Existing Conditions Report

April 2020

Clean Water Plan

Making the right investments at the right time

King County
Department of Natural Resources and Parks
Wastewater Treatment Division

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Alternative Formats Available

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List of Abbreviations and Acronyms

°F	degree(s) Fahrenheit
AMP	asset management plan
BOD	biochemical oxygen demand
Brightwater	Brightwater Treatment Plant
Carnation	Carnation Treatment Plant
CDC	Centers for Disease Control and Prevention
CECs	contaminants of emerging concern
County	King County
CPI	Consumer Price Index
CSI	Conveyance System Improvement
CSO	combined sewer overflow
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ETS	effluent transfer system
GHG	greenhouse gas
GSI	green stormwater infrastructure
HPO	high-purity oxygen
I/I	infiltration and inflow
LEED	Leadership in Energy and Environmental Design
MBR	membrane bioreactor
MGD	million gallons per day
MS4	Municipal Separate Storm Sewer System
MTCA	Model Toxics Control Act
NPDES	National Pollutant Discharge Elimination System
O&M	operations and maintenance
PAH	polycyclic aromatic hydrocarbon
PBDE	polybrominated diphenyl ether
PCB	polychlorinated biphenyl
Plan	Clean Water Plan
PSE	Puget Sound Energy
PUMA	Public Use Microdata Area
RWSP	Regional Wastewater Services Plan
SAMP	Strategic Asset Management Plan
SCAP	Strategic Climate Action Plan
SCL	Seattle City Light
SLR	sea level rise
SMS	sediment management standards
SPU	Seattle Public Utilities
South Plant	South Treatment Plant
SVI	Social Vulnerability Index
TAIP	Technology Assessment and Innovation Program
TMDL	total maximum daily load
TSS	total suspended solids
Vashon	Vashon Treatment Plant
WAC	Washington Administrative Code
West Point	West Point Treatment Plant
WTD	Wastewater Treatment Division
WWTS	wet weather treatment station

Glossary of Terms

Term	Definition
activated sludge	A biological wastewater treatment process in which sludge is recycled from the end of the process to the beginning to maintain a healthy microbial population. The activated sludge process requires a reactor (see “aeration basin”), settling stage for removing solid material (sludge), and internal recycle stream that returns sludge to the reactor.
aeration basin	A tank of pond air or oxygen used to contain and treat wastewater.
air deposition	The process by which pollution in the air settles onto or into nearby land and water.
anaerobic digestion	The biological degradation of organic matter in the absence of oxygen.
asset management	The process by which utilities manage their infrastructure, facility, and equipment assets. Utilities typically use asset management tools to store detailed asset inventories (pipes, structures, machinery); identify critical assets (probability and consequence of failure); manage facility maintenance; and improve capital decision-making (repair and replacement planning, asset whole-life cost optimization).
biochemical oxygen demand	A measure of the quantity of oxygen used by microorganisms to break down pollutants in water or wastewater.
biosolids	A primarily organic product produced from the wastewater treatment plant process that can be beneficially recycled.
Class A biosolids	The U.S. Environmental Protection Agency’s designation for biosolids that have been treated to reduce pathogens to below detectable levels. Federal regulations require this level of quality for biosolids that are sold or given away in a bag or other container or applied to lawns or home gardens.
Class A reclaimed water	The Washington State Department of Ecology designation for reclaimed water that, at a minimum, is at all times an oxidized, coagulated, filtered, and disinfected wastewater.
Class B biosolids	The U.S. Environmental Protection Agency’s designation for high-quality biosolids that have been treated to significantly reduce pathogens to levels that are safe for beneficial use in land application. Federal regulations require site management, crop harvest, and access restrictions when biosolids of this quality are land-applied.
contaminants of emerging concern	Chemical pollutants that may be discharged to surface waters, but that, to date, are unregulated. Contaminants of emerging concern include pharmaceuticals and personal care products, among other substances.
Clean Water Act	Enacted in 1972, the primary federal law in the United States responsible for regulating water quality.
climate change	A change in global or regional climate patterns; in particular, a change apparent from the mid to late 20th century onward and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels.
cogeneration	The concurrent production of power and heat from the same source.
combined sewer overflow	Discharge into water bodies by combined sewer systems designed to collect both stormwater and wastewater. Combined sewer overflows are comprised of approximately 10% wastewater and 90% stormwater, and occur during times of high flow caused by heavy rain or snowmelt.
digester	A tank used to contain and treat solid materials during the wastewater treatment process.
effluent	The treated water discharged from a wastewater treatment plant.

Term	Definition
flows and loads	The amount of liquid (flows) and solid material (loads) received by a sewer system or wastewater treatment plant. Capacity constraints are determined by a plant's flow and loading.
grit removal	A process used to remove sand, silt, and grit from water. Grit (and sand) removal is often found in the headworks of wastewater treatment plants.
headwaters	A tributary stream of a river close to or forming part of its source.
infiltration	Groundwater that enters a sewer system through cracks or leaks in pipes, often in old or damaged pipes.
inflow	Stormwater that enters a sewer system through direct connections. Examples include sump pumps, roof drains, yard drains, and leaky maintenance hole covers.
infiltration/inflow	The combined measure of infiltration and inflow; groundwater and stormwater that enters a sewer system through leaks and cracks in, and direct connections to, the sewer system.
known organic toxins	A vast suite of chemicals (for example, pesticides, polychlorinated biphenyls, solvents, and so on) that have been identified and monitored for many years and can be toxic to human and aquatic life.
Municipal Separate Storm Sewer System (MS4)	A Municipal Separate Storm Sewer System (MS4) is a collection of pipes and facilities designed to gather stormwater in urbanized areas and discharge it into local streams and rivers to minimize flooding during storm events. MS4 facilities can also be designed to reduce the amount of pollutants carried by stormwater, and to store or infiltrate stormwater to reduce the adverse impacts that high peak storm flows can have on natural systems. MS4s operate under a National Pollutant Discharge Elimination System permit. The U.S. Environmental Protection Agency oversees the MS4 program as the federal agency charged with implementing the Clean Water Act.
National Pollutant Discharge Elimination System	Instituted as part of the Clean Water Act, a permit program that controls water pollution by regulating point sources that discharge pollutants into U.S. waters.
operations and maintenance	The decisions and actions regarding the control and upkeep of property and equipment to maintain the desired quality and quantity of treated water.
pathogens	Microorganisms that can cause disease in other organisms or humans, animals, and plants. Pathogens include bacteria, viruses, fungi, or parasites found in sewage, in runoff from farms or city streets, and in water used for recreational activities such as swimming.
pollution pathways	Pollution pathways, also called "pollutant pathways," determine how pollutants travel from their source to a water body. Most pollutants entering surface water in King County travel through one of four pathways: wastewater treatment plant discharge, combined sewer overflow discharge, surface runoff, and air deposition.
primary treatment	Primary treatment of sewage is the removal of floating and settleable solids through sedimentation. Primary clarifiers reduce the content of suspended solids and pollutants embedded in those suspended solids.
regulator structure	A structure that controls the flow of wastewater from two or more input pipes to a single output. Regulators can be used to restrict or halt flow, thus causing wastewater to be stored in the conveyance system until it can be handled by the treatment plant.
risk management	Risk management relies on strategies to minimize impacts to customers, the environment, and utility finances that may be caused by failing infrastructure, either due to deterioration or events such as earthquakes. The King County Wastewater Treatment Division uses a mix of risk management strategies for different types of infrastructure.
runoff	Water originating from rainfall and other precipitation that ultimately flows into drainage facilities, rivers, streams, springs, seeps, ponds, lakes, and wetlands as well as shallow groundwater.

Term	Definition
secondary treatment	Secondary treatment of sewage is a biological process to remove dissolved and suspended organic compounds. Secondary treatment typically uses aeration basins followed by settling basins as the second step of treatment (after primary treatment).
source control	The process of finding sources of contaminants, characterizing them, and then taking actions to stop or reduce them before they reach a treatment facility, waterway, or water body.
stormwater	Rainfall or snowmelt that flows over the ground and into collection systems or open water bodies.
sustainability	The long-term viability, health, and robustness of environmental, social, and economic systems.
total suspended solids	Solids in a water or wastewater sample that can be trapped by a filter of a specified size. Total suspended solids are a water quality parameter used in wastewater treatment to assess the quality of a wastewater sample before and after treatment in a wastewater treatment plant.
toxic contaminants	Synthetic or naturally occurring chemical pollutants that are not regulated or typically monitored, but are suspected to be harmful to humans or the environment and include pharmaceuticals and personal care products.
wastewater treatment	A process used to remove contaminants from wastewater or sewage and convert them into an effluent that can be returned to the water cycle with minimum impact to the environment or directly reused. The latter is often referred to as “water reclamation” because treated wastewater can be used for other purposes.
watershed	The areas that drain to surface water bodies, including lakes, rivers, estuaries, wetlands, streams, and the surrouding landscape.
wet weather management	“Wet weather management” refers to the flow of precipitation and runoff into three different collection systems: combined sewer systems, separated storm sewer systems (see “MS4”), and separated sewer systems. The remaining dispersed wet weather flows that enter receiving waters are referred to as “nonpoint flows.”

Executive Summary

King County is facing critical and expensive decisions about future water quality investments it needs to make in the near term, through 2030, and the long term, through 2060. These decisions will have lasting impacts on regional water quality and clean water services for decades to come. The County launched the Clean Water Plan (Plan) in 2019 to determine the Wastewater Treatment Division's (WTD) future plans and address broader wastewater and stormwater water quality concerns. The Plan will ensure King County is making the right investment decisions at the right time for the best water quality outcomes.

This Existing Conditions Report presents an overview of current (or existing) conditions in King County and the Puget Sound region. It is designed to provide a snapshot of regional characteristics, water quality, and clean water services to inform the actions and investment decisions that will ultimately be made under the Plan. After the Plan is developed, it will serve as a lasting resource and formal record of conditions that form the foundation of the Plan.

In essence, the report seeks to answer the following question: Where are we? Knowing where we (the region) currently are in terms of demographics, the economy, water quality, and wastewater infrastructure will help us better determine where we should be going in the future.

In addition to serving as a resource to support development of the Clean Water Plan, the existing conditions report accompanies broader community outreach and engagement efforts that are an essential component of the planning process. Those outreach efforts include running advertising campaigns, advisory groups, community workshops and interviews, and webinars to educate the public about water quality topics and to collect feedback on water quality priorities and issues important to them. The primary goal of these efforts is to create a Clean Water Plan that reflects regional priorities.

The Existing Conditions Report is organized into the following seven sections:

- **1.0, Introduction**, explains the purpose of the Clean Water Plan and lays out key issues facing the region and King County that are driving the actions on water quality investments that will be developed under the Plan.
- **2.0, Regional characteristics**, summarizes the region's Indian tribes and treaty rights; population and demographics; geography, geology, and climate; land use; and economic conditions.
- **3.0, Factors affecting water quality**, gives an overview of the types of pollutants, sources of pollution, and pollution pathways that affect water quality in the region. It also describes the main impacts of water pollution.
- **4.0, Protecting water quality**, outlines regional clean water services and programs, such as wastewater treatment, stormwater management, and combined sewer overflow control, and state and federal regulations that are designed to protect water quality.
- **5.0, Regional water quality**, describes current water quality conditions for each major water body in the central Puget Sound region organized by basin—the Cedar-Sammamish, Green-Duwamish, Snoqualmie, and Central Basin of Puget Sound—in addition to smaller rivers and streams within these basins.

- **6.0, Regional wastewater system and operations**, details King County's wastewater conveyance and treatment system; its treatment plants, operations, and staffing; wet weather treatment; sustainability and climate change; and resource recovery programs.
- **7.0, Maintaining and funding the regional wastewater system,** presents information on asset management of the regional wastewater system, including existing and planned infrastructure improvements, and national and local utility financing.

1.0 Introduction

King County is developing the Clean Water Plan (Plan) to determine future water quality investments from now through 2060. The scope of water quality investments being considered includes wastewater treatment and stormwater.[1] The decisions the County makes now will impact regional water quality and clean water services in the near and long term—and beyond.

This Existing Conditions Report provides relevant information on regional characteristics, current water quality conditions, and clean water services to support development of the Plan. The report lays the foundation for forthcoming actions that will be developed under the Plan. It provides an overview of the current state of the region and is intended to be used as a reference to inform the ultimate decisions of the Plan.

1.1 The Clean Water Plan: purpose and process

King County is facing critical decisions that will shape the scope and focus of water quality investments in the coming decades. These decisions will have both benefits and tradeoffs for regional water quality and public spending. The purpose of the Plan is to proactively guide these future water quality investments so they are made thoughtfully and transparently, and in the best interest of the region.

The Plan is a continuation of over 60 years of regional water quality comprehensive planning to ensure King County meets its responsibilities of providing a resilient clean water enterprise and is prepared for the coming decades. The County's last comprehensive wastewater system plan, the Regional Wastewater Services Plan (RWSP), was approved by King County Council in 1999. The RWSP established King County's plans, programs, and policies for the 2000 to 2030 planning horizon.[2] The Clean Water Plan will amend and update the RWSP.

In developing the Clean Water Plan, King County is committed to a fair and inclusive planning process to deliver the best water quality, economic, social, and health outcomes. Early on in the process, King County sought input from the public through a variety of engagement and outreach activities.[3] As a result of these efforts, the Plan identified a list of community priorities that include protecting the region's waterways, lakes, and Puget Sound; supporting a healthy ecosystem; and furthering equity and social justice. Collectively, these priorities align with the core values held by King County residents of living in a healthy environment and taking an active stewardship role in protecting and preserving that environment for the future.[4] The actions developed under the Plan will take into account these priorities.

[1] Potable or drinking water supply and/or quality are not part of the scope of the Clean Water Plan.

[2] King County Regional Wastewater Services Plan. King County, 2016. https://www.kingcounty.gov/depts/dnrp/wtd/capital-projects/system-planning/regional-wastewater-services-plan.aspx

[3] For more information on public outreach, see the Clean Water Plan 2019 Outreach Summary. https://kingcounty.gov/~/media/depts/dnrp/wtd/capital-projects/system-planning/clean-water-plan/docs/2001_2019-Outreach-Summary-Report.ashx?la=en

[4] Powers, E., 2019. Priorities of Communities. O'Brien360. Prepared for the Trends for Scenario Planning Summary Report.

1.2 Issues facing the region

King County is facing a number of complicated issues as it develops actions for future water quality investments. These issues, which are the underlying drivers of the Plan, encompass broader water quality concerns in the region as they relate to public health, equity and environmental justice, and affordability. Systematically addressing these issues in the Plan will ensure King County is not only on the right track to deliver the best water quality outcomes, but the best economic, social, and health outcomes as well. The key issues are summarized here and further expanded upon throughout subsequent sections of the Existing Conditions Report.

1.2.1 Threats to regional water quality

Since the late 1950s, the region has been working to improve water quality in the area's streams, rivers, lakes, and Central Puget Sound.[5] Although these collective efforts have yielded positive results—including transforming once-polluted Lake Washington into an urban recreational haven for residents and wildlife—challenges remain to improving water quality. For instance, as the region continues to grow, there is more human waste and more impervious surface to deal with, creating polluted runoff that flows into water bodies. The consequences of these challenges have been most visible lately with the region's declining orca and salmon populations. Another consequence is the potential risk to human health of consuming fish and shellfish harvested from polluted King County water bodies. The Plan will explore the environmental outcomes of water quality investments to guide decision-making that results in the greatest overall benefit to the region.

For more information on regional water quality, see Section 3.0, Factors affecting water quality; Section 4.0, Protecting water quality; and Section 5.0, Regional water quality.

1.2.2 An increasing population

King County has experienced steady population growth for decades. According to estimates released by the U.S. Census Bureau in 2019, Seattle is among the top five fastest growing cities in the United States.[6] Population in the King County Wastewater Treatment Division (WTD) service area, in particular, is expected to increase by approximately 629,000 people over the next 30 years. This historical and projected growth trend, coupled with the region's diverse metropolitan economy, suggest that some level of population growth will continue into the foreseeable future. The Washington State Growth Management Act and current regional land use planning call for this growth to largely occur in urban areas, resulting in denser development than what occurred in the 1980s and 1990s. As a result, expanded and/or new wastewater treatment facilities will be needed to accommodate the region's growing population. Determining what treatment plant investments should be made to accommodate this population growth will be a focus of the Clean Water Plan.

For more information on population growth, see Section 2.2, Population and demographics; Section 2.4, Land use; Section 2.5, Economic conditions; Section 3.2.2, Human activities; and Section 6.2, Wastewater treatment.

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[5] History of our mission. King County, 2016. https://www.kingcounty.gov/depts/dnrp/wtd/about/history.aspx

[6] U.S. Census Bureau. https://www.census.gov/newsroom/press-releases/2019/subcounty-population-estimates.html

1.2.3 Rising cost of living

Along with steady population growth, for the past 10 years King County and the surrounding region have experienced steady economic growth. Despite the benefit to the economy, however, that growth has driven the cost of homes and other consumer goods and services in the region even higher. Although incomes in the region have also increased, the increase has not been felt by all residents. For instance, while residents with a bachelor's degree or higher have realized income growth, those with only a high school or limited college education have seen their incomes remain flat. This income disparity impacts the ability of many households to pay monthly bills, including bills for public services such as wastewater treatment. The Plan will consider how future wastewater investments will be paid for equitably, taking into account the socioeconomic diversity of all of the County's residents.

For more information on the rising cost of living, see Section 2.5, Economic conditions, and Section 7.2.6, Affordability.

1.2.4 Aging wastewater treatment infrastructure

King County, like other communities in the United States, has been investing in water pollution control infrastructure for decades to ensure it upholds its fundamental mission of protecting public health and the environment. That infrastructure consists of pipes, facilities, tanks, and other equipment to pump and treat wastewater from the community's homes and businesses. For King County, a signficant amount of this infrastructure was built almost 60 years ago and is beginning to reach the end of its useful life. How and when this aging infrastructure is replaced or rebuilt is a core issue of the Plan. Determining the appropriate level of replacement and redundancy for the County's system is also needed to define the level of investment that should be made to avoid system failures and maintain efficient and resilient operations.

For more information on aging infrastructure, see Section 6.1.1, Combined sewer system; Section 6.1.2, Separated sewer system; Section 6.2.3, Wastewater treatment capacity constraints; and Section 7.1, Asset management.

1.2.5 Meeting current and future regulations

The collection and treatment of wastewater is subject to a number of federal and state regulations. For King County, these regulations are primarily associated with the Clean Water Act as administered by the Washington State Department of Ecology (Ecology).[7] Although the County is meeting current regulations for treating wastewater, there is additional work that must be done to fully comply with combined sewer overflow (CSO) regulations. As King County takes steps toward meeting current regulations, there are discussions simultaneousy underway by regulatory agencies that would require nutrient removal (and, potentially, trace organic compounds removal) at treatment plants. Given the high cost to build and operate technologies to address these potential new requirements, the Plan will take into account the water quality benefits of investments in wastewater and CSO treatment facilities as well as the equitable distribution of these investments.

For more information on regulations, see Section 4.1.3, Combined sewer systems and overflow control; Section 4.2, Federal and state regulations; and Section 6.1.1, Combined sewer system.

[7] Water Quality. Ecology, 2020. https://ecology.wa.gov/About-us/Get-to-know-us/Our-Programs/Water-Quality

1.2.6 Combating climate change

Increasingly warmer air and water temperatures, sea level rise (SLR), and changing precipitation patterns because of climate change will adversely impact water quality in King County and the surrounding region. A combination of SLR and more frequent and intense storm events—as well as periods of drought—are anticipated in the future, which would compromise the County's wastewater treatment infrastructure, particularly its pump stations and CSO facilities. This may mean that improvements to wastewater facilities will be needed just to maintain current water quality. Through its Strategic Climate Action Plan (SCAP) and recovery programs targeting biosolids, biogas, and other resources, King County has already taken steps to reduce greenhouse gas (GHG) emissions and increase the use of renewable resources.[8] As future water quality investments are considered, the Plan will build upon the work the County is doing to confront climate change and support resiliency in communities that are disproportionately impacted by it.

