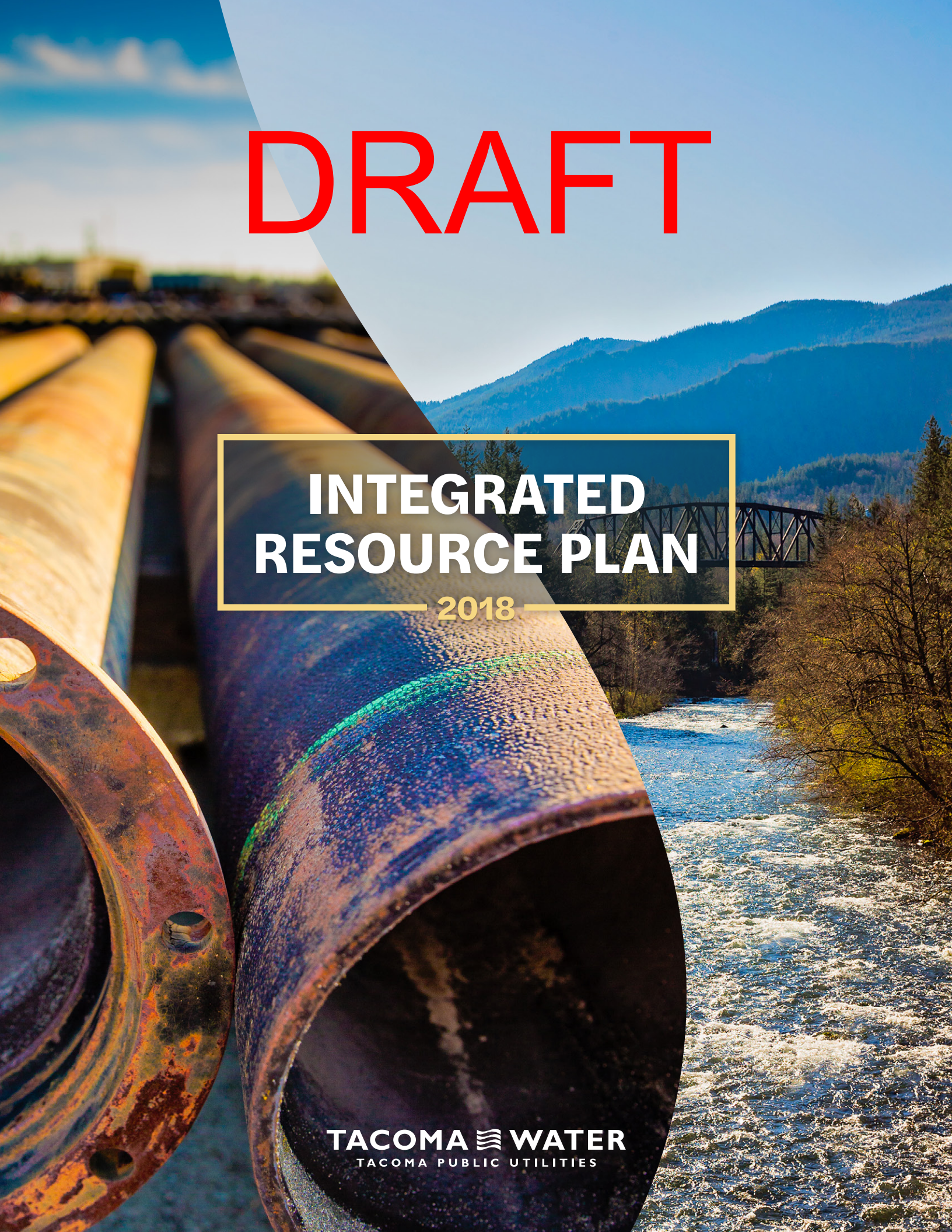
DRAFT
INTEGRATED
RESOURCE PLAN
2018
TACOMA WATER
TACOMA PUBLIC UTILITIES

acknowledgements

Tacoma Water recognizes the following organizations and individuals for their contributions to the 2018 Integrated Resource Plan:

Tacoma Water Steering Team

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HDR

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- Department of Natural Resources and Parks
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U.S. Army Corps of Engineers, Seattle District

Pacific Northwest National Laboratory

Seattle Public Utilities

IRP Public Advisory Committee *(see page 14)*

Dr. Alan Hamlet, Notre Dame University

contact information

Tacoma Water

- www.mytpu.org/tacomawater
- (253) 502-8600

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Contents

acronyms

AMI – Automated Metering Infrastructure

ASR – Aquifer Storage and Recovery

AWSP – Additional Water Supply Project

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act

CFS – Cubic Feet per Second

CWSP – Coordinated Water System Plan

EPA – Environmental Protection Agency

FDWR – First Diversion Water Right

HCP – Habitat Conservation Plan

IRP – Integrated Resource Plan

JBLM – Joint Base Lewis-McChord

MGD – Million Gallons per Day

MIT – Muckleshoot Indian Tribe

OASIS – Optimizing Aquifer Storage for Increased Supply

PAC – Public Advisory Committee

RAS – Resource Adequacy Standard

RCP – Representative Concentration Pathway

RWSS – Regional Water Supply System

SDWR – Second Diversion Water Right

SSP – Second Supply Project

USACE – United States Army Corps of Engineers

WSRP – Water Shortage Response Plan

WYSDM – Water Yield Supply and Demand Model

public utilities board resolution

the 2018 Integrated Resource Plan was approved by the Public Utilities Board in Board Resolution No. _____ on _____, 2018.

EXECUTIVE SUMMARY

Tacoma Water, a division of Tacoma Public Utilities, 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.

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 managed, 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. This IRP incorporates supply and demand in a single analysis, and addresses trends and uncertainties in both.

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.

resource adequacy standard

Tacoma Water established a Resource Adequacy Standard (RAS) that serves as a "yardstick" for determining whether water supplies are sufficient to meet demands now and in the future. The RAS states that 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 step that utility managers can use to require the system's water customers 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.

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 and scenarios, representing alternative future conditions. It can also provide insights into how climate change might affect supply and stream flow. WYSDM greatly improves Tacoma Water's ability to make decisions on use of limited water supplies during a drought or other temporary shortage.

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 twenty-five years on average. Tacoma Water's firm yield is 107 MGD.

Tacoma Water's supply sources should remain adequate through the 2050s.

conservation program and water shortage response plan

As part of the IRP process, Tacoma Water also assessed and updated the demand-management programs already in place: the Water Conservation Program and Water Shortage Response Plan. The conservation program is a regular and ongoing program, while the Water Shortage Response Plan applies 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, meeting customer expectations and controlling the costs of developing and operating the water-supply system.

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 PAC, 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.

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.

1

INTRODUCTION

What is an Integrated Resource Plan?

An Integrated Resource Plan incorporates supply and demand into a single analysis, and addresses trends and uncertainties in both.

This IRP is one of several planning documents that Tacoma Water uses to make its **Strategic Plan** operational.

the resource planning process

1. ***identify the factors***
   that will influence water demands in the future.
2. ***develop models and metrics***
   to analyze future water supply and demand.
3. ***define and assess alternate scenarios***
   of population growth, economic activity, technology and climate conditions.
4. ***analyze future resource performance –***
   Are Tacoma Water's existing water resources sufficient to handle a range of future conditions?

   If the answer is "no", identify new water supplies and/or ways to reduce water needs in the future.
5. ***develop a long-term resource strategy and action plan.***

Historically, water, power and other utilities conducted supply and demand analyses separately. Demand was viewed as an independent factor, and supplies were simply sized to meet those demands. This approach has changed in recent decades. Water and power managers, government regulators and informed citizens now view customer demand as a variable that can be managed, just as supplies can be managed. Integrated Resource Planning brings supply- and demand-side solutions into a single framework.

In 2015, a severe drought placed significant stress on Tacoma's water system. At the same time, some Tacoma citizens expressed concerns over how water is allocated, particularly to large new industries. In response to these concerns, Tacoma Water decided to improve the capabilities of its supply forecasting methods and take a fresh look at how current and future water demands align with available supplies. The IRP resulted from these activities.

Further, in considering options to keep supply and demand in balance, the Integrated Resource Plan examines both supply-management options and demand-management options. Tacoma Water convened a Public Advisory Committee to contribute to the integrated planning vision and approaches, so that a wide range of views could be applied to the planning effort.

The IRP will lead to a better balance of the various constituent needs, support regional economic vitality, honor Tacoma Water's commitment to and desire for the health of the Green River ecosystem, and support the treaty rights of the Muckleshoot Indian Tribe to a sustainable fishery. The IRP enables Tacoma Water to take stock of its needs and resources, update forecasts, and produce new management tools to create an even more robust and resilient system for the future.

Tacoma Water Today

Tacoma Water, a division of Tacoma Public Utilities, has been providing water to local communities ever since the City purchased Tacoma Light and Water in 1893. Tacoma Water has expanded its supply portfolio and infrastructure and continually updates management practices to meet the needs of a changing customer base and satisfy evolving state and federal requirements.

Currently, Tacoma Water directly serves approximately 330,000 people, in the City of Tacoma and nearby communities in Pierce and King County. This includes residential, commercial, and industrial customers. In 2017, the average winter-season demand was 44 million gallons per day (MGD), and the maximum daily demand in the summer was 90 MGD. Tacoma Water also has the ability to sell water in bulk to other cities in Pierce County, and maintains a partnership with three water utilities in King County that partnered with Tacoma to develop new supply and transmission capacity in recent decades.

Tacoma Water has made substantial commitments recognizing the value of water as an environmental resource. It follows stringent protocols and engages with partner agencies to protect Green River flows and fish runs during low-flow periods, and works closely with stakeholders on the Green River to ensure environmental commitments are met, consistent with State law and an agreement with the Muckleshoot Indian Tribe.

As Tacoma, Pierce County and the adjoining region continue to grow, Tacoma Water will work to meet community needs, while balancing those needs with environmental sustainability and economic vitality in its planning and operations.

OUR MISSION

Providing clean, reliable water now and in the future.

