 and TP47 O&M manuals (see Appendix L). These will be replaced after the recent SCADA Master Plan recommendations have been fully implemented.

6.4.1 Production Well Startup

The City's production wells are controlled by pre-programmed water level set points in the distribution storage reservoirs. Based on the set points, a level switch in the well house motor control center (MCC) transmits a signal to the treatment MCC to begin the startup sequence:

1. Blower startup
2. Solenoid valve closes on tower inlet pipe drain system
3. Well pump starts
4. Solenoid valve on upstream chemical feed system opens and chemical feed pump is activated
5. Solenoid valve on downstream chemical feed system opens and chemical feed pump is activated.

6.4.2 Production Well Shutdown

As the storage rises to the maximum set point, a level switch in the well house MCC transmits a signal to the treatment MCC to begin the shutdown sequence:

1. Well pump stops
2. Solenoid valve on tower inlet pipe drain opens
3. Solenoid valve on upstream chemical feed system closes and chemical feed pump stops
4. Solenoid valve on downstream chemical feed system closes and chemical feed pump stops
5. Blower stops.

6.4.3 Booster Pump Station Operation

Booster pumps in the clearwell operate separately from the well pumps and the treatment systems. Pump starts and stops are controlled by float switches based on levels in the clearwell. A high-water set point prevents the clearwell from overflowing during a booster pump failure. A high-water condition shuts down the well pumps and treatment system and signals an alarm. A low-water set point prevents loss of pump impeller submergence by shutting down the booster pumps. During a low-water condition, the well pumps and treatment systems remain in operation.

6.5 PROCEDURES FOR SHUTDOWN AND RESTART

The following routine shutdown and restart procedures are followed when a pump, storage tank, or transmission main must be taken offline for maintenance:

- Pump repair
  - Check and start standby pump
  - Adjust valves and remove pump for repair
  - Install repaired pump
  - Bleed air to avoid cavitation
  - Adjust valves and start pump
  - Refer to pump manual for information as needed
- Reservoir cleaning or maintenance
  - Notify customers of cleaning and maintenance and possible turbid water and low pressure
  - Notify the fire district that a specific storage tank will be emptied for cleaning or repair but that normal pressure will be maintained, if possible
  - Install a temporary bypass on the pump manifold
  - Maintain normal system pressure as much as possible with bypass regulators and pop-off valves
  - Turn off inlet to the storage tank and drain for cleaning
  - Clean the storage tank
  - Slowly fill the tank while maintaining normal pressure to customers
  - When the tank is full, remove the bypass regulator and pop-off valves.
  - Begin normal pumping
- Transmission main maintenance or repair
  - Notify customers of cleaning and maintenance and possible turbid water and low pressure
  - Turn off all meter settings that will be affected by the area shutdown
  - Turn off the pumps at the lower storage tank
  - Report to the dispatcher and general manager the estimated time needed to clean or repair the line
  - Isolate the area by turning off the valves
  - Turn off the low valve first
  - Restrict flow by use of a second valve
  - Clean line or make repair
  - Flush line, if needed, to remove debris and/or air
  - Check for leaks after the pump has been restarted

- Return all meter settings to their previous state before the shutdown occurred
- Notify dispatcher that the water main has been cleaned or repaired
- Check storage tank level

6.6 TYPICAL ALARMS

The SCADA system provides for a number of alarm conditions that notify the control center of operational conditions requiring immediate attention. The SCADA system activates a visual alarm at the HMI and initiates an automated phone call to the responsible operator during off-hours. These alarm conditions include:

- Line power outage
- Communication fault
- Pump fault/failure to start
- Blower fault/failure to start
- Reservoir low level condition
- Reservoir high level condition
- High discharge pressure/low suction pressure
- Free chlorine residual exceedance
- Tower high water level
- Clearwell/sump high water level

6.7 PREVENTIVE MAINTENANCE

The City does not currently have a formal preventive maintenance program. Maintenance recommended in the 1991 TP235 and TP47 O&M manuals (see Appendix L) is summarized in Table 6-2. It is generally recommended that public works departments conduct an annual operation and maintenance review to critique plan operation, review operating costs and make recommendations for more efficient plan operation. A performance review on system pumps was performed by BacGen in 2019.

Table 6-2. Recommended Preventive Maintenance Summary

System Component	Maintenance	Frequency
Air Stripping Towers	Backwash	6 – 8 weeks
	Inspection of interior components	Annual
	Exterior coating	Varies
Blowers	Inspection and lubrication	Weekly
	Fan belt inspection	Quarterly
	Fan belt replacement	Bi-annually
	Major overhaul	Varies
	Air filter inspection	Monthly
	Air filter replacement	Varies
	Expansion joint inspection	Monthly

System Component	Maintenance	Frequency
Chlorination System	Chlorinator cleaning	Varies (when deposits are visible)
	Injector and tailway cleaning	Every 6 months
	Chlorinator overhaul	Every 2 years
	Vacuum regulator recondition	Every 2 years
	Gas detector replacement	Annually
Vertical Turbine Pumps	Inspect oil and grease levels	As required
	Change oil	Manufacturer's recommendation
	Refill grease box	As required
	Adjust packing gland	As required
Sand Separator	Manually purge	As required
Chlorine Residual Monitor	Replace sensor membrane and electrolyte	4 – 8 weeks
Standby Generator	See equipment manual	See equipment manual
Chlorine Feed Pumps	Inspect	Periodically
	Lubrication	After 15,000 hours
Transfer Pumps	Lubricate bearings	Varies
	Re-grease motor	Every 1,500 hours
Air valves	Located, marked, inspected, and repaired or replaced	5 years
Altitude valve	General maintenance	5 years
Pressure reducing valves	General maintenance	5 years
Pump control valves	General maintenance	5 years
Valve Program	Inspect and repair in-line and hydrant valves	Every 2 years
Meters	Maintain as needed	Routine
Hydrants	Verify location, inspect, and repair	Annually
Pumps	Inspect; grease as needed, check pressure, alternate pumps Log water pumped, check against average residential usage to monitor pump hours, pump efficiency, and detect water potential system leaks	Weekly
Pump Houses	Miscellaneous (paint pump house and manifolds, check heaters and all SCADA alarms)	As required
Reservoirs	Visually inspect access ladders and hatches to ensure security. Visually inspect outside walls for cracks or damp spots, flush SCADA transducers.	Weekly
	Cleaning	As needed
Service connections	Maintain	Routinely
Transmission and distribution lines	Visually inspect and repair leaks	As needed

The City is in the process of identifying and addressing deferred maintenance issues. The City uses Cityworks Asset Management software to manage maintenance needs.

6.8 EMERGENCY RESPONSE PLAN

The City completed a Water Emergency Response Plan addressing water system vulnerabilities and response to water emergencies as required by the federal Public Health and Security Bioterrorism Preparedness and Response Act of 2002 and OAR 333-061-0064. That report contains the following information:

- Communication and authority
- Water system security
- Water system hazard review
- Emergency equipment and water supplies
- Emergency response procedures
- Emergency contacts
- Emergency resources
- Public notices
- Drinking water hauling guidelines
- Isolating water facility procedures
- Emergency disinfection procedures
- Water rationing plan

In 2021, the City completed an updated emergency response plan in compliance with the America's Water Infrastructure Act. The updated plan is included in Appendix M.

6.9 WATER RATIONING PLAN

The City has developed a water rationing plan to address local, system-wide, and regional service interruptions. The plan is described in Municipal Code Chapter 13.06 (Drought and Emergency Water Regulation) and is included in Appendix N.

Upon implementation of a water rationing declaration, the water operations supervisor will coordinate with the City's public information officer to notify water system users through one or more of the following media: radio, television, written notification at public facilities, City website, or CodeRED emergency notification system. The water operations supervisor is responsible for notifying the Milwaukie Code Enforcement Department, which will coordinate with the Milwaukie Police Department to enforce the rationing plan.

The following sections describe the two levels of water use restrictions: Level 1 (Critical) and Level 2 (Emergency).

6.9.1 Level 1—Critical

Restriction of the following on a voluntary basis is encouraged:

- Watering of lawns, grass, or turf except on designated alternate days based on address number
- Landscape watering between 9:00 a.m. and 7:00 p.m.

- Hosing or washing sidewalks, driveways, streets, parking lots, open ground, buildings, or other hard surfaces except where necessary for public health and safety; exceptions include the following:
    - Power washing of buildings, homes, and roofs prior to painting, repair, remodeling, or construction, and not solely for aesthetic purposes
    - Where there is demonstrable need in order to meet public safety requirements, such as to alleviate immediate fire or sanitation hazards or for dust control to meet air quality standards mandated by the Oregon Department of Environmental Quality
- Washing cars, boats, trailers, or other vehicles without hoses with shutoff nozzles, unless done at a commercial or fleet washing facility that recycles water. Owners of vehicles are encouraged to use facilities that recycle water
- Serving water for drinking at a restaurant, motel, cafe, cafeteria, or other public place where food is sold and served unless specifically requested
- Any other voluntary restrictions deemed necessary, including but not limited to restrictions outlined under Level 2.

6.9.2 Level 2—Emergency

The following activities are expressly prohibited under a Level 2 water emergency declaration:

- Watering any lawn, grass, or turf; exceptions include the following:
    - New lawn, grass, or turf that has been seeded or sodded after March 1 of the calendar year may be watered as necessary until established
    - Lawn, grass, or turf that is part of a commercial sod farm
    - High-use athletic fields that are used for organized play
    - Golf tees and greens
    - Park and recreation areas deemed by the City Council to be of particular significance and value to the community that would allow exception to the prohibition
- Watering landscape plants except on alternate day watering and between 7:00 p.m. and 9:00 a.m.
- Hosing or washing sidewalks, driveways, streets, parking lots, open ground, buildings, or other hard surfaces except where necessary for public health and safety; exceptions include the following:
    - Power washing of buildings, homes, and roofs prior to painting, repair, remodeling, or construction, and not solely for aesthetic purposes
    - Where there is demonstrable need in order to meet public safety requirements, such as to alleviate immediate fire or sanitation hazards or for dust control to meet air quality standards mandated by the Oregon Department of Environmental Quality
- Washing cars, boats, trailers, or other vehicles without hoses with shutoff nozzles unless done at a commercial or fleet washing facility that recycles water
- Serving water for drinking at a restaurant, motel, cafe, cafeteria, or other public place where food is sold and served unless specifically requested
- Cleaning, filling, and maintaining decorative water features, natural or manmade, including but not limited to fountains, lakes, ponds, and streams, unless the water is recirculated through the decorative feature

- Any other restrictions deemed necessary
- Elimination of any exceptions deemed necessary.

6.10 CROSS CONNECTION CONTROL PROGRAM

The City maintains a cross connection control program that is governed by Municipal Code 13.08 and Ordinance No. 2082, adopted August 5, 2014 (see Appendix O). The purpose of the program is to protect the water supply and distribution system from contamination or pollution due to any existing or potential cross connections and to comply with OAR Chapter 333, Division 61, Sections 333-061-0070, 0071, 0072, 0073 and 0074.

The cross-connection control program applies to every premise and property served by the City's water system. It regulates cross connections and specifies backflow prevention assembly requirements for new construction, retrofitting, irrigation, and double check detector assemblies for fire systems. It specifies annual testing, maintenance, and repairs. The responsibilities of the City's backflow prevention assembly testers are listed below:

- All backflow assembly testers operating within the City of Milwaukie water system service area shall be certified in accordance with all applicable regulations of the OHA and must abide by the requirements of Milwaukie Municipal Code Chapter 13.08 and the City's cross connection control program.
- Persons certified as backflow assembly testers shall agree to abide by all requirements of the federal Occupational Safety and Health Administration and Oregon Occupational Safety and Health Administration.
- It is the responsibility of backflow assembly testers to submit records of all backflow assembly test reports to the City of Milwaukie within 10 days of completing the test.

6.11 EQUIPMENT AND SUPPLIES INVENTORY

As outlined in the water system emergency response plan and required under OAR 333-061-0065, the Water Division is required to maintain an inventory of replacement parts and equipment on hand to ensure continuity of service. When this inventory is used during routine maintenance, replacements are ordered and placed into storage. The water operations supervisor is responsible for maintaining the list of parts and reordering the inventory. A list of contacts is maintained in case parts or equipment are required immediately. A review of inventory is performed annually.

A summary of inventory groups and suggested storage protocol are described below:

- Emergency equipment required for a chlorine leak is stored in a building separate from the chlorine room
- Maintenance equipment used in response to a mechanical or electrical equipment failure is stored at the Johnson Creek facility
- Spare parts for general maintenance repairs are stored at the 40th and Harvey Well #2 building.

6.12 RECORDKEEPING

The City maintains water system records in compliance with OAR 333-061-0040. Table 6-3 summarizes these records and the minimum retention period. The City also maintains the additional records described in Table 6-4.

Table 6-3. OAR 333-061-0040 Recordkeeping Requirements

Record	Minimum Retention Period
Microbiological analysis	5 years
Chemical analysis	10 years
Secondary contaminants	10 years
Turbidity	10 years
Radioactive substances	10 years
Monitoring plans	10 years
Records of action to correct non-compliance items	3 years
Sanitary surveys	10 years
Variances or permits	5 years
Residual disinfectant measurements	2 years
Sampling data and reports	12 years
Documentation of corrective action	10 years
Public notices	3 years
Cryptosporidium reporting	3 years
Initial distribution system evaluation reports	10 years
Records associated with invalidation of E. coli positive samples	5 years
40/30 Certification to EPA	10 years
Coliform investigation and documentation	5 years

Table 6-4. Additional Records Maintained by the City of Milwaukie Water Division

Record	Minimum Retention Period	Frequency
Pump station hours and master meter usage	3 years	Logged weekly. Checked against average residential usage. Used to monitor pump flow, pump efficiency, water consumption, and to detect large leaks.
Manager's report	7 years	Statement of profit and loss with budget comparison, water system income statement, water system balance sheet including assets, debts, and operating revenues and expenses.
Field logs	3 years	Daily. Document field activities.
Pump hour sheets	3 years	Completed weekly as part of pump inspection.
Work Orders	Utility discretion	Generated as needed to direct system component maintenance. Part of computerized utility management program.
Chlorine residual monitoring	3 years	Monthly. Maintained at City Office
Lead and copper	As long as operational	As scheduled. Maintained in Public Works building
THM/HAA monitoring[a]	As long as operational	Quarterly. Maintained at Public Works building
Asbestos	As long as operational	Every 9 years. Maintained at Public Works building
Other water quality records	As long as operational	As scheduled. Maintained at Public Works building
Source meter readings	7 years	Summarized monthly. Maintained at Public Works building
Pumping power usage	7 years	Recorded Monthly. Maintained at City Hall
Service meter reading	7 years	Recorded Monthly. Maintained at City Hall
Meter read quality control	7 years	Monthly. Random sampling of meter reads. Maintained at City Hall

a. THM = trihalomethane; HAA = halogenic acetic acids (THM and HAA are both types of disinfection byproducts)

7. PERFORMANCE STANDARDS

7.1 INTRODUCTION

The City has established performance standards to describe the objectives and criteria for water system asset design, construction, and performance. This is accomplished by maintaining standard details and specifications to guide the development of water system assets. The City's criteria are within accepted industry standards as recommended by the American Water Works Association. The criteria are summarized in Table 7-1. The City's Public Works Standards and Standard Drawings are included in Appendix P.

Table 7-1. Planning and Design Standards

Component	Criteria	Remarks / Issues
Fire Flow Requirements—Flow @ Duration		
Single-Family Residential	1,500 gpm @ 2 hours	Fire flows based on new development requirements. Existing development will be evaluated on a case-by-case basis, because of the historical varying standard.
Multi-Family Residential	1,500 gpm @ 3 hours	
Institutional (schools, hospitals, etc.)	2,000 gpm @ 4 hours (with approved automatic sprinkler system)	
Commercial/Industrial	3,000 gpm @ 4 hours (with approved automatic sprinkler system)	
Water Supply Capacity		
Maximum-Day Demand Plus Fire Flow	Provide capacity equal to maximum-day demand plus fire flow	.
Peak-Hour Demand	Provide capacity equal to peak-hour demand	
Pumping Facility Capacity		
Booster Pump Capacity	Equal to the maximum-day demand for the pressure zone.	Design for maximum day plus fire flow or peak hour (whichever is larger), only if no gravity storage is available within the pressure zone and/or service area.
Backup Power	Equal to the firm capacity of the pumping facility.	On-site generator for critical stations[a] Plug in portable generator for less critical stations.

