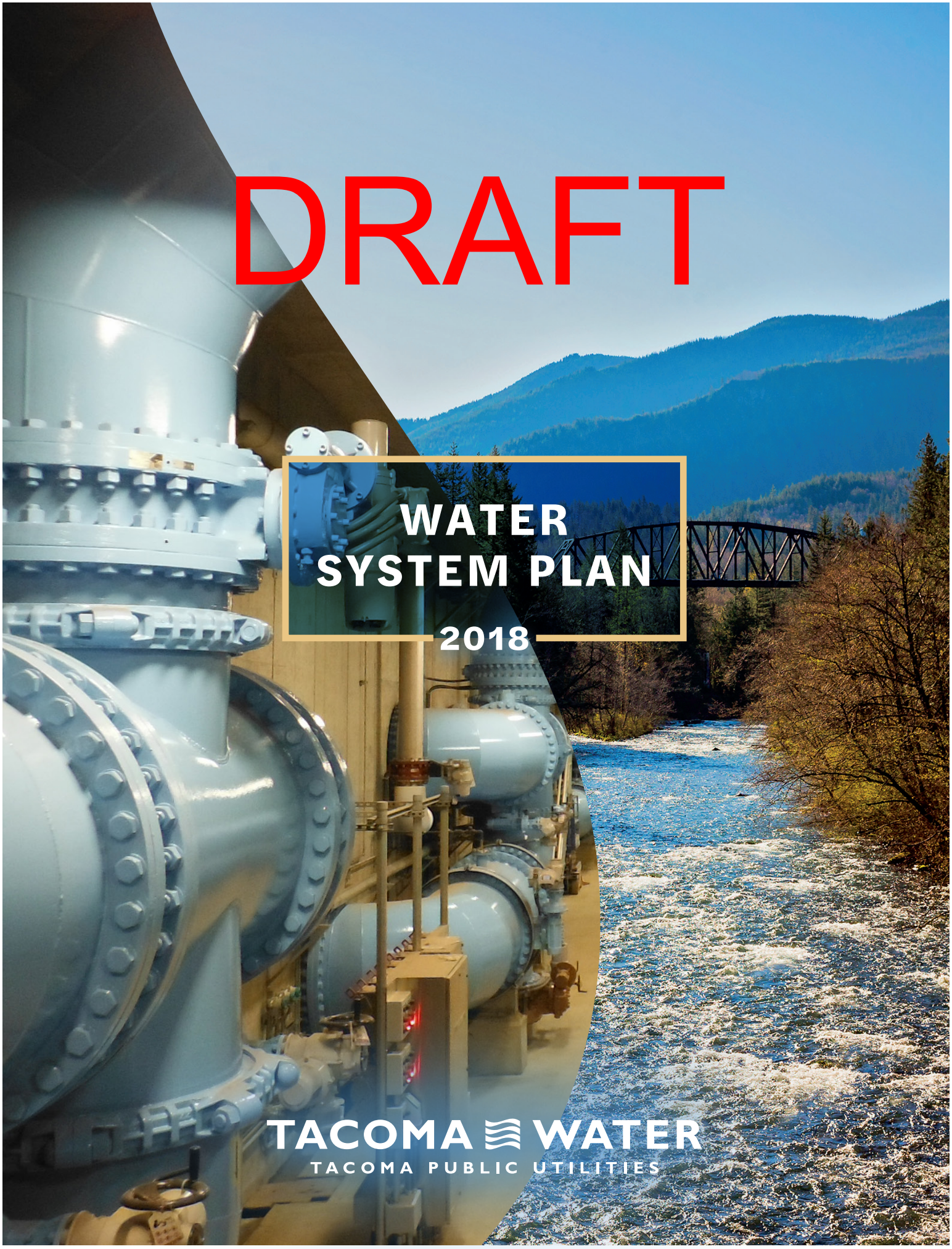
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TACOMA PUBLIC UTILITIES

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2018 Water System Plan

Updated February 2019

TACOMA WATER
TACOMA PUBLIC UTILITIES

HDR

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Certification of Adoption by Public Utility Board

To Be Provided for Final

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Certification of Adoption by City Council

To Be Provided for Final

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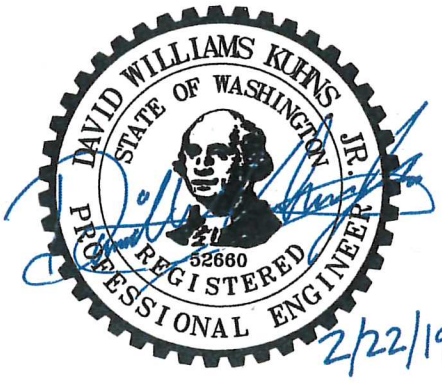
Engineer Certification

This 2018 Water System Plan Update for Tacoma Water was prepared by HDR, Inc., and Tacoma Water staff under the direction of the following Registered Professional Engineers:



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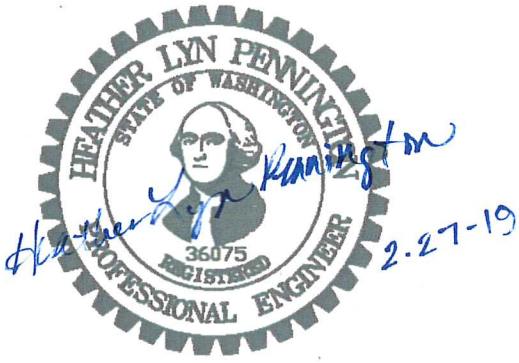

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Table of Contents

Tables

Figures

Appendices

Appendix A: Consistency Statement, Correspondence, Plan Comments and Public Information Materials
- A1 – Consistency Statement
- A2 – Correspondence
- A3 – Water System Plan Comments
- A4 – Public Meeting Information Materials

Appendix B. Checklists (DOH, Counties, SEPA)

Appendix C. Capital Improvement Program Needs Assessment

Appendix D: Interties

Appendix E: Watershed Management Plan

Appendix F: Water Rights Self-Assessment

Appendix G: Storage Capacity Analysis Results

Appendix H: Source Capacity Analysis

Appendix I: Distribution System Analysis
- I1 – Modeled Demands
- I2 – Peak Hour Demand Assessment
- I3 – Maximum Day Demand + Fire Flow Assessment
- I4 – Model Update Technical Memo
- I5 – Model Calibration Technical Memo

Appendix J: Sanitary Surveys

Appendix K: Wellhead Protection Program

Appendix L: Demand Forecast
- L1 – 2015 Demand Forecast
- L2 – Water System Plan Demands Metadata

Appendix M: Service Area
- M1 – Water Service Area Agreements List
- M2 – Service Area Map

Appendix N: King County Water Reclamation Evaluation Checklist

Links to Relevant Materials

**Some of these links are only available if the Water System Plan is opened directly from a CD issued by Tacoma Water.*

Chapter 1:
- Water System Plan: http://MyTPU.org/WaterSystemPlan
- Tacoma Water Strategic Plan*
- 2017 Strategy Map*

Chapter 2:
- Second Supply Project Partnership Agreement: https://www.mytpu.org/file_viewer.aspx?id=6023
- Water Supply Forum: http://www.watersupplyforum.org/
- Customer Service Policies: https://www.mytpu.org/file_viewer.aspx?id=59028

Chapter 3:
- Midnight Report: https://www.mytpu.org/tacomawater/AWSP-Resource-Agencies.htm
- Pierce County Buildable Lands Report 2014: http://www.co.pierce.wa.us/DocumentCenter/View/30444
- Pierce County Community Plans: http://www.co.pierce.wa.us/925/Adopted-Community-Plans
- Puget Sound Regional Council Vision 2040: https://www.psrc.org/vision-2040-documents
- Water Conservation Plan: https://www.mytpu.org/file_viewer.aspx?id=70625

Chapter 4:
- Tacoma Water Shortage Response Plan: https://www.mytpu.org/tacomawater/water-source/water-supply-outlook/water-shortage-response.htm
- Integrated Resources Plan: https://www.mytpu.org/file_viewer.aspx?id=70623
- Pierce County Unified Sewer Plan: http://www.co.pierce.wa.us/3108/Unified-Sewer-Plan
- Chambers Creek Regional Park Master Site Plan: https://www.cityoflakewood.us/documents/community_development/Documents/Chambers_Creek_Master_Site_Plan_Council_Presentation_060517.pdf

Chapter 5:
- Schematic Diagram: Gravity, Wells and Distribution System*
- Schematic Diagram: Gravity, Wells and Distribution System Details*
- Drawing 17-56-1: Standard Details*
- Customer Service Polices: https://www.mytpu.org/file_viewer.aspx?id=59028
- TMC 12.10 Water – Regulations and Rates: https://www.mytpu.org/file_viewer.aspx?id=58976

Chapter 7:
- DOH Sentry Internet Database: https://fortress.wa.gov/doh/eh/portal/odw/si/Intro.aspx
- Tacoma Water's Water Quality Website: https://www.mytpu.org/tacomawater/water-quality/

Chapter 8:
- Customer Service Policies: https://www.mytpu.org/file_viewer.aspx?id=59028
- Cross-connection Control Webpage: https://www.mytpu.org/tacomawater/water-quality/cross-connection-control/
- Cross-Connection Control Plan*
- Habitat Conservation Plan: https://www.mytpu.org/file_viewer.aspx?id=63671

Chapter 9:
- Forum resiliency study and associated technical memoranda for each of the 4 risks: http://www.watersupplyforum.org/home/resiliency.html

- Seismic Vulnerability Assessment*

Chapter 10:
- Asset Management Philosophy and Framework*
- Asset Management Roadmap and Initiatives*
- Strategic Maintenance Management Program*
- Tacoma Water Strategic Plan*

Chapter 11:
- City of Tacoma 2017-2022 Capital Facilities Program*
- Tacoma Public Utilities 2017/2018 Preliminary Biennium Budget*
- Tacoma Water Capital Budget 2017-2026*
- Tacoma Water Budget Development Decision Making Process*
- Tacoma Water Strategic Plan*

Chapter 12:
- Financial Report: http://cms.cityoftacoma.org/Finance/Financial_Reports/Annuals/WaterAnn17.pdf
- Water Rate and Financial Policy: https://www.mytpu.org/file_viewer.aspx?id=58947

Abbreviations and Acronyms

ADD	Average Day Demand
AF	Acre-feet
AM	Asset Management
AMI	Advanced Metering Infrastructure
APWA	American Public Works Association
AWSP	Additional Water Storage Project
AWWA	American Water Works Association
BAT	Backflow assembly tester
CCF	Hundred (centum) cubic feet
CCS	Cross-connection control specialist
cfs	Cubic feet per second
CIP	Capital Improvement Plan
CMMS	Computerized Maintenance Management System
CWSP	Coordinated Water System Plan
DOH	Washington State Department of Health
DNS	Determination of Non Significance
Ecology	Washington State Department of Ecology
EPA	Environmental Protection Agency
ERU	Equivalent residential unit
FDWR	First Diversion Water Right
GIS	Geographic Information System
gpcd	Gallons per capita per day
gpm	Gallons per minute
GRFF	Green River Filtration Facility
HCP	Habitat Conservation Plan
HGL	Hydraulic grade line
IRP	Integrated Resource Plan
LCR	Lead and Copper Rule
LCR-LTR	Lead and Copper Rule Long-Term Revisions
LTF	Long-term forecast
MCL	Maximum contaminant level
MCLG	Maximum contaminant level goal
MDD	Maximum Day Demand
MG	Million gallons
MGD	Million gallons per day

MIT	Muckleshoot Indian Tribe
NTU	Nephelometric turbidity units
O&M	Operations and Maintenance
OSHA	Occupational Safety and Health Administration
PCA	Project Cooperation Agreement
PE-LOS	Post-earthquake level of service
PFAS	Perfluoroalkyl substances
PHD	Peak Hour Demand
Plan	Water System Plan
PRV	Pressure reducing valve
PSE	Puget Sound Energy
RAMCAP	Risk Analysis and Management for Critical Asset Protection
RCW	Revised Code of Washington
RWSS	Regional Water Supply System
SAMP	Strategic Asset Management Plan
SCADA	Supervisory control and data acquisition
SDC	System Development Charge
SDWR	Second Diversion Water Right
SEPA	State Environmental Policy Act
SMA	Satellite Management Agency
SPU	Seattle Public Utilities
SSP	Second Supply Project
STF	Short-term forecast
STGPD	South Tacoma Groundwater Protection District
TMC	Tacoma Municipal Code
TPCHD	Tacoma-Pierce County Health Department
TPU	Tacoma Public Utilities
UGA	Urban growth area
USACE	U.S. Army Corps of Engineers
VOC	Volatile organic compound
WAC	Washington Administrative Code
WISHA	Washington Industrial Safety and Health Act
WHPA	Wellhead Protection Area
WHPP	Wellhead Protection Program
WSDOT	Washington State Department of Transportation
WSMP	Watershed Management Plan
WSP	Water System Plan

WSRP	Water Shortage Response Plan
WUE	Water use efficiency
WYSDM	Water Yield, Supply and Demand Model

Executive Summary

Tacoma Water, a division of Tacoma Public Utilities, has updated its *Water System Plan* (WSP) consistent with requirements of Pierce County, King County, and the Washington State Department of Health. The WSP builds from Tacoma Water's 2012 *Strategic Plan*, and contains information of interest to Tacoma Water customers, staff, partner agencies, and the public. The update process included coordination with local land-use departments, water systems that receive supply from Tacoma Water, and water systems adjoining the Tacoma Water service area to help achieve consistency among local jurisdictions.

Water Supplies and Recent Improvements

Tacoma Water uses both surface water and groundwater sources. The Green River is the primary water source under Tacoma Water's First Diversion Water Right (FDWR) and a Second Diversion Water Right (SDWR) shared with the Second Supply Project (SSP) Partners. Tacoma Water operates its diversions and stored water to protect minimum streamflow in the Green River consistent with an agreement with the Muckleshoot Indian Tribe (MIT). Tacoma Water consults extensively with the U.S. Army Corps of Engineers (USACE) regarding operation of Howard Hanson Dam and use of SDWR water stored behind the Howard Hanson Dam in Eagle Gorge Reservoir. Tacoma Water and USACE have a Project Cooperation Agreement (PCA) that provides the basis for this relationship.

Tacoma Water also owns and operates multiple supply wells located in and around the city. Groundwater produced from these wells augments the Green River supply during summer months when peak demands and lower in-stream flows occur. A separate groundwater source, the North Fork wells, is situated along a tributary to the Green River near Howard Hanson Dam. The North Fork wells are used to substitute for Green River water when needed, usually in response to short-term spikes in turbidity during periods of high surface runoff.

Since the prior WSP was issued in 2006, Tacoma Water has implemented several significant projects and operational changes. These include:

- 2007 – Ozone treatment at the Green River Facilities to control taste and odor, and enhance the performance of water filtration.
- 2012 – McMillin Reservoir replacement to meet state and federal requirements. This improves water stability, water quality, and seismic resiliency at this facility.
- 2013–2016 – Groundwater treatment improvements including corrosion control to protect public health, fluoridation at the Hood Street Reservoir, and disinfection improvements.
- 2015 - Tacoma Water's Green River water supply officially became a filtered surface water supply on May 1, 2015 with the completion of the Green River Filtration Facility (GRFF).

- Ongoing – Activation of a formal Asset Management program to help to control the life-cycle costs of owning, operating, and maintaining infrastructure and equipment.
- 2018 – The Water Yield, Supply and Demand Model (WYSDM) was developed together with an *Integrated Resource Plan* (IRP). These tools will help Tacoma Water balance water production with customer needs, both in annual operations and long-term resource planning.

Service Area and Water Demand Forecast

Tacoma Water's service area includes retail service within the City of Tacoma and several nearby jurisdictions, wholesale water service to other water systems in Pierce County, and supply enhancement for the three SSP Partners in King County.

Tacoma Water's demand forecast provides a basis for evaluating water supply adequacy, system capacity and the need for growth-related infrastructure improvements. Tacoma Water uses econometric analysis of water demand coupled with projections for service-area growth to develop its water demand forecast. Population in the direct retail service area is projected to grow by 6.5 percent over the next 20 years (from 326,800 in 2017 to 348,500 in 2037). Without Tacoma Water's water conservation program, demand is projected to remain relatively flat during this period, due to continued efficiency improvements from Washington State's plumbing code and other factors that reduce per capita water use. After accounting for Tacoma Water's conservation program, retail demand is projected to decline over the 20-year period, even as population increases.

Taking into account retail and wholesale uses, Tacoma Water's Most Likely Forecast shows total average day demand is decreasing from approximately 49 million gallons per day (MGD) in 2017 to 44 MGD in 2037. Peak day demand is projected to fall from 83 MGD in 2017 to 75 MGD in 2037. The WSP also presents low and high demand forecasts around Most Likely Forecast.

Tacoma Water is planning a transition to Advanced Metering Infrastructure (AMI). Once implemented, this will improve the utility's ability to monitor water uses in real time and evaluate trends for forecasting purposes.

Water Conservation

The Washington State Department of Health (DOH) requires that municipal water systems establish water conservation goals, and define programs to achieve them. As part of the WSP and IRP, Tacoma Water has updated its conservation goals and program. Tacoma Water's conservation goal for the period 2018-2027 is a population-adjusted 6.65 percent peak (May-October) reduction in consumption for direct retail customers and includes outdoor conservation measures. The goal is not a requirement from DOH, but one to address responsible stewardship of the resource. The conservation program emphasizes a reduction in peak demands that result mainly from lawn and landscape watering practices during the summer months.

Annual costs for implementation of the 10-year conservation program are estimated to be approximately $80,000. Tacoma Water projects annual savings of approximately 250,000 gallons per day, and peak season savings of 280,000 gallons per day.

Approximately 80 percent of the annual savings are projected to come from the residential sector, and the remaining 20 percent from the commercial/industrial sector.

Tacoma Water also complies with related requirements under state law, such as metering of customer water use, a rate structure that promotes efficient water use, and control of distribution system leakage.

Water Infrastructure

Tacoma Water owns and operates a diverse array of facilities and equipment that enable production, treatment, transmission, storage, and delivery of drinking water throughout its service area. Major elements of the system include:

- Howard Hanson Dam and Eagle Gorge Reservoir (owned and operated by USACE)
- Green River Diversion Dam situated downstream from Howard Hanson Dam
- Green River Filtration Facility
- North Fork Wellfield
- 24 active wells, one spring source, and several inactive or emergency wells
- McMillin Reservoir (67-million-gallon [MG] capacity) and numerous smaller reservoirs (from 0.1 to 21 MG capacity) distributed throughout the system
- 142 miles of large-diameter transmission mains that convey water from the Green River and production well sites to the retail distribution system, wholesale customers, and SSP Partners
- Nearly 1,250 miles of distribution pipes throughout the retail distribution system
- 28 pump stations that move water from lower pressure zones to higher pressure zones
- 76 pressure-reducing-valve (PRV) stations with 160 individual PRVs and 17 pressure relief valves; these are used in combination with pump stations to control flow and pressure among the system's 51 pressure zones
- Over 11,500 fire hydrants

Asset Management

Assets are physical infrastructure and facilities that are built and maintained to meet level of service standards. Decisions for when assets need to be built, maintained, or replaced are based on defined information and strategies. The asset management program enables decisions to be made based on a clear understanding of lifecycle costs (economic, social, and environmental), established levels of service, and the risk associated with system assets. As a result, the asset management program touches nearly every aspect of resource allocation within the utility, including risk management, service levels, tradeoffs between maintenance costs and capital improvements, efficiency in service delivery, and tracking of results. The utility's maintenance crews, operators, analysts, engineers, and managers all contribute to managing assets successfully.

Operational tools of the program include Strategic Asset Management Plans (SAMPs) for each of the utility's 19 asset classes; business-case evaluations of capital improvement projects, and hydraulic and economic models for assessing transmission and distribution piping improvements.

Tacoma Water has identified 14 asset management improvement initiatives that address the vision and principles of the asset management program. Four of these are at or near completion, four are the subject of current focus, and the remaining six initiatives will receive attention in upcoming years.

Water System Analysis

Storage Capacity Analysis

A storage capacity analysis was completed looking at Tacoma Water's storage facilities and comparing the existing available storage to the DOH required storage given current and forecasted future demands for the six primary service areas of the system. The analysis found that there is sufficient storage to meet current demands when excluding a small number of service connections in the Cumberland and Sunrise Service Areas that were are at high enough elevations to see pressures slightly below (about 1 psi) required pressures when storage is depleted. It is forecasted that additional storage will be needed for the Prairie Ridge and Sunrise Service Areas as those areas develop.

Source Capacity Analysis

A source capacity analysis was completed looking at sources (pump stations and wells) for various parts of the Tacoma Water system and comparing the existing available capacity to the DOH required capacity given current and forecasted future demands. The analysis found that slight deficiencies currently exist for the Bonney Lake and Cumberland Service Areas. However, improvements are currently planned for the Bonney Lake Service area in the mid-2020s and a portable pump is available to resolve the deficiency in the Cumberland Service Area.

Distribution System Analysis

Tacoma Water uses a hydraulic model tied to the City's Geographic Information System (GIS) to evaluate distribution system conditions and potential improvements. The model is used for pressure analysis, fire flow analysis, pressure zone modeling, sizing/timing of pipeline improvements, analysis of storage and pumping facilities, modeling the effects of temporary water main shutdowns, and pinpointing pressure or flow deficiencies in the water system. This data is used as part of an overall plan for water main replacements or new water main construction.

Under peak hour demand conditions, it is required to maintain a minimum pressure of 30 psi throughout the water system. Modeling identified discrete areas in the water system with potentially less than 30 psi during peak hour demand conditions. These potential areas consist of an estimated 267 equivalent residential units (out of a total estimated 357,874 equivalent residential units for the entire system). Generally, these areas are localized elevation peaks within pressure zones or located along pressure zone boundaries. These areas are being further evaluated to determine the improvements

necessary following field verification of pressures at each location. The system is required to deliver required fire flow during maximum day demand conditions. Model results show that the majority of the system is able to provide fire flows in excess of 1,000 gpm. Discrete locations were identified where modeled fire flows are potentially less than the present day required fire flow. A review of specific locations is planned for the 2019-2020 biennium. If discrete improvement projects are identified, Tacoma plans to approve and allocate project funds to the Capital Improvement Plan through the typical budgeting process to begin improvements in the 2021-2022 biennium.

Drinking Water Quality

Tacoma Water uses source water controls, treatment, and extensive monitoring to provide safe drinking water meeting state and federal regulations. Surface water from the Green River is treated at the Green River Filtration Facility, completed in 2015 as an upgrade of the Green River Treatment Plant. The upgrade added a filtration process to the facility to supplement disinfection and other processes.

Tacoma Water has updated the *Watershed Management Plan* (WSMP) for the Green River watershed. The WSMP describes physical conditions and land ownership in the watershed, agreements that help to protect the water supply, potential risks, and controls to manage them. While the specific State and Federal requirements for watershed control are less rigorous with Tacoma Water's installation of the Green River Filtration Facility compared with past years without filtration, Tacoma Water intends to maintain the same level of watershed management on a voluntary basis. This will provide an extra margin of safety in protecting drinking water quality.

Tacoma Water has a wellhead protection program to protect local aquifers from contamination threats associated with chemicals, fuels, and other products or activities. The South Tacoma Groundwater Protection District (STGPD) was established in 1988, and protections for groundwater within the district are enforced by the Tacoma-Pierce County Health Department (TPCHD). This includes permitting and inspections of businesses; consultations; and oversight of tank removals, tank installations, and contamination cleanup activities. Tacoma Water's most recent *Wellhead Protection Plan* update was updated in 2017.

Groundwater from in-City supply wells is disinfected before entering the distribution system. The pH in the supply from the South Tacoma Wellfield is also adjusted as part of the corrosion control program.

The Environmental Protection Agency (EPA) has been overseeing cleanup activities at a Superfund site in South Tacoma formerly operated by Time Oil. Tacoma Water is currently engaged in discussion with EPA and Washington State agencies regarding their plans for assuring completion of the necessary cleanup activities.

In addition to source water protection and water treatment, Tacoma Water monitors water quality conditions throughout the distribution system. This monitoring complies with state and federal requirements for large drinking water systems. Tacoma Water has developed the following monitoring plans to guide this activity: *Coliform Monitoring Plan*, *Disinfection Byproducts Monitoring Plan*, *Lead and Copper Rule Monitoring Plan*, and *Source Monitoring Plan*. Monitoring results are reported to the public annually in a *Water Quality Monitoring Report*.

Water System Resiliency

Tacoma Water is engaged in various activities to make the water system more resilient to natural hazards or other factors that could disrupt delivery of drinking water. These include resiliency studies, development of a dual supply, development of emergency response plans, coordination with other jurisdictions, and development of a *Water Shortage Response Plan*. Tacoma Water participates actively in the Water Supply Forum with other regional water utilities and related organizations in King, Pierce, and Snohomish Counties. The Water Supply Forum is currently engaged in a *Regional Resiliency Study* that focuses on four risk categories: earthquakes, water quality, drought, and climate change. This study will assist Tacoma Water in better understanding risks as well as the costs and benefits of potential mitigation actions.

In addition to this regional effort, Tacoma Water conducted an all-hazards evaluation of its water system in 2015. This evaluation showed that seismic events pose the highest risk to the water system and are therefore the most critical for developing mitigation strategies. System upgrades to improve seismic resiliency are typically very costly, and are therefore best considered in the context of a long-term strategy for system improvement. Tacoma Water has been funding resiliency improvements and will continue to consider mitigation of seismic and other hazards during each capital planning cycle.

In the event of a significant disruption to the water supply, whether from an earthquake, drought, or other condition, Tacoma Water can activate its *Water Shortage Response Plan* (WSRP). This plan includes four stages of actions that match the degree of severity of reduced water supply conditions. An updated WSRP is being adopted in the course of this WSP update. Tacoma Water also has an *Emergency Operations Plan* to guide decision-making, communications, and actions in response to emergencies.

Capital Improvement Plan

Tacoma Water maintains a 10-year Capital Improvement Plan (CIP) that identifies capital projects needed to meet the objectives of the *Strategic Plan*. The CIP is updated every two years. The current 10-year CIP covers years 2017 through 2026 (Table ES-1). Projects in the first two years of the CIP reflect projects in Tacoma Water's approved biennial capital budget. An update will be prepared in 2018 and will cover capital spending needs through 2027.

Table ES-1. 2017-2026 Capital Improvement Plan Summary

Category	Capital Cost ($M)	
	2017/2018	2019-2026
General Projects	5.1	19.3
Water Supply	9.7	40.3
Water Quality	4.4	4.7
Water Distribution	27.9	105.2
Regional Water Supply System	0.9	3.3
Totals	**48**	**173**

Some of the key projects in the 10-year CIP include:

- **Advanced Metering Infrastructure:** Tacoma Public Utilities (TPU) is planning to deploy AMI across its entire water and electric service territory. AMI will modernize utility operations and improve services to customers.
- **Lead Gooseneck Replacement:** The goal of this project is to find and replace lead goosenecks throughout the water system to reduce water quality risks. Lead goosenecks will be replaced with non-lead piping.
- **Puyallup River Crossing:** Between the Green River Filtration Facility and the McMillin Reservoirs, Pipeline 1 crosses the Puyallup River through two parallel 39-inch-diameter pipelines supported by a truss bridge structure. The bridge structure is vulnerable to seismic and flood events, and is difficult to maintain. Tacoma Water has been exploring options to replace the crossing. Installing it on a new proposed county road bridge is currently considered the best option.
- **Corrosion Control at Gravity Pipeline Wells:** This project includes the design, permitting, and construction of a new corrosion control treatment facility, connecting pipeline(s) between the two gravity pipeline wells, provisions for chemical truck deliveries, and related appurtenances.
- **Tehaleh Main Extension:** To better serve the growing Tehaleh community, Pierce County Public Works and Utilities is planning a 2017 road widening project along 198th Avenue East. Tacoma Water has previously installed 24-inch mains in some sections of this roadway. The project would install additional 24-inch pipe segments in coordination with Pierce County's road project.
- **TPU Decant Facility:** The TPCHD requires that all spoils (i.e., soils created from underground utility excavations) taken from the Tacoma Smelter Plume region containing arsenic and lead receive special handling. TPU is planning to design and construct a new decant facility to support spoil handling operations in compliance with regulatory requirements.
- **Main Replacement Projects:** The CIP includes several categories of main replacement projects. These include those identified from the economic and hydraulic models; mains that can be economically replaced during roadway improvements; and older galvanized steel mains that may be subject to failure. The CIP also provides funds for immediate response to main breaks wherever they occur.
- **Seismic Projects:** Seismic improvements funded in the CIP were selected to improve the resiliency of critical infrastructure sited in vulnerable areas.

Financial Plan

Tacoma Water's Finance and Analytics section analyzes the utility's revenue requirement every two years to determine if rates are adequate. Tacoma Water typically implements annual rate adjustments to keep up with inflationary cost increases and meet anticipated needs. Tacoma Water has consistently maintained a strong financial position with total operating and capital reserve fund balance above policy minimums and increasing every year in the past 5 years. Historically the utility has increasingly strong debt service coverage and increased liquidity.

Historic and projected financials, shown in Table ES-2, show a declining revenue from 2013 to 2017, and an increasing revenue from 2018 to 2022. Projected rate increases have slowly declined from 6 percent in 2013 to 3 percent in 2022.

Table ES-2. Historical Financials

	($ Thousands)				
	2013	2017	2018	2020	2022
Operating Revenue	$96,119	$88,628	$88,493	$93,425	$98,593
Non-Operating Revenue (Expense)	(18,536)	3,090	3,140	3,143	3,146
System Development Charge Revenue	1,703	3,840	4,061	8,151	6,651
Total Revenue Available	79,286	95,558	95,695	104,719	108,390
Operating Expenses less Depreciation	44,330	58,751	58,098	62,045	65,724
Net Revenue Available for Debt Service	34,956	36,807	37,597	42,674	42,666
Net Debt Service	19,306	18,660	18,704	18,703	18,708
Ratio and Other					
Debt Service Coverage - Senior Lien	1.81x	1.97x	2.01x	2.28x	2.28x
Year End Operating Fund Balance	$39,351	$52,287	$50,197	$38,874	$32,036
Year End SDC Fund Balance	$53,720	$60,847	$63,333	$47,018	$9,828
Year End Capital Reserve Fund Balance	$19,403	$31,097	$31,886	$9,821	$10,334
Adopted Rate Increases	6.0%	4.0%	4.0%	3.0%	3.0%

Tacoma Water regularly adjusts rates to comply with its financial policies and keep up with the cost of operational and capital expenditures. The main source of revenue is from rates charged for water service, which Tacoma Water can control through adjustments.

Aside from customer rates, Tacoma Water has established two special funds that provide flexibility in ensuring timely acquisition, replacement, and upgrade of the water system infrastructure and capital assets. Funding of the capital improvement plan is executed through a mixture of system development charges, capital reserves, rate revenue, and bond funds.

Tacoma Water's current rates are a combination of a ready to serve charge and consumption charges. The ready to serve charge varies depending on the size of the customer's meter. The consumption charge is based on the quantity of water used.

Customers outside of City limits are charged a 20% differential for their rates.

1 Introduction and Purpose

1.1 Introduction

Tacoma Water has prepared this *2018 Water System Plan* (WSP) to comply with the requirements of the Washington State Department of Health (DOH) as set forth in the Washington Administrative Code (WAC) 246-290-100. In addition to meeting DOH requirements, the WSP serves as a source of information for Tacoma Water customers, staff, partner agencies, and the public regarding the water system. The WSP highlights Tacoma Water's key objectives for the next several years in areas such as water use efficiency, capital improvements, asset management, and fiscal management.

Key Capital Facility Changes from the 2006 Water System Plan

Major system developments and operational changes completed since the prior WSP have improved service quality, delivery, and reliability. Key improvements include:

- **2007 – Ozone treatment and centralized operations center at the Green River Diversion Dam**
  Tacoma Water installed ozone treatment at the Green River Facilities in 2007 in anticipation of adverse impacts to taste and odor due to increased water storage behind Howard Hanson Dam and water extraction from upper reservoir water levels. Water quality testing has confirmed both the need for and efficacy of ozone to destroy taste and odor causing compounds, and to enhance filter performance.

  The Green River Operations Center was constructed to centralize Water Treatment, Environmental Stewardship, and Watershed Operations offices at the Green River Facilities.

- **2012 – McMillin Reservoir replacement**
  In response to State and Federal requirements, the combined open basins located on the South Hill of Puyallup were replaced in 2012 with twin 33-million-gallon (MG) concrete storage tanks, reducing the bulk stored volume from 210 MG to 66 MG, and markedly improved water stability, water quality, and seismic strength of the storage facilities.

- **2013-2016 – Groundwater treatment improvements**
  To improve overall protection of public health and extend the longevity of plumbing materials in customer homes, new corrosion control facilities were completed at the Hood Street Reservoir and the South Tacoma Pump Station. To meet the voter-approved policy objective of improving dental health protection, fluoridation was added at the Hood Street facility. In addition, chlorine disinfection equipment was replaced at the Hood Street facility during this period, and new chlorination equipment was installed at the Gravity Pipeline wells.

- **2015 – Green River Filtration Facility**
  Tacoma Water's Green River water supply officially became a filtered surface water supply on May 1, 2015 with the completion of the Green River Filtration Facility

(GRFF). This is providing substantial improvements to water quality through the removal of organic and inorganic particles, and improving the reliability of system yield. Major investments in staffing and facilities have provided highly reliable operations since start-up of the facility.

Strategic Plan and Balanced Scorecard

In 2012, Tacoma Water completed a *Strategic Plan* that replaced the *Tacoma Water Business Plan* and now serves as the foundation for subsequent planning documents. The *Strategic Plan* includes eight initiatives that are intended to be the strategic focus for Tacoma Water for 3- to 5-year periods. Tacoma Water has addressed a number of the issues identified in the 2012 *Strategic Plan*, and continues to make progress on the remaining initiatives. The year 2017 was the fifth year of using a Balanced Scorecard approach to manage the strategic planning work. Each year a strategy map is updated to identify the next strategic objectives to be addressed. In 2015, a playbook was also developed to reinforce and clearly communicate Tacoma Water's mission, values, and highest priority work. The strategy map and playbook are intended to help align and focus resources on Tacoma Water's utility-wide priorities.

A link to the 2012 *Strategic Plan* is provided at the end of this chapter.

Asset Management

Tacoma Water has a formal asset management program. Below is a chronology of the program's implementation. Additional details on asset management are found in Chapter 10.

- 2007– HDR *Tailored Asset Management Readiness Review* and Public Utility Board presentation
- 2008 – International Water Association (IWA) – Water Services Association of Australia (WSAA) Asset Management Process Benchmarking Project
- 2009 – Contract with CH2M Hill to develop an *Asset Management Framework and Implementation Plan*
- 2010 – Began formal Asset Management implementation with assigned staff

Geographic Information System

Tacoma Water has switched its Geographic Information System (GIS) platform to ESRI. This platform supports both the BlueWave viewer on the utility's intranet and the Innovyze hydraulic distribution system model.

1.2 Purpose

Tacoma Water's planning activities center on the need to meet demands in an expanding service area; address local, state, and federal government planning policies and regulations; satisfy Washington State DOH planning guidelines; and satisfactorily meet customer expectations. The WSP serves as a tool to assist the utility in making the best use of available resources to provide quality water service and protect the health of its customers. The 2018 WSP update complies with DOH regulations under Washington

Administrative Code 246-290-100, which requires water purveyors to update WSPs every ten years. It replaces the September 2006 *Comprehensive Water System Plan*. The *Green River Watershed Management Plan* has also been updated and is included as Appendix E.

Integrated Resource Plan

Tacoma Water's *Integrated Resource Plan* (IRP) was developed during 2018. The IRP focuses on managing the availability and reliability of water supplies in relation to customer needs, as influenced by Tacoma Water's water conservation program. It is described further in Section 4.5.

Stakeholder Involvement and Local Government Consistency

Tacoma Water convened an advisory committee to provide input on the IRP. The advisory committee met five times while the WSP and IRP were being developed. In addition, Tacoma Water provided a draft of the WSP to adjacent water systems for comment, and to local governments with jurisdiction over land use planning to confirm consistency of the WSP with land use plans. Finally, the updated water conservation goals were presented at a consumers' meeting held in October 2017.

Correspondence from stakeholders and local governments, as well as Water System Plan comments public information meeting materials are provided in Appendix A.

Plan Structure

The organization of this plan differs from the standard DOH list of chapters with the intent to provide a concise, streamlined document that summarizes Tacoma Water's facilities and programs while also meeting DOH requirements. The first three chapters of this plan describe Tacoma Water's organizational structure, service area, demand projections, and water conservation program. Chapters 4 through 9 describe system infrastructure, operations, and asset management. Chapters 11 and 12 summarize planned capital improvements and financial management of the water utility.

The last section of each chapter includes links to relevant Tacoma Water documents. Appendix B includes the Water System Plan Checklists for the Washington State DOH, King County, and Pierce County. The Washington State Environmental Policy Act checklist is also provided in Appendix B.

Strategy Map

Tacoma Water developed a Strategy Map (see link in Section 1.3) to highlight its commitments to its customers, the environment, rate payers, and its employees. The strategy includes outcome perspectives, internal process perspectives, and employee perspective.

1.3 Links to Relevant Materials

- Water System Plan: http://MyTPU.org/WaterSystemPlan
- Tacoma Water Strategic Plan*
- 2017 Strategy Map*

2 Tacoma Water History, Service Area, and Organizational Structure

2.1 History

In 1884, the Tacoma Light and Water Company was incorporated. Over the next several years, it developed a water distribution system using local surface water sources. In 1893, the City of Tacoma purchased Tacoma Light and Water and, due to poor water quality of the surface water sources and a growing population, began developing wells for groundwater supply.

In 1910, the Tacoma City Council authorized construction of the Green River gravity supply system. A 30-mile pipeline from the west slope of the Cascade Mountains to Tacoma was completed in 1913. It was built with wood stave pipe, which was replaced with either concrete or steel pipe in the 1920s, 30s and 40s. Many wells have been added to the original South Tacoma Wellfield, in addition to other wells both inside and outside of the City. See Chapter 4 for comprehensive water source details.

The most recent major expansion of the Tacoma Water system was the Second Supply Project (SSP) completed in 2005. Tacoma Water constructed and operates the SSP through a partnership with Lakehaven Water and Sewer District, the City of Kent, and the Covington Water District. This partnership is known as the Regional Water Supply System (RWSS).

Tacoma Water, RWSS, and the U.S. Army Corps of Engineers (USACE) are working in cooperation on the Additional Water Storage Project (AWSP), a component of the SSP. This project allows the storage of up to 20,000 acre-feet behind Howard Hanson Dam for use by Tacoma Water and its Partners[1] as needed to meet municipal and industrial demands, and to support Tacoma Water's in-stream flow commitments.

Details of the infrastructure components of the RWSS as well as the Partnership's governance and management can be found in the SSP Partnership Agreement (link provided in Section 2.7).

2.2 Governance by City of Tacoma and Tacoma Public Utilities

The City of Tacoma was incorporated in 1884. Tacoma Public Utilities (TPU), a City of Tacoma department, is comprised of Tacoma Power, Tacoma Rail, and Tacoma Water. TPU has been publicly owned since 1893, and is the largest department in Tacoma City government.

The City of Tacoma operates under a Council Manager form of government; the City Council is comprised of a Mayor and eight Council members (five Council districts and

[1] Tacoma Water, City of Kent, Covington Water District, and Lakehaven Water and Sewer District are known as the Partners.

three at-large) elected to serve four-year terms. The Council is responsible for enacting and amending City laws, adopting the Biennial Budget, and approving rates.

TPU is overseen by the Public Utility Board, which is a five-member volunteer board. The Public Utility Board governs the operations of TPU. The Board sets policy for all TPU activities related to supplying customers with electricity, telecommunications, water, and rail freight switching services. The utilities operate entirely from revenues from sales of services, not from taxes. The City Council appoints the board members and they serve 5-year terms.

The Director of Utilities is appointed by the Public Utility Board and confirmed by the City Council. The Director is responsible for coordinating activities among the various divisions of TPU. Each division is overseen by a superintendent.

2.3 Water System Organization and Authority

2.3.1 Personnel Responsibilities and Authority

Tacoma City Council

The City Council approves the biennial budget, rates, and changes to city code.

Public Utility Board

The Public Utility Board provides TPU policy direction and guidance and approves major expenditures and contracts.

Director of Utilities

The Director of Utilities is appointed by, and is directly responsible to, the Public Utility Board. This individual is responsible for coordinating planning efforts among the various divisions of TPU and for administering the policies, laws, and ordinances governing the operation of the utilities.

Water Superintendent

The Water Superintendent is responsible to the Director of Utilities. This individual is responsible for developing Tacoma Water budgetary requirements, as well as the administration and management necessary for effective performance of the water system, and implementation of City ordinances and departmental policies regarding water service.

Section Managers

The managers of each of the six sections of Tacoma Water (shown in Figure 2-1) are responsible to the Water Superintendent. They organize, oversee, and direct the management and activities of their respective sections.

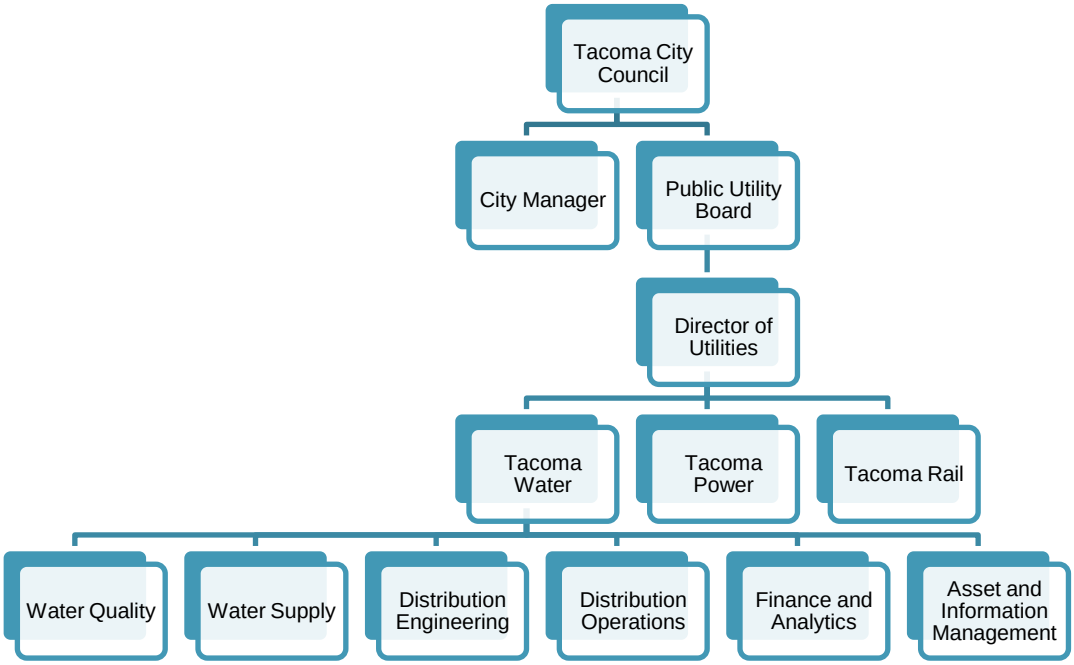
Support Services

As part of the City of Tacoma, Tacoma Water receives support services from the General Government in several areas including Legal, Finance (Accounting, Purchasing, Accounts Payable, and the City Treasurer), Human Resources, and Information Technology. TPU's Customer Services provides billing for Tacoma Water, as well as Tacoma Power and the General Government's Environmental Services (Solid Waste, Surface Water, and Wastewater).

2.3.2 Tacoma Water Organizational Structure

Tacoma Water is responsible for management of the water system, including: planning, design, construction, inspection, maintenance, monitoring, operation, and optimization of the system. The utility has 271 full time employees (as of budgeted year end 2018). Responsibility for performing these duties is separated into six different sections of Tacoma Water, shown in Figure 2-1, and is described further below.

Figure 2-1: Tacoma Water Organization



Distribution Engineering

This section forecasts, plans, and models distribution system expansion, renewal and replacement; engineers, designs, and oversees construction of mains, hydrants, services, meters, pressure reducing vales and pressure zones; provides customer service and key account management; supports growth and development through coordination, permitting and contracting; and promotes water conservation through outreach and customer programs.