CORE VALUES

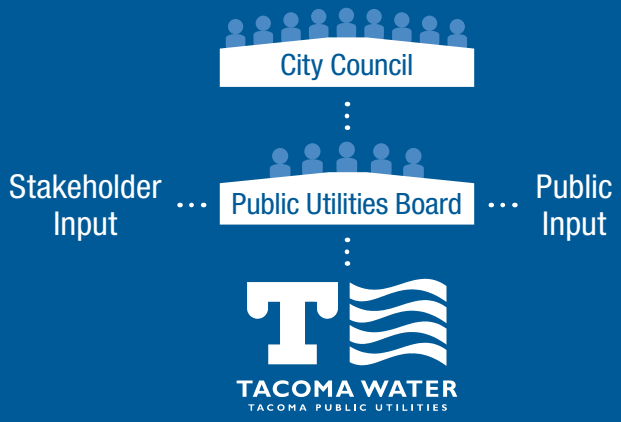
Our core values guide all the work we do on behalf of our customers and the region in which we operate, and reflect what we want the future of Tacoma Water to be.

- Customer-focused
- Reliable
- Responsible

ASPIRATIONAL VALUES

- Safety first
- Courage to challenge and be challenged
- Mutual respect
- Innovation

GOVERNANCE



Tacoma Water is governed by the Public Utilities Board, appointed by the City Council. As a public utility, Tacoma Water considers diverse community needs, stakeholder concerns, and public input.

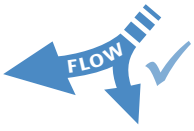
The utility operates as an "enterprise", funding its operations, infrastructure and debt service entirely from water sales. It is the largest water provider in Pierce County and second largest in Washington State, serving urban, suburban, and even some rural customers.

FACTS & FIGURES

Direct Retail Service population served in 2018:
approx. 330,000

Numerous **rebates** and **free services** geared towards reducing customers' water use

Uses surface water from **Green River** and groundwater from **local aquifers.**



Green River **diversions** are **managed carefully** under a Habitat Conservation Plan and an agreement with the Muckleshoot Indian Tribe

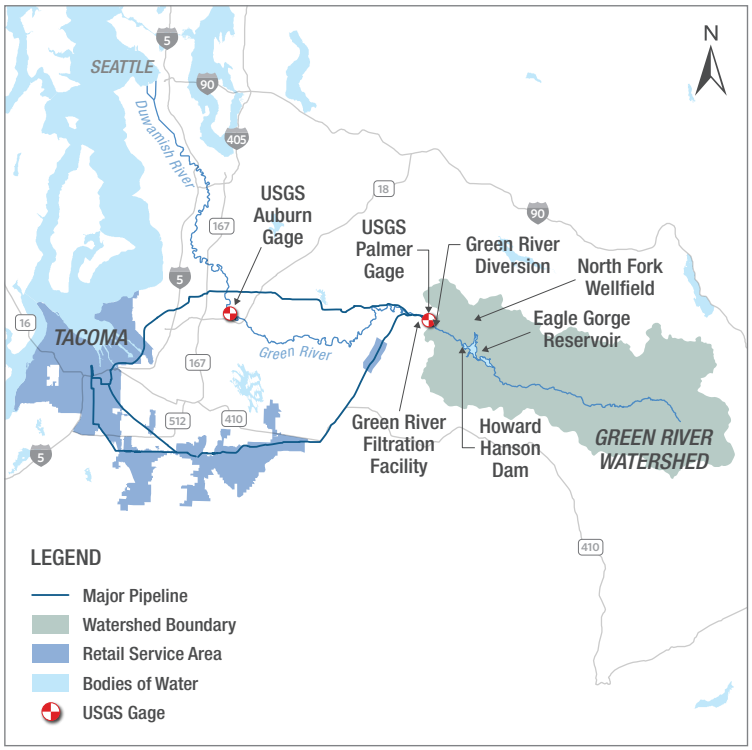
Water Supply Sources

surface water

Tacoma's primary water source is water diverted from the Green River. Water originates in the Green River watershed, a forested valley in the Cascade Range northeast of Tacoma. In the fall and winter months, the Green River is primarily fed from frequent rain events; in the late spring and early summer months, river flow is augmented by melting snow in the higher elevation areas of the watershed. Local inflow from groundwater supports stream flow from mid-summer into fall until the rains return.

Tacoma holds two water rights on the Green River, which meet customers' needs when ample water is available for diversion. The First Diversion Water Right (FDWR) can supply up to 73.0 MGD from natural flow in the river, and dates back over a century. Beginning in 2007, up to an additional 64.6 MGD from the Second Diversion Water Right (SDWR) on the Green River became available. The SDWR is conditional based on minimum flows in the Green River, and is therefore only available approximately 60% of the time on an annual basis (not accounting for water stored behind Howard Hanson Dam in Eagle Gorge Reservoir). When natural flow in the river declines in the dry months of summer and fall, Tacoma's share of water stored in the reservoir can be strategically released to serve Tacoma's customers or can be used to maintain instream flows to support fish habitat and associated ecosystem functions.

Fig 1.1 Green River watershed and supply system



Tacoma Water relies on both surface water and groundwater to reliably meet customer needs for water

ground water

Tacoma Water owns and operates wells in and around the city to provide additional supply. In a typical year, groundwater pumping supplies approximately 11% of total requirements, usually during the summer period when customer needs increase, or in the fall after much of the stored surface water has been depleted. However, wells can be operated as a substitute source of supply whenever the Green River source is insufficient to meet demands, or must be temporarily taken off line for operational reasons.

The advantage of groundwater is its reliability; the aquifer will normally recharge every year during the wet winter season, and if the wells are not pumped at full capacity for an extended period of time, the aquifer can produce ample water through the dry season. However, groundwater is not sufficient to meet the total summer demand. It has an additional downside of elevated cost: pumping ground water from wells requires electrical power, while water from the Green River can flow by gravity to most areas without pumping.

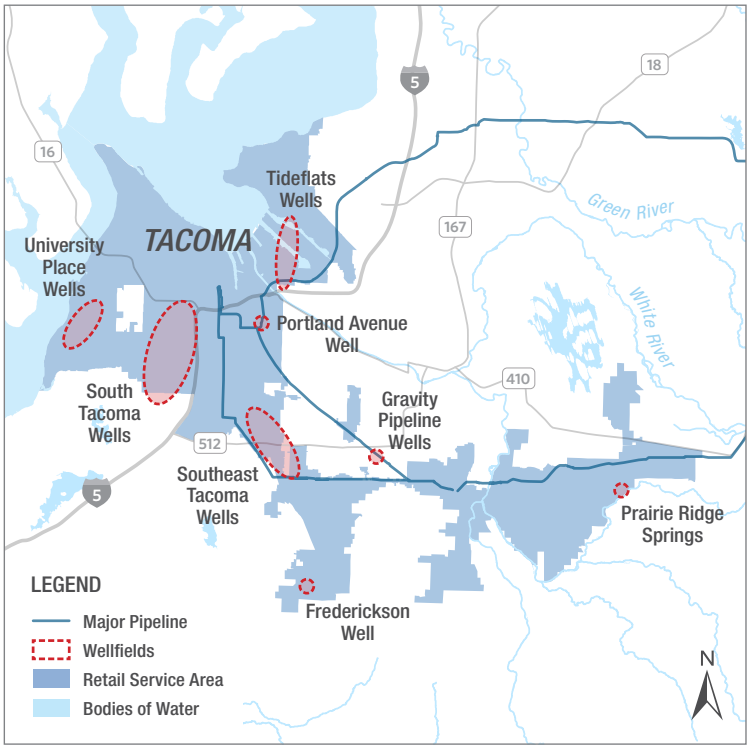
water rights

An evaluation of water rights available to the system is an important part of any system-wide analysis. Along with the physical capabilities to supply water, the legal right to use the water must be monitored and ensured.

Tacoma Water has sufficient water rights to meet anticipated future needs. These water rights include two surface water rights from the Green River, and groundwater rights for the water system's 25 wells, which are located in multiple regions of the water service area.

As the community continues to grow and evolve, Tacoma Water will require changes to some of its water rights. Extensions to several water right permits will be required in the near future. During the last decade it has become increasingly difficult for water systems to manage their water rights due to uncertainties in legal interpretation and the administration of these rights. Tacoma Water is active with industry and regulatory associations to monitor developments and provide input as the water rights landscape changes.

Fig 1.2 Tacoma Water's wellfields



the benefits of a diverse supply

Every year sees different weather conditions and customer water use patterns; both of these factors carry an element of uncertainty. Having supplies from both surface water and groundwater allows Tacoma to be highly resilient in the face of these uncertainties, and to control impacts of water withdrawals from the Green River.

Contractual Relationships

Several agreements and permits shape how and when Tacoma Water can use its surface water sources. These affect how the supply system can be operated under different conditions. The various provisions and commitments affecting flow management and water diversions have been incorporated into the Water Yield, Supply, and Demand Model (WYSDM) developed as part of the IRP project.

muckleshoot indian tribe (MIT)

The Muckleshoot Indian Tribe (MIT) holds treaty rights to certain natural resources in the Green River basin, and federal courts have recognized its legal standing along with the federal government and Washington State in managing these resources. Tacoma Water is committed to respecting tribal rights as it exercises its water rights to Green River water supplies, under Washington State law.

In 1995, the City of Tacoma and MIT signed an agreement regarding management of resources in the Green and Duwamish River system. The agreement addresses Tacoma's use of its First and Second Diversions and Second Supply Project. Among other provisions, the agreement states that Tacoma Water shall provide guaranteed minimum continuous instream flows in the Green River. Natural inflows, water stored in Eagle Gorge Reservoir, and pumping groundwater to meet a portion of system demand help meet this commitment.

us army corps of engineers (USACE)

Howard Hanson Dam is located approximately three river miles upstream of the Green River Diversion Dam and is owned and operated by the United States Army Corps of Engineers (USACE). Its primary function is to reduce flood risk for communities in the Green River Valley by storing high volumes of winter runoff and releasing them gradually. Another authorized function of Howard Hanson Dam is augmentation of in-stream flows in the Green River downstream of the dam during the summer-fall low flow period.

The Additional Water Supply Project (AWSP) at Howard Hanson Dam added municipal water supply to the project purposes. Tacoma Water's access to this supply is defined in a 2003 Project Cooperation Agreement with USACE. At the present time, Tacoma Water and its Second Supply Project partners can divert only up to 10,000 of the 20,000 acre-feet of water stored in the spring for municipal use and released in the summer and fall from Howard Hanson Dam. The remainder is typically donated back for use by the resource agencies to supplement stream flows at levels that promote fish survival and reproduction. This has been an interim measure only. After downstream fish passage facilities are completed by USACE as part of the Additional Water Supply Project, Tacoma Water anticipates the remaining 10,000 acre-feet will be used for municipal supply purposes.