Component	Criteria	Remarks / Issues
Water Storage and System Peaking Capacity		
Operational Storage	Equal to source or booster pump normal cycling under normal operating conditions. The required operational storage volume is determined according to the estimated time and duration of the shutdown during a maximum demand period.	Additive to equalization and emergency (standby) storage components, and to fire flow storage if fire flow component exists for any given tank. The City's treatment systems and pump stations are equipped with backup power systems and are capable of operating for the duration of a shutdown during a period of maximum demand. Therefore, the City does not need to dedicate operational storage volume to its reservoirs.
Equalization	25 percent of the maximum daily demand.	This equalization storage volume must be located within the specific pressure zone that it serves.
Fire	Varies (see remarks)	Varies depending on required fire flow duration. Highest fire flow demand in any particular area controls size of required storage (see Table 4-2). Recommended fire storage volume does not include volume associated with 500 gpm sprinkler flow. 1,500 gpm @ 2 hours = 0.18 MG 1,500 gpm @ 3 hours = 0.27 MG 2,500 gpm @ 4 hours = 0.60 MG
Emergency (standby)	Three days of average-day demand	Policy decision based on the assessment of risk failures and system reliability requirements
Total Water Storage Capacity	Equalization + Fire + Emergency	
Water Transmission Line Sizing		
Diameter	18-inch diameter or larger	
Average-Day Demand		Criteria based on requirements for new development, existing transmission mains will be evaluated on case-by-case basis. Evaluation will include age, material type, velocity, head loss, and pressure.
Minimum Pressure	40 psi	
Maximum Pressure	100 psi	
Maximum Velocity	3 feet/second	
Maximum-Day Demand		
Minimum Pressure	40 psi	
Maximum Head loss	3 feet/1,000 feet	
Maximum Velocity	5 feet/second	
Peak-Hour Demand		
Minimum Pressure	40 psi	
Maximum Head loss	3 feet/1,000 feet	
Maximum Velocity	5 feet/second	
Hazen Williams "C" Factor	140	For consistency in hydraulic modeling.
Pipeline Material	Ductile Iron	

Component	Criteria	Remarks / Issues
Water Distribution Line Sizing		
Diameter	Less than 18-inch diameter	Must verify pipeline size with max day and fire flow analysis.
Average-Day Demand		Criteria based on requirements for new development, existing distribution mains will be evaluated on case-by-case basis. Evaluation will include age, material type, velocity, head loss, and pressure. Future development must demonstrate no impact to the existing system through calculations, hydraulic modeling, or onsite improvements.
Minimum Pressure	40 psi	
Maximum Pressure	100 psi	
Maximum Velocity	3 - 5 feet/second	
Maximum Day w/ Fire Flow Demand		
Minimum Pressure (at fire node)	20 psi	
Maximum Head loss	10 feet/1,000 feet	
Maximum Velocity	10 feet/second	
Peak-Hour Demand		
Minimum Pressure	40 psi	
Maximum Head loss	10 feet/1,000 feet	
Maximum Velocity	7 feet/second	
Hazen Williams "C" Factor	140	For consistency in hydraulic modeling.
Pipeline Material	Ductile Iron	
Maximum Valve Spacing		
Supply Pipeline	1 mile	
Transmission Pipeline	1,300 feet (minimum)	
Residential Distribution Pipeline	800 feet	
Commercial Distribution Pipeline	500 feet	
Uniform Fire Code Hydrant Distribution Requirements		
Residential	500	
Commercial, Industrial, and Other High Value District	200-500	
Other Criteria		
Maximum Number of residential lots that can be served by a non-looped water pipeline	25 lots	If a non-looped water line goes out-of-service, all associated residences lose water service.

a. A pumping facility is defined as critical if it provides service to pressure zones and/or service areas without sufficient emergency storage and meets the following criteria:
- Is the largest facility that provides water to a particular pressure zone and/or service area
- Provides the sole source of water to single or multiple pressure zones and/or service areas
- Provides water from a supply turnout into pressure zones and/or service areas.

7.2 SERVICE PRESSURE AND PRESSURE ZONES

The Oregon Health Authority (OHA) requires a minimum service pressure of 20 psi at all times as measured at the property line, including under fire flow conditions. The City's standard requires a minimum static pressure of 35 psi at each connection. City standards also require that the water system design meets the distribution requirements for maximum water usage and consumption within each pressure zone. System pressure is maintained within each of the City's four pressure zones through the use of pressure reducing valves (PRVs), booster pump stations and gravity flow.

Under normal operating conditions, system service pressure ranges between 40 and 100 psi. Service connections operating above 80 psi are equipped with pressure reducing valves at the site to prevent appliance damage. This ensures adequate pressure at the lower pressure range during maximum demand conditions while minimizing damage to plumbing fixtures and piping at the higher end of the range. Lower system pressures are allowable under fire flow conditions.

7.3 PIPELINE SIZE AND SYSTEM HYDRAULICS

The City's current pipeline design criteria is based on requirements for new development and provide the following criteria for pipeline sizing and system hydraulics:

- Appropriately sized to provide a minimum residual pressure of 20 psi within the existing system during fire flow conditions and 40 psi during normal demand conditions.
- A flow velocity of 3 - 5 feet per second (fps) for normal operating conditions and a maximum of 7 fps during peak-hour demand. The 5 fps is used for designing new improvements; the 7 fps maximum is used in evaluating the need for improvements.
- All public water distribution systems shall be constructed with ductile-iron pipe. All such pipe shall be cement mortar-lined pipe with push-on or mechanical type joints. All joints are required to be restrained regardless of connection type. All pipe, valves, and fittings shall be pressure rated for 250 psi or 350 psi.
- When a potentially corrosive condition is encountered, ductile-iron pipe and fittings may be polyethylene encased with an 8- mil tubing meeting manufacturer and American Water Works Association (AWWA) standards. A corrosion control assessment performed by the City indicated that the use of polyethylene material on ductile iron piping causes the copper service lines to become sacrificial, however, and failure can occur within 10-20 years, depending on soil conditions. Ideally, service lines would be constructed of PEX piping or another means of corrosion control would be installed. Another option is to install fused HDPE for the main and service piping. Where an active cathodic protection system is encountered as a result of other utilities, a deviation from the normal pipe design/material/installation practice may be required by the City Engineer.
- All fittings shall be factory cement lined and coated (domestic fittings only). Pipe constructed per Subsection 4.0025 (Relation to Watercourses) will require the use of restrained pipe joints or ball and socket river pipe. The City is interested in transitioning to fused encased HDPE piping, however that is not yet considered standard.
- Four-inch distribution mains may only be used with approval of the City Engineer in residential zones on dead-end streets with a center line distance of less than 250 ft measured from the center of the intersecting street to the radius point of the cul-de-sac; with service to not more than 12 residences; and shall be connected to a looped minimum 6-inch main. Fire hydrants are not permitted on 4-inch lines. All 4-inch lines shall terminate with a standard blow-off (Oregon Standard Drawing RD262).
- Six-inch distribution mains are the minimum size for residential subdivision water service for the grid (looped) system, not to exceed an unsupported length of 600 feet and shall not be permanently dead-ended. Looping of the distribution grid shall be at least every 600 feet. As

pipelines are installed or replaced, the City may want to consider increasing the minimum size for looped systems to 8 inches as other municipalities are doing.

- Eight-inch distribution mains are the minimum size for permanently dead-ended mains supplying fire hydrants with a fire flow less than 1,500 gpm and for primary feeder mains in residential subdivisions.
- Mains of 10-inches and larger may be installed as required for primary feeder lines in subdivisions, industrial, and commercial areas Water age and stagnation should be taken into consideration to prevent poor water quality conditions.

7.4 VALVES AND HYDRANTS

Water system pipelines must include an adequate number of valves that are properly located for pipeline isolation. The following is a general guideline for valve spacing:

- Supply Pipeline—1 mile
- Residential distribution pipeline—800 feet
- Commercial distribution pipeline—500 feet

Hydrants are typically installed on 8-inch diameter or larger water mains and are located no more than 40 feet from the distribution main. The Clackamas County Fire District #1 (CCFD) determines the required fire hydrant distribution on a case by case basis. In areas that exceed fire flow conditions of 1,500 gpm, more than one hydrant must be installed. A general guideline for hydrant spacing is summarized in Table 7-2.

Table 7-2. General Guideline for Hydrant Spacing

Fire Flow Requirement (gpm)	Minimum Number of Hydrants	Average Spacing Between Hydrants (feet)[a, b, c]	Maximum Distance from any Point on Street or Road Frontage to a Hydrant (feet)[d]
1,750 or less	1	500	250
2,000 — 2,250	2	450	225
2,500	3	450	225
3,000	3	400	225
3,500 — 4,000	4	350	210
4,500 — 5,000	5	300	180
5,500	6	300	180
6,000	6	250	150
6,500 — 7,000	7	250	150
7,500 or more	8 or more[e]	200	120

a. Reduce by 100 feet for dead-end streets or roads.
b. Where streets are provided with median dividers which cannot be crossed by fire fighters pulling hose lines, or where arterial streets are provided with four or more traffic lanes and have a traffic count of more than 30,000 vehicles per day, hydrant spacing shall average 500 feet on each side of the street and be arranged on an alternating basis up to a fire-flow requirement of 7,000 gallons per minute and 400 feet for higher fire-flow requirements.
c. Where new water mains are extended along streets where hydrants are not needed for protection of structures or similar fire problems, fire hydrants shall be provided at spacing not to exceed 1,000 feet to provide for transportation hazards.
d. Reduce by 50 feet for dead-end streets or roads.
e. One hydrant for each 1,000 gallons per minute or fraction thereof.

7.5 FIRE FLOW

The CCFD establishes the minimum requirements for firefighting in the City of Milwaukie. CCFD uses the 2019 Oregon Fire Code to determine minimum fire flows and durations (Fire Code Appendix B, Table B105.1 *Minimum Required Fire-Flow and Flow Duration for Buildings*).

The City follows the National Fire Protection Association *Standards for Fire Flow* requirements. The City's minimum fire flow design standards are 1,500 gpm for single and multi-family residential units, which is consistent with the CCFD minimum requirements. Commercial building fire flow requirements are 3,000 gpm and industrial building fire flow requirements are 3,000 gpm.

The actual fire flow requirement for each building is determined by the CCFD and Insurance Service Office on a case-by-case basis. Fire flow requirements are based on building size and construction materials and design. Table 7-3 tabulates general fire flow requirements used for planning the City's water system. The fire flow requirements used by the City are also used in similar sized cities and are equal to or greater than the minimum criteria of the 2019 Oregon Fire Code. Future development must demonstrate no impact to the existing system through calculations, hydraulic modeling, or onsite improvements.

Table 7-3. Recommended Fire Flow Requirements

	Non-Sprinklered			Sprinklered[c, d]		
Designation[a, b]	Fire Flow (gpm)	Duration (hours)	Recommended Storage (MG)	Fire Flow (gpm)	Duration (hours)	Recommended Storage (MG)[e]
Single-Family Residential[f]	1,500	2	0.18	--	--	--
Multi-Family Residential[g]	1,500	3	0.27	--	--	--
Institutional[h]	3,000	4	0.72	2,000[i]	4	0.36
Industrial/Commercial[j]	5,000	4	1.20	3,000[i]	4	0.60

a. Construction type and fire area are not generally known during the development of a master plan; consequently, fire flow requirements set forth in this table are based on previous estimates for these land use types and similar communities.
b. Unique projects or projects with alternate materials may require higher fire flows and will be reviewed by the Fire Marshal on a case-by-case basis (e.g., proposed commercial/industrial areas and schools).
c. The Fire Marshal normally allows up to a 50 percent reduction in fire flows if a building is sprinklered. However, the Fire Code also requires that no fire flow be less than 1,000 gpm for single-family residential or 1,500 gpm for all other building types. For a more conservative fire flow estimate, Single Family and Multiple Family buildings were considered non-sprinklered for this Water Master Plan Update.
d. Specific fire flows were determined from Table B105.1 of the 2007 Fire Code and depend on construction type and fire area. These fire flow requirements are based on buildings being fully sprinklered.
e. Recommended storage volumes do not include volume associated with 500 gpm sprinkler flow.
f. Single Family includes Low Density Residential and Medium Density Residential land use.
g. Multiple Family includes High Density Residential land uses.
h. Institutional includes Parks & Recreation and Public and Quasi-Public land uses.
i. Fire flow includes a 500 gpm demand for on-site sprinkler flow.
j. Industrial/Commercial includes Commercial, Mixed Use Corridor, Mixed Use Downtown, Mixed Use Employment, Industrial

7.6 WATER STORAGE

The minimum water storage volume typically includes four storage components: operational, equalization, fire flow and emergency (see Figure 7-1). A recommended best practice is that the combined total volume for these components be available to each pressure zone. The State of Oregon does not mandate storage capacity but allows it to be determined by the considered risk and resilience of the system. The typical rule of thumb includes an emergency storage capacity equal to three days of average-day demand. Storage capacities that exceed a five-day turnover, based on average-day demand, are not recommended because the longer retention time can lead to water quality issues. General standards for determining treated water storage capacity are described in AWWA Manual 32 and are summarized below.

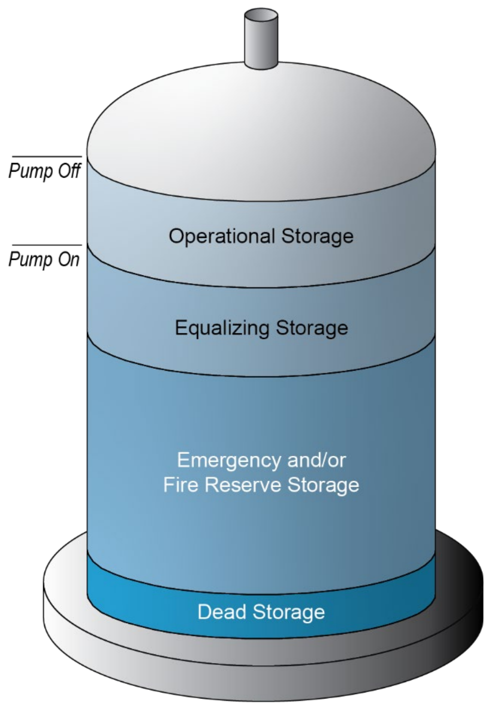


Figure 7-1. Reservoir Storage Components

Because the City's water supply includes wells, the groundwater basin can offset the storage requirement in the form of a groundwater credit. The credit can only include the groundwater supply that can be reliably accessed during emergency situations (i.e., wells that are equipped with emergency backup power systems).

7.6.1 Operational Storage

The operational storage component is intended to provide a continuous supply of water during temporary shutdowns of treatment systems or pump stations. The required operational storage volume is determined according to the estimated time and duration of the shutdown during a maximum demand period. Therefore, the operational storage volume will vary depending on the characteristics of each system. The City's treatment systems and pump stations are equipped with backup power systems and are capable of operating for the duration of a shutdown during a period of maximum demand. Therefore, the City does not need to dedicate operational storage volume to their reservoirs.

7.6.2 Equalization Storage

Typically, utilities strive to provide an equalization storage volume necessary to supplement the supply to consumers when the peak-hour demand exceeds the total source pumping capacity, though this standard is not defined in state regulations. Equalization storage is defined as the volume of storage needed to supplement supply to consumers when the peak hourly demand exceeds the total source pumping capacity. Water demand typically fluctuates in a diurnal pattern throughout the day, with higher demands occurring in the morning and in the evening. It is not unusual for demand to exceed production during higher demand periods of the day. When demand is lower than production, the equalization storage volume is recharged through normal production activities. The additional volume required to meet the equalization storage volume is typically 25 percent of the maximum daily demand. This equalization storage volume must be located within the specific pressure zone that it serves.

7.6.3 Fire Reserve Storage

The fire reserve storage volume is based on the highest fire flow requirement of a given pressure zone multiplied by the required duration. This volume is typically stored in reservoirs; however, pumped fire flows are allowed in small areas where gravity storage is not feasible. The City plans to adopt a new standard that will ensure the City's existing fire system is not compromised by new development through either modeling, calculations, or onsite improvements by the developer.