Distribution Operations

This section is responsible for the effective operation and maintenance of the various components of the distribution system including mains, hydrants, valves, services, and meters; to respond to and repair main breaks and leaks; to install new services and hydrants as needed for development; to manage the warehouse and materials purchasing; to provide customer service for outages and all other water service issues; to oversee and manage the apprenticeship program (see Section 8.3); and to provide effective leadership for Tacoma Water's safety program.

Water Quality

This section is responsible for the management, operation, and maintenance of the Green River Facilities and Watershed; to ensure natural resource management of water utility lands, including the Watershed; to provide for fish and wildlife habitat management; to install, operate, and maintain water treatment equipment within the system; to respond to all matters relating to water quality from the source to the customer; to monitor for contaminants and assure regulatory compliance; to participate in shaping water quality legislation and regulations; to be aware of changes in water system security needs and to coordinate as needed; and to support wholesale water customers.

Water Supply

This section designs, constructs, operates, and maintains the following City water supply structures: transmission mains and appurtenances; rights-of-ways; wells; pump station; and other mechanical/electrical equipment, storage tanks, and reservoirs; pressure reducing stations; Tacoma Water buildings and properties; communication and telemetry systems (including the Water Control Center); and corrosion control facilities. It also administers water rights and tracks water system security issues while overseeing and managing Tacoma Water's emergency preparedness and coordinating with outside agencies.

Asset and Information Management

This section prepares system and strategic plans; supports Tacoma Water's GIS and hydraulic model operations and technologies; promotes use and maturity of information technologies; and oversees asset management implementation, which incorporates risk, levels of service, and lifecycle costs into the Tacoma Water decision-making process.

Finance and Analytics

This section is responsible for the utility's long range financial plan, rates and charges, budget development and monitoring, and rate and financial policies. This group provides financial, supply and demand, and customer analytics and reports to support decision making by executive management, policymakers, and the SSP Partners. This group develops and administers special retail and wholesale water supply agreements in pursuit of the utility's strategic objectives, and is responsible for leading new performance management, risk management, and advanced metering objectives through cross-functional engagement with the utility and TPU.

2.4 Service Area

Tacoma Water's service area includes retail water service within the City of Tacoma and nearby jurisdictions, wholesale water service to other municipalities in the region, and is a Partner in the SSP. The areas served in each of these categories are shown in Figure 2-2 and described in further detail below.

Tacoma Water provides retail water service within the City of Tacoma, unincorporated areas of Pierce and King Counties, and other jurisdictions including Federal Way, Fircrest, University Place, Lakewood, Puyallup, Bonney Lake, and the Town of Ruston.

Since the 2006 WSP, Tacoma Water has acquired the Andrain Water System and the Curran Road system at the time of the 2018 WSP update. Tacoma Water anticipates the possibility of acquiring other systems over the life of this WSP depending on circumstances. Typically this occurs when an adjacent system is facing operational, capital or regulatory difficulties and they request outside assistance. The Department of Health is normally involved in these discussions and service conversions.

Tacoma Water is a Group A public water system. Per Section 6.C.13. of Chapter 3 (Water Regulations) of the Tacoma-Pierce County Health Department Environmental Health Code, "…if an existing lot of record or a proposed lot is…within the service area of a Group A public water system with the willingness and capacity to serve, then it may not use a well or establish a Group B water system as a water source". Similarly, King County Code 13.24.138B. states "New development…must be served…By a Group A water system through direct service, if the proposed development is in an approved service area that has been assigned to a Group A water system."

A franchise agreement with Pierce County (Ordinance No. 2015-38) is in place until 2030. Ordinance 14349 is the franchise agreement (which expires in 2027) with King County for Pipeline 5. A franchise renewal process is underway for other Tacoma Water infrastructure in King County.

See listing of Service Area Agreements and Service Area Map in Appendix M.

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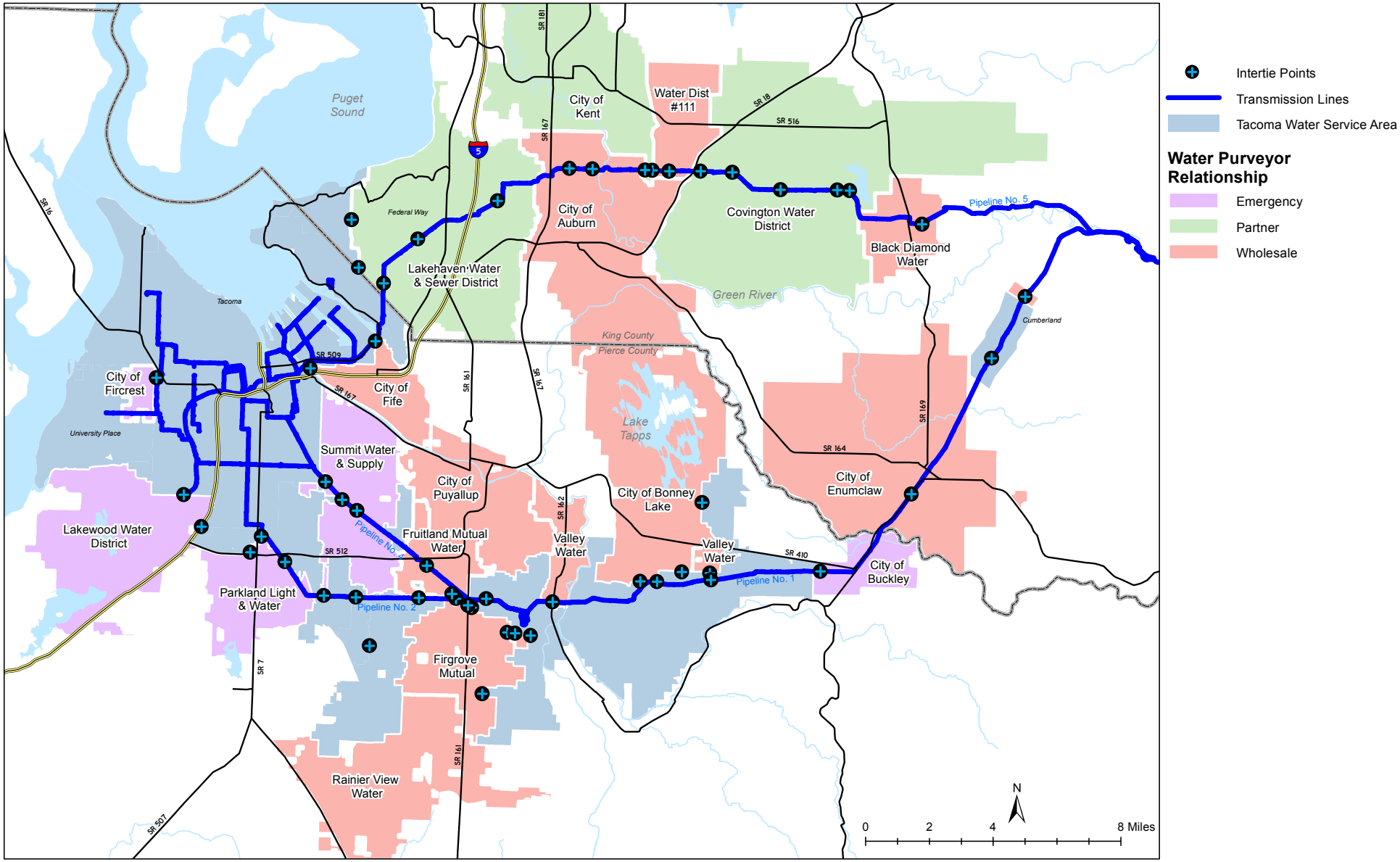
Figure 2-2. Tacoma Water Service Area



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Tacoma Water has 16 wholesale water customers with connections in Pierce and King Counties, listed in Table 2-1.

Table 2-1. Tacoma Water Wholesale Customers

City of Fife	Rainer View Water Co.	Coal Creek Water Society
City of Auburn	Cumberland	City of Enumclaw
Firgrove Mutual Water Co.	City of Puyallup	Valley Water District
City of Bonney Lake	Summit	City of Black Diamond
Mountain Terrace	RSN Enterprises, Inc.	Water District #111
Fruitland Mutual Water Co.	Cascade Water Alliance	

In addition, Tacoma Water has a contract to supply water to the Cascade Water Alliance, an organization comprised of King County water purveyors, which includes the cities of Bellevue, Issaquah, Kirkland, Redmond, and Tukwila; Sammamish Plateau Water; and the Skyway Water and Sewer District. Tacoma Water is a Satellite Management Agency[2] (SMA), with a contract area in Pierce County east of Puget Sound, west of Range 7 East, and north of Township 16 North.

The retail service areas of Tacoma Water's principal existing wholesale customers are contained in the respective utility's water system plan and are general depicted on Figure 2-2.

The Pierce County CWSP identifies Tacoma Water as a regional water purveyor. Tacoma Water will provide wholesale water service to water systems operating within Pierce County that request wholesale service provided such service is consistent with Tacoma Water policy and capacity. Due to the lack of transmission network linking Tacoma to the Gig Harbor and Key Peninsula, the likelihood of providing wholesale water service west of the Narrows Bridge is slight.

Pierce County is the lead agency for determination of service area boundaries in Pierce County. If service area boundaries require adjustment, Tacoma Water coordinates with the other involved water purveyor and informs Pierce County, who then updates the GIS layer. Tacoma Water then incorporates that information into the utility's GIS (BlueWave) to verify the service area boundary.

2.4.1 Adjacent Water Systems

Twenty-six Group A[3] public water systems border Tacoma Water, shown in Table 2-2 and shown on Figure 2-3[4].

[2] Approved Satellite Management Agencies (SMAs) are entities authorized by the Department of Health to own and/or manage and operate public water systems. Washington drinking water regulations require that all public water systems approved after January 1, 1995 be owned or operated by a SMA in perpetuity unless one is not available. This requirement applies to both Group A and Group B water systems (DOH, 2017)

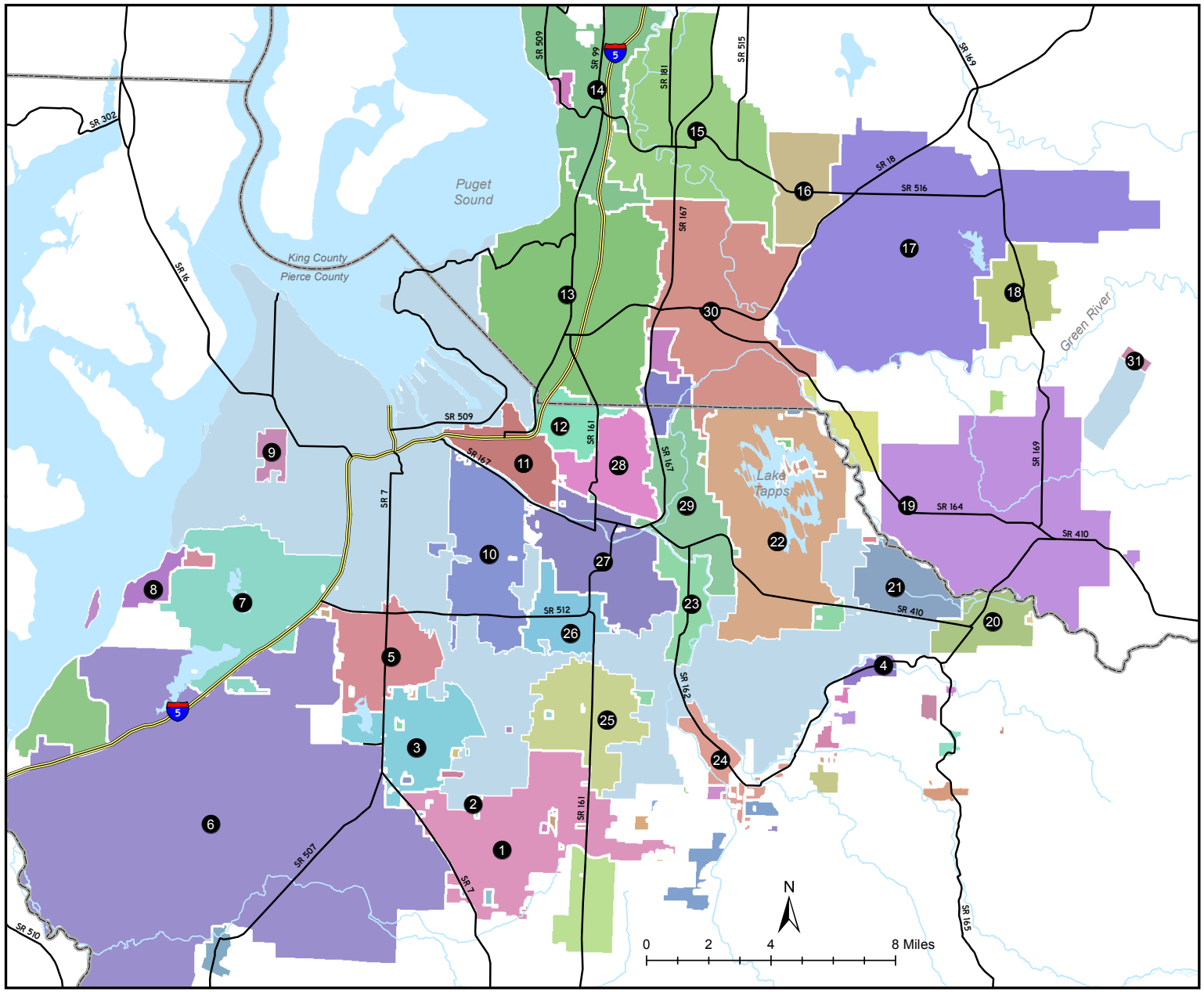
[3] Group A water system are those that have 15 or more service connections or serve 25 or more people 60 or more days per year.

[4] Consistency Statements provided in Appendix A.

Table 2-2. Adjacent Water Systems

< 1,000 Connections	1,000-10,000 Connections	10,000-25,000 Connections	> 25,000 Connections
Bethel Water Company	City of Fife	City of Bonney Lake	Lakehaven Water and Sewer District
Bethel Ranchettes	Town of Milton	City of Puyallup	Lakewood Water District
Cumberland Water Cooperative[a]	City of Orting	Firgrove Mutual Inc.	
Marion Water Company	Fruitland Mutual Water	Parkland Light and Water	
County Services, Inc.	City of Buckley		
Valley Water System	City of Enumclaw		
View Royal	Spanaway Water Company		
	Town of Steilacoom		
	Summit Water and Supply		
	Town of Fircrest		
	Southwood Water System		

Figure 2-3. Adjacent Water Systems



LEGEND

- County Boundaries
- Bodies of Water
- Retail Service Area

Adjacent Water Systems

1 Rainier View Water
2 Bethel Water Company
3 Spanaway Water System
4 South Prairie
5 Parkland Light & Water
6 Joint Base Lewis McChord
7 Lakewood Water District
8 Town of Steilacoom
9 City of Fircrest
10 Summit Water & Supply
11 City of Fife
12 City of Milton
13 Lakehaven Water & Sewer District
14 Highline Water District
15 City of Kent
16 Water Dist #111
17 Covington Water District
18 Black Diamond Water
19 City of Enumclaw
20 City of Buckley
21 Marion Water
22 City of Bonney Lake
23 Valley Water
24 City of Orting
25 Firgrove Mutual
26 Fruitland Mutual Water
27 City of Puyallup
28 Mountain View-Edgewood Water
29 City of Sumner
30 City of Auburn
31 Cumberland Coop Water System

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2.4.2 Interties

Tacoma Water currently has 20 emergency interties with ten local water purveyors (Figure 2-2). Tacoma Water also has 23 metered wholesale connections to 16 local water purveyors with an additional wholesale contract with Cascade Water Alliance. Additionally, 13 interties with the SSP Partners are in place. New emergency interties and wholesale services are added at the request of local water purveyors. If the emergency intertie provides benefit to Tacoma Water, then Tacoma Water will share the cost of the intertie, commensurate with the benefit. A list of interties is provided in Appendix D.

Tacoma Water was in discussions regarding potential interties with Firgrove and Spanaway, as well as an emergency intertie with Lakehaven at the time of the 2018 WSP update, and was also discussing an additional intertie with Covington Water District. Other interconnections may occur within the 10-year plan period as requested by other purveyors or initiated by Tacoma Water.

2.4.3 Second Supply Partners and Agreements

Tacoma Water, City of Kent, Covington Water District, and Lakehaven Water and Sewer District (the “Partners”) participate in the SSP under the terms of the SSP Agreement. Although the SSP was developed as the RWSS joint venture, and operation and maintenance of the RWSS is jointly funded by the Partners, the operation and maintenance of the RWSS is carried out entirely by Tacoma Water, in a manner described in the 2002 SSP Partnership Agreement.

The SSP consists of the following components:

- Green River water supply as allowed under Tacoma Water Green River Second Diversion Water Right;
- The 34-mile-long SSP Pipeline;
- Improvements made at the Tacoma Water Green River diversion dam and intake;
- SSP fisheries and environmental enhancements, including a new fish trap-and-haul facility at the Green River diversion dam;
- The right to store water as a result of the Howard Hanson Dam Additional Storage Project; and
- New treatment facilities, including the Green River Filtration Facility (disinfection, pH adjustment, fluoridation, ozone, and filtration).

2.4.4 Regional Collaboration

Tacoma Water collaborates with several organizations and agencies to address regional water management issues. This regional collaboration includes the Water Supply Forum, whose member agencies include the Cascade Water Alliance, City of Everett, East and South King County Regional Water Associations, Everett Water Utility Committee, King County, Pierce County Regional Water Association, Seattle Public Utilities, and Tacoma Water. The Water Supply Forum, “addresses current and future water supply issues,

including supply system resiliency, planning, policy and regulation, and environmental stewardship" (Water Supply Forum, 2017). Recent Forum projects include the 2009 Regional Water Supply Outlook and the ongoing Resiliency Project, which began in 2015 and is examining ways to improve regional resiliency to potential water supply disruptions.

Tacoma Water also collaborates with the Muckleshoot Indian Tribe (MIT), particularly in regards to management of the Green River Watershed and Green River per the *Habitat Conservation Plan*, as well as state and federal resource agencies and USACE, which operates Howard Hanson Dam.

As noted in Section 2.4.2, Tacoma Water has over 20 emergency interties with adjacent water purveyors. Some of the interties are with wholesale customers but others, such as the Cascade Water Alliance, support regional water supply capacity.

2.4.5 Duty to Provide Service

As a municipal water supplier, Tacoma Water must provide service for all requests within its retail service area, unless one or more of four threshold factors cannot be met. Tacoma Water provides service to customers in accordance with our Customer Service Policies (latest revision - February 2017). Tacoma Water has a duty to provide service to all new connections within our retail service area when the circumstances meet the following four threshold factors:

1. The municipal water supplier has sufficient **capacity** to serve water in a safe and reliable manner.

   Tacoma Water forecasts expected demand growth consistent with best practices, and plans to have sufficient capacity to meet those projected demands.

2. The service request is **consistent** with adopted local plans and development regulations.

   The local governmental authority will make a consistency determination. Tacoma Water will abide by the consistency determination.

3. The municipal water supplier has sufficient **water rights** to provide service.

   Tacoma Water has performed a water right self-assessment and provided the assessment as part of the Water System Plan. Expected demand growth has been accounted for in the Water System Plan. Tacoma Water has sufficient water rights to meet those projected demands for at least the duration of the Water System Plan cycle.

4. The municipal water supplier can provide service in a **timely and reasonable** manner.

   Tacoma Water will work with the applicant to determine if we can provide water service in a timely and reasonable manner, as described in the Customer Service Policies (as found in section 2.7 of the Water System Plan).

Tacoma Water will provide service in accordance with the Customer Service Policies for all requests within its retail service area, if the four threshold factors above are met.

2.4.6 Growth, New Development, and Redevelopment

Tacoma Water coordinates with planning departments and private developers as development opportunities arise or are projected. This includes involvement with the Economic Development Board and local jurisdiction planning staff. Prospective projects are reviewed and new demands hydraulically modeled to determine sufficiency of existing infrastructure and specific project requirements associated with growth.

New development typically pays for required infrastructure additions or improvements to meet new system demands. This construction methodology is also true for redevelopment projects. On occasion, and upon Tacoma Water's review of future zoning in an area, the utility may pay to increase water main sizing to accommodate future growth.

In developing areas, capital projects are planned and executed in advance of projected growth. Tacoma Water ensures planned and long-term fire flow requirements are met based on parcel zoning on a jurisdiction by jurisdiction basis. Tacoma Water periodically reviews long range planning documents for every jurisdiction it serves retail in to identify and plan for new development. These long range planning documents include the comprehensive plans and regional planning documents listed in Section 2.6. Specifically, Vision 2040 and the 2014 Buildable Lands Report were reviewed as part of this Water System Plan development. Anticipated development in unincorporated King County is planned for based on land-use and zoning in the adopted King County Comprehensive Plan. Urban versus Rural land quantities are not typically calculated, but accounted for in planning assessments and parcel zoning analysis regarding minimum required fire-flow. Planning for infill development and the addition of accessory dwelling units are usually supported and accounted for through existing infrastructure.

Generally speaking, most water system growth is anticipated to occur in the east Pierce County region as the urban growth area becomes developed. Significant areas of redevelopment include Tacoma's downtown core, Tacoma Port area, Tacoma Mall subarea, and Point Ruston as high density residential and mixed use centers are constructed.

Tacoma Water has identified two areas within east Pierce County where new development has begun and is projected to continue. The first is the planned residential community of Tehaleh, located south of Bonney Lake. To meet growth here, Tacoma Water coordinates infrastructure planning meetings with the community developer on a monthly basis (including review of demand projections and zoning), and has been a part of the community design discussions since they began in the mid-2000s. Tacoma Water continues to reevaluate new infrastructure timing as construction occurs, accounting for projected build out demands in updated hydraulic modeling and meeting today's service levels with existing infrastructure. Specific capital projects related to this development identified in Tacoma Water's CIP include a new storage tank, new pump station, and 16-inch water main to provide sufficient fire flow and system redundancy.

A second area of growth identified in east Pierce County is located in the Fredrickson vicinity, generally bound by 112th St. E on the north, Canyon Road on the west, Meridian Ave E on the east, and 200th St. E on the south. Tacoma Water identified the potential for larger commercial and industrial growth in this area several decades ago, and has continued to install water main to meet and exceed development. Specifically, this area

is served by large, 24-inch ductile iron water mains whose source of water is pumped from the 58-inch transmission pipeline directly conveying water from the Green River Filtration Facility. Tacoma Water continues to monitor and hydraulically model this area, to ensure the existing infrastructure remains sufficiently robust as new development occurs.

Within the City of Tacoma, redevelopments in the Downtown regional growth center (including condos, apartments, mixed use, retail, and the University of Washington Tacoma Campus), in the Tacoma Mall regional growth center, the Port area, and along Ruston Way (Point Ruston/Town of Ruston) highlight urban growth. Tacoma Water remains keenly aware of these redevelopments and coordinates with private developers early to ensure adequate water is available for new demands and fire flow. Water mains are upsized as needed when opportunities occur, with two examples being the 24-inch ductile iron main constructed along Market Street and the 12-inch ductile iron main along Pacific Ave. Water main along Ruston Way, specifically to Point Ruston, is historically robust from Tacoma Water serving industries previously along Ruston Way. This is also true of the Tacoma Port area, which is served by large distribution and transmission mains.

Growth is expected to continue, with Tacoma Water planning in coordination with demands, planned infrastructure projects, and future timing. Limited growth is anticipated in Tacoma Water's retail service area within the jurisdictions of Federal Way, University Place, Puyallup, Bonney Lake, Orting, Fircrest, and Lakewood. Each of these will see varying forms of redevelopment and smaller new developments within Tacoma Water's service area, but remain within the capacity of the planned or already built water system.

By City Charter (Section 4.7) and Tacoma Municipal Code (TMC) (Title 12, Chapter 10, Section 035) and the Water - Customer Service Policy (CSP) (Section 4), Tacoma Water is required to serve the inhabitants inside the City Limits unless temporary permits are authorized by Council upon recommendation of the Utility Board where it is shown that because of peculiar physical circumstance or conditions, the City cannot reasonably serve said inhabitants. The TMC Section 12.10.350 and CSP Section 15, 19, and 20 describe the situations when there is no water main abutting the parcel and provides the options to install a temporary main or a permanent main. There are circumstances where it's unreasonable for the customer to extend a water main a significant distance and it's not beneficial at the time of request for Tacoma Water to own the temporary main or oversized permanent main. The Distribution Engineering Manager makes the determination for temporary connection to the adjoining water purveyor until such time that Tacoma Water installs distribution facilities abutting the subject parcel. At that time, the property owner will be required to connect to Tacoma Water and will be responsible for the payment of all applicable fees subject to the current operating ordinance at time of connection. This understanding is recorded on an agreement with the customer and the adjoining water purveyor. Inside the city limits the Tacoma Water Superintendent approves a minor waiver (with authorization per TMC Section 12.10.350) and outside the city limits the Distribution Engineering Manager approves the temporary connection to the adjoining water purveyor until such time that Tacoma Water installs distribution facilities abutting the subject parcel. At that time, the property owner will be required to connect to Tacoma Water and will be responsible for the payment of all applicable fees subject to the current operating ordinance at time of connection. This understanding is

recorded on an agreement with the customer and the adjoining water purveyor. The situation is more common outside the city limits. Customers who are temporarily served by Tacoma Water outside of our service area will be handled per the CSP, Section 11 - Direct Service from Supply and Transmission Pipelines.

2.5 Policies

The activities of Tacoma Water are guided by a number of policy documents. Among these documents are:

- Water Regulations and Rates (Tacoma Municipal Code 12.10)
    - This chapter of city code regulates water utility service by the municipal water supply system of the City of Tacoma.
- Customer Service Policies
    - The primary purpose of the Customer Service Policies (link in Section 2.7) is twofold: to assist potential customers in obtaining water service, and to guide Tacoma Water employees in providing such service to customers.
- City of Tacoma Comprehensive Plan called the One Tacoma Plan
    - The *City of Tacoma Comprehensive Plan* (One Tacoma Plan) guides decisions concerning land use regulations, programs, capital improvements and services. As a City of Tacoma department, Tacoma Water operations must be consistent with the One Tacoma Plan.
- Satellite System Management Program
    - Tacoma Water is approved as a Satellite Management Agency (SMA), which means it can own and/or operate more than one public water system without the necessity for physical connection between the systems. As such, Tacoma Water offers various services as deemed prudent and feasible to new and existing water systems in Pierce County east of Puget Sound, or to water systems in areas owned by other City of Tacoma departments.
- Water Rate and Financial Policy
    - The Water Rate Policy gives direction to planning decisions and helps ensure that Tacoma Water provides an adequate supply of safe, clean water to all customers efficiently, reliably and at the lowest possible cost consistent with prudent utility management.

These documents contain policies that help guide legislative decisions, administrative actions, and the development of Tacoma Water programs, activities and budgets. In simplistic terms, the policies serve as the “rule-book” for Tacoma Water management and staff as well as existing and future Tacoma Water customers.

Tacoma Water’s customer service policies can be found online, and a link is provided in Section 2.7. Taken together, the overall objective of Tacoma Water policies is to ensure the implementation of the Tacoma Water mission: Providing clean, reliable water now and in the future.

Table 2-3 shows the relationship between the DOH WSP policies and Tacoma Water policies.

Table 2-3. Department of Health and Tacoma Water Policies

DOH Policy Name	Policy Description	Tacoma Water Policy	Source
Wholesaling Water	Conditions to obtain a wholesale agreement, including the conditions of service for wholesaling water.	Wholesale service may be made available to all water purveyors operating in compliance with DOH regulations and in accordance to resource availability. Wholesale service is subject to the City's conservation and curtailment plan and system development charge. Wholesale customers may elect to take service under a short-term contract or with firm long-term supply assurance.	Customer Service Policy 15 Tacoma Municipal Code 12.10.400.F
Wheeling Water	Conditions met for water to another system, i.e., compatible water quality, engineering, etc.	Tacoma Water does not wheel water through its water system at this time. In the event Tacoma Water is requested to wheel water through its water system, Tacoma Water will negotiate a case-specific wheeling agreement with the applicable water system(s). Tacoma Water has a single water wheeling agreement with Lakewood Water District and Rainier View Water Company, Inc.	n/a
Annexation Policy	How city annexation relates to the provision of water service.	Availability of service within the established annexation area and the Division's service area will depend on a potential customer's willingness to sign a petition agreeing to support future annexation.	Customer Service Policy 5. City of Tacoma One Tacoma Comprehensive Plan, Public Facilities and Services Element Goal PFS-2, policies 2.2, 2.3 and 2.5
Direct Connection And Remote System Policy	New developments directly connect to existing water system, or whether satellite systems will be allowed.	Tacoma Water is approved to provide SMA direct service within its retail service area. In general, Tacoma Water will require extension of water mains to any proposed development. For any proposed residential development under 20 lots in size, and where the shortest route from the proposed development and connection to the water system is greater than 1,000 feet, Tacoma Water will consider other options to serve including main extension or SMA operation until main extension occurs.	Satellite System Management Plan

Table 2-3. Department of Health and Tacoma Water Policies

DOH Policy Name	Policy Description	Tacoma Water Policy	Source
Design And Performance Standards Policy	Minimum design and performance standards for new development.	Construction of the Tacoma Water system occurs in accordance with standards of the Washington State Department of Transportation/American Public Works Association (APWA) Standard Specifications for Road, Bridge and Municipal Construction, including APWA Amendments and State Amendments, the American Water Works Association (AWWA) Standard Specifications, the most current State of Washington, Department of Ecology "Criteria for Sewage Works Design" and applicable local jurisdiction regulations.	Construction Project Specifications
Surcharge For Outside Customers	City's surcharge for customers outside corporate limits.	Rates for retail and wholesale customers located outside the corporate boundaries of the City of Tacoma will be 20 percent higher than rates for inside City Limits. Tacoma Water maintains utility service reliability and rates such that they are an inducement for future annexation.	Water Rate Policy – C.8. City of Tacoma One Tacoma Comprehensive Plan, Public Facilities and Services Element, Goal PFS-2
Urban Growth Areas	Responsibility of service provided in the UGA, how provided and how financed.	The City of Tacoma should be the primary provider of services within its designated urban growth area. The same level of service should be applied throughout the service area of City-owned utilities. Tacoma Water provides water service to most of the City's UGA.	City of Tacoma One Tacoma Comprehensive Plan, Public Facilities and Services Element, Goal PFS-2
Oversizing Policy	City provides funds to install larger than needed facilities to allow for future development, if needed.	Tacoma Water will consider contributing funds to install larger than currently needed facilities, including system extensions, in cases where such oversizing will result in an overall benefit to the distribution grid.	Customer Service Policy 27
Cross-Connection Control Program	Policy on regulation of cross-connections, including steps taken if a cross-connection is discovered.	The control or elimination of cross connections shall be in accordance with Washington Administrative Code and City Code Section 12.10.220. Furnishing of service shall be contingent upon the customer providing cross-connection control. If an immediate hazard to health is caused by the cross connection, water service to the premises shall be discontinued until the cross connection has been eliminated or protected.	Customer Service Policy 16. Tacoma Municipal Code Section 12.10.220

Table 2-3. Department of Health and Tacoma Water Policies

DOH Policy Name	Policy Description	Tacoma Water Policy	Source
Extension Policy	Policies regarding extension of the system, including identification of responsible party. Design standards and payment included in conditions of service.	Extensions of permanent main are paid for by development via the private contract process. The developer shall select a contractor experienced in ductile iron water main construction and enter into an agreement with the contractor and Tacoma Water for construction of the extension. Tacoma Water is responsible for the design, planning and specifications as well as the inspecting of all work completed via a private contract. Upon completion of construction and satisfactory pressure testing and sampling by Tacoma Water, the ownership of the newly constructed main will be turned over to Tacoma Water. The developer is responsible for all costs incurred by Tacoma Water for preparation of plans and specifications, construction inspection, pressure testing, flushing and other work necessary to complete the new water main to Tacoma Water standards and specifications.	Customer Service Policy 25. Customer Service Policy 28. Tacoma Municipal Code Section 12.10.170; 12.10.200
Late-Comer Agreements	Policy on allowing late-comer agreements for those who propose to extend the water system and provisions of pay back.	In the event a premise(s) requiring water service does not abut a permanent water main, a water main charge is collected prior to service main construction. When a permanent main is constructed in the abutting right-of-way, the originally collected water main charge(s) is provided to the developer of the new main.	Customer Service Policy 19. Tacoma Municipal Code Section 12.10.350

2.6 Related Plans

Tacoma Water's 2018 WSP update is consistent with the goals and policies or several local and regional plans:

Tacoma Water Plans

- *Strategic Plan*
- *Water Shortage Response Plan*
- *Habitat Conservation Plan*
- *Watershed Management Plan*
- *Integrated Resource Plan*

Comprehensive Plans

- City of Tacoma (called the *One Tacoma Plan*)

- Pierce County
- King County
- Adjacent Municipalities (Federal Way, University Place, Puyallup, Bonney Lake, Orting, Fircrest, Lakewood)

Countywide Planning Policies

- *Pierce County*
- *King County*

Coordinated Plans

- *Pierce County Coordinated Water System Plan*
- *South King County Coordinated Water System Plan*
- *Vision 2040*
- *2014 Buildable Lands Report*

2.7 Links to Relevant Materials

- Second Supply Project Partnership Agreement: https://www.mytpu.org/file_viewer.aspx?id=6023
- Water Supply Forum: http://www.watersupplyforum.org/
- Customer Service Policies: https://www.mytpu.org/file_viewer.aspx?id=59028

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3 Water Demand and Water Conservation Program

This chapter describes Tacoma Water's water demand forecast and conservation program. The information presented in this chapter is also used in the IRP to assess the ability of Tacoma Water to serve future water supply needs.

The population and demand forecasts presented in this chapter use the same methodology as that of the short-term (10-year) forecast in the *Demand Forecast* 2015 Report (Appendix L). While the short-term forecast in that report extended only to year 2024, the projections presented in this chapter extend to 2037, representing a 20-year planning period.

The water conservation program has been updated as part of Tacoma Water's IRP. This chapter provides a description of how the water conservation program has been implemented since the 2006 WSP, lists the adopted goals of the updated conservation program, and presents anticipated conservation savings.

3.1 Demand Forecast

Tacoma Water published a *Demand Forecast* report in 2015 (Appendix L) that included both long- and short-term forecasts based on multivariate time series regression methods. For the purposes of the WSP, Tacoma Water utilized the Short-Term Forecast (STF) model, updated to include the 2017-18 biennium. The STF uses a mix of bi-monthly and monthly billing data to monitor demands by month and year and is derived from customer billing records.

The main variables used in the STF are consumption by customer category and weather (temperature and precipitation). The STF uses historical growth in the number of service accounts and considers forecasted population in projecting water demands. The forecasted population is tied to forecasted households, a measure which is used in a Long-Term Forecast (LTF) model. The household growth estimates were based on buildout assumptions from the Pierce County Buildable Lands Report 2014. Population was derived from these household buildout assumptions and is considered Tacoma Water's "Most Likely Forecast." However, Tacoma Water has also examined and forecasted higher growth scenarios (e.g., from the Puget Sound Regional Council and Pierce County), but has not historically seen those rates of growth to warrant planning around them. Additional information about how the forecasted population data was incorporated is in the Water System Plan Demands Metadata document provided in Appendix L2. Also, Table 3-1 below breaks out demand by jurisdiction.

Table 3-1. Demands by Jurisdiction

	2018 (forecasted)			2027 (forecasted)			2037 (forecasted)		
Jurisdiction	**Average Day Demand [a] (MGD)**	**ERUs Served by Tacoma Water [b]**	**Percentage of Demand**	**Average Day Demand [a] (MGD)**	**ERUs Served by Tacoma Water [b]**	**Percentage of Demand**	**Average Day Demand [a] (MGD)**	**ERUs Served by Tacoma Water [b]**	**Percentage of Demand**
City of Tacoma	34.842	189,359	71.6%	33.032	179,521	72.6%	31.896	173,348	73.3%
Pierce Country (unincorporated)	8.609	46,790	17.7%	7.779	42,278	17.1%	7.258	39,447	16.7%
City of University Place	3.331	18,102	6.8%	3.010	16,357	6.6%	2.808	15,261	6.5%
City of Federal Way	0.842	4,578	1.7%	0.761	4,137	1.7	0.710	3,860	1.6
City of Fife	0.687	3,733	1.4%	0.621	3,373	1.4%	0.579	3,147	1.3%
Town of Ruston	0.154	835	0.3%	0.139	754	0.3%	0.130	704	0.3%
City of Fircrest	0.054	295	0.1%	0.049	266	0.1%	0.046	248	0.1%
City of Puyallup	0.052	281	0.1%	0.047	254	0.1%	0.044	237	0.1%
King Country (unincorporated)	0.036	194	0.1%	0.032	175	0.1%	0.030	163	0.1%
City of Lakewood	0.020	110	< 0.1%	0.018	100	< 0.1%	0.017	93	< 0.1%
City of Bonney Lake	0.002	10	< 0.1%	0.002	9	< 0.1%	0.001	8	< 0.1%
City of Buckley	0.001	6	< 0.1%	0.001	5	< 0.1%	0.001	5	< 0.1%
Total	48.63	264,293	100%	45.49	247,228	100%	43.52	236,522	100%

[a] Based on most likely forecast with conservation and demand locations geospatially implemented for hydraulic modeling.
[b] ERU value of 184 gpd used for calculation.

Table 3-2 shows Tacoma Water's Most Likely Forecast of population and number of accounts for Tacoma Water's retail service area.

Table 3-2. Population Estimate (Most Likely Forecast)

Year	Direct Retail Service Area Population	Percent Change in Population	No. of Accounts	Percent Change in No. of Accounts
2017	326,763		101,226	0.32
2018	328,757	0.61	101,552	0.29
2019	330,751	0.60	101,845	0.26
2020	332,745	0.60	102,113	0.24
2021	334,739	0.60	102,360	0.23
2022	336,733	0.59	102,592	0.21
2023	338,886	0.64	102,809	0.20
2024	339,572	0.20	103,015	0.19
2025	340,257	0.20	103,210	0.18
2026	340,943	0.20	103,397	0.17
2027	341,628	0.20	103,575	0.16
2028	342,314	0.20	103,746	0.16
2029	342,999	0.20	103,911	0.15
2030	343,685	0.20	104,071	0.15
2031	344,371	0.20	104,225	0.14
2032	345,056	0.20	104,375	0.14
2033	345,742	0.20	104,521	0.13
2034	346,427	0.20	104,662	0.13
2035	347,113	0.20	104,800	0.13
2036	347,799	0.20	104,935	0.12
2037	348,484	Total Population Change from 2017: 6.50% (rounded)	105,066	Total Account Change from 2017: 3.5%

3.1.1 Demand Projections

Table 3-3 shows the "Most Likely Forecast" scenario for water demand by customer class with and without conservation. Current (2018) and 20-year (2037) demands are shown in the table, along with demands in 2024 and 2028. The year 2024 represents the end of the 6-year planning horizon used in the 2015 report; 2027 represents the 10-year planning horizon.

The demand values were developed assuming that weather patterns similar to historic observations would continue over the planning period. The probabilities that weather conditions would occur were created from daily weather data observed in the Tacoma Water service territory from 1964 to 2013. The year 1964 was chosen as the

beginning of the data reference period because of an increase in accuracy of the weather data at this time.

Table 3-3. Water Demand (Most Likely Forecast)

Customer Class	Millions of Gallons per Day (MGD)			
	2018	2024	2027	2037
Single-Family Residential	16.00	16.23	16.30	16.41
Multi-Family	5.34	5.34	5.34	5.34
Commercial/Industrial	5.70	5.71	5.71	5.72
Irrigation	1.43	1.47	1.50	1.54
Large Volume Commercial/Industrial	1.91	1.92	1.92	1.92
Private Fire	0.04	0.04	0.04	0.04
Pulp Mill	16.07	16.07	16.07	16.07
Wholesale Customers	1.66	1.64	1.64	1.64
Losses/Unaccounted for Water	2.39	2.24	2.21	2.14
Average Day Demand (Without Conservation)	**50.54**	**50.66**	**50.74**	**50.82**
Peak Day Demand (Without Conservation)	**85.92**	**86.13**	**86.25**	**86.39**
Market-driven Conservation Savings	(1.88)	(3.86)	(4.97)	(7.02)
Programmatic Conservation Savings	0.03	0.19	0.28	0.28
Average Day Demand (with Conservation)	**48.63**	**46.61**	**45.49**	**43.52**
Peak Day Demand (with Conservation)	**82.77**	**79.89**	**78.27**	**74.93**
25th Percentile Average Day Demand (with Conservation)	47.53	45.49	44.36	42.38
75th Percentile Average Day Demand (with Conservation)	49.65	47.65	46.53	44.56

Figure 3-1 shows historical (2004-2016) average day demand and forecasted (2017-2037) average day and peak day demands. The forecasts include both demand without any conservation savings, and demand with market-driven and programmatic conservation [5] savings.

Figure 3-2 shows the average day demand forecast with conservation savings with 25th and 75th percentiles. Demands are projected to fall in between these percentile bounds 50 percent, based on the variability of climate during the historic period of reference. The demand projections include large volume users, the pulp mill, private fire, and wholesale demands. Demands of the three SSP Partners are managed by these individual utilities and are not included in the *Demand Forecast*; more information about the Partners is in Section 4.1 and in their respective Water System Plans.

[5] Market-driven conservation savings are those from plumbing and appliance efficiencies, plumbing code, and increased awareness of water costs; programmatic savings are those conservation measures being promoted and funded directly by Tacoma Water, described in Section 3.2.