Water can be stored behind Howard Hanson Dam until late fall each year, when flood control season begins. At that time, remaining water is released downstream, so the reservoir can absorb high runoff events in the winter to minimize flooding downstream. This means there is no carryover of stored municipal water from one year to the next.

habitat conservation plan (HCP)

Tacoma is committed to implementation of a Habitat Conservation Plan for its Green River operations, issued in 2001. This was part of obtaining an Incidental Take Permit from the National Marine Fisheries Service and US Fish and Wildlife Service under Section 10 of the federal Endangered Species Act.

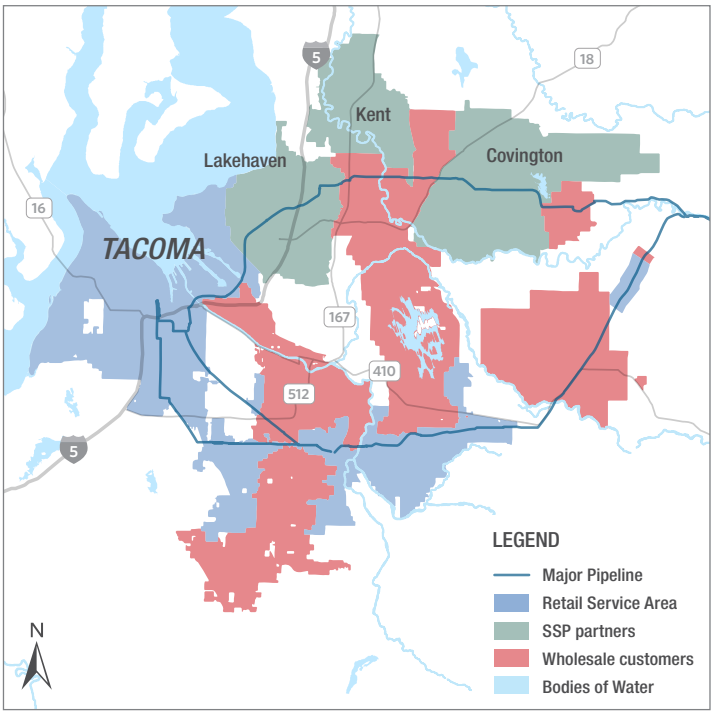
Out of the numerous actions listed in the HCP, one section is particularly critical with regard to water supply availability from the Green River. The HCP guarantees minimum instream flow at the Auburn gage, above the state-mandated level. Required flows are the same as those described under the MIT Agreement.

An essential element of the HCP is its adaptive management framework, which provides an ongoing process to evolve the strategy for managing water releases from Howard Hanson Dam to meet downstream flow needs. This involves frequent communication with the Green River Flow Management Committee, which is an interagency committee consisting of representatives from MIT, Tacoma Water, natural resource agencies, and other groups. The USACE considers input from the committee to adjust the refill and release regime based on a short-term planning horizon. In drought situations, the parties have historically agreed to institute consensus derived water use restrictions to make the best use of the available resource.

The HCP also calls for Tacoma Water to provide funding support to USACE for a downstream fish passage facility at Howard Hanson Dam and for a monitoring and research program to support conservation of listed species and for purposes of adaptive management. Tacoma has fulfilled all its other commitments under the HCP and stands ready to partner with the USACE on this important new fisheries project.

The HCP includes numerous other actions aimed at improving the fisheries resource in the Green River basin, as well as actions to protect a wide array of non-fish species.

Fig 1.3 Tacoma Water wholesale customers and SSP partners



wholesale water contracts

Tacoma Water serves water directly to retail service customers in Tacoma, other communities in Pierce County and some in southern King County. In addition, Tacoma Water has contracts to deliver water on a wholesale basis to the following 15 water purveyors in Pierce and King Counties:

City of Fife	Rainier View Water Co.	Coal Creek Water Society
City of Auburn	Firgrove Mutual Water Co.	City of Enumclaw
City of Bonney Lake	City of Puyallup	Valley Water District
Cumberland Co-op		Summit Water
Mountain Terrace		RSN Enterprises
Fruitland Mutual Water Co.		Water District 111 of King County

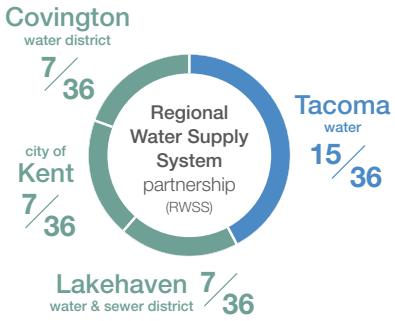
Tacoma Water also has a contract with the Cascade Water Alliance, an organization comprised of seven suburban King County water purveyors.

second supply project (SSP) partnership

In 1979 Tacoma Water requested Washington State Department of Ecology resume processing and act on its 1933 application to develop a second water right on the Green River, which would add to the allowed diversions from Tacoma's original 1913 claim. Tacoma Water also developed a plan to construct several new facilities, including a new water treatment plant and a new transmission pipeline (Pipeline 5, or the Second Supply Pipeline) to deliver that water to its retail service area. Ultimately the water right was granted and the facilities were constructed. These actions together are called the "Second Supply Project" or SSP.

At the same time, certain communities located along the Pipeline 5 route in King County expressed an interest in partnering with Tacoma Water to finance the project, in return for a share of the SSP water. Communities that joined the partnership are the City of Kent, Covington Water District, and Lakehaven Water and Sewer District. The project also includes certain related facilities, including portions of storage capacity behind Howard Hanson Dam, operated by the Corps of Engineers.

Fig 1.4 Breakdown of SSP shares



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). Only the Second Diversion Water Right is included in the RWSS, and Tacoma's First Diversion Water Right is solely used for the needs of Tacoma Water.

Water Conservation

Tacoma serves approximately the same amount of water annually as it did in the late 1950s, with over a 40% increase in population. This is due to changes in the industrial and commercial base, improved technology and metering, and conservation programming. Tacoma Water has promoted water conservation by its customers since the 1980s.

The conservation program is updated regularly to incorporate new technologies, build on past water savings and promote positive customer engagement. Conservation is integral to Tacoma Water's values of serving its customers efficiently while protecting environmental resources.

2018 Water Conservation Program Update

Tacoma water updated its water conservation goal and plan in 2017. The actions identified will be implemented over a 10-year period from 2018-2027.

The conservation program will aid Tacoma Water in meeting its water use reduction goals, contribute to ongoing environmental stewardship, and provide customer opportunities for using water more efficiently.

Although the costs of operating the utility are largely fixed rather than proportional to annual water production, conservation is a way to avoid having to find and develop expensive additional sources in the future. Tacoma Water has a portfolio of existing water rights that could be further developed, but new water rights are generally not available. Moreover, conservation helps avoid a need to upsize existing distribution infrastructure (such as pipes, pumps, and reservoirs) that would only be fully utilized during peak hours of perhaps a handful of the hottest days each year.

A well-designed conservation program can provide numerous benefits:

- **Cost Effectiveness:** New supply sources/ infrastructure can be costly to develop. Conservation can delay and sometimes avoid the need for certain projects, saving ratepayers from unnecessary costs.
- **Environmental Stewardship:** Less water diverted from the Green River means more water for aquatic species and a healthier Green River ecosystem.
- **Energy Savings:** Reduced water use means less energy is needed to treat and distribute water, and also less energy is used to heat water in residences and businesses.
- **Customer Satisfaction:** Equipment rebates and fixture giveaways save customers money. Reducing water use leads to lower water bills for participating customers (though the resulting loss to utility revenue must be made up by other customers).

program development

Tacoma Water established a population-adjusted 6.65% peak (May–October) water use reduction goal for the 2018–2027 planning period with an expected annual budget of $80,000, in addition to internal staff time. The program is presented as a package of conservation actions, or "measures," that Tacoma Water and customers will implement to save water across multiple uses.

Tacoma Water used a multi-step process to develop this goal and compile potential measures into a final conservation plan:

1. **Screening:** Initial selection of potential measures for consideration based on relevance and potential effectiveness in achieving Tacoma Water's conservation goal.
2. **Validation:** Quantitative evaluation of which measures would be the most effective in achieving Tacoma Water goals.
3. **Packaging:** Conservation measures grouped together to eliminate redundancy and address alternative goals. These packages were presented to the PAC for feedback, which led to the creation of a final package of measures that was selected as the conservation program for implementation over the next 10 years. Savings from this package generated the updated goal of reducing peak, population-adjusted water use among Tacoma Water's retail customers by 6.65%.

targeting outdoor use

Domestic uses ("indoor use") occur in generally consistent patterns throughout the year. In contrast, outdoor water use occurs almost entirely during the dry season. Outdoor water use (especially landscape irrigation) can nearly double total water use during the summer season.

River flow volumes taper off after the snowmelt season is over, at which point storage in Eagle Gorge Reservoir becomes an important component of the water supply until the rains return in the fall. Reduction of peak demands can reduce withdrawals from the river and stretch the water stored in the reservoir. For these reasons, the conservation plan targets peak season uses of water.

the program

Highlights:

- Includes all customer classes, all times of the year
- Peak season savings up to 278,000 gallons per day
- Increased programming for multifamily residences
- Outdoor efficiency measures for residential and commercial customers

The conservation package chosen for implementation is focused on maximizing peak-season savings. It includes a diversity of measure applications across customer classes and water uses.

water conservation economics

- The water utility operates as an enterprise such that annual revenues must cover annual costs.
- Anything that reduces water use also reduces revenue.
- When revenue dips unexpectedly, it must be made up elsewhere because most costs of operating the utility are fixed and do not change with water use.
- Impacts to individual customers can be reduced by enlarging the customer base, for example by adding industrial and wholesale customers.

customers and the environment

Tacoma Water uses water conservation as a best-management practice for balancing the needs of the Green River watershed, the customers, and the utility.