The Clackamas County Fire District defines fire flow storage as the maximum fire flow in the pressure zone multiplied by the required duration. For Zones 1 and 2, this equals a fire flow of 3,000 gpm for a duration of 4 hours. For Zones 3 and 4, this equals a fire flow of 1,500 gpm for a duration of 4 hours.

7.6.4 Emergency and Fire Reserve Storage

The minimum emergency storage volume must meet demand when the normal supply is interrupted. This volume is typically equal to 3 days of the average-day demand. An emergency is defined as an unforeseen or unplanned event that may degrade the quality or quantity of potable water supplies available to serve customers. Emergency events are typically divided into three categories:

- Minor emergency. A routine, normal, or localized event that affects few customers, such as a pipeline break, malfunctioning valve, hydrant break, or a brief power loss. Utilities plan for minor emergencies and typically have staff and materials available to correct them.
- Major emergency. A disaster that affects an entire, and/or large, portion of a water system, lowers the quality and/or quantity of the water, or places the health and safety of a community at risk. Examples include water treatment plant failures, raw water contamination, or major power grid outages. Water utilities infrequently experience major emergencies.
- Natural disaster. A disaster caused by natural forces or events that create water utility emergencies. Examples include earthquakes, forest or brush fires, hurricanes, tornados or high winds, floods, and other severe weather conditions such as freezing or drought.

The storage volume attributed to emergency conditions is a policy decision based on the assessment of risk failures and system reliability requirements. The AWWA does not have a formula for determining the amount of emergency storage that is required, therefore the City can determine the volume after consideration of risk and reliability. Other considerations include supply source diversity, redundancy and reliability of production systems, and the anticipated duration of the emergency event. The City has two emergency intertie connections for use during emergency situations and also has a portable truck mounted treatment system. Due to these benefits, it has been assumed that the City's emergency storage volume shall be based on minor emergencies and specific major emergency criteria. Therefore, the minimum emergency volume shall be equal to three days of the average-day demand.

7.6.5 Dead Storage

Dead storage is the volume of stored water that is not available to any consumers at the minimum design pressure. Dead storage is excluded from the volumes provided to meet operational storage, equalization storage and emergency and/or fire reserve storage. The total storage capacity of a reservoir minus the dead storage is the volume of effective storage.

7.6.6 Storage Capacity Analysis by Pressure Zone

The City's storage capacity was evaluated to determine if the system meets the requirements under existing conditions and over the planning period. Ideally, each pressure zone would be equipped with its own gravity storage. This scenario is not always possible due to elevation, siting issues and other constraints. Shared storage between pressure zones is common in these situations when water is transported via pressure-reducing valves or reliable pumping capacities. Zone 4 gets its water from Zone 1 via the Lava Drive Pump station, so storage for Zones 1 and 4 have been combined in this analysis. All groundwater credits were applied to Zones 2 and 3 since all wells pump to those two pressure zones.

Demand was proportioned across the pressure zones according to the number of connections based on the hydraulic model. Future growth was applied proportionately to each pressure zone. Table 7-4 tabulates the required storage volumes for the current demand and projected demand scenarios for 2025, 2030, 2035 and 2040. The storage deficit, or surplus, for each pressure zone was determined for each demand scenario. If the City were to increase the well pumping capacity to Zone 2 by 1,001 gpm, as recommended in Section 5.4.1, the projected storage deficit for Zone 2 in 2040 would be reduced from 4.4 MG to 3.0 MG.

7.6.7 Summary

On a system-wide basis, the City has surplus storage through 2030. The system-wide deficit reaches 1.2 MG by 2035 and 2.6 MG by 2040, based on the projections and assumptions of this master plan. However, on a zone basis, Zones 1, 2, and 4 currently are in a deficit storage condition and that deficit will continue to increase, reaching a deficit of 4.4 MG in Zone 2 by 2040. To address this deficit, it is recommended that the City begin allotting capital funds and land acquisition for a 5-MG reservoir within the next 10 years. In Zones 1 and 4, it is recommended that the City monitor development over the next 10 years and re-evaluate the need for additional storage at that time.

Table 7-4. Storage Requirements by Pressure Zone

Pressure Zone	Primary Storage Capacity (MG)[c]	Equalization Volume (MG)	MDD (gpm)	Fire Flow Volume (MG)	ADD (gpm)	Emergency Volume (MG)	Sub-total (MG)	Groundwater Credits (MG)[a, b]	Total Required Volume (MG)	Surplus (Deficit) Volume (MG)
Current Storage Requirements										
1 & 4	1.5	0.13	372	0.72	180	0.78	1.6	--	1.6	(0.1)
2	1.5	0.90	2,497	0.72	1,205	5.25	6.8	4.9	1.9	(0.4)
3	3.0	0.10	283	0.27	137	0.60	1.0	1.0	--	3.0
									TOTAL STORAGE SURPLUS (DEFICIT)	**2.5**
2025 Storage Requirements										
1 & 4	1.5	0.15	406	0.72	196	0.85	1.7	--	1.7	(0.2)
2	1.5	0.98	2,725	0.72	1,314	5.68	7.4	4.9	2.4	(0.9)
3	3.0	0.11	309	0.27	149	0.64	1.0	1.0	0.1	2.9
									TOTAL STORAGE SURPLUS (DEFICIT)	**1.8**
2030 Storage Requirements										
1 & 4	1.5	0.16	440	0.72	212	0.92	1.8	--	1.8	(0.3)
2	1.5	1.06	2,953	0.72	1,424	6.15	7.9	4.9	3.0	(1.5)
3	3.0	0.12	335	0.27	162	0.70	1.1	1.0	0.1	2.9
									TOTAL STORAGE SURPLUS (DEFICIT)	**1.1**
2035 Storage Requirements										
1 & 4	1.5	0.17	474	0.72	229	0.99	1.9	--	1.9	(0.4)
2	1.5	1.15	3,182	0.72	1,534	6.63	8.5	4.9	3.6	(2.1)
3	3.0	0.13	361	0.27	174	0.75	1.2	1.0	0.2	2.8
									TOTAL STORAGE SURPLUS (DEFICIT)	**0.4**
2040 Storage Requirements										
1 & 4	1.5	0.18	508	0.72	245	1.06	2.0	--	2.0	(0.5)
2	1.5	1.23	3,410	0.72	1,644	7.10	9.1	4.9	4.1	(2.6)
3	3.0	0.14	387	0.27	187	0.81	1.2	1.0	0.3	2.7
									TOTAL STORAGE SURPLUS (DEFICIT)	**(0.3)**

a. Groundwater credits are based on the well pump capacity as determined in the performance analysis performed by BacGen.
b. Groundwater credits do not include the recommended increase in pumping of 1,001 gpm to fully utilize water rights that was recommended in Section 5.4.1.
c. The current storage volume in the Stanley Reservoir is reduced by approximately 250,000 due to seismic issues. This analysis did not include reduction and assumes full capacity.

7.7 PUMPING CAPACITY

The City's pumping capacity was evaluated to determine if the system meets firm capacity requirements, currently and over the planning period. A water system with adequate capacity will be able to provide maximum-day demand plus fire flow or peak-hour demand. In conducting the analysis, the pumping firm capacity is defined as the pumping capacity with the largest pump out of service. If a pump station is equipped with a single pump and a backup generator, the pumping capacity of that single pump is included as the firm capacity. If gravity storage is available, the required capacity does not need to include fire flow and is reduced to just the maximum-day demand.

7.7.1 Groundwater Pumping Capacity

The firm capacity of the groundwater system is defined as the total capacity that can be accessed during a power outage. All of the City's well pumps are equipped with emergency power systems and therefore contribute to the total firm capacity of the groundwater pumping system. Since each operational well within the City's groundwater pumping system is connected to gravity storage, the required firm pumping capacity must provide at least the maximum-day demand.

Table 7-5 summarizes the existing operational capacity of the groundwater pumps against the firm pumping capacity requirements over the planning period. Section 5.4 recommended that the City's future groundwater pumping capacity be increased by 1,001 gpm to utilize full water rights through the construction of additional wells or reinstatement of existing wells that are currently offline. If the groundwater pumping capacity is not increased, the maximum-day demand is projected to exceed the operational capacity just before 2030, and the total deficit in 2040 would be 1,146 gpm. If the groundwater pumping capacity is increased by the recommended amount to a total of 5,094 gpm, any deficit can be delayed until 2040.

Table 7-5. Groundwater Firm Pumping Capacity Requirements

Operational Capacity of Well Pumps (gpm)		Firm Pumping Capacity Requirement Based on MDD (gpm)				
Existing	Improved[a]	Current	2025	2030	2035	2040
4,093	5,094	3,153	3,661	4,170	4,678	5,239

a. Based on the recommended increase described in Section 5.4.

7.7.2 Distribution Pumping Capacity

The City manages and operates two transfer pump stations and two booster stations. The pumping capacity at the booster and transfer pump stations was evaluated to identify deficit or surplus in the reliable firm capacity at each pressure zone. The same population projections used to determine the average-day demand (ADD) for each pressure zone were used to determine the maximum-day demand (MDD) and peak-hour demand (PHD) in each pressure zone. Adequate pumping capacity is determined by meeting the greater of the maximum-day demand plus fire flow or the peak-hour demand, with the largest pump out of service. When gravity storage is available, the pumping capacity does not include fire flow.

If fire flow is not supplied by gravity storage, the pump station must be equipped with a National Fire Protection Association rated fire pump. If the pump station is not equipped with a fire rated pump, the pumps and backup power source must have capacity to meet the required maximum fire flow and minimum residual pressure requirements, as determined by the Clackamas County fire marshal.

A pumping facility is considered critical if it provides service to pressure zones and/or service areas that do not have sufficient emergency storage and meets one of the following criteria:

- It is the largest facility that provides water to the pressure zone and/or service area.
- It provides the sole source of water to single or multiple pressure zones and/or service areas.
- It provides water from a supply turnout into a pressure zones and/or service areas.

Zone 1 is entirely gravity fed and therefore was not included in the distribution pumping capacity analysis. Zone 2 is supplied by two pump stations and is also gravity fed by the Elevated Reservoir; therefore, fire flow was not required in the Zone 2 capacity analysis. Zones 3 and 4 are not gravity fed and therefore require fire flow to be included in the analysis. Zones 3 and 4 are residentially zoned with a fire flow requirement of 1,500 gpm.

Table 7-6 summarizes the existing pumping capacity, MDD, fire flow, PHD, required firm pumping capacity and deficit or surplus for each pressure zone at five-year intervals through the planning period. The firm pumping capacity requirement for each pressure zone is shown in boldface. The analysis indicates that Zone 2 is currently operating at a deficit of 2,815 gpm, which will increase to 4,815 gpm by 2040. Zone 3 is also operating at a deficit of 873 gpm, with an expected increase to 971 gpm by 2040. Zone 4 is operating at a surplus capacity of 827 gpm and will remain in surplus capacity through 2040.

Table 7-6. Pumping Capacity Requirements

Pressure Zone [a]	Pump Station	Existing Capacity Each Pump (gpm) [b]	Capacity w/ largest pump out of service (gpm)	MDD (gpm)	Fire Flow (gpm)	MDD plus Fire Flow (gpm)	PHD (gpm)	Pumping Capacity (gpm) (Deficit) or Surplus
Current Pumping Capacity Requirements								
2	W6 Transfer Pump Station W2 Transfer Pump Station	850 940 430 601	1881	2,497			**4,052**	(2,171)
3	3rd Pressure Zone Booster Pump Station	200 200 600 600	1000	283	1,500	**1,783**	460	(783)
4	Lave Drive Booster Pump Station	300 300 1,750 1,750	2350	23	1,500	**1,523**	38	827
					TOTAL SURPLUS (DEFICIT)			**(2,128)**
2025 Pumping Capacity Requirements								
2	W6 Transfer Pump Station W2 Transfer Pump Station	850 940 430 601	1881	2,900			**4,696**	(2,815)
3	3rd Pressure Zone Booster Pump Station	200 200 600 600	1000	329	1,500	**1,829**	533	(829)
4	Lave Drive Booster Pump Station	300 300 1,750 1,750	2350	27	1,500	**1,527**	44	823
					TOTAL SURPLUS (DEFICIT)			**(2,821)**

Pressure Zone [a]	Pump Station	Existing Capacity Each Pump (gpm) [b]	Capacity w/ largest pump out of service (gpm)	MDD (gpm)	Fire Flow (gpm)	MDD plus Fire Flow (gpm)	PHD (gpm)	Pumping Capacity (gpm) (Deficit) or Surplus
2030 Pumping Capacity Requirements								
2	W6 Transfer Pump Station W2 Transfer Pump Station	850 940 430 601	1881	3,303			**5,341**	(3,460)
3	3rd Pressure Zone Booster Pump Station	200 200 600 600	1000	375	1,500	**1,875**	606	(875)
4	Lave Drive Booster Pump Station	300 300 1,750 1,750	2350	31	1,500	**1,531**	50	819
							TOTAL SURPLUS (DEFICIT)	**(3,516)**
2035 Pumping Capacity Requirements								
2	W6 Transfer Pump Station W2 Transfer Pump Station	850 940 430 601	1881	3,705			**5,985**	(4,104)
3	3rd Pressure Zone Booster Pump Station	200 200 600 600	1000	421	1,500	**1,921**	679	(921)
4	Lave Drive Booster Pump Station	300 300 1,750 1,750	2350	35	1,500	**1,535**	56	815
							TOTAL SURPLUS (DEFICIT)	**(4,210)**
2040 Pumping Capacity Requirements								
2	W6 Transfer Pump Station W2 Transfer Pump Station	850 940 430 601	1881	4,149			**6,696**	(4,815)
3	3rd Pressure Zone Booster Pump Station	200 200 600 600	1000	471	1,500	**1,971**	760	(971)
4	Lave Drive Booster Pump Station	300 300 1,750 1,750	2350	39	1,500	**1,539**	63	811
							TOTAL SURPLUS (DEFICIT)	**(4,975)**

a. Zone 1 was not included in this analysis because it is entirely fed by gravity.
b. Based on pump performance analysis performed by BacGen.

7.7.3 Summary

To address the current deficit in Zone 2, it is recommended that the W2 Transfer Pump Station be replaced with two 3,000-gpm pumps. To address the projected 2040 deficit, the W6 Transfer Pump Station pumps should be replaced near 2030 with two 2,000-gpm pumps, with space for a third pump. To address the current and future deficit in Zone 3, the 3rd Pressure Zone Booster Pump Station pumps should be replaced with two 2,000-gpm pumps.

7.8 EMERGENCY POWER GENERATION

Emergency power systems, which include standby diesel generators and automatic transfer switches, are required at critical pump stations. Portable generators are acceptable at less critical pump stations. Each generator must be capable of operating for at least 48 consecutive hours without refueling. The City's current water system includes five permanent standby generators, four automatic transfer switches, and one portable generator. Table 7-7 summarizes the pump stations, existing emergency power systems and emergency power shortfalls.

Table 7-7. Emergency Power Generation Requirements

Facility	Existing Emergency Power Equipment	Required Emergency Power Equipment
Wells No. 2 and No. 3, TP235 and W2 Transfer Pumps	• Standby generator must be manually started and stopped. Generator is not routinely tested or maintained. Fuel level and age are unknown. Fill port is at building exterior and may not have a lock.	• Automatic Transfer Switch
Well No. 4, 3rd Pressure Zone Booster Pumps and TP47	• Standby generator. Maintenance history is uncertain. There appeared to be a leak. • Automatic transfer switch	
Well No. 5	• Standby generator tested on an annual basis. Fuel level is unknown, no visible level indicator. Fuel tank is at building exterior. Last maintenance unknown. • Automatic transfer switch. No recent use and unsure if ATS would work during an outage.	
Well No. 6 and W6 Transfer Pumps	• Standby generator • Automatic transfer switch • Both are tested on a weekly basis	
Well No. 7	• Standby generator (testing, maintenance and operability are unknown. Fuel level and quality are unknown) • Automatic transfer switch	
Lava Drive Pump Station	• Emergency power is provided by portable trailer-mounted generator. • Connection is located on building exterior. Portable generator is kept at the W2 Warehouse. Trailer-mounted generator must be moved to parking lot.	
Well No. 8	• Standby generator • Automatic transfer switch • Well No. 8 is not currently operational.	