For more information on climate change, see Section 6.4, Sustainability and climate change, and Section 7.1.5, Resiliency and redundancy.

1.2.7 Ensuring healthy communities and healthy habitat

King County is responsible for the protection and restoration of healthy watersheds and the people and salmon—and other native species—that depend on them. For more than 50 years, King County has been protecting public health and the environment by restoring clean water and healthy habitats through land conservation, habitat restoration, wastewater treatment, stormwater management, and cleanup of historical pollution. Most recently, King County's Clean Water Healthy Habitat initiative has formalized these efforts.[9] Even with these efforts, however, orcas remain critically endangered and Puget Sound salmon runs continue to decline. As the region experiences rapid growth, a changing climate, and other issues, the Plan will identify investments that benefit both public health and healthy ecosystems.

For more information related to protecting public health and the environment, see Section 3.4, Impacts of water pollution, and Section 4.0, Protecting water quality.

1.2.8 Advancing equity and social justice

The vision of King County's Equity and Social Justice Strategic Plan, 2016–2022, is "a King County where all people have equitable opportunities to thrive" with a goal of "full and equal access to opportunities, power and resources so all people may achieve their full potential."[10] This vision seeks to address disproportionate and systemic impacts to historically disadvantaged communities in the region such as education and income gaps, gentrification, and increased risks of exposure to pollution. Following the County's blueprint for action outlined in its Equity and Social Justice Strategic Plan, the Clean Water Plan will incorporate equity and social justice considerations in determining the policies, programs, and projects of the Plan. An overarching goal of the Plan is to ensure strategies consider opportunities for improved access to, equitable service of, and equitable pricing for clean water services.

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[8] Strategic Climate Action Plan. King County, 2015. https://your.kingcounty.gov/dnrp/climate/documents/2015_King_County_SCAP-Full_Plan.pdf

[9] Clean Water Healthy Habitat. King County website. https://www.kingcounty.gov/elected/executive/constantine/initiatives/clean-water-healthy-habitat.aspx

[10] Equity and Social Justice Strategic Plan. King County, 2016. https://aqua.kingcounty.gov/dnrp/library/dnrp-directors-office/equity-social-justice/201609-ESJ-SP-FULL.pdf

For more information on equity and social justice, see Section 2.2, Population and demographics; Section 2.4, Land use; Section 2.5, Economic conditions; Section 4.1.5, On-Site Sewage System Program; Section 7.1.2, Renewal of aging infrastructure; Section 7.2.5, Rate structure; and Section 7.2.6, Affordability.

1.2.9 Recycling resources from wastewater

The increased recycling or recovery of resources from wastewater (referred to as "resource recovery") and resource management have become common practice for wastewater treatment utilities around the country, and King County is no exception. The County has a long history of resource recovery dating back to its first regional treatment plant—a practice that aligns with WTD's overall mission of being an innovative clean water enterprise revolutionizing the recovery of valuable resources. Resources recovered from wastewater in King County include water, biosolids, and energy. As the County looks to invest in future water quality infrastructure through the Plan, the level of investment committed to specific resource recovery efforts needs to be balanced and aligned with potential future legislation and regulations and advanced treatment technologies that are often costly and energy- and resource-intensive.

For more information on resource recovery, see Section 4.1.1, Wastewater treatment; Section 6.2.1, Wastewater treatment plants; and Section 6.5, Resource recovery.

1.2.10 Funding for public services

In addition to funding water quality improvements, residents in King County are being asked to help fund other important regional efforts such as transit, roads, stormwater, salmon recovery, and affordable housing through additional rates, fees, and taxes. Consideration of how the combination of these costs affects peoples' livelihoods as the region becomes increasingly more expensive is an important task of the Plan. For example, a survey of local, regional, and state agencies conducted to put the Plan into context with other current and potential programs determined that transportation-related expansions and improvements will represent the largest fraction of spending in the region in the near term. The ability of the region to fund water quality improvements along with the other public services and facilities that are needed will be considered during development of the Clean Water Plan.

For more information on funding for public services, see Section 7.0, Maintaining and funding the regional wastewater system.

2.0 Regional characteristics

King County's residents, geography, and natural environment all contribute to a unique culture diverse in makeup and landscape. Its proximity to large amounts of water, mountains, and agricultural valleys—and its reputation as the epicenter of the Pacific Northwest—are part of what makes the area distinctive and special. This section summarizes key characteristics of King County and the surrounding region, including indigenous tribes and treaty rights, population and demographics, geography and land use, and economic conditions.

2.1 Indian tribes and treaty rights

The land, water, and resources of the Salish Sea basin have comprised the homeland of Coastal Salish people since time immemorial. From 1854 to 1855, representatives of the Salish people of Puget Sound signed the Treaties of Medicine Creek and of Point Elliott with the United States by which they reserved unto themselves homeland reservations and the right to continue to exercise their traditional ways of life in order to meet their subsistence, spiritual, and economic needs. Contemporary descendants of Salish people in the Puget Sound basin have organized themselves into 12 federally recognized Indian tribal governments that occupy 12 homeland reservations, and that exercise traditional lifeways in their usual and accustomed places throughout the basin (see Table 1).

Table 1. Indian tribal governments in the Puget Sound basin		
Tribe	**Homeland reservation**	**Location (in Washington state)**
Lummi Nation	Lummi Reservation	Bellingham
Muckleshoot Indian Tribe	Muckleshoot Reservation	Auburn
Nooksack Indian Tribe	Nooksack Reservation	Deming
Puyallup Tribe of Indians	Puyallup Reservation	Tacoma
Samish Indian Nation	Samish Reservation	Anacortes
Snoqualmie Tribe	Snoqualmie Reservation	Snoqualmie
Squaxin Island Tribe	Squaxin Island Reservation	Shelton
Stillaguamish Tribe of Indians	Stillaguamish Reservation	Arlington
Suquamish Tribe	Port Madison Reservation	Suquamish
Swinomish Indian Tribal Community	Swinomish Reservation	LaConner
Tulalip Tribes	Tulalip Reservation	Tulalip
Upper Skagit Indian Tribe	Skagit Reservation	Sedro Woolley

The Muckleshoot and Snoqualmie Tribes each have a homeland reservation located within King County. The Muckleshoot, Puyallup, Suquamish, and Tulalip Tribes all have federally adjudicated use rights, including fishing rights, within King County. The County recognizes all federally recognized Indian tribal governments as sovereign nations and strives to engage with them in a government-to-government capacity.

Additionally, there is a group of people in King County who are indigenous to the lower Green-Duwamish River basin that have organized themselves into the Duwamish Tribe. Although not federally recognized, King County nonetheless strives to engage in meaningful consultation with the Duwamish Tribe about County actions that impact the land, water, and resources of the lower Green-Duwamish River basin.

2.2 Population and demographics

The Washington State Office of Financial Management publishes annual population estimates for Washington counties and cities. Its estimate of King County's 2018 population is 2,190,200, which comprises nearly 30% of the state's population overall.[11] King County is the largest metropolitan county in the state of Washington in terms of population, number of cities, and employment. It is the 13th most populous county in the United States.

[11] Washington tops 7.5 million residents in 2019. Office of Financial Management, 2019. https://www.ofm.wa.gov/sites/default/files/public/dataresearch/pop/april1/ofm_april1_press_release.pdf

Since 1990, the population of King County has steadily increased (see Figure 1). Seattle, the largest city in King County, is among the top five U.S. cities that experienced the largest population increases between 2017 and 2018, according to population estimates for cities and towns released by the U.S. Census Bureau 2019.[12]

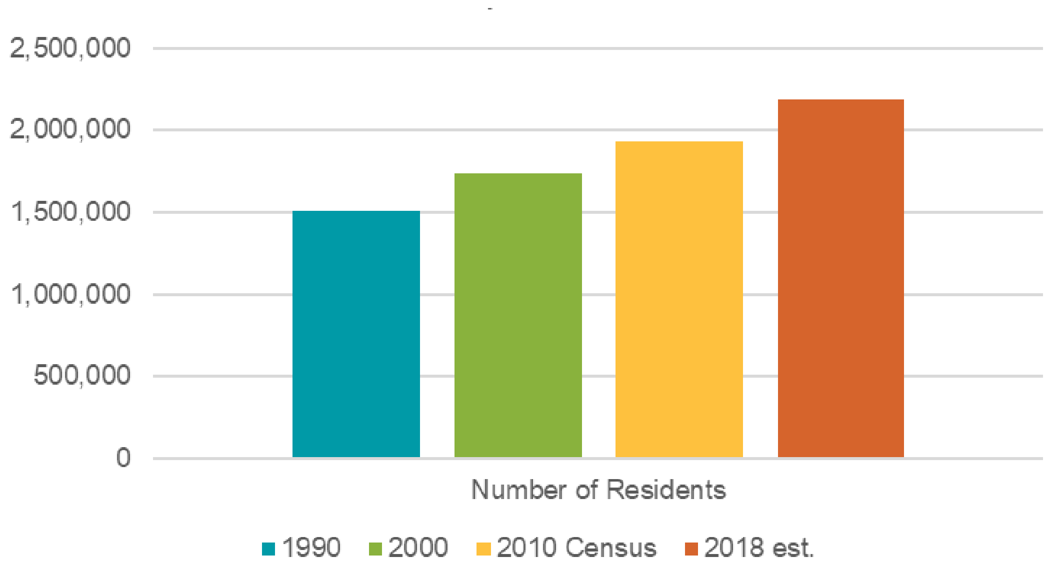

Figure 1. King County population growth

The most recent census data forecasts from the Puget Sound Regional Council project a continuing increase in population in Seattle, King County, and the region overall.[13] In total, the four-county region (King, Kitsap, Pierce, and Snohomish) is expected to grow from a current population of 4.24 million to 5.82 million over the next 30 years, an increase of over 1.58 million people. This equates to an average annual growth rate of 1.09%.

In terms of demographics, as of the 2010 Census, the most recent national census from the U.S. Census Bureau, King County residents are predominantly non-Hispanic white (64.8%), followed by Asian and Pacific Islander (15.2%) and Black or African American (6%). In total, persons of color make up 35.2% of all residents in King County. Additionally, according to the 2010 Census, residents between 25 and 44 years old represent the largest age group in King County (31.6%), followed by residents between 45 and 64 (26.9%), and residents 17 and under (21.4%). Figure 2 shows the graphical breakdown of King County's race and ethnic categories and age structure.

Snohomish County and Pierce County border King County to the north and south, respectively. Population growth in those counties over recent decades has also been rapid, but at a slower pace than King County has experienced. The population of each county has similar age distributions to King County, and higher percentages of non-Hispanic white residents, with about a quarter of the population of each county being persons of color.

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[12] U.S. Census Bureau. https://www.census.gov/newsroom/press-releases/2019/subcounty-population-estimates.html

[13] Regional Macroeconomic Forecast. Puget Sound Regional Council, 2018. https://www.psrc.org/regional-macroeconomic-forecast

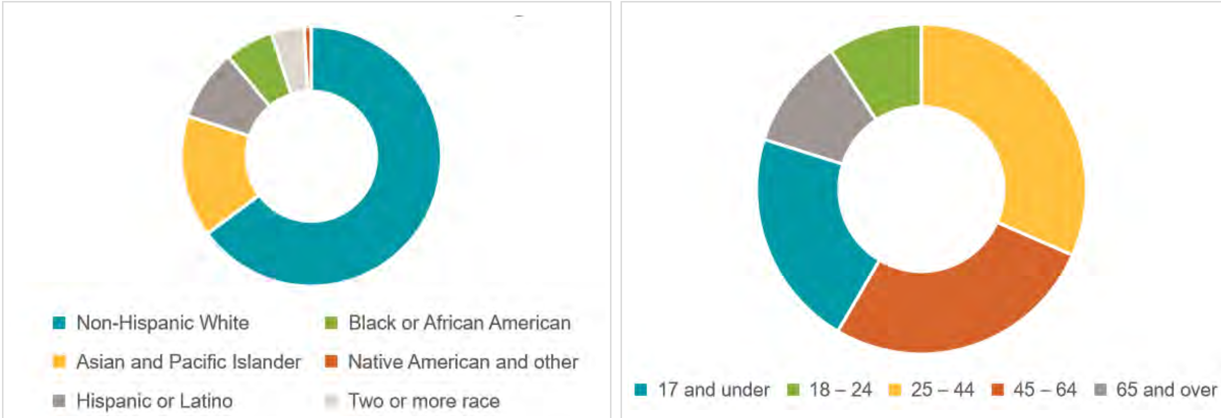

Figure 2. King County demographics, race and ethnicity (left) and age (right)

Overall, according to the Centers for Disease Control and Prevention's (CDC) Social Vulnerability Index (SVI) 2016, King County has a relatively high level of racial and ethnic diversity, with more concentrated areas of diversity located to the south of Seattle and in Bellevue.[14] "Social vulnerability" refers to the resilience and capacity of communities to respond to stresses on human health from natural disasters, such as tornadoes or disease outbreaks, and human-caused disasters, such toxic chemical spills. CDC's SVI is used to help identify demographic groups and geographic locations with higher vulnerability to environmental and public health hazards.

Figure 3 presents an SVI map for the urban growth areas in and around King County based on CDC's SVI 2016 census tract data. (Urban growth areas are areas designated by the state's Growth Management Act where most future growth and development are to occur to limit sprawl, enhance open space, and protect rural areas.) Census-derived factors used to assess vulnerability (from low to high) are grouped into the following themes: socioeconomic status, household composition/disability, race/ethnicity/language, and housing/transportation.

The most socioeconomically vulnerable communities in the close vicinity of King County are concentrated to the south of the urban core of Seattle, stretching all the way to the southern boundary of the County. Since 2000, there has been an outward migration of the non-white population earning less than 80% of the annual median income toward the north and south of the region, as evident in specific census tracts (see Figure 4). Figure 4 shows that, between 2000 and 2018, the demographics in the south of King County have shifted. An exception is the area surrounding the University of Washington, where students are identified as a special case of socioeconomically vulnerable communities.[15, 16]

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[14] Centers for Disease Control and Prevention Social Vulnerability Index 2016, King County, Washington. Agency for Toxic Substances and Disease Registry.https://svi.cdc.gov/Documents/CountyMaps/2016/Washington/Washington2016_King.pdf

[15] U.S. Census Bureau. https://data.census.gov/cedsci/table?q=dp&tid=ACSDP5Y2018.DP05&t=Race%20and%20Ethnicity&vintage=2018&g=0500000US53033.140000&y=2018

[16] U.S. Census Bureau. https://data.census.gov/cedsci/table?q=dp&tid=ACSDP5Y2018.DP03&t=Income%20and%20Poverty&vintage=2018&g=0500000US53033.140000

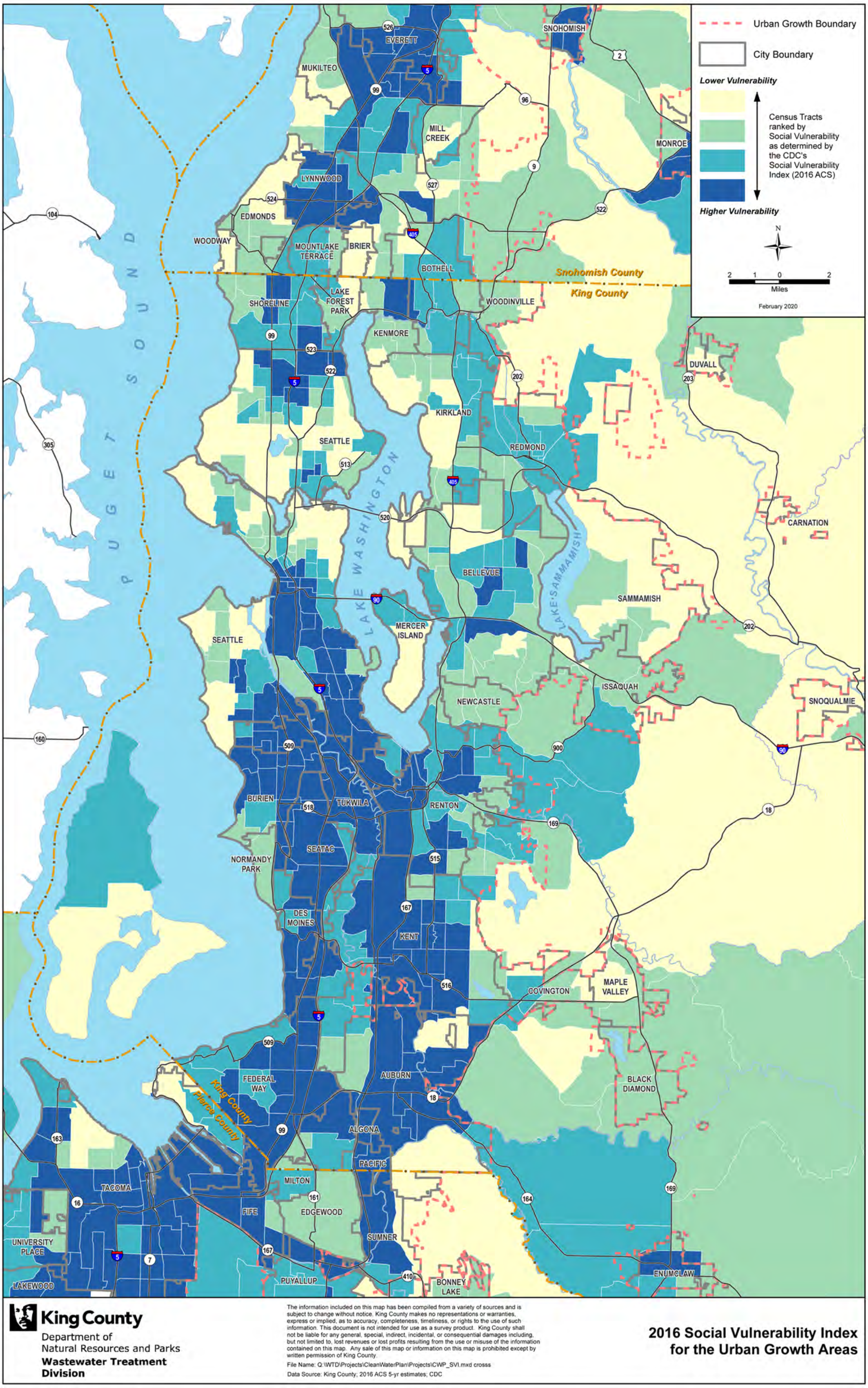


Figure 3. Social Vulnerability Index for King County and surrounding areas

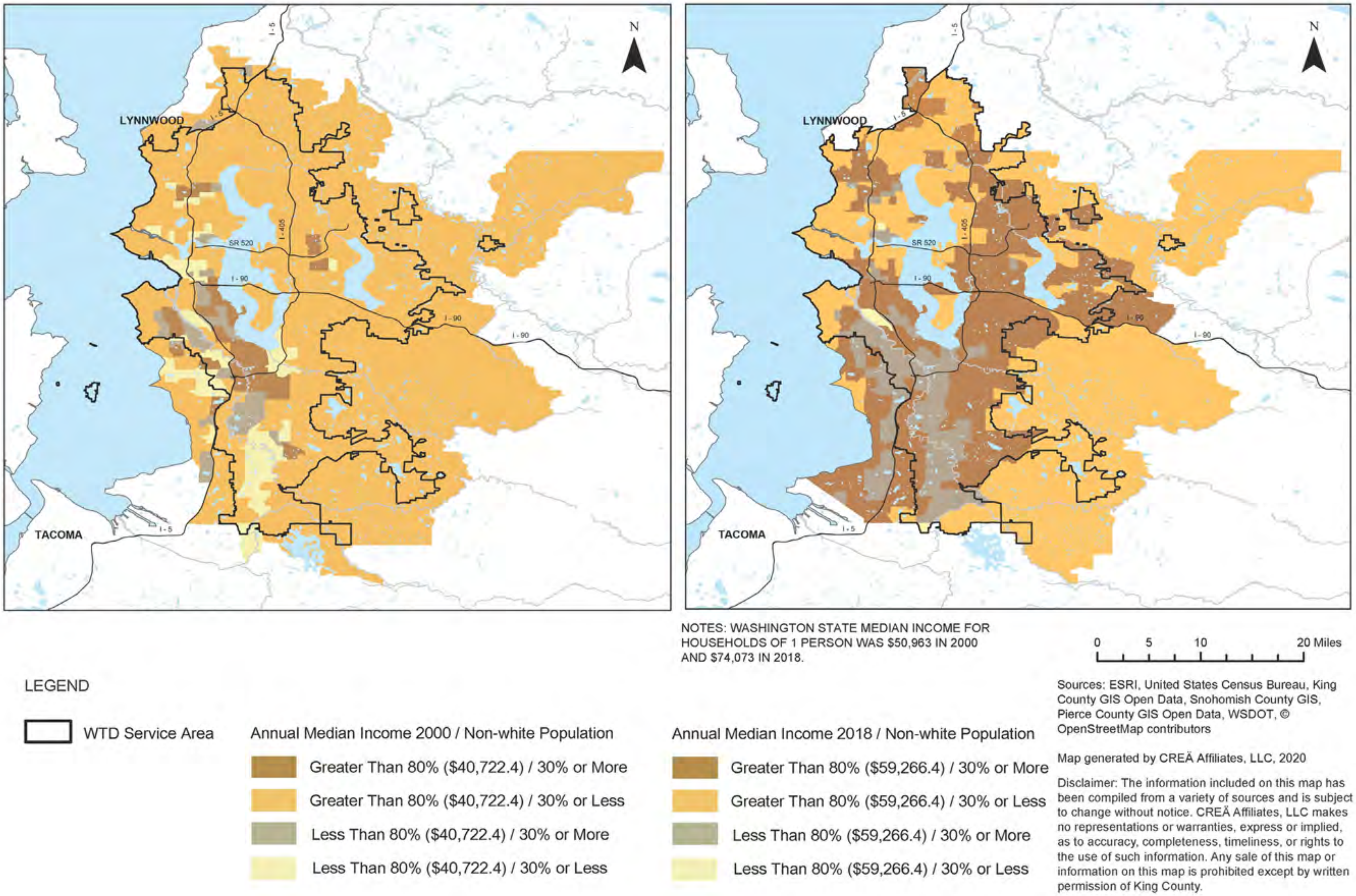


Figure 4. Change in population distribution by race and income, 2000 (left) and 2018 (right)

2.3 Geography, geology, and climate

King County and the neighboring region are geographically diverse, with the Cascade Mountains to the east and Puget Sound to the west. Both King County and Puget Sound lie in the lowland between the Olympic Mountains and the Cascade Range. The region has experienced such events as glacial scouring, deposition, and tectonic activity, all of which have shaped the topography of the area.[17] The physical landscape of hills and valleys creates distinct watersheds; this means that moving water from one watershed to another requires significant pumping, even over short distances.