IRP Public Advisory Committee

Tacoma Water formed a Public Advisory Committee to provide stakeholder input during development of the Integrated Resource Plan. The questions posed and comments provided at Public Advisory Committee meetings helped Tacoma Water shape the IRP analysis and this document.

represented organizations

- **ATLANTIC POWER**
  Ric Chernesky
- **COVINGTON WATER DISTRICT**
  Tom Malphrus
- **CITY OF FIFE**
  Russ Blount
- **FIRGROVE MUTUAL WATER COMPANY**
  Leonard Horton
  Larry Jones
- **GORDON THOMAS HONEYWELL** – *facilitator*
  Jim Waldo
- **CITY OF KENT**
  Sean Bauer
- **LAKEHAVEN WATER AND SEWER DISTRICT**
  John Bowman
- **METRO PARKS TACOMA**
  Matt Keough
- **NEIGHBORHOOD COUNCILS REPRESENTATIVE FROM THE COMMUNITY COUNCIL**
  Doug Shafer
- **PIERCE COUNTY PLANNING AND PUBLIC WORKS**
  Rich McGowan
- **SAVE TACOMA WATER**
  Todd Hay
- **SUSTAINABLE TACOMA COMMISSION**
  Alexandra Brewer
- **TACOMA-PIERCE COUNTY CHAMBER OF COMMERCE**
  David Schroedel
- **TACOMA-PIERCE COUNTY DEPARTMENT OF HEALTH**
  Brad Harp
- **CITY OF UNIVERSITY PLACE**
  Mayor Javier Figueroa
- **WASHINGTON STATE DEPARTMENT OF HEALTH**
  Bob James
- **WESTROCK COMPANY**
  Bruce Martin

the IRP Public Advisory Committee met five times, and provided input on:

Purpose and objectives of IRP	Content and development of the Water Yield, Supply and Demand Model (WYSDM)	Dynamics of supply and demand
Future scenarios of population growth, economic development and technological changes	Treatment of climate change in the IRP process	Water conservation program update
Triggers for customer curtailment during water shortages	Potential options for managing supply and demand including surface water, ground water, reclaimed water, and water conservation	Resource Adequacy Standard (RAS)

2

KEY FACTORS FOR THE INTEGRATED RESOURCE PLAN

Tacoma Water must continually plan for the future to ensure reliable water service as the Tacoma area grows and changes. Development of new water supplies can take decades, so planning for the future requires a long view of social, economic, and natural resource conditions.

Weather Variability and Drought

Snowpack and rainfall patterns in the Puget Sound region can vary sharply from year to year. Some winters deliver damaging floods, and some summers are unusually hot and dry. Dry winters can also be problematic by reducing snowmelt that feeds the Green River.

Dry conditions reduce Tacoma's surface water supply and stress fish populations in the Green River, its tributary creeks, and other local streams. Many of Tacoma Water's actions during dry years are driven by its responsibilities for protecting fish, and the related set of agreements with the state, federal government, and Muckleshoot Indian Tribe.

In developing the Integrated Resource Plan, Tacoma Water drew on weather and streamflow data from the 103-year period stretching from 1915 to 2017. Significant droughts occurred in the early 1900s, and in 1987 and 2015. In fact, snowpack in the Green River watershed was at a historical and alarming low in 2015. Each of these past droughts illustrate the need for vigilance in maintaining adequate water supplies for extreme dry periods.

Most droughts can be sufficiently managed by reductions in discretionary water uses (known as "curtailment"). It is important to keep in mind that occasional curtailment is not failure; it is a cost-effective means of managing the water system. Infrequent curtailment enables Tacoma and its customers to deal with the variable climate of the region and minimize impacts to the natural environment.

Fortunately, multi-year droughts have been rare over the past 100 years in the Puget Sound region. The pronounced pattern of wet winters, coupled with available storage capacity, help to buffer Tacoma Water from multiple-year events.

Fig 2.1

Historic Natural Green River Streamflow

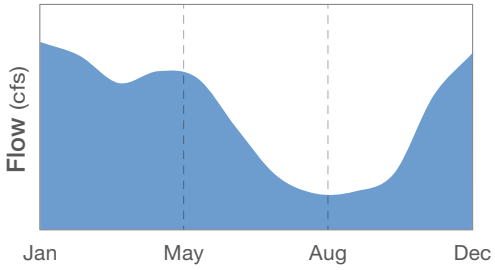


Fig 2.2

Typical First Diversion Water Right (FDWR)

during a drought

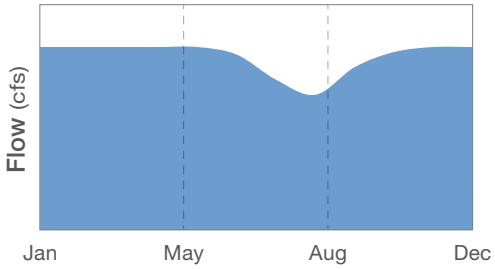


Fig 2.3

Typical Second Diversion Water Right (SDWR)

excluding stored water

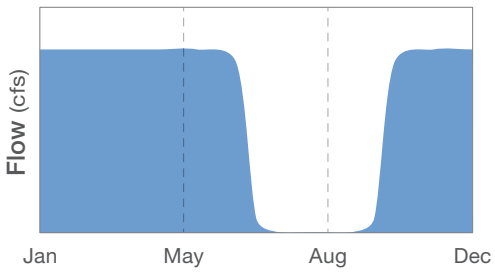
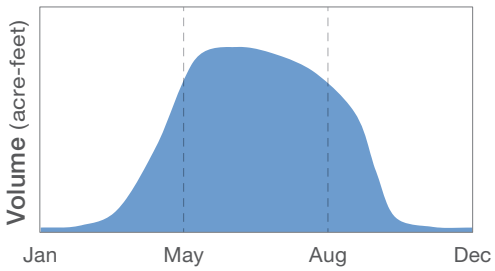


Fig 2.4

Eagle Gorge Reservoir Total Storage



Climate Change

Government scientists and university researchers in the Pacific Northwest and other regions have shown that our climate is becoming warmer and that extreme weather events are likely to become more frequent. Climate change is a worldwide phenomenon that is occurring now and is expected to impact societies in the coming decades. Specific effects can vary substantially from one region to another, including the types, rates, and magnitudes of change.

In the Puget Sound region, climate change models point to warmer weather year-round, drier summers, and wetter winters. However, climate change is forecasted over large time scales, and thus carries uncertainty in how it will manifest in day-to-day weather. For example, average temperature increases may be different in summer months than in winter months. Land elevation, proximity to water bodies, and vegetation also affect local conditions. Tacoma and Pierce County are diverse in these characteristics.

Climate change is expected to impact both supply and demand. From the demand perspective, increased summer temperatures will require more water demand for lawn irrigation, absent other changes in irrigation practices. Peak season demands could be affected strongly relative to year-round demands.

Warmer winter weather in the Green River watershed may reduce the amount of water stored annually in snowpack. The winter surface water supplies may therefore be plentiful but flows from snowmelt could be reduced substantially during spring and summer. The overall impact to Tacoma Water's surface water supply system is expected to be on the order of 18 percent reduction. Flows in the Green River could dip more frequently to minimum flow levels that must be protected. In this event, unless new storage capacity is created, this would reduce Tacoma's ability to divert surface water for municipal supply.

Fig 2.5

Climate Change Effects on Green River Flow

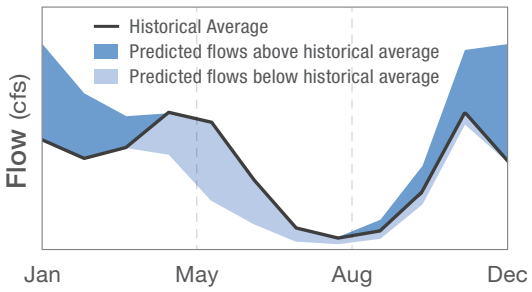


Figure 3.5 displays the predicted range of future Green River flows based on 10 climate change models.

time of emergence

It is impossible to know whether a particular drought or other weather event was caused by climate change. Extreme weather events have always happened, and weather is quite variable. For example, some of the worst droughts in the Puget Sound region over the last 100 years occurred during the 1920s. However, climate change is expected to increase the likelihood of extreme weather.

"Time of Emergence" focuses on predicting the time at which climate change emerges from the background noise of historic natural climate. It is impacted by the magnitude of projected change relative to historic variability. Ecosystems and engineered systems evolved, or were designed, to manage conditions within a historical range of variability. When conditions move significantly outside this normal range, impacts may be experienced. The concept of Time of Emergence is used to try to determine when, as well as where and how, climate change will force systems adaptation.

Future climate cannot be predicted precisely, so a range of plausible futures are considered to study how sensitive systems are to these changes. In general, researchers predict accelerating impacts from the early decades of the current century to the later decades. Thus water managers must anticipate more substantial changes with the passing decades.

Tacoma industrial area

Water Needs of Large Industries

The Tacoma and Pierce County economy has historically included a mix of government, service sector, and industrial employment. While industrial activity has undergone major changes since the 1980s, this sector remains a healthy contributor to the region's employment base and household income.

Tacoma Water's largest single customer is located in Tacoma's Tideflats area, and has reduced its water consumption by 50% (from 32 MGD to 16 MGD) since the 1980s. Current use represents one third of Tacoma Water's total demand. Tacoma Water serves a variety of other industrial facilities within Tacoma and its neighboring communities, and occasionally receives inquiries from other industrial enterprises seeking to locate facilities within the Tacoma Water service area. From a long-range planning perspective, Tacoma Water seeks to maintain sufficient capacity in its supply system to allow businesses conforming to local land use requirements to locate within the service area.

The Integrated Resource Plan addresses potential future needs for large increments of supply by monitoring the surplus quantity of water above projected demands; water that could be made available for large new users entering the regional economy. At the same time, Tacoma Water will monitor plans by existing large users, and the implications that their service poses for water supply. Large changes in industrial needs could require substantial system adjustments with associated financial implications.

Time Oil Superfund Site

Time Oil was a business enterprise that handled bulk oil at a site in south Tacoma for several decades during the mid-20th century. Business operations at this site left a legacy of soil and groundwater contamination, including migration of contaminated groundwater offsite, impacting a large area beneath the city. In the 1980s the U.S. Environmental Protection Agency (EPA) took over management of the site, under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) commonly known as "Superfund."

The plume of contaminated ground water originating at the Time Oil Superfund site affects aquifers underlying the South Tacoma Wellfield. Therefore effective containment and clean-up of the Time Oil plume is in the best interest of the City of Tacoma. Tacoma currently operates an air-stripping tower at its Well 12A to remove contamination from groundwater pumped from this particular well. In addition, pumping at well 12A helps to keep the plume from spreading south to other, larger Tacoma Water production wells.