The City currently has all required permanent generators installed at critical pump stations; however, load testing and fuel monitoring have become a deferred maintenance issue. The Lava Drive Pump Station is considered less critical and is currently in compliance with a portable generator. One standby generator is tested on a weekly basis and one standby generator is tested on an annual basis. City staff are uncertain of the functionality of the remaining three generators. All generators except the generator serving Wells No. 2 and No. 3 are equipped with automatic transfer switches.

7.9 PRESSURE REDUCTION

Pressure-reducing valves are typically used:

- When an area is geographically or topographically isolated from the zone to which it logically belongs
- To compensate for elevation variations in a zone
- When a zone does not have storage
- When a zone experiences high pressures
- At service connections that exceed 80 psi per plumbing code to prevent site plumbing damage.

PRV design and hydraulic criteria are specific to the area served. The City's water distribution system is divided into four pressure zones. Where water system piping crosses these boundaries, a pressure-reducing valve station is required. The City's PRVs are summarized in Table 7-8.

Table 7-8. Pressure Reducing Stations

Station	Street	Cross Street	From Zone	To Zone	PRV Setting or Control Used in Hydraulic Model (psi)	Diameter (inches)	PRV Elevation in Hydraulic Model (feet)
V-PRV-1[a, b]	SE Waverly	17th	1	4	Opens on lower Zone 4 pressure	8	92
			4	1	Open	2	92
V-PRV-2[a]	SE McBrod	17th	1	4	Opens on lower Zone 4 pressure.	8	110
V-PRV-3[c]	Harrison	32nd	2	1	43	8	102
V-PRV-4[c]	Lake	33rd	2	1	40	8	110
V-PRV-5[c]	Sparrow	River	2	1	30	8	132
V-PRV-6[c]	32nd	Lake	2	1	40	6	109

a. Operates as a check valve.
b. Set to pass about 20 gpm.
c. Opens on Zone 1 pressure lower than Elev. 202 in Concrete Reservoir. Concrete tank top hydraulic grade line is at elevation 211.

7.10 STANDARD DETAILS AND DESIGN STANDARDS

The City maintains standard drawings for several key assets including:

- ¾" – 1" water service.
- 1 ½" – 2" water

- Water meters > 2”
- Wet tap 2 ½” and larger
- Valve box
- Fire hydrant installation

For equipment that is not currently included in the City’s Public Works Standards, the current version of the Oregon Standard Drawings published by the American Public Works Association and Oregon Department of Transportation is referenced. These standard drawings include the following:

- RD250: Thrust Blocking
- RD262: Typical main dead-end blowoff assembly
- RD270: Combination air release air vacuum valve assembly (2” and smaller)
- RD282: Water sampling station

These standard drawings and specifications being adhered to provide consistency and assurance that the City’s water system is be designed to meet Oregon Administrative Rules (OARs) and AWWA Standards. The City’s design standards are supplemental to those rules and standards.

The City maintains detailed design standards and specifications for City staff, developer, and contractor installation of all utility assets. These standards address the following:

- Pipe material and size
- Looped system and dead-end mains
- Restrained joints
- Right of way location
- Minimum cover
- Separation with sewer lines
- Easements
- Watercourse crossings and underwater crossings
- Valves
- Fire hydrants
- Pressure reducing and air release valves
- Railway and freeway crossings
- Appurtenances
- Backflow prevention
- Water service lines
- Fire service
- Fire vaults
- System testing
- Water quality sampling stations

8. Natural Hazard Resiliency Assessment

This chapter addresses the new Oregon Health Authority (OHA) seismic resiliency assessment for water system plans. The objective of this new requirement is to lay the foundation for a seismic resiliency plan to assist water utilities in achieving the 50-year resiliency plan and level-of-service objectives outlined by the Oregon Resiliency Plan. The Oregon Resiliency Plan objectives are designed to position utilities to be able to maintain service, or return to service, within a prescribed timeframe following a magnitude 9.0 Cascadia Subduction Zone event.

The actionable outcomes of this assessment are a set of seismic design standards for future construction and a 50-year CIP that addresses recommended improvements based on asset criticality, current condition, and remaining asset life.

In addition to the required seismic considerations, this section identifies water system risks associated with natural hazards, malevolent act, and climate change. The natural hazards and malevolent acts are based on the U.S. EPA comprehensive list of water system threats developed to conduct risk and resilience assessments required under the America's Water Infrastructure Act. A full risk and resilience assessment is being completed separately from this water master plan update.

8.1 WATER SYSTEM BACKBONE ASSETS

The City's water system assets were reviewed based on their criticality to the system. The review identified the following as critical backbone water system facilities for the initial seismic evaluation:

- Elevated Water Tower
- Stanley Reservoir
- Concrete Reservoir
- Treatment Air Stripping Towers
- TP47 Building
- Well No. 2 Pumphouse
- Well No. 3 Pumphouse
- Well No. 4 Pumphouse
- Well No. 5 Pumphouse
- TP235 Building
- Well No. 6 Pumphouse
- Well No. 7 Pumphouse
- 3rd Pressure Zone Bldg.
- Lava Drive Pump Station

8.2 SEISMIC EVALUATION

8.2.1 Approach and Considerations

The initial review of potential seismic resiliency and vulnerability was based on review of photographs and, in some cases, design drawings provided by the City. The assessment highlights potential vulnerabilities in each asset that may affect its seismic resiliency.

During the lives of the subject structures, there have been many changes to building codes and design standards. The catalysts for many of these changes were seismic deficiencies that were noted in buildings during post-earthquake inspections. There is no mandate that the City upgrade its facilities to keep pace with these changes, and it is generally accepted by building officials and the engineering community in general that it is unreasonable to hold existing structures to new code standards. However, these revisions to codes and design standards are important in assessing seismic vulnerabilities.

Some areas where the subject structures do not meet current engineering standards merit additional investigation and seismic analysis. The City should conduct evaluations of existing buildings using American Society of Civil Engineers (ASCE) 41-17, *Seismic Evaluation and Retrofit of Existing Buildings*. Evaluations using ASCE 41-17 will identify and quantify seismic deficiencies using seismic parameters, structure capacities and load path requirements that are appropriate for existing buildings. Evaluations of the existing reservoirs should use ASCE 41-17 to determine the seismic loads. However, ASCE 41-17 does not specifically address hydrostatic pressures, hydrodynamic loading or tank construction materials and methods; therefore, a tank-specific standard such as American Concrete Institute (ACI) 350 or AWWA D100 should be used to evaluate the structural elements of the tanks.

Loads generated using the ASCE 7 Online Hazard Tool and ASCE 41-17 were used to evaluate seismic resiliency. All structures were assumed to be Risk Category III facilities. Soil Site Class D was chosen by default in the absence of a geotechnical report, as prescribed in ASCE 7-16. Table 8-1 summarizes the seismic criteria of the analysis.

Table 8-1. Seismic Analysis Criteria

Seismic Design Parameters	Design Acceleration (g)
Short Period Spectral Acceleration Parameter, Ss	0.886
1-sec. Period Spectral Acceleration Parameter, S1	0.392
Short Period Design Spectral Acceleration Parameter, SDS	0.709
1-sec. Period Design Spectral Acceleration Parameter, SD1	0.499
Seismic Design Category	D

8.2.2 Evaluation of Storage Assets

Elevated Water Tower

The elevated water tower (see Figure 8-1) is a 1.53-million-gallon capacity tank that has an overall height of 122.5 feet and a diameter of 86 feet. The tank is supported by 12 columns. Diagonal bracing at the columns provides lateral support for the structure. The bottom of the tank shell is about 74 feet above grade. A seismic retrofit of this tank was performed in 2004.

Potential Seismic Vulnerabilities

Due to the relatively recent seismic retrofit, the structure is assumed to be resilient to potential seismic hazards. A noted area of concern is at the column base plates. The anchor bolts appear to be small, in comparison to size of the tank, columns, base plates and braces (see Figure 8-2).

Figure 8-1. Elevated Water Tower

Figure 8-2. Tower Base Plate

Recommendations

The following actions are recommended for seismic resilience of the Elevated Water Tower:

- Verify the capacity of the base plate anchorage. The 2004 seismic retrofit analysis is a good place to start the investigation, as it is likely that the anchor capacity was verified as part of the retrofit.
- Regularly monitor the interior and exterior of the structure for rust and touch up painting where necessary.
- Regularly monitor concrete foundation for settlement or cracks, especially near base plate anchors.

Stanley Reservoir

The Stanley Reservoir is a 128-foot diameter welded steel tank with a maximum operating level of 30 feet. The side wall shell of the tank is 30 feet high. A knuckle with a 3-foot radius gives the tank an overall height of 33 feet.

Potential Seismic Vulnerabilities

A 2019 structural assessment found that the existing tank does not have sufficient freeboard and was unable to confirm that the tank anchorage meets current ACI 318 and ASCE 7-16 requirements. A structural/seismic check of this tank confirmed the conclusions in the 2019 report. The 2019 report also indicates that the existing piping connections may not allow for the displacements required by AWWA D100. An uncontrolled loss of the tank contents could cause significant damage to the tank. The close proximity of residences to this reservoir adds to the seismic risk, as a significant loss of tank contents could damage adjacent properties.

Recommendations

The following actions are recommended for seismic resilience of the Stanley Reservoir:

- Perform a seismic evaluation using seismic forces determined using ASCE 41-17 and the load distributions, load combinations, material strength, etc. found in AWWA D100.
- Based on findings for the analysis, decrease water storage height to a maximum allowed or retrofit the tank as required. Retrofit items may include:
    - Remove the existing roof
    - Add a shell course at the top of the of the tank
    - Reinstall the existing roof or construct a new roof
    - Retrofit the foundation, anchor chairs and anchors

Concrete Reservoir

The Concrete Reservoir is a circular, load-tensioned tank with a domed roof. It has an inside diameter is 95 feet, a height of 31.5 feet, and a maximum water depth is 29 feet. The tank has a capacity of 1.5 million gallons. the November 8, 1948 design drawings showed design options for either conventionally reinforced or prestressed concrete walls. It is unclear from the drawings which type of construction was used for the tank wall. For the purposes of this analysis, it was conservatively assumed that the wall is conventionally reinforced, as this is typically the less seismically resilient of the two options.

Potential Seismic Vulnerabilities

The existing hoop tension capacity in the circumferential reinforcing steel is insufficient for seismic loading per ASCE 41-17, which is lower than the design loads per the current code. If the tank has a prestressed wall, it is also likely that the circumferential prestressing is undersized. The only apparent shear transfer between the wall and foundation is the bearing of the wall against the edge of the floor slab. Resistance of lateral seismic load in this manner would probably damage the existing gum rubber seal at the inside face of the wall. The seismic loading will create out-of-plane flexural stresses that would exceed the capacity of the wall.

Recommendations

The following actions are recommended for seismic resilience of the Concrete Reservoir:

- Add galvanized steel seismic cables at the wall base and foundation to create a seismic shear transfer mechanism that will not induce unwanted flexural moments in the wall. The installation of seismic cables will require the partial demolition and reconstruction of the wall footing. This type of seismic restraint is common in the construction of circular prestressed concrete tanks per the AWWA D110 standard. Figure 8-3 shows the installation of seismic cables at an existing tank.
- Add circumferential steel strand prestressing and shotcrete to the outside face of the concrete wall to increase its hoop tension capacity. The prestressing will also tie the seismic cables into wall.

Figure 8-3. Seismic Cables Installed on an Existing Concrete Tank

- As an alternative to the circumferential prestressing described above, add fiberglass reinforced plastic (FRP) jacketing to one or both faces of the concrete wall to increase its hoop tension capacity. The addition of seismic cables will not be possible with FRP jacketing. In this case, add a reinforced concrete curb around the perimeter of the base of the wall to transfer the anticipated seismic shear from the existing wall to the existing foundation. The curb will need to be carefully detailed to minimize the out-of-plane flexural stresses on the wall.

8.2.3 Evaluation of Source Water Assets

Well No. 2 Pumphouse

The Well No. 2 Pumphouse is a multi-use building constructed in 1936. The building has multiple occupancy groups as defined by the International Building Code. The building houses a generator and pumps (Group F), an office space and restroom (Group B) and a storage area (Group S). Photos show this structure is made of composite siding panels attached to steel framing. Diagonal bracing in the steel framing provides lateral support for wind and seismic loads. Even though the lateral force resisting system definitions of ASCE 41-17 or 7-16 did not exist in 1936, the existing bracing most likely falls under the Ordinary Steel Braced Frame category.

Potential Seismic Vulnerabilities

Any discontinuity in the lateral force load-resisting path could create a significant seismic vulnerability. A discontinuity could occur at a roof-to-wall connection, wall-to-foundation anchor bolts or at the ends of the brace members.

Recommendations

The recommended action for seismic resilience of the Well No. 2 Pumphouse is to conduct a field investigation and seismic evaluation using ASCE 41-17 to look for discontinuities in the lateral force load resisting paths, including the discontinuities listed above.

Retrofit actions, if needed, could include the following:

- Add bracing members to increase the seismic force resisting system
- Repair rusted, deteriorated or broken members of the braced frames
- Repair or replace damaged connectors and/or anchor bolts.

Well No. 3 Pumphouse

Well No. 3 Pumphouse is a small building with concrete masonry walls, a gable roof framed with wood trusses, and wood-framed gable end walls (see Figure 8-4).

Figure 8-4. Well No. 3 Pumphouse

Potential Seismic Vulnerabilities

It is likely that this building was constructed using materials, methods and detailing that the current building code would classify as an unreinforced or ordinary reinforced shear wall system. This type of construction offers very little wall strength or ductility and is no longer permitted in the seismic design category in which this building occurs (Seismic Design Category D). Certain seismic force mitigation features were not commonly incorporated in the construction of buildings of this era. The tops of masonry walls were not typically mechanically anchored to the roof diaphragms, and the seismic shear force transfer from the roof to the walls is often less than is currently desired.

Recommendations

The recommended action for seismic resilience of the Well No. 3 Pumphouse is to conduct a seismic evaluation using ASCE 41-17 to identify discontinuities in the seismic load path, quantify the seismic forces and determine the capacities of the existing seismic force resisting elements of the building. Seismic retrofit items may include the following:

- Add steel hardware and anchors to anchor the tops of the walls to the roof
- Add steel cross ties as part of the seismic wall anchorage
- Add roof diaphragm boundary nailing to increase diaphragm capacity
- Add seismic shear transfer clips to strengthen the roof-to-wall connection
- Verify anchorage capacities for onsite equipment (generators, fuel tanks, chemical cylinders, pumps, motors, piping, etc.)

Well No. 4 Pumphouse

The Well No. 4 Pumphouse is a small building constructed in 1960 with concrete masonry walls, a gable roof framed with wood trusses, and wood-framed gable end walls.

Potential Seismic Vulnerabilities

It is likely that this building was constructed using materials, methods and detailing that the current building code would classify as an unreinforced or ordinary reinforced shear wall system. This type of construction offers very little wall strength or ductility and is no longer permitted in the seismic design category in which this building occurs (Seismic Design Category D). Certain seismic force mitigation features were not commonly incorporated in the construction of buildings of this era. The tops of masonry walls were not typically mechanically anchored to the roof diaphragms, and the seismic shear force transfer from the roof to the walls is often less than is currently desired.

Recommendations

The recommended action for seismic resilience of the Well No. 4 Pumphouse is to conduct a seismic evaluation using ASCE 41-17 to identify discontinuities in the seismic load path, quantify the seismic forces, and determine the capacities of the existing seismic force resisting elements of the building. Seismic retrofit items will be similar to those for the Well No. 3 Pumphouse.

Well No. 5 Pumphouse

Photos of the Well No. 5 Pumphouse show it to be wood roof framed with wood siding walls. There is a strong probability that the walls are light framed wood shear walls.

Potential Seismic Vulnerabilities

It is likely that this building was constructed using materials, methods and detailing that the current building code would classify as an unreinforced or ordinary reinforced shear wall system, which is no longer permitted in Seismic Design Category D. This is similar to the condition noted at the Well No. 4 Pumphouse.

Recommendations

The recommended action for seismic resilience of the Well No. 5 Pumphouse is to conduct a seismic evaluation using ASCE 41-17 to identify discontinuities in the seismic load path, quantify the seismic forces, and determine the capacities of the existing seismic force resisting elements of the building. Seismic retrofit items will be similar to those for the Well No. 3 Pumphouse.