Figure 3-1. Water Demand (Most Likely Forecast - all users, with and without conservation)

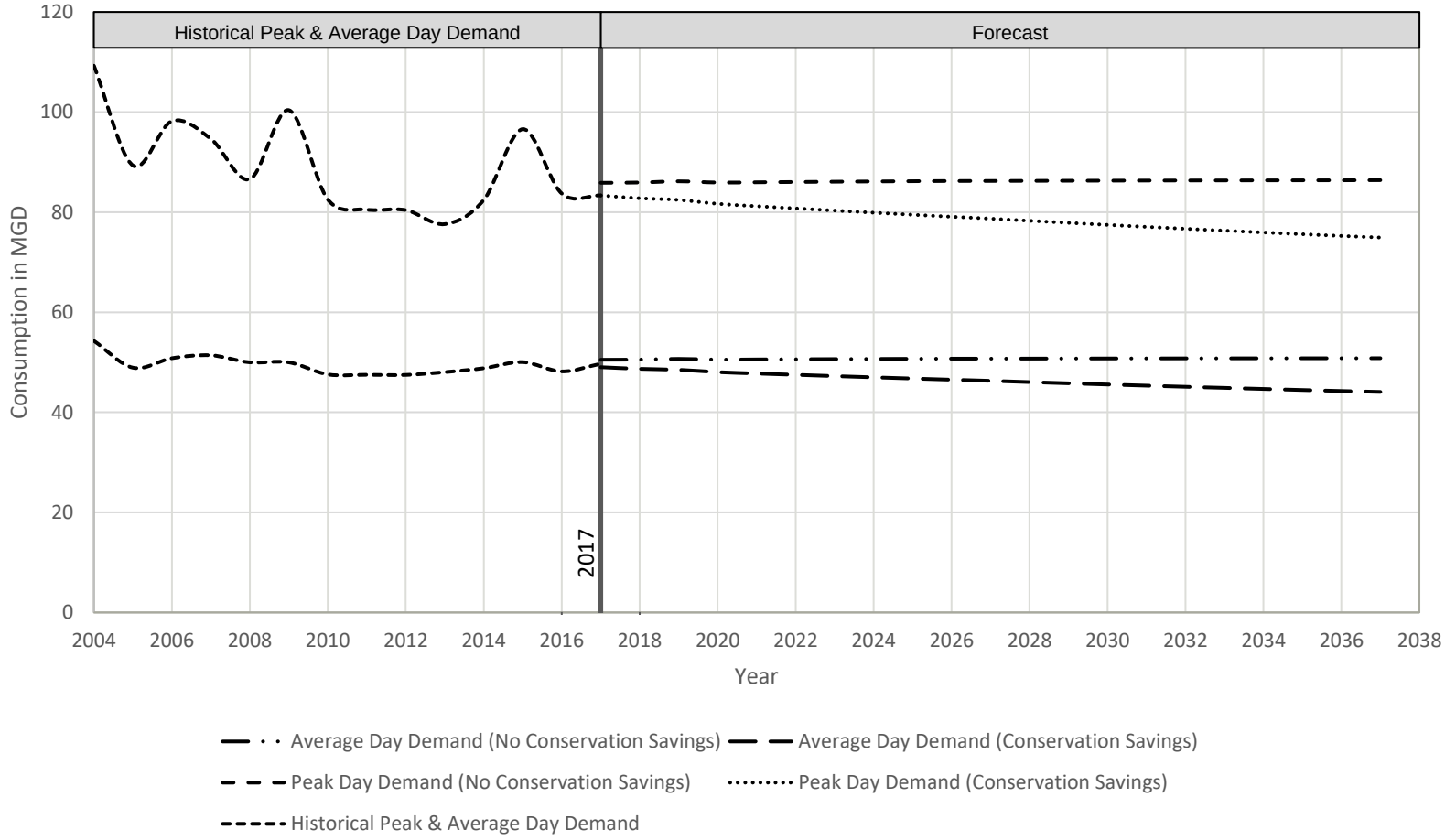

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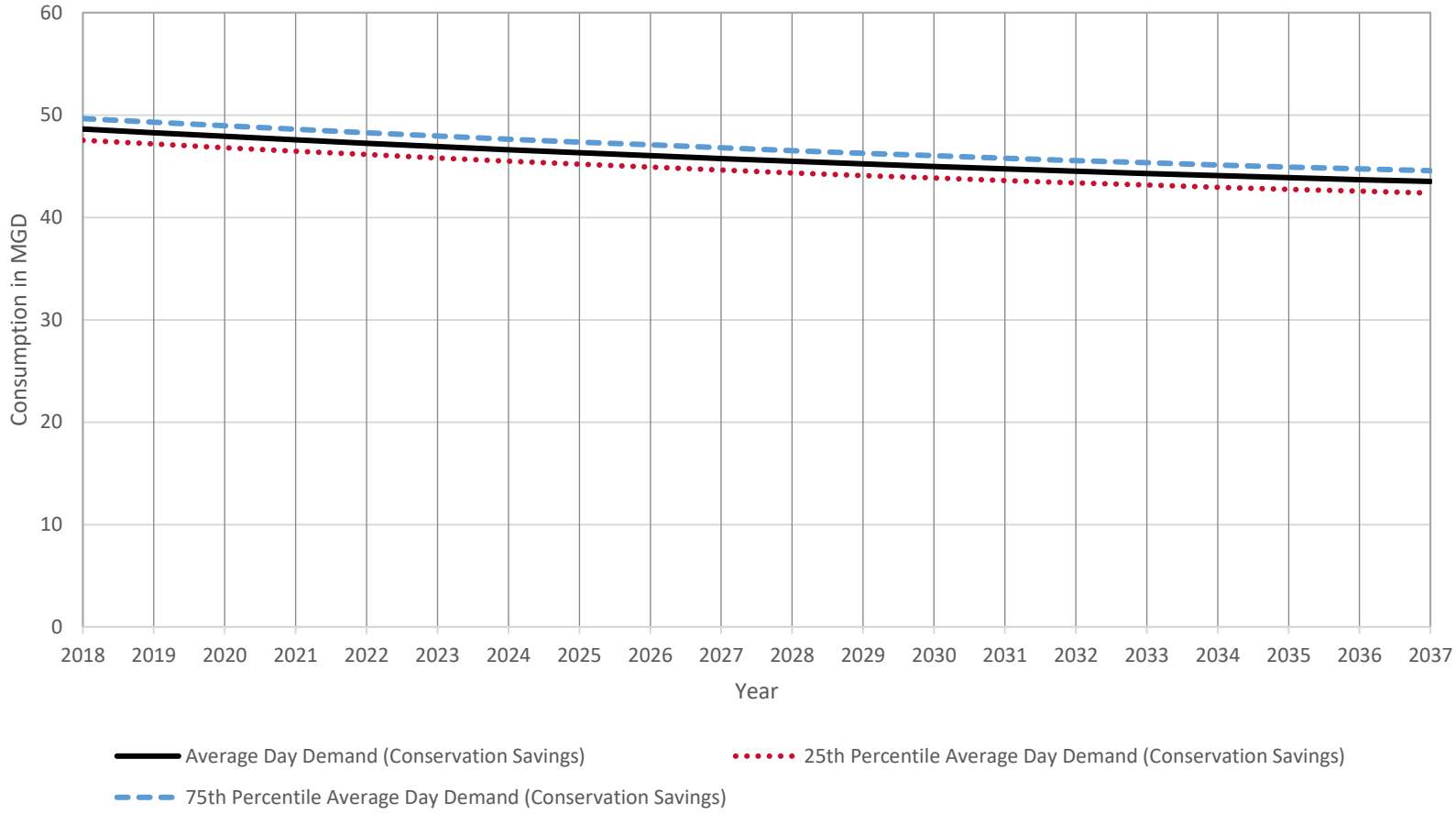
Figure 3-2. Average Day Water Demand (Most Likely Forecast with Conservation Savings) with 25th and 75th percentiles



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3.1.2 Equivalent Residential Units

The water demand for a water system and a water system's physical capacity can be analyzed in terms of equivalent residential units (ERUs). An ERU is a water-system-specific unit of measure used to express the amount of water that is consumed by a typical single family residence. This can be used to express water demand of non-residential customers as an equivalent number of single family residences.

The value of an ERU is calculated by taking the total single family residential demand in the service area (both inside and outside the City of Tacoma) from billing data, and dividing it by the total number of active single family residential connections. The calculation includes both base season (November through June) and peak season (July through October)[6]. To determine the current ERU value, this calculation was completed for years 2010 through 2016 (excluding 2015, an outlier drought year). The resulting values were then averaged to produce an ERU value of 184 gallons per day.

3.2 Conservation Program

Tacoma Water has had a conservation program since the early 1990s. The program is updated periodically and meets DOH requirements for large water systems. Tacoma Water's program consists of both hardware measures (i.e. water-saving devices) and behavior measures addressing year-round water consumption as well as peak season use. Tacoma Water's conservation program, described in detail in Section 3.2.4, continues to address year-round consumption, but is putting a special emphasis on peak season increased use (PSIU), which for single family customers can exceed the base use[7].

Figure 3-3 through Figure 3-5 show the 2014 to 2016 average water consumption by customer class

[6] The base season/peak season months are staggered due to billing cycles.

[7] The PSIU represents irrigation water and the base use represents non-irrigation water. The base use is based on consumption in the winter (Dec-Feb) months. Consumption for three years is averaged to smooth out any potential annual anomalies. This analysis relies on billing data, which may reflect a moderate delay between use and billing. This time delay is not a concern since the key PSIU factor is the volume, not the timing. Note that all three graphs use the same scale on the y-axis in order to show the relative amount of PSIU between the single family, multifamily, and non-residential sectors.

Figure 3-3. Single Family Peak Season Increased Use

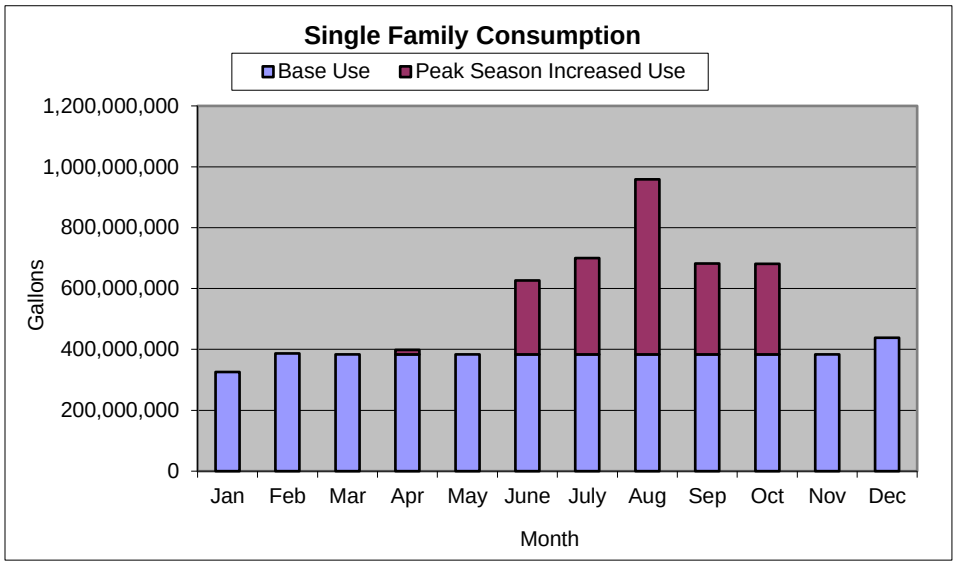


Figure 3-4. Multifamily Peak Season Increased Use

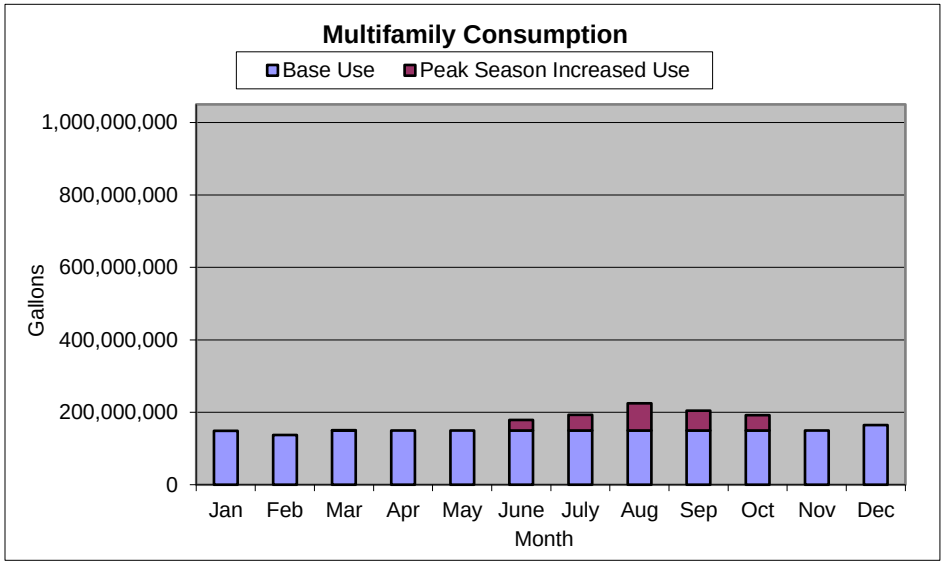
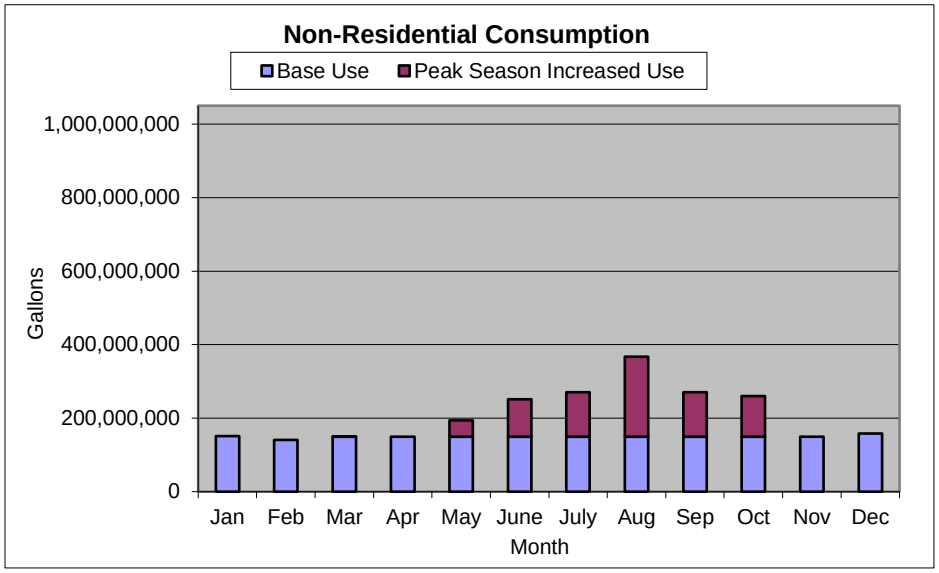


Figure 3-5. Non-Residential Peak Season Increased Use



3.2.1 Water Use Efficiency Requirements and Compliance Summary

The Washington State 2003 Municipal Water Law established "that all municipal water suppliers must use water more efficiently in exchange for water right certainty and flexibility to help them meet future demand." The law is implemented through WAC 246-290 and WAC 246-290-830.

The Municipal Water Law, directed DOH develop the Water Efficiency Rule, which became effective on January 22, 2007 and established planning and operational requirements for water purveyors. Tacoma Water's conservation program is intended to meet the requirements of the Water Efficiency Rule, and to protect and preserve present and future water resources. Table 3-4 lists the rule requirements and Tacoma Water's compliance status for each requirement.

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Table 3-4. Summary of Water Use Efficiency Program Requirements

Category	WAC Section	Requirement	Tacoma Water in Compliance?
1. Meters	246-290-496	1. Meter all **sources.**	Yes, See Section 3.3
		2. Meter all **service connections**.	Yes, See Section 3.3
2. Data Collection	246-290-100	1. Provide monthly and annual **production/purchase** numbers for each source.	Yes, See Appendix F and Midnight Reports, link provided in Section 3.4.
		2. Provide annual **consumption** by customer class.	Yes, See Table 3-3
		3. Provide "**seasonal variations**" consumption by customer class.	Yes, See 2015 *Demand Forecast* Report, provided in Appendix L
		4. Provide annual quantity **supplied to other public water systems**.	Yes, See 2015 *Demand Forecast* Report, provided in Appendix L
		5. Evaluate **reclaimed water** opportunities.	Yes, See Section 4.6
		6. Consider water use efficiency **rate structure**.	Yes, See Chapter 12
3. Distribution System Leakage	246-290-820	1. **Calculate** annual volume and percent using formula defined in the WUE Rule.	Yes, See Table 3-8
		2. **Report** annually: annual leakage volume, annual leakage percent, and, for systems not fully metered, meter installation progress and leak minimization activities.	Yes, See annual WUE Reports
		3. Develop water loss control **action plan** (if leakage is over 10% for 3 year average).	N/A: See Table 3-8 for 3 year average
4. Goals	246-290-830	1. **Establish** measurable (in terms of water production or usage) conservation goals and re-establish every 10 years. Provide schedule for achieving goals.	Yes, See Section 3.2.3
		2. Use a **public process** to establish the goals.	Yes, See Section 3.2.3
		3. **Report** annually on progress.	Yes, See annual WUE Reports

Table 3-4. Summary of Water Use Efficiency Program Requirements

Category	WAC Section	Requirement	Tacoma Water in Compliance?
5. Conservation Program	246-290-810	1. **Describe existing** conservation program.	Yes, See Section 3.2.2
		2. **Estimate water saved** over last 6 years due to conservation program.	Yes, See Section 3.2.2
		3. Describe conservation **goals**.	Yes, See Section 3.2.3
		4. Implement or evaluate 9 measures (relating to the following sectors: residential, outdoor, and industrial/commercial).	Yes, See Section 3.2
		5. Describe conservation programs for next 10 years including schedule, budget, and funding mechanism.	Yes, See Section 3.2
		6. Describe how customers will be **educated** on efficiency practices.	Yes, See Section 3.2
		7. Estimate **projected water savings** from selected measures.	Yes, See Section 3.2
		8. Describe how efficiency program will be **evaluated** for effectiveness.	Yes, See Section 3.2
		9. Estimate **leakage from transmission lines** (if not included in distribution system leakage).	N/A, all leakage is included in the distribution system leakage number.
6. Demand Forecast	246-290-100	1. Provide demand forecast reflecting **no additional conservation**.	Yes, See Table 3-3
		2. Provide demand forecast reflecting **savings from efficiency program**.	Yes, See Table 3-3
		3. Provide demand forecast reflecting **all "cost effective" evaluated measures,** if not implementing the minimum number of measures.	N/A, the City plans to implement at least 9 measures.
7. Performance Reports	246-290-840	1. **Develop** annual report including: goals and progress towards meeting them, total annual production, annual leakage volume and percent, and, for systems not fully metered, status of meter installation and actions taken to minimize leakage.	Yes, See annual WUE Reports
		2. **Submit annually** to DOH and customers and make available to the public.	

3.2.2 Implementation since the 2006 Plan

Tacoma Water's previous conservation program can be divided into residential, commercial, and education sections. Residential customers can receive free showerheads, shower timers, toilet leak detection dye tabs, kitchen sink aerators, and bathroom sink aerators. These customers can also receive tailored, in-person recommendations for home water walk-throughs, which can improve water efficiency. For commercial customers, Tacoma Water offers two rebate programs. The first is a customized program, in which any water-saving fixture is eligible for a rebate based on projected water savings (e.g. water-recycling laundry facilities at Pierce County Jail). The second is a commercial kitchen equipment program, in which clients receive a set rebate amount for purchase and installation of specific fixtures (e.g. water-efficient commercial dishwashers). Upon request, commercial clients can also receive water audits to make specific recommendations based on the needs of their facilities. Tacoma Water's educational component includes printed material (e.g. the "Know your H2O" guide), web resources, and extensive community outreach. They organize events in local neighborhoods (street fairs, National Night Out, community meetings, etc.), as well as, offer workshops at the EnviroHouse, local libraries, and other venues in their service territory. Tacoma Water works with other organizations (e.g. EnviroChallengers, Junior Achievement, Healthy Homes/Healthy Neighborhoods) and internal staff to encourage additional promotion of water efficiency in schools and communities.

Tacoma Water's conservation program activities since 2006 are summarized in Table 3-5.

Table 3-5. Water Conservation Activities: 2006-2017

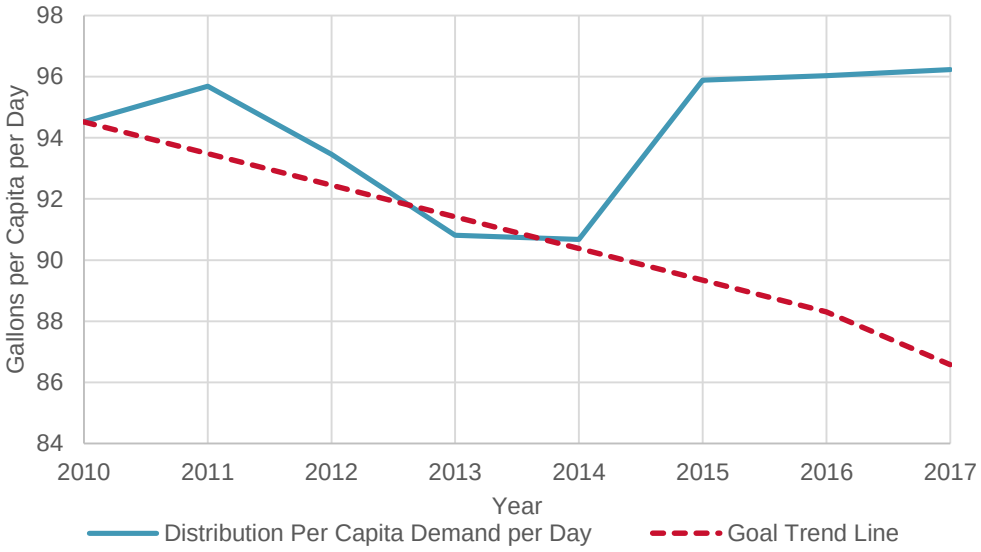
Customer Class	Measure	Description
Commercial/Industrial, Institutional	Rebates	Various indoor fixture rebates
Commercial/Industrial, Institutional	School Audits	Three Elementary Schools Audited
Single Family Residential/Multi-family Residential	Showerhead Giveaways	331 showerheads distributed
Single Family Residential/Multi-family Residential	Showerhead giveaways (partnership with PSE and Tacoma Power) in 2008	4,416 showerheads distributed
Single Family Residential/Multi-family Residential	Faucet Aerators	258 kitchen, 397 bathroom aerators distributed/installed
Single Family Residential/Multi-family Residential	Efficiency Kit Mailers	2010: 6,847 mailers 2011 :1,451 mailers 2012: 6,184 mailers 2016: 749 mailers 2017: 1,150 mailers
Single Family Residential/Multi-family Residential	Clothes Washer Rebates	5,522 high efficiency clothes washer rebates issued
Commercial/Industrial, Institutional	Spray Nozzles and Aerators	1,412 aerators, 753 Spray Nozzles distributed/installed in 2006

Table 3-5. Water Conservation Activities: 2006-2017

Customer Class	Measure	Description
Single Family Residential	Residential Water Audits	27 homes audited in 2017, more audits planned
All	Public Outreach	Workshops, TV spots, outreach at community meetings/events
Single Family Residential/Multi-family Residential	Public Outreach	Children's Water Festival approx. 1,000 students per year
Single Family Residential/Multi-family Residential	Shower Timer Giveaways	2,000 shower timers distributed
Single Family Residential/Multi-family Residential	Public Outreach	Sponsorship of conservation outreach through Junior Achievement – 10,675 students from Tacoma Schools reached from 2006-2016

Tacoma Water's conservation to date is shown in Figure 3-6. Water savings from conservation has been difficult to quantify as summer weather has a significant impact on the measures of goal progress. Though indoor water use has continued to become more efficient, summertime water use (including outdoor irrigation) has increased over the last few years, perhaps due at least in part to recent relatively hot and dry summers. The average total water use per capita per day has therefore increased by 1.18%, and we did not meet our goal of a decrease of 8.4%. That said, with Tacoma Water's new tracking system (online in 2017), the estimated residential fixture giveaways alone saved over 3 million gallons of water in 2017.

Figure 3-6. Conservation Goal Progress



3.2.3 Adopted goals

Tacoma Water is in the process of adopting a new goal of 6.65 percent reduction (2017 baseline) in population-adjusted daily demands (measured as gallons per capita per day)

during the peak water use season of May through October by 2027. This population-adjusted daily demand goal is calculated through the following formula:

> Pop. Adjusted Daily Demand (gpcd) = [Average Daily Water System Distribution (May through October) – Wholesale Customers Demand – Large Volume Customers Demand (> 1 MGD)] / Population

Estimated per capita demand, non-programmatic water savings, and active conservation water savings are summarized in Table 3-6.

The goal amount is based on projections of non-programmatic conservation (housing upgrades, code improvements, etc.) and estimated savings from conservation modeling outputs (described in Section 3.2.4).

To establish the goals, Tacoma Water first came up with several options, working with the model from the engineering and consulting firm HDR. These options were groups of individual measures centered on a focus (such as “most participation” or “most overall savings”). Tacoma Water initially presented several options to the Integrated Resource Plan public advisory committee, and received a great deal of valuable feedback. Using this feedback, as well as feedback from the Tacoma Water managers, Tacoma Water crafted a new option, which the managers felt was greatly improved. This option was presented to the public in a public meeting as well as on the TPU website. Tacoma Water solicited both online and paper comments on the plan, and received 38 responses from members of the public. These responses did not give cause for any major changes in the plan. As a result, Tacoma Water chose to move forward with the proposed plan, which will focus on peak demand reduction for the 2018-2027 period.

3.2.4 Program Design and Delivery

Tacoma Water’s 2018–2027 conservation program is designed with an emphasis on peak demand reductions. Tacoma Water has modeled several conservation programs to estimate savings based on packages of various measures and customer participation rates. The selected conservation measure package includes both indoor and outdoor measures, targeting both residential and commercial customers.

Annual costs for the 10-year program are estimated to be approximately $80,000, and are expected to result in an average savings of nearly 247,000 gallons per day and peak season savings of 278,000 gallons per day. Table 3-7 shows a summary of Tacoma Water’s conservation program.

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Table 3-6. Projected Water Uses With and Without Active Conservation Program Savings-May through October

Program Year	Water Distribution to System (MGD) [a]	Service Area Population	Non-Programmatic Conservation			Active Conservation-Related Reduction (MGD)	Active Conservation		
			Per Capita Demand (gallons per person per day) without Active Conservation	Percent Change Year over Year	Cumulative Percent Change (without Active Conservation) [b]		Per Capita Demand (gallons per person per day) with Active Conservation [c]	Percent Change Year over Year	Cumulative Percent Change
2017	39.96	326,763	122.27				122.27		
2018	39.92	328,757	121.44	-0.71	-0.71	0.03	121.34	-0.76	-0.76
2019	39.89	330,751	120.61	-0.68	-1.38	0.05	120.44	-0.75	-1.50
2020	39.87	332,745	119.84	-.064	-2.01	0.08	119.59	-0.71	-2.20
2021	39.81	334,739	118.91	-0.76	-2.75	0.11	118.60	-0.83	-3.00
2022	39.74	336,733	118.03	-0.76	-3.48	0.14	117.62	-0.83	-3.80
2023	39.68	338,886	117.10	-0.79	-4.24	0.16	116.62	-0.86	-4.63
2024	39.53	339,572	116.39	-0.59	-4.81	0.19	115.85	-0.66	-5.26
2025	39.42	340,257	115.84	-0.48	-5.26	0.22	115.21	-0.55	-5.78
2026	39.32	340,943	115.34	-0.44	-5.68	0.25	114.62	-0.51	-6.26
2027	39.27	341,628	114.96	-0.33	-5.99	0.28	114.15	-0.41	**-6.65[d]**

[a] Total water distribution from May through October minus wholesale, pulp mill, and large volume customers.

[b] Reduction mainly due to system upgrades, code improvements, and other market-savings measures. See the 2015 *Demand Forecast* Report (Appendix L)

[c] Projected population-adjusted demand with non-programmatic and active conservation measures. Equation = ("Water Distribution to System" - "Conservation-related reduction")/"Population" × 1,000,000

[d] Program Goal

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Table 3-7. Conservation Package Summary

Conservation Measure [e]	Sector [d]	Seasonality	Hardware vs. Behavior	Customer Definition	Participation			Savings			Costs	
					All Customers			Savings for All Customers at Full Implementation		Savings for All Customers	Total Cost over Planning Period	Cost per CCF Saved Over Measure Life
					Participating Customers [a]	Savings-Generating Customers [b]	Devices/ Rebates/ Audits	Annual Average (gallons per day)	Peak Season (gallons per day)	CCF (hundreds cubic feet)[c]		
Faucets - 1.0 gpm Bathroom Aerators	SF	Year Round	Hardware	Single Family Households	17,158	8,579	42,895	43,765	43,765	304,319	$97,220	$0.32
Faucets - 1.0 gpm Bathroom Aerators	MF	Year Round	Hardware	Multifamily Households	23,503	11,752	35,255	62,302	62,302	433,199	$38,530	$0.09
Showerhead 2.0 gpm	MF	Year Round	Hardware	Multifamily Households	24,793	12,397	37,190	44,629	44,629	310,319	$116,670	$0.38
Irrigation Controllers - ET Model	SF	Peak Only	Hardware	Single Family Households	883	883	883	7,494	14,987	34,739	$134,480	$3.87
Irrigation Controllers - ET Model	MF	Peak Only	Hardware	Multifamily Accounts	71	71	71	1,831	3,662	8,487	$9,850	$1.16
Irrigation Controllers - ET Model	NR	Peak Only	Hardware	Non-Residential Accounts	53	53	53	5,997	10,280	27,798	$13,170	$0.47
Outdoor Irrigation Kits	SF	Peak Only	Hardware	Single Family Households	10,390	5,195	14,546	14,696	29,392	66,764	$245,868	$3.68
Outdoor Audit	NR	Peak Only	Behavior	Non-Residential Accounts	158	40	237	4,526	7,758	15,538	$3,825	$0.25

Table 3-7. Conservation Package Summary

Conservation Measure [e]	Sector [d]	Seasonality	Hardware vs. Behavior	Customer Definition	Participation			Savings			Costs	
					All Customers			Savings for All Customers at Full Implementation		Savings for All Customers	Total Cost over Planning Period	Cost per CCF Saved Over Measure Life
					Participating Customers [a]	Savings-Generating Customers [b]	Devices/ Rebates/ Audits	Annual Average (gallons per day)	Peak Season (gallons per day)	CCF (hundreds cubic feet)[c]		
Faucets - 2.0 gpm Kitchen Aerators	MF	Year Round	Hardware	Multifamily Households	14,876	7,438	14,876	23,802	23,802	165,505	$17,950	$0.11
Combination Oven - Efficient	NR	Year Round	Hardware	Non-Residential Accounts	21	21	21	10,103	10,103	56,202	$5,710	$0.10
Ice Maker - Efficient	NR	Year Round	Hardware	Non-Residential Accounts	21	21	27	18,799	18,799	79,304	$8,788	$0.11
Steamer - Efficient	NR	Year Round	Hardware	Non-Residential Accounts	21	21	27	4,796	4,796	20,234	$7,150	$0.35
CII Rebate	NR	Year Round	Behavior	Non-Residential Accounts	10	10	10	3,918	3,918	237,240	$99,640	$0.42
Total					**N/A**	**N/A**	**N/A**	**246,658**	**278,193**	**1,759,648**	**$798,851**	**N/A**

Source: HDR Water Conservation Model

[a] Participating customers are those that participate in the conservation program, but may not follow through with implementing the measure.

[b] Savings-generating customers are those that implement the measure and therefore produce water savings.

[c] Units of hundreds of cubic feet are used for cost-effectiveness calculations

[d] SF = single family, MF = multifamily, NR = non-residential (i.e. commercial / industrial / institutional)

[e] ET= evapotranspiration, CII = commercial / industrial / institutional

The conservation measures shown in Table 3-7 are a component of Tacoma Water's overall conservation program, and public outreach activities will continue. Additional education and public outreach activities include:

- Continuation of educational programs at school and community events;
- Workshops and educational collaborations with the EnviroHouse and other local groups;
- New conservation curriculum to be offered to schools (aligned with new Next Generation Science Standards); and
- Other marketing and outreach items as needed.

In addition to water efficiency goal tracking, program effectiveness will be measured by participation in rebate and giveaway programs, the number and attendance of public outreach activities, and other qualitative measurements. All activities will be tracked and water efficiency programming will be re-evaluated annually for participation and effectiveness (actual water savings).

3.3 Leakage

Tacoma Water meters its water supply sources, water that is exported through interties to wholesale customers and customer service connections. Supply source metering provides a record of water production. Service connection metering indicates the amount of water consumed by each customer and provides the basis for collecting revenues. In an ideal water system, consumption records would be nearly equal to production records. In other words, nearly all water produced would be purchased for consumption. However, it is inevitable that a portion of water produced will not be billed, whether it is due to system leakage, flushing and cleaning, mainline breaks, firefighting, or metering errors. Accordingly, this "unaccounted-for water" represents the difference between water produced and water consumed.

WAC 246-290-810(4)(C)(i) requires municipal water suppliers to evaluate and report distribution system leakage as part of the Water Use Efficiency rule. Leakage is reported to DOH through the WUE annual reporting worksheet and made available to the public through the DOH Sentry Internet database.

WAC 246-290-820(1)(b)(i) requires municipal water providers have less than 10 percent leakage based on a 3-year average. If this goal is not met, purveyors are required to develop and implement a water loss control plan. Table 3-8 shows Tacoma Water's annual WUE report for 2014 through 2016. The 3-year average leakage rate is 3.91 percent, which meets the standard under WAC 246-290-820.

Table 3-8. Leakage/Unaccounted for Water

Year	Total Water Produced and Purchased (billions of gallons)	Authorized Consumption (billions of gallons)	Unaccounted for Water Volume (billions of gallons)	Percent Unaccounted for Water
2014	23.29	22.37	0.92	3.95
2015	23.06	22.42	0.64	2.77
2016	24.15	22.90	1.25	5
Three-year Average				**3.91**

3.4 Links to Relevant Materials

- Midnight Report: https://www.mytpu.org/tacomawater/AWSP-Resource-Agencies.htm
- Pierce County Buildable Lands Report 2014: http://www.co.pierce.wa.us/DocumentCenter/View/30444
- Pierce County Community Plans: http://www.co.pierce.wa.us/925/Adopted-Community-Plans
- Puget Sound Regional Council Vision 2040 https://www.psrc.org/vision-2040-documents
- Water Conservation Plan: https://www.mytpu.org/file_viewer.aspx?id=70625

4 Water Sources

Tacoma Water relies on the conjunctive use of surface and groundwater to meet customers' demands for water. This chapter describes Tacoma Water's surface and groundwater sources of supply, water rights, experiences with drought effects, climate change considerations, and the outcomes of the *Integrated Resource Plan* (IRP) that was prepared in conjunction with this WSP. Links to relevant materials are provided in Section 4.7.

4.1 Green River Supply

The Green River is Tacoma Water's primary source of drinking water. Water is diverted at the Green River Diversion Dam, which is approximately 30 miles east of Tacoma. The watershed, located above the diversion, consists of approximately 230 square miles of timbered and mountainous terrain.

Tacoma Water's First Diversion Water Right (FDWR) claim can supply up to 113 cfs (73.0 MGD), subject to minimum stream flows. The Second Diversion Water Right (SDWR) permit on the Green River is an interruptible additional supply that allows for diversion of up to another 100 cfs (64.6 MGD), and is the source for the Second Supply System. The SDWR is conditional based on Green River flow and is, therefore, only available as run-of-river (absent stored) approximately 60% of the time on an annual basis.

The Second Supply Project (SSP) became operational in October 2005. The SSP Agreement defines the rights and obligations of the Participants. Tacoma Water has a 15/36 Participant Share, and the City of Kent, Covington Water District, and Lakehaven Water and Sewer District each have a 7/36 Participant Share in the SSP. This partnership is known as the Regional Water Supply System (RWSS). Generally, a Participant Share represents a Participant's proportional right to receive water delivered by the RWSS. It should be noted that only the SDWR is included in the RWSS and Tacoma's FDWR is solely used for the needs of Tacoma Water (i.e. not for use by the Partners).

The U.S. Army Corps of Engineers (USACE) owns and operates Howard Hanson Dam, forming the Eagle Gorge Reservoir, about three miles upstream from Tacoma Water's Diversion Dam. The primary authorized purpose of the dam is to provide flood control for the Green River valley during the winter. Secondary authorized purposes include augmentation of low summer flows downstream of the dam, and storing water under the Howard Hanson Additional Water Storage Project (AWSP) for municipal water supply purposes by Tacoma Water and its RWSS Partners.

Second Diversion Water is stored behind Howard Hanson Dam in the spring, and as the water is being stored at a rate not to exceed the SDWR rate, it may be withdrawn at a later date, at any rate. Therefore, when needed in the peak season, water from the Green River source may be used at a rate that is limited only by pipe/plant capacity.

Tacoma Water and USACE have a Project Cooperation Agreement (PCA) that outlines the relationship between Tacoma Water and USACE. The PCA defines the scope of project modifications and documents the cost share agreement for the project.

All elements of Phase I of the AWSP have been completed since the last WSP update in 2006, except development of the downstream fish passage facility at Howard Hanson Dam, which remains for future completion by USACE. This fish passage facility is expected to take ten years or more to fund, design, and construct.

During the spring refill period, USACE stores about 26,000 acre-feet of water to support its 110 cfs minimum flow requirement in the Green River at the USGS Palmer gage, 5,000 acre-feet for additional in-stream flow support purposes, and up to 20,000 acre-feet for the RWSS operated by Tacoma Water. Of the 20,000 acre-feet, Tacoma Water and the regional Partners have been donating, on a year-by-year basis, half of the water stored for the RWSS back for use by the resource agencies, in recognition that Phase I of the AWSP is not complete. Therefore, Tacoma is currently able to use up to 4,167 acre-feet (half of the 8,333 acre-feet that will eventually be available). The remainder is for other Partners in the RWSS.

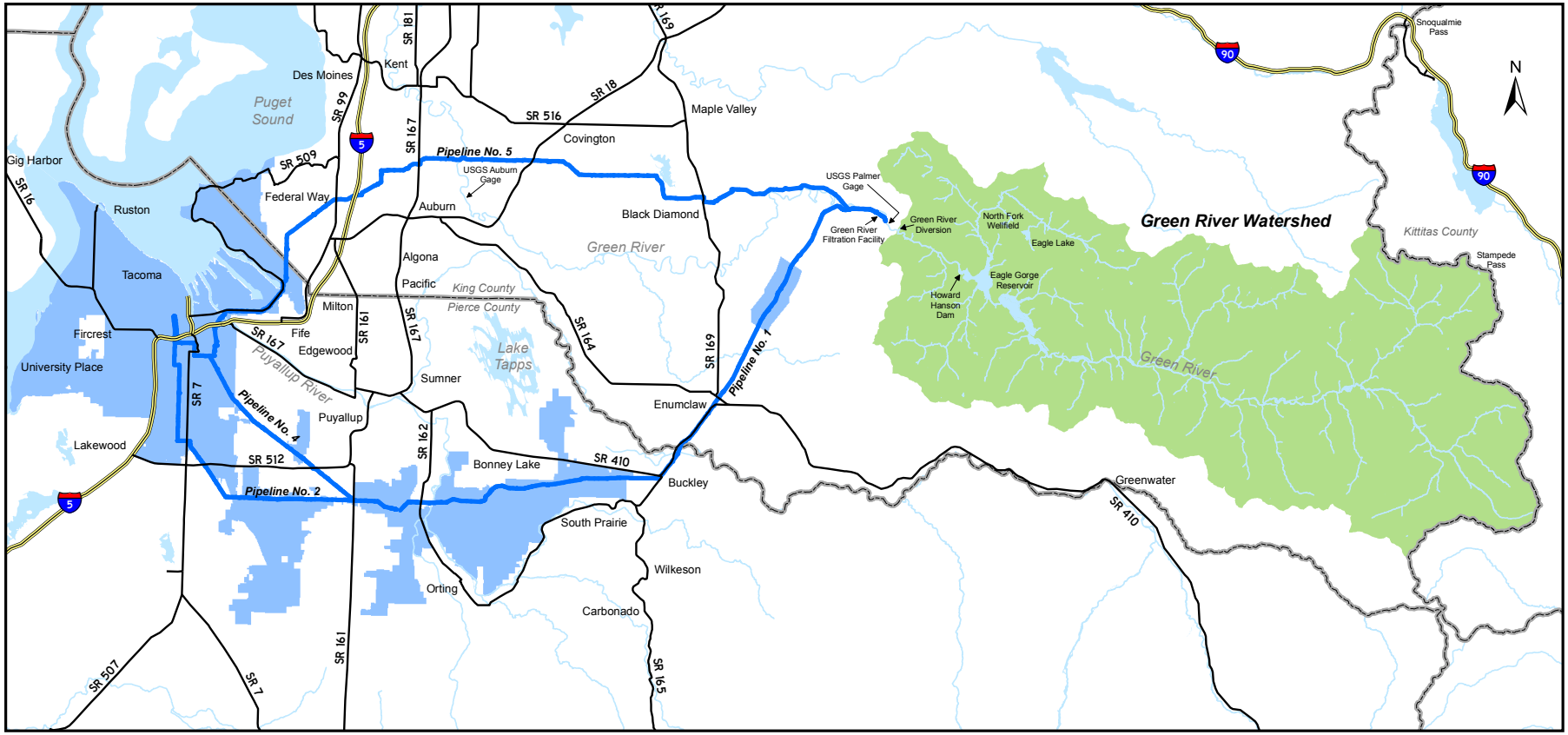
An agreement reached with the Muckleshoot Indian Tribe (MIT) in 1995 requires Tacoma Water to guarantee minimum flow in the Green River at the USGS Auburn gage. In the event the minimum flows would not otherwise be met, Tacoma Water is required to reduce use of the FDWR or use water stored at Howard Hanson Dam to supplement stream flow as part of the Howard Hanson Dam AWSP.

The potential future Phase II of the Howard Hanson AWSP would provide for additional storage capacity, including an additional 2,400 acre-feet for municipal and industrial supply, and an additional 9,600 acre-feet for low-flow augmentation. The exact requirements and the timeframe for Phase II have not yet been determined.

The supplies provided under the surface water rights (FDWR and SDWR) can be replaced with water from the North Fork Wells when water in the Green River is turbid, or cloudy. These wells are located along the North Fork of the Green River, located a short distance from Howard Hanson Dam. The North Fork aquifer is relatively small and cannot support sustained pumping without recharge from precipitation or snowmelt. Actual production capacity varies sharply seasonally from 84 MGD to as low as 12 MGD. However, the aquifer does not exhibit long-term (year over year) changes in water levels. The shallow North Fork wells are considered part of the Green River supply source, and are separate from the production wells discussed in Section 4.2.

The Green River supply, North Fork wellfield and Howard Hanson Dam are shown on Figure 4-1. Additional information on the water supply infrastructure is included in Chapter 5.

Figure 4-1. Tacoma Water Green River Supply



LEGEND

- County Boundaries
- Bodies of Water
- Retail Service Area
- Watershed Boundary

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When deciding to use water from the Green River source, water is used on a prioritized availability basis:

- It is first determined if Second Diversion Water is available, and how much may be diverted or stored. This water right is interruptible based on minimum in-stream flows in the river at both the Palmer and Auburn gages. Minimum flows vary by gage, and time of year. It is usually fully available in the winter, unavailable in the summer, and partially available in the spring and fall.
- It is then determined if water is available from the FDWR, and how much of this right may be used. Tacoma Water must ensure a minimum flow at the Auburn Gage is present in order to use this water right. Use of the SDWR and FDWR occurs in the priority order mentioned below, until either the instantaneous maximum allowed flow rate (Qi) of the water right is fully used, or no more water is needed. If additional water is needed, the use of the next right is initiated.
- During the reservoir fill period (from approximately February 15th until near the end of May or early June) all SDWR-Run-of-River is stored in Eagle Gorge Reservoir, net of such water delivered down the pipeline during this time to the three Partners. Tacoma Water uses FDWR. If Tacoma or the other Partners use up their first source, SDWR-Stored is used.
- The Reservoir drawdown period begins when the reservoir is declared full near the end of May or early June, and ends when all the stored water has been used, the Corps declares a need to begin flood control, or November 1st occurs (whichever comes first). During this time Tacoma Water uses water in the following priority (if available): SDWR-Run-of-River (not usually available at this time of year), then FDWR, then SDWR-Stored. The other RWSS Partners use water in the following priority (if available): SDWR-Run-of-River (not usually available at this time of year), then SDWR-Stored.
- During the winter period, storage has been depleted, the reservoir is available for flood control, and water is usually plentiful on the Green River. Tacoma Water uses water in the following priority: SDWR-Run-of-River, then FDWR, and the other Partners use SDWR-Run-Of-River.

Portions of the Green River and its tributaries are on the Washington State Department of Ecology's 303(d) list for temperature, which led to a Green River Temperature Total Maximum Daily Load (TMDL) study produced by the Washington State Department of Ecology in June 2011. This report concludes with a discussion about establishing and improving mature riparian vegetation for shade along the middle and lower Green River and its tributaries. Tacoma Water supports planning policies from King County and others to restore and protect the quality of the natural environment for future generations. As discussed above, Tacoma Water has multiple environmental commitments on its diversion from the Green River, including maintenance of a minimum in-stream flow at the Auburn gage. In addition, Section 3.2 of the WSP discusses Tacoma Water's conservation program.

4.2 Groundwater Production Wells

In addition to the supply from the Green River and North Fork wellfield, Tacoma Water owns and operates multiple supply wells located in and around the city. These wells are used primarily to augment Green River supply during summer months when peak demands occur. In a normal weather year, these groundwater wells supply approximately 5 percent of total annual water requirements. Additional information on the wells is included in Section 5.2.

The following wells and wellfields are shown in Figure 4-2.