Tacoma Water plans future increases in pumping rates to maximize the use of water rights from this resource. Both current production and future increased production could be compromised, or could involve long-term costs for water treatment, if the Time Oil site is not cleaned up effectively. Therefore this has been identified as a significant issue for the long-term capacity of Tacoma Water's supply system.

Well 12A air stripping at Time Oil Superfund site

Tacoma Water closely monitors cleanup actions and plans by EPA and its contractors at the Time Oil Site. Cleanup has been under way for years and will take still more years to complete to permanently preserve the South Tacoma Wellfield as a vital source of supply.

Seismic Risk

Tacoma and Pierce County lie on a fault zone that has seen significant earthquakes with a return period measured in the low thousands of years. The entire coastal Northwest faces additional and more frequent risks from earthquakes along the Cascadia subduction zone. Tacoma Water has partnered with other water systems in King, Pierce and Snohomish counties to assess regional seismic risks, and has also undertaken its own seismic vulnerability assessment.

While the Integrated Resource Plan does not directly address seismic risks, the actions recommended here overlap and interact with actions the utility has taken or may take in the future to manage water-supply risks to its customers and potential damage to its infrastructure from major earthquakes.

Downtown Tacoma

Population and Economic Growth

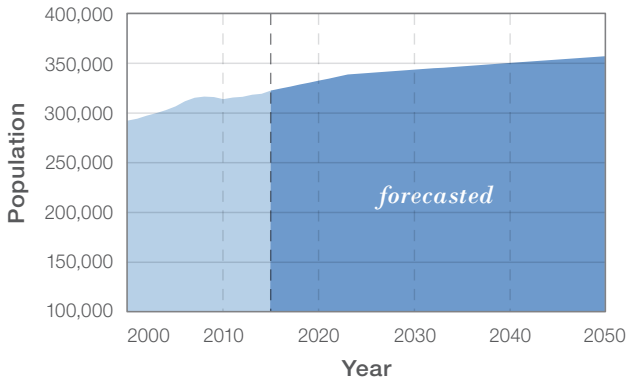
Except for the downturn caused by the 2008 financial crisis, the Puget Sound region has been growing rapidly for three decades. The emergence and global presence of leading technology-sector businesses, the continued strength of Boeing in aeronautics, an increasingly active U.S. military in the years following 2001, ports supporting agricultural trade, and the region's lifestyle attractions have all contributed to growth. Within Tacoma, WestRock Pulp and Paper Mill remains a vibrant economic presence, along with other major employers such as the University of Washington – Tacoma.

Despite these trends, the future can never be predicted with certainty. Water planners must account for either increased growth or slower growth in the coming decades.

Fig 2.6

Service Area Population Growth

2015 demand forecast long-term model



Factors that may affect growth in Pierce County specifically during the coming years and decades include:

Housing Affordability: Housing prices in Seattle and King County have risen rapidly, making Pierce County communities more affordable in comparison. Workers employed in King County may increasingly choose to live in Tacoma, particularly as public transport is improved, such as the planned light rail extension from SeaTac Airport south.

Business Opportunities and Competitiveness: Large businesses may choose to put operations or headquarters in Tacoma where property values and wage rates relative to King County can help their competitiveness. Conversely, large employers could choose to leave the region due to competitive pressures.

Joint Base Lewis-McChord (JBLM): JBLM is a large military base south of Tacoma. Due to its size and proximity, it has significant influence on the economy and population of Pierce and adjoining counties. This includes military and civilian employees working at the base, as well as service industries, school districts, and other employers that meet the needs of JBLM employees and their families.

Future changes in the scale or nature of U.S. military operations or Pentagon redirection in the distribution of personnel across the U.S. could either increase or reduce the number of personnel stationed at JBLM. This would affect the population and economic activity throughout Tacoma Water's service area.

Technology

New technologies are improving water system operational efficiencies and facilitating customer water conservation. Water-efficient technology, in concert with other best-management practices, has contributed to reducing total demands in utilities all over the country, even in regions experiencing rapid population growth.

The effects on water use can be measured in two ways: the quantity of water use reduction from a single action, and the trend towards "saturation" of a given water-saving technology across the customer base. Water savings can be multiplied when many or most customers adapt them. However, the public's adoption of new technologies or water-saving behaviors is not automatic.

technology for water utilities

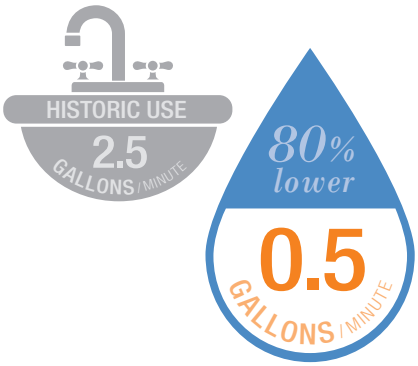
Advances in water system technology have improved system monitoring, maintenance procedures, and conservation. An emerging technology numerous water utilities are implementing is automated metering infrastructure (AMI). AMI allows real-time monitoring of water deliveries and is useful for detecting abnormal water use patterns (often indicative of a leak). This allows customers and the water utility to work together in solving problems. AMI can also enable dynamic pricing to support demand management efforts, if needed in the future. Tacoma Water currently has plans to convert the entire metering system to AMI by 2021.

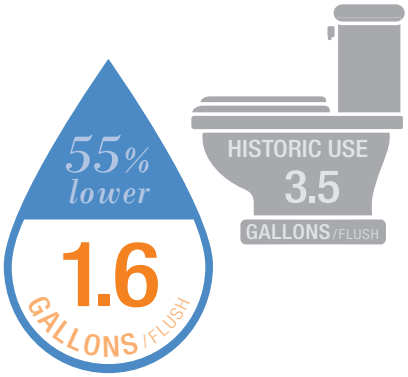
On another front, technology for finding and fixing leaks in water distribution mains and large-diameter transmission pipelines is constantly evolving. Tacoma's ongoing program to find and fix leaks is expected to continue producing water savings.

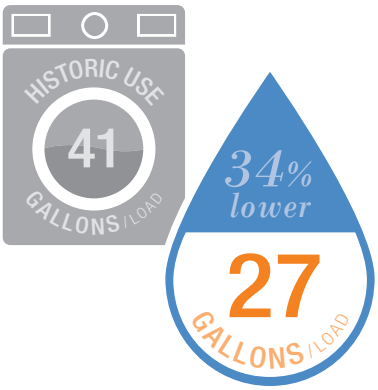
technology for customers

Customers can install high-efficiency water fixtures in their houses such as low flow showerheads, faucets, and toilets. Efficient fixtures have the same effectiveness as normal fixtures but use less water per minute. Fixtures are a one-time installation and provide year-round savings. During the peak season, weather-sensors, soil-moisture sensors, and irrigation controllers can monitor rain and soil conditions and adjust lawn watering times accordingly, to reduce water use. In addition, customers can adopt new "norms" of landscaping practice, moving away from irrigation-reliant vegetation to plants and hardscape materials that do not require supplemental irrigation and yet look attractive year round.

As available technology is implemented, new breakthroughs may occur, creating opportunities for even more conservation savings.







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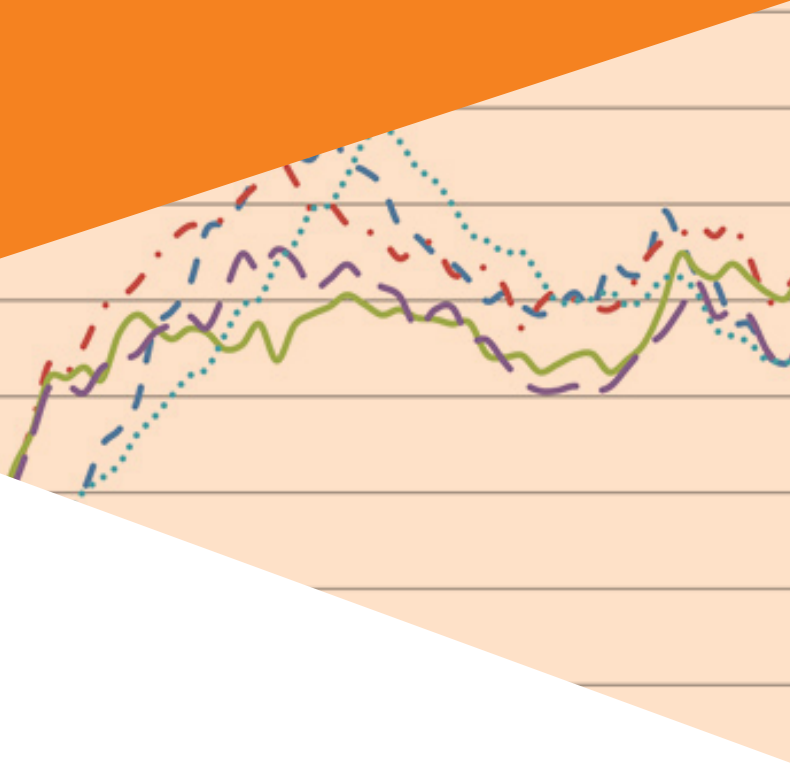


ANALYTICAL TOOLS

Forecast of Water Demand

A demand forecast prepared by Tacoma Water economists in 2015 examined growth patterns among different categories of water demand. Econometric methods based on regression techniques were used in the forecast. Short-term demand was forecasted 10 years out (2024) to support financial management of the utility. Long-term demand was forecasted 60 years out (2073).

Water demand was forecasted using predicted trends in the number of accounts and households from Pierce County's Coordinated Water System Plan. Tacoma Water's analysts made assumptions about the future application of water conservation programming. As a result, per-capita demands are forecasted to continue falling.

Weather variables were also used in the regression analysis. Separate forecasts were then prepared for large-volume commercial, industrial and wholesale customers. After 2024, these latter demands were held constant in the long-term forecast.