Additionally, earthquakes occasionally occur in the region because of the proximity of the Cascadia Subduction Zone. A major earthquake from a Cascadia Subduction Zone event occurs approximately every 500 years, and experts have estimated a 10 to 14% probability of a magnitude 9.0 event in the next 50 years.[18]

Historically, the Pacific Ocean has provided moderate weather in King County. In general, the County is prone to mild, dry summers with cool and wet winters. Although the region typically receives a smaller annual volume of rainfall than other areas of the United States, it has more days with rainfall than most other areas, particularly during winter months. This pattern of precipitation translates to a profile in the wastewater system of lower flows in summer months, a "first flush" of increased solids in the fall, and higher flows in winter months.

However, like many areas of the country, climate change is affecting typical weather patterns, contributing to more extreme weather and temperatures. For instance, average annual temperatures in the region are expected to rise approximately 4.5 to 5.0°F by 2050 and between 6.0°F and just over 10.0°F by 2100, depending on future emissions. SLR is anticipated to be between 0.3 and 1.8 feet by 2050 and between 0.5 and 4.2 feet by 2100. Changing precipitation patterns are expected to result in more intense storms that bring 13 to 56% more rain over shorter durations of time.[19]

In addition to warmer summer temperatures, which drive up water demand, more frequent droughts for areas that rely on snowmelt are also anticipated for the region. In 2015, for example, Washington state experienced low snowpack conditions arising from warmer-than-average temperatures, which led to significant water stress for irrigators, managers of small water systems, fisheries, and forests. Reductions in streamflow also exacerbate warming of streams, making it more difficult for coldwater fish, such as salmon, to thrive.

[17] Geology of Seattle and the Seattle area, Washington. Troost and Booth, 2008. https://www.researchgate.net/publication/240671083_Geology_of_Seattle_and_the_Seattle_area_Washington

[18] Big earthquake coming sooner than we thought, Oregon geologist says. Tobias, 2009. https://www.oregonlive.com/news/2009/04/big_earthquake_coming_sooner_t.html

[19] *State of Knowledge Report* – Climate Change in Puget Sound. Climate Impacts Group, University of Washington, 2015. https://cig.uw.edu/resources/special-reports/ps-sok/

2.4 Land use

King County's total land area is 2,130 square miles, which accounts for 3% of all land in Washington State while being home to nearly 30% of the state's population. Through the Growth Management Act, the state requires local governments to manage growth and protect natural resources with a goal of providing a high quality of life for residents.[20] Growth management in King County is implemented largely by directing development within the urban growth boundary.

Figure 5 illustrates land use for the more urbanized western half of the County and neighboring areas, including the urban growth area.[21] A regional land use category to note in the figure is the "industrial/manufacturing" category. Land use and zoning supporting industrial activity has contributed to legacy pollution (see Section 3.2.3), and some of these industrial areas have historically been inhabited by disadvantaged communities. Recently, for example, zoned industrial areas like the Green River Valley, located near the city of Kent, have had emerging concerns with respect to the impacts of pollution on disadvantaged communities.[22]

[20] Growth Management – Planning by Selected Counties and Cities. Washington State Legislature. https://app.leg.wa.gov/rcw/default.aspx?cite=36.70a

[21] King County Comprehensive Plan. 2017. https://www.kingcounty.gov/~/media/depts/executive/performance-strategy-budget/regional-planning/2016-Comprehensive-Plan-Update/2017/e-Land_Use_Map_100217.ashx?la=en

[22] Industrial Lands Analysis for the Central Puget Sound Region. Puget Sound Regional Council, 2015. https://www.psrc.org/industrial-lands

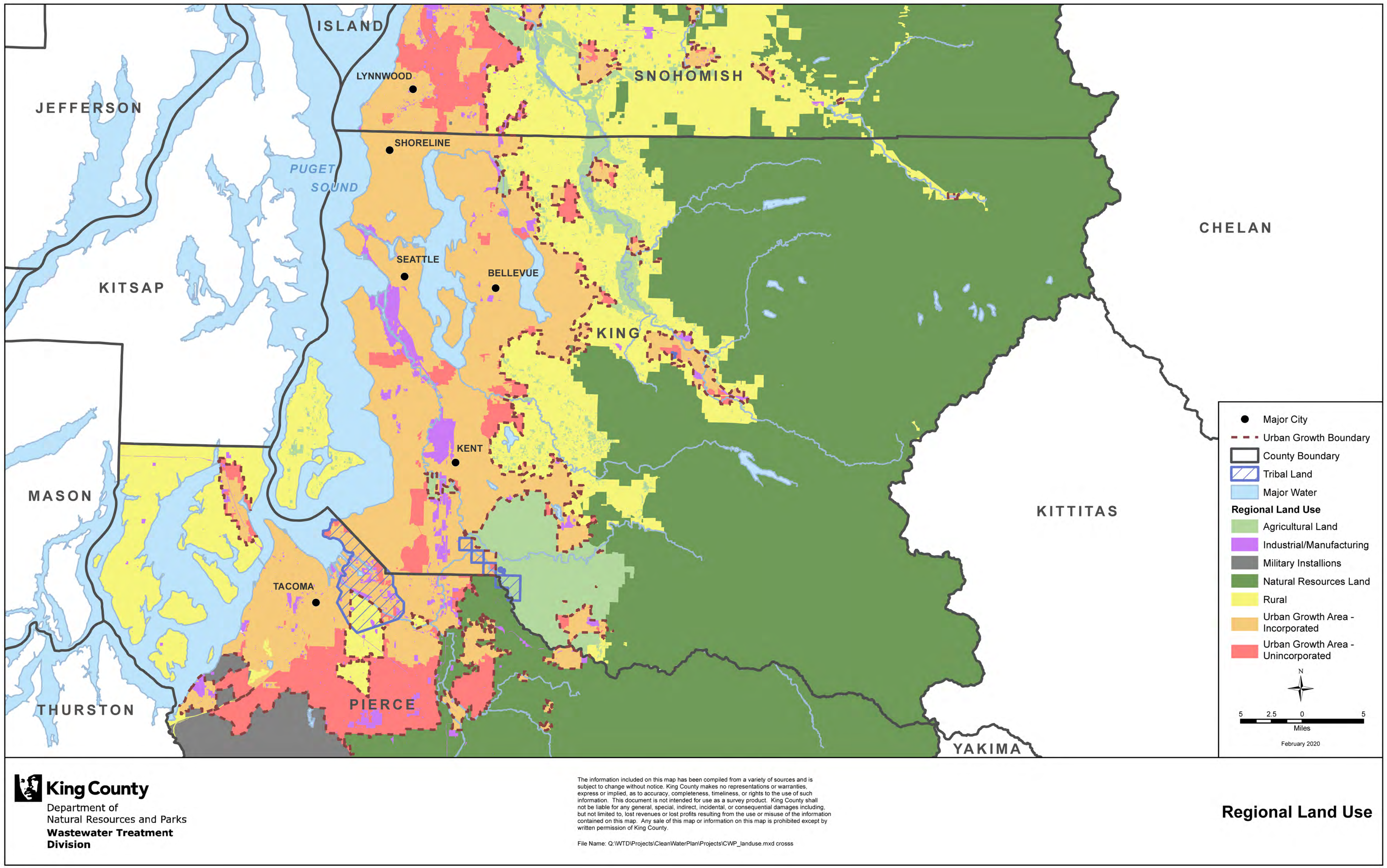


Figure 5. King County land use map

One goal of the Growth Management Act is for population, housing, and employment growth to be allocated so that the cities with urban centers—the "metropolitan" and "core" cities—receive the majority of the County's growth. Although each of the five regional geographies shown in Figure 5 has sufficient capacity for growth, 81% of King County's capacity is in the metropolitan cities (Seattle and Bellevue) and core cities (Auburn, Kent, and Tukwila). Furthermore, 11% of additional capacity can be found in larger cities (Des Moines, Mercer Island, and Shoreline).[23]

The King County Buildable Lands Report analyzed recent urban development to determine whether King County and the cities within it have sufficient capacity in the urban growth area to accommodate forecasted population and job growth, through 2031 and beyond. Figure 6 provides a summary of the housing targets and available capacity in King County. As the figure shows, the housing capacity in urban King County (417,000 housing units) is prepared to accommodate growth in the region and exceeds the 2012 to 2031 target of 178,000 housing units. Eighty-two percent of the available housing capacity is located in metropolitan and core cities.[24]

Geography	2012-2031 Housing Target	2012 Housing Capacity Count / Percentage		2012 Surplus/ Deficit
Metropolitan Cities	71,792	250,394	60%	178,602
Core Cities	67,579	91,782	22%	24,203
Larger Cities	21,731	41,424	10%	19,693
Small Cities	8,518	20,842	5%	12,324
Unincorporated Urban	7,969	12,761	3%	4,792
Urban King County Total	**177,589**	**417,203**	**100%**	**239,614**

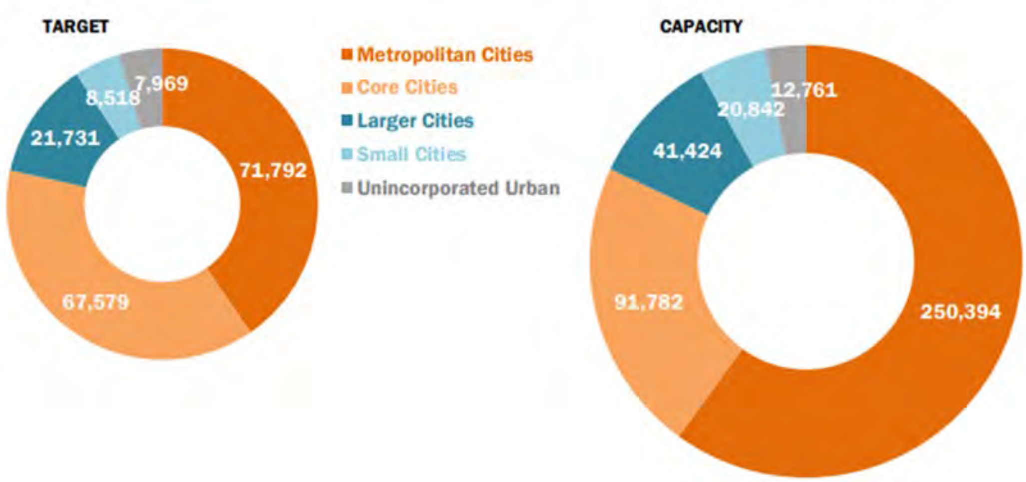


Figure 6. Housing capacity summary

[23] Vision 2040. Puget Sound Regional Council, 2009. https://www.psrc.org/sites/default/files/7293-v2040_0.pdf

[24] The King County Buildable Lands Report 2014. https://www.kingcounty.gov/~/media/depts/executive/performance-strategy-budget/regional-planning/buildable-lands-report/king-county-buildable-lands-report-2014.ashx?la=en

2.5 Economic conditions

In the last 10 years, King County has realized strong economic growth, with significant increases in wages, jobs, housing prices, and overall inflation. As evident with the Great Recession of 2008, the region is prone to periodic recessions that cause economic downturn, including higher rates of unemployment. However, economists generally maintain a positive outlook on the long-term economic forecast for the County because of regional attributes such as a diverse economy and natural beauty. The following sections describe historical economic conditions through 2019 in King County.

2.5.1 Historical growth

Demographic trends project population and age growth, but also have implications for changes in the underlying distributions. Real incomes (that is, inflation-adjusted incomes) in the Seattle metropolitan area have increased slightly across the entire population since 2007, but the increase has not been uniform across all households.

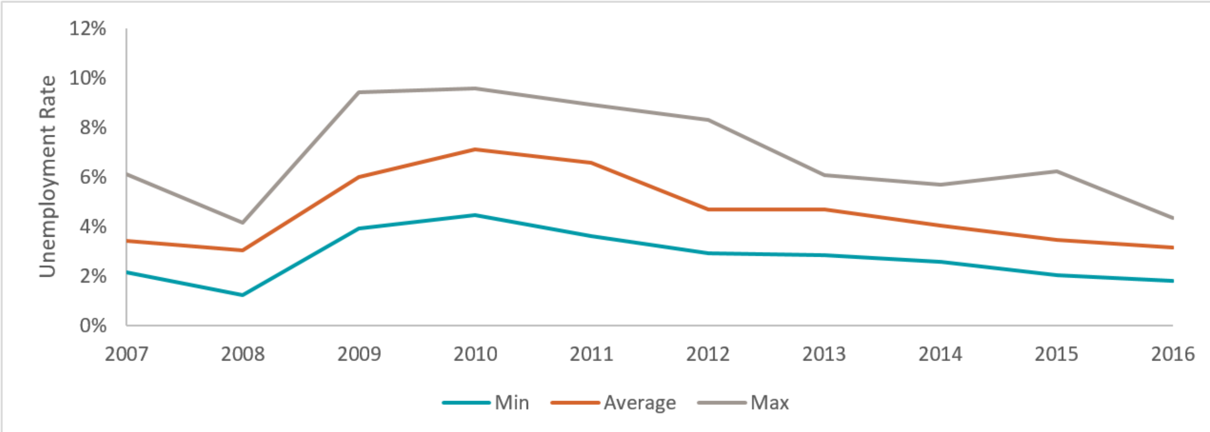
As Table 2 shows, the 80th percentile of household income increased from approximately $151,000 (2007) to $176,000 (2016), an increase of more than $25,000 (nearly 17%), while the 20th percentile of household income increased only $4,500 (about 13%) over the same period.

Table 2. Household income distribution in metropolitan Seattle since 2007

Percentile	2007	2016	Average annual percentage change
20th	$ 33,973	$ 38,465	1.3%
40th	$ 62,912	$ 72,656	1.5%
60th	$ 100,659	$ 112,190	1.1%
80th	$ 150,989	$ 176,299	1.7%

Regional unemployment increased to a peak of over 7.0% in 2010 before gradually declining to 3.2% in 2016 (see Figure 7). As of September 2019, unemployment in King County is at 3.0%. However, this unemployment pattern was not evenly distributed across the area. For example, some areas (Burien, Tukwila, and Renton) have seen unemployment rates that are consistently 1 to 3% higher than the regional average, whereas other areas (Kirkland, Bellevue, and Issaquah) are consistently 1 to 2% lower.[25]

[25] U.S. Census American Community Survey. https://www.census.gov/programs-surveys/acs



Note: Lines denote the lowest Public Use Microdata Area (PUMA) level rate, the area average, and the highest PUMA-level rate.

Figure 7. Unemployment rate in metropolitan Seattle area since 2007

According to the King County 2018 Statistical Profile, which provides information on industries in the region, the highest number of jobs in King County are in the information/technology sector category. This includes employers such as Microsoft and Amazon. Administration/other services and government/education are the two other most heavily employed categories.[26] Boeing also has an outsized influence on regional employment, directly employing about 70,000 people in Washington, and indirectly influencing employment via multiple suppliers.[27]

2.5.2 Income disparity

As Table 2 shows, there is a broad range of incomes in the region, with the lowest 20% of households earning $38,000 per year or less while the upper 20% earn $176,000 or more. Table 2 also demonstrates how recent growth in household incomes has disproportionately benefitted the highest income bracket.

Recently, the greatest increase in job types in King County has been in higher-wage brackets, replacing lower-wage jobs. Real incomes for those earning less than the median incomes in the 20th and 40th percentile brackets have regressed to 1970s levels. Residents with a college degree have benefitted from the robust economy for the past 10 years, while those who do not have a college degree have largely not benefitted.

With increasing population and economic activity in King County, competition over scarce resources such as land, housing, and skilled labor drives prices higher for all manner of living expenses. Based on the Consumer Price Index (CPI) provided by the U.S. Bureau of Labor Statistics[28], prices have been higher in Seattle than the average for all U.S. cities over the last decade (2010 to 2019). Furthermore, the CPI for Seattle has increased more rapidly over this time period than for all other U.S. cities, on average.

[26] Statistical Profile of King County. 2018. https://www.kingcounty.gov/~/media/depts/executive/performance-strategy-budget/regional-planning/Demographics/Dec-2018-Update/KC-Profile2018.ashx?la=en

[27] In Boeing's tough year, Washington state employment still rose. Seattle Times, 2020. https://www.seattletimes.com/business/boeing-aerospace/in-boeings-tough-year-washington-state-employment-still-rose/

[28] Bureau of Labor Statistics, 2020. Division of Consumer Prices and Price Indexes. https://www.bls.gov/cpi/

3.0 Factors affecting water quality

Water is one of the Puget Sound region's greatest resources, and keeping that water clean is critically important to the health and well-being of residents, fish and wildlife, and their habitat. There are many factors that collectively contribute to water pollution in the region, which, in turn, affects the region's water quality. Some of these factors are universal for major metropolitan areas, and some are unique to the Puget Sound region. This section presents an overview of the major factors that affect water quality by describing the types of pollutants, sources of pollution, and pollution pathways, as well as how water pollution impacts human health and aquatic species, in particular.