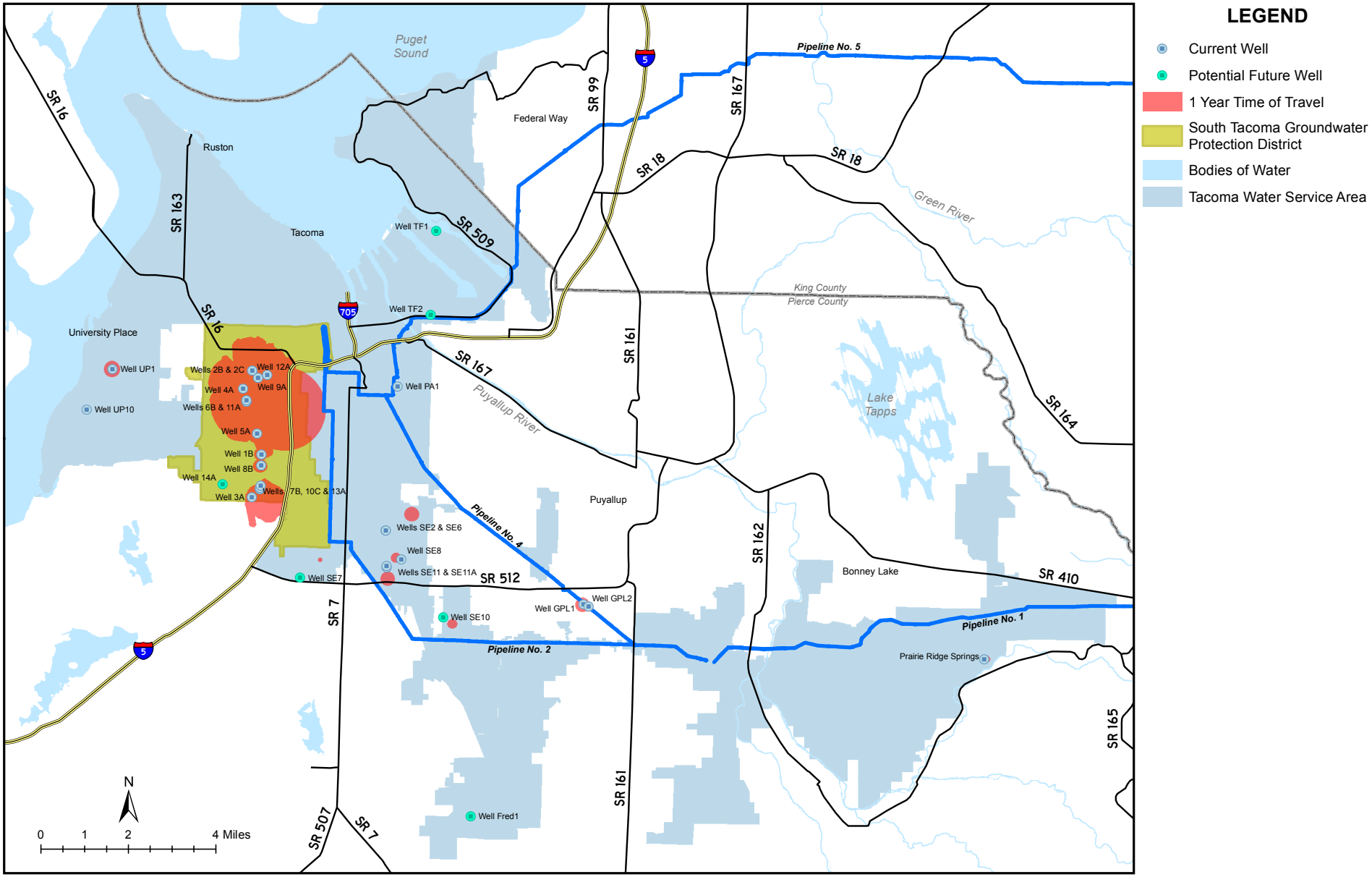
- South Tacoma Wellfield
  - North Wells (Wells 2B, 2C, 4A, 5A, 6B, 9A, 11A, 12A)
  - South Wells (Wells 1B, 3A, 7B, 8B, 10C, 13A, 14A*)
- Southeast Tacoma Wells (Wells SE2, SE6, SE7*, SE8, SE10*, SE11, SE11A)
- University Place Wells (UP1, UP10 - Emergency well)
- Gravity Pipeline Wells (GPL1, GPL2)
- Tideflats Wells (TF1*, TF2*)
- Portland Avenue Well (PA1)
- Fredrickson 1 Well (Fred1*)
- Prairie Ridge Springs (PRS)

* Potential Future Well

Tacoma Water has water rights to withdraw and use groundwater from all of its wells. The water rights for various wells are listed in Section 4.3

The Tacoma Water groundwater supply system is operated seasonally to meet high-demands during the period from approximately April to October. In an attempt to conserve power (and reduce costs), wells are only operated when surface water is or may be insufficient to meet demand. The specific period of operation of the wells is based on the amount of flow available in the Green River and the stored water in the Eagle Gorge Reservoir behind the Howard Hanson Dam. During dry years (like 2015), wells may go on as early as April and continue pumping until October when fall rains increase river flow. During normal years, groundwater wells may not be turned on until later in the summer. During wet years, when surface water supplies are able to meet all demands (including all anticipated late summer/early fall demands), wells may not be used except for routine maintenance and testing.

Figure 4-2. Tacoma Water Groundwater Sources



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As groundwater pumping starts in the spring or early summer and continues through the year, groundwater levels decline. Declining groundwater levels can cause the groundwater pumping rates to need to be reduced to keep pump intakes submerged. Groundwater wells and pumps are equipped with supervisory control and data acquisition (SCADA)-controlled throttling valves that automatically reduce pumping rates as needed to maintain adequate water levels in the wells. This avoids over-pumping the well beyond the aquifer capacity and dewatering of the pump intakes.

South Tacoma groundwater levels have stayed relatively constant each year since the 1950s when storm sewers were built in the area. The aquifer is expected to completely recharge each winter. Monitoring well level readings in recent years have been within a foot during the spring.

The Tacoma Water wells are operated in order of priority based on a variety of factors including efficiency, yield, reliability, infrastructure limits, and water quality. Generally, wells are turned on to meet demand in an order of priority based on these factors.

In the South Tacoma Wellfield, Well 12A is equipped with a treatment system (stripping tower) to remove volatile organic compound (VOC) contaminants from the pumped water, and to prevent these contaminants from migrating north to other wells in the wellfield. If the large capacity wells that pump water from the upper aquifer in the north part of the wellfield are on, then Well 12A is typically also operated. Wells in the south part of the wellfield are typically turned on before the wells in the north part of the wellfield.

Controlling the risk of lead and copper in drinking water is a factor in the operation of all of the Tacoma Water wells. The implementation of corrosion control measures and the operation of wells with or without corrosion control are being evaluated by Tacoma Water at this time.

Time Oil Site

The Environmental Protection Agency (EPA) has been overseeing cleanup activities at a Superfund site in South Tacoma formerly operated by Time Oil. This site affects the aquifer that provides water to the South Tacoma Wellfield. Tacoma Water uses specialized treatment equipment at one of its wells to remove contaminants that originate from the Time Oil site. Monitoring of water produced at that well shows that contaminants entering the well from the aquifer have been declining in recent years, and the treatment system is effective at removing the remaining contamination. Balancing pumping from the treatment well with pumping from other Tacoma Water wells in the area prevents contaminants from entering the other wells used for drinking water production. While this approach enables production of safe drinking water from the aquifer, Tacoma Water believes that the long-term protection of drinking water must include continued, stringent cleanup requirements for the Time Oil site. Tacoma Water is currently engaged in discussion with EPA and Washington State agencies regarding their plans for assuring completion of the necessary cleanup activities.

4.3 Water Rights

Table 4-1 provides a summary of Tacoma Water's existing groundwater and surface water rights. Compared with the demand forecast presented in Chapter 3, Tacoma Water has sufficient water rights to meet projected demand through 2037. A complete inventory of Tacoma Water's water rights is available in Appendix F.

Table 4-1. Water Rights Summary

Surface Water Rights								
	Permitted / Certified				**Developed Capacity [e]**			
Source	**CFS**	**GPM**	**MGD**	**AF/Yr**	**CFS**	**GPM**	**MGD**	**AF/Yr**
Green River – FDWR [a]	113	50,719	73.04	81,800	113	50,719	73.04	80,053
Green River – SDWR [c]	100	44,886	64.64	72,397	100	44,886	64.64	43,330
Prairie Ridge Springs [b]	1.26	565	0.80	450	1.2	530	0.76	195
North Fork Wells [g]	130	58,300	84.00	30,244	111	49,997	72.00	22,746
Subtotal [d]	**214**	**96,170**	**138.48**	**154,197**	**214**	**96,135**	**138.44**	**123,383**

Groundwater Rights							
	Permitted / Certified			**Developed Capacity [e]**			**Approx. Nominal Capacity Existing (MGD)**
Source	**GPM**	**MGD**	**AF/Yr**	**GPM**	**MGD**	**AF/Yr**	
So. Tacoma Wells	54,315	78.22	31,298	51,585	74.29	25,480	44.9
University Place [h]	7,950	11.45	3,641	6,616	9.53	1,440	1.6
Dash Point	1,130	1.63	470	970	1.40	139	0
SE Tacoma Wells	5,690	8.19	1,899	4,445	6.40	1,899	3.5
Other Wells	10,750	15.48	1,970	8,950	12.31	1,484	9.5
Subtotal [f]	**79,835**	**114.97**	**39,278**	**72,566**	**103.59**	**30,442**	**59.5**

Footnotes:
[a] Although the claim was recorded for 400 cfs (258 MGD), maximum pipeline capacity is 113 cfs (73 MGD). Tacoma capped the claim at 113 cfs per Habitat Conservation Measure HCM 1-01, 2001 Habitat Conservation Plan.
[b] Supplemental water right. Annual quantity not additive to primary rights.
[c] Annual quantity is based on diversion of 100 cfs, 365 days/year. In-stream flow constraints as described on the permit will limit the annual average diversion to approximately 70 percent of the amount listed. Additional constraints in tribal agreements reduce the yield to approximately 60 percent. The water available from this source would therefore be about 43,000 acre-feet in an average year.
[d] Limits the 400 cfs water right claim at 113 cfs and assumes that the 100 cfs permit provides an annual yield averaging 43,000 AF/YR.

Table 4-1. Water Rights Summary

[e] Maximum historic instantaneous flow rate and annual production, which has occurred under the water right or declamation of claim. Instantaneous flow rate is obtained within one hour of well startup; production flow rate is generally lower. In cases where instantaneous flow rate data is not available, rated pump capacity is used.
[f] Total annual use under all rights shall not exceed 111,000 AF or 0.5 AF/capita, whichever is greater.
[g] The North Fork water right is only to be used in place of Green River surface water diversions, so it does not add to the total rate or quantity of water rights.
[h] Estimated, pending review of historical records.

4.4 Effects of Drought on Supply

The Green River supply can be reduced substantially during droughts that occur periodically in the region. Droughts may be driven by reduced snowpack in the Cascade Range, low precipitation levels, or both. Groundwater supplies have been less susceptible to droughts, but are not necessarily immune from adverse effects. In addition to the reduced aquifer recharge that occurs during precipitation droughts, groundwater levels may be further affected by increased pumping that occurs during dry periods by both Tacoma Water and adjoining water systems.

Tacoma Water's experience with drought led to the development of a *Water Shortage Response Plan* (WSRP) in 2005. The WSRP serves as a guide for the best management of Tacoma Water's supplies for the duration of any type of water shortage. The WSRP outlines the actions that can be taken to reduce customer water demand, with a primary focus on non-essential water use (such as lawn watering), and additional actions that Tacoma Water may take to stretch supplies of water. Tacoma Water is looking at ways to shore up the ability to obtain water in years with low river flow, and have surety in how and when water is stored and released for municipal use.

While typical water conservation programming involves ongoing promotion of efficient water use, the WSRP is a short-term tool to organize reductions in water demand in concert with appropriate supply augmentation. The WSRP is designed to complement Tacoma Water's WSP and *Habitat Conservation Plan* (HCP). Additionally, the WSRP:

- Reinforces Tacoma Water's objectives to be environmentally responsible and well prepared to service customers when dealing with water shortage and system problems.
- Complements existing water conservation programs and provides guidelines and options to address extended low flows in the Green River or reduced availability of groundwater.
- Provides a menu of possible responses to emergencies such as loss of well capacity or loss of transmission capacity because of major water main or pumping system disruptions.

The WSRP includes four stages of response related to droughts or other supply shortages. These include Advisory (Stage 1), Voluntary (Stage 2), Mandatory (Stage 3), and Emergency (Stage 4). Stages 1 through 3 are intended to be used in response to droughts and water system disruptions, and Stage 4 is intended to be used in response to disasters. A link to the *Water Shortage Response Plan* is provided in Section 4.7.

Tacoma Water's HCP includes provisions for reducing Green River water withdrawals to protect fish habitat. Depending on the severity of the water shortage affecting the Green River, drought coordination meetings between Tacoma Water, local, state and federal resource agencies, the MIT, and USACE may be required to "fully explore all alternatives that will allow the maintenance of guaranteed minimum stream flows" and to institute "consensus-derived" water use restrictions. Before reducing river flows at the Auburn gauge below 250 cfs, Tacoma Water is required to institute water use restrictions consistent with Tacoma Water's HCP and 1995 agreement with the MIT.

The drought in 2015 was unprecedented. Records were broken for low snowpack and low Green River inflows. The year also tied for the most consecutive days above 90°F, which occurred in June, instead of the more typical July or August timeframe. USACE did not achieve full storage in Eagle Gorge Reservoir. In addition, this was the first significant drought since the SSP and the AWSP came online.

Tacoma Water continues to evaluate and develop strategies and alternatives for addressing the issue of obtaining water in dry years. There is a desire to increase clarity as to the quantity and use of municipal water stored using a state water right permit by the federal government.

Another part of Tacoma Water's response is the creation of an *Integrated Resource Plan* (IRP). The IRP provides an in-depth assessment of how drought conditions affect Tacoma Water's source production and outlines both supply-side and demand-side management responses. A link to the IRP can be found in Section 4.7.

4.5 Integrated Resource Plan

Tacoma Water has developed an Integrated Resource Plan (IRP) to improve its ability to manage available water supplies, plan for new supplies as needed, and protect stream flow for fish in the Green River watershed.

Historically, water utilities treated water needs ("demand") as an independent factor, and developed supplies sufficient to meet those needs. This has been changing in recent decades. Utility managers, regulators and customers now understand that water demand can be controlled, just as supplies can be increased. Tacoma Water has promoted water conservation by its customers since the 1980s and maintains a Water Shortage Contingency Plan to reduce water use during droughts or other supply shortages. By integrating supply and demand into a single analysis, the IRP recognizes these changes and provides a robust framework for water management decisions in the coming decades.

Tacoma Water convened an IRP Public Advisory Committee (PAC) to assist in developing the plan. The PAC met on five occasions to review stages of IRP development and provide input on the approaches used and on expectations for future conditions that will influence water needs in Tacoma and Pierce County.

Tacoma's water sources include the Green River and local groundwater supplies. Together these sources serve the City of Tacoma, other communities adjoining the City or located near its supply pipelines, and Tacoma's Second Supply Project partners in King County. Historically, the Green River has supplied most of Tacoma Water's needs, with groundwater used only in the summer months. However, the availability of multiple

supplies provides flexibility to manage a range of supply, demand and environmental conditions that may occur over longer periods, especially during droughts such as the ones that occurred in 2001, 2005 and 2015.

4.5.1 Resource Adequacy Standard

Tacoma Water established a Resource Adequacy Standard (RAS) that serves as a "yardstick" for testing whether water supplies are sufficient to meet demands now and in the future. The RAS states Tacoma Water's "sources and system will be sufficient to meet demands such that mandatory curtailments will occur not more than once in 25 years, as a long-term average." Mandatory curtailments are a normal but infrequent requirement that public officials can call for, in which the system's water customers are required to reduce water uses in order to get through a drought or other temporary supply shortage. The IRP examines how often mandatory curtailments would be needed under various combinations of future supply and demand conditions. If the RAS is met, Tacoma Water's resources are considered adequate.

4.5.2 Water Yield Supply and Demand Model (WYSDM)

As part of the IRP project, Tacoma Water developed a sophisticated computer model of water supplies and demands, called the Water Yield, Supply, and Demand Model (WYSDM). WYSDM is flexible in its modeling capabilities; it can model current and historic conditions; it can model scenarios representing alternative future conditions; and it can provide insights into how climate change might affect supply and stream flow. WYSDM also greatly improves Tacoma Water's ability to make decisions on use of limited water supplies during a drought or other temporary shortage lasting a few months to a year or more.

Tacoma Water also used WYSDM to determine the firm yield of the supply system. For this IRP, firm yield is defined as the maximum water quantity that can be produced with 95% confidence from the existing Green River supply and ground water production facilities, such that mandatory curtailment of customer consumption would not be needed more than once every 25 years on average. Tacoma Water's firm yield is 107 MGD as an annual average.

4.5.3 Water Conservation Plan and Water Shortage Response Plan

As part of the IRP process and in conjunction with development of this Water System Plan, Tacoma Water also assessed and updated the demand-management programs already in place: the Water Conservation Plan and Water Shortage Response Plan. The conservation program is permanent and ongoing, while the Water Shortage Response Plan applies water use curtailment only during occasional droughts or other supply shortages. These demand-side solutions complement the use of supply-side solutions, while helping to protect stream flows and controlling the costs of developing and operating the water-supply system.

4.5.4 Planning Scenarios and Modeling Results

Numerous factors will influence future supply and demand conditions, including population and economic growth, how climate change affects western Washington state,

changes in societal attitudes regarding water use, technological advances and customer adoption of water conservation practices. With input from the Advisory Committee, Tacoma Water developed three planning scenarios that represent potential future supply and demand conditions. These range from a scenario where water conservation technology improves at a rapid pace, to one where population grows faster than expected and climate change leads to a substantial reduction in water available from the Green River. These scenarios were modeled in WYSDM, and the results were compared against the RAS and other metrics of system performance.

WYSDM results for the planning scenarios suggest that in all but the most stressed of scenarios, Tacoma Water's supply sources should remain adequate through the 2050s. In order to safeguard against the most stressed conditions, Tacoma Water considered a range of additional water supplies that could contribute to future system reliability. These included using more groundwater, storing water in local aquifers, expanding surface water supplies, contracting with other utilities in the Puget Sound region, developing reclaimed water supplies, desalination, and advanced water conservation practices.

Three solutions were selected for ongoing and future development.

1. Tacoma Water will continue to work with the federal government (U.S. Army Corps of Engineers) to complete the Additional Water Storage Project (AWSP) at Eagle Gorge Reservoir.
2. Tacoma Water will explore the feasibility and cost of enhancing its groundwater production facilities to make full use of its existing groundwater rights. This aligns with related efforts to upgrade groundwater treatment systems for compliance with the federal Safe Drinking Water Act, and to improve the water supply system's resiliency to major earthquakes that may occur in the Puget Sound region.
3. Tacoma Water plans to implement long-term aggressive "peak shaving" strategies. These are demand management actions that reduce peak summer water use, retaining water in storage as a buffer for the supply system in the fall.

When added to current system capabilities, these projects are expected to achieve the RAS, even under the most-stressed scenario that was evaluated using WYSDM.

4.5.5 Future Updates

Tacoma Water will periodically revisit and update the IRP and continue to improve its supply/demand management programs to ensure they are performing efficiently and effectively for customers, stakeholders, and the environment.

4.6 Potential Uses of Reclaimed Water

4.6.1 City of Tacoma

The 2003 Municipal Water Law amended RCW 90.46 to require public water systems serving 1,000 or more connections to evaluate opportunities for reclaimed water use when completing Water System Plans. With three wastewater treatment plants located in the Tacoma Water service area, Tacoma Water, in 1994, recognized water reuse as a supply alternative that merited consideration. At that time, Tacoma Water undertook a water reuse feasibility study.

The water reuse feasibility study considers two categories of uses for reclaimed water: landscape irrigation and industrial processes. Potential irrigation sites (parks, schools, and golf courses) are identified in the vicinity of each wastewater treatment plant. Ten industries, representing five industrial segments, are identified as potential candidates for reclaimed water use. The study concludes that alternatives using reclaimed water for industrial processes appeared to be more attractive than those alternatives using reclaimed water for landscape irrigation, primarily because of the cost to install distribution facilities for a seasonal demand.

A meeting in 2017 with the Business Operations Division of City of Tacoma Environmental Services indicated that reclaimed water is not cost competitive with other sources currently available. Environmental Services said that they envision their wastewater treatment system as a potential source, with any future marketing and sale planned and coordinated with Tacoma Water. If they do produce water to sell, it would probably be to users on the Tideflats. Their plant currently produces Class C water; there would be a large per gallon increase in cost to produce Class A water. Tacoma Water will continue to monitor reclaimed water projects and/or reclaimed water planning activities of local wastewater facilities, and will participate in planning activities as they may occur in the future.

4.6.2 Pierce County

Pierce County's update to the *Unified Sewer Plan* was approved by the Pierce County Council and the Washington State Departments of Health and Ecology in October 2012. Section 6.8 about reclaimed water states:

> …the Pierce County Sewer Utility integrates reclamation and reuse into the sewer service general plan as policy, as follows:
>
> - Continue to work towards water reclamation and reuse opportunities in the Chambers Creek Properties Master Site Plan.
> - Cooperate with water purveyors neighboring Pierce County-owned wastewater treatment plants.
> - Investigate the economic feasibility of off-site reuse of reclaimed water from the Chambers Creek Regional WWTP [Wastewater Treatment Plant] and the opportunities for use of reclaimed wastewater per the Chambers Creek Properties Master Site Plan.

The *Chambers Creek Regional Wastewater Treatment Plant Facilities Plan* is an element of the *Unified Sewer Plan*. Appendix D of the Facilities Plan is a Reclaimed Water Market Assessment, which states in part:

> …The goal of this assessment is to determine if there are sufficient potential commercial/industrial users within proximity of the CCRWWTP [Chambers Creek Regional Wastewater Treatment Plant] to provide a cost-effective, reliable, long-term alternative to effluent discharge. To be viable, the reclaimed water system would have to support year-round use in order to offset the cost of an increase in outfall capacity…

> The feasibility of supplying reclaimed water to end users is dependent on the user location, the level of demand, and seasonality of the use. If the total potential demand is low or the users are located far from the source, it is difficult to recoup the capital costs for construction of the production facilities and distribution system within a reasonable time period. Additionally, seasonal uses might not reduce the need for future increased outfall capacity unless the use occurs during the time of peak flows. As stated in the Draft Flow and Loadings Projection Technical Memorandum, peak flow occurs in the winter months (defined as December, January, and February). Landscape irrigation is assumed to be the predominant seasonal use for reclaimed water and would appear to have limited benefit to reducing the need for outfall capacity improvements.

The Plan concludes:

> Based on the preliminary results of this assessment, very limited potential exists for commercial/industrial reclaimed water use in the County's wastewater service area within a 6-mile radius of the CCRWWTP. However, there is potential for reclamation (and reduction in discharge of CCRWWTP effluent) for beneficial use by non-residential irrigation users [such as cemeteries, parks, and golf courses]…with the greatest diversion potential (approximately 2.25 MGD average up to 10 MGD peak) occurring during the summer months (June-August).

Sections 4.2.4 and 5.5.6 of the 2017 *Chambers Creek Regional Park Master Site Plan* discuss that, while the timing is undetermined at this time:

> In the long-term, a portion of the wastewater treated at the Wastewater Treatment campus will be reclaimed and reused for irrigation, wetland and aquatic habitat, groundwater recharge, industrial, municipal and commercial uses. Irrigation facilities using reclaimed water will be integrated throughout the Chambers Creek Properties…The initial water reclamation facility will be a Class A production facility including sand filtration and on-site storage. Future projects may include the use of constructed wetlands for the treatment of reclaimed water, or other technologies available at the time of development.

Tehaleh, a master planned community near Bonney Lake and in Tacoma Water's service area, is building a wastewater treatment plant that will produce Class A reclaimed water (the highest standard in Washington). The highly treated effluent will be reused for irrigation, commercial businesses, and infiltration. Piping for distribution of the reclaimed water ("purple pipe") is being installed in the development in preparation for completion of the plant.

Tacoma Water is in contact with the organizations proposing reclaimed water for municipal use, and has reviewed their current plans. Tacoma Water will continue to coordinate efforts and enter into agreements when both parties deem appropriate. Tacoma Water supports reclaimed water as a key element of our water future, however also recognizes that policy and regulatory issues regarding the role of reclaimed water in water supply planning and its potential adverse impacts remain to be analyzed and addressed. Tacoma Water will continue to explore opportunities to integrate reclaimed water into long-term planning and to work with stakeholders to address potential impacts on ratepayers, water system investments, and groundwater source protection areas.

4.6.3 King County

Tacoma Water has a relatively small retail service area in King County, consisting of a relatively small residential portion of Federal Way (adjacent to northeast Tacoma) and Cumberland (outside the Urban Growth Area along Pipeline 1). There are no wastewater treatment plants in the Cumberland area, so further evaluation of reclaimed water was not feasible. However, Tacoma Water does provide water via wholesale and partnership agreements to several other utilities in South King County, who have their own Water System Plans and reclaimed water analyses.

Also, Tacoma Water's Green River Filtration Facility in King County recovers all solids streams of fine sediment removed during water treatment, which the site had few viable options for disposing of. Achieving zero liquid discharge minimizes total water withdrawal from the Green River. A mechanical dewatering system is used to concentrate solids to approximately 30 percent (which is similar in feel to moist soil). This reduces the waste stream from potentially up to 10 percent of the water produced, to an average of just one or two truckloads (approximately 22 cubic yards each) of dewatered residuals per week.

The King County Water Reclamation Evaluation Checklist can be found in Appendix N.

4.7 Links to Relevant Materials

- Tacoma Water Shortage Response Plan: https://www.mytpu.org/tacomawater/water-source/water-supply-outlook/water-shortage-response.htm
- Integrated Resources Plan: https://www.mytpu.org/file_viewer.aspx?id=70623
- Pierce County Unified Sewer Plan: http://www.co.pierce.wa.us/3108/Unified-Sewer-Plan
- Chambers Creek Regional Park Master Site Plan: https://www.cityoflakewood.us/documents/community_development/Documents/Chambers_Creek_Master_Site_Plan_Council_Presentation_060517.pdf

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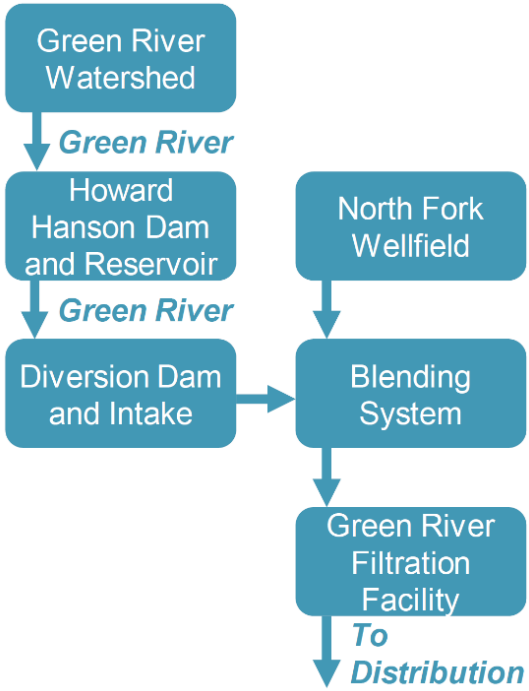
5 Water Infrastructure

This chapter provides an overview of Tacoma Water's infrastructure, including facilities for water supply, treatment, storage, and distribution.

5.1 Surface Water Supply

As discussed in Chapter 4, the primary water source for Tacoma Water is the Green River. The Green River supply infrastructure consists of the Howard Hanson Dam and Eagle Gorge reservoir, the Green River Diversion Dam and Intake, the North Fork Wellfield, and the Green River Filtration Facility. A schematic of the surface water supply is shown in Figure 5-1. A map of the watershed and Tacoma Water service area is previously shown in Figure 2-2.

Figure 5-1: Surface Water Supply



5.1.1 Howard Hanson Dam

The Howard Hanson Dam is located upstream of the Green River Diversion Dam and is owned and operated by USACE. Its original function was to provide flood control for the Green River Valley. Additional functions include augmentation of in-stream flows in the Green River downstream of the dam during summer, along with a water supply function for municipal use.

5.1.2 Green River Diversion Dam and Intake

Water supply for Tacoma Water is diverted from the Green River by means of a concrete diversion dam and intake located approximately 3 miles downstream of the Howard Hanson Dam. The total hydraulic capacity for the diversion facilities is 450 cfs (291 MGD). Flow passes from the intake through a short tunnel into a settling basin, passes through a fish screen (sized for juveniles), and is conveyed through one-half mile of pipeline and tunnel to the GRFF.

5.1.3 North Fork Wellfield

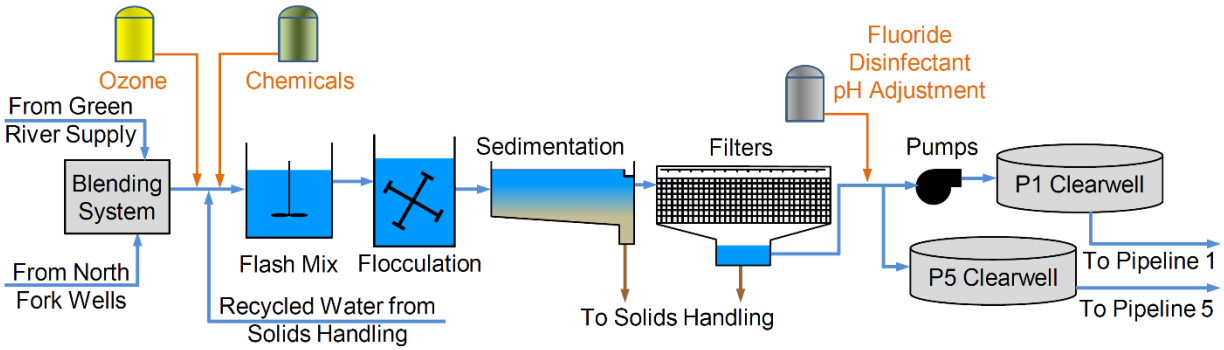
The North Fork Wellfield consists of seven wells located along the North Fork of the Green River approximately 6 miles upstream from the Green River Diversion Dam and treatment facility. The maximum wellfield supply capacity with seven operational wells is 84 MGD. However, only five wells are currently available with plans in place to make a sixth well available.

Water from the wellfield is conveyed through the North Fork Pipeline to the North Fork Tank, a 3 MG reservoir located at the GRFF. From there, the groundwater flows to a blending system where it is then conveyed to the GRFF treatment process.

5.1.4 Green River Filtration Facility

Since the last WSP update, Tacoma Water has added flocculation, sedimentation, and filtration processes to the Green River Treatment Plant to comply with the Long-Term 2 Enhanced Surface Water Treatment Rule (LT2). With the filtration process upgrades, which came online in 2014, the surface water treatment plant is referred to as the Green River Filtration Facility (GRFF). Figure 5-2 provides a schematic overview of the major GRFF features and treatment processes.

Figure 5-2. Green River Filtration Facility Water Treatment Schematic



The GRFF treats water from the Green River Diversion Dam and Intake, and/or the North Fork Wellfield, consistent with applicable federal and state treatment requirements for surface water supply. Depending on turbidity levels in the Green River and other operational considerations, the raw water supply to the GRFF may come directly from the river, directly from the North Fork wellfield, or as a blend of the two sources.

The GRFF facility is configured for “conventional” filtration operations, including coagulation chemical dosing and flash mix, flocculation, and sedimentation processes prior to dual media filtration, or may be operated in a “direct” filtration mode where the sedimentation process is bypassed. The facility is configured for 90-MGD capacity when operating as a conventional filtration plant, and 150-MGD capacity operating as a direct filtration plant. Typically, the plant is operated in a conventional filtration mode during the lower water demand fall, winter, and spring periods when Green River raw water turbidities and treatment challenges are higher, and in direct filtration mode during higher summer water demand periods when river turbidities and treatment challenges are lower.

In addition to the filtration processes, the GRFF also uses ozone for disinfection and taste and odor control, pH adjustment for water corrosivity management, fluoridation to help promote dental health, and chlorination to provide sustained disinfection in the treated water prior to delivery. Also included are a variety of solids handling processes used to treat, recycle, and recover backwash water and solids generated by the main treatment processes.

Water produced at the GRFF is stored onsite in two clearwells and delivered to the Tacoma water system via the Pipeline 1 and Pipeline 5 transmission systems.

5.1.5 Critical Infrastructure in Floodplains

Within the Tacoma water system, there are several locations where pressurized transmission lines (which are considered critical facilities) cross flood plains. Within King County, these locations include intake and transmission piping near the Green River Filtration Facility; Pipeline 5's crossings of Big Soos Creek and the Green River; and Pipeline 1's crossings of Newaukum Creek and the White River, and its alignment next to Boise Creek southwest of Enumclaw.

5.2 Groundwater Wells

In addition to the surface water supply, the Tacoma Water system includes 24 wells (in addition to the North Fork wells) and one spring that are used to supplement the Green River supply. Five additional wells are not actively maintained. These wells are either not properly equipped to be operational, are not connected to the system, or are for emergency use only. Table 5-1 provides a summary of the wells in the system and Figure 4-2 shows their locations. Tacoma Water's goal is to increase in-town groundwater production to 55 MGD. The following sections provide a brief description of the wells.

Table 5-1. Summary of Actively Maintained Wells

Well	Wellfield / Location	Nominal Capacity (MGD)	Not Equipped[a]	No Corrosion Control	Notes
1B	South Tacoma	3.5			
2B	South Tacoma	2.0	•		Use restricted due to potential contamination concerns.
2C	South Tacoma	2.9			Use restricted due to high ammonia levels. Requires breakpoint chlorination for ammonia treatment.
3A	South Tacoma	4.1			
4A	South Tacoma	1.3			
5A	South Tacoma	6.5			
6B	South Tacoma	3.9			
7B	South Tacoma	1.2			
8B	South Tacoma	4.4			
9A	South Tacoma	4.5			
10C	South Tacoma	0.6			Includes fill station available to the public for un-fluoridated water supply.
11A	South Tacoma	8.8			
12A	South Tacoma	5.0			
13A	South Tacoma	1.1			

Table 5-1. Summary of Actively Maintained Wells

Well	Wellfield / Location	Nominal Capacity (MGD)	Not Equipped[a]	No Corrosion Control	Notes
GPL1	Gravity Pipeline	4.6		•	
GPL2	Gravity Pipeline	3.2		•	
UP-1	University Place	1.6		•	
UP-10	University Place	2.0		•	Emergency use only. Does not have disinfection equipment.
PA-1	Portland Avenue	1.7		•	
SE-2	Southeast Tacoma	0.6			
SE-6	Southeast Tacoma	0.6			
SE-8	Southeast Tacoma	0.6	•	•	Includes fill station available to the public for un-fluoridated water supply.
SE-11	Southeast Tacoma	1.1		•	
SE-11A	Southeast Tacoma	0.6		•	
Prairie Ridge Springs	Prairie Ridge Springs	0.8		•	Spring with horizontal collectors rather than a vertical well.

Note: Table does not include North Fork Wells, which are described in Section 5.1.4.
[a] Does not include components to make the well operational

5.2.1 Wellfields

South Tacoma Wellfield

The South Tacoma Wellfield includes 15 wells, 13 of which are currently equipped, drawing from three aquifers. This is the largest wellfield in the Tacoma Water system and provides the majority of the available groundwater supply. The total wellfield capacity is approximately 45 MGD, declining to 40 MGD in the late summer when aquifer levels typically decline.

The Wells Pipeline collects water from the South Tacoma Wellfield and delivers it to the South Tacoma Pump Station (to be pumped to the Gravity Pressure Zone) or to the Hood Street Reservoir (which normally feeds the Low Service Zone, or may be plumbed to feed the Gravity Pressure Zone). Treatment for groundwater sourced from this wellfield is provided at the South Tacoma Pump Station and at the inlet to the Hood Street Reservoir.

If needed to meet future demands, Well 14A could be equipped and put into use. Timing of the well will be determined in response to the *Integrated Resource Plan* (IRP).

Gravity Pipeline Wellfield

The two Gravity Pipeline Wells pump directly into Pipeline 4 and have a combined capacity of 7.5 to 8 MGD. Both wells include disinfection equipment, and corrosion control treatment is planned to be installed at both wells.

Because of the high pumping costs associated with their operation, the Gravity wells are used primarily for peaking purposes or to provide an alternative source of supply when other sources may become limited.

University Place Wellfield

The University Place Wellfield consists of two wells located in the University Place Pressure Zone. One well is for emergency use only while the other well is used seasonally. If both wells are operating, the wellfield capacity is 3.6 MGD.

Portland Avenue

The Portland Avenue well with a capacity of 1.7 MGD feeds directly into the Portland Avenue Reservoir. Chlorination of well water occurs via blending with chlorinated reservoir water and through rechlorination at the reservoir's outlet.

Southeast Tacoma Wellfield

The wellfield consists of five wells that pump directly into the distribution system and have a combined capacity of 3.5 MGD.

Prairie Ridge Springs

Prairie Ridge Springs consists of a horizontal collection gallery extending into the base of a hillside. The gallery captures spring water, which otherwise discharges to a stream. Water is pumped from the collection gallery, chlorinated, delivered to a pair of steel tanks, and then is pumped from the tanks into the Prairie Ridge Pressure Zone. This system is rarely used. However, due to its location in the system, it could be a valuable source if Pipeline 1 (or the surface water source) were to become unavailable. The capacity of the springs is 0.8 MGD.

Tideflats

Two artesian wells are located in the Tideflats wellfield. Neither well is currently in service. One well is high in ammonia and is reserved for emergency use only, while the other does not have a pump installed. Timing of the well will be determined in response to the IRP.

Frederickson

This supply source includes one well that does not currently have a pump installed. Timing of the well will be determined in response to the IRP.

5.2.2 Future Wells

In response to the IRP, additional wells may be added to the system in addition to those previously mentioned to increase supply.

5.3 Groundwater Treatment

Tacoma Water employs four types of treatment for its groundwater supply sources. These include:

- **Disinfection** to impart a chlorine residual. Systems include liquid sodium hypochlorite, chlorine tablets, and on-site generation.
- **Corrosion Control** to manage water pH levels within distribution system. This helps prevent the leaching of lead and copper from piping. This is typically done through the addition of caustic soda, but is also done by air stripping at the South Tacoma Pump Station.
- **Fluoridation** to impart a fluoride residual to promote dental health.
- **VOC Control** to remove volatile organic compounds (VOCs) via air stripping at Well 12A.

In general, treatment is provided at a common location for groups of wells or for each wellfield rather than via individual treatment systems located at each well head.

5.4 Storage

Water storage within the Tacoma Water system is provided by a variety of reservoirs, tanks, and standpipe water storage facilities. Some of these facilities provide storage for an individual pressure zone or group of pressure zones, and some support system-wide storage functions. Storage facilities are used to help meet peak demands and minimize the need to cycle sources and pumps on and off by providing equalizing and operational volumes, to provide standby storage reserves to enhance system service reliability and provide for emergency supply, and to support delivery of fire suppression flows.

5.4.1 Pressure Zone Storage Facility Summary

A summary of Tacoma Water storage facilities is provided in Table 5-2. Their locations throughout the system are shown in Figure 5-3.

Table 5-2. Summary of Storage Facilities

Name	Primary Pressure Zone Served	Volume (MGD)	Type of Storage Facility
Alaska Street	Middle Service 446	6.01	Welded steel
Bismark	High Service 478	0.34	Riveted steel standpipe
Cumberland	Cumberland 931	0.12	Welded steel
Fletcher Heights	High Service 478	0.56	Riveted steel standpipe
GRFF Backwash	GRFF [a, c]	10.00	Welded steel

Table 5-2. Summary of Storage Facilities

Name	Primary Pressure Zone Served	Volume (MGD)	Type of Storage Facility
Hood Street	Low Service 251	10.24	Prestressed concrete (buried)
Indian Hill	NE Tacoma 549	3.50	Prestressed concrete (partially buried)
Indian Hill	NE Tacoma 549	1.00	Prestressed concrete (partially buried)
Indian Hill	NE Tacoma 549	0.25	Reinforced concrete (buried)
Indian Hill	NE Tacoma 549	0.25	Reinforced concrete (buried)
McMillin Reservoir 1	McMillin Reservoir 581	33.81	Prestressed concrete (partially buried)
McMillin Reservoir 2	McMillin Reservoir 581	33.81	Prestressed concrete (partially buried)
North End	North End 446	10.32	Prestressed concrete (partially buried)
North End Standpipe	High Service 478	1.35	Riveted steel standpipe
North Fork Tank	GRFF	3.0	Prestressed concrete
Pipeline 1 Clearwell	Supply and transmission system [a]	1.30	Prestressed concrete
Pipeline 5 Clearwell	Supply and transmission system [a]	6.60	Traditional cast-in-place concrete (partially buried)
Portland Avenue	Low Service 251	20.67	Prestressed concrete (partially buried)
Prairie Ridge	Prairie Ridge 810	2.48	Welded steel
Prairie Ridge Springs 1	Prairie Ridge 810	0.10	Welded steel
Prairie Ridge Springs 2	Prairie Ridge 810	0.10	Welded steel
South Tacoma	Gravity 581 [b]	0.50	Reinforced concrete (buried)
Sunrise	McMillin 706	3.91	Welded steel standpipe
University Place Tank No. 5	High Service 478	0.40	Welded steel standpipe
University Place, Tank No.6	High Service 478	1.00	Welded steel

Source: Tacoma Water Strategic Asset Management Plan (SAMP) – Storage Facilities, updated October 2014.

[a] Provides storage for the supply and transmission system; does not directly serve a distribution system pressure zone.

[b] Serves the Gravity 581 Pressure Zone via the South Tacoma Pump Station.

[c] Only used for potable water in an emergency.

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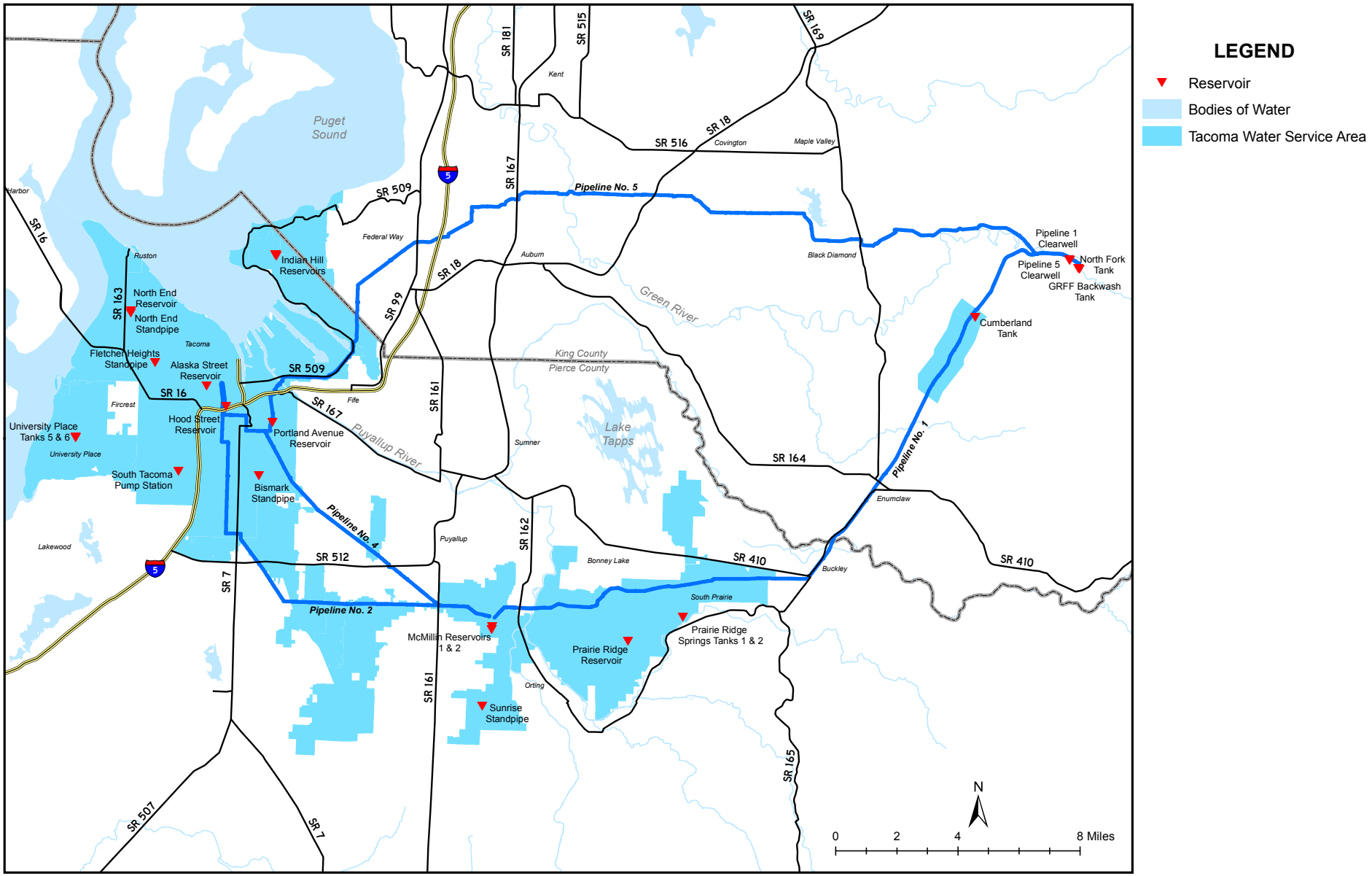
Figure 5-3. Locations of Storage Facilities



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5.4.2 Recent Changes to Storage Facilities

Since the last WSP update in 2006, Tacoma Water has completed improvements to the McMillin Reservoir and has made additional storage adjustments associated with completion of the GRFF. These are described in more detail below.