This process generated a "Most Likely Forecast" that was used as a key input to the Integrated Resource Plan. Other growth scenarios were modeled as adjustments to the Most Likely Forecast. *For more information, see the Tacoma Water 2015 Demand Forecast Report.*

Fig 3.1

Per-Capita Demand

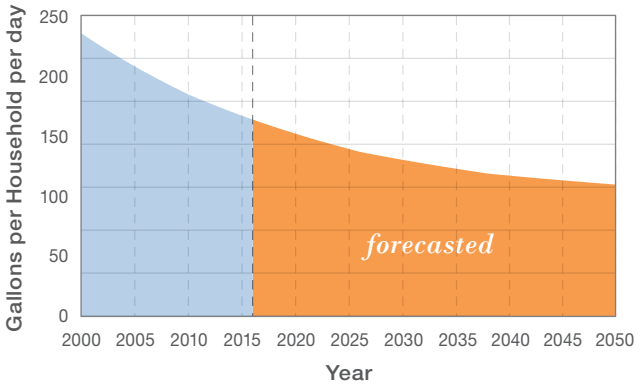


Fig 3.2

Total Customer Demand

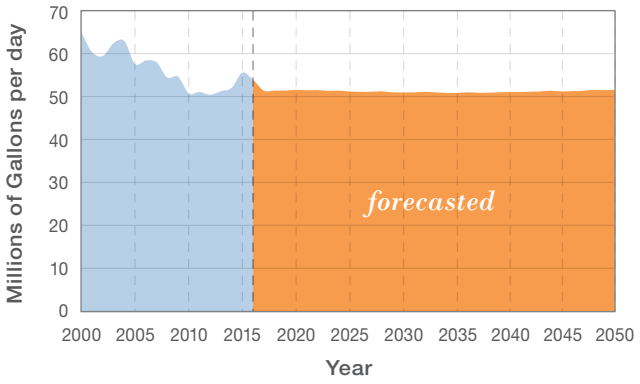
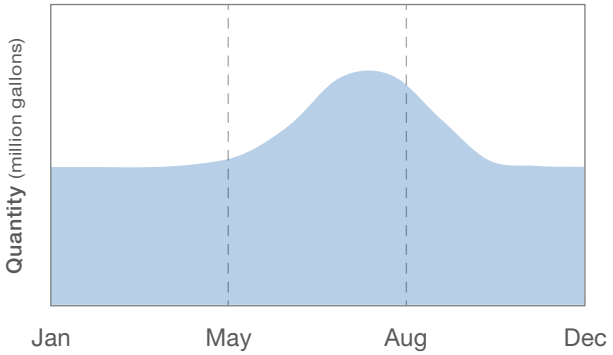


Fig 3.3

Seasonal Water Demand



Climate models

Climate scientists have developed complex global circulation models of Earth's climate systems, which have been combined with assumptions about the impacts of future human activity on greenhouse gas production to simulate world-wide temperatures and precipitation in the future. Global climate model results can be downscaled and applied to a watershed hydrology model to predict future weather and streamflows for a range of climate change scenarios.

Tacoma Water considered multiple global circulation models described in the most recent assessment of world climate projections by the Intergovernmental Panel on Climate Change. All global circulation models considered used the RCP 8.5 greenhouse gas emission pattern, which assumes emission rates continuing to follow recent trends through the end of the 21st century. Through guidance from climate experts and other large, neighboring utilities,

SCENARIO	PERCENT OF DEMAND
Historic/Pre-Climate Change	89%
Future/Climate Change*	65%

* 'Most likely' scenario from p. 27, using climate conditions in the 2050's.

Table 3.3 Median Water Supply Provided by the Green River

Tacoma Water considered five climate change scenarios that represent a range of future moisture and temperature conditions. The University of Washington Climate Impacts Group, in conjunction with King County, developed a set of downscaled climate-impacted hydrologic data for the Green River watershed, based on the selected climate scenarios. The scenarios selected for model application are described in the Planning Scenarios section.

Planning Scenarios

Tacoma Water convened a workshop in September 2017 with the IRP Public Advisory Committee. The workshop engaged this group in a wide-ranging discussion of future trends and developments that could affect water supplies and demands.

Planning scenarios consolidate and quantify speculations about future changes. This opens the door for modeling and informed decision making.

Three key factors emerged from the workshop that could affect Tacoma's water supplies and water needs:

- Higher or lower rates of population growth and economic development.
- Technological changes and different levels of customer participation in water conservation programs.
- Moderate versus more severe changes in western Washington's climate.

To develop this Integrated Resource Plan, Tacoma Water defined three scenarios using these factors. The scenarios extend for the planning period selected for the Integrated Resource Plan, which runs through year 2037. The scenarios span a range of future supply and demand conditions used in evaluating needs for new supply resources.

Scenarios used in the WYSDM simulations

\+ increases demand − decreases demand

PLANNING SCENARIO	POPULATION	TECHNOLOGY	CLIMATE CHANGE
Most-likely	+	-	+
Most-stressed	+++	-	+++
Least-stressed	+	---	+

most-likely scenario

The most-likely scenario represents an extension of the status quo: the trends of the recent past will continue through 2037. The trends are laid out in Tacoma Water's 2015 demand forecast described above.

- Population will grow at the rate developed in the 2015 forecast, slowing gradually over time as buildable land is used up. The buildout population is consistent with Pierce County's Coordinated Water System Plan (CWSP) and Regional Supplement (2001).
- Water use per household will continue to decrease as a result of water conservation programs. The rate of water savings will be greatest in the earlier years and will slow down in the later years of the forecast. This will offset population growth such that demand will actually decline slightly from recent levels.
- Wholesale customers will experience a slight decrease in demand to year 2024 and this demand is held constant after 2025.
- Large commercial customers (not including the largest industrial customer) will experience a slight increase in demand to year 2024 and this demand is held constant after 2025.
- The largest industrial customer's demand is held constant over the entire planning period at a level of 16 MGD which was the plant's usage in 2014.
- There will be moderate changes in climate on the west side of the Cascade Range through the decades to come, which will slightly reduce water production and increase the frequency of droughts.

most-stressed scenario

The most-stressed scenario includes increased economic activity and more growth in the Tacoma service area.

- Population will increase at twice the annual growth rate used in the most-likely scenario. As with the most-likely scenario, the increase will slow down over time. Buildout limitations were not explicitly imposed.
- Water use per household will continue to decrease over time due to conservation, as in the most-likely scenario.
- The climate in future decades will be warmer and drier than in the most-likely scenario.
- Water needs of large commercial customers, wholesale customers, and the largest industrial customer are the same as in the most-likely scenario.

least-stressed scenario

The least stressed future scenario considers how new improvements in water conservation participation or technology would reduce demands compared with the most-likely scenario.

- Population will grow at the same rate as the most-likely scenario.
- Improvements in technology and increased customer acceptance of conservation programs will produce larger water savings, faster.
- Climate change is the same as in the most-likely scenario.
- Water needs of large commercial customers, wholesale customers, and the largest industrial customer are the same as in the most-likely scenario.

RESOURCE ADEQUACY STANDARD

Water 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.

Resource Adequacy Standard

For purposes of developing this Integrated Resource Plan, Tacoma Water developed a Resource Adequacy Standard (RAS). The RAS is a basis for determining whether water supplies will remain sufficient to meet service area demands, including annual variations and future growth and development.

The RAS is a fixed measure of system performance that can be applied over a range of natural hydrologic conditions, assumptions on growth rates, and improvements to the supply system. The WYSDM model described later in this section provides a means for testing Tacoma Water's supply system against the standard.

In the event the standard cannot be met, there are a range of possible measures that could be taken. These include demand-side measures to hold demand within supply limits, operational changes in how stored water is managed, and/or capital projects to add new supplies or increase storage capacity. All of these responses are considered in this Integrated Resource Plan.

The RAS recognizes that occasional curtailment of water use is one of the standard responses available within the community's "toolkit" for managing droughts. This is more practical and cost-effective than building a system that would be immune to any possibility of water shortage.

WYSDM Model

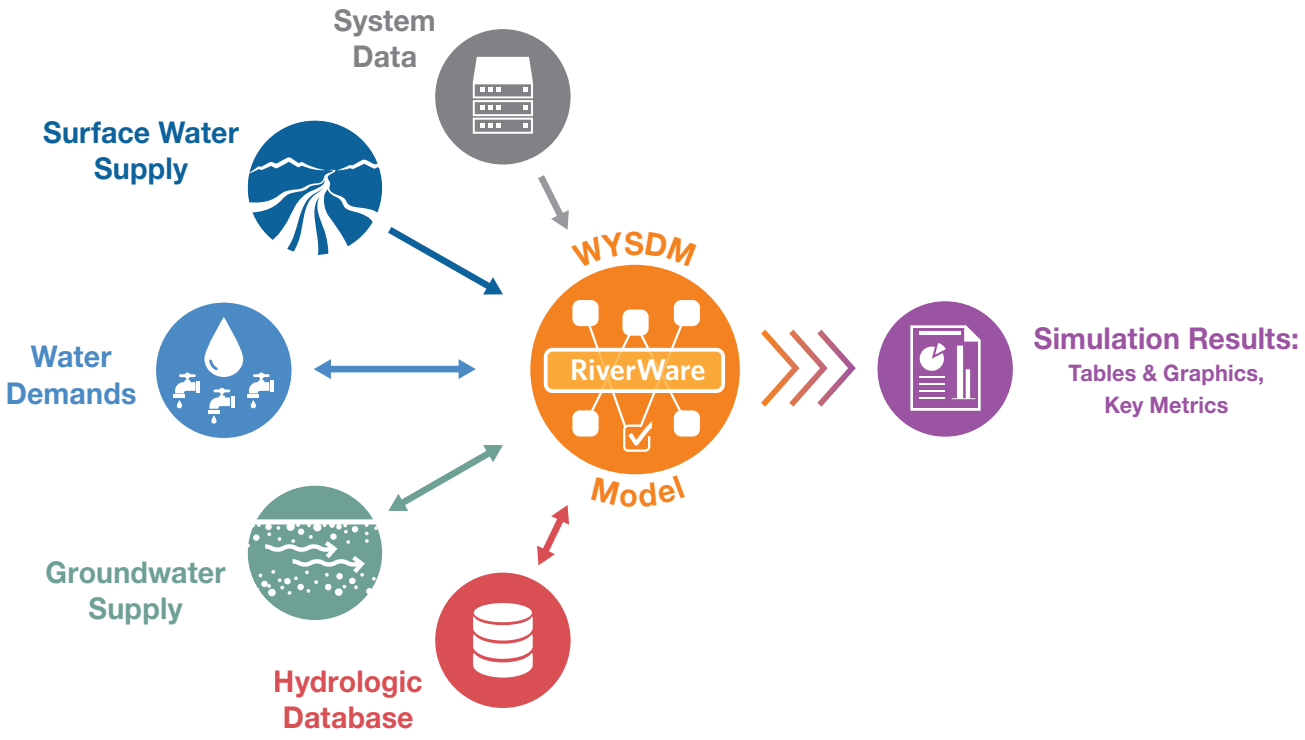
Tacoma Water developed a computer model called the Water Yield, Supply, and Demand Model (WYSDM) as the primary tool for analyzing reliability of the water supply system. WYSDM allows Tacoma Water to evaluate water supply reliability under a wide range of conditions, predict the effects of future operations on supply reliability, and test ways to improve reliability. The modeling software enables Tacoma Water to make refinements and adjustments over time, as water supplies, demands and other conditions change.