3.1 Types of pollutants

Water quality is often described in terms of the presence and quantity of different categories of pollutants, including bacteria, nutrients, and known or suspected toxins. Other physical measurements of water quality, such as temperature and pH, are not necessarily pollutants, but are critical for evaluating how well the water can support aquatic life. A summary of each of these categories follows.

3.1.1 Bacteria

Bacteria are a type of biological cell. Bacteria pose human health concerns because they are often associated with pathogens that make humans sick. Traditionally, bacteria were most often measured as fecal coliform bacteria, but *Escherichia coli* (*E. coli*) and enterococci are also now used as evidence of bacterial pollution.[29]

3.1.2 Nutrients

Nutrients are chemical compounds that plants and animals need to grow and survive but, in excess amounts, can harm aquatic environments. Elevated levels of the nutrients nitrogen and phosphorous are the main cause of poor water quality. Phosphorus and nitrogen are the two nutrients that are most commonly measured in surface waters. Typically, phosphorus is the nutrient of most concern in fresh water, whereas nitrogen is the nutrient of most concern in marine water. Generally, nutrients themselves are not a problem for humans or aquatic life, but, because algae use nutrients to grow, changes in concentrations of nutrients can result in a domino effect in the food chain, thus affecting water quality.

For example, at higher concentrations, nutrients can cause excessive algae growth that can, in turn, result in large decreases in dissolved oxygen within the water body and subsequent fish kills because not enough oxygen is available for fish. Even more subtle changes in nutrients can cause shifts in algae communities to troublesome species that form unattractive scums or produce toxins that can harm humans and pets.

[29] Water Quality Assessment and Monitoring Study: Bacteria Sources/Pathways in CSO Receiving Waters. King County, 2017. https://your.kingcounty.gov/dnrp/library/2017/kcr2928/kcr2928.pdf

3.1.3 Known or suspected toxins

Toxins of concern to water quality can be divided into three groups: metals, known organic toxins, and other organic chemicals, referred to here as “contaminants of emerging concern” (CECs).

3.1.3.1 Metals

Although many metals can be present in surface waters, those of most concern to water quality include copper, cadmium, zinc, mercury, and lead—all of which can be toxic to humans and aquatic life at higher concentrations. Toxic effects can result in subtle impacts such as behavioral changes, lower growth rates, and greater susceptibility to disease, which can lead to population declines or, at higher concentrations, can result in direct mortality. An important regional example occurs when coho salmon are exposed to elevated copper concentrations. Research has shown that this exposure can impair salmon’s ability to navigate and avoid predators, potentially negatively impacting the coho population’s health and mortality.

3.1.3.2 Known organic toxins

Organic toxins represent a vast suite of chemicals, including pesticides, polychlorinated biphenyls (PCBs), petroleum products, solvents, and many others. Similar to metals, these pollutants can be toxic to humans and aquatic life and their impacts can range from subtle effects, which may be difficult to observe or measure, to mortality. Some organic toxins tend to bioaccumulate in aquatic food webs.

A regional example of bioaccumulation occurs in orca whales. Orcas consume large numbers of Chinook salmon that have small amounts of PCBs in their fat. Because the PCBs do not degrade, the concentrations of PCBs in the fat tissue of the orcas continue to increase as the orcas eat more Chinook salmon. Thus, orcas are suffering from high PCB contamination even though these chemicals have been banned since 1979.[30]

3.1.3.3 Contaminants of emerging concern

A wide array of chemicals are discharged to surface waters for which there are little or no data on their toxicity or possible environmental impacts; this category of pollutants includes substances as diverse as pharmaceuticals, industrial chemicals, and personal care products like cosmetics and toothpaste. An example CEC is the group of organic chemicals referred to as “perfluoroalkyl substances.” These chemicals have been used in industry and consumer products since the 1950s, including in food packaging, nonstick cookware, stain-resistant carpet treatments, water-resistant clothing, paints, firefighting foams, and some cosmetics. These chemicals are persistent and do not break down in the environment.[31]

3.1.4 Physical parameters

Physical parameters include measurements such as water temperature, dissolved oxygen, pH, turbidity, and total suspended solids (TSS). They are termed as such because, in a sense, they represent the basic physical habitat needs of aquatic life. For example, fish have a certain range of temperature, dissolved oxygen, and pH in which they can survive and an even narrower

[30] Southern Resident Orca Task Force. Inslee, 2018. https://www.governor.wa.gov/issues/issues/energy-environment/southern-resident-orca-recovery/task-force

[31] Water Quality Assessment and Monitoring Study: Contaminants of Emerging Concern. King County, 2017. https://your.kingcounty.gov/dnrp/library/2017/kcr2929/kcr2929.pdf

range in which they can thrive. Salmon, in particular, need colder water and more dissolved oxygen than many other species.

3.2 Sources of pollution

"Pollution source" refers to where a pollutant was generated. Sources can be identified in a very specific way, such as the zinc that is generated by tire wear, or in a general way, such as zinc generated by human activities. For the purpose of this report, sources have been described in the following general categories: natural sources, human activities, and legacy pollution (that is, from past human activities).

3.2.1 Natural sources

Many substances that are considered pollutants at higher concentrations are naturally occurring in the soils, rock, and organic material that cover the earth. In fact, all nutrients, metals, and bacteria occur naturally. Even some known organic toxins are naturally existing. There are also places where natural concentrations of a substance are high enough to exceed water quality criteria. For example, background concentrations of arsenic in some areas in Washington State can exceed water quality criteria, and oceanic currents are a major contributor of nitrogen to Puget Sound. However, most of the time these naturally occurring substances exist at very low concentrations in the environment.

3.2.2 Human activities

Sources of pollution related to human activities are as varied as the list of activities humans perform. Industrial and manufacturing activity, yard and lawn care, automobile use, agricultural and forestry practices, and even home cleaning and use of pharmaceuticals are common ongoing sources of pollution from human activities.

3.2.3 Legacy pollution

"Legacy pollution" refers to pollution that stems from historical sources of contaminants. PCBs in building materials, copper in antifouling paints, polycyclic aromatic hydrocarbons (PAHs) in creosoted pilings, and the many contaminants that have built up in sediments in depositional areas all are examples of sources that will continue to release pollutants until these sources are removed or isolated.

3.3 Pollution pathways

Pollution pathways determine how pollutants travel from their source to a water body. Most pollutants entering surface water in the King County region travel through one of four pathways: wastewater treatment discharge, CSO discharge, surface runoff, and air deposition.[32] Although other pathways exist, such as upstream watersheds, groundwater, and leaching from boats or in water structures, these four pathways have been identified as the more significant pollutant pathways in the King County region. Approaches to managing pollution typically rely on preventing pollutants from entering the pathway (source control) or treating pollution once it is present (treatment).

[32] Control of Toxic Chemicals in Puget Sound. Ecology and King County, 2011. https://fortress.wa.gov/ecy/publications/documents/1103055.pdf

Although these pathways collectively contribute to pollution in the region's water bodies, in an extensive study of pollutant loads to Puget Sound, surface runoff, which primarily consists of stormwater, was found to be the most significant pathway, contributing more than one-half of the total load for the majority of pollutants studied.[33] Each pollution pathway is described in more detail in the following subsections.

3.3.1 Wastewater

Wastewater entering treatment plants includes industrial, commercial, and residential waste sources. Although this wastewater is highly treated before it is discharged to surface waters, it is not possible to remove all of the pollutants. Although the concentration of pollutants in treated wastewater is typically low, the large volume of water discharged from these facilities and the fact that they discharge continuously to a few discrete locations can intensify water quality impacts from this pathway.

3.3.2 Combined sewer overflows

Combined sewers, which carry both wastewater and stormwater in the same pipes, exist in many U.S. and international cities with infrastructure established before 1950, including older portions of the King County sewer system. CSOs are relief points designed into combined sewers that discharge excess stormwater and wastewater into water bodies when the capacity of the combined sewer system is exceeded. These overflows protect wastewater treatment plants from being overwhelmed with too much flow, and also reduce flooding into homes, businesses, and streets during periods of heavy rain.

CSO discharges are typically made up of approximately 10% wastewater and 90% stormwater.[34] Because CSOs contain a mixture of untreated wastewater and stormwater, they represent a pathway for pollutants to enter surface water.

3.3.3 Surface runoff

Surface runoff includes stormwater (or meltwater) generated from the land surface, and the pollutants it carries reflect the highly variable types of land surfaces and uses. Highways, industrial sites, urban development, and agricultural and forest lands all contribute pollutants to surface runoff. The stormwater generates flows either directly into surface water or into a stormwater conveyance system and then to surface water. Although great progress has been made over the past few decades to control and treat stormwater, most stormwater enters surface waters untreated.

3.3.4 Atmospheric deposition

Particles and gases, many of which are generated from human activities, collect in the air and eventually are deposited on the land or water surface. Atmospheric deposition can be a significant source of some metals and organic toxins. Acid rain is one of the most well-known impacts of atmospheric, or air, deposition in some areas of the world.

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[33] Estimated present-day contaminant loadings to Duwamish Estuary/Elliott Bay and Lake Union/Ship Canal. King County, 2017. https://your.kingcounty.gov/dnrp/library/2017/kcr2926/kcr2926.pdf

[34] CSO Control Program Update. King County, 2018. https://www.kingcounty.gov/~/media/services/environment/wastewater/cso/docs/program-updates/2018_CSO-control-program-update-secure.ashx?la=en

3.4 Impacts of water pollution

Impacts of water pollution can be as varied as the types and sources of pollution themselves. These impacts can be both direct and indirect, depending on the situation and pollutant(s) involved. For example, direct impacts include sickness or mortaility and indirect impacts include low reproductive rates or poor health. Additionally, for some pollutants, data may clearly document a specific impact, whereas for other pollutants, the line of evidence is less clear. The following are general descriptions of how water pollution impacts human health and aquatic species.

3.4.1 Human health

The most commonly noted direct human health impact from water pollution is through direct exposure to common pathogens, such as bacteria, through drinking untreated water or through primary contact (for example, swimming or wading) with polluted water. However, human health impacts may also occur from eating aquatic species such as fish and shellfish that contain pathogens, toxics, or biotoxins, although the likelihood of this happening, particularly in the Puget Sound region, is extremely low. Some biotoxins, such as those that cause paralytic shellfish poisoning, are naturally occurring and not directly derived from human-caused pollution; therefore, they are not included as contaminants of concern in this report.

3.4.2 Declining aquatic species

Aquatic species are exposed to toxins through the water and sediment or through ingestion of other aquatic species whose tissue has accumulated the toxins. Certain toxic contaminants are known to bioaccumulate, meaning that their concentrations in tissue continue to increase with age as well increase at higher levels of the food chain. PCBs and mercury are the most common examples of bioaccumulating toxins; their concentrations are high in Chinook salmon (a fish high up on the food chain) and even higher in orca whales, which are large consumers of Chinook. Although high levels of toxic pollutants can result in direct mortality, there are many less obvious side effects, such as behavioral changes, lower growth rates, and greater susceptibility to disease that can result in the long-term decline of an entire population of aquatic species.

4.0 Protecting water quality

Protecting water quality is fundamentally important to the residents of Puget Sound, including members of the many area tribes who have been fishing local waters for millennia and for whom salmon and shellfish are considered protected subsistence foods. Proper wastewater collection and treatment not only protects the public from exposure to harmful pathogens, it protects the health of local water bodies to support healthy populations of salmon, orca whales, and the thousands of other aquatic species that live in the region’s waters. Collectively, King County, local governments, and state agencies are responsible for implementing numerous projects and programs designed to protect water quality in the region. This section describes the major clean water services, programs, and federal and state regulations currently in effect for that purpose.

4.1 Regional clean water services and programs

4.1.1 Wastewater treatment

Wastewater from homes, businesses, and other buildings with public sewer connections is collected, conveyed, and treated at wastewater treatment plants across the region. King County WTD is the largest provider of wastewater services in the region; however, other cities and sewer districts own and operate their own treatment facilities, including, but not limited to, the City of Duvall, City of Enumclaw, Lakehaven Utility District, Midway Sewer District, Southwest Suburban Sewer District, City of North Bend, and the City of Snoqualmie. WTD protects public health and the environment by serving approximately 1.8 million people and treating an average of 175 million gallons per day (MGD) of wastewater.[35]

Wastewater treatment plants use a mix of physical, biological, and chemical processes to remove potentially harmful pollutants and pathogens from the wastewater stream. Because of the way WTD has configured its treatment processes, it is also able to capture and recycle valuable resources for the Puget Sound region, including reclaimed water for irrigation or industrial reuse; Loop® (WTD's brand name for its nutrient-rich biosolids product), which returns carbon and nutrients to the land and aids plant growth; and renewable energy generated from biogas produced as a byproduct of the wastewater treatment process.

4.1.2 Stormwater management

There are a number of stormwater management systems and programs in operation across the region to meet multiple objectives, including protecting against property damage and transportation impacts from urban flooding during rain storms, protecting stream channels from artificially high flows caused by human development that can contribute to erosion and habitat loss, and protecting surface water bodies from pollution. Regionally, it is estimated that approximately 146 billion gallons of stormwater runoff from developed land enters receiving waters annually, of which over 12 billion gallons is treated within the wastewater system and about 15 billion gallons is treated by stormwater treatment facilities before discharge. Approximately 118 billion gallons is untreated stormwater and a little over half a billion gallons enters receiving waters from uncontrolled CSO outfalls.

Figure 8 shows estimated annual stormwater runoff from developed land uses in King County.[36] The following subsections describe regional efforts to manage this runoff.

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[35] Facts about the King County regional wastewater system. King County, 2018. https://www.kingcounty.gov/depts/dnrp/wtd/system/facts.aspx

[36] Updated Estimate of the Annual Average Volume of Treated and Untreated Stormwater Runoff from Developed Lands in King County. Burkey 2018.

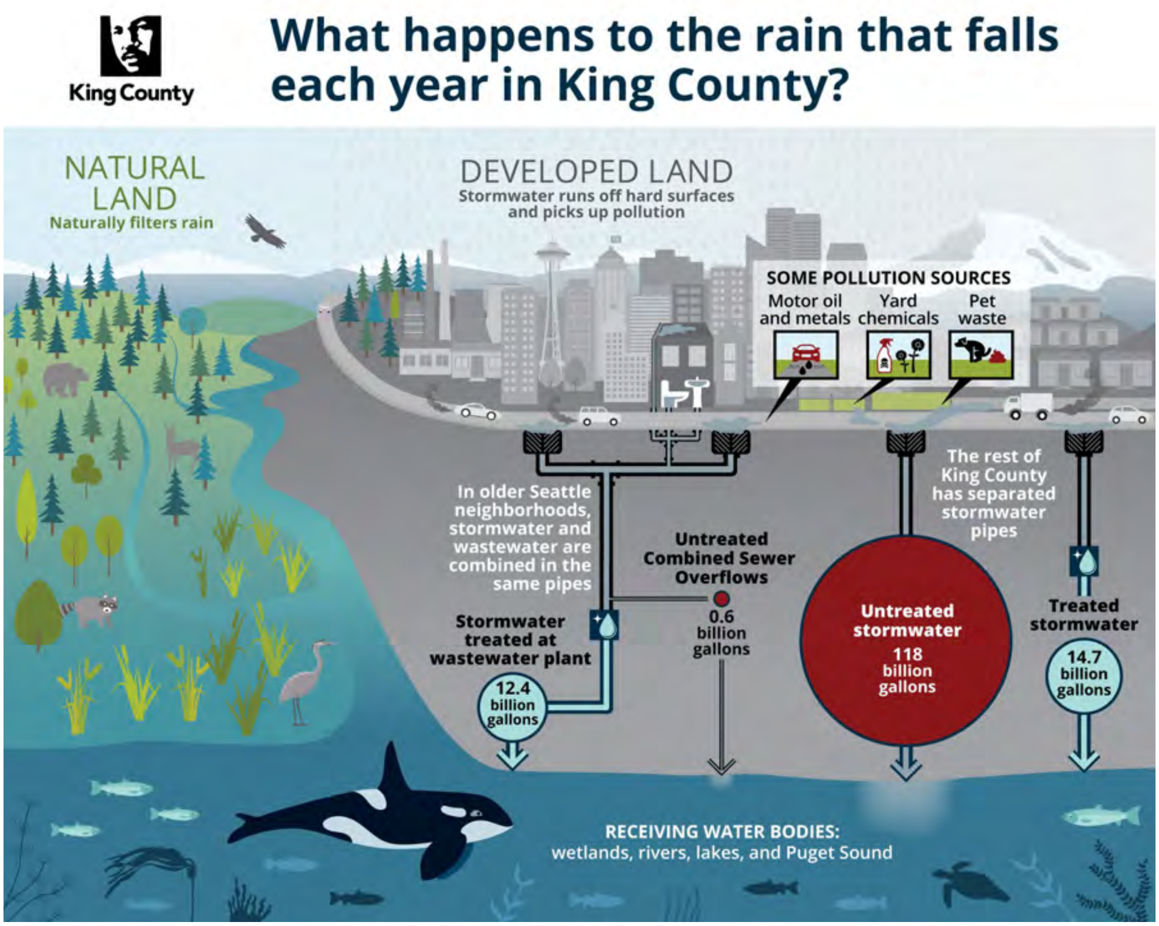

Figure 8. Estimated annual stormwater runoff from developed land uses in King County

4.1.2.1 Municipal Separate Storm Sewer System

In urbanized areas of the County, Municipal Separate Storm Sewer System (MS4) pipes and facilities are used to convey and store stormwater flows from streets, buildings, and other surfaces to regional water bodies. An MS4 includes conveyance infrastructure such as pipes, ditches, swales, and streams, as well as storage and treatment facilities such as ponds, underground tanks and vaults, and bioswales.

While originally designed to minimize urban flooding during storm events, MS4s can also be configured to reduce the amount of pollutants carried by stormwater, and to store or infiltrate stormwater to reduce the adverse impacts that high peak storm flows can have on natural systems. King County Water and Land Resources Division operates stormwater management infrastructure and programs for unincorporated areas of the County, while cities are responsible for stormwater management within their boundaries.

4.1.2.2 Stormwater management programs and facilities

King County maintains a stormwater management program for its MS4, consistent with state regulations, which includes a range of stormwater management activities, including developing and enforcing local stormwater regulations, conducting public education, and participating in water quality monitoring programs.[37]

Within the MS4, a range of infrastructure may be used to achieve stormwater management objectives:

- Stormwater conveyance infrastructure is used to move stormwater from its runoff location to an outfall, where it enters a surface water body. Conveyance infrastructure is typically designed to manage surface runoff for a certain size of storm; for larger (and less frequent) storms, urban surface flooding may occur.
- “Green stormwater infrastructure” (GSI) is a common term in stormwater management to describe stormwater facilities that are intended to mimic the natural behavior of the landscape by capturing stormwater from small areas, close to the source, and infiltrating it into the ground instead of conveying it off-site. This infiltration process can help to recharge near-surface groundwater, which is beneficial to groundwater aquifers.
- Flow control and storage facilities provide detention or retention of flows. A detention facility (for example, a pond or underground vault) stores accumulated stormwater runoff and slowly releases it downstream. Some detention ponds also function as water quality treatment ponds or engineered wetlands and are intended to permanently retain some water. A retention facility (for example, an infiltration pond) collects stormwater and allows the water to percolate into the soil, similar to a GSI facility.
- Treatment facilities help to protect water quality by incorporating features that filter or remove sediments, excess nutrients, and toxic chemicals. Treatment facilities may use a physical configuration to separate out pollutants from stormwater, media layers (like sand or compost) to filter out pollutants, or plants and other biota to consume or break down pollutants. Water quality facilities are often combined with flow control facilities for comprehensive management of stormwater.

4.1.3 Combined sewer systems and overflow control

Combined sewer systems are designed to have one set of pipes that transport both sewage and stormwater. This combined flow is conveyed to wastewater treatment plants where both the sewage and stormwater receive treatment. Combined systems treat stormwater that, in a separated system, would generally flow directly into receiving waters without treatment.