GRFF Backwash Tank

The 10 MG Backwash Tank (previously known as the Headworks Reservoir) formerly operated as an equalizing tank. Water pumped from the North Fork Wells was stored in the reservoir before being sent to the blending system at the head of the Green River Treatment Plant. With the completion of the GRFF, the function of the reservoir has changed. The reservoir now stores filtered water for use in filtering backwash and as utility process water. The Backwash Tank can also be used as an emergency backup to the GRFF clearwell storage tanks.

North Fork Tank

A new 3 MG tank was constructed to provide an equalization function similar to what had been provided by the Headworks Reservoir (now GRFF Backwash Tank) prior to completion of the GRFF. The North Fork Tank receives and stores water from the North Fork Well system prior to delivery to the GRFF. This equalizes wellfield raw water supply flows into the GRFF. The stored water provides an immediate source of North Fork well water that can be used to replace Green River supply during high turbidity events, which helps reduce solids handling needs at the GRFF.

McMillin Reservoir

The McMillin Reservoir serves as an equalizing facility for demands experienced throughout the distribution system. Prior to the recent improvements, the McMillin Reservoir included three separate uncovered concrete-lined basins that provided a total storage volume of 210 MG.

In 2012, the three basins were replaced with two 33.8 MG circular concrete storage tanks. The smaller size reduced the cost of covering the reservoirs, increased the turnover rate, and reduced water age and the potential for stagnation. The McMillin Reservoir improvements also increase the hydraulic grade of the Gravity Pressure Zone to an elevation of 581 feet from the previous 576 feet.

Eliminating the open basins at McMillin provided significant water quality benefits, including reduced treatment requirements for disinfection and corrosion control.

A third tank may be constructed at the McMillin site in the future. The storage analysis does not indicate a need for the additional storage volume in the 2018–2038 timeframe.

5.5 Transmission System

The Tacoma Water transmission system includes over 142 miles of large-diameter pipes that convey water from the various supply sources to the distribution system. The major transmission pipelines in the system include:

- **Pipeline 1** – Conveys water (up to 73 MGD historically) from the GRFF to McMillin Reservoir.
- **Pipeline 2** – Conveys water from the McMillin Reservoir to the J Street Standpipe, to Pipeline 4, and to numerous smaller distribution mains.
- **Pipeline 4** – Conveys water from Pipeline 2 and into the distribution system providing the main gravity feed into the Low Service Pressure Zone.
- **Pipeline 5 (Second Supply Project Pipeline)** – Conveys water (up to 95 MGD design capacity) from the GRFF to Pipeline 4. Along its alignment, the pipeline also supplies the SSP Partners (City of Kent, Covington Water District, and Lakehaven Water and Sewer District) with water associated with the Second Diversion Water Right. The pipeline also supplies the Indian Hill service area through the 356th Street Pump Station.
- **64th Street** – Ties Pipelines 2 and 4 together and carries flow by gravity west to South Tacoma and to the West End Transmission Main.
- **West End Transmission Main** – Conveys supply from the 64th Street main, and well water from South Tacoma Pump Station to the west side of the City.
- **North End Transmission Pipeline** – Conveys water from the downstream ends of Pipelines 2 and 4 at the J Street Standpipe to the North End Reservoir.
- **North End Intertie** – Provides a connection between the West End Transmission Main and the North End Transmission Pipeline.
- **40th Street Trunk Main** – Conveys water to University Place**.**
- **Wells Pipeline** – Conveys water from the South Tacoma Wells and delivers it to the South Tacoma Pump Station and Hood Street Reservoir.

Summaries of the transmission main sizes and materials are provided in Table 5-3 and Table 5-4.

Table 5-3. Summary of Transmission System Pipe Sizes

Size	Length (miles)	Percent of Total
24" and smaller	5.1	3.6
>24" to 30"	9.5	6.7
>30" to 36"	15.9	11.2
>36" to 42"	13.5	9.5
>42" to 54"	45.5	32.0
>54" to 60"	41.2	29.0
>60" to 84"	10.3	7.3
Greater than 84"	1.1	0.8
TOTAL	142	100

Source: Tacoma Water GIS, accessed July 2017.

Table 5-4. Summary of Transmission System Pipe Materials

Material	Length (miles)	Percent of Total
Steel	104.4	73.4
Concrete (Steel Cylinder)	33.1	23.3
Ductile Iron	1.6	1.1
Riveted Steel	1.6	1.1
High Density Polyethylene	0.91	0.64
Cast Iron	0.32	0.23
Unknown	0.23	0.16
TOTAL	142	100

Source: Tacoma Water GIS, accessed July 2017.

5.6 Distribution System

The distribution system includes the smaller-diameter water mains, pressure zones, pressure reducing valves, pump stations, valves, hydrants, service connections, meters, and other related infrastructure that deliver water to individual customers.

5.6.1 Piping

Tacoma Water distribution mains provide water service and fire protection to its residential, commercial, and industrial customers. The system includes more than 1,240 miles of distribution mains generally ranging in size from 4 inches to 24 inches. Table 5-5 and Table 5-6 provide summaries of the pipe sizes and materials that make up the distribution system.

Table 5-5. Summary of Distribution System Pipe Sizes

Size	Length (miles)	Percent of Total
1.5" and smaller	0.4	0.03
2"	7.2	0.58
>2" to 3"	0.1	0.01
4"	72.9	5.85
6"	381.2	30.60
8"	441.8	35.46
10"	16.9	1.36
12"	221.0	17.74
14"	0.2	0.01
16"	56.9	4.57
18"	5.3	0.43
20"	18.5	1.48

Table 5-5. Summary of Distribution System Pipe Sizes

Size	Length (miles)	Percent of Total
24"	22.1	1.77
30"	1.0	0.08
Greater than 30"	0.2	0.02
TOTAL	1,246	100

Source: Tacoma Water GIS, accessed July 2017.

Table 5-6. Summary of Distribution System Pipe Materials

Material	Length (miles)	Percent of Total
Ductile Iron	631.3	50.7
Cast Iron	436.3	35.0
Asbestos Cement	123.3	9.9
Plastic / PVC	49.0	3.9
Steel	2.7	0.22
Galvanized	1.9	0.15
Copper	0.7	0.06
Unknown	0.4	0.03
PE / HDPE	0.05	< 0.01
TOTAL	1,246	100

Source: Tacoma Water GIS, accessed July 2017.

5.6.2 Pressure Zones

The Tacoma Water distribution system is divided into pressure zones configured to provide customers with appropriate water pressure to meet delivery needs. Pressure zones are defined by their hydraulic grade line (HGL), expressed as an elevation above sea level. The Tacoma Water distribution system is divided into six primary service areas, which are comprised of groupings of pressure zones based on similar service elevations and sources of supply. These service areas include Cumberland, Fennel Creek, Prairie Ridge, Indian Hill, and McMillin Gravity.

For more information…

Details on how the pressure zones interconnect can be found in Schematic Diagram: Gravity, Wells and Distribution System and Schematic Diagram: Gravity, Wells and Distribution System Details.

The six primary service areas are further divided into 51 different pressure zones, which are maintained to accommodate the topography while providing adequate water pressure. Flow between the zones is supported through a combination of pressure reducing valves, pumping stations, and associated piping. Table 5-7 summarizes the pressure zones and HGL

within each primary service area and sorts them from highest to lowest HGL. A map of the pressure zones is shown in Figure 5-4.

Table 5-7. Pressure Zones

Pressure Zone and HGL Elevation (ft)	Service Area
Bonney Lake 1010	Prairie Ridge
Bonney Lake 950	Prairie Ridge
Cumberland 931	Cumberland
Bonney Lake 860	Prairie Ridge
Prairie Ridge 810	Prairie Ridge
McMillin 706	Sunrise Standpipe
Fennel Creek 705	Fennel Creek
S Summit High 669	McMillin Gravity - 581 Gravity
Indian Hill 649	Indian Hill
80th Ave E 626	McMillin Gravity - 581 Gravity
Alder Lane 626	McMillin Gravity - 581 Gravity
Highland 621	Sunrise Standpipe
Frederickson 588	McMillin Gravity - 581 Gravity
SE Tacoma 581	McMillin Gravity - 581 Gravity
Fletcher Heights 581	McMillin Gravity - 581 Gravity
Woodland 581	McMillin Gravity - 581 Gravity
South Hill 581	McMillin Gravity - 581 Gravity
Canyon 581	McMillin Gravity - 581 Gravity
Bonney Lake 581	McMillin Gravity - 581 Gravity
Park Royal 556	McMillin Gravity - 478 High Service
NE Tacoma 549	Indian Hill
Westgate / Fletcher Service 538	McMillin Gravity - 581 Gravity
University Place 531	McMillin Gravity - 478 High Service
SE Tacoma 520	McMillin Gravity - 581 Gravity
Sunrise Terrace 519	Sunrise Standpipe
Beverly Heights 486	Indian Hill
High Service 478	McMillin Gravity - 478 High Service
Middle Service 446	McMillin Gravity - 446 Middle Service
North End 446	McMillin Gravity - 446 Middle Service
Harbor View 426	Indian Hill
Woodland 426	McMillin Gravity - 581 Gravity
Dash Point High 411	Indian Hill
Fife Heights Low 411	Indian Hill

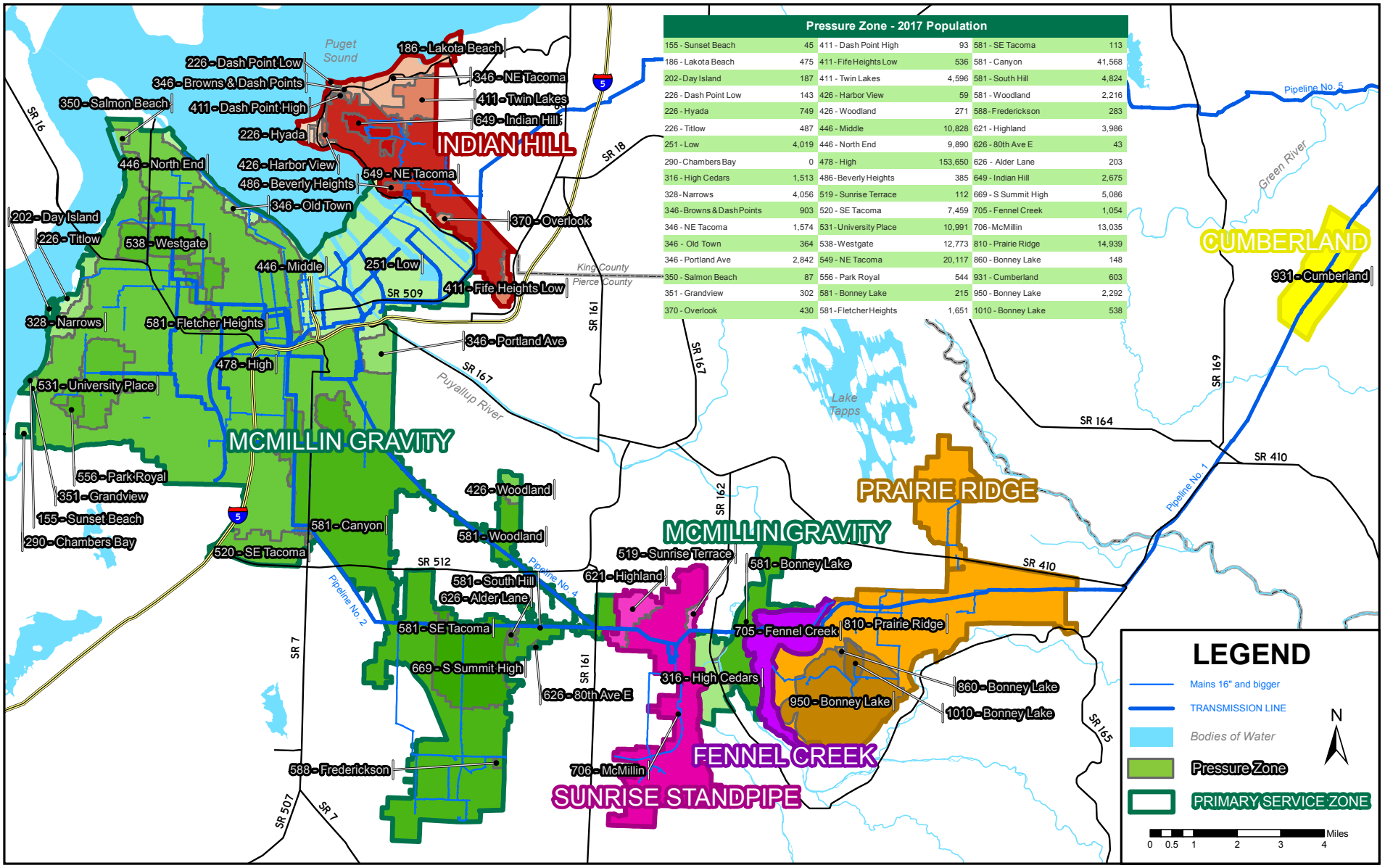
Table 5-7. Pressure Zones

Pressure Zone and HGL Elevation (ft)	Service Area
Twin Lakes 411	Indian Hill
Overlook 370	Indian Hill
Grandview 351	McMillin Gravity - 478 High Service
Salmon Beach 350	McMillin Gravity - 446 Middle Service
Browns & Dash Points 346	Indian Hill
NE Tacoma 346	Indian Hill
Old Town 346	McMillin Gravity - 478 High Service
Portland Ave 346	McMillin Gravity - 478 High Service
Narrows 328	McMillin Gravity - 478 High Service
High Cedars 316	McMillin Gravity - 581 Gravity
Chambers Bay 290	McMillin Gravity - 478 High Service
Low Service 251	McMillin Gravity - 251 Low Service
Dash Point Low 226	Indian Hill
Hyada 226	Indian Hill
Titlow 226	McMillin Gravity - 478 High Service
Day Island 202	McMillin Gravity - 478 High Service
Lakota Beach 186	Indian Hill
Sunset Beach 155	McMillin Gravity - 478 High Service

Pressure Reducing Valves

Water is delivered from higher- to lower-elevation pressure zones through pressure reducing valve (PRV) stations, each of which typically includes two or more individual PRVs. To protect against high pressure surges and failures, PRV stations may also be equipped with pressure relief valves that serve to limit the maximum pressures conveyed through the station. Tacoma Water has 76 PRV stations with 160 individual PRVs and 17 pressure relief valves.

Figure 5-4. Pressure Zone Map



Pressure Zone - 2017 Population					
155 - Sunset Beach	45	411 - Dash Point High	93	581 - SE Tacoma	113
186 - Lakota Beach	475	411 - Fife Heights Low	536	581 - Canyon	41,568
202 - Day Island	187	411 - Twin Lakes	4,596	581 - South Hill	4,824
226 - Dash Point Low	143	426 - Harbor View	59	581 - Woodland	2,216
226 - Hyada	749	426 - Woodland	271	588 - Frederickson	283
226 - Titlow	487	446 - Middle	10,828	621 - Highland	3,986
251 - Low	4,019	446 - North End	9,890	626 - 80th Ave E	43
290 - Chambers Bay	0	478 - High	153,650	626 - Alder Lane	203
316 - High Cedars	1,513	486 - Beverly Heights	385	649 - Indian Hill	2,675
328 - Narrows	4,056	519 - Sunrise Terrace	112	669 - S Summit High	5,086
346 - Browns & Dash Points	903	520 - SE Tacoma	7,459	705 - Fennel Creek	1,054
346 - NE Tacoma	1,574	531 - University Place	10,991	706 - McMillin	13,035
346 - Old Town	364	538 - Westgate	12,773	810 - Prairie Ridge	14,939
346 - Portland Ave	2,842	549 - NE Tacoma	20,117	860 - Bonney Lake	148
350 - Salmon Beach	87	556 - Park Royal	544	931 - Cumberland	603
351 - Grandview	302	581 - Bonney Lake	215	950 - Bonney Lake	2,292
370 - Overlook	430	581 - Fletcher Heights	1,651	1010 - Bonney Lake	538

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5.6.3 Pump Stations

The Tacoma Water system includes a number of distribution system pump stations used to boost pressure and move water from lower to higher elevation pressure zones. Some pump stations are run continuously in order to maintain system pressures, while others may only be used seasonally to support water conveyance during high demand periods. Tacoma Water operates 28 pump stations as part of its distribution system, as summarized in Table 5-8.

Table 5-8. Summary of Pump Stations

Name	Pressure Zone/Pipeline Pumped From	Pressure Zone Pumped To	Capacity (MGD)
Alaska Street	Middle Service 446	High Service 478	7.2
Alder Lane	Gravity 581	Alder Lane 626	0.04
Cumberland	Pipeline 1	Cumberland 931	0.5
Fennel Creek	Pipeline 1	Fennel Creek 705	2.4
Frederickson	Gravity 581	Frederickson 588	0.2
Highland	Gravity 581 thru Pipeline 2	Highland 621	1.5
Hood Street	Low Service 251	Gravity 581	15
Indian Hill #1	NE Tacoma 549	Indian Hill 649	2.3
Indian Hill #2	NE Tacoma 549	Indian Hill 649	1.8
Marine View Drive	Low Service 251	NE Tacoma 549	9.1
McMillin #1	Gravity 581 thru Pipeline 2	McMillin 706	2.8
McMillin #2	Gravity 581 thru Pipeline 2	McMillin 706	7.1
Mildred Street	478 High Service	Westgate 538	1.4
North End High Service pump Westgate pumps	 North End 446 North End 446	 High Service 478 Westgate 538	 8.6 2.6
Palmer	Pipeline 1	Misc. services off Pipeline 1	0.05
Prairie Ridge	Prairie Ridge 810	Bonney Lake 1010	3.3
Prairie Ridge Springs	Prairie Ridge Springs Collection System	Prairie Ridge 810	2.0
South Tacoma	Low Service 251 thru Wells Line	Gravity 581	17
128th & Canyon	Gravity 581 thru Pipeline 2	S Summit High 669	1.1
62nd Ave E	Gravity 581 thru Pipeline 2	S Summit High 669	0.8
N 21st & Pearl	478 High Service	Westgate 538	3.2
83rd Ave W & Cirque Dr	High Service 478	Park Royal 556	0.9
214th Ave E	Pipeline 1	Prairie Ridge 810	8.6
198th Ave E	Pipeline 1	Prairie Ridge 810	3.5
356th Street	Pipeline 5	NE Tacoma 549	5.8

Table 5-8. Summary of Pump Stations

Name	Pressure Zone/Pipeline Pumped From	Pressure Zone Pumped To	Capacity (MGD)
80th Ave E & 132nd Ln E	Gravity 581	80th Avenue East 626	0.1
Pipeline 1 Finished Water Pump Station	GRFF	Pipeline 1	73

Source: Tacoma Water 2016 Capital Facilities Plan Inventory; Schematic Diagram Gravity, Wells and Distribution System, updated September 2014.

5.6.4 Hydrants

The Tacoma Water distribution system contains more than 10,545 fire hydrants in its service area, approximately 40 percent of which are inside the city limits.

5.6.5 Rehabilitation and Replacement Activities

Strategies for the rehabilitation and replacement of distribution and transmission system infrastructure are detailed in Tacoma Water's *Strategic Asset Management Plans* (see Chapter 10). The following provides brief summaries of the strategies for various types of distribution system infrastructure:

- **Hydrants** are replaced when parts to rebuild the hydrant are not available or if the hydrant is damaged to a degree where it cannot be repaired. Hydrant renewals occur when the main hydrant valve or seat are replaced.
- **Valves** within the distribution system are usually replaced rather than repaired when issues are encountered. Larger transmission valves are assessed for repair or replacement periodically on an individual basis, but there is no formal maintenance plan that proactively seeks to schedule maintenance work on supply valves.
- **Service meters** larger than 1-1/2 inches are replaced after reaching a specified age or total metered volume. Smaller meters are only replaced when it is suspected that the meter may be failing.
- **Water mains** are replaced using a risk-based, economic model approach that determines the optimal time of replacement based on a variety of factors. The approach incorporates the pipe's material, age, risk of failure, criticality, and opportunities to pair replacement with other project activities such as planned roadwork or adjacent utility improvements in determining replacement schedules.

5.7 Design Standards and Standard Details

Tacoma Water has developed design standards and standard details for the design and construction of infrastructure related to the water system. This section provides a summary of these standards.

5.7.1 Design Standards

Fire Flow

Fire flow requirements throughout Tacoma Water's service area are established by jurisdiction and local code, including the *Uniform Fire Code*, Pierce County Code 17C.60.165, and King County Code 17.08.070 (*South King County Coordinated Water System Plan*, Appendix E).

For single family residential locations, Tacoma Water fire flow delivery capacity and fire hydrants are designed to provide the Uniform Fire Code standard of 1,000 gpm and are required to maintain this level inside the city limits.

In commercial and industrial areas, the Uniform Fire Code determines the fire flow delivery requirements based on the type of structure and site conditions. Generally, this is at least 1,500 gpm for commercial areas and 2,000 gpm for industrial areas.

Where the Tacoma Water system provides service for areas of unincorporated Pierce County, the county fire marshal has set a minimum single family residential fire flow of 750 gpm. For urban multi-family residential areas and urban commercial, a minimum fire flow of 1,500 gpm is required. For industrial development, 2,000 gpm is required. Pierce County minimum fire flow durations are specified in 17C.60.165. Areas in unincorporated King County require a minimum of 1,000 gpm, with durations specified by the fire marshal. The land-use and zoning designations used for unincorporated portions of Tacoma Water's service area in King County are consistent with the adopted King County Comprehensive Plan. In the rural area of King County, fire flow is generally not required per the exception for fire flow in King County Code 17.08.030.

In order to provide a target level of service for planning and sizing future water facilities, and to meet existing and projected demands, Tacoma Water has established general planning-level fire flow targets (Table 5-9) beyond those required by jurisdiction and code. These general planning-level fire flow levels meet or exceed the regulatory required fire flows and are defined by general land use type. Tacoma's planning level fire flow targets are for planning purposes and sizing future water facilities and do not necessarily equate to minimum required fire flows in the water system. The water system analyses presented in Chapter 6 of the 2018 WSP are based on an evaluation of the water system for providing sufficient fire flow in accordance with regulatory fire flow requirements, not planning level targets. Tacoma Water generalized planning-level fire flow targets are referenced where applicable, but are not used for regulatory required minimum fire flow assessment.

The fire flow requirements shown in Table 5-9 do not necessarily equate to actual existing or future fire flow requirements for all buildings, since this is typically based on the Uniform Fire Code by building size, construction type, and fire suppression systems provided. Improvements to increase the available fire flow to meet fire flow requirements greater than regulatory fire flow requirements shall be the responsibility of the developer.

Table 5-9. Planning Level Fire Flow (Level of Service)

Tacoma Water's General Land Use Class	Planning Level Fire Flow Target (gpm)	Minimum Duration (hours)
Agriculture	1,000	2
Park	1,000	2
Residential	1,500	2
City	3,500	4
Mixed Use	3,500	4
Residential High Density	3,500	4
Undesignated	3,500	4
Commercial	5,000	5
Industrial	5,000	5

Distribution Piping

Water mains are designed for a maximum water velocity of 15 feet per second, and are sized to support projected customer demands and fire flow delivery requirements. This includes maintaining a minimum residual pressure of 20 psi when delivering fire flows under maximum day demand conditions, and 30 psi minimum during peak hour demand conditions. In general, Tacoma Water seeks to exceed these minimums and strives to maintain static system pressures of at least 45 psi. Additionally, it is a design goal to keep pressures below 100 psi in the distribution system. Where needed, pressures are reduced through the use of PRVs and the establishment and extension of pressure zones to meet the Uniform Plumbing Code.

The standard Tacoma Water distribution main material for new main installations is Ductile Iron Special Class 52 with a minimum size of 4 inches. For dead-end water mains that serve fire hydrants, a minimum standard of 8 inches is applied.

Storage

Tacoma Water designs storage facilities to meet required storage volumes for operational, equalizing, standby, and fire suppression storage per the DOH *Water System Design Manual* (publication # 331-123).

Booster Pump Stations

Design of booster pump stations within the Tacoma Water system is consistent with the DOH *Water System Design Manual* (publication # 331-123). A minimum of two pumps are installed at each pump station to provide flexibility and system redundancy.

Pump stations serving closed systems, which have no storage, continuously pump to maintain system pressure. These stations are set up with either a variable frequency drive lead pump motor, or fixed speed pumps and pressure relief valve to control zone pressure. Stations serving closed systems are always backed up by standby power since a pump must always be operating to pressurize closed systems.

Pump stations serving open systems, which have storage facilities, have pumps turn on or off based on the level within the storage facility serving the system. The lead pump turns on to refill storage back to the full storage set point, which is typically the zone's static elevation. When that elevation is reached, the pump turns off until the storage level drops down to a "Pump On" set point. If the lead pump cannot keep up and storage continues to drop, additional pumps (lag pumps) come on in sequence to help keep up with demand and refill storage. Pump stations serving open systems can have standby power on site or the capability to move in a mobile genset as necessary.

Service Connections

Standards for service connections are provided in Tacoma Water's Standard Details, Customer Service Polices, and in TMC 12.10 Water – Regulations and Rates.

"No new retail services shall be allowed" from Pipelines 1 or 5, per Section 11.0A. of the Customer Service Policies. TMC 12.10 defines a water service from a transmission line (Pipeline 2 or 4) as temporary; Section 12.10.350 details policies for this situation within Tacoma Water's service area.

5.7.2 Standard Details

Below is a list of the standard details maintained by Tacoma Water. A copy of these details can be found in Drawing 17-56-1: Standard Details.

- Standard Fire Hydrant Setback
- Typical Fire Hydrant Location (Pierce County)
- Typical Fire Hydrant Location (City of Tacoma)
- Fire Hydrant Landscaping Detail
- Detail of Fire Hydrant Guard Post
- Standard Fire Hydrant Setting
- >6-foot Bury Fire Hydrant Setting
- Fire Hydrant Ditch Detail
- Detail of 2-inch Blow-Off Assembly
- Vertical Ell with Concrete Anchor
- Permanent Sampling Station
- Temporary Blow-Off Detail
- Reducer with Concrete Anchor
- Standard Gate Box Detail
- Thrust Block Detail

5.8 Links to Relevant Materials

- Schematic Diagram: Gravity, Wells and Distribution System*
- Schematic Diagram: Gravity, Wells and Distribution System Details*
- Drawing 17-56-1: Standard Details*
- Customer Service Polices: https://www.mytpu.org/file_viewer.aspx?id=59028
- TMC 12.10 Water – Regulations and Rates: https://www.mytpu.org/file_viewer.aspx?id=58976

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6 System Analysis

This chapter provides an overview of the analyses that were completed to determine the ability of Tacoma Water's existing storage, source, and distribution system facilities to supply a sufficient quantity of water to meet existing and projected demands.

6.1 Storage Capacity Analysis

6.1.1 Background

The storage capacity analysis compares the volume of existing water storage provided by a number of reservoirs and standpipes in the water system, to the volume of storage required to serve current and projected water demands.

The storage capacity analysis only looks at supply/demand flow rates, existing reservoir volumes, and system elevations for determining the capacity of the storage facilities. Additional analysis that takes into consideration the movement of water through the distribution system and associated impacts on pressure (such as head loss) are completed as part of the distribution system analysis (Section 6.3).

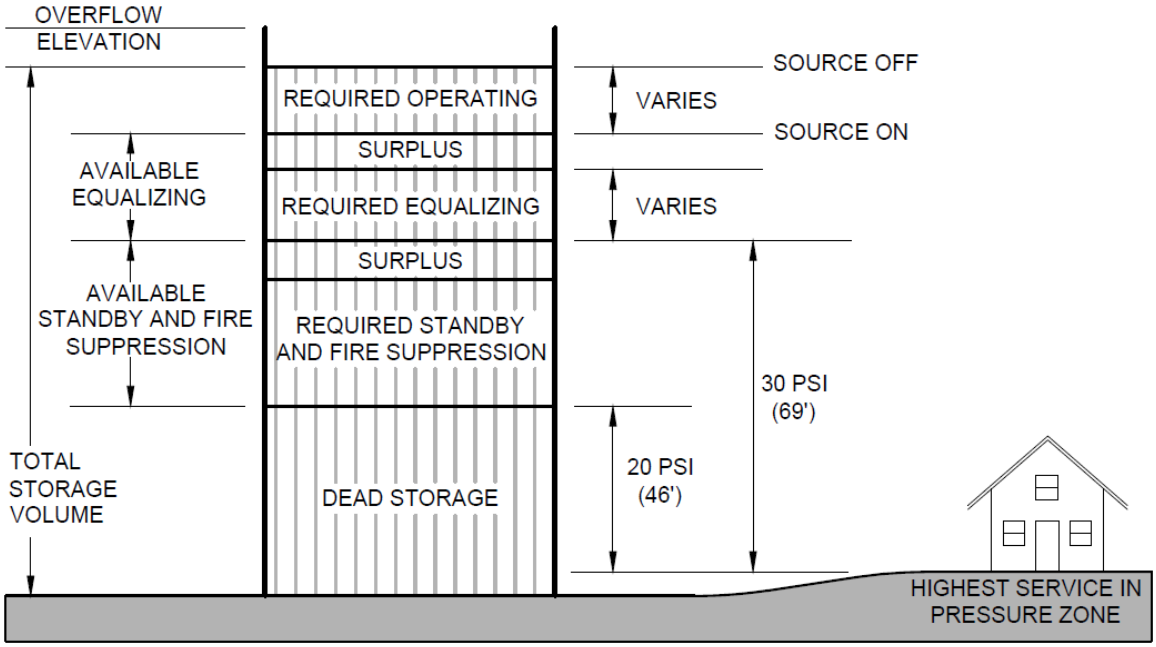
There are five types of storage volumes that must be accounted for per WAC 246-290-235. These are described below and shown in Figure 6-1.

- **Operational Storage** - the volume of storage associated with source or booster pump normal cycling times under normal operating conditions. This is calculated as the volume of water that is delivered to the system from the storage facility between the storage facility's sources switching from off to on. Operating storage must be provided at a pressure of at least 30 psi.
- **Equalizing Storage** - the volume of storage needed to supplement supply to consumers when the peak hourly demand exceeds the total source pumping capacity. Equalizing storage must be provided at a pressure of at least 30 psi. Equalizing volume requirements are greatest on the day of maximum demand.
- **Standby Storage** - the volume of stored water available for use during a loss of source capacity or power, or similar short-term emergency. This storage component is equal to the greater of (1) the amount of storage required to meet average day demands for two days if the largest source supplying the storage facility is out of service, or (2) 200 gallons per the number of ERUs served by the facility. Standby storage must be provided at a pressure of at least 20 psi.
- **Fire Suppression Storage** - the volume of stored water needed for fire suppression activities. This is calculated to be the volume associated with the highest fire demand (flow × duration) served by the storage facilities. The standby storage and fire suppression storage can be "nested" meaning the larger of the two becomes the required storage volume. Fire suppression storage must be provided at a pressure of at least 20 psi.

- **Dead Storage** - the volume of stored water not available to consumers at the minimum required design pressures.

The total required storage volume is equal to the greater of standby and fire suppression storage added to the sum of operational and equalizing storage, the volumes of which must be provided at the pressures shown in Figure 6-1.

Figure 6-1. Schematic of Storage Components



6.1.2 Methodology

The storage capacity analysis is based on an evaluation of the existing storage reservoirs and their ability to meet the demands and minimum pressure requirements in the areas they serve. The evaluation is based upon two primary calculations:

4. An evaluation of the ability of existing storage facilities to provide required operational and equalizing storage volumes under current and future conditions at a minimum of 30 psi to the highest customer in the service area.
5. An evaluation of the ability of existing storage facilities to provide required operational, equalizing, standby, and fire suppression storage volumes under current and future conditions at a minimum of 20 psi to the highest customer in the service area.

Required storage volumes for each of the storage components follows the methodologies provided in the DOH *Water System Design Manual*.

In some cases, pressure zones served by a storage facility are not directly served by gravity but through a pump station. In this case, the demands of the pressure zone served through a pump station are included in determining required storage volumes, but the elevations of customers in that zone are ignored when determining pressures associated with the storage components.

6.1.3 Results

The Tacoma Water distribution system is divided into six primary service areas: Cumberland, Sunrise Standpipe, Fennel Creek, Prairie Ridge, Indian Hill, and McMillin Gravity. A storage analysis was completed for each of these service areas except for Fennel Creek, which has no storage.

A summary of the storage capacity analysis results by service area is shown in Table 6-1. Table 6-2 through 6-7 provide more detailed results of the storage capacity analysis for each service area. The tables show the maximum number of equivalent residential units (ERUs) that can be supported by the existing storage facility. The required storage volumes listed in the tables under the "maximum supported" column indicate the required storage volumes corresponding to the maximum number of supported ERUs. If a deficiency currently exists due to fire suppression or standby storage not being provided at an adequate pressure to the highest service connection, the maximum number of ERUs is indicated as zero.

The results for each area show that zero equalizing storage is necessary across each planning horizon. This is because the capacity of the sources feeding each zone exceeds the projected peak hour demand. More detailed tables are provided in Appendix G, which also includes annual and monthly production.

Table 6-1. Summary of Storage Capacity Analysis Results

Storage Service Area	Notes
Prairie Ridge	The analysis shows that storage is adequate for the 10-year planning horizon, but deficient for the 20-year planning horizon for storage required at 20 psi. This is due to an increase in the required standby storage component related to the projected increase in demand **Potential Improvements:** In the mid-2020s, it is planned to add storage to the Bonney Lake 950 zone, which will resolve storage deficiency seen in 20-year planning horizon.
Cumberland	Cumberland has one storage reservoir with a volume of 0.12 MG. The King County fire flow requirement in residential and small commercial areas is typically 1,000 gpm for 2 hours, per a December 22, 2017 email from Mark Ossewaarde of King County Fire Marshal Services. When the Cumberland Tank is full, the available storage is adequate to meet this requirement, assuming the peak-hour demands can be met through pumping. The King County Fire Marshal has previously approved the volume of storage available in Cumberland**. The total available storage exceeds the recommended equalizing and standby storage. This zone is also backed up by gravity flow from Pipeline 1. The controlling storage requirement in Cumberland is based on fire flow requirements, and the existing volume of storage has been approved by the King County Fire Marshal. Because of the Fire Marshal's approval, no immediate expansion of storage is recommended in the Cumberland zone. An expansion should be considered, however, in future system planning, especially if new development is proposed. However, the rural unincorporated community of Cumberland is outside the King County Urban Growth Area boundaries. ***Previous approvals of the volume of storage available in Cumberland include the following:* • *A telephone conversation with Bill Mudd, Fire Engineer with King County Building Services, on July 13, 1995.* • *A June 18, 1991 memo from King County Fire Marshal Thomas W. McDonald stated, "The Cumberland Community was subdivided prior to 1977. As a result, it qualifies for the exemptions set forth in KCC 17.08.030 A-5 and does not have to meet King County Fire Flow and Fire Hydrant Standards." Where local standards are not adopted, Washington Administrative Code 246-293-640 identifies a minimum fire flow requirement of 500 gpm for*

Table 6-1. Summary of Storage Capacity Analysis Results

Storage Service Area	Notes
	30 minutes, which results in a storage volume of 15,000 gallons. • *Decision item 4 on an Appeal from the King County Zoning Adjustor dated September 7, 1984 for File No. 84-32-AC stated, "only a 120,000 gallon storage structure may be installed".* • *Conclusion 3 in the Decision dated May 31, 1984 on File No. 84-32-AC from King County stated, "A 120,000 gallon storage capacity is adequate to serve existing residential customers and probably other future residential customers in the service area with fire flow." This was based on Finding I.3. in this Decision, which references a May 2, 1984 memo from King County Fire Marshal Tom McDonald, stating "King County Ordinance 5828…establishes the minimum acceptable fire flow for residences at 1,000 gallons per minute for a duration of (2) hours. Based on these factors the minimum acceptable size of reservoir or storage tank for fire flow purposes would be 120,000 gallons."* • *On August 8, 1983, Item 2 in King County Ordinance 6494 approved a 120,000 gallon tank to serve Cumberland.* The analysis shows that storage is currently deficient for storage required at 30 psi. This is based on the highest service connection being at an elevation of 860.2 ft. The system is able to provide the required operational storage at a minimum of 30 psi to a maximum service elevation of 858.7 ft (about a 1 psi difference to the 860.2 ft service elevation). Six connections exist above this elevation. Because the deficiency is minor and only impacts a small number of service connections, no capital projects are currently planned. Operational changes may be made to reduce the operating band (and associated operating storage) to reduce deficiency. Sufficient storage does not exist to fully supply the design fire flow event while maintaining 20 psi in the zone. A potential solution to the storage deficiency is to have a portion of the fire suppression volume supplied by the Cumberland Pump Station. However, assuming the pump station makes up the difference in required volume causes a deficiency in the Cumberland Pump Station. More discussion of this deficiency and potential improvements is provided in the source capacity analysis results in section 6.2.2.
Sunrise	The analysis shows that storage has small deficiencies for both the 20 psi and 30 psi requirements. This result is based on a highest service connection at an elevation of 628.8 ft. Storage required at 30 psi is driven by the required operational storage, which remains constant through the planning horizon. Between the standby and fire suppression storage components, 20 psi storage is driven by standby storage, which increases across the planning horizon due to projected growth in demands. Required storage can be provided at adequate pressure to service connections at an elevation of 623.6 ft or below. Only one service connection exists above this elevation, which will see a slight deficiency (about 1 psi max) given 2017 demands. As growth continues in the area, it is forecasted that by 2037 service connections above an elevation of 607.8 ft would see a deficiency (about 9 psi max). **Potential Improvements:** Modifications to storage and/or booster pumps will be necessary to allow the entire forecasted required standby storage volume to be available at the minimum 20 psi pressure to all service connections. As the area is developed, further analysis will be completed to determine the appropriate course of action.
Indian Hill	The analysis found that storage in the service area is adequate throughout the 20-year planning horizon.
McMillin Gravity	The McMillin Gravity Service Area consists of a number of interconnected pressure zones and storage facilities. Because of the interconnections between facilities, the area was analyzed as a whole. The available storage for each storage facility within the service area was based on the highest service connection directly served by each facility. The analysis found that storage in the service area is adequate throughout the 20-year planning horizon.

Table 6-2. Prairie Ridge Service Area Storage Capacity Analysis

Component	2017	2027	2037	Max. Supported
ERU Demand	5,228	5,618	8,737	7,446
Required Storage (MG)				
Operational Storage	0.794	0.794	0.794	0.794
Equalizing Storage	0.000	0.000	0.000	0.000
Standby Storage	1.046	1.124	1.747	1.489
Fire Suppression Storage	0.840	0.840	0.840	0.840
Storage Required at 30 psi	0.794	0.794	0.794	0.794
Storage Required at 20 psi	1.840	1.918	2.542	2.283
Existing Available Storage (MG) [a]				
Storage Available at 30 psi	1.836			
Storage Available at 20 psi	2.283			
Storage Surplus or (Deficiency) (MG)				
30 psi Storage	1.042	1.042	1.042	1.042
20 psi Storage	0.444	0.366	**(0.258)**	0.000

[a] Based on available storage in the Prairie Ridge Reservoir.

Table 6-3. Cumberland Service Area Storage Capacity Analysis

Component	2017	2027	2037	Max. Supported
ERU Demand	76	82	132	449 [c]
Required Storage (MG)				
Operational Storage	0.023	0.023	0.023	0.023
Equalizing Storage	0.000	0.000	0.000	0.000
Standby Storage	0.015	0.016	0.026	0.090
Fire Suppression Storage [b]	0.090	0.090	0.090	0.090
Storage Required at 30 psi	0.023	0.023	0.023	0.023
Storage Required at 20 psi	0.113	0.113	0.113	0.113
Existing Available Storage (MG) [a]				
Storage Available at 30 psi	0.023			
Storage Available at 20 psi	0.113			
Storage Surplus or (Deficiency) (MG)				
30 psi Storage	**(0.017)**	**(0.017)**	**(0.017)**	**(0.017)**
20 psi Storage	0.000	0.000	0.000	0.000

Table 6-3. Cumberland Service Area Storage Capacity Analysis

[a] Based on available storage in the Cumberland storage facility.
[b] The Cumberland tank does not have adequate capacity to store the entire design fire flow event (1,000 gpm flow for two hours). The storage analysis assumes the fire suppression storage is equal to the available 20 psi storage volume less required operational and equalizing storage. The remainder of the fire flow volume would be provided directly by the Cumberland Pump Station.
[c] Maximum ERU supported without causing a deficiency in 20 psi storage.

Table 6-4. Sunrise Service Area Storage Capacity Analysis

Component	2017	2027	2037	Max. Supported
ERU Demand	606	656	1,058	553 [b]
Required Storage (MG)				
Operational Storage	0.263	0.263	0.263	0.263
Equalizing Storage	0.000	0.000	0.000	0.000
Standby Storage	0.947	1.025	1.654	0.865
Fire Suppression Storage	0.840	0.840	0.840	0.840
Storage Required at 30 psi	0.263	0.263	0.263	0.263
Storage Required at 20 psi	1.210	1.288	1.917	1.128
Existing Available Storage (MG) [a]				
Storage Available at 30 psi	0.259			
Storage Available at 20 psi	1.128			
Storage Surplus or (Deficiency) (MG)				
30 psi Storage	**(0.004)**	**(0.004)**	**(0.004)**	**(0.004)**
20 psi Storage	**(0.082)**	**(0.160)**	**(0.789)**	**0.000**

[a] Based on available storage in the Sunrise Reservoir.
[b] Maximum ERU supported without causing a deficiency in 20 psi storage.

Table 6-5. Indian Hill Service Area Storage Capacity Analysis

Component	2017	2027	2037	Max. Supported
ERU Demand	8,503	9,206	14,854	19,346
Required Storage (MG)				
Operational Storage	0.848	0.848	0.848	0.848
Equalizing Storage	0.000	0.000	0.000	0.000
Standby Storage	1.701	1.841	2.971	3.869
Fire Suppression Storage	0.840	0.840	0.840	0.840
Storage Required at 30 psi	0.848	0.848	0.848	0.848

Table 6-5. Indian Hill Service Area Storage Capacity Analysis

Component	2017	2027	2037	Max. Supported
Storage Required at 20 psi	2.548	2.689	3.819	4.717
Existing Available Storage (MG) [a]				
Storage Available at 30 psi	4.280			
Storage Available at 20 psi	4.717			
Storage Surplus or (Deficiency) (MG)				
30 psi Storage	3.432	3.432	3.432	3.432
20 psi Storage	2.169	2.028	0.899	0.000

[a] Based on available storage in the three Indian Hill reservoirs.