Well No. 6 Pumphouse

This small structure has a rectangular plan and a sloped gable roof. Very little documentation is available for this building. The photographic evidence shows that the walls have exterior siding. The interior faces of the walls have a wall covering. It is not clear if these walls are light framed shear walls or concrete or concrete masonry shear walls.

Potential Seismic Vulnerabilities

If the walls are light framed shear walls, then discontinuities may occur at the top of the wall, at the roof attachment, and/or at the base of the wall where the sill plate attaches. If this structure has concrete or concrete masonry walls, it will have the same seismic vulnerabilities as the Well No. 4 Pumphouse.

Recommendations

The recommended action for seismic resilience of the Well No. 6 Pumphouse is to verify the seismic load path through an evaluation using ASCE 41-17. For light framed shear walls, verify that there are good connections between the roof diaphragm and walls. Also verify that the walls are adequately bolted to the foundation. If this building has concrete or concrete masonry walls, the recommendations will be similar to those for the Well No. 3 Pumphouse.

Well No. 7 Pumphouse

Photographs of the Well No. 7 Pumphouse show that this building has wood roof framing and wood siding on the walls. There is a strong probability that the walls are light framed wood shear walls.

Potential Seismic Vulnerabilities

It is likely that this building was constructed using materials, methods and detailing that the current building code would classify as an unreinforced or ordinary reinforced shear wall system, which is no longer permitted in Seismic Design Category D. This is similar to the condition noted at the Well No. 4 Pumphouse.

Recommendations

The recommended action for seismic resilience of the Well No. 7 Pumphouse is to conduct a seismic evaluation using ASCE 41-17 to identify discontinuities in the seismic load path, quantify the seismic forces, and determine the capacities of the existing seismic force resisting elements of the building. Seismic retrofit items will be similar to those for the Well No. 3 Pumphouse

8.2.4 Evaluation of Water Treatment Assets

TP47 Building (Lower Treatment Plant)

This structure is a small building with concrete masonry walls. A gable roof framed with wood trusses reportedly was constructed in 1990. Vinyl siding was applied to the exterior faces of the walls.

Potential Seismic Vulnerabilities

This structure is similar in construction to the Well No. 4 Pumphouse and, even though it is several years newer, it has the same seismic vulnerabilities.

Recommendations

The recommended action for seismic resilience of the TP47 Building is to conduct a seismic evaluation using ASCE 41-17 to identify discontinuities in the seismic load path, quantify the seismic forces, and determine the capacities of the existing seismic force resisting elements of the building. Seismic retrofit items will be similar to those for the Well No. 3 Pumphouse.

TP235 Building (Upper Treatment Plant)

This small structure has a rectangular plan and a sloped gable roof. Very little documentation is available. The reviewed photographs show that the walls of the building have exterior siding. The interior faces of the walls have a wall covering. It is not clear if these walls are light framed shear walls or concrete or concrete masonry shear walls.

Potential Seismic Vulnerabilities

If the walls are light framed shear walls, then discontinuities may occur at the top of the wall, at the roof attachment, and/or at the base of the wall where the sill plate attaches. If this structure has concrete or concrete masonry walls it will have the same seismic vulnerabilities as the Well No. 4 Pumphouse.

Recommendations

The recommended action for seismic resilience of the TP235 Building is to verify the seismic load path through an evaluation using ASCE 41-17. For light framed shear walls, verify that there are good connections between the roof diaphragm and walls. Also verify that the walls are adequately bolted to the foundation. If this building has concrete or concrete masonry walls, the recommendations will be similar to those for the Well No. 3 Pumphouse.

Air Stripping Towers

The air stripping towers were constructed in approximately 1990. They are FRP structures 6.5 feet in diameter and 31.25 feet tall. The towers are located at the TP47 and TP235 water treatment plants. Each tower is anchored to concrete foundations with five anchor lugs with one anchor bolt at each lug. The fabrication drawings show that the holes in the anchor lugs are 1-1/8 inches in diameter, which indicates that anchors may be 1 inch in diameter. There is no indication of the anchor type or embedment. A notation on the fabrication drawing states: “Type II Lugs for 9758# (pounds) each…”. The same drawings show that the exterior surfaces of the towers were provided with a protective ultraviolet gel coat.

Potential Seismic Vulnerabilities

It is highly likely that the anchoring system described above was adequate when the towers were new, but anchor bolt design requirements have changed dramatically in the last 15 years. It is possible that the anchors no longer meet code requirements, even when reduced seismic loads per ASCE 41-17 are considered.

Recommendations

The following actions are recommended for seismic resilience of the air-stripping towers:

- Regularly monitor the FRP shell and components for deterioration, particularly damage due to ultraviolet rays.
- Perform a detailed evaluation of the anchor bolts and anchor lugs if additional information can be obtained.
- Conduct post-earthquake evaluations of the anchoring systems and foundations to look for:
    - Deformations, cracking, loosening, etc. of the anchor lugs
    - Elongation of the anchor bolts
    - Cracking or settlement of the foundation

8.2.5 Evaluation of Distribution Operational Assets

Lava Drive Pump Station

The Lava Drive Pump Station is small structure partially buried into a slope near the corner of SE Lava Drive and SE Riverway Lane. The floor, walls and roof are made of cast-in-place concrete.

Potential Seismic Vulnerabilities

The reinforced concrete floors, walls and roof of this structure make it seismically resilient. The connections of the walls at the floor, roof and wall corners create effective seismic force transfer load paths. These connections add to the seismic resiliency. However, the weight of the structure could lead to large seismic forces and result in cracking during strong ground shaking. Improperly anchored piping and equipment inside the structure may be displaced during an earthquake.

Recommendations

The recommended action for seismic resilience of the Lava Drive Pump Station is to evaluate anchorage for the piping, valves, electrical cabinets, etc. Any inadequate anchorage systems should be replaced or strengthened. Post-earthquake examinations of the structure should look for diagonal cracking in the roof deck and walls, as this type of cracking often indicates that the structure has experienced seismic loads that are in excess of the structure's capacity.

3rd Pressure Zone Building

This small structure has a rectangular plan and a sloped gable roof. Little documentation is available. The reviewed photographs show that the walls of the building have exterior siding. The interior faces of the walls have a wall covering. It is not clear if these walls are light framed shear walls or concrete or concrete masonry shear walls.

Potential Seismic Vulnerabilities

If the walls are light framed shear walls, then discontinuities may occur at the top of the wall, at the roof attachment, or at the base of the wall where the sill plate attaches. If this structure has concrete or concrete masonry walls, it will have the same seismic vulnerabilities as the Well No. 4 Pumphouse.

Recommendations

The recommended action for seismic resilience of the 3rd Pressure Zone Building is to verify the seismic load path through an evaluation using ASCE 41-17. For light framed shear walls, verify that there are good connections between the roof diaphragm and walls. Also verify that the walls are adequately bolted to the foundation. If this building has concrete or concrete masonry walls, the recommendations will be similar to those for the Well No. 3 Pumphouse.

8.2.6 Recommendations Summary

Table 8-2 summarizes the observed potential points of risk and recommended actions to increase seismic resiliency. The priority levels were determined based on criticality to operations, available redundancy, necessary improvements, past improvements, ease of implementation.

Table 8-2. Summary of Points of Risk and Recommended Actions

Asset	Priority	Potential Point of Failure	Recommendation
Storage Assets			
Elevated Tank	Low	• A noted area of concern is at the column base plates. The anchor bolts appear to be small, in comparison to size of the tank, columns, base plates and braces.	• Conduct an investigation to verify the capacity of the base plate anchorage. The 2004 seismic retrofit analysis is a good place to start the investigation, as it is likely that the anchor capacity was verified as part of the retrofit. • Regularly monitor the interior and exterior of the structure for rust and touch up painting where necessary. • Regularly monitor concrete foundation for settlement or cracks, especially near base plate anchors.
Stanley Reservoir	High	• The existing tank does not have sufficient freeboard • Cannot be confirmed that the tank anchorage meets current ACI 318 and ASCE 7-16 requirements. • Existing piping connections may not allow for the displacements required by AWWA D100. • An uncontrolled loss of the tank contents could cause significant damage to the tank and residential property	• Perform a seismic evaluation using seismic forces determined using ASCE 41-17 and the load distributions, load combinations, material strength, etc. found in AWWA D100. Based on results, do one of the following: o Decrease water storage height to a maximum allowed, or o Retrofit as follows: ▪ Remove the roof and add a shell course at the top of the of the tank ▪ Reinstall the existing roof or construct a new roof ▪ Retrofit the foundation, anchor chairs and anchors
Concrete Reservoir	Medium	• The existing hoop tension is insufficient • It is likely the circumferential prestressing is undersized. • The only shear transfer between the wall and foundation is the bearing of the wall against the floor slab. • The seismic loading will create out-of-plane flexural stresses that would exceed the capacity of the wall.	• Add galvanized steel seismic cables at the wall base and foundation. • Add circumferential steel strand prestressing and shotcrete to the outside face of the concrete wall, or • Add FRP jacketing to one or both faces of the concrete, and add a reinforced concrete curb around the perimeter of the base of the wall.

Asset	Priority	Potential Point of Failure	Recommendation
Source Water Assets			
Well No. 2 Pumphouse	Low	• Discontinuity in the lateral force load resisting path could occur at a roof-to-wall connection, wall-to-foundation anchor bolts or at the ends of the brace members.	• Conduct a field investigation for discontinuities in the lateral force load resisting paths. • As needed: o Add bracing members to increase the seismic force resisting system o Repair rusted, deteriorated or broken members of the braced frames o Repair or replace damaged connectors and/or anchor bolts.
Well No. 3 Pumphouse **Well No. 4 Pumphouse** **Well No. 5 Pumphouse** **Well No. 6 Pumphouse** **Well No. 7 Pumphouse**	Low	• Certain seismic force mitigation features were not commonly incorporated in the construction of buildings of this era. The tops of masonry walls were not typically mechanically anchored to the roof diaphragms and the seismic shear force transfer from the roof to the walls is often less than is currently desired.	• Conduct a seismic evaluation • As needed: o Add steel hardware and anchors to anchor the tops of the walls to the roof o Add steel cross ties as part of the seismic wall anchorage o Add roof diaphragm boundary nailing to increase diaphragm capacity o Add seismic shear transfer clips to strengthen the roof-to-wall connection o Verify anchorage capacities for onsite equipment
Water Treatment Assets			
TP47	Medium	• Certain seismic force mitigation features were not commonly incorporated in the construction of buildings of this era. The tops of masonry walls were not typically mechanically anchored to the roof diaphragms and the seismic shear force transfer from the roof to the walls is often less than is currently desired.	• Conduct a seismic evaluation • As needed: o Add steel hardware and anchors to anchor the tops of the walls to the roof o Add steel cross ties as part of the seismic wall anchorage o Add roof diaphragm boundary nailing to increase diaphragm capacity o Add seismic shear transfer clips to strengthen the roof-to-wall connection o Verify anchorage capacities for onsite equipment
TP235	Medium		
Air Stripping Towers	Low	• It is possible that the anchors no longer meet code requirements, even when reduced seismic loads per ASCE 41-17 are considered.	• Monitor the FRP shell and components for deterioration due to ultraviolet rays. • Perform a detailed evaluation of the anchor bolts and anchor lugs. • Conduct post-earthquake evaluations of the anchoring systems and foundations.

Asset	Priority	Potential Point of Failure	Recommendation
Distribution Operational Assets			
Lava Drive Pump Station	Low	• The weight of the structure could lead to large seismic forces and result in cracking during strong ground shaking. • Improperly anchored piping and equipment inside the structure may be displaced during an earthquake.	• Evaluate anchorage for the piping, valves, electrical cabinets and replaced inadequate anchorage systems. • Conduct and document post-earthquake examinations for diagonal cracking in the roof deck and walls.
3rd Pressure Zone Building	Low	• Certain seismic force mitigation features were not commonly incorporated in the construction of buildings of this era. The tops of masonry walls were not typically mechanically anchored to the roof diaphragms and the seismic shear force transfer from the roof to the walls is often less than is currently desired.	• Conduct a seismic evaluation • As needed: o Add steel hardware and anchors to anchor the tops of the walls to the roof o Add steel cross ties as part of the seismic wall anchorage o Add roof diaphragm boundary nailing to increase diaphragm capacity o Add seismic shear transfer clips to strengthen the roof-to-wall connection • Verify anchorage capacities for onsite equipment

8.2.7 Future Seismic Resiliency Construction

The City of Milwaukie's engineering and construction standards need to meet current seismic code for future water infrastructure facilities. The following City procedures for design and construction of infrastructure were reviewed:

- *City of Milwaukie Building Inspection Operating Plan* addressing guidelines for inspection and permitting procedures for compliance with City requirements
- *Oregon Specialty Codes* (adopted per the City of Milwaukie Municipal Code § 15.04.070)
- *2019 Oregon Structural Specialty Code*
- *Clackamas County Structural Design Criteria*

Based on the review, the following are general recommendations for future construction of all water system infrastructure:

- Establish a list of required design codes and standards for well houses, pump stations and water storage tanks.
- Require reviews of drawings and specifications for projects, including verification that the requirements of the codes and standards have been met.
- Include in contract drawings and specifications for these projects an outline of the inspections and observations required
- Upon beginning construction, develop with the contractor a schedule that lists all anticipated special inspections and structural observations.
- Prequalify consultants for reservoir design experience.
- Develop written guidelines for design requirements and construction inspections.
- Develop checklists for reviews of design documents.

Below are recommendations for the design, City review and inspection for well houses, pump stations and water storage structures.

Well Houses and Pump Stations

The design of well houses and pump stations is governed the 2018 International Building Code (IBC), as amended by the 2019 Oregon Structural Specialty Code. These codes reference the following codes and standards that apply to the design and construction of buildings:

- ASCE 7-16 Minimum Design Loads for Buildings and Other Structures
- 318-14 Building Code Requirements for Structural Concrete
- 530-13 Building Code Requirements for Masonry Construction
- TMS 402 Building Code Requirements and Specifications for Masonry Structures
- TMS 403 Direct Design Handbook for Masonry Structures
- AISC 360 Specification for Structural Steel Buildings
- AISC 341 Seismic Provisions for Structural Steel Buildings

The design requirements in these codes and standards should be strictly followed. It is particularly important that the code requirements for the design of the following structural elements be met:

- Anchorage of concrete and masonry walls to flexible floor/roof diaphragms
- Seismic collectors
- Anchor bolt strengths, ductility, and failure mode checks
- Building irregularities
- Floor/roof diaphragms strengths

Meeting the code-prescribed requirements will help ensure that critical seismic force resisting elements will have sufficient strength. It also will ensure the continuity of the load path that transfers seismic loads from the top of each structure down to the foundation. These considerations are critical to the seismic resiliency of a building.

The selection of durable, ductile construction materials is important to the seismic resiliency of well houses and pump stations. Hot-rolled steel framing, corrugated steel roof decks, solid-grouted reinforced masonry walls, reinforced concrete walls, and reinforced concrete foundations are good choices for seismic resiliency. Construction materials should be adequately protected from the elements. Coatings should be used to extend the life of masonry and concrete walls. Steel framing and roof decks should be hot-dip galvanized. Steel anchor bolts installed in the interior of the buildings should be hot-dip galvanized. Stainless steel anchor bolts should be used in exterior or highly corrosive conditions.