WYSDM simulates key physical and operational features of the Tacoma Water system to estimate the ability to meet demands on the system. These include:

Physical Features: Physical components of the system include Eagle Gorge Reservoir (the seasonally impounded lake behind Howard Hanson Dam), local inflows upstream of the Auburn gage, Tacoma's various wells, the Green River Filtration Facility, and major water transmission pipelines (see Figures 1.1 and 1.2). Delivery points to wholesale customers and Second Supply Project Partners are included. Hydrologic and climate characteristics are also represented in the model.

Operational Features: Operational features are modeled to represent how water is stored, diverted, and transferred to Tacoma Water's retail and wholesale customers or Second Supply Project Partners. Operational components include the legal framework under which Tacoma Water operates including water rights, Howard Hanson Dam operational constraints, and required stream flows in the Green River under the agreements described previously.

Water Demand: The model includes representations of demand, based on output from Tacoma Water's econometric demand model.



modeling uncertainty

Tacoma Water and many other water purveyors have historically used deterministic models (without statistical variation in supply or demand characteristics over time) to inform management decisions. Deterministic modeling is useful in generating information about specific supply or demand predictions. For example, it can be used to test system performance against a specific, worst-case scenario.

However, system variables that control supply and demand, such as rainfall, stream flow, and wholesale customer demand, are uncertain and vary from year to year. There are a range of possibilities each system variable may exhibit year-to-year, and not all possibilities are equally likely to occur. Therefore, WSDYM allows the water supply system to be tested under a wide range of conditions. The model can be run deterministically, but also provides options for statistical analysis of variable conditions.

The WYSDM model's database includes approximately 100 years of historical streamflow and meteorology data. This time period is too short to produce reliable answers regarding the statistical probabilities of low frequency hydrologic conditions occurring, such as a 1 in 50 year drought. To improve the reliability of the model-generated frequencies of rare events, HDR developed 1,000 year streamflow and meteorology data sets using a statistical technique called Autoregressive Moving Average Methodology. This larger, synthetic dataset can produce more reliable probabilities for rare hydrologic conditions, such as very low flows in the Green River.

anticipated uses of WYSDM

WYSDM is a flexible tool that can be used in two distinct modes to answer questions about long-term capacity or short-term management options.

Long-Term Capacity Planning:

WYSDM can use scenarios to examine how changes in future decades could alter the balance between water supplies and customer demand. Scenario simulations help to identify conditions under which the Resource Adequacy Standard may not be met, and point towards the need for additional supplies, reduced demand, or changes in operational practices. Scenario runs can also help to quantify the magnitude of shortages, and the approximate timeline for when shortages might begin occurring. With this information in hand, Tacoma Water can make better-informed plans for the future.

Short-Term Management Options:

WYSDM can also be used within a single year to monitor system performance and explore the effects of operational decisions made from month to month (or day to day). Tacoma Water's analysts can input current system conditions and simulate end-of-year outcomes based on a range of climate conditions that have occurred in past years. The user can also test different operational decisions and select the ones with the best outcomes. This will allow water shortage response to be better informed and quantified and avoid excess focus on unlikely combinations of conditions.

firm yield

Water systems commonly use "firm yield" to measure the quantity of water they can produce with high reliability. 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 twenty-five years on average. Tacoma Water's firm yield is 107 MGD. The includes water available for Tacoma Water's direct retail customers, wholesale customers, and Second Supply Project Partners.

application to the integrated resource plan

To develop this Integrated Resource Plan, Tacoma Water simulated each of the three scenarios described previously, and tested whether current facilities would be sufficient to meet the Resource Adequacy Standard. Tacoma Water then used WYSDM to assess how different projects or programs would perform to overcome any deficiencies. The simulation results are presented later in this plan.

4

RESULTS, CONCLUSIONS AND PATH FORWARD

Resource Performance

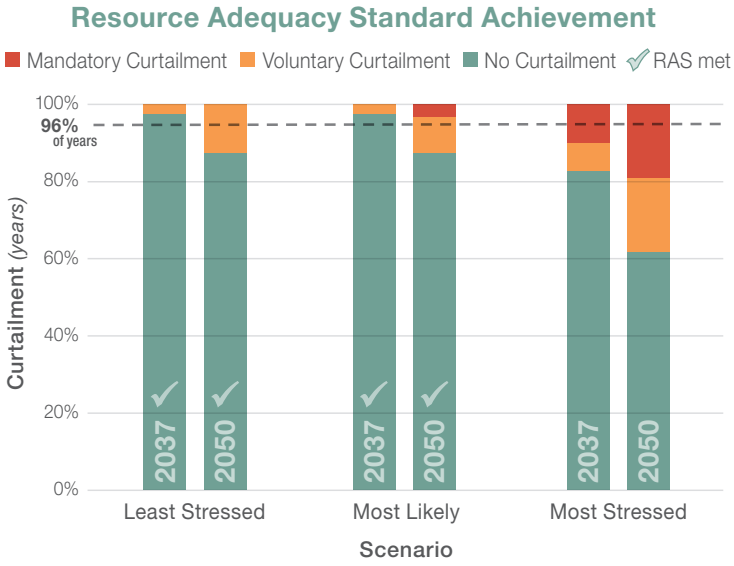
Tacoma Water used outputs from WYSDM to assess system reliability and to examine the effects of alternate supply solutions on reliability in the future. Selected model outputs pertinent to the IRP include:

- Number of voluntary curtailments expected in any 25-year period
- Number of mandatory curtailments expected in that time frame (values of once in 25 years or less achieve the Resource Adequacy Standard)
- Groundwater pumping rate as a percent of total groundwater rights

The three planning scenarios described previously were run through the model using population and climate change patterns expected by year 2037, as well as the year 2050. Figure 4.1 illustrates the relative proportions of years with curtailment. In Figures 4.1 and 4.2, the green portion of the bars represents years when no curtailment is needed. The orange portion represents voluntary curtailment (to offset a minor water shortage) and the red portion represents mandatory curtailment (to offset a significant shortage). The dashed line at 96 percent represents a long-term average of 24 out of 25 years. Mandatory curtailments (red) occuring less than once in 25 years remain above that line, indicating that RAS is achieved. Mandatory curtailments (red) occuring more than once in 25 years extend below the line and indicate the RAS was not achieved. Voluntary curtailments (orange) are also shown. If voluntary curtailments occur too frequently, they could cause some customers to become dissatisfied, or may become ineffective. Table 4.1 summarizes the relevant WYSDM outputs for the three planning scenarios.

The results indicate that, in both year 2037 and 2050, water resources will be adequate in all but the most stressed conditions. Under the most stressed conditions in 2050, the RAS would not be achieved.

Figure 4.1 Potential for failure of resource adequacy standard



	Least-Stressed	Most-Likely	Most-Stressed
Number of voluntary curtailments *(out of 25 years)*	<1	<1	2
	3	2	5
Number of mandatory curtailments *(out of 25 years)*	0	0	3
	0	<1	5
Is the RAS met?	Yes	Yes	No
	Yes	Yes	No
Percent of groundwater rights utilized	50%	55%	60%
	60%	60%	70%

Number of curtailments represents the long-term average, standardized to the expected frequency in any 25-year period.

Table 4.1 WYSDM outputs for planning scenarios

unutilized water

Tacoma Water's water rights are infrequently used to its full allowance. For example, a large quantity of winter flows are not utilized due to lower winter demands. During flood control operations at Howard Hanson Dam, the reservoir pool is kept low so that if large storms occur, the reservoir can be filled up to minimize flood conditions downstream. While the pool level is held down, water cannot be stored for later use. This is referred to as "unutilized water."

Quantity and timing of unutilized water provides insight into which water supply improvements will be most valuable. The model suggests most curtailments result from lack of storage in the later summer months. Supply solutions that allow for water to remain in storage, or increase the total volume of storage that can be reliably filled, are most likely to improve Tacoma's long term water security.

Alternatives Evaluated

In developing the IRP, Tacoma Water considered a range of alternative solutions that could contribute to future reliability of the water system if needed. Alternatives can be grouped in six categories:

- Ground Water Supplies
- Surface Water Supplies
- Storage Facilities
- Interties with Other Systems
- Demand Reduction
- Reclaimed Water

Projects within each category were compiled from prior regional studies conducted by the Water Supply Forum, as well as Tacoma Water's own planning documents. From an initial list of 33 distinct options, Tacoma selected five options for detailed analysis using WYSDM. Factors considered in narrowing the list of alternatives included whether they are already on track for development, the magnitude of expected supply benefits and costs, the expected complexity of implementation, and the degree to which they will contribute to resiliency against drought and climate change.