Table 6-6. McMillin Gravity Service Area Storage Capacity Analysis

Component	2017	2027	2037	Max. Supported
ERU Demand	169,823	176,688	231,587	637,794
Required Storage (MG)				
Operational Storage	39.4	39.4	39.4	39.4
Equalizing Storage	0.0	0.0	0.0	20.2
Standby Storage	34.0	35.3	46.3	129.5
Fire Suppression Storage	22.4	22.4	22.4	22.4
Storage Required at 30 psi	39.4	39.4	39.4	59.7
Storage Required at 20 psi	73.4	74.8	85.8	189.2
Existing Available Storage (MG) [a]				
Storage Available at 30 psi	85.4			
Storage Available at 20 psi	189.2			
Storage Surplus or (Deficiency) (MG)				
30 psi Storage	46.0	46.0	46.0	25.8
20 psi Storage	115.8	114.4	103.4	0.0

[a] Based on available storage in the Alaska Street, Bismark, Fletcher Heights, Hood Street, McMillin, North End (both reservoir and standpipe), Portland Avenue, South Tacoma, and University Place storage facilities. Available storage volumes are based on maintaining either a 20 psi or 30 psi pressure for customers directly served by each storage facility.

6.2 Source Capacity Analysis

6.2.1 Background and Methodology

The source capacity analysis examines the adequacy of pump stations throughout the distribution system to supply pressure zones. Pressure zones are either open or closed systems. Open system pressure zones have a storage facility that is open to atmospheric pressure (non-pressurized) that supplies the pressure zone via gravity when a zone's source(s) are not operating or cannot keep up with peak demands. Closed system pressure zones do not have a storage facility and are typically supplied directly from a pump station.

Per WAC 246-290-230 and the DOH *Water System Design Manual*, the following design requirements apply to pump stations:

- Pump stations serving open systems:
  - Capable of supplying the maximum day demand with all pumps operating.
  - Capable of supplying the average day demand with the largest pump out of service.
- Pump stations serving closed systems:
  - Capable of supplying the peak hour demand. Recommended that peak hour demand can be supplied with the largest pump out of service.
  - Capable of supplying the required fire flow during maximum day demand with the largest pump that is routinely[8] used out of service.

In some cases, a pump station serving a closed system does not need to supply the required fire flow if the fire flow is also supplied from connections to other pressure zones through pressure reducing valve (PRV) stations.

Pump stations serving the same areas are grouped together into a single analysis. In total, 14 different source groupings were analyzed, and are summarized in Table 6-7.

The distribution system source capacity analysis did not look into the adequacy of the overall sources to the system (Green River Filtration Facility and wells) to supply the entire system. Discussion of source adequacy for the entire system is provided in Chapter 4.

Peak hour demands for the areas served by the pump stations are based on using the DOH *Water System Design Manual*'s peak hour demand equation.

[8] A separate pump dedicated to fire demands that is not used to meet maximum day or peak hourly demands is not considered to be routinely used.

Table 6-7. Source Capacity Analysis Area Descriptions

Source Capacity Analysis Area	Sources	Pressure Zones Served	Serves Normally Closed or Open System
Bonney Lake	Prairie Ridge PS	Bonney Lake 581, 860, 950, 1010	Closed system
Prairie Ridge	214th Ave E PS 198th Ave E PS Prairie Ridge Springs PS	Bonney Lake 581, 860, 950, 1010 Prairie Ridge 810	Open system
Cumberland	Cumberland PS	Cumberland 931	Open system
Fennel Creek	Fennel Creek PS	Fennel Creek 705	Closed system
Highland	Highland PS	Highland 621	Closed system
Sunrise	McMillin 1 & 2 PS	McMillin 706 Sunrise Terrace 519	Open system
Indian Hill	Indian Hill 1 & 2 PS	Indian Hill 649	Closed system
Park Royal	83rd Ave & Cirque PS	Park Royal 556	Closed system
Westgate	N 21st and Pearl PS Mildred Street PS North End PS	Westgate 538 Fletcher 538	Closed system
Frederickson	Frederickson PS	Frederickson 588	Closed system
S Summit High	128th and Canyon PS 62nd Ave E PS	S Summit High 669	Closed system
80th Ave E	80th Ave E & 132nd Ln PS	80th Ave E 626	Closed system
Alder Lane	Alder Lane PS	Alder Lane 626	Closed system
NE Tacoma	356th Street PS Marine View Drive PS	NE Tacoma 549 Twin Lakes 411 NE Tacoma 346 Lakota Beach 186 Dash Point High 411 Harbor View 426 Browns & Dash Point 346 Dash Point Low 226 Hyada 226 Beverly Heights 486 Overlook 370 Fife Heights Low 411 Indian Hill 649	Open system

6.2.2 Results

A summary of the distribution source capacity analysis results is given in Table 6-8. The complete details of the analysis can be found in Appendix H.

Table 6-8. Summary of Source Capacity Analysis Results

Source Capacity Analysis Area	Notes
Bonney Lake	A slight deficiency currently exists for supplying fire flow during maximum day demand conditions with the largest pump out of service. This deficiency does not exist if all pumps are operating. **Potential Improvements:** In the mid-2020s, it is planned to modify the Bonney Lake area by having the Prairie Ridge Pump Station pump to the Bonney Lake 950 zone instead of the Bonney Lake 1010 zone and add storage to the 950 zone. An additional pump station would be added that would pump from the 950 zone to the 1010 zone. The current deficiency (and future identified deficiencies) would be resolved by these improvements.
Prairie Ridge	Adequate
Cumberland	If assuming the Cumberland Pump Station handles the portion of the design fire flow event that cannot be met by storage in the Cumberland tank, the pump station has a deficiency of approximately 126 gpm during maximum day demand conditions if the largest pump is out of service. This deficiency does not exist if all pumps are operating. Alternatively, changes can be made to Cumberland 931 zone storage to fully accommodate the required fire suppression storage. The required fire flow and maximum day demand could be met with the largest pump out of service if the portable pump is also used. Tacoma Water has available a 450-gpm gasoline powered pump that can be readily hooked up to an existing connection point in the Cumberland Pump Station in the event that a pump goes out of service. The Cumberland zone can also have flows supplemented through gravity flow from Pipeline 1 through a check valve during fire events. **Potential Improvements:** This area will need be reviewed in greater detail to determine what possible methods, improvements or alternatives would meet the system operating requirements. A Business Case Evaluation will be used to analyze each of the alternatives and identify the lowest lifecycle cost method of meeting the system operating requirements.
Fennel Creek	When using the Pierce County Code fire flow requirement of 750 gpm, the Fennel Creek Pump Station has adequate capacity. However, if using Tacoma Water's planning fire flow requirement of 1,500 gpm, which goes beyond the legal requirement, a deficiency exists. If modifications occur to the pump station, the planning fire flow requirement of 1,500 gpm will be considered.
Highland	Capacity is adequate to meet peak hour demand conditions. Fire flow is supplied through PRVs instead of through pumping.
Sunrise	Adequate
Indian Hill	Adequate
Park Royal	Capacity adequate to meet peak hour demand conditions. Fire flow is supplied through check valves instead of through pumping.
Westgate	Capacity is adequate to meet peak hour demand conditions. Fire flow is supplied through check valves instead of through pumping.
Frederickson	Peak hour demands can be met per regulatory requirements if all pumps are online. However, additional capacity needed to meet peak hour demand conditions if largest pump is out of service (DOH recommended practice for closed systems). Fire flow is supplied through check valves instead of through pumping.

Table 6-8. Summary of Source Capacity Analysis Results

Source Capacity Analysis Area	Notes
S Summit High	Capacity adequate to meet peak hour demand conditions. Fire flow is supplied through check valves instead of through pumping.
80th Ave E	Capacity adequate for 10-year planning horizon to meet peak hour demand conditions. However, deficiency shown for 20-year planning horizon. Fire flow is supplied through check valves instead of through pumping. **Potential Improvements:** Additional pump station capacity will be added as needed if peak hour demands begin approaching pump station capacity after 2027.
Alder Lane	Although the pump station is not capable of meeting the peak hour demand predicted from DOH Water System Design Manual's peak hour demand equation, actual observed peak hour demands for have not approached the calculated values. The pump station has had sufficient capacity to meet historically observed demands.
NE Tacoma	Adequate

6.3 Distribution System Analysis

The distribution system analysis is used to determine the distribution system's ability to meet forecasted demands and required fire flows with adequate pressure and to help identify system deficiencies and needed system improvements. This section presents the results of computer modeling and analysis of Tacoma Water's distribution system.

6.3.1 Background

Tacoma Water's distribution system is modeled using InfoWater by Innovyze. InfoWater is a GIS-based modeling software that combines the features and geospatial tools of ArcGIS with a numerical modeling engine. The model is able to derive information from Tacoma Water's ESRI GIS Geodatabase.

Tacoma Water previously utilized a Bentley WaterCAD hydraulic model originally developed for the 2006 WSP. Unlike the previous model, the InfoWater model encompasses the entire system without segmenting zones and includes the Green River Filtration Facility, gravity transmission mains, supply facilities, and distribution mains.

Construction of the model was completed by Tacoma Water staff. It uses components of pipe length, pipe diameter, elevations of system components, reservoir sizes, pump curves, pressure relief valve (PRV) settings, and other measurements provided in Tacoma Water's fully developed GIS Geodatabase.

Components of the model are being updated continuously both through manual improvements as the model is used and by syncing the model data with Tacoma Water's GIS Geodatabase, which is updated weekly. This syncing process is intended to occur quarterly, and ensures the model remains current with infrastructure in the field.

Tacoma Water uses its hydraulic model extensively for a number of purposes including pressure analysis; fire flow analysis; pressure zone modeling; sizing/timing of pipe replacements, storage and pump facilities improvements; water main shutdown

modeling; and to pinpoint any pressure or flow deficiencies in the transmission and distribution water system. These data are used as part of an overall plan for water main replacements or new water main construction.

6.3.2 Methodology

Projected water demands for the average day demand (ADD), maximum day demand (MDD), and peak hourly demand (PHD) were added to the model for the years 2017, 2027, and 2037.

Spatial allocation of demands was based on consumption information from Tacoma Water's customer information database and Tacoma Water's projected demand modeling. Demands were added to the model by overlaying a parcel grid with the model and then spatially assigning individual customer demands (based on parcel) to the nearest model node.

Peaking factors were used to convert forecasted ADD to MDD and PHD demand scenarios. Details regarding the peaking factors used are provided in Appendix I.

The model was calibrated for steady-state modeling. A steady-state model provides a "snapshot" look at the system at a particular instant in time given boundary conditions entered into the model (reservoir levels, demands, on/off conditions of pumps, etc.). Calibration was accomplished by performing 263 hydrant flow tests, 282 static pressure tests, and collecting 174 pressure transducer readings (1.5 million pressure readings) throughout all zones of the distribution system. Using this data, along with the available SCADA data for each pressure zone (578,000 data points), the model was adjusted to approximate real world conditions. The model is considered calibrated for static pressure readings based on Engineering Computer Application Committee (ECAC) standards, with 91 percent of static readings within ± 2 psi of field measurements. The model is considered calibrated for steady state modeling based on the Walski standards (Walski et al., Advanced Water Distribution Modeling and Management Book, 2003), with 98 percent of modeled dynamic tests within 5 to 10 feet (4.33 psi) of field measured hydraulic grade loss. As such, calibrated model results are conservatively assumed to represent field conditions within ±10 percent. Further details regarding model calibration and specific adjustments in the model are provided in Appendix I.

For this WSP, basic system performance was evaluated for two conditions:

- **PHD Pressure** – Evaluation of the ability of the system to provide 30 psi to all customers under PHD conditions.
- **MDD + Fire flow** – Evaluation of the ability of the system to provide required fire flows under MDD conditions while maintaining pressure above 20 psi throughout the system.

PHD Pressure scenarios were analyzed for both the 30 psi condition and within 10 percent of 30 psi (27 psi) to account for uncertainty in the calibrated model.

MDD scenarios were analyzed for the years 2017, 2027, and 2037 for each pressure zone. This was accomplished by first evaluating results from the 2037 model run, and working through 2027 and 2017 model runs, respectively, if deficiencies were found in

the 2037 results. PHD scenarios were tested for the years 2017, 2027, and 2037 for each pressure zone.

Tacoma Water intends to complete Extended Period Simulation (EPS) model calibration in 2018. An EPS model provides a look at how the system operates over a period of time. Following the EPS calibration, the model is intended to be used for water age analysis, mock or emergency contaminant tracking (such as a main depressurization), pressure zone optimization, pumping efficiency, and tank storage cycles.

6.3.3 Results

Detailed results of the distribution system analysis are provided in Appendix I, including a summary of the water system's ability to maintain adequate system pressure during PHD conditions and to provide required fire flow during MDD conditions for each pressure zone by forecast year. Results of the distribution system analysis are provided in Appendix I, including a summary of the water system's ability to maintain adequate system pressure during PHD conditions and to provide required fire flow during MDD conditions for each pressure zone by forecast year.

PHD Pressure

Under PHD conditions, the water system must be able to maintain a minimum pressure of 30 psi. Evaluating modeled pressures for a 30 psi minimum identified discrete areas in the water system with potentially less than 30 psi during PHD conditions. These potential areas consist of 35 model nodes (an estimated 267 ERUs) out of a total 58,503 model nodes (a total estimated 357,874 ERUs). Generally, these areas are localized elevation peaks within pressure zones or located along pressure zone boundaries. Tacoma Water is evaluating each area further to review and make improvements following field verification of pressure at every location. Preliminary recommended actions (next steps) for each area are provided in the detailed appendix results. If discrete improvement projects are identified, Tacoma Water plans to approve and allocate project funds to the CIP through the typical budgeting process to begin improvements in the 2021-2022 biennium.

To account for uncertainty in the hydraulic model and to identify any areas needing urgent improvement, results were assessed at 10% less than 30 psi, or 27 psi. By identifying locations less than 27 psi, this indicates where PHD static pressure is most certain to be less than 30 psi when accounting for model uncertainty.

Evaluating for 27 psi, only one localized area was identified, which is located in the High Service 478' Zone along East 64th Street, between Pacific Avenue and McKinley Avenue. Tacoma Water is presently improving water pressure in this vicinity by adjusting pressure zone boundaries between the High Service 478' Zone and Canyon 581' Zone and plans to have this work complete in the 2019-2020 biennium.

Aside from the above mentioned areas, modeling shows that the rest of the system has the capacity to meet peak hour demands through 2037.

MDD + Fire Flow

Model results show that the majority of the system is able to provide fire flow in excess of 1,000 gpm. Detailed results of the analysis are included in Appendix I. Further discussion is included here regarding fire flow requirements for specific areas of the City. Discussion regarding fire flow design standards is included in Chapter 5.

Although the City of Tacoma has not established minimum fire flow requirements in the downtown core, consultation with the Fire Protection Engineer for the City of Tacoma indicates that fire flow requirements in that area are generally less than 2,500 gpm.

There are several other areas of higher than typical residential fire flow requirements. These include the Tideflats, an area of heavy and medium industry; the Frederickson Industrial area, which includes a division of the Boeing Commercial Airplane Division, two power plants, several wood products manufacturing and distribution companies, a food products company and a composites manufacturing firm; and a relatively small light industrial park located in the Orting Valley.

The fire flow available in the Tideflats area substantially exceeds the Uniform Fire Code requirement of 2,500 gpm. Due to a backbone grid of large diameter mains, available fire flow is generally greater than 5,000 gpm and in many areas greater than 10,000 gpm. Available fire flow in the Frederickson Industrial area is approximately 8,000 gpm, which exceeds the required minimum. This is due to a looped feed of 20-inch and 24-inch mains in Canyon Road and 38th Avenue E connected to Tacoma Water's 58-inch transmission main on 128th Street E. Source water for this main is the 66 MG McMillin Reservoir on the South Hill of Puyallup. The final industrial area served by Tacoma Water is in the Orting Valley. This small area is fed through a backbone of 12-inch main from a single connection to Pipeline 1, which consists of two 39-inch steel mains at that location. Fire flows in the industrial park area also exceed 2,500 gpm.

It should be noted that discrete locations were identified where modeled fire flows are potentially less than the present day required fire flow. This context is important to recognize as the distribution system in these locations was designed, approved, and constructed to historical standards of the day. These mains are planned for improvement during the typical redevelopment process of each associated neighborhood and Tacoma continues to review these locations regularly for replacement in concert with upcoming development and local jurisdiction projects (such as county road projects).

This circumstance occurred for 1,574 out of the 58,503 modeled fire flow nodes (2.7 percent). Preliminary recommended actions (next steps) for each location are provided in the detailed appendix results. A review of specific locations is planned for the 2019-2020 biennium. If discrete improvement projects are identified, Tacoma plans to approve and allocate project funds to the CIP through the typical budgeting process to begin improvements in the 2021-2022 biennium.

7 Water Quality

This chapter summarizes existing water quality conditions and compliance with drinking water quality regulations.

7.1 Water Quality Regulations

Washington State DOH has been designated by the EPA as the "primacy" agency in matters related to drinking water quality. To maintain primacy, DOH must adopt federal drinking water criteria as minimum standards and must administer the state's drinking water program. This includes regulatory aspects, enforcement, monitoring and surveillance, technical assistance, laboratory analysis, laboratory certification, and program development.

For more Information…

Information on regulated contaminants and their allowed levels in drinking water can be found in Chapter 246-290 of the Washington Administrative Code.

In meeting these requirements, the state has published drinking water regulations that are contained in Chapter 246-290 of the Washington Administrative Code, which establishes monitoring requirements, maximum contaminant levels, and requirements for follow-up actions. Standards for water quality are often specified in terms of Maximum Contaminant Levels (MCLs), and are categorized as either primary or secondary. Primary MCLs are based on chronic and/or acute human health effects. Secondary MCLs are based on factors other than health effects, such as the aesthetic quality of the water. Maximum Contaminant Level Goals (MCLGs) are based on the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.

The EPA is also in the process of adopting or considering to adopt a number of other regulations, which would regulate additional contaminants or modify existing regulations. These future regulations and a brief summary of their potential effect on Tacoma Water are provided in Table 7-1.

Table 7-1. Future Regulations Potentially Affecting Tacoma Water

Regulation	Anticipated Adoption Date	Potential Effect on Tacoma Water
Lead and Copper Rule Long-Term Revisions (LCR-LTR)	2017 (draft) 2018 (final)	Changes to water quality sampling and reporting program. Potential further adjustments to drinking water pH and alkalinity at each supply.
Use of Lead Free Pipes, Fittings, Fixtures, Solder and Flux for Drinking Water	2017 (draft) 2018 (final)	None. Tacoma Water is already compliant with the requirements.
Perchlorate	2018 (draft) 2019 (final)	No impacts expected.

Table 7-1. Future Regulations Potentially Affecting Tacoma Water

Regulation	Anticipated Adoption Date	Potential Effect on Tacoma Water
Chromium (Total/Hexavalent Chromium)	2018 (draft) Uncertain for final	No impacts expected.
Carcinogenic Volatile Organic Compound (cVOC) Rule	2018 (draft) Uncertain for final	Possible change in how individual wells at the South Tacoma Wellfield are used.
Final Fourth Unregulated Contaminant Monitoring Rule (UCMR 4)	2018	Additional monitoring. No impacts expected.
Strontium	2018 (draft) 2019 (final)	No impacts expected.
Cyanotoxins	2022 (draft) 2024 (final)	No impacts expected.
Nitrosamines	Uncertain	No impacts expected.
Chlorate	Uncertain	No impacts expected.
Perfluoroalkyl Substances	Uncertain	Increased monitoring of groundwater supplies and changes to well operations, especially the South Tacoma Wellfield.

7.2 Water Quality Monitoring

Tacoma Water monitors water quality for operational, informational, and regulatory compliance purposes. Tacoma Water conducts a significant amount of monitoring in each of these categories. To conduct appropriate sampling for regulatory compliance, Tacoma Water maintains monitoring plans that define the schedules and locations for collecting water quality samples. These plans include:

- **Coliform Monitoring Plan** – DOH requires Tacoma Water to collect a minimum of 150 samples for coliform bacteria at locations throughout the distribution system. It is expected that the required number of monthly samples will increase later in 2018 from 150 to 180. The monitoring plan has been updated in anticipation of this, but the update will not be formally added until the requirement changes. The current plan has Tacoma Water collecting at least a minimum of 180 samples every month.
- **Disinfection Byproduct Monitoring Plan** – This plan addresses sampling for compounds that occur in drinking water as a byproduct from disinfecting water with chlorine. Every three months Tacoma Water collects samples from 12 locations in the distribution system.
- **Lead and Copper Rule Monitoring Plan** – This plan outlines the sampling schedule and locations for lead and copper monitoring. Tacoma Water collects samples from 50 or more locations once every three years.
- **Source Monitoring Plan** – This plan outlines sampling required for all Tacoma Water sources for volatile organic, synthetic organic, inorganic, and radiological contaminants.

7.3 Water Quality Information and Compliance

Tacoma Water maintains a water quality website (link in Section 7.8), which provides an overview of Tacoma Water's water quality program, key initiatives, and latest water quality monitoring reports.

Table 7-2 provides a summary of the water quality parameters listed in the water quality monitoring reports from 2012 through 2016. For all parameters, Tacoma Water met EPA requirements, except for a brief turbidity event in 2014 that affected only a small number of customers.

For more Information…

Copies of recent annual water quality monitoring reports can be found at: https://www.mytpu.org/news-publications/tpu-publications.htm. Additionally, all water quality measurements can be found on DOH's Sentry Internet database under water system ID 86800: https://fortress.wa.gov/doh/eh/portal/odw/si/Intro.aspx.

Water quality testing is performed by laboratories accredited by the Washington Department of Ecology to perform the relevant testing. Tacoma Water uses a variety of laboratories based on competitive bidding each biennium. Current labs utilized in 2017 include:

- Seattle Public Utilities Water Quality Laboratory (Seattle)
- Water Management Laboratory (Tacoma)
- AmTest Laboratory (Kirkland)
- EuroFins Eaton Analytical (Monrovia, California)

Of these laboratories, Water Management (which completes coliform testing) and Seattle Public Utilities Water Quality Laboratory (which completes many of the watershed sample testing) are under an extended contract and used every year. The other laboratories are awarded contracts based on the competitive bidding process held every two years and are subject to change.

Table 7-2. Summary of Water Quality Parameters 2012 – 2016 (Highest Level Detected for All Sources)

Parameters	Units	MCL	MCLG	2012	2013	2014	2015	2016
Arsenic	ppb	10	0	7	7	7	6	6
Barium	ppm	2	2	0.07	0.07	0.07	0.044	0.05
Chromium	ppb	100	100	2	2	2	2	2
Nitrate	ppm	10	10	4.61	4.54	4.73	4.2	4.2
Trichloroethylene	ppb	5	0	2	1.3	1.7	0.99	0.99
Chloroform	ppb	N/R	N/R	6.68	6.68	1.16	0.76	0.76
Fluoride	ppm	4	4	2.02	1.34	2.03	1.44	1.77
Turbidity	NTU	5	N/A	4.1	4.23	6.76 [a]	3.43	0.041
TTHM [c]	ppb	80	N/A	N/A	21.4	19.1	12.5	10.3
Haloacetic Acid [c]	ppb	60	N/A	N/A	23.5	20.9	8.3	6.3
Bromate	ppb	10	0	ND	0	0	0	0
Lead [b]	ppb	15	0	14	10	10	10	2.1
Copper [b]	ppm	1.3	1.3	0.392	0.223	0.223	0.223	0.049
Total Coliform	% positive	<5%	0%	0.00%	0.001%	0.001%	0.00%	0.00%

Source: Tacoma Water Water Quality Reports from 2012 through 2016

MCL = maximum contaminant level

MCLG = maximum contaminant level goal

TTHM = Total trihalomethane

[a] Finished water turbidity exceeded the 5 NTU limit on 11/19/2014 for approximately 6 minutes. The high turbidity water was collected and disposed of at the McMillin Reservoir complex. Only 7 customers closest to the Tacoma Water Treatment Facility were affected and were immediately notified. No other Tacoma Water customers were affected.

[b] Lead and copper values are the 90th percentiles for each 3-year period.

[c] TTHM and haloacetic acid values are the running annual averages.

7.4 Sanitary Survey

As part of the Groundwater Rule, all Group A[9] public water systems with groundwater sources are required to complete routine sanitary surveys of the system every three to five years.[10] The surveys evaluate the critical elements of the water system and its operation, including:

- Planning and management documents

[9] Under Washington State law, Group A water systems are those that have 15 or more service connections or serve 25 or more people 60 or more days per year.

[10] Per WAC 246-290-416, water systems must have a sanitary survey every three years but may qualify to be surveyed every five years given the number of violations or deficiencies found in the last survey. Systems that use a surface water source must also have a survey every three years but this may be reduced to every five years upon written approval from DOH. Currently, Tacoma Water's entire system receives a sanitary survey every five years. The GRFF receives a sanitary survey every three years.

- Distribution system and status of cross-connection control program
- Source and sanitary control area
- Source pumps and pumping facilities
- Source treatment procedures and equipment
- Monitoring, reporting, and data verification
- Finished water storage
- Operator certification status

In Washington, sanitary surveys are administered by DOH. The most recent sanitary surveys for Tacoma Water were conducted in 2013 for the entire water system, in 2016 for the GRFF only, and 2018 for the distribution system. These surveys examined the groundwater and surface water sources, the Green River Watershed, and the storage reservoirs. Copies of the 2013, 2016, and 2018 sanitary surveys and their findings, as well as Tacoma Water's response to the findings, are included in Appendix J.

The 2013 sanitary survey found eight significant deficiencies (requiring immediate action) and had 12 recommendations for potential deficiencies. Significant deficiencies consisted primarily of insufficient air gaps in blow off and overflow piping at various facilities. All significant deficiencies were addressed after being identified.

The 2016 sanitary survey of the GRFF found no significant deficiencies and included four recommendations for potential deficiencies. All recommendations were addressed after being identified.

The 2018 sanitary survey of the distribution system found six significant deficiencies, one significant finding, and two recommendations. Tacoma Water's action plans are detailed in our response to DOH found in Appendix J.

The next sanitary survey is due in 2019 for the GRFF[11].

7.5 Treatment Initiatives

Based on the upcoming regulatory actions described in Table 7-1, Tacoma Water expects to develop additional physical treatment infrastructure and initiatives related to the Lead and Copper Rule Long-Term Revisions (LCR-LTR). This includes potential changes to corrosion control and lead gooseneck removal. Additional treatment improvements and initiatives are also planned that do not tie directly to federal rulemaking. An overview and description of these projects are provided below.

[11] Past practice has been for DOH to perform a sanitary survey of the complete water system including the GRFF during years when the distribution system is due.

7.5.1 Initiatives Driven by Rulemaking

Green River Filtration Facility

The GRFF was completed as an upgrade of the Green River Treatment Plant and came online in December 2014. The upgrade added a filtration process to the facility to meet requirements of the Long Term 2 Enhanced Surface Water Treatment Rule (LT2), which was finalized in 2006. Tacoma Water officially transitioned from unfiltered to filtered water on May 1, 2015. Further information on the GRFF can be found in Section 5.1.4.

For more Information…

Additional information on lead testing available for customers can be found at: https://www.mytpu.org/tacomawater/water-quality/water-kit.htm.

Lead Gooseneck Removal

Tacoma Water has identified about 1,200 potential locations where short pieces of lead pipe may exist in the water system. Called lead goosenecks (or whips), the pipes connect the water main to the service pipe that runs to a customer's water meter.

Tacoma Water generally has very little lead pipe in its system, and it employs corrosion control in its treatment process to reduce the amount of lead in the water to levels well below EPA standards. Still, the utility is committed to removing all lead goosenecks from the water system.

Due to the age of some parts of the water system, installation records for some service connections do not exist, and this makes it challenging to locate all lead goosenecks. Tacoma Water is looking for additional records and digging for actual pipe in the street to verify pipe material. When a lead gooseneck is found, the service line and gooseneck are replaced with a new copper pipe. This work is ongoing and is expected to be completed by the end of 2020.

Tacoma Water also provides customers free testing for lead in their drinking water.

Corrosion Control

Tacoma Water routinely monitors lead and copper concentrations throughout its distribution system to comply with DOH requirements associated with the federal Lead and Copper Rule (LCR). Corrosion control is accomplished by adjusting the finished water quality to prevent the leaching of lead and copper from premise plumbing into the water.

The utility has been in continuous compliance with the LCR since it was promulgated in 1991. However, from 2001 to 2013, monitoring results taken during summer months when groundwater was used indicated an increase in lead concentrations (at the 90th percentile) compared to periods when groundwater was not used.

To further reduce potential lead exposure to its customers, Tacoma Water began operating corrosion control treatment for the South Tacoma Wellfield, the utility's principal groundwater supply, in 2013. The new treatment facilities provide caustic soda feed at the Hood Street Reservoir and aeration at the South Tacoma Pump Station.

Tacoma Water previously operated a corrosion control facility at 214th Avenue to treat the Green River surface water. This facility was phased out following transition of full pH adjustment for the surface water supply to the Green River Facilities in 2005, and was decommissioned permanently in 2016. Tacoma Water's remaining groundwater supplies do not have corrosion control treatment. These wells have lower production capacities and are used less frequently than the South Tacoma Wellfield.

The optimized water quality parameters (OWQP) for corrosion control for the utility were established based on a study completed in 1994, with water quality parameters designated by DOH in 1998 specifically for the Green River supply. Tacoma Water is implementing a comprehensive four-pronged approach to limit overall lead exposure to its water customers. The approach includes:

- Eliminating the use of lead in all new and replacement distribution materials, such as using non-leaded brass or alternative materials for valving and meters.
- Removing all remaining known lead goosenecks in the distribution system by 2020.
- Increasing the water pH and alkalinity of the Green River finished water to reduce the potential for metal corrosion in premise plumbing.
- Conducting an investigation of appropriate corrosion control measures for each of Tacoma Water's groundwater supplies.

The end result of the plan is to further improve the utility's continued compliance with the LCR and reduce potential lead exposure to its customers.

7.5.2 Non-Regulatory Driven Initiatives

Fluoridation

Tacoma Water fluoridates the surface water supply at the GRFF. Groundwater from the South Tacoma Wellfield is also fluoridated at the Hood Street Reservoir, while groundwater from other sources is not. Tacoma Water may consider fluoridating at other wells in the future, particularly if production from other wells increases substantially.

Groundwater Disinfection

Tacoma Water disinfects groundwater at Hood Street Reservoir and South Tacoma Pump Station for the South Tacoma Wellfield, and at Prairie Ridge Springs, South East Tacoma Wellfield, and University Place Wellfield Well UP1. Additionally, installation of chlorination equipment for the Gravity Pipeline wells was completed in 2016. No major new disinfection projects are currently planned.

7.6 Watershed Management Plan

The Green River Watershed above the intake facilities comprises approximately 147,446 acres. Tacoma Water owns approximately 11 percent of the watershed area, primarily land immediately adjacent to the Green River and its main tributaries. Public agencies and private companies own the remainder. These agencies and companies own lands that are dispersed throughout the Green River Watershed, which are generally undeveloped forestland managed for timber production and wildlife habitat.

Prior to the addition of filtration, Tacoma Water implemented a rigorous watershed control program, designed to meet DOH requirements for unfiltered surface water supply systems under WAC 246-290.

Even though Tacoma Water is now a filtered surface water supply system, the utility plans to continue applying the same level of watershed controls previously implemented under requirements for unfiltered surface water supply. This higher level of watershed control provides benefits to water quality, water treatment plant operations and maintenance, fisheries, environmental stewardship, land management, and forest health. Therefore, it is Tacoma Water's intent to continue to manage and improve the watershed program consistent with practices for an unfiltered surface water supply system.

The *Watershed Management Plan* provides more detailed information on the watershed controls for the Green River Watershed. The *Watershed Management Plan* is provided in Appendix E.

7.7 Wellhead Protection Program

The Federal Safe Drinking Water Act requires states to develop a wellhead protection program (WHPP) to protect groundwater used for public drinking water supply. In 1994, DOH implemented WHPP requirements for large public water systems, including Tacoma Water. WHPP requirements are described in the following:

- WAC 246-290-135: Source Water Protection
- WAC 246-290-100: Water System Plan
- Washington State Wellhead Protection Program Guidance Document (DOH, 2010)
- Source Water Protection Requirements (DOH, 2012).

Tacoma Water began wellhead protection activities prior to the state's 1994 WHPP rules. The South Tacoma Groundwater Protection District (STGPD) was established in 1988 (City Ordinance No. 24083, Tacoma Municipal Code 13.09), and the special protections for groundwater supplies within the district are enforced by the Tacoma-Pierce County Health Department (TPCHD). Since 1988, completion of Tacoma Water's wellhead protection activities has been coordinated with the ongoing activities associated with the STGPD. Today, the STGPD is active in the protection of the sensitive South Tacoma Aquifer, which supplies over half of Tacoma Water's wells and holds the potential for additional viable groundwater supplies. The TPCHD enforcement activities within the protection district include permitting and inspections of businesses, consultations, tank removals, tank installations, and cleanup oversight. In the 1990s, Tacoma Water completed critical wellhead protection activities for all of their wells, including those located outside the STGPD, and continues to update and expand its wellhead protection program today.

A WHPP is to contain the following key components (DOH, 2010; DOH, 2012):

- A completed Susceptibility Assessment Form for each water source (e.g., well, spring);

- A delineated wellhead protection area for each well, wellfield, or spring, with mapped 6-month, 1-, 5-, and 10-year time-of-travel zones for wells and mapped watershed control areas for springs;
- A secured sanitary control area around each water source (100-foot-radius for wells, 200-foot-radius for springs);
- An inventory of potential contaminant sources in the wellhead protection area, updated every two years;
- Documentation showing the water system sent delineation and inventory findings to required entities;
- Contingency plans for providing alternate drinking water sources if contamination does occur; and
- Coordination with local emergency responders for appropriate spill or incident response measures.

Tacoma Water's most recent update to the WHPP was completed in 2015, and included in Appendix K. Updates were made to the inventory of potential contaminant sources, owners/operators of potential contaminant sources were notified, contamination contingency plans were developed for all wells, and recommendations were made for further improvement of the WHPP. Tacoma Water meets with TPCHD at least once a year to review contaminant sources and the monitoring system that is in place to detect contaminants in groundwater. The monitoring program, including a list of wells that are sampled, which contaminants are tested for, and the frequency of sampling, is reviewed at least twice per year.

Since the 2015 update, susceptibility assessments, wellhead protection areas (WHPAs), and time-of-travel mapping have been, or are currently being, updated. Notification letters have been sent to regulatory agencies and local jurisdictions that overlap with Tacoma's WHPAs, and also to local emergency responders regarding the importance of protecting groundwater within WHPAs. Currently, Tacoma Water is working with TPCHD to update its GIS mapping and contaminant inventories. The WHPP and the contaminant inventories were updated in 2017.

Tacoma Water will continue to meet regulatory requirements for wellhead protection, while also investing in the continued collaboration with the TPCHD to provide focus beyond the regulations in significant industrialized areas around major groundwater sources.

7.8 Links to Relevant Materials

- DOH Sentry Internet Database: https://fortress.wa.gov/doh/eh/portal/odw/si/Intro.aspx
- Tacoma Water's Water Quality Website: https://www.mytpu.org/tacomawater/water-quality/

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8 System Operations

This section provides an overview of the operations of the Tacoma Water system, including its organizational structure, operator certifications, customer service, safety, and water control and monitoring programs as well as a description of normal operating conditions and routine operations.

8.1 Organizational Structure and Authority

Information on the organizational structure of Tacoma Water, the various sections that make up Tacoma Water, and personnel responsibilities and authority is located in Chapter 2.

8.2 Operator Certification

WAC 246-292 requires that all Group A[12] public water systems have certified operators designated for key functions. This program, referred to as the State Waterworks Operator Certification Program, is administered by DOH. The minimum certification requirements for Tacoma Water personnel are shown in Table 8-1. All personnel currently occupying these positions are at least at the level indicated. In addition, several other persons within Tacoma Water hold Waterworks Operator Certifications at a variety of levels.

Table 8-1. Certified Operator Positions and Certification Levels

Position	Certification Level
Water Superintendent	WDM 4
Distribution Engineering Manager	WDM 3
Distribution Operations Manager	WDM 3
Water Quality Manager	WDM 3
Water Supply Manager	WDM 3
Water Treatment Plant Manager	WTPO 4
Water Treatment Plant Supervisor	WTPO 4
Water Treatment Plant Operator	WTPO 3
Cross-connection Control Specialist	CCS

Notes: WDM = water distribution manager, WTPO = water treatment plant operator, CCS = cross-connection control specialist.

Because asbestos cement pipe exists in the distribution system, Tacoma Water also has certified asbestos workers and staff trained in handling asbestos cement pipe and

[12] Group A water system are those that have 15 or more service connections or serve 25 or more people 60 or more days per year

meeting Washington Industrial Safety and Health Act (WISHA) requirements for worker exposure to asbestos.

8.3 Apprenticeship Program

Tacoma Water has run a Washington State Apprenticeship and Training Council approved Potable Water Supply and Service Worker apprenticeship program since 1995. All water distribution and supply staff in field positions are required to successfully complete the apprenticeship program prior to advancing in the organization and performing responsible, independent activities on the system. The program provides pre-journey-level training consisting of detailed instruction and experience to become a journey-level worker.

The apprenticeship program includes 3,000 hours of on-the-job training that covers potable water distribution system operations and maintenance, water meters, fire hydrants, and potable water supply systems operations and treatment. The program also includes two years of after-hours college level courses in basic water works, including hydraulics, water quality, basic electricity, survey, construction, blueprint reading, water applied arithmetic, instruments and control systems, water distribution, basic welding, and other subjects.

A person wishing to join the apprenticeship program enters into Tacoma Water at the entry-level position of “Water Utility Worker.” All permanent Water Utility workers are required to successfully complete the apprenticeship training within three and a half years from their permanent hire date.

8.4 Customer Service

8.4.1 Customer Service Policies

Tacoma Water has adopted customer service policies for new services, main extensions, meter turn ons/offs, hydrant rentals, and various other conditions and requirements for service from Tacoma Water’s system. The current policies were adopted in February 2017.

For more Information…

Additional information on customer service policies can be found in Customer Service Policies.

8.4.2 Service Complaints

All service complaints are logged and responded to. A database is maintained with information on who made the complaint, when it was made, and what it was regarding. It is Tacoma Water’s operating goal that complaints logged as Priority 1 (emergency) are responded to within one hour. Other complaints are prioritized and responded to with response time goals varying from less than one day to less than 20 days depending on the prioritization. A summary of all water quality complaints is provided to DOH each month. Analysis of service complaints is factored into the selection of specific mains or service lines for replacement. Additionally, over the past 30 years Tacoma Water has had an ongoing program to convert areas of low pressure to higher service zones, and to improve water pressure for the customers in the affected area.

8.5 Safety Program

Tacoma Water's safety program involves a commitment by management and staff to provide a safe working environment for all employees. Tacoma Water adheres closely to OSHA and WISHA guidelines in order to provide a safe working environment for all Tacoma Water employees. Safety related education, training, and meetings occur at all levels throughout the organization on a regular, scheduled, and continual basis. Tacoma Water has a Safety Coordinator whose duties are solely dedicated to the health and safety of Tacoma Water employees.

8.6 Cross-Connection Control Program

As stipulated by WAC 246-290-490, the purpose of a water purveyor's cross-connection control program shall be to protect the public water system from contamination via cross-connections. Categories of cross connections requiring backflow prevention assemblies are defined by Washington State law and Tacoma Water policy. Tacoma Water policy requires that backflow prevention assemblies must be models approved by DOH. An effective program requires coordination among the purveyor, the customer, the administrative authority, and DOH. Trained personnel and the enabling of local ordinances are critical to establishing and maintaining an effective cross-connection control program.

Tacoma Municipal Code Section 12.10.220 prohibits uncontrolled cross connections and provides for enforcement actions related to customer non-compliance. Tacoma Water operates a thorough cross-connection control program designed to comply with DOH standards and manuals of standard practice, including the American Water Works Association's manual Backflow Prevention and Cross-Connection Control: Recommended Practices (M14).

For more Information…

Additional information on the cross-connection control program can be found in Section 13.0 of the Customer Service Policies, the written Cross-Connection Control Plan, and on the Cross Connection Control webpage.

Key elements of this program include plan review of proposed new construction and remodeling projects, field inspections to identify potential cross connections, inspection of new and replacement installations of backflow prevention assemblies, and mandatory testing of all backflow prevention assemblies. The cross-connection control program is administered by the Water Quality section of Tacoma Water using staff certified as cross-connection control specialists (CCS). One CCS is the designated program manager and is responsible for the development and implementation of the program.

Tacoma Water maintains a record of all inspections, testing, and correspondence related to the backflow prevention assemblies. Paper copies of the records are maintained for a minimum of one year; electronic copies are maintained for the life of the assembly.

The customer is responsible for the initial and annual testing of the backflow assemblies. Tacoma Water notifies the customer that they must obtain the services of a state-certified backflow assembly tester (BAT) to perform the annual test and return the test results to Tacoma Water.

8.7 Sampling Procedure and Violation Response Procedures

DOH provides an annual Water Quality Monitoring Schedule that outlines many of the federal- and state-mandated regulatory monitoring requirements. Tacoma Water uses this information to schedule applicable compliance monitoring, along with monitoring plans for Disinfection Byproducts, the Total Coliform Rule, and routine Lead and Copper Rule. Monitoring generally occurs at the source, in the distribution system, and in some cases at the customer's tap. Chapter 7 provides additional information regarding Tacoma Water's monitoring programs.

The Federal Public Notification Rule is codified in Washington under WAC 246-290-71001. This rule establishes three tiers of notification based on the real or perceived seriousness of a specific violation. These three tiers are:

- Tier 1 (Immediate Notice, Within 24 Hours)
- Tier 2 (Notice as Soon as Possible, Within 30 Days)
- Tier 3 (Annual Notice)

Tacoma Water has experience successfully completing Tier 2 and Tier 3 notifications, although no specific treatment technique or MCL violations have occurred in the last 6 years except for a brief turbidity event in 2014 when the 5 NTU limit was exceeded and impacted 7 customers.

Tacoma Public Utilities maintains 24-hour Community and Media Services availability with established media contacts, and templates for notifications from the Public Notification Rule Guidance Manual, which would help facilitate a Tier 1 notification.

Detailed procedures for loss of treatment, or contamination of supply at the Green River Filtration Facility, have been developed, and include immediate notifications to the water quality and water supply managers. Tacoma Water also has established well-defined procedures to address water service disruptions and quality issues in the distribution system.

In the case of an event that may result in contamination of the water distribution system, such as major main break or loss of system pressure, written procedures are in place that ensure proper notification of customers, Tacoma Water management, and regulators. These procedures also specify the actions to be taken to ensure that repairs are properly completed and water samples taken prior to returning the affected portion of the system to service. Staff are trained on these procedures and provided periodic refresher trainings on protocols.

All Water Quality staff have been trained to know that contact to DOH, and the Tacoma-Pierce County Health Department must be made immediately after the situation is brought under control.

Tacoma Water maintains 24-hour staffing, and alternate phone numbers for all senior staff are available to the Water Control Center.

Tacoma Water also regularly provides non-regulatory notifications to customers. Commercial customers with process water needs are informed whenever there is a

change from Green River supply (very soft, low in alkalinity) to groundwater supply (moderate in hardness, moderate alkalinity). A list of kidney dialysis patients' addresses in the Tacoma Water service area is maintained so that Tacoma Water staff can attempt to notify these customers if turbid water or a water service disruption is expected in their neighborhoods.

8.8 System Operating Conditions

A range of water supply and water quality conditions are accommodated during normal operations. These include the following, which are discussed in detail below:

- In-stream Flow Requirements
- Howard Hanson Dam
- Winter Demands
- Summer Demands
- Pipeline 1 Customers
- Pipeline 5 Customers and SSP Partners
- Raw Water Quality
- North Fork Wellfield

8.8.1 In-stream Flow Requirements

In 1906, a representative of the City filed two notices of intent to divert water from the Green River, each for 100 cfs. Since the water right predates the 1917 surface water right law, it remains in claim status. Tacoma Water has since agreed through the 2001 *Habitat Conservation Plan* (link in Section 8.11) to limit the amount of water taken under its FDWR to the maximum amount that had historically been taken, or 113 cfs (73 MGD). The Muckleshoot Agreement of 1995 (MIT Agreement) requires Tacoma to guarantee specific minimum river flows by reducing the use of FDWR water or using water stored at Howard Hanson Dam for stream flow support.