Diligent inspections are required to ensure that the seismic design considerations and material selections are properly implemented in the field during construction. In addition to the daily inspections provided by City inspectors, special inspections and structural observations are described in Chapter 17 of the 2018 IBC. Special inspections are performed by registered deputy inspectors who are trained and certified by the International Code Council. The registered deputy inspectors verify the construction materials, monitor the methods used by field crews, and confirm that construction crew members are properly certified, where such certifications are required. Special inspections are performed at these key construction milestones:

- Subgrade preparation
- Installation of reinforcing for concrete and masonry
- Installation of cast-in-place anchor bolts in concrete and masonry
- Placement of concrete
- Placement of masonry grout
- Installation of post-installed adhesive or expansion anchor
- Construction of steel framing for floors and roofs
- Installation of fasteners for steel floor and roof decks

The IBC prescribed structural observations are performed by an Oregon registered engineer or architect familiar with the design of such structures. Structural observations at the following construction milestones should verify that the intent of the design documents is properly implemented in the field:

- Installation of reinforcing for concrete and masonry
- Installation of cast-in-place anchor bolts in concrete and masonry
- Construction of steel framing for floors and roof
- Installation of fasteners for steel floor and roof decks

Water Storage Structures

The design of water storage structures is governed by many of the same codes and standards as those used for well houses and pump stations. In addition, the following are nationally recognized publications for the design and construction of specific types of water storage tanks:

- **ACI 350 Code Requirements for Environmental Engineering Concrete Structures—**This standard governs the materials, design, and construction of conventionally reinforced concrete tanks. Considerations that are unique to the design and construction of conventionally reinforced concrete tanks are outlined in this standard. These considerations include reinforcing sizing and spacing to control cracking (due to stresses, shrinkage, and temperature changes), concrete mix ingredients and proportions (for durability and permeability), and construction joint spacing and design (for crack control and watertightness).
- **AWWA D100 Standard for Welded Carbon Steel Tanks for Water Storage—**This standard is specifically for flat-bottom ground-supported steel tanks and elevated steel tanks. It prescribes the stresses in the thin wall of the cylindrical shells of steel tanks. It defines compressive and tensile stress limits on the thin wall shells. This standard provides a procedure for the stability of ground-supported steel tanks and it covers the seismic bracing requirements of elevated tanks. It has comprehensive requirements for the inspections of welded steel tanks. These inspection procedures should be followed closely.
- **AWWA D110 Standard for Wire and Strand Wound Circular Prestressed Concrete Water Tanks—**This standard addresses the design and construction requirements for vertical and circumferential prestressing in the wall shells and flexible roof-to-wall joints and wall-to-foundation base joints. These are design features that are not found in conventionally reinforced tanks.

These standards consider the forces imposed on the tank structures by the hydrostatic and hydrodynamic (seismic) forces created by the water in the tank. The magnitudes and distribution of these forces are prescribed in these codes and standards. These standards also consider forces, materials, construction methods, leak testing procedures, etc. that are unique to water storage tanks. The City should specify these standards as requirements for the design and construction of future tank projects.

8.3 IDENTIFICATION OF NATURAL HAZARDS AND MALEVOLENT ACT RISKS

The U.S. EPA developed a comprehensive list of malevolent acts and natural hazards to use in preparing risk and resilience assessments under the America's Water Infrastructure Act. That list was modified for water systems under the AWWA J100 methodology. The assessment for Milwaukie began with the AWWA J100 list and pared it down to risks that are relevant to the City's water system. This pared-down list serves as the set of risks evaluated for the separate completion of the City's risk and resilience assessment. Table 8-3 describes each threat and identifies which were selected as relevant to the water system.

Table 8-3. Identification of Natural Hazard and Malevolent Act Risks

Threat Code	Threat	Description	Applies to City	Reason for Exclusion
Natural Hazards				
N(H)	Hurricane	Not a natural hazard threat to region		
N(E)	Earthquake	Graduated damage from each Richter magnitude exceeding Uniform Building Code design-basis threat for earthquake zone or IBC peak ground acceleration method and construction date; frequency from U.S. Geological Survey data	X	
N(T)	Tornado	Total destruction assumed in area hit by tornado (averaging about 25 acres); frequency from actual number of tornadoes in county/parish in last 50 years and area of county/parish.		Region does not experience tornados
N(F)	Flood	100-year flood	X	
Dependency and Proximity				
D(U)	Utilities	Unable to provide service for the number of days set as the organizational resilience standard	X	
D(S)	Key Suppliers	Service interruption for the number of days set as the supplier resilience standard	X	
D(E)	Key Employees	Employee critical to any operation whose technical capabilities do not exist elsewhere	X	
D(C)	Key Customers	Damage is so severe that customers leave their homes/businesses or a large customer that the facility depends on monetarily no longer needs the services of the facility		The system serves primarily a residential customer base and service outage severe enough to cause customers to relocate is remote

Threat Code	Threat	Description	Applies to City	Reason for Exclusion
D(T)	Transportation	Facilities into and/or out of the site are inoperable for the number of days set as the transportation resilience standard	X	
D(P)	Proximity	Assets are near other assets that are at risk of damage by human or natural causes		There are no proximity targets near water system assets
Contamination				
C(B)	Chemical		X	
C(C)	Radionuclide		X	
C(P)	Biotoxin		X	
C(R)	Pathogen		X	
C(S)	Weaponization		X	
Process Sabotage				
S(PI)	Physical Insider	Intent is to cause harm by damaging, disabling, or destroying process control systems	X	
S(PU)	Physical Outsider		X	
S(CI)	Cyber Insider		X	
S(CU)	Cyber Outsider		X	
Theft or Diversion				
T(PI)	Physical Insider	intent is to steal or divert information, dangerous substances, valuable resources, etc.	X	
T(PU)	Physical Outsider		X	
T(CI)	Cyber Insider		X	
T(CU)	Cyber Outsider		X	
Maritime				
M1	Small Boat	Less than a 10-foot draft carrying an explosive charge of 400 pounds		There are no water system assets in the proximity of the Willamette River and more attractive targets exist on the river.
M2	Fast Boat	Less than a 10-foot draft carrying an explosive charge of 2,000 pounds		
M3	Barge	Carrying an explosive charge of 20,000 pounds		
M4	Deep Draft Ship	Carrying an explosive charge greater than 20,000 pounds		Not accessible
Aircraft				
A1	Helicopter	Fuel capacity of 184 gallons and a maximum air speed of 117 mph. It would be carrying 800 pounds of explosives		With the proximity to downtown Portland, more attractive and visible targets exist.
A2	Small Plane	Fuel capacity of 56 gallons and a maximum air speed of 123 mph. It would be carrying 800 pounds of explosives		
A3	Regional Jet	Weighs 12,500 pounds with a fuel capacity of 1,200 gallons and a maximum air speed of 465 mph		
A4	Long Haul Jet	Weighs 450,000 pounds with a fuel capacity of 12,000 gallons and a maximum air speed of 530 mph.		

Threat Code	Threat	Description	Applies to City	Reason for Exclusion
Vehicle Borne Explosive				
V1	Car	Carries 400 pounds of explosives	X	
V2	Van	Carries 4,000 pounds of explosives		With the proximity to downtown Portland more attractive and visible targets exist.
V3	Midsize Truck	Carries 10,000 pounds of explosives		
V4	Semi-Trailer	Carries 40,000 pounds of explosives		
Assault Team				
AT1	1 Assailant	Active Shooter	X	
AT2	2-4 Assailants			Attack by trained and armed multi-assailant teams is not reasonable.
AT3	5-8 Assailants			
AT4	9-16 Assailants			
Specific Regional / Utility Specific Threats				
N(I)	Ice Storm	Severity level that results in a loss of electricity to the facility for greater than 24 hours.	X	
N(W)	Wind	Sustained winds in excess of 30 mph	X	

8.4 CLIMATE CHANGE VULNERABILITIES

Climate change affects the hydrologic cycle, source availability and demands, and ultimately the long-term quantity, quality, and reliability of water supplies. Addressing potential impacts on municipal water supply systems includes assessing risk and uncertainty, as well as improving resiliency and sustainability of water sources.

The following are predicted long-term climate trends for northwest Oregon with the potential to impact the availability and quality of surface water and groundwater sources (Mote et al., 2019; Oregon Climate Change Research Institute, 2019):

- Increased average annual air temperature and frequency of extreme heat events:
  - Increases in summer warming are projected to be of greater magnitude than winter warming.
  - Recent abnormally hot summers, like those experienced in 2015, 2017, and 2018, are expected to be the norm by the mid-21st century.
  - Elevated temperatures are likely to increase cyanobacterial blooms and cause other adverse impacts on surface water quality.
- Increased incidence of drought:
  - Several types of drought are predicted to increase, all of which can adversely affect overall water availability: low spring snowpack; high evaporative demand (spring/summer); low summer precipitation, moisture, and/or runoff; low annual to multi-annual precipitation.
  - Declines in snowpack are very likely, particularly in lower-elevation mountain regions.
- Increased frequency of extreme precipitation events and frequency and magnitude of damaging floods:

- Extreme events are predicted to be mostly likely in eastern Oregon, although localized impacts are anticipated for all regions.
- Average annual precipitation is not projected to change appreciably, but models suggest modest increases in winter precipitation and decreases in summer precipitation.

- Temporal changes in stream hydrology:
  - Annual stream flows are not projected to change substantially, but the timing and magnitude of seasonal runoff are expected to change, especially in mountainous regions: fall/winter flows are very likely to increase, whereas spring/summer flows are expected to decrease.

Regionally, these predicted climate change factors are expected to generally increase the demand for water, and to increase the competition over allocation for water. The following sections provide an overview of the City of Milwaukie's groundwater supply source, the potential vulnerabilities of the City's local groundwater source to climate change, and recommendations to evaluate and plan for climate change.

8.4.1 Potential Groundwater Vulnerabilities Due to Predicted Climate Change

Groundwater sources are expected to be less directly or less immediately affected by climate change than surface water sources will be. For example, seasonal drought typically leads to low flows in surface water sources, thus possibly reducing water availability from that source during and for some time after the drought. Surface water quality is also often degraded during drought. Most groundwater sources are relatively unaffected by short-term drought as adverse impacts tend to be delayed and attenuated because the overall timeframe of the hydrologic cycle is relatively long.

Despite inherently protective characteristics, the City of Milwaukie's groundwater supply system may be susceptible to climate change effects, as summarized in the sections below.

Potential Reduction in Groundwater Recharge and Availability

Predictions of less snowpack in the western Cascades and foothills, which are the primary recharge zones for the TGA and other Portland Basin aquifers, could lead to reduced recharge of those aquifers. The predicted increases in winter and spring rainfall events means much of the water that would otherwise infiltrate as snowmelt may instead be transported relatively rapidly out of upland recharge areas as surface water runoff, making it no longer be available for aquifer recharge.

Potential reduction of recharge due to climate change would likely occur on a decadal timescale; adverse impacts on groundwater availability would be correspondingly gradual. Due to inherent complexities in the overall hydrologic cycle, it is difficult to quantify and correlate any observed long-term declines in TGA water levels solely due to reduced aquifer recharge caused by climate change. Nonetheless, with predicted decreases in regional snowpack and increases in fall and winter rainfall events, the amount of water recharged to the TGA and other Portland Basin aquifers could decrease, resulting in corresponding long-term declines in groundwater availability.

Competing Groundwater Uses / Increased Groundwater Withdrawals

Several other municipal water providers pump groundwater from Portland Basin aquifers. These include the Portland Water Bureau, City of Fairview, City of Troutdale, and Rockwood Water Public Utility District. Some of these providers are expanding their pumping capacity, or in the case of the City of Gresham, planning to develop an independent groundwater source. Large-scale pumping by these municipalities places a collective demand on groundwater available in the aquifers. This overall demand is likely to increase with population increases predicted for the region, and in response to various climate change impacts (e.g., drought and less surface water availability).

However, these other municipal pumping centers are generally located in the northern and eastern portions of the Portland Basin, whereas the City of Milwaukie's supply wells are located several miles away near the southwestern margin of the basin. Furthermore, most existing large-scale municipal pumping is from the Sand and Gravel Aquifer, which is the deepest of several major aquifers and separated from the TGA by one or two major confining units. Thus, any potential increases in pumping stresses imposed on the Sand and Gravel Aquifer by other municipal providers would be less likely to directly impact groundwater availability in the shallower TGA.

There is fairly limited large-scale pumping from the TGA within or near the City. The other existing local groundwater uses are primarily industrial, commercial, manufacturing, and domestic. It is unlikely that significant future increases in local pumping from the TGA for these uses will occur due only to climate change reasons, and thus there is a low potential for any related adverse impacts on the City's long-term groundwater supply.

Potential Changes in Surface Water Flow Characteristics

With climate change, the frequency of both extreme precipitation events and drought conditions are expected to increase. These effects could adversely impact the availability and reliability of local surface water supplies: flood conditions could temporarily degrade surface water quality (e.g., excessively high turbidity) or damage infrastructure; whereas droughts could lead to reduced availability of surface water.

The City's redundant water supply sources could be adversely impacted by climate change. The City currently has emergency interties with the Clackamas River Water District and the Portland Water Bureau and is considering a possible future connection with Oak Lodge Water Services. The primary water source for all three of these providers is surface water: Bull Run for the Portland Water Bureau, and the Clackamas River for the Clackamas River Water District and Oak Lodge (the Portland Water Bureau also has a secondary groundwater source in the Columbia South Shore Wellfield). Therefore, any potential disruptions in the availability of those surface water sources would affect the City's emergency water supply options.

Future flooding of the Willamette River and local tributaries such as Kellogg Creek is unlikely to adversely impact the City's current groundwater supply system. The ground surface elevations at the City's wellheads are at least 100 feet above these local streams, and thus even extreme river flood events are unlikely to affect groundwater infrastructure. On the other hand, potential increases in the frequency and magnitude of localized street flooding could impact City wells and related infrastructure if local storm drainage capacity is exceeded during such events.

8.4.2 Recommendations to Evaluate and Plan for Climate Change

The following recommendations will help the City evaluate the impacts of climate change on its groundwater supply and plan for changes that will be needed in order to respond to climate change.

Employ a Groundwater Monitoring Program Focused on Identifying Long-Term Trends

Acquisition and compilation of groundwater level data is common during municipal pumping operations. However, the data are typically used for short-term operational decisions, not for long-term assessment of aquifer conditions. Possible future reductions in aquifer recharge or increases in large-scale pumping could lead to a reduction in overall groundwater availability in the TGA. It will become more important to obtain and regularly assess groundwater level data for potential aquifer-wide declining trends. These water-level data can be obtained from existing production wells, but measurements from dedicated observation wells that are not directly affected by pumping influences are preferable.

Assessment of monitoring data alone will likely not be able to differentiate potential aquifer declines due solely to climate change effects; such declines could instead be caused by changes in City pumping strategies, or by new groundwater users. However, climate change impacts could exacerbate or accelerate these other changes, so it will become more important to regularly assess long-term aquifer trends.

Maintain Redundant/Emergency Water Supply Agreements; Periodically Assess Capability and Reliability of Redundant Sources

The City's current emergency water supply sources are distributed among surface water sources (Bull Run, Clackamas River) that are sufficiently independent from the City's groundwater source (the Portland Water Bureau also has its own secondary groundwater source). It is highly unlikely that all of the City's primary and redundant water source options could become simultaneously unavailable due to climate change factors alone.

It is recommended that the City maintain its existing emergency intertie agreements. It is also recommended that the City periodically assess the capability and reliability of each of the redundant source options, particularly as primary demands on each of those systems are likely to increase in the future.

Implement a Proactive Water Conservation Program

As a member of the Regional Water Providers Consortium (RWPC), the City participates in the regional conservation education efforts. The City could consider developing a more proactive conservation more in line with activities of other RWPC members including:

- Indoor appliance rebate program
- Landscape irrigation management tool rebates
- Landscape modification rebates
- Landscape water audits
- Demonstration garden

- Indoor leak kit distribution
- Water use data billing inserts

It is also recommended that the City integrate conservation planning and tracking into future WMPs. While the Oregon Water Resources Department (OWRD) requires Water Management and Conservation Plans (WMCPs) addressing source of supply, demand projections, and conservation activities as a condition for new municipal water rights or a condition for obtaining permit extensions, the City has not triggered the requirement. Until the statutory requirement is triggered inclusion of the WMCP elements into the WMP will help the City plan, implement, and track conservation efforts and impact of those activities to identify those that are most cost effective.

Integrate Climate Related Design Standards into Facility Design

For public infrastructure sustainability will be a key issue in terms of sourcing materials, construction methods, and operation to minimize impact to the environment. Since these apply to rehabilitation, replacement, and new construction the impacts can be long-term but the opportunities for implementation are less frequent. Looking forward to a water system reflecting the City's sustainability objectives it is recommended that the City begin the integrate green requirements into its design practices and standards. These may include:

- Requiring design teams include LEED or ENVISION certified staff
- Adopting appropriate LEED certification that may include consideration of:
    - Location and transportation – Taking into consideration the location of your project and how it can be combined with the transportation option within the area, in other words how the users of the facility can get in and out of the facility
    - Materials and Resources- Use sustainable and earth-friendly products, while reducing waste
    - Water efficiency – Design features that reduces/reuses potable water usage
    - Energy and atmosphere – Enhanced energy performance
- Making ENVISION Sustainability Professional credentials a scored element of consultant selection.
- Implementing a triple bottom line evaluation of design alternatives that takes into account economic, social, and environmental impacts.