Alternatives

Develop Full Groundwater Rights	Tacoma's current level of groundwater production falls well within its existing water rights. Using existing wells, Tacoma can currently pump a maximum of 25,000 acre-feet in a year; while the utility's water rights allow for up to 39,000 acre-feet per year. More groundwater could be pumped if Tacoma Water enhanced pumping capacity of its current wells, or added new wells. Increased pumping of groundwater during the spring and early summer would improve the utility's ability to hold surface water in Eagle Gorge Reservoir into the late summer and fall.
OASIS	The Lakehaven Water and Sewer District is developing an aquifer storage and recovery (ASR) program named "Optimizing Aquifer Storage for Increased Supply" or OASIS. During periods of high flows in the winter, Lakehaven plans to divert water from the Green River and pump it into an aquifer below the district. Some of this water could be available to Tacoma Water in the summer to use as an alternative supply, allowing more water to remain in storage in Eagle Gorge Reservoir to satisfy demands in late summer.
Additional Water Supply Project (AWSP) Phase 1 (Howard Hanson Fish Passage)	As mentioned in the "Contractual Relationships" discussion, Tacoma Water and the second supply partners donate half of their municipal pot storage (up to 10,000 acre-feet) to supplement Green River streamflows for fish habitat purposes. Upon construction of fish passage facilities at Howard Hanson Dam in Phase 1 of the AWSP, Tacoma Water and the partners will have the full municipal allotment available for municipal supply purposes, subject to the second supply project water allocations. This will increase water supply for municipal purposes by up to 10,000 acre-feet. However, in water-stressed years where SDWR water is not available for diversion into this storage pot, this additional storage may not be available. Tacoma Water views Phase 1 of the AWSP as a certainty, based on commitments made by USACE. The exact timing, however, remains uncertain.
Additional Water Supply Project (AWSP) Phase 2 (Reservoir Pool Raise)	Following AWSP Phase 1, further permitting and negotiation of AWSP Phase 2 can begin. Phase 2 would raise the pool elevation of Eagle Gorge Reservoir by ten feet, increasing storage capacity by 12,000 acre-feet. Of this, 9,600 acre-feet would be reserved to support stream flow at times to be determined by tribal and resource agencies, and the remaining 2,400 acre-feet would become available to Tacoma Water and its Second Supply Project partners. Various issues such as shoreline protection mitigation measures would need to be resolved as part of Phase 2.
Aggressive Peak Shaving	During hot, dry periods in the summer, residents and businesses use substantial amounts of water for landscape irrigation. This creates a "peak" in demand that must be met with increased supply. The summer peak in demand coincides with seasonal conditions when less rain is falling and natural streamflow declines. Moreover, while rainfall typically increases again in the fall in western Washington, the date of renewed rainfall can vary from September to December in any given year. Tacoma modeled a scenario in which the normal peaking pattern of water demand is sharply reduced. This generates a more modest peak and decreased annual water demand. This demand pattern could allow for water to remain in storage into the late summer. However, it would require substantial changes in turf and landscape design, permanent reductions in residential and commercial irrigation uses within the water service area, and changes in the rate structure.

Model Results for the Alternatives

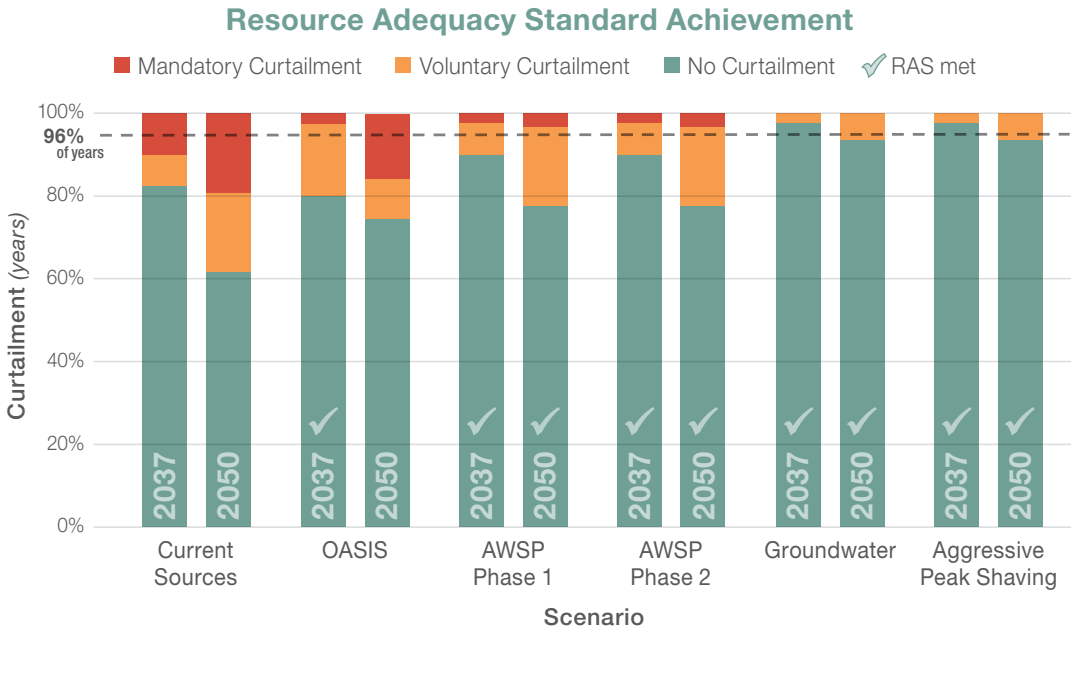
Results from WYSDM simulations indicate that each alternative would improve water supply availability and help Tacoma Water achieve its resource adequacy standard even under the most-stressed planning scenario in year 2037. Figure 4.2 illustrates the relative proportions of years with curtailment, and shows whether the RAS is met in all three scenarios. Table 4.2 provides additional information. These results focus on the most-stressed scenario because only that scenario did not achieve the RAS in the pre-solution runs.

The results for 2037 show:

- Both development of full groundwater rights and aggressive peak shaving would result in no mandatory curtailments and rare voluntary curtailments.
- The AWSP (both phases) would see both voluntary and mandatory curtailments, but at a rate consistent with RAS achievement.
- The OASIS project would result in a modest frequency of voluntary curtailment events; mandatory curtailments will still be infrequent enough to achieve the RAS.

The results for the 2050 runs show similar curtailment patterns as the 2037 model runs for each solution, but with higher curtailment rates. In the most-stressed scenario, all solutions will see modest rates of voluntary curtailment. The AWSP would result in infrequent mandatory curtailments but within the range of resource adequacy. If OASIS were the only solution used, Tacoma Water would not achieve resource adequacy in 2050 under the most stressed conditions.

Figure 4.2 Performance of alternatives under the "most-stressed" scenario



	Current Sources	OASIS	AWSP Phase 1 *(Howard Hanson Fish Passage)*	AWSP Phase 2 *(Reservoir Pool Raise)*	Develop Full Groundwater Rights	Aggressive Peak Shaving
Number of voluntary curtailments *(out of 25 years)*	2	4	2	2	<1	<1
	5	2	5	5	2	2
Number of mandatory curtailments *(out of 25 years)*	3	<1	<1	<1	0	0
	5	4	<1	<1	0	0
Is the RAS met?	No	Yes	Yes	Yes	Yes	Yes
	No	No	Yes	Yes	Yes	Yes
Percent of groundwater rights utilized	60%	60%	60%	60%	75%	55%
	70%	70%	70%	70%	95%	67%

Table 4.2 WYSDM outputs for resource alternatives in the most-stressed scenario

Resource Strategy and Action Plan

Analysis of Tacoma Water's supply system using WYSDM demonstrates that the system has ample water to meet customer needs under normal conditions. It takes a record drought, such as the one in 2015, to put substantial stress on the system. Furthermore, all five solutions considered would enable Tacoma Water to meet the RAS through 2037, even in the most-stressed scenario. However, in the more distant future, Tacoma Water expects implementation of select alternatives will be necessary to continue meeting its water supply, customer service, and environmental obligations.

water shortage response plan (WSRP)

Tacoma Water maintains a Water Shortage Response Plan, which has been updated in conjunction with this 2018 Integrated Resource Plan. The Water Shortage Response Plan includes specific actions the utility and its customers can take to reduce demands during droughts or other water-supply shortages. This provides policy and the operational guidance for applying water use curtailment as a normal part of Tacoma Water's management practices. Employing curtailment at intervals that are acceptable to the public per the RAS helps to control the overall cost of supplying water, and helps to protect the Green River's aquatic ecosystem during dry years.

additional water supply project

Tacoma Water and the USACE have already agreed to carry out Phase 1 of the AWSP. Tacoma Water will continue to advocate for timely development of the fish passage facilities to be installed by USACE as part of this phase. Tacoma Water expects to receive its SSP share (up to 4,150 acre-feet), of the 10,000 acre-feet potentially available, when Phase 1 of the AWSP has been completed.

develop full groundwater rights

WYSDM outputs show that development of enhanced groundwater sources could significantly improve supply reliability. Tacoma Water owns groundwater rights that are not being fully utilized, and the various aquifers the wells pull from have enough capacity and annual recharge to supply the full groundwater right of approximately 39,000 acre-feet per year.

Multiple projects could improve Tacoma Water's groundwater supply, including well rehabilitation, installation of pumps with larger capacity, and drilling new wells at strategic locations. Tacoma Water needs to conduct more evaluations before deciding which groundwater developments would be most beneficial. These decisions will interact with parallel efforts regarding water treatment for corrosion control, seismic resiliency, and the overall costs of development.

aggressive peak shaving

The WYSDM results in tables 4.1 and 4.2 indicate that imposing aggressive peak shaving would have the same effect on frequency of curtailments as developing new groundwater wells.

action plan

In the near term, Tacoma Water will undertake improvements to enable its existing groundwater supplies to provide optimal production and reliability. Over the longer term, the groundwater improvements will be coupled with more aggressive peak shaving strategies used conjunctively to achieve multiple benefits. The basis for this approach includes:

- The proposed groundwater system improvements can use existing water rights and leverage existing facilities. Changes to the groundwater system can be carried out in phases to match changing conditions, enabling costs to be spread over time.
- Improvement of groundwater supplies offers significant benefits for seismic resiliency in addition to drought resiliency.
- The utility recently adopted a new conservation goal that targets peak season water-use reductions.
- In the near term, customers have an expectation that they will be able to irrigate their existing landscapes. Transitioning to a peak-demand cap will involve substantial costs to replace existing turf and other landscape materials. This can be achieved best using a planned approach over time, in collaboration with customers and the communities Tacoma Water serves.

The resource landscape will change in the future. Tacoma Water plans to revisit the IRP process periodically to ensure it is always using the most relevant information for long-term planning, and keep a regular schedule for updating next steps to maintain resource adequacy.

cost considerations

Costs of supply alternatives will be weighed carefully in applying this resource strategy. As a next step, Tacoma Water will evaluate a range of alternatives for augmenting its groundwater production, seeking the most cost-effective combination of demand management, well production, water treatment and delivery to meet resource goals as well as other objectives. Contributions from the federal government's implementation of the Additional Water Supply Project will also be taken into account. Since additional groundwater production will address longer-term needs, investment in these facilities can be phased over time. Decisions on new capital investments will undergo the same, rigorous process of evaluation and decision-making as other capital projects.

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