The SDWR is the water right permit associated with the SSP. It provides up to 65 MGD, of which Tacoma's share is 27 MGD. The remainder is shared between the SSP Partners (Lakehaven Water and Sewer District, City of Kent, and the Covington Water District). The SDWR is limited by minimum river flows established by the Washington State, and by guaranteed minimum river flows set by the MIT Agreement. The limitations are such that only SDWR water that was previously stored during spring will generally be available during summer and early fall.

The availability of surface water is also subject to many other regulatory documents, including the following:

- AWSP Environmental Impact Statement (EIS)
- Biological Assessments and Biological Opinions (BA/BOs)
- *Habitat Conservation Plan*

- USACE *Water Control Manual: Howard A. Hanson Dam*
- MIT Agreement
- Project Cooperation Agreement
- SSP Partnership Agreement
- Section 1135

8.8.2 Howard Hanson Dam

The Howard Hanson AWSP allows the storage of up to 20,000 acre-feet of municipal SDWR water behind the Howard Hanson Dam at 95 percent reliability (19 in 20 years on average). Tacoma Water's share of the RWSS storage is 8,300 acre-feet, with the other three SSP Partners getting equal shares of the remainder. As part of the project, which allows the RWSS to store water at the Howard Hanson Dam, a number of environmental improvements were planned. Most have been completed, with the exception of construction of a fish passage facility downstream of the dam. In recognition of this work not yet being completed, Tacoma Water and the SSP Partners have been annually donating half of the RWSS storage allotment for in-stream flow support purposes.

Howard Hanson Dam and its Eagle Gorge Reservoir are operated by USACE for flood-control purposes. As a result, Tacoma Water's water quality and water supply goals must be pursued in a manner that is compatible with the USACE flood control goals. To the extent possible, the USACE coordinates activities to minimize adverse impacts on Tacoma Water. During flood events and other periods of high turbidity, Tacoma Water has the ability to use the North Fork Wellfield water in place of Green River water.

8.8.3 Winter Demands

Typical winter demands are currently less than the capacity of the river diversion. During winter, the diversion is reduced to match demand, and Tacoma's in-town wells are usually not needed.

8.8.4 Summer Demands

The high summer demand periods could exceed the supply available from the Green River. Groundwater wells are used to supplement the surface water supply to help meet peak demands during these periods. Wells are less affected by droughts than are river flows, so the wells add valuable diversity to the sources available to Tacoma. The wells provide a critical supplement and backup water supply to meet demands that cannot be met from the Green River system.

To minimize pumping costs, well water is generally supplied to the lowest pressure zones first and is only pumped to the higher pressure zones when necessary. Wells are sequenced taking into consideration energy, water quality, equipment exercise needs, and operational flexibility considerations.

8.8.5 Customers along Pipeline 1

Tacoma Water provides wholesale water service to customers along the upper sections of Pipeline 1 from direct connections to the pipeline, such as the Cities of Enumclaw, Buckley, and Bonney Lake. Other customers are fed further upstream from the small distribution system at Cumberland, which also receives its water from Pipeline 1. A small number of direct retail customers also receive service directly from the pipeline.

These service arrangements require operational awareness in terms of water supply and water quality. The point of compliance for disinfection inactivation requirements for service from Pipeline 1 is at the Enumclaw intertie.

8.8.6 Customers along Pipeline 5

In addition to providing a second source of supply into the Tacoma Water distribution system, Pipeline 5 supplies RWSS Partners (City of Kent, Covington Water District, and Lakehaven Water and Sewer District) with water associated with the SDWR.

The point of compliance for disinfection CT requirements for service from Pipeline 5 is at the City of Black Diamond intertie.

8.8.7 Raw Water Quality

Tacoma Water uses both surface and groundwater for water supplies. Facilities are available to withdraw up to 150 MGD from the Green River and deliver it to the Tacoma Water Service Area and to the SSP Partners in South King County. The raw water quality of the Green River varies seasonally and affects operating conditions at the GRFF.

Turbidity is the water quality parameter with the greatest effect on GRFF operations. The GRFF is operated in direct filtration mode in seasons with typically low turbidity, but is switched to conventional filtration mode (with sedimentation) in seasons when the river is typically more turbid (see Section 5.1.4 for further information on the treatment process). Turbidity influences coagulant chemical dosing and solids handling. Turbidity also drives the use of the North Fork Wellfield for blending purposes. Blending well water with turbid river water decreases influent turbidity to the GRFF and decreases chemical requirements and treatment solids production.

In addition to turbidity, other raw water quality parameters that affect how the GRFF operates include alkalinity, pH, and algae biovolumes. Raw water alkalinity and pH influence sodium hydroxide and carbon dioxide dosing requirements, while algae levels affect ozone dosing and filter run lengths.

8.8.8 North Fork Wellfield

The seven wells in the North Fork Wellfield are influenced by surface water, and therefore are used as supplemental under either the FDWR or SDWR. These wells are typically used for blending purposes to offset river turbidity. The North Fork Wellfield is located over a small, yet highly productive aquifer. The aquifer is recharged by runoff from the North Fork Green River drainage basin. Since the aquifer stores a relatively small amount of water, the wellfield's capacity is highly dependent on seasonal

precipitation. In late summer, the wellfield can only produce about 12 MGD for a week at a time, but in winter, the wellfield can sustain 72 MGD or more.

8.9 Routine Operations

Routine operations involve regular tasks and procedures Tacoma Water performs to ensure that the water system provides safe, economical, high-quality water to customers. Inspection, monitoring, testing, cleaning, control, maintenance, and reporting systems are developed to achieve the goal of high-quality service. Several key procedures are described in this section.

8.9.1 Reservoir Cleaning and Main Flushing

Tacoma Water's reservoirs and standpipes are normally drained, cleaned, and inspected every three years.

The Water Quality Section is responsible for design, planning, and monitoring of main flushing programs while the Water Distribution Operations Section is responsible for the implementation of the flushing programs. Both sections work closely together to ensure effective flushing operations occur.

Two full-time staff members are assigned to flushing all dead-end water mains in the system, as scheduled in the established water main flushing program. Other field crews assist, as needed, with main flushing in response to water quality calls from customers. The program goal is for all dead-end hydrants and blow-offs to be flushed every 12 months. Additionally, Tacoma Water has implemented a unidirectional flushing program to remove silt buildup in the distribution system, which is routinely carried out by two three-person crews.

8.9.2 Use of Fire Hydrants

City of Tacoma Municipal Code Section 12.10.305 provides for the authorized use of fire hydrants. Only authorized Tacoma Water, Fire Department, or Public Works employees may operate the hydrants, unless specific permission is given and a fee is paid. Contractors, street cleaning firms, and others often obtain permission for specific use of hydrants. However, anyone applying for a hydrant use permit (except for Tacoma Water personnel) are required to attend a hydrant operator training session and provide proof of backflow prevention prior to a hydrant use permit being issued. Restrictions are in place for use of hydrants in areas where known water quality problems occur or with intermittent hydrant flow. Additionally, hydrants used by others are checked to ensure they are properly shut off after use to reduce leakage and verify compliance with usage permit requirements.

Hydrant flow tests are conducted by Tacoma Water crews, as requested by customers, or as needed to verify water system conditions and calibrate the hydraulic model.

8.10 Maintenance

A discussion of maintenance activities is provided in Chapter 10 - Asset Management.

8.11 Links to Relevant Materials

- Customer Service Policies: https://www.mytpu.org/file_viewer.aspx?id=59028
- Cross-connection Control Webpage: https://www.mytpu.org/tacomawater/water-quality/cross-connection-control/
- Cross-Connection Control Plan*
- Habitat Conservation Plan: https://www.mytpu.org/file_viewer.aspx?id=63671

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9 Enhancing System Resiliency

This chapter explains the importance of water system resiliency to Tacoma Water, describes the current resilient capacity of the Tacoma Water system, and what actions are being taken to improve the resiliency of the system.

9.1 Purpose

Water systems, like all infrastructure, are susceptible to stress. Stresses can be operational (e.g., droughts leading to water restrictions) or structural (e.g., system damage due to earthquakes) and typically derive from uncontrollable adverse environmental conditions. Reliable delivery of ample clean water is necessary for maintaining public health, public safety, and the local economy and associated jobs. For these reasons, the water system must be able to provide service even when experiencing adverse conditions.

Reliable supply is achieved by designing resiliency into the system. Resiliency is the ability of a system to withstand, or recover quickly from significant stress. Resiliency can be measured with qualitative and quantitative metrics, including:

- Ability to use alternate sources if the main supply becomes unavailable or experiences reduced capacity
- Ability of system infrastructure to withstand damage from earthquakes, and how quickly damage can be repaired
- How rapidly the system can return to normal service after an interruption
- Customer awareness of their role in demand reduction

All water systems face numerous risks, each with a unique profile of impacts that cannot all be addressed by a single resiliency strategy. Each risk warrants an analysis from which resiliency strategies, informed by the nature of each risk's impacts, can be developed. Resiliency strategies, similar to stresses, can either be operational or structural. If management knows what kind of impacts to expect from the type and magnitude of system stresses, operational plans or structural reinforcements/ redundancies can be developed to preemptively mitigate risks.

Tacoma Water has undertaken various tasks geared towards improving resiliency that include resiliency studies (both external and internal), development of a dual supply, development of emergency response plans, coordination with other jurisdictions, and development of a *Water Shortage Response Plan*.

9.2 Water Supply Forum Resiliency Study

9.2.1 Background

The Water Supply Forum is an organization of public water systems in the Central Puget Sound region. Its mission is to, "Provide a venue for policy discussions on critical water

supply and stewardship issues while sharing utility perspectives and insights with regional stakeholders." The member agencies of the Forum are Tacoma Water, Seattle Public Utilities, the City of Everett, Cascade Water Alliance, East & South King County Regional Water Association, Everett Water Utility Committee, King County, and Pierce County Regional Water Cooperative. These utilities serve over 2.3 million residents and diverse economic infrastructure, including ports, local and international businesses, schools, and medical facilities.

Beginning in 2014, The Forum began phase 1 of a regional resiliency study (Forum study) that analyzed risks to water systems in the Central Puget Sound, evaluated current system resiliency to those risks, and offered suggestions to improve resiliency. The stresses identified in the various risk scenarios in the study are not mutually exclusive and have overlapping impacts, which leads to mitigation measures that can protect against multiple risks.

The study focused on four risk categories: earthquakes, water quality, drought, and climate change. Each of the following sections describes a risk category and its potential negative consequences (on Tacoma Water's system specifically where available), and identifies mitigation measures pertinent to that risk. Table 9-1 shows a summary of mitigation measures for each risk category, which can be categorized as either proactive or responsive.

Table 9-1. Summary of mitigation measures for each risk category

Mitigation Measure	Earthquake	Water Quality	Drought	Climate Change
Construct Interties	X	X	(X[a])	Mitigation measures were not identified in this phase of the Resiliency Project
Upgrade System Components	X			
Enhance Emergency Preparedness and Response Plans	X	X		
Conduct Component-specific Vulnerability Evaluations	X	X		
Expand/Develop Secondary Water Supplies	X	X	X	
Expand/Develop Groundwater Supplies	X		X	
Stockpile Equipment, Materials, Chemicals, etc.	X	X		
Acquire Emergency Power Supplies	X	X		
Conduct Incident Training		X		
Implement Mutual Aid Agreements	X	X	X	
Increase System Monitoring and Surveillance		X		
Conduct Public Outreach	X	X		
Make Operational Modifications		X	X	
Promote Demand Reductions			X	

Source: Water Supply Forum Resiliency Study

[a] Initial findings suggest that interties may not contribute to improving the region's resiliency to drought because multiple systems would be affected. Therefore, additional future investigation will likely not be undertaken.

9.2.2 Earthquakes

There are numerous geologic faults in the Central Puget Sound region leading to high potential for seismic activity. The primary impacts on the Tacoma Water system from earthquakes would be loss of delivery due to damaged infrastructure and compromised water quality. The Forum study analyzed different types of potential regional earthquakes, all of which would impact Tacoma Water's system. A 7.1 magnitude earthquake along the Tacoma Fault would produce the most serious impacts, potentially including major damage to key facilities and over 60 transmission pipeline breaks. In addition, up to 3,000 water mains in distribution systems throughout the region could be damaged. Preliminary evaluation suggests that following the earthquake, it could take up to 40 days to restore average winter day demand to 90 percent of customers. Other earthquakes along different faults could cause similar but less severe damage, and recovery would be quicker.

Earthquake mitigation strategies were sorted into three categories: intersystem, intrasystem, and general mitigation strategies. Intersystem strategies involve interties between systems where the lesser impacted systems could provide emergency water to the heavily impacted systems depending on the severity and spatial distribution of damage. The Forum study described three potential interties with neighboring utilities that could benefit Tacoma Water: SPU, Lakehaven, and Lakewood. Interties already exist between Tacoma Water and both Lakehaven and Lakewood. Tacoma Water and SPU periodically discuss the merits of an intertie between the two regional systems. Their current thinking, based on the Forum study, is that investments in intrasystem improvements will be more cost-effective than construction of a regional intertie. Intrasystem mitigation options include upgrading vulnerable facilities and transmission lines, developing earthquake response plans, securing necessary equipment and materials to perform emergency system repairs, and investing in secondary water supplies. Tacoma Water has already undertaken a number of these measures. The Forum study also suggested other general strategies that could contribute to individual utility resiliency.

The Forum study also identified development of post-earthquake level of service (PE-LOS) goals as a high priority task. PE-LOS goals establish system performance targets following a seismic event, generically measured by the time it takes to restore water delivery to customers. The goals aid in seismic planning efforts and can be used post-event as a tracking tool for mitigation work. As part of phase 2 of the Forum study, the Forum is developing, evaluating, and expected to implement PE-LOS goals for each utility that could guide design of new and upgraded facilities. For further discussion about PE-LOS goals specific to Tacoma Water, see Section 9.3.1.

9.2.3 Water Quality

The Forum identified six notable risk events of an "immediate, emergency nature with high consequences" pertaining to water quality. These are wildfire, volcanic activity, resource supply chain disruption, accidental contamination, severe adverse weather, and earthquakes.

The following paragraphs summarize the nature of each risk and their potential impacts:

- Wildfire effects on water quality are highly variable and site specific. This risk, as it relates to Tacoma Water's supply, only applies to surface water sources. The intensity and spatial extent of burn damage in the Green River watershed would determine the magnitude of negative effects, as well as watershed recovery rate. In general, wildfires can lead to increased turbidity, nutrient loading, pH, alkalinity, temperature, and metals in the source water. Experience in September 2017 with a relatively small (approximately 1,100 acre) wildfire in the Green River Watershed highlighted this risk.
- Mount Rainier is an active volcano that poses a direct threat to Tacoma Water's water supply. Volcanic activity can produce ash falls, tephra falls, and debris flows, which can lead to reduced water availability and increased turbidity, acidity, and metal concentrations. Though the effects of volcanic activity are similar to wildfire, they tend to be less spatially concentrated since volcanic outfall can be much more widely spread out.
- Water treatment supply chain issues are identified as "an inability to get staff, chemicals, fuel, or equipment to water treatment facilities". Supply chain issues could significantly disrupt water treatment plant operations and result in immediate adverse effects on public health, lead to regulatory violations, or require boil water orders.
- Accidental contamination is defined as when a fuel, oil, or any hazardous material contaminates a utility's water supply and creates unsafe drinking water conditions. This risk assumes contamination in the source water (surface or ground) prior to treatment rather than naturally occurring contamination or internal chemical overdosing. Unnatural contaminants can bypass treatment processes and reach the distribution system, putting customers at risk.
- Severe adverse weather includes intense wind, snow, rain, lightning, or ice storms of sufficient magnitude to trigger flooding, freezing, fires, landslides, or power loss. These events could result in treatment facility failure, equipment damage, communication loss, SCADA loss, and supply chain disruptions.
- Earthquakes can damage critical infrastructure, lead to supply chain disruptions, reduce water availability, and potentially damage or disrupt groundwater supplies. See Sections 9.2.2 and 9.3.1 for in-depth analyses of the earthquake risk.

Five types of mitigation measures were identified for water quality risks:

- **Preventative** – measures to lessen the long-term probability of a water quality risk occurrence.
- **Pre-event** – measures to lessen the severity of a water quality risk if it were to occur.
- **Detection** – measures to determine whether the risk event has occurred.
- **Immediate Response** – measures to respond to the risk event as it is occurring.
- **Recovery** – measures to clean up after the risk event and restore production of safe, acceptable drinking water.

Water quality risks are not mutually exclusive and may occur hand in hand. For example, if a wildfire occurs in the Green River watershed, fire suppression chemicals may accidentally enter the water supply. Additionally, severe adverse weather is likely to exacerbate effects of environmental risks (e.g., wildfire, volcanoes, and earthquakes). Therefore, mitigation planning for water quality risks should be comprehensive in scope. Examples of specific recommended measures include emergency response planning, mapping of risk locations, and water supply and infrastructure redundancy. To optimize resiliency for Tacoma Water's system, the utility should determine which water quality risks are the most likely threats to operations and then determine the most feasible mitigation strategies that can be employed.

9.2.4 Drought

Water providers in the Central Puget Sound region consider drought an important issue and have implemented measures to prepare for shortages. A drought is defined as a reduction of water availability due to reduced precipitation; depletion of snowpack; and/or extended warm, dry periods. These conditions constrain water supply and typically increase demand (i.e., increased landscape irrigation), which can lead to water shortages. The Forum analyzed the major regional water systems' supply capacities and assessed whether or not they could meet what were forecasted demands for years 2015 and 2035 under two drought scenarios, including the historic drought of 1987 (scenario 1) and a hypothetical extreme drought where inflows to the systems were 25 percent lower than in 1987 (scenario 2).

At the time of the report, Tacoma Water was expected to meet demands in both 2015 and 2035 in scenario 1, but expected to experience shortages requiring mandatory curtailments in scenario 2 in 2035. This analysis assumed all normal management techniques, including voluntary curtailment and conjunctive use of all supply sources, were implemented. Groundwater is generally less affected by droughts and is particularly resilient during short-term events. However, significant multi-year events may lead to notable groundwater depletion, particularly when coupled with hot and dry, high-demand summers when Tacoma Water may need to pump more groundwater. Overall, Tacoma Water is well-positioned and highly resilient to drought scenarios.

Mitigation strategies particularly beneficial during drought include development of reclaimed water infrastructure and aquifer storage and recovery programs. These strategies create additional water sources that are notably resilient to drought conditions relative to additional reservoir storage or wholesale purchases. Demand management is also a drought mitigation strategy and is explained further in Section 9.3.3.

Phase 1 of the Forum study was conducted during the unprecedented 2015 drought. Prompted in part by that experience, Tacoma Water developed an IRP with the purpose of improving management methods related to drought and climate change.

9.2.5 Climate Change

Climate change is an umbrella term representing changes to the historical normal climate patterns of a region. Projected changes include alterations to the water cycle, such as reductions in snowpack quantity and changes in melt regimes, increased intensity/duration of drought events, and increased water levels on marine shorelines.

These diverse climate pattern changes may lead to similarly diverse consequences, including reduced surface and groundwater supply; climate-induced migration; compromised water quality; and more widespread, frequent, and high intensity wildfires. The specific changes that will occur are temporally and spatially variable, meaning Tacoma Water (and other regional utilities) must monitor which specific impacts they experience and expect to be exacerbated by climate change.

The Forum did not develop a distinct list of mitigation strategies for climate change. However, a number of strategies employed for other risks can apply to climate change as well due to the similar nature of impacts. A notable difference in resiliency strategies for climate change is the lack of intertie usefulness. Each geographic supply region is expected to share similar negative effects due to their close proximity. The benefits of interties due to this factor are less apparent.

9.3 Tacoma Water-Specific Initiatives

9.3.1 Seismic Vulnerability Assessment

In 2015, Tacoma Water conducted an all-hazards vulnerability assessment of the entire water system, which addressed many potential hazards. The study identified seismic risk as greater than all other risks combined. As a result, the seismic vulnerability sections of the assessment were consolidated into a separate report.

The seismic evaluation process involved quantifying physical consequences of likely earthquakes, estimating impacts of those consequences on the water system infrastructure (both high- and low-level impacts), and assessing the expected recovery time and expenses from damage. Multiple seismic hazards were considered, with the Tacoma Fault scenario assumed to cause the worst impacts (same conclusion reached in the Forum study). The primary metrics developed to measure impacts are: damage states for physical assets, system outage time, and timelines for restoration-of-service to a given percentage of customers.

Another method used to identify risk consequences was the AWWA J-100-10 (R13) RAMCAP analysis. This methodology is a process for assessing and managing risks associated with threats to critical infrastructure. The process contains 7 steps that iteratively screen out lower-risk items as the process moves forward. Seismic risk was carried through all 7 analysis steps, with the final step providing recommendations for risk and resiliency management.

Using the results of both risk analyses, the study lays out actions Tacoma Water could take to mitigate earthquake risk. Among the actions suggested is adoption of mitigation measures guided by PE-LOS goals. These goals act as a schedule for post-event mitigation, which can inform design standards for water system infrastructure with the intent of rapid recovery. The goals operate with 3 variables: system functionality metrics, the time it takes to reach those metrics, and the progress toward these goals at specific milestones, measured as a percentage. Table 9-2 and Table 9-3 display the PE-LOS goals recommended for Tacoma Water for a 500-year earthquake and a 2,500-year earthquake. The study suggests specific mitigation measures informed by the PE-LOS goals.

Table 9-2. Cascadia Scenario compared to Preliminary Target Long-Term PE-LOS Goals for Example 500-Year Return Earthquake

System Function	Event Occurs	0-24 Hours	1-3 Days	3-7 Days	1-2 Weeks	2-4 Weeks
Potable water available at supply source		▲	✖	●	◆	
Main Transmission facilities, pipes, pump stations, and reservoirs operational		◆			✖	
Water supply to critical facilities available[a]		●	◆			
Water for fire suppression at key supply points		◆			✖	
Water for fire suppression at fire hydrants				▲	●	◆ ✖
Water available at community distribution centers/points			● ✖	◆	✖	
Distribution system operational			▲	●	◆	✖

◆	Desired time to restore component to 80-90% operational
●	Desired time to restore component to 50-60% operational
▲	Desired time to restore component to 20-30% operational
✖	Tacoma Water Anticipated Results (80-90% operational)
✖	Tacoma Water Anticipated Results (20-30% operational)

[a] Further evaluation required to evaluate scorecard for Water supply to critical facilities

Table 9-3. Shifted Tacoma Scenario compared to Preliminary Target Long-Term PE-LOS Goals for Example 2,500-Year Return Earthquake

System Function	Event Occurs	0-24 Hours	1-3 Days	3-7 Days	1-2 Weeks	2-4 Weeks	1-3 Months
Potable water available at supply source		▲	✕	●		◆	
Main Transmission facilities, pipes, pump stations, and reservoirs operational		●	◆			✕	
Water supply to critical facilities available[a]			●	◆			
Water for fire suppression at key supply points		●	◆			✕	
Water for fire suppression at fire hydrants					▲	●	◆ ✕
Water available at community distribution centers/points			▲	● ✕	◆	✕	
Distribution system operational				▲	●	◆	✕

◆ Desired time to restore component to 80-90% operational

● Desired time to restore component to 50-60% operational

▲ Desired time to restore component to 20-30% operational

✕ Tacoma Water Anticipated Results (80-90% operational)

✕ Tacoma Water Anticipated Results (20-30% operational)

[a] Further evaluation required to evaluate scorecard for Water supply to critical facilities

9.3.2 Interties

Interties are physical connections between two adjacent water systems, typically separated by a closed isolation valve or control valve. Tacoma Water maintains interties for three purposes:

- **Wholesale Supply** – Water bought and sold by Tacoma Water is moved between water systems via interties.
- **Second Supply Project Partners** – Tacoma Water maintains multiple interties with the three SSP Partners.
- **Emergencies** – In case of emergency where Tacoma Water is unable to provide a sufficient quantity of water to its customers, water from adjacent providers can be brought in through interties, and vice versa.

A robust intertie system is identified as a resiliency strategy for most risks. Tacoma Water maintains interties with many of the surrounding utilities for all three purposes.

9.3.3 Water Shortage Response Plan

Tacoma Water developed a *Water Shortage Response Plan* (WSRP) in 2005 to act as a guide for best management practices during water shortages. The objectives of the WSRP are to preserve essential public services while minimizing adverse effects on public health and safety, community and economic activity, environmental resources, and quality of life. The WSRP provides only operational strategies, meaning no infrastructure reinforcements or redundancies are involved in the plan. It is Tacoma Water's most detailed mitigation response to water shortage conditions.

The plan includes four stages of response related to the magnitude of the supply shortage:

- **Stage 1 – Advisory:** Potential water supply problems exist and early indications suggest additional responses will be needed if conditions deteriorate.
- **Stage 2 – Voluntary:** Available water sources are not expected to be sufficient to support both normal demands and adequate in-stream flows.
- **Stage 3 – Mandatory:** Available sources combined with voluntary demand reductions are not expected to be sufficient to support both projected demands and adequate in-stream flows.
- **Stage 4 – Emergency:** Significant impact to the water system prevents adequate supply from reaching customers and extraordinary measures must be taken to bring the system back to operational standards.

The response stages are implemented in sequence based on Tacoma Water's evaluation of current and projected conditions. The stages trigger standard procedural and situational actions pertaining to each level or shortage such as communicating with customers about the shortage, planning for higher response stage implementation, and reducing wholesale deliveries based on contracts. The situational nature of the shortage informs which response actions will be most important to take.

The WSRP is not exclusively reserved for drought conditions; water shortages can also result from compromised water quality in the Green River or system failure (pump stations, transmission pipelines, etc.) requiring use of secondary supplies. These shortages are generally characterized as emergencies (stage 4) and are mitigated using a variety of methods in addition to the WSRP.

An updated WSRP was developed as part of Tacoma Water's IRP process and a link can be found in section 4.7.

9.3.4 Other Resiliency Considerations

Tacoma Water has numerous operational redundancies, which aid in resiliency. Maintaining surface water and groundwater resources from two geographically disparate locations increases the probability that during a localized event, one source will remain largely unaffected and be able to provide water to the system. Incorporating redundancy where possible is part of Tacoma Water's design philosophy.

EPA requires development of an emergency operations plan (EOP) following a vulnerability assessment. The EOP acts as a functionally redundant plan of actions to take in the face of emergency.

The Tacoma Water EOP was reformatted and updated in 2014, and is updated annually.

9.4 Links to Relevant Materials

- Forum resiliency study and associated technical memoranda for each of the 4 risks: http://www.watersupplyforum.org/home/resiliency.html
- Seismic Vulnerability Assessment*

10 Asset Management

This chapter provides an overview of Tacoma Water's asset management program. Development of the current program began in 2007, as Tacoma Water began a detailed asset management review. In 2008, a comprehensive gap analysis was completed to compare prior practices with desired asset management approaches. These steps led to development of an asset management framework and implementation plan in 2009. Tacoma Water began formal implementation of the updated asset management approaches in 2010 using a phased approach to execute the program.

10.1 Asset Management Overview

10.1.1 What is Asset Management?

Asset management is an integrated set of processes that seek to minimize the lifecycle costs of owning, operating, and maintaining assets, at acceptable levels of risk, while maximizing benefits and continuously delivering established levels of service. This is accomplished by individually managing and maintaining assets based on a triple bottom line perspective (which considers the economic, social, and environmental costs, risks, and benefits surrounding a course of action), instead of applying a generic management plan for system assets based solely on their age, level of use, or subjective criteria.

For Tacoma Water, asset management is a way to make quality decisions that are focused on the most efficient and effective use of staff, resources, technologies, and methods. It reduces risk exposure and ties level of service to defined risk and asset criticality metrics.

10.1.2 Why Have an Asset Management Program?

Assets are physical infrastructure and facilities that are built and maintained to meet level of service standards. Tacoma Water currently has 19 separate asset classes. Decisions for when assets need to be built, maintained, or replaced are based on defined information and strategies.

Prior to the initiation of the current asset management program, a program did exist that prioritized infrastructure renewal and replacement based on materials, age, apparent condition, history of leaks and failures, and potential liability, but system maintenance tended to be more reactive (i.e., responding to a failure) than proactive, and equipment maintenance was typically performed on time-based preventative maintenance schedules.

The current asset management program takes a more comprehensive approach and seeks to allocate resources more effectively and efficiently around the entire lifecycle of an asset. The goal of the program is to see that decisions are

Asset Classes

- Buildings, Structures, and Grounds
- Cathodic Protection Systems
- Distribution Water Mains
- Electrical
- Electrical Genset (backup generators)
- Environmental Stewardship
- Fleet and Equipment
- Hydrants
- Information Systems and Communication
- Meters
- Pressure Reducing Valve (PRV) Stations
- Pump Stations
- Security Infrastructure
- Storage Systems
- Transmission Pipelines
- Treatment and Monitoring
- Valves
- Water Service Connections
- Wells

made based on a clear understanding of lifecycle costs (from a triple bottom line perspective), established levels of services and the risk associated with system assets. To achieve this goal, asset management principals must penetrate nearly every facet of capital and operational resource allocation decision making, including risk management, customer and environmental service levels, tradeoffs between capital and Operations and Maintenance (O&M) dollars, efficiency in delivery of services, and the tracking and reporting of results. The program involves engagement through all workforce roles and levels including maintenance crews, operators, engineers, and management.

The end result of these asset management approaches is a more efficient utility that performs the right work, on the right equipment, at the right time, for the right cost.

10.1.3 Asset Management Principles

The asset management program strives to embody the following principles:

- **Customer Focused** – Understand and meet the priorities of Tacoma Water's customers and expected levels of service.
- **Risk Management** – Understand asset and operational risks, and allocate resources to most effectively mitigate risks and meet level of service goals and expectations.
- **Decision Making Process** – Allocate resources for asset construction, maintenance, and replacement based on lifecycle triple bottom line costs, risks, and benefits. Use decision models to ensure consistency and efficiency instead of relying on intuition or advocates able to make the most passionate argument for a given solution.

For more Information…

Additional information on the vision and frame work for the asset management program can be found in Asset Management Philosophy and Framework.

- **Asset Operations and Maintenance, Information, and Technology** – Have detailed knowledge of Tacoma Water infrastructure to better ensure solid financial decision making. This includes quality data and records detailing the condition of assets, and projections of asset condition changes over time, to support risk mitigation and appropriate resource allocation toward asset maintenance and renewal. Collect comprehensive data on assets that can be used to prepare business case evaluations (a type of financial evaluation) relative to asset issues and needs. Implement information technology solutions driven by utility-wide needs that are structured to meet organization-wide objectives.
- **Employee Engagement** – Foster a productive, accountable and continually improving work environment where staff routinely search for innovation and best practices, and are proactive in gaining new skills. Promote staff engagement and understanding of their organizational roles and how they relate to and support the asset management program.
- **Organizational Performance** – Understand the levels of service Tacoma Water customers expect, actively evaluate performance, and seek continual improvement. Routinely track budget, schedule, scope, and performance outcomes, and use this information to focus improvement efforts.

10.1.4 Asset Management Initiatives

To meet the vision and principles desired for the fully implemented asset management program, a number of improvement initiatives were created. These initiatives, as summarized in Table 10-1, provide a roadmap of the areas Tacoma Water is actively working on as an organization to fully implement its asset management program.

Table 10-1. Asset Management Program Improvement Initiatives

No.	Initiative
1	Incorporate Asset Management into Strategic Plan and other Business Plans
2	Provide Organizational Development to support Asset Management
3	Develop Levels of Service
4	Develop and Implement a Performance Management Program
5	Develop and Implement Utility-wide Asset Management Program and Strategic Asset Management Programs by Major Asset Class
6	Develop a Risk Based Decision Model for Rehabilitation and Replacement of Assets
7	Develop and Implement a Strategic Maintenance Management Program
8	Enhance Computerized Maintenance Management System, and Select and Implement other Core Technology Systems
9	Develop Project Delivery and Project Management Guidelines
10	Develop Effective Knowledge Management Practice for Assets
11	Establish Asset Management Procedures/Standards
12	Focus on Efficiency and Practice Improvements
13	Improve the Procurement Process
14	Implement a Quality Management and Audit System

Source: Asset Management Roadmap and Initiatives, 2009, CH2M.

Tacoma Water utilizes a strategic planning process (balanced scorecard) where the initiatives are scored and prioritized to focus resource allocation. The effort to continuously improve and mature the asset management program is an ongoing and continuous process.

The initiatives to: (1) Incorporate Asset Management into the Tacoma Water Business Plan, (2) Provide Organizational Development to support Asset Management (AM), (6) Develop a Risk-based Decision Model for Rehabilitation and Replacement of Assets, and (13) Improve the Procurement Process, have seen significant progress and are at a level approaching completion.

The current initiatives that are being focused on for improvement include: (3) Develop Levels of Service, (4) Develop and Implement a Performance Management Program, (7) Develop and Implement a Strategic Maintenance Management Program, and (8) Enhance CMMS and Select and Implement other Core Technology Systems.

As part of this focus, Tacoma Water will be working on improving its understanding of customer needs, finalizing level of service metrics, using automated metric reporting and

performance targets to drive performance improvements and staffing levels, further implementing predictive maintenance strategies, and advancing the integration between Tacoma Water's GIS and SAP systems.

In 2019, Tacoma Water intends to refresh its *Strategic Plan*. As part of this effort, an overall Asset Management Plan and Roadmap will be updated and timelines for the remaining initiatives will be identified: (5) Develop and Implement Utility-wide Asset Management Program and Strategic Asset Management Programs by Major Asset Class,(9) Develop Project Delivery and Project Management Guidelines, (10) Develop Effective Knowledge Management Practice for Assets, (11) Establish Asset Management Procedures/Standards, (12) Focus on Efficiency and Practice Improvements and (14) Implement a Quality Management and Audit System.

10.2 Key Asset Management Tools

The AM program uses a number of tools to collect and manage asset data, evaluate risk, make decisions, and allocate resources to asset maintenance and renewal programs and projects. The following sections provide an overview of the key tools used by the AM program.

10.2.1 Computerized Maintenance Management System

A Computerized Maintenance Management System (CMMS) is a tool for digitally managing the maintenance work necessary for sustaining an asset. A CMMS tends to focus on maintenance management, but can also extend into inventory management and other systems. The CMMS can be thought of as a communication tool that allows for the communication of maintenance needs, and documents needs through work orders and failure tracking. CMMS can also provide other functions, such as collection of material and labor costs, and can also act as a repository for maintenance information.

Tacoma Water uses an information system purchased from the firm SAP. The SAP Plant Management (PM) module is Tacoma Water's CMMS. Using SAP, assets can be tracked through their complete life cycle, from the purchase/installation of an asset, through projects involving the asset, and including the maintenance tasks and individual work orders involved in sustaining each asset.

At its core, the SAP PM module tracks assets down to the equipment level (organized in a hierarchy), collects failure information and performance data through the use of notifications, captures work order information related to operation and maintenance costs, collects measurement information related to inspections and aggregates all of this information into meaningful performance and financial reports.

Data collected through SAP is shared with and utilized by a number of other asset management program tools, such as BlueWave GIS, various economic models, and in business case evaluations.

Tacoma Water is currently working on improving the use of their CMMS system to better track failures and operation and maintenance costs at the equipment level, versus the use of standing work orders at the facility level. This level of cost capturing will provide the necessary data to understand maintenance costs, measure effectiveness of maintenance activities and optimize maintenance strategies and frequencies going forward.

10.2.2 Supervisory Control and Data Acquisition

Tacoma Water uses a SCADA system for the control and data logging of equipment and facilities throughout the water system. Data from SCADA provides information on system operational histories and trends that are used by staff to troubleshoot emergencies and operational anomalies/situations. Greater integration of SCADA with the GIS and CMMS systems is being considered to better inform decision making around how the system is operated (a date has not been determined for this to take place). However, cyber security is a critical consideration as this effort goes forward.

10.2.3 Geographic Information Systems

The GIS is used for mapping of system assets. In 2014, Tacoma Water adopted ArcGIS by ESRI as its GIS and mapping platform. Tacoma Water has named their GIS tool "BlueWave." The BlueWave system allows mapping/information to be updated weekly and made available to other systems that pull information from GIS. In addition to mapping the locations of assets, these systems also capture assets materials, installation, maintenance, and field note information.

The GIS system can consume data from SAP and is integrated with the economic model. The GIS system also provides the pipe network data needed to support the hydraulic model.

Since 2015, Tacoma Water has been moving systematically through the GIS in a prioritized manner to field verify and update location data for assets using a survey-grade GPS unit. This ensures that the locations of assets in GIS reflect their real-world position as opposed to a potentially imprecise schematic representation.

10.2.4 Hydraulic Model

Since the last WSP update, Tacoma Water changed from a Bentley hydraulic modeling platform to the Innovyze InfoWater GIS-based modeling system. This allows for direct model integration with the GIS and the other asset management tools connected to GIS.

The hydraulic model is used to predict and evaluate expected water system performance and levels of service under prescribed scenarios. It is used to assess how the water system might respond and perform relative to changes in system infrastructure and assets, operational procedures and controls, and customer water demands. The model can be used to explore what-if scenarios relating to system operation, new water mains, facilities, or other proposed system improvements, or for evaluating expected water quality within the system (water age, chlorine residuals, fluoride levels, etc.).

The hydraulic model is further discussed in Chapter 6.

10.2.5 Strategic Asset Management Plans

Tacoma Water works to develop a strategic asset management plan (SAMP) for each class of water system assets. SAMPs provide strategic, tactical, and operational guidance for individual categories of assets, based on guidance from groups of Tacoma Water staff involved with each asset class.

The SAMP for each asset class typically includes the following:

- **Asset Registry** – Provides a list of the types of assets that are a part of the asset class, and a description of each type of asset, the demographics (age, size, materials, etc.) and the history of its performance at Tacoma Water.
- **Levels of Service** – A description of the level of service requirements for the asset class, the drivers behind the levels of service, and the performance indicators and measures for determining how well levels of service are being met.
- **Condition Assessment** – A description of how asset condition is evaluated, and a summary of data from past condition assessments.
- **Risk** – An objective assessment of risk for all assets within the asset class. Standardized values and criteria are used to ensure that each asset class is scored in a consistent manner. The benefits of this approach allow the risk of different assets to be compared directly to each other in an "apples to apples" manner. A risk score is calculated for each asset by analyzing the consequences and likelihood of failure. The consequence of failure takes into consideration financial, public/customer, safety, service/supply, and water quality/regulatory concerns. Likelihood of failure considers asset age/remaining useful life, condition, state of maintenance, and performance measures.
- **Operation and Maintenance Strategy** – Outlines the strategies used for the operation and maintenance of an asset across its service life.
- **Renewal and Replacement Strategy** – Outlines the strategy used for the renewal or replacement of an asset once its useful life has been reached.
- **Finances** – Provides an overview of financial information relative to the asset class. This can include the values of assets, summary of business case evaluations, operational costs, budgets, etc.
- **Data and Analysis Tools** – Provides a summary of the data and analysis tools available for an asset class relative to asset management. This can include information on how assets are incorporated and referenced into SAP, economic models, GIS, etc.
- **Recommendations** – Provides a list of prioritized recommendations and action items developed by the SAMP work group for the asset class that should be considered for implementation.

10.2.6 Business Case Evaluations

Business case evaluations (BCEs) are completed using a standard framework and methodology to provide appropriate analysis and justifications for all Tacoma Water capital improvement projects. Through the BCE development process, improvement project alternatives are evaluated using standard financial indicators to ensure that Tacoma Water goes forward with the lowest lifecycle cost option, as viewed from a triple bottom line perspective of project costs, risks, and benefits. By looking at the overall triple bottom line cost of ownership across the life of an asset, the initial investment decision may be significantly different and offer significant overall cost savings as compared to considering initial capital costs alone.

Tacoma Water staff are continually trained on standardized BCE approaches to promote consistency in analysis and decision making across the organization.

10.2.7 Economic Models

Economic models are used to review the risks to transmission and distribution assets, and to characterize risks associated with aging assets. The economic model uses a number of variables to calculate when proactive replacement of an asset would be more cost effective than maintaining the asset and employing a run-to-failure strategy. The economic model factors in information such as pipe material, age, replacement cost, probability of failure, and consequence of failure to determine optimal timing of renewal or replacement. The economic modeling process draws information from both GIS and SAP to provide details of each asset's construction and history of maintenance.

Probability of failure is calculated based on a statistical analysis using industry standards and historical pipe break data. The consequence of failure looks at different types of failures (e.g., a small/slow pipe leak versus a catastrophic main break) and the criticality of the asset and areas it could impact (e.g., whether the pipe cross a major highway or a local residential road, its proximity to wetlands or other environmentally sensitive areas, or what customers would be impacted by a failure). These factors, and many others, are all evaluated to determine the costs of a failure in addition to the replacement cost for the pipe.

Large costs can result when major or critical assets are not replaced at an appropriate time and are allowed to fail instead. However, unnecessary or avoidable costs (in the form of sacrificed life) are incurred when assets are replaced well before they need to be. An economic model determines the optimal replacement timing by estimating an asset's economic end of life.

Pipe segments in the Tacoma Water system are all individually analyzed using economic model data to determine optimal asset replacement timing. However, this process has identified that it would be beneficial to replace all galvanized mains in the system.

10.2.8 Strategic Planning

Tacoma Water's *2012 Strategic Plan*, which replaced the *Tacoma Water Business Plan*, includes eight strategic initiatives. These initiatives, as well as the recommended strategies to meet those initiatives, are included below:

- Retail Customer Strategic Initiative:
    - Strategy 1 – Enhance the Understanding of Customer Needs.
    - Strategy 2 – Enhance Retail Customer-Focused Service Offerings.
    - Strategy 3 – Enhance Customer Service and Communications.
- Wholesale Customer and the Region Strategic Initiative:
    - Strategy 1 – Define and Understand the Demand Needs, Constraints, and Consideration for Existing and Potential Wholesale Customers.
    - Strategy 2 – Develop and Describe Tacoma Water's Supply-side Position as a Regional Wholesale Provider.

  - Strategy 3 – Develop Wholesale Customer-Focused Service Offerings.
- Water Strategic Initiative:
  - Strategy 1 – Benchmark Risk Models and Risk Mitigation Strategies.
  - Strategy 2 – Conduct an All Hazards Vulnerability Assessment.
  - Strategy 3 – Include the Vulnerability Assessment Recommendation in the Tacoma Water-wide Risk Maturity Model.
  - Strategy 4 – Implement the Risk Mitigation Strategies Identified in the Vulnerability Assessment.
- Infrastructure Strategic Initiative:
  - Strategy 1 – Continue Work Begun in 2009 to Develop a Strategy and Implement the Asset Management Program.
  - Strategy 2 – Perform a Leadership Role within TPU and City of Tacoma Asset Management Teams.
  - Strategy 3 – Ensure Organizational Preparedness.
- Employee Strategic Initiative:
  - Strategy 1 –Investigate Options for a Flexible Workforce.
  - Strategy 2 – Clarify Roles to Help Support an Organization that is Accountable for the Effective and Efficient Conduct of Business Activities that Support Tacoma Water's Mission.
  - Strategy 3 – Provide Staff Business-based Opportunities for Growth and Development in the Key Areas of Leadership, New Skills, Technology, and Current Business Strategies.
  - Strategy 4 – Ensure that the Appropriate Knowledge and Resources are Provided to Support Tacoma Water Activities Related to the Health and Safety of Staff.
- Information Management Strategic Initiative:
  - Strategy 1 –Continue to Actively Participate in the City's IT Governance Committees.
  - Strategy 2 – Continue to Actively Participate in the Development of the City's Information Technology Department's *Strategic Plan*.
  - Strategy 3 – Participate and Lead, Where Appropriate, the Development of TPU Technology Business Cases.
  - Strategy 4 – Complete the Development of Tacoma Water's *Technology Plan*.
- Financials and Financing Strategic Initiative:
  - Strategy 1 – Support Financial Management of Tacoma Water.
  - Strategy 2 – Monitor the Effectiveness of the Financial Policies and Revise as Needed.

  - Strategy 3 – Design and Implement a Utility-wide Risk Maturity Model.
  - Strategy 4 – Review and Restructure the Rate Model.
- Relationships and Communication Strategic Initiative:
  - Strategy 1 – Focus on Creating Strong Relationships with Key Stakeholders.
  - Strategy 2 – Develop Tailored Communication Plans for each Strategic Initiative and Execute in 2012.