9. CAPITAL IMPROVEMENT PROGRAM

This chapter summarizes recommended capital improvements and planning level costs based on the analyses performed for this water master plan update. Table 9-1 (located at the end of this chapter) lists the improvements by category—source, storage, pumping, distribution, and planning and evaluation—with a schedule of expenditures for each. Projects not included in the first 10 years are long-range projects that may be included in subsequent 10-year CIPs depending on need. The following criteria were the basis for project selection priority:

- Compliance with regulatory/health and public safety requirements
- Seismic resiliency
- Transmission, distribution, and storage improvements
- Sources of supply to meet projected growth
- System reliability/repair
- Scheduling of project budgets for financing

Unless there was an identified need to implement a given improvement by a specific date, the projects were scheduled to equalize annual capital costs to the extent possible. This CIP is based on current system conditions and needs to provide a direction for City budgeting. As system needs change over the course of the planning period, projects may be combined, modified, or removed as necessary to address development, regulatory changes, and other future circumstances. Locations of distribution system improvement projects in the next 10 years are included in Appendix Q.

Planning-level cost estimates in 2021 dollars were developed for the projects identified in the 10- and 20-year planning windows to include:

- Mobilization (8 percent)
- Construction Contingencies (25 percent)
- Engineering, Architectural, Administration, and Legal Fees (20 percent)

The transmission and distribution main planning-level cost estimates consist of unit and lump-sum prices based on RS Means and recent bid tabulations for public works projects in Oregon and Washington. Cost estimates include:

- Furnishing and installation of piping
- Valves and fittings
- Gravel
- Asphalt repair
- Fire hydrant assemblies
- Construction contingency

- Engineering and administration.

Cost estimates were developed using the following assumptions as appropriate:

- All pipe is ductile iron, cement-mortar lined, AWWA Class 52.
- Pipe bedding will consist of 6 inches of crushed rock above and below the pipe.
- 10 percent of the pipeline trench length is backfilled with select imported backfill.
- Along arterials, 80 percent of the pipeline trench length is filled with controlled density backfill to a depth of 4 feet.
- Hydrant assemblies are installed every 800 feet.
- Isolation valves are installed every 600 feet.
- Where pipeline is in a roadway, asphalt restoration includes an 8-foot-wide patch of asphalt, 4 inches thick, overlying 6 inches of crushed surfacing. Concrete restoration includes a 10.5-foot-wide patch of concrete, 8 inches thick, overlying 6 inches of crushed surfacing.

Table 9-1. Capital Improvement Program

Capital Improvement Project					Recommended Schedule											
Title	**Description**	**Primary Material**	**Primary Installation Year**	**Purpose**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033-2038**	**2039-2042**
Source Improvements																
SS1	Unspecified miscellaneous equipment replacement and upgrades as needed.			Maintenance	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000		
SS2	Intertie Development			Resiliency			$100,000			$100,000				$100,000		
SS3	Re-establish the production of Well 8 to maximize supply			Supply		250,000										
SS4	HVAC upgrades all wellhouses			Maintenance	$100,000		$100,000		$100,000							
SS5	Well electrical upgrades			Operation		$75,000		$75,000		$75,000		$75,000		$75,000		
**	Well #4 Reconditioning			**	$60,000											
**	Well #7 Reconditioning			**	$60,000											
**	Well #3 Reconditioning			**		$60,000										
**	Well #5 Reconditioning			**				$60,000								
**	Well #6 Reconditioning			**						$60,000						
**	Well #2 Building improvements			**				$100,000								
**	CRW / Oak Lodge Intertie			**		$122,000										
Treatment Improvements																
T1	WTP 235 generation replacement/ relocation and automatic transfer switch/ blower replacement/striping tower replacement and expansion of additional tower/conversion to sodium hypochlorite			Ops, Capacity				$1,600,000								
T2	WTP 47 generation replacement/ relocation and automatic transfer switch/ blower replacement/striping tower replacement and expansion of additional tower/conversion to sodium hypochlorite			Ops, Capacity					$1,600,000							
Storage Improvements																
S1	Stanley Reservoir: 3.0 MG tank recoating. Modernize mixing system			Seismic Resilience	$1,335,000	$1,335,000										
S2	Construct additional 3MG storage reservoir to address storage deficiency in Zone 2			Capacity Deficiency							$1,000,000	$5,500,000				
S3	Concrete Tank liner replacement (per Potable Divers Inc. Report July 2020) and external appurtenances. Add galvanized steel seismic cables at the wall base and foundation. Add circumferential steel strand prestressing and shotcrete to the outside face of the concrete wall or add FRP jacketing to one or both faces of the concrete, and add a reinforced concrete curb around the perimeter of the base of the wall.			Maintenance	$600,000											
Pumping Improvements																
P1	Address deferred maintenance			Maintenance	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000		
P2	Replace W2 PS with two 3,000 gpm pumps.			Capacity			$1,500,000									
P3	Replace the 3rd Zone PS with two 2,000 gpm pumps			Capacity					$1,200,000							
P4	Replace the W6 PS with two 2,000 gpm pumps.			Capacity										$1,200,000		
P5	Lava Pump Station backup generator			Ops			$97,000									
Distribution Improvements																
D1	This improvement in Waverly Court has been identified as part of a different City project and is therefore removed from the CIP for this plan.	CAS	1952													
D2	Replace 10-inch pipe with 650 feet of 12-inch pipe on Main St. Replace 6,10-inch pipe with 890 feet of 12-inch pipe on Ochoco St. Replace 6,10-inch pipe with 1000 feet of 12-inch pipe on Moores St. Replace 6-inch pipe with 450 feet of 12-inch pipe on 25th Ave.	CAS, Unknown	1952	Fire Flow				$1,041,850								
D3	Install 1470 feet of 12-inch pipe on Firwood St.	NA	NA	Fire Flow					$511,050							
D4	Install 800 feet of 12-inch pipe on Flavel Dr.	NA	NA	Fire Flow					$280,000							
D5	Replace 4-inch pipe with 500 feet of 8-inch pipe on Winworth Ct.	Unknown	1962	Fire Flow						$125,500						
D6	Install 750 feet of 12-inch pipe on 23rd Ave. Replace 6-inch pipe with 600 feet of 12-inch pipe on Clatsop St. Replace 6-inch pipe with 660 feet of 12-inch pipe on Loughlin Blvd.	CAS, Unknown	1960, 1980	Fire Flow					$700,150							
D7	Replace 4-inch pipe with 240 feet of 8-inch pipe on Elk St. Install 380 feet of 8-inch pipe on 51st St. Install 380 feet of 8-inch pipe on 52nd Ave.	C900	1999	Fire Flow			$252,000									
D8	Replace 4-inch pipe with 260 feet of 8-inch pipe on 44th Ave. Replace 4-inch pipe with 440 feet of 8-inch pipe on Howe Ln. Replace 4-inch pipe with 260 feet of 8-inch pipe on 46th Ave.	CAS	1954	Fire Flow					$239,800							

Capital Improvement Project					Recommended Schedule											
Title	Description	Primary Material	Primary Installation Year	Purpose	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033-2038	2039-2042
D9	Replace 6-inch pipe with 360 feet of 8-inch pipe on Drake St. Replace 4, 6-inch pipe with 780 feet of 8-inch pipe on 38th Ave.	CAS, Unknown	1955, 1966	Fire Flow									$286,700			
D10	Replace 16-inch transmission main from the Concrete Reservoir to Zone 2 with 3800 feet of 18-inch pipe.	CAS	1950	Transmission						$1,786,000						
D11	Replace 6-inch pipe with 1550 feet of 8-inch pipe on Adams St. Replace 6-inch pipe with 300 feet of 8-inch pipe on 47th Ave. Replace 6-inch pipe with 900 feet of 8-inch pipe on Ada Ln. Replace 4, 6-inch pipe with 1010 feet of 8-inch pipe on Rio Vista St. Replace 6-inch pipe with 190 feet of 8-inch pipe on Washington St.	Unknown	1954, 1964	Fire Flow						$993,250						
D12	Replace 6-inch pipe with 800 feet of 16-inch pipe on Oak St. Replace 6-inch pipe with 550 feet of 16-inch pipe on Campbell St. Replace 8-inch pipe with 220 feet of 12-inch pipe in the Industrial Area. Replace 8-inch pipe with 1820 feet of 16-inch pipe in the industrial area west of 37th Ave. Replace 6-inch pipe with 240 feet of 12-inch pipe on Oak St. Replace 4-inch pipe with 800 feet of 8-inch pipe on Myrtle St.	CAS, DIP	1930, 1981	Fire Flow					$1,722,950							
D13	Replace 10-inch pipe with 300 feet of 16-inch pipe on Sparrow St. Replace 10-inch pipe with 250 feet of 16-inch pipe on Lakewood Dr. Replace 10-inch pipe with 850 feet of 16-inch pipe off road. Install PRV at Oatfield Rd and Guildford Ct. Replace 6-inch pipe with 330 feet of 16-inch pipe at Kellogg Lake Apartments. Replace 10-inch pipe with 380 feet of 16-inch pipe on Oatfield Rd. Install PRV at Lakewood Dr and McLoughlin Blvd.	Unknown, DIP	1969, 1980s	Fire Flow							$1,165,150					
D14	Install 450 feet of 8-inch pipe between Roswell St and Boyd St.	NA	NA	Fire Flow		$113,750										
D15	Replace 4-inch pipe with 220 feet of 12-inch pipe on 54th Ave. Install 340 feet of 12-inch pipe between Woodhaven St and Harlene St. Replace 4-inch pipe with 1010 feet of 12-inch pipe on Woodhaven St.	CAS	1961	Fire Flow												$590,500
D16	Replace 4-inch pipe with 180 feet of 8-inch pipe on 30th Ave.	C900	1993	Fire Flow										$43,900		
D17	Replace 4-inch pipe with 180 feet of 8-inch pipe on 31st Ave.	C900	1993	Fire Flow										$43,900		
D18	Replace 4-inch pipe with 300 feet of 8-inch pipe on 55th Ave.	C900	1995	Fire Flow										$76,500		
D19	Replace 6-inch pipe with 470 feet of 8-inch pipe on 41st Ct.	Unknown	1969	Fire Flow										$118,850		
D20	Install 580 feet of 16-inch pipe on Minthorn Springs. Replace 10, 12-inch pipe with 3600 feet of 16-inch pipe on International Way. Replace 8-inch pipe with 670 feet of 16-inch pipe on Minthorn Loop. Replace 6-inch pipe with 400 feet of 8-inch pipe in the industrial area east of 37th Ave.	DIP	1979 - 1990	Fire Flow						$2,182,250						
D21	Replace 6-inch pipe with 250 feet of 8-inch pipe on 47th Ave. Replace 4, 6-inch pipe with 1750 feet of 8-inch pipe on Fieldcrest Dr. Replace 6-inch pipe with 1120 feet of 8-inch pipe on Fieldcrest Ave.	Unknown	1958	Fire Flow							$782,600					
D22	Install 440 feet of 8-inch pipe on Llewellyn St.	Unknown	1936	Fire Flow											$109,200	
D23	Replace 6, 8-inch pipe with 1660 feet of 12-inch pipe on King Rd. Replace 8-inch pipe with 1300 feet of 12-inch pipe on Llewellyn St. Replace 8-inch pipe with 670 feet of 12-inch pipe on Harrison St. Replace 4, 10-inch pipe with 270 feet of 12-inch pipe on 42nd Ave.	Unknown	1930, 1937	Fire Flow									$1,358,500			
D24	Replace 6-inch pipe with 710 feet of 8-inch pipe on 30th Ave. Replace 6-inch pipe with 520 feet of 8-inch pipe on Sellwood St. Replace 6-inch pipe with 560 feet of 8-inch pipe on 32nd Ave. Replace 6-inch pipe with 250 feet of 8-inch pipe on Wister St.	Unknown, DIP	1930, 1984	Fire Flow									$511,200			
D25	Reconnect King Rd Hydrants to 10-inch line.	NA	NA	Fire Flow									$19,400			
D26	Replace 8-inch pipe with 420 feet of 12-inch pipe on Grogran St. Replace 4, 6-inch pipe with 1280 feet of 12-inch pipe on 36th Ave.	CAS, Unknown	1960, 1975	Fire Flow												$590,500
D27	Replace 4-inch pipe with 330 feet of 8-inch pipe on 36th Ave.	Unknown	1956	Fire Flow											$83,150	
D28	Replace 4-inch pipe with 700 feet of 8-inch pipe on Balfour St.	CAS	Unknown	Fire Flow											$175,500	
D29	Install 240 feet of 8-inch pipe between 63rd and 64th Ave.	NA	NA	Fire Flow											$60,200	
D30	Replace 6-inch pipe with 430 feet of 8-inch pipe on Northridge Dr. Replace 6-inch pipe with 630 feet of 8-inch pipe on 41st Ct.	Unknown	1979, 1990	Fire Flow												$265,300
D31	Replace 6-inch pipe with 340 feet of 8-inch pipe on Hunter St.	CAS	1964	Fire Flow											$84,700	
D32	Install 380 feet of 8-inch pipe between 41st Ave and 42nd Ave at Meadowcrest Ct.	NA	NA	Fire Flow											$95,900	
D33	Replace 6-inch pipe with 360 feet of 12-inch pipe on 32nd Ave.	CAS, Unknown	1930, 1950	Fire Flow											$125,400	
D34	Install 410 feet of 12-inch pipe between Wichita Ct and Woodhaven St.	NA	NA	Fire Flow											$143,150	
D35	Replace 10-inch pipe with 600 feet of 12-inch pipe on 26th Ave.	Unknown	1969	Fire Flow												$209,000
D36	Install 390 feet of 12-inch pipe from the industrial area to Railroad Ave.	NA	NA	Fire Flow											$136,850	
D37	Replace 6-inch pipe with 630 feet of 8-inch pipe on 30th Ave. Replace 6-inch pipe with 400 feet of 8-inch pipe on Madison St. Replace 6-inch pipe with 300 feet of 8-inch pipe on Washington St.	CAS	1930	Fire Flow												$335,150
D38	Replace 6-inch pipe with 550 feet of 8-inch pipe on 29th Ave. Replace 6-inch pipe with 270 feet of 10-inch pipe on Washington St.	CAS	1930	Fire Flow												$221,550
D39	Install 352 feet of 8-inch pipe at Quail Ridge Apartments.	NA	NA	Fire Flow											$88,560	