However, every combined sewer system has a capacity limitation and, when that capacity is exceeded, excess flow is discharged into receiving waters as a CSO. CSOs in the County exist only in older Seattle neighborhoods. King County and Seattle have been working to control CSOs for decades and continue to do so. A controlled CSO overflows no more than one time each year on a long-term (20-year) average. This is a Washington State standard. Since the 1960s, through its CSO control programs, King County has reduced its overflows from approximately 20 to 30 billion gallons per year to around 600 million gallons per year.[38]

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[37] Stormwater Management Program Plan. King County, 2019. https://www.kingcounty.gov/depts/dnrp/wlr/sections-programs/stormwater-services-section/stormwater-program.aspx

[38] King County is Protecting our Waters. Controlling Combined Sewer Overflows. King County, 2019. https://kingcounty.gov/services/environment/wastewater/cso.aspx

4.1.4 Source control

The goal of source control programs is to target pollutants at or near their source, thereby avoiding the introduction of contaminants to the environment and wastewater, stormwater, and solid waste streams, where they can be difficult or impossible to remove with standard treatment approaches. King, Snohomish, and Pierce counties, along with their local partners, operate source control programs, which include household hazardous waste disposal programs, industrial waste programs, business inspections, and sewer and site investigations to trace potential sources of pollution.[39]

4.1.5 On-Site Sewage System Program

On-site sewage systems (septic systems) treat wastewater when homes and buildings are not connected to the public sewer systems. The King County Department of Public Health runs an On-Site Sewage System Program to provide educational, advisory, and permitting services for owners of on-site sewage systems and certifications for several septic professionals.[40] King County does not have funding to oversee operations or management of on-site sewage systems. When on-site sewage systems are not maintained properly, they can create risks to human health and water quality.

Figure 9 shows the distribution of septic tanks within WTD's service area and the urban growth boundary, as well as outside of both boundaries. There are approximately 85,000 septic systems in King County. As Figure 9 shows, some of the larger concentrations of septic tanks are located in the north and south of WTD's service area (see Figure 4 for information surrounding the demographics of the distribution of septic tanks).

4.2 Federal and state regulations

The U.S. Environmental Protection Agency (EPA) is responsible for developing and enforcing federal pollution regulations including the Clean Water Act and Comprehensive Environmental Response, Compensation, and Liability Act, also known as Superfund. In Washington State, portions of EPA's authority for pollution control are delegated to Ecology. Washington State also has state pollution laws and regulations that, in some cases, are stricter than federal standards.

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[39] Pollution Sources: Tracing and Controlling. King County, 2019. https://www.kingcounty.gov/services/environment/wastewater/duwamish-waterway/preventing-pollution/pollution-sources.aspx

[40] Developing a Pollution Identification and Correction Program in King County. Environmental Policy Matters, 2019. https://kingcounty.gov/depts/health/environmental-health/piping/~/media/depts/health/environmental-health/documents/pic/developing-PIC-king-county-report.ashx

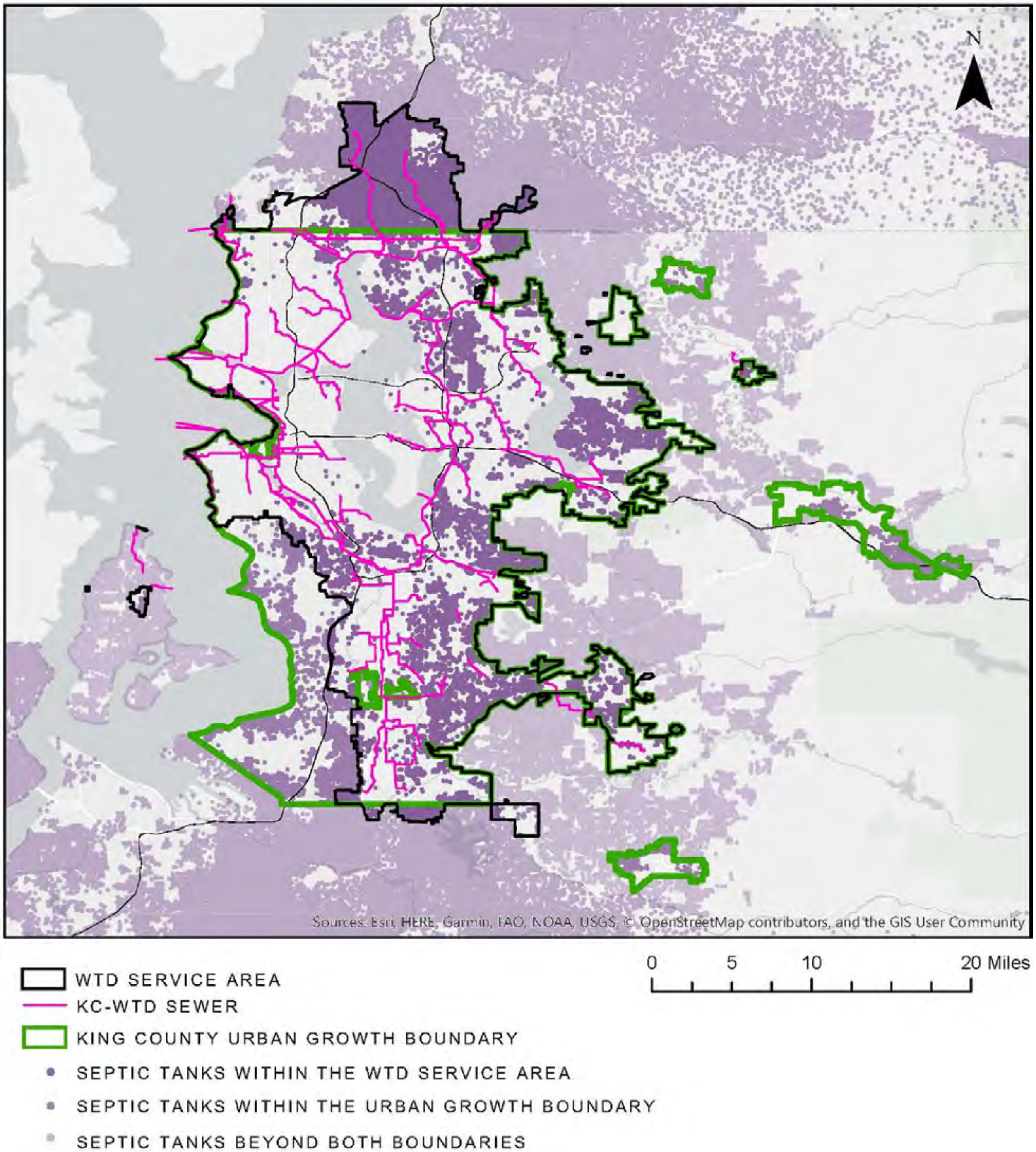

Figure 9. Distribution of septic tanks (2018)

State regulations are designed, in part, to help meet surface water quality standards adopted by the State of Washington under Washington Administrative Code (WAC) Chapter 173-201A.[41] Water bodies that do not meet the state standards are considered to be impaired, and are commonly referred to as "303(d) listed waters." Impaired water bodies may be subject to a total maximum daily load (TMDL), which is a plan for restoring impaired waters that identifies the allowable amount of a pollutant that can be discharged to that a water body and still allow it to meet state water quality standards. If a TMDL exists for a given water body, it affects how wastewater, stormwater, and other discharges to that water body are regulated.

The following subsections describe regulations for controlling pollution in wastewater, stormwater, and sediments.

4.2.1 Wastewater

Regulations are implemented for wastewater treatment through National Pollutant Discharge Elimination System (NPDES) permits. These permits are issued for individual wastewater treatment plants and identify the water quality required for the water leaving the treatment plant. The water quality is commonly defined by the maximum concentration of biochemical oxygen demand (BOD), TSS, and bacteria (fecal coliform) allowed in the treated water. The specific values in a permit (as well as potentially other water quality parameters) depend on the water body that the treatment plant discharges to, with more treatment required for more sensitive water bodies.

When under construction, wastewater projects that have a federal nexus (that is, projects that require action by a federal agency), either through federal funding or a federal permit, are subject to compliance with Section 7 of the Endangered Species Act (ESA) as well as Section 106 of the National Historic Preservation Act. These acts ensure that the project complies with all applicable federal regulations to protect sensitive resources such as critical habitat and historic sites.

Ecology also maintains regulations for construction and maintenance of on-site sewage (septic) systems that are enforced by local jurisdictions. In King County, the Department of Public Health is responsible for oversight of on-site sewage systems.

Regulations applicable to the King County wastewater treatment system for CSOs, nutrients, and biosolids have specific nuances; each is described in the following subsections.

4.2.1.1 Combined sewer overflow

Because of the highly variable nature of flows in combined sewers due to rainfall, special permit requirements are needed to define the capacity and treatment requirements of combined sewer facilities and when overflows are permissible. In 1987, Ecology defined "CSO control" such that no more than one untreated discharge per year on a 20-year average is allowed. This is the standard to which WTD is held. In 1994, EPA defined federal CSO control policies that are less stringent. The federal standard considers a utility in compliance if 85% of combined sewer flows are captured and treated, there are no more than four untreated discharges systemwide as a result of a precipitation event per year on average, or enough pollution is removed equivalent to what is contributed by 85% of combined sewer flows.

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[41] Title 173 WAC. https://apps.leg.wa.gov/WAC/default.aspx?cite=173

A Consent Decree between King County, EPA, and Ecology was filed in 2013 that commits the County to implement the 2012 Long-Term Control Plan, which identified several capital projects that are to be completed by 2030. The Consent Decree uses the Washington State standard to define CSO control instead of the federal standard.[42]

4.2.1.2 Nutrients

Limiting nutrient discharges to Puget Sound is a relatively new development and, at this time, there are only a limited number of wastewater treatment plants that discharge into Puget Sound that have nutrient limits in their NPDES permit. As such, Ecology's approach to regulating nutrient loadings is not clearly established and continues to evolve.

The Puget Sound Nutrient Source Reduction Project is an Ecology-led effort with communities and Puget Sound stakeholders to address human sources of nutrients.[43] This work includes modeling of the Salish Sea to investigate how nutrients in wastewater treatment plant effluent impact dissolved oxygen levels. Based on the results from this model, Ecology has stated their intention to limit nutrient discharges from wastewater treatment plants into Puget Sound. These limitations could apply to nearly 70 wastewater treatment plants, including King County owned facilities.

4.2.1.3 Biosolids

Ecology has issued a single general permit for the State of Washington to regulate biosolids production and use. Biosolids quality is defined by the extent to which the biosolids are treated before their final use. There are two major classifications of biosolids: Class A and Class B. Class B solids have been treated to the extent that most of the pathogens have been removed, but not all. Class A biosolids are treated to a greater extent such that they are nearly pathogen-free. These classifications are used to define how the biosolids may be used. Because they are nearly pathogen-free, Class A biosolids can be used by the general public while Class B biosolids require special permitting before they can be used.[44]

4.2.2 Stormwater

In Washington State, Ecology is the delegated authority, from the EPA, to implement the Clean Water Act through the NPDES permit and TMDL program. Ecology develops stormwater regulations in accordance with Revised Code of Washington Chapter 90.48, Water Pollution Control.[45] In the Puget Sound region, counties and cities that are issued Municipal NPDES stormwater permits are responsible for stormwater management within their jurisdictions. Ecology issues municipal NPDES stormwater permits for MS4s to those applicable counties and cities that identify the requirements for stormwater management programs that must be implemented by each jurisdiction. The permit requirements apply in separated storm sewer areas, but not in combined sewer areas, like large parts of Seattle.

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[42] Consent Decree. United States v. King County, Washington. https://www.epa.gov/sites/production/files/documents/kingcountywashington-cd.pdf

[43] Puget Sound Nutrient Reduction Project. Washington Department of Ecology. https://ecology.wa.gov/Water-Shorelines/Puget-Sound/Helping-Puget-Sound/Reducing-Puget-Sound-nutrients/Puget-Sound-Nutrient-Reduction-Project

[44] A Plain English Guide to the EPA Part 503 Biosolids Rule https://www3.epa.gov/npdes/pubs/owm0031.pdf

[45] Chapter 90.48 RCW. https://app.leg.wa.gov/rcw/default.aspx?cite=90.48

MS4 permits are based on conducting a program of required activities to the maximum extent practicable using all known, available, and reasonable methods of prevention, control, and treatment. The municipal NPDES permit does not require achieving numeric water quality limits for discharges. However, the TMDL program can require numeric limits for discharges to certain impaired water bodies.

In addition to incorporating source control programs, which prevent pollution from entering the stormwater system in the first place, stormwater management programs implemented by counties and cities include required activities such as the following:

- Maintaining local stormwater codes and development standards consistent with State guidance
- Investigating and resolving spills, leaks, and other concentrated sources of pollution to the stormwater system and looking for discharges causing pollution and illegal connections
- Maximizing operational efficiency by taking a broad, watershed-based approach (basin planning) and improving (retrofitting) older stormwater systems for better performance
- Conducting education and outreach to inform the public about the positive and negative impacts it can have on stormwater and surface water quality

A key regulatory feature is the requirement for sites (homes, businesses, and so on) that are newly constructed or redeveloped to install stormwater facilities on-site to treat, store, and/or allow water to infiltrate into the ground on-site. Examples of on-site stormwater facilities include rain gardens, roadside swales, storage tanks, and detention ponds. This requirement is a focus of the region’s efforts to mitigate the impacts of urban stormwater and improve surface water quality.

The County administers its stormwater management programs in accordance with King County Code.[46] The County is responsible for managing the MS4 located in unincorporated King County, while individual cities are responsible for the MS4s within their boundaries.

4.2.3 Sediments

With the passage of the Comprehensive Environmental Response, Compensation and Liability Act in the 1980s (also known as Superfund), EPA began to clean up highly polluted upland areas.[47]

In the late 1980s, voters in Washington State passed the Model Toxics Control Act (MTCA), providing a similar program at the state level.[48] As part of MTCA, sediment management standards (SMS) were set to guide cleanup of contaminated sediments. MTCA Cleanup Regulations (WAC Chapter 173-340) apply to all cleanups, whether they are upland cleanups on land or in groundwater or sediment cleanups in freshwater or marine environments. Sediment sites in Washington State are regulated by the SMS (Chapter 173-204 WAC).[49]

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[46] Title 9 Surface Water Management. King County, 2017. https://www.kingcounty.gov/council/legislation/kc_code/12_Title_9.aspx

[47] Superfund: CERCLA Overview. U.S. Environmental Protection Agency. https://www.epa.gov/superfund/superfund-cercla-overview

[48] Model Toxics Control Act. Ecology. https://ecology.wa.gov/Spills-Cleanup/Contamination-cleanup/Rules-directing-our-cleanup-work/Model-Toxics-Control-Act

[49] Title 173 WAC. https://apps.leg.wa.gov/WAC/default.aspx?cite=173

5.0 Regional water quality

Protecting and sustaining the region's waterways and watersheds is at the heart of King County's mission of providing for healthy, safe, and vibrant communities. It is also essential to residents, who place a high value on the quality of local waterways for recreational activities such as fishing, swimming, and boating. This section describes the current state of water quality of each of the major water bodies in the region, organized by four major basins: Cedar-Sammamish, Green-Duwamish, Snoqualmie, and the Central Basin of Puget Sound. Figure 10 shows the location of the major water bodies and watersheds in the region.

Water quality characteristics described in this section largely come from recent water quality assessments performed by King County. Information on the health of salmon and fish populations in the water bodies is from the Washington Department of Fish and Wildlife's SalmonScape, a computer mapping system that merges the latest fish and habitat data collected by state, federal, tribal, and local biologists.

5.1 Cedar-Sammamish Basin

The Cedar-Sammamish basin (see Figure 11) includes two large drainages: the Sammamish River (and Lake Sammamish) and the Cedar River as well as many small rivers and streams that are tributary to these drainages. Both drainages flow into Lake Washington, which is connected to the marine waters of Puget Sound via the Lake Washington Ship Canal, a federally authorized navigation channel linking the natural basins of Lake Union and Salmon Bay. Ultimately, water in the basin flows into the Central Basin of Puget Sound through the Hiram M. Chittenden Locks.

According to the SalmonScape database, Puget Sound Chinook, chum, coho, pink, sockeye, and kokanee salmon are all present in the basin, as are coastal cutthroat, steelhead, and bull trout.[50] Chinook, steelhead, and bull trout are all listed as threatened species under ESA, and coho and coastal cutthroat trout are listed as species of concern. Although most of the basin is recognized as providing habitat for these species, fish passage barriers in the upper basin limit the availability of habitat. Additionally, pollutants and high water temperatures are contributing to the decline of these species.

5.1.1 Lake Sammamish and the Sammamish River

Lake Sammamish has a watershed of approximately 98 square miles and a lake surface area of nearly 4,900 acres, making it the sixth largest lake in the state. The major inflow to the lake is Issaquah Creek and the major outflow is the Sammamish River. Although the headwaters of the watershed are still relatively undeveloped and forested, large areas of the watershed have been experiencing rapid urban and suburban development and the immediate shoreline is almost entirely developed.

Lake Sammamish is one of the major recreational lakes in the region, with high use by anglers, boaters, water skiers, swimmers, and picnickers. Both state and county parks are located along its shores. One unique aspect of Lake Sammamish is that it supports a native kokanee salmon run, a species that requires lake habitat, but that has been essentially eliminated from Lake Washington.

[50] SalmonScape. Washington Department of Fish and Wildlife. https://apps.wdfw.wa.gov/salmonscape/

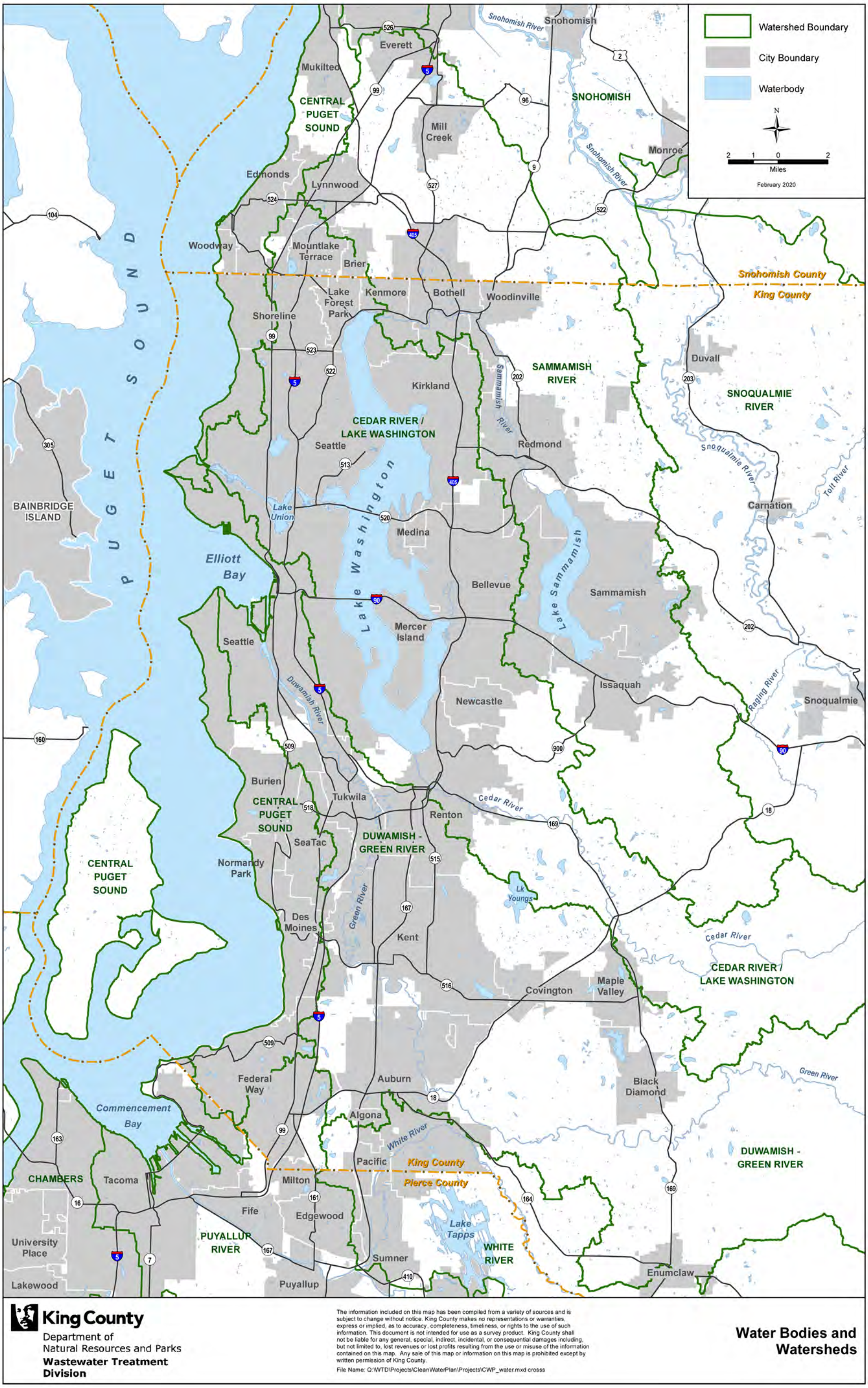

Figure 10. Major water bodies and watersheds in the region

Although the lake generally has good water quality, phosphorus, algae, and bacteria are persistent concerns, and beach closures because of bacteria, in particular, do occur.[51] PCBs in sediment and organic toxins in fish tissue have also been documented. The Sammamish River exceeds temperature, dissolved oxygen, fecal coliform bacteria, and pH standards. High nutrient (phosphorus and nitrogen) concentrations and resultant vegetative growth are believed to be exacerbating the low dissolved oxygen problems.[52]

No extensive pollutant loading studies of Lake Sammamish or the Sammamish River have been conducted recently. There are no wastewater or CSO discharges to these water bodies, but there are many stormwater discharges from adjacent communities including Bothell, Kenmore, Woodinville, and Redmond. Thus, surface runoff is likely the key pollution pathway for most pollutants, and atmospheric deposition is likely to be an important pathway for mercury in the lake.