A link to the Tacoma Water *Strategic Plan* is included in Section 10.5.

10.3 Strategic Maintenance Management Program

Maintenance of assets can either be proactive or reactive. Proactive maintenance focuses on completing maintenance before a failure occurs, while reactive maintenance is that which is only completed after a failure.

When practicing reactive maintenance, initial costs tend to be low since no maintenance costs are incurred until assets begin to fail. Once failures occur, repair and replacement costs, as well as ancillary costs related to the consequences of the failure, tend to be higher. Thus, reactive maintenance usually results in higher overall triple bottom line costs over the long run compared to proactive maintenance approaches.

With the current asset management program, the focus has been shifted to proactive maintenance as a means to reduce costs, maintain levels of service, appropriately limit risks, and maximize efficiency and benefits relative to the costs incurred. There are three types of proactive maintenance strategies employed for Tacoma Water asset classes:

- **Preventative Maintenance** – Maintenance performed either at recurring time intervals or based on cumulative equipment run-times.
- **Predictive Maintenance** – Maintenance performed based on the actual condition of an asset through use of measurements that detect the onset of asset degradation.
- **Reliability Centered Maintenance** – A strategy employing a systematic approach to evaluate asset maintenance needs and maintenance resources to best match and balance the two, resulting in a higher degree of reliability and cost-effectiveness. This strategy recognizes that assets all have different degrees of importance to the system as well as different probabilities of failure. Reliability centered maintenance considers not only the costs of maintaining an asset, but the economic costs and consequences to the system and customers if an asset were to fail. Weighing the risk of failure and criticality of an asset, this strategy may incorporate preventive or predictive maintenance cycles for more critical or higher risk assets, while allowing reactive maintenance for lower risk, less critical assets.

SAMPs provide details on the maintenance strategies to be employed for assets within each asset class. Tacoma Water maintenance activities are increasingly focused on reliability centered maintenance approaches using data developed through other related asset management program tools. This results in specific work orders being created for assets based on current conditions rather than the recurring standing work orders that are a characteristic of a preventative maintenance strategy.

For commonly occurring maintenance activities, Tacoma Water has developed Standard Maintenance Procedures (SMPs) and Standard Corrective Maintenance Procedure (SCMPs). SMPs cover preventative maintenance activities required to appropriately maintain an asset, while SCMPs cover activities used to modify/correct substandard asset performance. Both types of procedures contain information on safety precautions, required tools and parts, and steps that should be followed to ensure that maintenance activities are performed consistently.

10.3.1 Planning and Scheduling

In 2015, Tacoma Water began to introduce planning and scheduling philosophies to their operating sections. Planning is the process of identifying the "how" and the "what" of the repair, including safety equipment, permitting, equipment, staff, tools, materials and the steps of the task necessary for success. Scheduling is dedicated to the "who" and the "when" of the repair. Backlogs of maintenance activities are established (from both preventative and corrective maintenance), weekly schedules are created the week prior according to priority, availability of resources identified in the plan and needs of operation and maintenance staff. Daily schedules are created the day prior based on priorities, needs of staff, and any emergencies or break in work that need attention. To ensure low priority jobs are completed effectively, job priorities are escalated over time and reevaluated so that work orders can be coordinated for completion in an appropriate timeframe. The SAP CMMS is integral to maturing Tacoma Water's planning and scheduling efforts.

10.4 Operation and Maintenance, and Renewal and Replacement Strategies

This section provides a brief overview of the operation and maintenance, and renewal and replacement strategies employed for each asset class. Each strategy is further detailed in the SAMP for each asset class. Although many assets continue to use reactive or preventative maintenance (within set recurrence intervals), maintenance strategies for assets are in constant development with a trend toward increased reliability centered maintenance.

Buildings, Structures, and Grounds

The majority of maintenance work performed for structures and grounds is corrective maintenance that is triggered by SAP notifications from site inspections. Buildings and structures do not have a formal renewal and replacement strategy.

Cathodic Protection

Active cathodic protection corrosion control systems (those using rectifiers, anode wells, and test stations) are checked and measured annually as preventative maintenance. Replacement of systems is prioritized using the Transmission Mains economic model to determine criticality and evaluating risk of failure based on previously collected preventative maintenance data on the assets.

Distribution Mains

Maintenance for distribution system piping consists primarily of repairing leaks and breaks, and flushing. Tacoma Water currently does not have a formal leak detection program but investigates leak concerns when reported by customers. Tacoma Water plans to procure leak detection equipment and initiate a formal leak detection program.

Distribution system flushing is completed periodically to remove accumulated sediments from water mains to increase water quality. Dead-end lines are flushed at least once a year and a unidirectional flushing team is dedicated to a systematic flushing of the distribution grid. The required frequency of flushing is expected to decrease now that the GRFF is online.

An economic model is used to determine when distribution mains may need to be replaced. Further details on distribution main renewal and replacement can be found in Section 5.6.5.

Electrical and Instrumentation

There are presently no formal programs in place for preventative maintenance on electrical and instrumentation equipment. Maintenance is reactive to individual failures or issues. There is also no formal renewal or replacement strategy for electrical and instrumentation assets. Equipment is typically only replaced following a failure or observed performance issues.

Fleet and Equipment

Maintenance of the Tacoma Water vehicles and equipment fleet is primarily performed by TPU Fleet Services using a combination of preventative and reactive maintenance. TPU Fleet vehicles and equipment are tracked with replacement funds allocated on a rolling basis according to assumed service lives. The funds are used to purchase or lease new vehicles and equipment when replacements are needed.

Gensets

Gensets, including electrical generators and their drive systems, provide backup emergency power to maintain operation of critical equipment and facilities during electrical outages. Other than standard oil/filter/coolant changes, no formal preventative maintenance plan is in place; however, most gensets perform a weekly test run. Repairs are made if any genset fails to operate properly. Replacement is typically based on the manufacturer's recommended replacement cycle, or when equipment experiences multiple failures or becomes too costly to service.

Hydrants

A systematic hydrant maintenance program exists were hydrants are inspected and maintenance is performed on a 3-year cycle. Details on hydrant renewal and replacement can be found in Section 5.6.5.

Meters

Meter testing on Tacoma Water's meter test bench system is regularly performed to determine how accurately specific meters are performing; such testing is typically performed for larger meters and those serving high volume customers, as minor inaccuracies in smaller meters tend to be less problematic relative to system operations and utility billing revenues. Tacoma Water has developed a Meter Dashboard that can model meter accuracy to help determine optimal replacement timing for each meter. Details on renewal and replacement can be found in Section 5.6.5.

Pressure Reducing Valve Stations

Preventative maintenance is performed on PRV stations with various maintenance activities performed on a 6-month, 1-year, or 3-year occurrence interval. There is no proactive renewal or replacement strategy for PRV stations.

Pump Stations

A reliability centered maintenance program is used for pump stations combining preventative maintenance strategies for critical components, with run-to-failure reactive maintenance strategies for non-critical components. There is no formal replacement and renewal strategy for pump stations. Replacement is currently primarily reactive. However, Tacoma Water has recently purchased an ultrasonic listening device, as a predictive maintenance tool, that allows the potential for bearing failures to be detected earlier so that major pumping failures and outages can be avoided. As ultrasonic data is collected, this information may be used for determining bearing renewal strategies and preventative maintenance timing.

A significant portion of the operations budget for pump stations is associated with the energy costs involved in running the pumps. Each station is designed to optimize the use of the pumps within the station. Wire-to-water efficiencies of pump stations have been measured in the past, but no formal program currently exists to do this on a recurring basis. It is a goal of the AM program to have a wire-to-water efficiency program in place to help optimize the use of Pump Stations and increase overall efficiency in the system (no date has been set for this effort).

Storage

Storage facilities are cleaned and inspected approximately every 3 years, with checks completed at each site weekly. Renewal or replacement is completed on an as-needed basis depending on inspections of facilities and projected demands of the system.

Water Services

Other than minor repairs and adjustments to retighten and reseal any leaking fittings that may be discovered, maintenance is normally not performed on water service connections. When significant leaks are detected, it generally results in the renewal or replacement of the water connection line if the leak is between the meter and distribution system main. Piping and plumbing downstream of the service meter is the responsibility of the utility customer.

Transmission Mains

Preventative maintenance is completed annually on transmission main air valves and blow-offs. Corrective maintenance is completed as issues such as leaks are encountered.

A transmission main economic model was developed in 2015 for use in determining the capital budget for transmission main replacements. The economic model is a risk based modeling tool, which determines optimal replacement timing by comparing the annual risk cost of owning and operating the pipe with the annualized cost of its replacement. The approach incorporates the pipe's material, age, risk of failure, and criticality. The failure modes defined in the transmission main economic model are minor leaks or breaks, and catastrophic breaks.

A study of Pipeline 1 to document and gain a better understanding of the existing operating conditions, existing physical condition, maintenance deficiencies (if any), and future operational needs of the pipeline is scheduled to begin in 2018. The goal of the effort is to identify remaining useful life of the pipe segments and develop a long term roadmap and financial plan for managing/operating and ultimately replacing/rehabilitating portions of the pipeline to meet our future needs.

Seismic Resiliency will also drive capital budgeting in the future for Transmission Mains. A list of mitigation projects and associated costs is being developed for the proposed Post Earthquake Level of Service (PE-LOS) Service Goals (Chapter 9 discusses resiliency studies undertaken by Tacoma Water). Many of the projects would be focused on upgrading sections of large transmission pipelines that are installed in liquefiable soils or on steep slopes or constructed of pipe with unrestrained joints (eg. concrete pipe). Since the proposed work goes well beyond existing industry standards, and the capital cost of the effort (including upgrades to other infrastructure like Pump Stations, Reservoirs and Buildings) is estimated to be several hundred million dollars allocated and spent over multiple decades, further consideration with the Public Utility Board and other stakeholders would be needed before proceeding further.

Tacoma Water has budgeted in the 2019/2020 biennium for a consultant to continue the valuation and planning process for developing an approach to pressurizing the pipeline. Work to bring the consultant on board will occur in Q1 2019. We need to fully evaluate the impacts to the pipeline and other facilities in order to understand the implications of pressurizing the pipeline. As well, the analysis will consider the long term design capacity needed from Pipeline 1 given the redundancy and capacity available from the Second Supply Pipeline. Results from the study will be used to develop a long-term Capital Improvement Plan for the pressurization of Pipeline 1 by mid-2020. This timing will enable its inclusion in the 2021-2022 biennial budget, the longer range CIP, and thorough discussion with our Public Utility Board.

Treatment and Monitoring

A combination of preventative and reactive maintenance strategies is used for treatment and water quality monitoring infrastructure depending on their criticality. Replacement and renewal is primarily reactive.

Valves

Valves are routinely operated by staff for shutdowns and for flushing. There currently is no program to systematically exercise and record the condition of every valve in our system.

The majority of valves are replaced reactively after they fail to operate properly. Details on valve renewal and replacement can be found in Section 5.6.5.

Wells

Tacoma Water primarily uses its groundwater sources for summer peaking and to help maintain Green River minimum in-stream flows. Each well typically has a site specific preventative maintenance plan.

As with pump stations, a significant portion of the operating budget for wells is associated with the energy costs involved in running the well pumps. Wire-to-water efficiencies of wells have been measured in the past, but no formal program currently exists to do this on a recurring basis. It is a goal of the AM program to have a wire-to water-efficiency program in place to help optimize the use of wells and identify opportunities for improving system efficiencies.

There currently is no formal well rehabilitation program, in part because well rehabilitation is costly, and in most years there is far more well water available than is used. However, as evidenced in 2015, when a combination of dry weather, no snowpack, and low rainfall occur, the importance of well assets increases dramatically. Tacoma Water began work on an *Integrated Resource Plan* in 2016. Outcomes of this project will inform the required Level of Service of wells and influence a well rehabilitation strategy for the future.

10.5 Links to Relevant Materials

- Asset Management Philosophy and Framework*
- Asset Management Roadmap and Initiatives*
- Strategic Maintenance Management Program*
- Tacoma Water Strategic Plan*

11 Capital Improvement Plan

This chapter describes Tacoma Water's planned capital improvements along with estimated costs and a proposed implementation schedule. Together, these make up the utility's *Capital Improvement Plan* (CIP). Financing for the projects is discussed in Chapter 12 – Financial Plan.

11.1 Capital Improvement Plan Process and Development

Tacoma Water operates under the guidance of a *Strategic Plan* (last updated in 2012), which includes initiatives that are intended to be the strategic focus for Tacoma Water for 3- to 5-year increments. The 2012 *Strategic Plan* has been substantially implemented and a new Strategic Plan will be developed in 2019 for the period 2020-2025.

Tacoma Water maintains a 10-year CIP, which is a collection of capital projects necessary to meet the objectives of the *Strategic Plan*, and is updated every 2 years (link provided in Section 11.3). The current 10-year CIP covers years 2017 through 2026. An updated CIP extending to 2028 was adopted in 2018.

Projects shown in the first 2 years of the CIP represent projects that have been approved in the Tacoma Water biennial capital budget. The biennial budget proposal is developed by the Tacoma Water Superintendent and the TPU Director and presented to the Public Utility Board and City Council for approval.

However, before a project is included in the biennial budget or the 10-year CIP, projects go through a decision making framework as summarized below:

For more information…

A detailed figure of the entire decision making framework used for capital projects can be found in Tacoma Water Budget Development Decision Making Process.

- **Problem Identification** – The first step is the identification of a perceived need or problem. The need for a project can be identified through the transmission or distribution economic models, vulnerability assessment, regulatory mandate, or observed system deficiency.
- **Project Justification** – Once a need is identified, a reference group is assembled to discuss the problem and develop an initial problem statement. If it is clear that there is a problem that needs to be addressed, the development of a business case evaluation is required. The business case evaluation is scoped based on the cost, complexity, and risk of the project. This analysis will typically include project alternatives that could provide a solution to the problem and their associated financial, environmental, and social impacts. The goal of the business case evaluation is to identify the best solution at the right time and to support the business decision for the project. Funding for the recommended project may be determined to be either O&M or capital.
- **Management Team Review** – The project manager and the Division Manager who is sponsoring the project will present a summary of the proposed project to the Tacoma Water management team for discussion and ultimate approval by the

Superintendent. If approved, the project will be included in the Capital Budget if it is planned for the next biennium, or the CIP if it is planned for a later period.

If the project is not approved for the biennial budget or the 10-year CIP, it will go back to the reference group for further discussion. If a project is included on the 10-year CIP, the project manager will be required to update the business case evaluation in order to be considered for inclusion in the proposal for a biennial budget cycle.

- **Biennial Budget** – Projects that are approved by the Superintendent are included in the biennial budget proposal. This budget request will be presented to the Tacoma Public Utilities Public Utility Board (PUB) for approval and inclusion in the Tacoma Public Utilities biennial budget. The PUB will recommend that the budget be approved by the Tacoma City Council. The Tacoma Public Utilities budget is then presented and reviewed for approval by the Tacoma City Council and submitted to the City Clerk by October 31 for the following year.

Tacoma Water's capital projects that go through this process are divided into five different categories:

- **General Projects** – Projects related to upgrading various Tacoma Water facilities and equipment. General capital projects include items such as payments to MIT, plant/equipment failure contingency, advanced metering infrastructure, and GIS.
- **Water Supply Projects** – Projects related to upgrading, renewing, or expanding Tacoma Water's supply system. Projects include well modifications; large valve upgrade/replacement; commercial, industrial, and institutional conservation rebate program; and transmission main renewal/replacement.
- **Water Quality Projects** – Projects needed to maintain the quality of Tacoma Water's supply, which includes treatment and watershed management.
- **Water Distribution Projects** – Projects for upgrading, renewing, or expanding Tacoma Water's distribution system through capital programs such as Public Road Projects, Distribution Main Upgrade/Renewal, Local Improvement Districts, Hydrant Upgrade/Replacement, Water Service Replacement/Renewal, and Valve Upgrade/Replacement.
- **Regional Water Supply System (RWSS) Cost Share Eligible Projects** – Capital projects eligible for cost-sharing with the Partners in the RWSS. Project costs include First Diversion and RWSS related improvements that are allocated to Tacoma Water.

11.2 2017–2026 Capital Improvement Program

11.2.1 Overview

The current CIP covering years 2017 through 2026 is summarized in Table 11-1. Projects and funding amounts listed for years 2017 and 2018 have been appropriated as part of the Tacoma Public Utilities 2017/2018 biennial budget. Projects and funding amounts listed for the remaining years are associated with planned projects from Tacoma Water's CIP. Also, the Tacoma Water CIP Program Needs Assessment in

Appendix C provides a 20-year list of potential additions to the CIP pending approved business case evaluations.

11.2.2 Key Projects

Tacoma Water has identified a number of capital projects needed over the next 10 years. Below are descriptions of some of the larger, key projects planned for this upcoming biennium.

Advanced Metering Infrastructure

TPU is planning to deploy AMI across its entire water and electric service territory. The AMI Program will involve replacing non-communicating power and water meters with advanced, two-way communicating electric meters and installing new AMI two-way communication modules for water meters that will not be replaced. AMI technology will capture metering data at regular intervals, enable two-way communications, include remote capabilities, and provide advanced outage detection and verification. AMI will modernize utility operations and improve services to customers.

Lead Gooseneck Replacement

The goal of this project (see also Section 7.5.1) is to find and replace lead goosenecks throughout the water system to improve water quality. This will include continued efforts of reviewing system maps, drawings, and records to find potential lead goose neck locations. For lead goosenecks that are discovered, the project includes costs to remove the lead gooseneck and replace with non-lead piping, and any roadway repair costs associated with the replacement.

Puyallup River Crossing

Between the GRFF and the McMillin Reservoirs, Pipeline 1 crosses the Puyallup River through two parallel 39-inch-diameter pipelines supported by a truss bridge structure. The bridge structure is vulnerable to seismic and flood events, and is difficult to maintain. Because of this, Tacoma Water has been exploring options to replace the Puyallup River crossing.

A study completed in 2011 indicated that telescopic pipe ramming to provide an underground river crossing was the best option for replacing the existing crossing. Design was completed for the underground crossing. However, due to escalations in construction cost, the project was put on hold.

In 2017, Tacoma Water had discussions with Pierce County about the possibility of installing the crossing on a new proposed county road bridge. This is currently anticipated as the best option for Tacoma Water, instead of the underground river crossing. If the bridge option proceeds, design and construction could occur as early as 2020.

Corrosion Control at Gravity Pipeline Wells

This project includes the design, permitting, and construction of a new corrosion control treatment facility, connecting pipeline(s) between the two gravity pipeline wells,

provisions for chemical truck deliveries, and related appurtenances. The corrosion control treatment facility will include a new building, chemical storage tanks, secondary containment, chemical metering pumps, water quality analyzers, as well as electrical and communication equipment.

Tehaleh Main Extension

To better serve the growing Tehaleh community, Pierce County Public Works and Utilities is planning a 2017 road widening project along 198th Avenue East. Tacoma Water has previously installed 24-inch mains in some sections of 198th Avenue East; however, there are sections where large diameter mains have yet to be installed. The project would install approximately 2,600 feet of 24-inch pipe in coordination with Pierce County's road project to minimize restoration costs.

Tacoma Public Utilities Decant Facility

The TPCHD requires that all spoils (soils created from underground utility excavations) taken from the Tacoma Smelter Plume region containing arsenic and lead be characterized before being disposed of at the LRI Landfill, the only local landfill that accepts these contaminated soils.

TPCHD and the Washington State Department of Ecology also require a solid waste handling permit to properly manage and dispose of contaminated spoils. TPU currently lacks this permit and is at risk of having its soil disposal operations halted until it obtains a permit. Current soil operations, including decanting (the processing of drying spoils) are only allowed to continue if a new facility is planned and constructed.

As a result, TPU is planning to design and construct a new decant facility so that spoil handling operations can continue.

Main Replacement Projects

The CIP includes several categories of main replacement projects. These lines in the CIP cover projects that may have already been identified or to projects that have yet to be identified. Main replacement projects include those that were identified through the economic model; identified for replacement either due to an unexpected failure, or pairing with another project (such as a roadway improvement), etc.; and replacement of galvanized mains. (The City currently has a program for removing galvanized mains from the system with completion anticipated by 2022.)

Seismic Projects

A number of seismic improvements are planned in the CIP. These projects are intended to increase the resiliency of infrastructure during and following seismic events that were identified in the Vulnerability Assessment as being at higher risk during an earthquake (critical infrastructure with higher likelihood of failure).

Table 11-1. Tacoma Water Capital Improvement Plan 2017–2026

Project	Capital Cost by Year ($1,000s) [a]								
	2017/ 2018	2019	2020	2021	2022	2023	2024	2025	2026
General Projects									
Utility Technology Services (UTS) Projects	2,770								
Advanced Metering Infrastructure (AMI)	1,182	1,751	5,928	6,983					
Land Acquisition & Strategy	500	500		500		500		500	
Unanticipated Capital Project Contingency	400	200	200	200	200	200	200	200	200
Plant/Equipment Failure Contingency	260	130	130	130	130	130	130	130	130
Water Supply Projects									
Cathodic Protection	500	150	350	150	350	150	350	150	350
Emergency Intertie with Lakehaven Water and Sewer District at 356th Pump Station	100								
Heavy Construction Equipment Purchase/Lease and Pipe Acquisition		699							
Hood Street Facilities Seismic Improvements - Geotechnical & Structural Analysis	414		9,068						
New Wells			2,000						
Replace/Improve Wells	650	325	325	325	325	325	325	325	325
SCADA Systems - Intrusion Alarm Security Improvements	75								
South Tacoma Pump Station Building Seismic Improvements	152		4,831						
South Tacoma Pump Station Capacity Restoration			800						
Supply System Improvements	450	225	225	225	225	225	225	225	225
Replace/Improve Large Valves	300	150	150	150	150	150	150	150	150
Water Distribution Operations Building Seismic Improvements	176		9,807						

Table 11-1. Tacoma Water Capital Improvement Plan 2017–2026

Project	Capital Cost by Year ($1,000s) [a]								
	2017/ 2018	2019	2020	2021	2022	2023	2024	2025	2026
Demolition of McMillin Standpipe	122								
West McDonald Ridge Permanent Power	84								
Meter Installation Project	237								
Supply Tools	50	25	25	25	25	25	25	25	25
Replace Pipeline 1 at Puyallup River (Phase II)	5,723	2,204	2,204	838					
Pipeline 1 at Deep Creek	670								
Water Quality Projects									
Water Quality Tools and Equipment	200	100	100	100	100	100	100	100	100
Palmer Area Improvements	200								
Corrosion Control Gravity Pipeline Wells	2,000	500							
Pipeline 4 Swan Creek Crossing	700								
Kapowsin Remediation	600								
Built Forestland Assets	75	38	38	38	38	38	38	38	38
Dedicated Distribution System Sample Stations	96	48	48	48	48	48	48	48	48
Portable Sample Stations	50								
Muckleshoot Agreement	500	250	250	250	250	250	1,500		
Water Distribution Projects									
Franchise Required Projects	200	100	100	100	100	100	100	100	100
Projects of Opportunity (Prop 3 and Prop A)	200	100	100	100	100	100	100	100	100
Water Division Projects	717	400	400	400	400	400	400	400	400
Tehaleh Main Extension	1,039								

Table 11-1. Tacoma Water Capital Improvement Plan 2017–2026

Project	Capital Cost by Year ($1,000s) [a]								
	2017/ 2018	2019	2020	2021	2022	2023	2024	2025	2026
Main Replacement Projects (prior Biennia)	1,085								
Main Replacement Projects (Economic Model)	3,118	2,348	2,348	2,348	2,348	2,348	2,348	2,348	2,348
Main Replacement Projects (of Opportunity)	5,552	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Galvanized Main Replacement Projects (Economic Model)	1,292	203	203	80	80				
Main Retirements	156	80	80	80	80	80	80	80	80
Ground Penetrating Radar Equipment	18								
Leak Detection Equipment	59								
TPU Decant Facility	1,162								
Local Improvement District/Contract Contributions	200	100	100	100	100	100	100	100	100
Curran Road System Acquisition	1,000	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Lead Gooseneck Replacement Program	5,200	1,925	1,925						
Hydrant Installation & Replacement	722	361	361	361	361	361	361	361	361
Water Service Replace & Renewals	4,254	2,127	2,127	2,127	2,127	2,127	2,127	2,127	2,127
Valve Installation & Replacement	615	308	308	308	308	308	308	308	308
Capital Meter Replacements	700								
Meter Upgrade Project	300								
Blowoff Installation and Replacement	347	173	173	173	173	173	173	173	173
Regional Water Supply System (RWSS) Cost Share Eligible Projects (Tacoma Water's Total Obligation)									
RWSS Watershed Tools and Equipment	43	34	34	67	67	34	34	34	34
RWSS Watershed Betterments	94	34	34	34	34	34	34	34	34
RWSS Major Treatment and Equipment	109	101	67	101	67	101	67	101	67

Table 11-1. Tacoma Water Capital Improvement Plan 2017–2026

Project	Capital Cost by Year ($1,000s) [a]								
	2017/ 2018	2019	2020	2021	2022	2023	2024	2025	2026
RWSS North Fork Wells Control Valves	276								
RWSS North Fork 7 Motor	133								
Connection to United States Army Corps of Engineers Early Warning System at Howard Hanson Dam	17	99							
HCP Culvert Replacement	38	68	74						
Smay Creek Forest Road Crossing	170								
Trap and Sort Facility Upgrade		74	74						
Howard Hanson Additional Water Storage Project (100% RWSS)		208	208	521	521	104	104		
Total[b]	**48,051**	**22,636**	**51,693**	**23,361**	**15,206**	**15,009**	**15,925**	**14,655**	**14,321**

Source: 2017-2018 costs from Tacoma Public Utilities 2017-2018 Preliminary Biennium Budget (October 2016), 2021-2026 costs from Tacoma Water CIP 2017-2026

[a] Costs rounded to nearest $1,000.

[b] Total is rounded to nearest $1,000 after summing unrounded costs.

11.3 Links to Relevant Materials

- City of Tacoma 2017-2022 Capital Facilities Program*
- Tacoma Public Utilities 2017/2018 Preliminary Biennium Budget*
- Tacoma Water Capital Budget 2017-2026*
- Tacoma Water Budget Development Decision Making Process*
- Tacoma Water Strategic Plan*

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12 Financial Plan

12.1 Financial Program

This Chapter summarizes Tacoma Water's financial management system and demonstrates that the utility can fund its planned capital improvements. Tacoma Water's Finance and Analytics section analyzes the utility's revenue requirement every two years to determine if rates are adequate. Tacoma Water typically implements annual rate adjustments to keep up with inflationary cost increases and meet anticipated needs.

12.2 Financial Policies

Financial policies are key for the responsible management of a public utility. Financial policies guide planning decisions in a responsible and consistent direction for sustainable financial health. The Tacoma City Council adopted financial objectives and policies for Tacoma Water in April 2017 (Ordinance No. 28422), which can be found in the Water Rate and Financial Policy (see Section 12.7).

12.3 Past and Present Financial Status

Tacoma Water has consistently maintained a strong financial position with total operating and capital reserve fund balance above policy minimums and increasing every year in the past 5 years. Historically the utility has increasingly strong debt service coverage and increased liquidity. Table 12-1 shows historical financial results, financial ratios, ending fund balances, and rate increases.

The Regional Water Supply System (RWSS) is a partnership that was formed to develop and maintain the Second Supply Project (SSP). The four partners are Tacoma Water, City of Kent, Lakehaven Water and Sewer District, and Covington Water District. Each partner contributes a contracted share for funding the RWSS operating and capital expenses. This chapter includes only the portion allocated to Tacoma Water.

Table 12-1. Historical Financials

	($ Thousands)				
	2013	2014	2015	2016	2017
Operating Revenue	$96,119	$98,320	$86,445	$87,978	$88,628
Non-Operating Revenue (Expense)	($18,536)	($13,337)	$3,769	$3,723	$3,090
System Development Charge Revenue	$1,703	$2,061	$1,989	$2,987	$3,840
Total Revenue Available	$79,286	$87,044	$92,203	$94,688	$95,558
Operating Expenses less Depreciation	$44,330	$46,316	$48,439	$52,762	$58,751
Net Revenue Available for Debt Service	$34,956	$40,728	$43,764	$41,926	$36,807
Net Debt Service	$19,306	$18,277	$18,787	$18,297	$18,660
Ratio and Other					
Debt Service Coverage - Senior Lien	1.81x	2.23x	2.33x	2.29x	1.97x
Year End Operating Fund Balance	$39,351	$45,496	$49,447	$54,438	$52,287
Year End SDC Fund Balance	$53,720	$53,255	$55,890	$58,318	$60,847
Year End Capital Reserve Fund Balance	$19,403	$22,793	$25,192	$26,080	$31,097
Adopted Rate Increases	6.0%	6.0%	4.0%	4.0%	4.0%

Table 12-2 below provides Tacoma Water's projected financials in the next 5 years and shows a continued pattern of strong ending fund balances and debt service coverage. Forecasted rate increases are 4 percent in 2018 and then 3 percent annually through 2022.

Table 12-2. Projected Financials

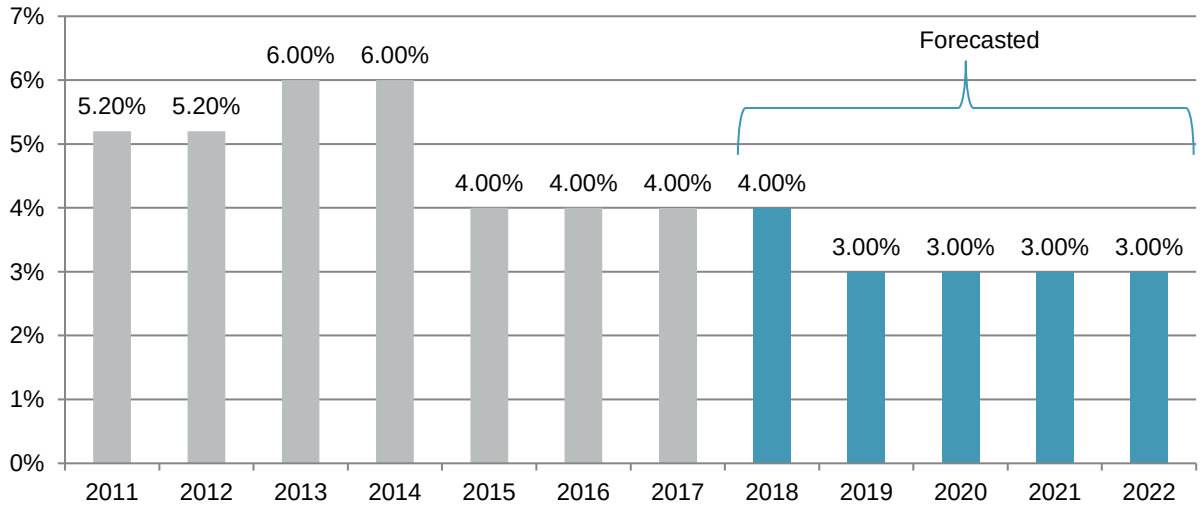
	($ Thousands)				
	2018	2019	2020	2021	2022
Operating Revenue	$88,493	$90,947	$93,425	$95,971	$98,593
Non-Operating Revenue (Expense)	$3,140	$3,142	$3,143	$3,144	$3,146
System Development Charge Revenue	$4,061	$8,151	$8,151	$6,651	$6,651
Total Revenue Available	$95,695	$102,240	$104,719	$105,766	$108,390
Operating Expenses less Depreciation	$58,098	$60,278	$62,045	$63,864	$65,724
Net Revenue Available for Debt Service	$37,597	$41,962	$42,674	$41,902	$42,666

Table 12-2. Projected Financials

	($ Thousands)				
	2018	2019	2020	2021	2022
Net Debt Service	$18,704	$18,713	$18,703	$18,710	$18,708
Ratio and Other					
Debt Service Coverage - Senior Lien	2.01x	2.24x	2.28x	2.24x	2.28x
Year End Operating Fund Balance	$50,197	$44,324	$38,874	$34,833	$32,036
Year End SDC Fund Balance	$63,333	$65,947	$47,018	$22,644	$9,828
Year End Capital Reserve Fund Balance	$31,886	$16,689	$9,821	$10,091	$10,334
Projected Rate Increases	4.0%	3.0%	3.0%	3.0%	3.0%

Tacoma Water regularly adjusts rates to comply with its financial policies and keep up with the cost of running the utility. Figure 12-1 provides the historical and projected rate adjustments.

Figure 12-1. Historical and Planned Rate Adjustments



12.4 Sources and Uses of Funds

Water utilities develop a revenue requirement to determine revenue needed for funding operational and capital expenditures. A revenue requirement compares sources of funds to the uses of funds to determine if the current rates are fully funding the utility's financial obligations.

12.4.1 Sources of Funds

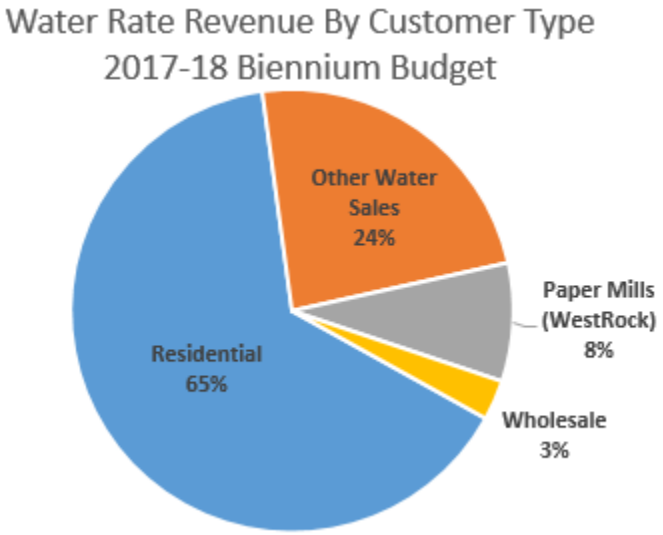
Rate Revenue

Tacoma Water's main source of revenue is from rates charged for water service. Rates are also the utility's only source of revenue that they have control over through rate adjustments.

Tacoma Water's current customer classes are:

- Residential
- Commercial/Industrial – General
- Commercial/Industrial – Large Volume
- Parks and Irrigation
- Wholesale

Figure 12-2. Breakdown of Revenue



Other Revenue

Tacoma Water has established two special funds that provide flexibility in ensuring timely acquisition, replacement and upgrade of the Utility's water system infrastructure and capital assets. The Capital Reserve Fund can be budgeted on a biennial basis as revenues become available for appropriate capital projects. Proceeds from the sale of surplus property, timber sales and other one-time revenues may be deposited to this fund. The System Development Charge Fund is intended to provide funding for source development, transmission, storage and related facilities. Proceeds from new services are subject to a System Development Charge (SDC) charge and are deposited to this fund.

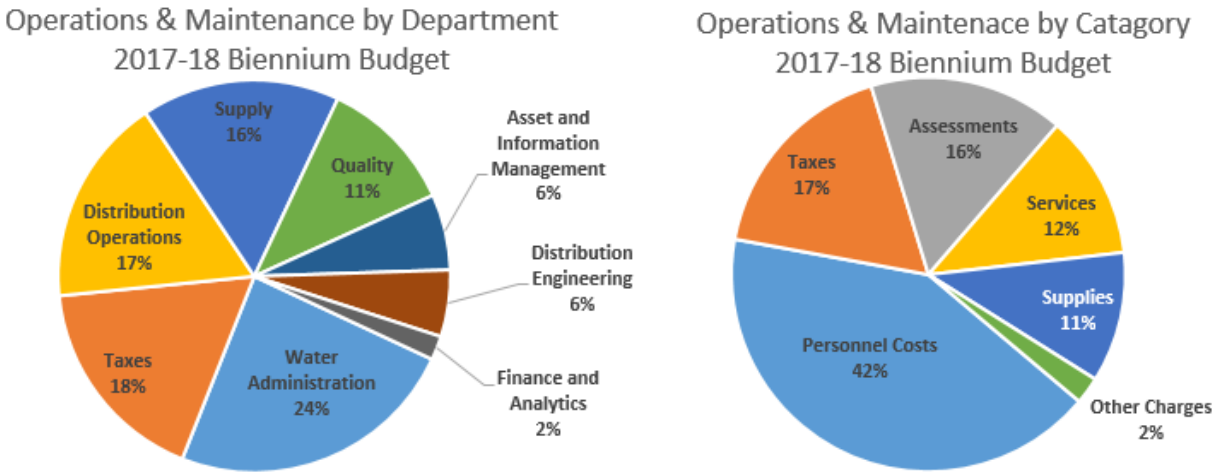
Tacoma water also has a number of smaller sources of revenue such as: contract revenue from Cascade Water Allience, late fees, fees for turn on or turn off, rental and easement revenue, earned interest, and Build America Bond interest subsidy.

12.4.2 Uses of Funds

Operation and Maintenance

Tacoma Water's budget is organized into 7 sections representing the functional areas of the water system, Water Administration, Distribution Engineering, Distribution Operations, Quality, Supply, Asset and Information Management, and Finance and Analytics. Within these sections are expenditures such as personnel costs, general government and customer service assessments, services, supplies, taxes, and other charges.

Figure 12-3. Breakdown of Expenditures



Debt Service

Responsible use of debt funding for capital is an effective way to eliminate sudden rate spikes when large capital outlays are needed as well as spreading those capital cost to future users of the system. Moody's assigned Tacoma Water a rating of Aa2 while Standard and Poor's assigned a rating of AA, ensuring access to low interest debt for the utility. These ratings are a result of the broad and diverse customer base, stable debt service coverage ratios, and strong liquidity position. Tacoma water historically has issued revenue bonds and received low interest loans from government sources.

Taxes

Tacoma Water customers pay a state utility tax and a local tax imposed by the City. The Washington State Tax for water utilities is 5.029 percent and the local City tax is 8 percent of gross revenue.

12.5 Funding the Capital Improvement Plan

The Capital Funding Plan (Table 12-3) shows how the utility is planning to fund future capital improvements. The mixture of funding sources is comprised of SDCs, Capital Reserves, Rate Revenue, and remaining bond funds. Table 12-3 also contains the ending fund balances for the two main reserves for funding capital. Throughout the analysis period, the ending fund balances for the SDC and Capital Reserve Funds maintain balances above their minimum targets.

The capital funding plan provides two key inputs, rate revenue needed to fund capital and the debt service resulting from new debt issues. Table 12-4 presents the utility's revenue requirements. The last revenue requirement study was performed for the 2017/18 biennium and the next revenue requirement will be performed in 2018 for the 2019/20 biennium.

12.6 Assessment of Rates

12.6.1 Existing Rate Structure

Tacoma Water's current rates are a combination of a ready to serve charge and consumption charges. The ready to serve charge varies depending on the size of the customer's meter. The consumption charge is based on the quantity of water used. Current rates can be found at the link listed at the end of this chapter.

Customers outside of City limits are charged a 20 percent differential for their rates.

12.6.2 Affordability

One of Tacoma Water's policies for development of their rates is to keep them as low as possible while still managing the utility in a responsible manner. The utility intends keep rates as low as possible by securing the least cost means of financing capital projects, exercising responsible cost controls and assessing SDCs to minimize impact to existing customers. Tacoma Water provides a 30 percent discount to qualifying low-income senior and/or low-income disabled residential customers.

Table 12-3. Projected Financials Capital Funding Plan

	($ Thousands)							
	2019	2020	2021	2022	2023	2024	2025	2026
Tacoma Base CIP	$22,887	$34,744	$31,862	$23,943	$24,590	$19,255	$18,754	$19,010
Less:								
Capital Funded from SDC Fund	$0	($21,421)	($26,543)	($14,708)	($6,712)	($3,652)	($1,651)	($1,651)
Capital Funded from Capital Reserve Fund	($18,639)	($10,323)	($3,318)	($3,536)	($3,728)	($3,986)	($4,202)	($4,416)
Reserve Funded Capital	($3,000)	($3,000)	($2,000)	($2,000)	($2,000)	($3,000)	$0	$0
Additional Proceeds	$0	$0	$0	$0	$0	$0	$0	$0
Remaining Bond Funding	($1,248)	$0	$0	$0	$0	$0	$0	$0
Total Tacoma Debt Funded Capital	**$0**	**($0)**	**$0**	**$3,698**	**$12,150**	**$8,617**	**$12,901**	**$12,943**
SDC Fund								
Beginning Balance	$63,333	$65,947	$47,018	$22,644	$9,828	$4,877	$2,935	$2,979
Ending Balance	$65,947	$47,018	$22,644	$9,828	$4,877	$2,935	$2,979	$3,024
Minimum Target Balance	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000
Capital Reserve Fund								
Beginning Balance	$31,886	$16,689	$9,821	$10,091	$10,334	$10,584	$10,779	$10,970
Ending Balance	$16,689	$9,821	$10,091	$10,334	$10,584	$10,779	$10,970	$11,163
Minimum Target Balance	$9,276	$9,624	$9,942	$10,182	$10,428	$10,620	$10,808	$10,998

Table 12-4. Projected Financials Revenue Requirement

	($ Thousands)							
	2019	2020	2021	2022	2023	2024	2025	2026
Revenues								
Rate Revenues	$81,579	$81,397	$81,218	$81,044	$80,872	$80,702	$80,537	$80,375
Non-Rate Revenues	$7,293	$7,443	$7,596	$7,753	$7,913	$8,077	$8,149	$8,321
Debt Subsidies Build America Bonds	$3,385	$3,385	$3,385	$3,385	$3,385	$3,385	$3,444	$3,404
Total Revenues	**$92,256**	**$92,225**	**$92,198**	**$92,181**	**$92,170**	**$92,164**	**$92,130**	**$92,100**
Expenses								
Operating Expenses	$78,545	$80,284	$82,079	$83,117	$83,805	$86,149	$87,058	$88,429
Existing Debt Service	$18,713	$18,703	$18,710	$18,708	$18,924	$17,379	$18,400	$19,357
New Debt Service	$0	$0	$0	$0	$707	$1,414	$2,475	$3,182
Rate Funded Capital	$3,000	$3,000	$2,000	$2,000	$2,000	$3,000	$0	$0
Total Expenses	**$100,258**	**$101,987**	**$102,789**	**$103,824**	**$105,436**	**$107,942**	**$107,933**	**$110,968**
Transfer to (or From) Current Reserves	($5,873)	($5,451)	($4,041)	($2,796)	($2,064)	($2,159)	$298	($220)
Annual Rate Adjustment	**3.0%**	**3.0%**	**3.0%**	**3.0%**	**3.0%**	**3.0%**	**3.0%**	**3.0%**
Cumulative Add'l Rate Revenue	$2,447	$4,957	$7,531	$10,172	$12,881	$15,660	$18,513	$21,442
Additional Taxes from Rate Increase	$319	$646	$981	$1,325	$1,678	$2,040	$2,412	$2,794
Net Rate Increase	$2,128	$4,311	$6,550	$8,846	$11,203	$13,620	$16,101	$18,648
Sr. Debt Coverage - After Rate Increases	2.24	2.28	2.24	2.28	2.29	2.31	2.12	2.05
Current Fund								
Beginning Fund Balance	$50,197	$44,324	$38,874	$34,833	$32,036	$29,972	$27,813	$28,111
Addition to Fund	$0	$0	$0	$0	$0	$0	$298	$0
Use of Fund	($5,873)	($5,451)	($4,041)	($2,796)	($2,064)	($2,159)	$0	($220)
Ending Fund Balance	$44,324	$38,874	$34,833	$32,036	$29,972	$27,813	$28,111	$27,891
Minimum Target Balance	$16,220	$16,220	$16,752	$16,752	$17,233	$17,233	$18,110	$18,110

12.7 Links to Relevant Materials

- Financial Report
  http://cms.cityoftacoma.org/Finance/Financial_Reports/Annuals/WaterAnn17.pdf
- Water Rate and Financial Policy
  https://www.mytpu.org/file_viewer.aspx?id=58947

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13 References

Department of Health

2010 Washington State Wellhead Protection Program Guidance Document, DOH 331-018. June.

2012 Source Water Protection Requirements, DOH 331-106. May.

2017 Satellite Management Agencies: https://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater/WaterSystemAssistance/SatelliteManagementAgencies

2017 Water Supply Forum http://www.watersupplyforum.org/home/about-water-supply-forum.html: accessed August 2017

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