Capital Improvement Project					Recommended Schedule											
Title	Description	Primary Material	Primary Installation Year	Purpose	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033-2038	2039-2042
D40	Replace 12-inch pipe with 1280 feet of 12-inch pipe on Hanna Harvester Dr.	CAS	1950	Fire Flow												$445,200
D41	Replace 4-inch pipe with 240 feet of 8-inch pipe on Waymire St.	Unknown	1956	Fire Flow												$60,200
D42	Replace 6-inch pipe with 350 feet of 8-inch pipe on Oxford Ln.	Unknown	1952	Fire Flow												$88,250
D43	Install 310 feet of 8-inch pipe between Brookside Apartments and Brookside Dr.	NA	NA	Fire Flow												$78,050
D44	Install 500 feet of 8-inch pipe on Se Furnberg St.	NA	NA	Fire Flow												$125,500
D45	Replace 8-inch pipe with 90 feet of 12-inch pipe on McLoughlin Blvd. Replace 8-inch pipe with 40 feet of 12-inch pipe on Washington St.	Unknown	1980	Fire Flow												$44,950
D46	Replace 6-inch pipe with 410 feet of 8-inch pipe on 41st Ave.	Unknown	Unknown	Fire Flow												$102,550
D47	Replace 6-inch pipe with 350 feet of 8-inch pipe on 29th Ave.	Unknown	1930	Fire Flow											$88,250	
D48	Install 800 feet of 12-inch pipe on Stanley Place.	NA	NA	Fire Flow											$280,000	
D49	Install 850 feet of 12-inch pipe between Riverway Ln and 17th Ave.	NA	NA	Fire Flow												$295,750
D50	Install 960 feet of 12-inch pipe on Monroe St.	NA	NA	Fire Flow												$335,400
D51	Replace 6-inch pipe with 460 feet of 8-inch pipe on White Lake Rd.	Unknown	Unknown, 1957	Fire Flow												$115,300
D52	Install 570 feet of 12-inch pipe on Clackamas Hwy.	NA	NA	Fire Flow												$198,550
D53	Replace 8-inch pipe with 550 feet of 12-inch pipe on Frontage Ave. Replace 8-inch pipe with 210 feet of 12-inch pipe on Milport Rd.	SP, Unknown	1952, 1969	Fire Flow												$264,400
D54	Replace 8-inch pipe with 255 feet of 12-inch pipe on 23rd Ave. Replace 6-inch pipe with 340 feet of 12-inch pipe on Adam St.	CAS	1956	Fire Flow												$270,925
D55	Install 380 feet of 8-inch pipe on 21st Ave to Main St.	NA	NA	Fire Flow												$95,900
D56	Install 340 feet of 8-inch pipe on 56th Ave to Beckman Ave.	NA	NA	Fire Flow												$84,700
D57	Install 330 feet of 12-inch pipe on Deering Ct to Linwood Ave.	NA	NA	Fire Flow												$114,950
D58	Install 450 feet of 12-inch pipe on 60th Ave to Linwood Ave.	NA	NA	Fire Flow												$156,750
**	Logus Road & 40th improvements			**	$262,000											
**	Milwaukie/El Puente SRTS improvements			**	$290,000											
**	Ardenwald South improvements			**		$832,000										
**	Waverley South improvements			**	$115,000											
**	International Way improvements			**		$277,000										
**	Monroe Street extension			**		$321,000										
**	Stanley Street extension			**		$88,000										
**	SAFE & SSMP FY 2025 improvements			**			$1,128,000									
**	Oatfield Rd & Shell Lane improvements			**				$100,000								
SCADA Upgrades and Maintenance																
	SCADA Implementation and Support			Ops		$40,000	$40,000	$40,000	$40,000	$40,000						$250,000
	Ongoing automation and control upgrades			Ops	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$250,000	$250,000
**	SCADA Design and construction			**												
Planning and Evaluation Studies																
PE1	Update existing Water System Plan.			Planning							$250,000					
PE2	Long-term Climate Change Vulnerabilities and Alternatives Study. Develop comprehensive evaluation based on available science to evaluate climate changes scenarios and the impact on the City's water supply and identify potential long-range alternatives to meet water demand.			Planning				$200,000								
PE3	Perform system wide seismic evaluation.			Evaluation							300000					
PE4	Planning and securing of additional water rights			Supply			$25,000	$25,000	$25,000	$25,000						
PE5	Revised Lead and Copper Rule Compliance Study			Compliance	125,000											
				Total Cost	**$3,057,000**	**$3,623,750**	**$3,352,000**	**$3,315,850**	**$6,528,950**	**$5,497,000**	**$3,607,750**	**$5,685,000**	**$2,285,800**	**$1,768,150**	**$1,720,860**	**$5,589,325**

** Water system projects previously identified in the City's 2022-2026 Capital Improvement Plan

10. Utility Rates and CIP Funding Options

Water system require continuous reinvestment in existing assets as well as financing for capital improvements to expand the system and replace assets beyond their service life. Therefore, financial viability is critical to management of the water system in order to meets customer needs. A water system remains financially viable and addresses operation and maintenance needs through rates and charges associated with water usage and system accessibility. Capital improvements addressing new/replaced facilities are often addressed through a combination of rates, system development charges, loans, grants, and municipal bonds. This section outlines the City's current rate structure and funding mechanisms for capital improvements.

10.1 WATER UTILITY RATE STRUCTURE

The City employs a base rate - usage rate structure that charges customers a fixed rate based on meter size plus a consumption charge. The consumption rate is differentiated based on user class and usage. For single-family residential customers a single-step increasing block rate approach charges customers at an initial rate per 100 cubic feet (ccf) for up to the first four ccf. The per ccf rate increases for additional demand above four ccf. Multi-family and commercial customers are charged a flat consumption rate for all usage. The City bills monthly based on actual usage. Table 10-1 and Table 10-2 summarize the current rate structure.

10.2 CAPITAL FUNDING RESOURCES

In addition to cash financing resulting from water rates, the City may use multiple sources to fund the water capital improvement program described in below.

10.2.1 Government Programs

Federal and state grant programs were historically available to local utilities for capital funding assistance. However, these assistance programs have been mostly eliminated, significantly reduced in scope and amount, or replaced by low-interest loan programs. Remaining grants programs are usually lightly funded and heavily subscribed. Nonetheless, even the benefit of low-interest loans makes the effort of applying worthwhile. Funding programs for which the District might be eligible include:

Table 10-1. Water Rate Unit Charges by Meter Size (Residential and Commercial) for 2020

Meter Size (inches)	Capacity Charge per Meter	Consumption Charge per Unit
5/8" - 3/4"	$8.69	Single-family Residential $3.94/ccf for < 3 ccf/month $4.07/ccf for >3 ccf/month Single family low use discount ($5.00) < 3 ccf/month Multi-family/Commercial $4.07/ccf
1"	$13.08	
1 ½"	$22.34	
2"	$33.90	
3"	$93.72	
4"	$164.62	
6"	$281.84	

Table 10-2. Fixed Charges for Standby Fire Flow Service for 2020

Connection Size (inches)	Fixed Charge
2"	$12.95
4"	$46.64
6"	$67.92
8"	$92.18
10"	$116.46
12"	$147.74

Special Public Works Fund

The Special Public Works Fund provides funds for publicly owned facilities that support economic and community development in Oregon. Funds are available to public entities for:

- Planning
- Designing
- Purchasing
- Improving and constructing publicly owned facilities
- Replacing publicly owned essential community facilities
- Emergency projects as a result of a disaster

Municipally incorporated entities as defined in Oregon Revised Statute (ORS) are eligible to receive funds, including the following:

- Cities (ORS 221), Counties (ORS 201), Special Districts (ORS 198), and Ports (ORS 777)
- Tribal Councils
- Domestic water supply districts (ORS 264) and water authority (ORS 450)
- Sanitary districts (ORS 450) and sanitary authority (ORS 450)
- Joint water and sanitary authority (ORS 450)
- County service districts (ORS 451)
- Airport districts (ORS 838)

Loan funding up to a $10 million maximum is available for financing small to large projects with very favorable interest rates and terms up to 30 years for most projects. Limited grant funding is available for technical assistance and emergency projects based on financial analysis.

Specific information can be obtained through contacting Economic Development Division staff at http://www.oregon4biz.com/directory.php?d=1.

Drinking Water Revolving Fund Loan and Drinking Water Source Protection Fund Programs.

These loan programs fund drinking water system improvements needed to maintain compliance with the federal Safe Drinking Water Act.

- The Safe Drinking Water Revolving Loan Fund is designed for collection, treatment, distribution, and related infrastructure projects.
- The Drinking Water Source Protection Fund is designed for the protection of drinking water sources.

The Safe Drinking Water Fund is funded by yearly grants from the EPA and matched with funds from the state Water/Wastewater Financing Program. The program is managed by the Oregon Health Authority, Drinking Water Services and the loans are managed by the Oregon Infrastructure Finance Authority. Safe Drinking Water letters of interest are due quarterly on March 15, June 15, September 15, and December 15.

Funding is available for all sizes of water systems, although 15 percent of the funds are reserved for systems serving a population of fewer than 10,000. Water systems that provide service to at least 25 year-round residents or systems that have 15 or more connections (or a non-profit with 25 or more regular users) are eligible. Owners can be a non-profit, private party or municipality, but systems cannot be federally owned or operated.

A funded project must solve an existing or potential health hazard or noncompliance issue under federal/state water quality standards. The following are the main types of eligible activities:

- Engineering, design, upgrade, construction or installation of system improvements and equipment for water intake, filtration, treatment, storage, transmission
- Acquisitions of property or easements
- Planning, surveys, legal/technical support, and environmental review
- Investments to enhance the physical security of drinking water systems, as well as water sources

The program provides up to $6 million per project (more with proper additional approval) with the possibility of subsidized interest rate and principal forgiveness for a Disadvantaged Community. The standard loan term is 20 years or the useful life of project assets, whichever is less, and may be extended up to 30 years under the Safe Drinking Water Revolving Loan Fund for a Disadvantaged Community. Interest rates are 80 percent of state/local bond index rate.

More information regarding these two programs is available at https://www.orinfrastructure.org/Infrastructure-Programs/SDW/.

Rural Economic Development Loan & Grant Program in Oregon

The Rural Economic Development Loan and Grant program provides funding for rural projects through local utility organizations. The U.S. Department of Agriculture (USDA) provides zero-interest loans to local utilities which they, in turn, pass through to local businesses (ultimate recipients) for projects that will create and retain employment in rural areas. The ultimate recipients repay the lending utility directly. The utility is responsible for repayment to USDA.

USDA provides grants to local utility organizations which use the funding to establish revolving loan funds (RLF). Loans are made from the revolving loan funds to projects that will create or retain rural jobs. When the revolving loan fund is terminated, the grant is repaid to USDA.

To receive funding an entity must be:

- A former Rural Utilities Service borrower who borrowed, repaid or pre-paid an insured, direct, or guaranteed loan
- Nonprofit utilities that are eligible to receive assistance from the Rural Development Electric or Telecommunication Programs; or
- Current Rural Development Electric or Telecommunication Programs borrowers

Intermediaries may use funds to lend for projects in rural areas or towns with a population of 50,000 or less. Up to $300,000 in grants may be requested to establish the RLF; up to 10 percent of grant funds may be applied toward operating expenses over the life of the RLF; and up to $2 million in loans may be requested. The intermediary applies to USDA for funding support on behalf of specified local projects. Projects may begin after an application is submitted, but there is no guarantee of approval.

Examples of eligible projects include:

- Business incubators
- Community development assistance to nonprofits and public bodies (particularly for job creation or enhancement)
- Facilities and equipment to educate and train rural residents to facilitate economic development
- Facilities and equipment for medical care for rural residents
- Start-up venture costs, including, but not limited to, financing fixed assets such as real estate, buildings, equipment or working capital
- Business expansion
- Technical assistance

Community Development Block Grant Program

Grants and technical assistance are available to develop livable urban communities for persons of low and moderate incomes by expanding economic opportunities and providing housing and suitable living environments.

The application period opens annually on October 1 and closes December 31. Non-metropolitan cities and counties in rural Oregon can apply for and receive grants. All projects must meet one of three national objectives:

- The proposed activities must benefit low- and moderate-income individuals.
- The activities must aid in the prevention or elimination of slums or blight.
- There must be an urgent need that poses a serious and immediate threat to the health or welfare of the community.

Funding amounts are based on:

- The applicant's need
- The availability of funds
- Other restrictions defined in the program's guidelines.

The maximum grants possible for any individual project are:

- Public works water and wastewater Improvements $2,500,000
- Public works preliminary/engineering planning $150,000
- Community/Public facilities: $1,500,000
- Emergency projects $500,000

Detailed information on Community Development Block Grant funding is available at orinfrastructure.org/Infrastructure-Programs/CDBG.

The Water Infrastructure Finance and Innovation Program

The Water Infrastructure Finance and Innovation Act of 2014 (WIFIA) established the WIFIA program, a federal credit program administered by the EPA for eligible water and wastewater infrastructure projects. WIFIA and the WIFIA implementation rule outline the eligibility and other requirements for prospective borrowers. Eligible borrowers are:

- Local, state, tribal, and federal government entities
- Partnerships and joint ventures
- Corporations and trusts
- Clean Water and Drinking Water State Revolving Fund (SRF) programs

The WIFIA program can fund development and implementation activities for eligible projects:

- Projects that are eligible for the Clean Water SRF, notwithstanding the public ownership clause
- Projects that are eligible for the Drinking Water SRF
- Enhanced energy efficiency projects at drinking water and wastewater facilities
- Brackish or seawater desalination, aquifer recharge, alternative water supply, and water recycling projects
- Drought prevention, reduction, or mitigation projects
- Acquisition of property if it is integral to the project or will mitigate the environmental impact of a project
- A combination of projects secured by a common security pledge or submitted under one application by an SRF program

Eligible development and implementation activities are:

- Development phase activities, including planning, preliminary engineering, design, environmental review, revenue forecasting, and other pre-construction activities
- Construction, reconstruction, rehabilitation, and replacement activities
- Acquisition of real property or an interest in real property, environmental mitigation, construction contingencies, and acquisition of equipment
- Capitalized interest necessary to meet market requirements, reasonably required reserve funds, capital issuance expenses and other carrying costs during construction

Important program features include:

- $5 million minimum project size for communities of 25,000 or less.
- The maximum portion of eligible project costs that WIFIA can fund is 49%.
- Total federal assistance may not exceed 80% of a project's eligible costs.
- Maximum final maturity date from substantial completion is 35 years.
- Maximum time that repayment may be deferred after substantial completion project is 5 years.
- Interest rate will be equal to or greater than the U.S. Treasury rate of a similar maturity at the date of closing.
- Projects must be creditworthy and have a dedicated source of revenue.
- National Environmental Protection Act, Davis-Bacon, American Iron and Steel, and all other federal crosscutter provisions apply.

10.2.2 Bond Financing

Revenue bonds, secured by revenues of the issuing utility, are commonly used to fund capital improvements that exceed a utility's financial resources. With this limited commitment, revenue bonds typically bear higher interest rates than other types of debt and often require additional security measures to protect bondholders from default risk. Such measures may include the maintenance of dedicated reserves and minimum financial performance standards (e.g. bond debt service coverage).

Oregon law does not require a public vote for issuing revenue bonds. While there is no explicit statutory bonding limit, the conditions that come with revenue bonds often impose practical limits on a utility's level of indebtedness. Excessive levels of debt may reduce flexibility to phase in rate increases as well as increase the overall cost of capital investment given the related interest payments. It is important to note that bond rating agencies also consider debt service coverage when assigning a debt rating - higher levels of indebtedness make it more difficult for a utility to meet the coverage ratios that the rating agencies require for the highest rating. In recent years, the coverage ratios required for higher ratings have often exceeded the minimum legal standards outlined in the applicable bond covenants. Ratings are financially important because higher ratings generally provide access to lower interest rates.

10.2.3 System Development Charges

System development charges (SDCs) are one-time charges assessed on new development (growth) to pay for the costs of expanding public facilities. Growth creates additional infrastructure demands; SDCs provide a mechanism to allow new growth in a community to pay for its share of infrastructure costs rather than existing taxpayers or utility ratepayers. The City's current water system SDC rate charges are summarized in Table 10-3.

Table 10-3. City of Milwaukie 2020 water utility SDC rates.

Meter Size (inches)	Fee ($)			
	Reimbursement	Improvement	Administration	TOTAL
¾ x ¾	1,007	836	141	1,984
1	1,678	1,396	236	3,310
1.5	3,357	2,788	470	6,615
2	5,369	4,464	754	10,587
3	10,738	8,925	1,505	21,168
4	16,779	13,946	2,353	33,078
6	33,556	27,895	4,707	66,158
8	53,691	44,632	7,530	105,853
10	77,179	64,158	10,825	152,162
12	151,005	125,529	21,178	297,712

The idea behind SDCs is that long-time residents have "paid their way" through property taxes, utility rates, and other means for the systems that are already in place. If those systems need to be expanded to accommodate growth, it is not paid for at the expense of the existing population.

State law authorizes SDCs collection for growth-related expansion of water, sewer, parks, transportation, and storm water management systems. State law has strict provisions that require a city to develop a formula or methodology that takes into account the value of existing or planned capacity in the infrastructure system to serve new development. Oregon law allows that an SDC may include a reimbursement fee, an improvement fee, or a combination of the two.

The reimbursement fee is based on the value of available reserve capacity for capital improvements already constructed or under construction. The methodology must consider the cost of existing facilities, prior contributions by existing users, the value of unused capacity, grants, and other relevant factors.

The improvement fee is designed to recover all or a portion of the costs of planned capital improvements that add system capacity to serve future development. The methodology must be designed in a manner that SDCs will not exceed the growth-related costs from the capital project list.

Reimbursement fee revenue may be spent only on capital improvements associated with the system for which the particular SDC is assessed including expenditures relating to repayment of indebtedness.

Improvement fee revenue may be spent only on capacity-increasing capital improvements on the project list (refer to each methodology), including expenditures relating to repayment of debt for such improvements.

By state law, revenue from SDCs may not be used to repair existing infrastructure or to otherwise address existing deficiencies. In addition, SDC expenditures are limited by type (water SDCs cannot be used for sewer projects, sewer SDCs cannot be used for water projects, etc.).

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