Figure 11. Cedar-Sammamish Basin

[51] Lake Swimming Beach Bacteria. King County website. https://green2.kingcounty.gov/swimbeach/

[52] Lake Sammamish. King County website. https://www.kingcounty.gov/services/environment/water-and-land/lakes/lakes-of-king-county/sammamish.aspx

5.1.2 Cedar River

The Cedar River, the largest watershed contributing to the Lake Washington basin, has a watershed area of approximately 190 square miles. The headwaters of the Cedar River are in a protected watershed for the Chester Morse water supply reservoir that provides Seattle Public Utilities (SPU) with a portion of its drinking water supply. Total land use in the watershed is approximately 70% forest, with some development and little agriculture. Approximately 13% is developed land and is currently a mix of open space and low-intensity development. Most development occurs in the lower basin, with resultant stormwater discharge.

Although the upper portion of the Cedar River has excellent water quality, water in the lower basin near its outlet to Lake Washington has problems related to temperature, dissolved oxygen, and pH. No extensive recent pollutant loading studies of the river have been conducted. However, there are wastewater and stormwater discharges from the communities that border the lower river; therefore, these represent important pollution pathways.[53]

5.1.3 Lake Washington

Lake Washington has a watershed of approximately 589 square miles and, with a water surface area of 34 square miles, is the second largest lake in the state. The major inflows to the lake are the Sammamish and Cedar rivers, which provide approximately 30% and 50% of the total inflow, respectively. Lake Washington is connected to the marine waters of the Central Basin of Puget Sound via Lake Union/Ship Canal.

The Lake Washington watershed has equal parts developed and undeveloped lands. Most development is found along the periphery of lakes Washington and Sammamish; additional development occurs along the northern tributaries discharging to the Sammamish River. There are over 20 municipalites and agencies that discharge stormwater directly to Lake Washington or its watershed.

Lake Washington is considered to have very good overall water quality for an urban lake, with low concentrations of bacteria and algae and high transparency. However, there are still water quality concerns. For instance, although concentrations of contaminants in sediments have been declining, they are still above background concentrations. Lake Washington exceeds water quality standards for bacteria and phosphorus, although the data used to justify the phosphorus exceedence have been questioned. In the past decade, summer algae levels have remained relatively unchanged, although there are infrequent toxic algae blooms and related swimming beach closures.

There are currently fish consumption advisories for Lake Washington carp, cutthroat trout, large yellow perch, and northern pikeminnow because of PCB contamination, in addition to a statewide advisory for bass because of mercury contamination.[54] According to a 2014 King County study, Lake Washington serves as both a source to the Central Basin via the Ship Canal as well as a partial repository for PCBs, primarily due to sediment accumulation and burial.[55]

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[53] For more information, visit the Cedar River-Lake Washington Watershed King County website: https://www.kingcounty.gov/services/environment/watersheds/cedar-river-lake-wa.aspx

[54] Fish Consumption Advisories in Washington State. Washington Department of Health. https://www.doh.wa.gov/DataandStatisticalReports/HealthDataVisualization/fishadvisory

[55] Modeling PCB Loadings Reduction Scenarios to the Lake Washington Watershed: Final Report. King County, 2014. https://your.kingcounty.gov/dnrp/library/water-and-land/watersheds/cedar-river-lake-wa/lake-washington-pcb-pbde-loadings/epa-lake-washington-final-report.pdf

Although there are no wastewater treatment plant discharges to Lake Washington, there are 41 CSOs that discharge to the lake, of which approximately half are uncontrolled. Pollutant loading studies have indicated that surface runoff was the most significant pathway for many pollutants including PCBs, polybrominated diphenyl ethers (PBDEs), nutrients, and bacteria. One exception is mercury, for which air deposition has been identified as a potentially important pathway.

5.1.4 Lake Union / Ship Canal

Lake Union/Ship Canal is in the heart of Seattle, with an immediate drainage area of approximately 24 square miles including the Portage Bay, Lake Union, and Salmon Bay areas. It is surrounded by high-intensity urban development and the shoreline is almost entirely developed with docks, houseboats, and bulkheads.

The main water quality pollutant issues for these waters are bacteria, temperature, salinity, dissolved oxygen, and known organic toxins. Although bacteria concentrations have declined in the last several decades, they represent a persistent water quality issue. Nutrients have decreased over the years because of reduced loading from upstream in Lake Washington and the Lake Union watershed.

A recent King County study presents a summary of pollutant load percentages by pathway for Lake Union/Ship Canal[56]. If Lake Washington (which represents all of the pollutant input from the upper watershed) is disregarded, stormwater runoff is the largest pathway for most of the contaminants, including suspended solids, nutrients, some metals, and most of the organics evaluated in the study. Uncontrolled CSOs are the major pathway for bacteria and a significant pathway (estimated at 5% or more of the total load) for phosphorus, zinc, PBDEs, and PCBs. Houseboats, watercraft, industrial shipping, and channel maintenance activities represent other important sources of pollutants to this water body.

5.1.5 Small rivers and streams

There are many small rivers and streams in the Cedar-Sammamish Basin. Some examples are Kelsey, Thornton and Juanita Creeks that flow into Lake Washington, Issaquah Creek that flows into Lake Sammamish, Evans Creek that flows into the Sammamish River, and many smaller, lesser known streams that flow into the Cedar River, including above the dam. In the lowermost part of the basin (that is, in the area around Lake Union/Ship Canal), there are some stream remnants remaining, but most of the surface runoff is conveyed through the stormwater conveyance network.

Because much of the Cedar River watershed is protected as a water supply, the rivers and streams in the upper watershed can be expected to be high quality. However, most of the other small rivers and streams in the basin can be expected to be exhibiting typical water quality problems associated with human development, including increased nutrient and bacteria concentrations, elevated temperature, and lower dissolved oxygen.

According to the SalmonScape database, some runs of Chinook, chum, coho, salmon, and steelhead trout are present in many of these streams. Although there are no wastewater

[56] Water Quality Assessment and Monitoring Study: Estimated Present-Day Contaminant Loadings to Duwamish Estuary/Elliott Bay and Lake Union Ship Canal. King County, 2017. https://your.kingcounty.gov/dnrp/library/2017/kcr2926/kcr2926.pdf

treatment plant discharges to these streams, stormwater runoff and on-site septic systems are likely pollutant sources.

5.2 Green-Duwamish Basin

The Green-Duwamish Basin (see Figure 12) has a drainage area of approximately 484 square miles. It extends from the crest of the Cascade Mountains at the headwaters of the Green River west into the Duwamish River, just downstream of the confluence of the Black and Green rivers. The Green River flows into the Duwamish River/Waterway, which then flows into Elliott Bay and the Central Basin of Puget Sound.[57]

According to the SalmonScape database, Puget Sound Chinook, chum, coho, pink, and sockeye salmon are all present in the basin, as are coastal cutthroat, steelhead, and bull trout. Chinook, steelhead, and bull trout are all listed as threatened species under the ESA, and coho and coastal cutthroat trout are listed as species of concern. Although most of the basin is recognized as providing habitat for these species, fish passage barriers in the upper basin limit the availability of habitat.

Additionally, pollutants and high water temperatures are contributing to the decline of these species. While shellfish including clams, mussels, and oysters may be present in the estuary area, because of the human population density and known sources of contamination, all of the area is permanently closed to shellfish harvest.

Figure 12. Green-Duwamish Basin

[57] Green River Watershed. King County, 2019. https://www.kingcounty.gov/services/environment/watersheds/green-river.aspx

5.2.1 Green River

The Green River watershed (462 square miles) extends from the crest of the Cascade Mountains and flows west to where the Green River and Black River join.[58] Land use in the upper part of the watershed is dominated by forest and serves as the primary water supply for the city of Tacoma. Land use in the middle portion of the watershed is also primarily undeveloped (56%), but residential development is also a major land use (33%). The lower portion of the river is almost entirely developed (83%), with very high-intensity development along the stream corridor.[59] No wastewater treatment plants or CSOs discharge to the river, but many cities discharge stormwater to surface waters in the watershed. Therefore, surface runoff is likely the key pollution pathway.

5.2.2 Duwamish Waterway

The Duwamish Waterway includes the Duwamish River, which is almost entirely tidally influenced and a saltwater estuary. The watershed (excluding the Green River) is approximately 22 square miles. The waterway is heavily used for commercial vessels and is located within one of Seattle's primary industrial zones. The quality of the water and sediments reflects many years of influence from mining, logging, shipping, discharge of untreated sewage and industrial wastes, and widespread use of organic contaminants, especially PCBs.

Bacteria, dissolved oxygen, temperature, and ammonia are documented water quality problems in multiple places in the waterway.[60] There are also numerous places where sediments and fish tissue are contaminated and do not meet standards for a wide variety of metal and organic toxics. Organic contaminants are prevalent in the Duwamish Waterway and there are three EPA-designated Superfund sites, each with multiple cleanup areas. Contaminated sediments are considered to be primarily a result of historical discharges of pollutants, although there are ongoing loadings from local drainages and the upstream watershed; PCB and mercury concentrations exceed sediment standards throughout the waterway.

The Washington State Department of Health has issued a fish consumption advisory because of elevated contaminants in the tissue of fish and shellfish.[61] The most frequently measured contaminants in tissue samples were PCBs, PAHs, and metals. There are 17 CSO outfalls that discharge to the Duwamish Waterway, including the County's largest remaining uncontrolled outfall. Many stormwater outfalls also discharge to the Duwamish Waterway.

According to a recent study by King County, stormwater runoff is the largest contributor of most contaminants to the Duwamish Waterway if the Green River (which represents all the pollutant input from the upper watershed) is ignored.[62] The exceptions are bacteria, which are generated primarily from uncontrolled CSOs; total PAHs, for which creosote-treated wood pilings have

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[58] Year 2003 Water Quality Data Report, Green-Duwamish Watershed Water Quality Assessment. Herrera, 2005. https://your.kingcounty.gov/dnrp/library/2005/KCR1583_2003/kcr1583_2003_1.pdf

[59] Completion of the 2011 Nation Land Cover Database for the conterminous United States. Homer, 2015. https://pubs.er.usgs.gov/publication/70146301

[60] Puget Sound Nutrient Source Reduction Project Volume 1: Model Updates and Bounding Scenarios. Ecology, 2019.

[61] Fish Consumption Advisories in Washington State. Washington Department of Health. https://www.doh.wa.gov/DataandStatisticalReports/HealthDataVisualization/fishadvisory

[62] Analysis of Existing Data on the Duwamish Estuary. King County, 2017. https://your.kingcounty.gov/dnrp/library/2017/kcr2934/kcr2934.pdf

been identified as the largest source; and total copper, for which antifouling vessel paint is the largest source.[63]

5.3 Snoqualmie River Basin

The Snoqualmie River Basin is approximately 700 square miles and extends from the crest of the Cascade Mountains to Puget Sound, flowing into Possession Sound near the City of Everett. The watershed consists of two major river systems: the Snoqualmie and the Skykomish. These two river systems converge near Monroe to create the Snohomish River. The Snoqualmie River watershed is primarily in King County, with a small portion of the lower extending into Snohomish County. The upper portion of the basin is comprised of three main forks of the Snoqualmie (North Fork, Middle Fork, and South Fork) that meet near the city of North Bend and combine to form the mainstem Snoqualmie River before flowing past the city of Snoqualmie.

Land use in the upper part of the basin is dominated by forest, much of which is in National Forest Service management. At approximately river mile 38.5, the Snoqualmie River drops 268 feet over Snoqualmie Falls, beginning at the lower portion of the basin. Land use in the lower basin is characterized by agriculture, rural development, and small rural communities and cities such as Fall City, Carnation, and Duvall. In the lowermost portions of the basin, rapid urban and suburban development is occurring.

Each of the incorporated cities in the Snoqualmie Valley has a wastewater treatment plant that discharges treated wastewater to the Snoqualmie River. The cities of Duvall, Snoqualmie, and North Bend operate their own wastewater treatment plants. King County operates the Carnation wastewater treatment plant. These are all small wastewater treatment facilities in terms of the volume of water they discharge. No CSOs discharge to the river.

The same communities discharge stormwater from developed land surfaces to the Snoqualmie River and its small tributaries, and surface runoff is likely a key pollutant pathway for most pollutants.

According to the SalmonScape database, Puget Sound Chinook, chum, coho, pink, and sockeye salmon are all present in the basin, as are steelhead, coastal cutthroat trout, and bull trout.[64] Chinook, steelhead, coastal cutthroat, and bull trout are all listed as threatened species under ESA, and coho are listed as species of concern. Additionally, pollutants and high water temperatures are contributing to the decline of these species.

5.4 Central Basin of Puget Sound

The Central Basin of Puget Sound (see Figure 13) extends from the White-Puyallup River watershed and Tacoma in the south to the Snoqualmie-Skykomish watershed north of Seattle. All of the surface waters in King County drain directly or indirectly to the Central Basin, including the two major basins described in previous sections, the Vashon-Maury islands area, and the many small rivers and streams that flow directly into Puget Sound.

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[63] Water Quality Assessment and Monitoring Study: Estimated Present-Day Contaminant Loadings to Duwamish Estuary/Elliott Bay and Lake Union Ship Canal. King County, 2017. https://your.kingcounty.gov/dnrp/library/2017/kcr2926/kcr2926.pdf

[64] SalmonScape. Washington Department of Fish and Wildlife. https://apps.wdfw.wa.gov/salmonscape/

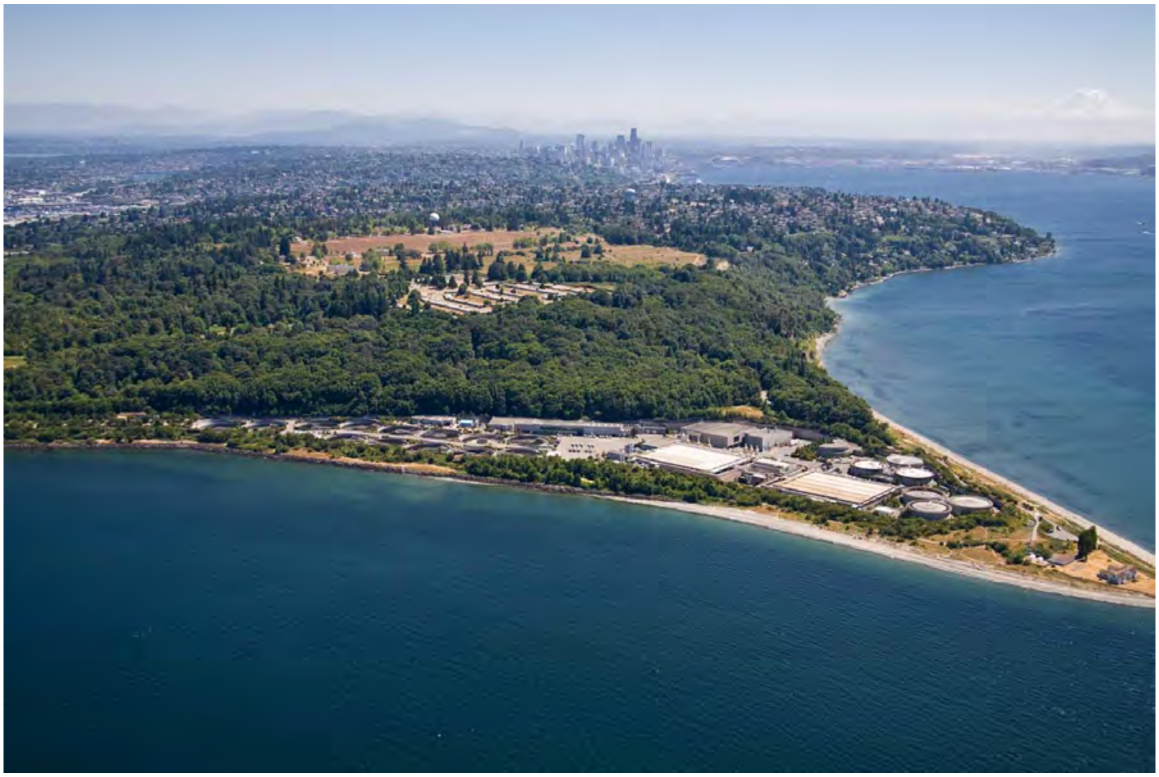

Figure 13. Central Basin of Puget Sound

All of the migratory salmon and trout species that are present in the major basins (Cedar-Sammamish,Green-Duwamish, and Snoqualmie-Skykomish) access these basins through Central Puget Sound; therefore, Chinook, chum, coho, pink, and sockeye salmon and steelhead, cutthroat, and bull trout can all be present in the basin. Chinook, steelhead, and bull trout are all listed as threatened species under the ESA, and coho and coastal cutthroat trout are listed as species of concern. Pollutants and high water temperatures are two of the important contributors to the decline of these species. Southern resident killer whales (also known as orcas) that use these waters are an endangered species under ESA, as are a number of other whale species.

Another important group of aquatic organisms in the Central Basin, because of their commercial and recreational importance, is shellfish. These include crabs, shrimp, clams (including scallops and geoduck), mussels, and oysters. Because of the population density and known sources of contamination, all of the eastern shoreline of Puget Sound in King County is permanently closed to shellfish harvesting. However, most of the shoreline of Vashon Island is approved for shellfish harvesting, with occasional closures because of biotoxins.

The Central Basin represents the most heavily populated and most urbanized portion of Puget Sound. It is also the water body to which all of the County's regional wastewater treatment plants directly or indirectly discharge. The associated watershed includes a wide variety of industrial, commercial, and residential infrastructure; large areas of pavement; heavily modified shorelines; and a large network of roads and highways. However, the headwaters of the major rivers in the basin are somewhat protected and, therefore, still forested because of their status as parklands, wilderness areas, and water supply watersheds. Approximately 77% of the watershed area draining to the Central Basin is not considered urban. However, two major rivers in the basin were placed on a list of the nation's most endangered water bodies in 2015 and 2016: the Green-Duwamish and the Puyallup-White.

Increased temperature, elevated bacteria, and decreased dissolved oxygen concentrations occur occasionally in localized areas of the Central Basin. Nutrient concentrations are also becoming an issue of concern, and Ecology is currently developing a nutrient reduction program for Puget Sound to address this issue.

Sediments in some nearshore areas of the Central Basin have exceeded state standards for various chemicals, including organic and metal contaminants. Biotoxins produced by marine algae (microscopic marine plants) have also been measured in the Central Basin at levels that are unsafe for shellfish consumption.[65] Aquatic tissue samples have also revealed several locations along the King County shoreline that have elevated concentraions of metals and/or organic contaminants.

There are 12 CSOs in the King County portion of the Central Basin, only a few of which are uncontrolled. Detailed data on all pollutant pathways into the Central Basin of Puget Sound are not available. However, Ecology directed a series of toxic pollutant loading studies that evaluated all of Puget Sound. In a final synthesis report for those studies, pollutant loadings of 16 toxic pollutants, including some metals and known organic toxins, were summarized and surface runoff was estimated to be the largest pollutant source for 14 of these contaminants that were evaluated.[66]

Typically, surface runoff accounted for more than half of the total loads from all of the other pollutant pathways combined. According to the pollutant loading studies, atmospheric deposition was a key loading pathway for two pollutants: PBDEs and certain PAHs. The studies also determined that wastewater treatment plants were a key pollution pathway for diethylhexyl phthalate and PBDEs. Although it was noted that pharmaceuticals were not addressed in the studies, concentrations of these CECs are expected to be much higher in wastewater discharges.

5.4.1 Elliott Bay

Elliott Bay is a highly modified urban embayment within the Central Basin that is influenced by freshwater outflow from the Duwamish Waterway. Historically, the inner portion of the bay was a complex, frequently flooded tidal marsh, but much of the area has been filled, drained, and dredged to support port and industrial activities. Downtown Seattle and the Port of Seattle, and

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[65]. Existing Conditions in the King County Puget Sound Nearshore. King County, 2019.

[66] Control of Toxic Chemicals in Puget Sound: Assessment of Selected Toxic Chemicals in the Puget Sound Basin, 2007–2011. Ecology and King County, 2011. https://fortress.wa.gov/ecy/publications/documents/1103055.pdf

the high-intensity industrial and commercial land uses they represent, occupy most of the shoreline.[67]

According to King County's most recent water quality study, bacteria, temperature, and dissolved oxygen are problems in many places in Elliott Bay. Nearshore bacteria concentrations have declined in the past decades, likely due, in part, to improved CSO control. There are also numerous places where sediments and fish tissue are contaminated by a variety of metal and organic toxins, including PAHs, PCBs, and phthalates. PBDE and dioxin/furan concentrations are also elevated. Although there are no standards associated with these contaminants, they are a concern because of their toxicity and propensity to bioaccumulate. Overall, the study found that sediments in the nearshore areas of inner Elliott Bay have the potential to adversely affect benthos (the flora and fauna on the bottom of the bay) because they often exceed the sediment management standards.

In King County's most recent pollutant loading study, pollutant load estimates were combined for Elliott Bay and the Duwamish estuary. Therefore, the principal pollution pathways are the same as those described in Section 5.2.2 (Duwamish Waterway) above.

5.4.2 Small rivers and streams

There are a number of small streams that discharge directly to the Central Basin. Some examples are Pipers Creek, Miller Creek, and Des Moines Creek; there are also many minor drainages along the shore. These streams can be expected to exhibit typical water quality problems associated with human development, including increased nutrient and bacteria concentrations, elevated temperature, and lower dissolved oxygen.

According to the SalmonScape database, some of these streams do support some salmon species runs. While there are no wastewater treatment plant discharges to these streams, stormwater runoff and on-site septic systems are likely pollutant sources.

6.0 Regional wastewater system and operations

In 1958, voters in the greater Seattle area approved the creation of Metro (officially the Municipality of Metropolitan Seattle), giving it responsibility for creating a regional wastewater treatment system based on watersheds instead of jurisdictional boundaries. As a result, by the late 1960s, regional water quality had improved dramatically. In 1994, King County assumed authority of Metro and its legal obligation to treat wastewater for 34 local jurisdictions and local sewer agencies that contract with the County. This section describes the County's current regional wastewater system and operations, including wastewater conveyance, wastewater treatment, wet weather management, sustainability and climate change efforts, and resource recovery programs.

6.1 Wastewater conveyance

King County provides wholesale wastewater conveyance and treatment services to 17 cities, 16 local sewer utilities, and one Indian tribe in King, Snohomish, and Pierce counties (see Figure 14). Overall, WTD's collection system consists of nearly 400 miles of sewer pipelines, 25 regulator stations, and 48 pump stations. The local agencies that WTD serves own and

[67] Water Quality Assessment and Monitoring Study: Analysis of Existing Data on Elliott Bay. King County, 2017. https://your.kingcounty.gov/dnrp/library/2017/kcr2930/kcr2930.pdf

operate independent collection systems, which include an estimated 5,900 miles of pipelines and numerous pump stations, to collect and carry wastewater flows in their service areas to the County's regional system for treatment and disposal.

WTD's conveyance system consists of separated sewers, combined sewers, and associated pump stations. This section describes the collection and conveyance services that WTD provides.

6.1.1 Combined sewer system

Combined sewer systems consist of sewers designed to transport sanitary sewage during dry weather, with the addition of stormwater during wet weather events. Every combined sewer system has a capacity limitation and, when that capacity is exceeded, excess flow is discharged through regulator structures into receiving waters. This excess flow discharge is called a "combined sewer overflow," or CSO. WTD owns and maintains about 100 miles of combined sewers, which represents about 25% of WTD's pipe system.

Combined sewers are typically found in the older portions of wastewater collection systems. In King County, the combined sewers are limited to the city of Seattle and most combined sewage is conveyed to West Point Treatment Plant (West Point) for treatment. The level of service for WTD's combined sewer system is to convey 2.25 times the average wet weather flow to treatment as well as to meet the following (refer to Section 4.2, Federal and state regulations, for further discussion on these topics):

- The state's CSO control standard of an average of no more than one untreated discharge per CSO outfall per year based on a 20-year average
- Conditions of the NPDES permit requirements
- Conditions of the EPA/Ecology Consent Decree

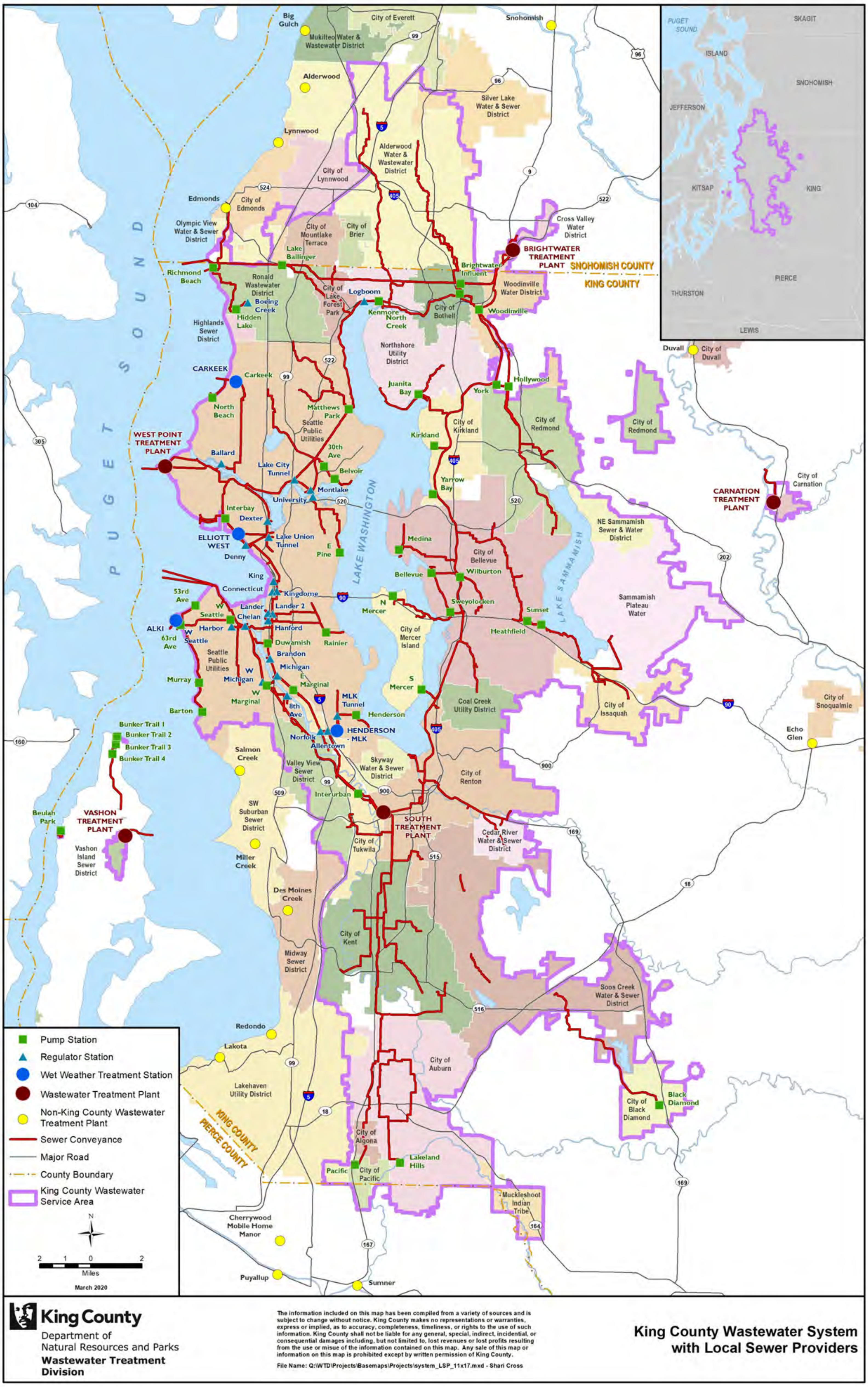

Figure 14. WTD service area by local sewer service provider

6.1.2 Separated sewer system

Separated sewer systems consist of sewers designed to convey sanitary sewage as well as infiltration and inflow (I/I). (Refer to Section 6.3.3, Infiltration and inflow management, for further discussion of I/I.) In the urban landscape, the separated sewer system works in concert with separate stormwater collection systems to manage sanitary and wet weather flows, respectively. WTD owns and maintains about 250 miles of separated sewer systems, which represent about 65% of WTD's pipe system.

Newer sewer systems do not combine sanitary and stormwater into a single sewer system. As a result, separated sewer systems serve all of the WTD service area except those in most of Seattle. WTD's separated sewers convey flow primarily to South Treatment Plant (South Plant) and Brightwater Treatment Plant (Brightwater) for treatment.

For the sanitary separated sewer system, level of service goals have been established to protect public health and water quality. WTD's conveyance policy requires that separated wastewater conveyance must convey the 20-year peak flow (a 20-year return interval storm) to avoid sanitary sewer overflows.[68]

6.1.3 Outfalls

Outfalls are used to convey treated effluent from WTD's wastewater treatment plants to the receiving water body that each plant discharges to. WTD owns and maintains about 35 miles of effluent outfalls, which represent about 9% of WTD's pipe system.[69]

6.1.4 Pump stations

Figure 15 and Figure 16 show WTD's separated system and combined system pump stations, respectively, including the installed capacity and completion date of construction or last major retrofit.[70] For the design of pump stations in the separated system, a 20-year peak flow is used to set the total pumping capacity. Additionally, a 5-year peak flow of all pumps in service, except the largest pump operating, is used to set the firm pumping capacity.

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[68] RWSP 2006 Comprehensive Plan Review and Annual Report. King County, 2006. https://your.kingcounty.gov/dnrp/library/wastewater/wtd/construction/Planning/RWSP/CompReview/06/Ch03.pdf

[69] Facts about the King County regional wastewater system. King County, 2016. https://www.kingcounty.gov/depts/dnrp/wtd/system/facts.aspx

[70] Recommendations to Enhance the Resiliency and Recovery of King County's Regional Wastewater Treatment Facilities. King County, 2018.

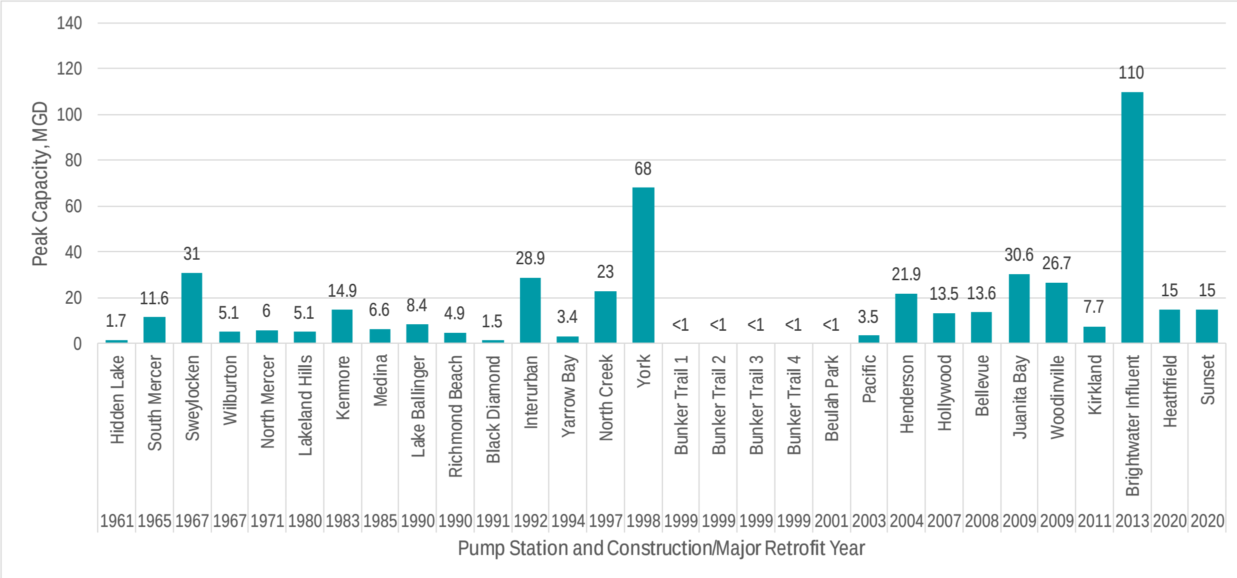

Figure 15. Separated system pump stations

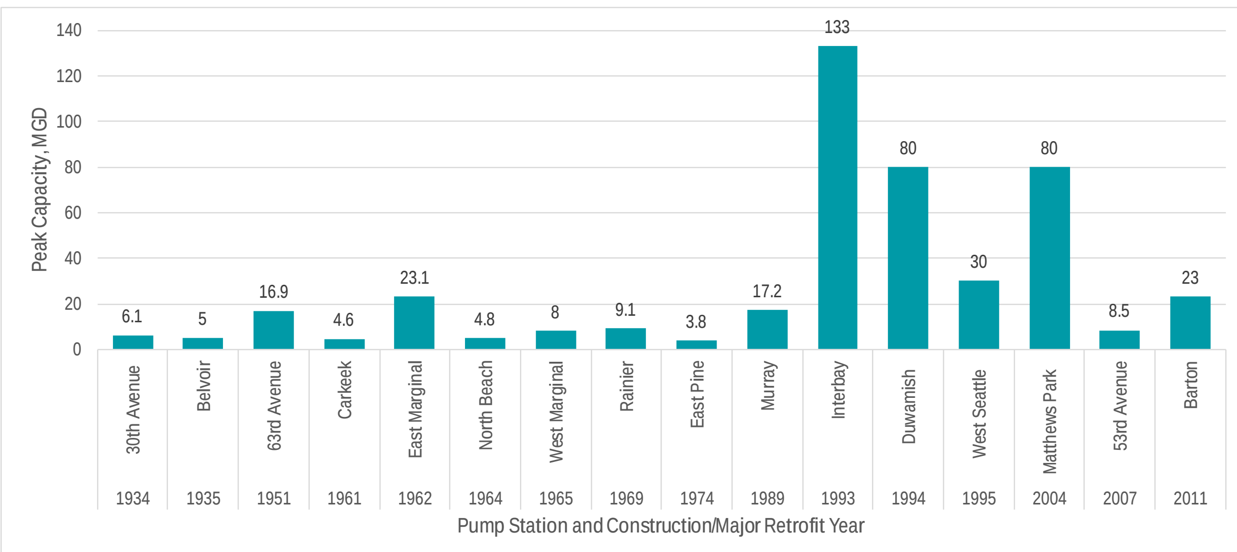

Figure 16. Combined system pump stations

6.1.5 Flow transfers

WTD's system includes some capability to transfer wastewater flows from one wastewater treatment plant's service area to another; however, downstream conveyance capacity limitations limit the ability to implement these flow transfers, particularly during wet weather. WTD system transfer capabilities include the following:

- Flow transfer with Edmonds: King County and the City of Edmonds have an agreement for Edmonds to treat all flows from the County's Richmond Beach service area while the County receives and treats a matching volume from the eastern portion of the Edmonds service area, which flows into the Lake Ballinger Pump Station. The Lake Ballinger Pump Station also has the capability to transfer flows to the Edmonds service area.[71]
- Between West Point and Brightwater: There is limited capability at the Kenmore Pump Station to direct flows that would typically be routed to the West Point service area to the Brightwater service area instead.[72]
- Between Brightwater and West Point: The Brightwater Diversion Structure and North Creek Diversion Structure can be configured to direct flows that would typically be routed to the Brightwater service area to Kenmore Pump Station and on to West Point instead. In addition, flows from Swamp Creek Trunk can be diverted away from Brightwater toward Kenmore Pump Station and flow to West Point.
- Between Brightwater and South Plant: The North Creek Pump Station can direct up to 36 MGD of flow to York Pump Station. Flow upstream of Hollywood Pump Station can also be directed to York Pump Station. York Pump Station can transfer up to 68 MGD to South Plant.[73]
- Between South Plant and West Point: The Allentown Diversion Structure can be configured to direct flows from a small portion of south Seattle that would typically be routed to South Plant to West Point instead.

6.2 Wastewater treatment

This section describes King County's wastewater treatment plants, current wastewater flow and loading conditions, and historical inequities associated with wastewater treatment.

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[71] City of Edmonds King County Agreement for Sewage Treatment. Edmonds and King County, 2000. \\bcseafp01\projects\King County\152700 KC WTD Systemwide Comp Plan\Task 300\Subtask 310 - Review Existing System, Studies and Background Info\King County Documents\42-Edmonds Flow Swap Agreement and Amend.pdf

[72] Treatment Plant Flow and Wasteload Projections. King County, 2014. https://your.kingcounty.gov/dnrp/library/wastewater/wtd/construction/Planning/RWSP/CompReview/13/1411_TPFlowAndWasteloadProjections_2010-2060.pdf

[73] Treatment Plant Flow and Wasteload Projections. King County, 2014. https://your.kingcounty.gov/dnrp/library/wastewater/wtd/construction/Planning/RWSP/CompReview/13/1411_TPFlowAndWasteloadProjections_2010-2060.pdf

6.2.1 Wastewater treatment plants

King County operates three regional wastewater treatment plants in the metropolitan area: West Point, South Plant, and Brightwater. The County also operates two local wastewater treatment plants (Vashon and Carnation) with much smaller capacity than its regional facilities (representing only 0.1% of all flows). The following are brief summaries of these plants:

- **South Plant**, located in Renton, treats wastewater mainly from the separated sewer systems in communities located east and south of Lake Washington.[74]
- **West Point**, located in Seattle, treats wastewater from the combined sewer system in Seattle as well as other communities in northwest King County.[75]
- **Brightwater**, located near Woodinville, treats wastewater from the mostly separated sewer system in communities located east of Lake Washington and in south Snohomish County.[76]
- **Carnation**, located in Carnation's urban growth area, serves the city of Carnation.[77]
- **Vashon**, located on Vashon Island, treats residential and commercial wastewater in the Vashon Sewer District.[78]

Each system is described in greater detail in the following subsections. Figure 17 shows the WTD service area by sewershed (that is, the defined area where the sewers flow to each wastewater treatment plant), including the location of the County's wastewater treatment plants.

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[74] South Treatment Plant. King County, 2017. https://www.kingcounty.gov/depts/dnrp/wtd/system/south.aspx

[75] West Point Treatment Plant. King County, 2019. https://www.kingcounty.gov/depts/dnrp/wtd/system/west.aspx

[76] Brightwater Treatment Plant. King County, 2017. https://www.kingcounty.gov/depts/dnrp/wtd/system/brightwater.aspx

[77] Carnation Treatment Plant. King County, 2017. https://www.kingcounty.gov/depts/dnrp/wtd/system/carnation.aspx

[78] Vashon Treatment Plant. King County, 2017. https://www.kingcounty.gov/depts/dnrp/wtd/system/vashon.aspx

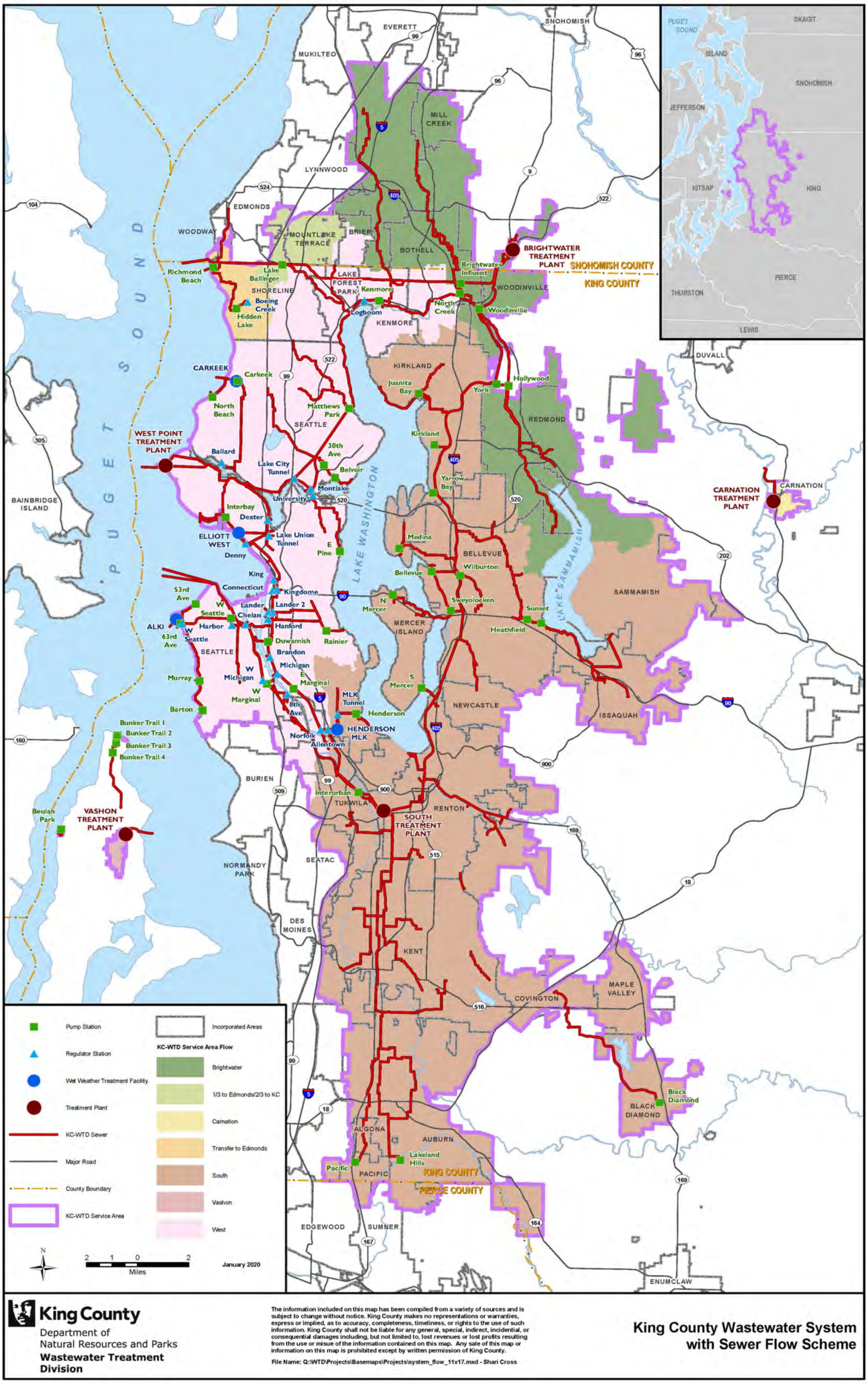

Figure 17. WTD service area by sewershed

6.2.1.1 South Treatment Plant

South Plant treats wastewater mainly from the separated sewer system in communities located east and south of Lake Washington. Liquid stream treatment at South Plant includes preliminary treatment (screening and grit removal), primary clarification, air activated sludge secondary treatment, and disinfection using sodium hypochlorite. Disinfected effluent is pumped via the effluent transfer system (ETS) to a deep-water outfall in Puget Sound or treated through sand filters and additional disinfection for non-potable reuse. Screenings and grit are hauled off-site for landfill disposal and the remaining solid stream treatment processes include dissolved air flotation thickening, anaerobic digestion, and centrifuge dewatering. Class B biosolids are generated and trucked off-site for beneficial use, while biogas generated in the digestion process is upgraded to renewable natural gas and used to meet on-site heating needs, to generate electricity on-site, or sold off-site. Figure 18 presents the South Plant process flow schematic.

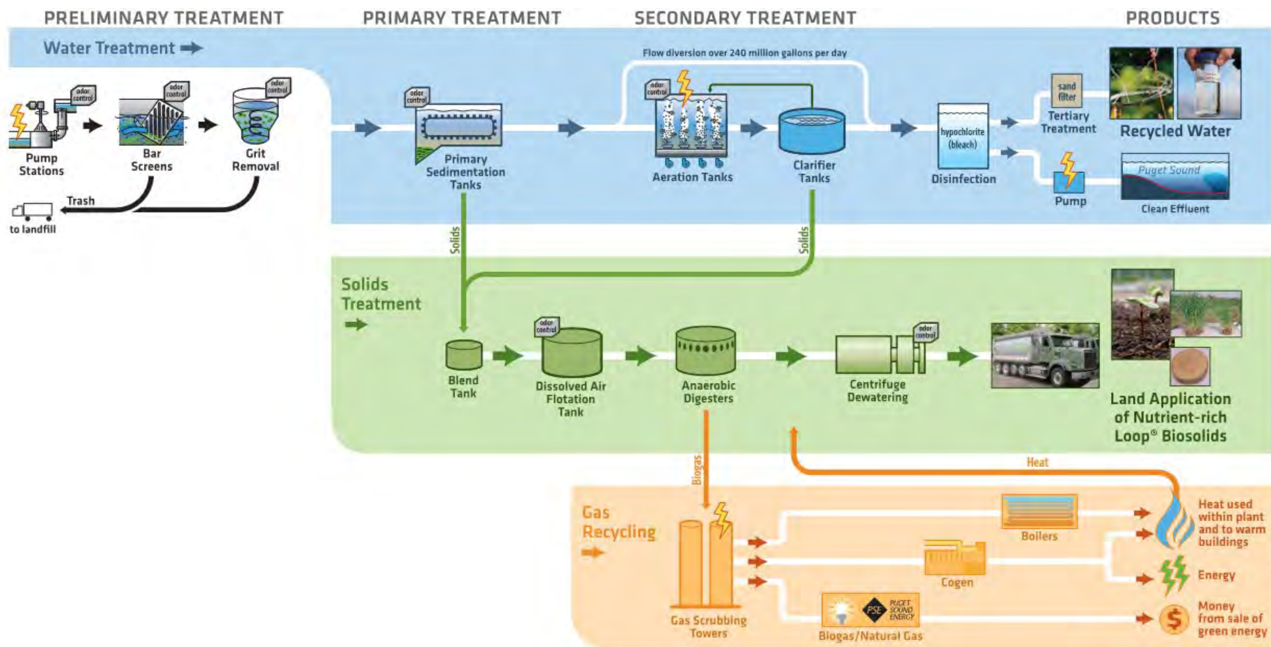

Figure 18. South Plant process flow schematic

South Plant has a septage-receiving station to treat septage and manage solids from the Vashon and Carnation treatment plants. On average, septage accounts for approximately 0.1% of South Plant's influent flow and 8% of influent solids loading.

South Plant is designed to provide secondary treatment for flows up to 240 MGD and secondary bypass for flows above 240 MGD. Flows above between 240 and 325 MGD receive primary treatment with disinfection and are sent directly to the ETS. If flows exceed the capacity of the ETS (that is, 325 MGD), excess disinfected secondary effluent is sent to the emergency outfall in the Green River.[79] The South Plant site has space allocated for future capacity expansion of the liquid and solids treatment processes at the current levels of treatment. Upgrading to a

[79] South Plant process flow schematic. King County, 2017. https://www.kingcounty.gov/~/media/depts/dnrp/wtd/system/Process/1801_south-treatment-process.ashx?la=en

higher level of treatment would require changes to the treatment processes and using portions of the site allocated for capacity expansion.

6.2.1.2 West Point Treatment Plant

West Point treats wastewater from the combined sewer systems in Seattle as well as other communities in northwest King County. The West Point liquid stream treatment processes include preliminary treatment (screening and grit removal), primary clarification, high-purity oxygen (HPO) activated sludge secondary treatment, and disinfection using sodium hypochlorite. Disinfected effluent is pumped via the effluent pump station to a deep-water outfall in Puget Sound. Screenings and grit are hauled off-site for landfill disposal, and the remaining solid stream treatment processes include gravity belt thickening, anaerobic digestion, and centrifuge dewatering. Class B biosolids are generated and trucked to beneficial-use sites in eastern Washington. Biogas generated during the digestion process is used on-site to meet heating needs, to power the raw sewage pumps, and produce renewable electricity on-site. Figure 19 presents the West Point process flow schematic.[80]

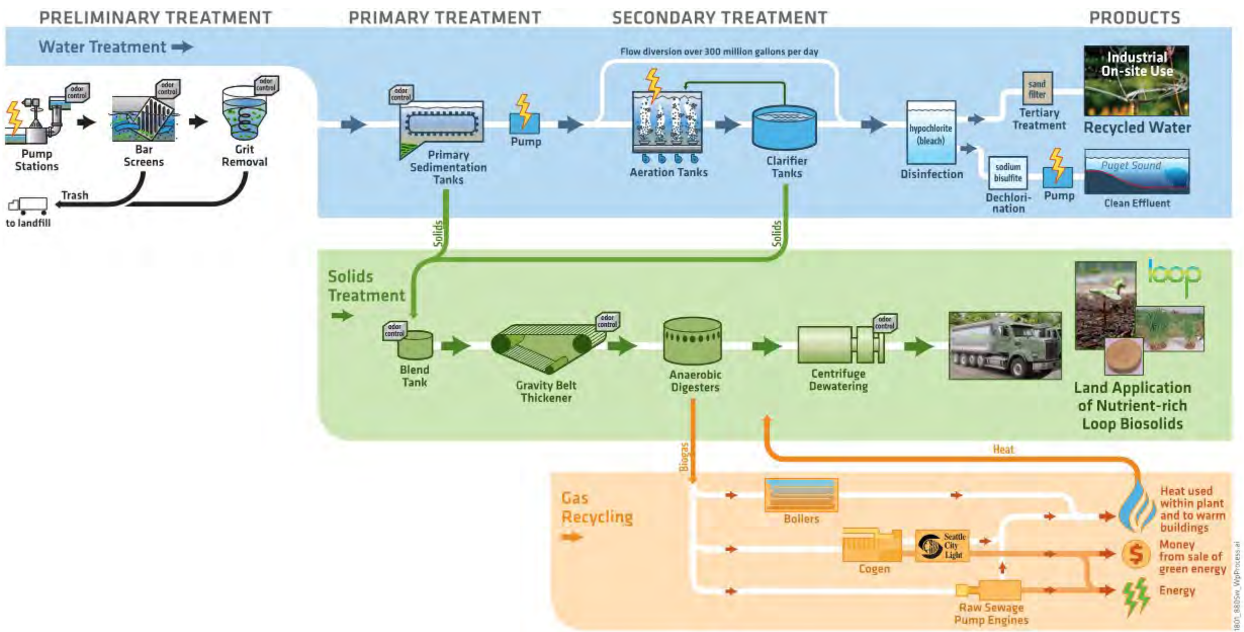

Figure 19. West Point process flow schematic

Because West Point serves an area with combined sewers, the wastewater treatment plant was not designed to treat all of the flows it receives to a secondary treatment standard. Instead, West Point is designed to provide primary and secondary treatment for flows up to 300 MGD and primary treatment only for excess flows over 300 MGD and up to 440 MGD.

The West Point site is a relatively small site that is nearly completely built out with very limited opportunities for expansion. The HPO aeration system is used instead of a conventional activated sludge process to maximize the capacity with the space available. By using high-purity oxygen instead of air (which is only 21% oxygen), the space for aeration tanks is reduced significantly.

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[80] West Point process flow schematic. King County, 2019. https://www.kingcounty.gov/~/media/depts/dnrp/wtd/system/Process/1801_west-point-treatment-process.ashx?la=en

Further expansion of West Point for either increased capacity or upgraded treatment would likely require a shift to a new process technology that can provide more treatment within the same space. Construction of these modifications would be challenging because the limited available space would require significant consideration for how construction could be completed while continuing to treat wastewater.

6.2.1.3 Brightwater Treatment Plant

Brightwater, located in Snohomish County just north of Woodinville, treats wastewater from the separated sewer system in communities located east of Lake Washington and in south Snohomish County. Liquid stream treatment processes at Brightwater include preliminary treatment (screening and grit removal), primary clarification, fine screening, membrane bioreactor (MBR) secondary treatment, and disinfection using sodium hypochlorite. Disinfected effluent flows through a deep-water outfall into Puget Sound or is used for recycled water applications. Screenings and grit are hauled off-site for landfill disposal and the remaining solid stream treatment processes include gravity belt thickening, anaerobic digestion, and centrifuge dewatering. Class B biosolids are generated and trucked off-site for land application beneficial use. Biogas generated in the digestion process is used to meet on-site heating needs. Figure 20 summarizes the Brightwater treatment process.[81]

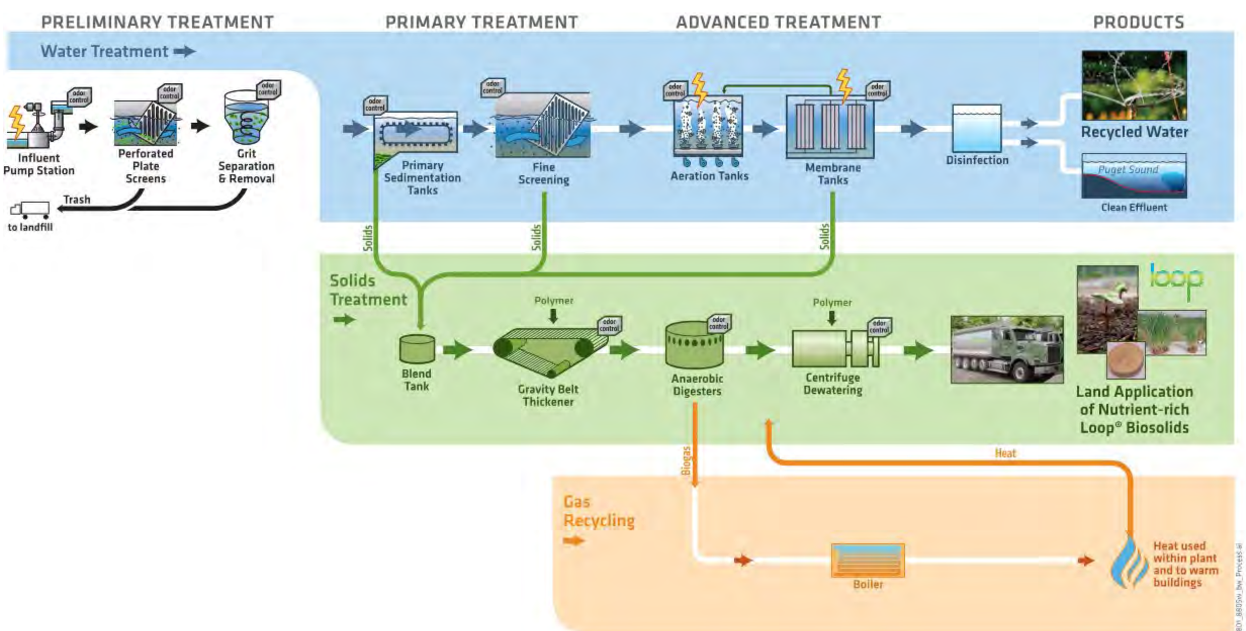

Figure 20. Brightwater process flow schematic

Brightwater is designed to provide split-flow treatment during wet weather events. In this treatment scheme, when flows exceed the capacity of the MBR system (as well as the available capacity for storage and diversion to other County wastewater treatment plants), excess flows are bypassed around the MBR system. The bypassed flow receives chemically enhanced primary treatment and is blended with the MBR effluent prior to disinfection.

[81] Brightwater Plant flow schematic. King County, 2019. https://www.kingcounty.gov/~/media/depts/dnrp/wtd/system/Process/1801_brightwater-treatment-process.ashx?la=en

Brightwater is designed to provide secondary treatment for up to 44 MGD and can provide chemically enhanced primary treatment for flows up to 110 MGD. Secondary treatment capacity at Brightwater suffers from occasional filterability limitations that temporarily reduce the process capacity below the design capacity. The County is investigating the filterability limitations in conjunction with the MBR manufacturer in an attempt to eliminate them and maintain full capacity at all times.

The Brightwater site is fairly space constrained. During design, the MBR process was selected to maximize the treatment capacity within the space available. Space is reserved for limited phased capacity expansion of each of the treatment processes over time.

6.2.1.4 Carnation Treatment Plant

Carnation is designed to treat a maximum of 0.4 MGD. In 2018, the average flow was 0.1 MGD. The wastewater treatment plant receives wastewater from residential and commercial customers in Carnation's urban growth area through a collection system owned and maintained by the City of Carnation.

Carnation uses preliminary treatment (screening and grit removal), MBR secondary treatment, and ultraviolet disinfection. All of the plant effluent is treated to Class A reclaimed water standards and is used for wetland enhancement at the Chinook Bend Natural Area.

No solids treatment facilities are located at Carnation. Screening and grit are hauled for landfill disposal and the remaining solids removed in the liquid stream process are trucked to South Plant for treatment.[82]

6.2.1.5 Vashon Treatment Plant

Vashon treats residential and commercial wastewater within the Vashon Sewer District. A maximum of 1.4 MGD can be treated at the plant. In 2018, an average of 0.2 MGD was treated.

Vashon uses preliminary treatment (screening and grit removal), an oxidation ditch, secondary clarification, and ultraviolet disinfection with effluent discharge into Puget Sound.

No solids treatment facilities are located at Vashon. Screening and grit are hauled for landfill disposal and the remaining solids removed in the liquid stream process are trucked to South Plant for treatment.[83]

6.2.2 Equity impact assessments of facilities

Between 2010 and 2014, WTD conducted a series of assessments to evaluate the equity impacts of the siting, design, construction, operation, and maintenance of WTD facilities, including wastewater treatment plants, pump stations, and other operations. These studies did not show a direct link between neighborhood demographics and facility location or design and service quality.[84]

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[82] Carnation Treatment Plant. King County, 2017. https://www.kingcounty.gov/depts/dnrp/wtd/system/carnation.aspx

[83] Vashon Treatment Plant. King County, 2017. https://www.kingcounty.gov/depts/dnrp/wtd/system/vashon.aspx

[84] Equity and Social Justice Review of Facilities: Assessment of Residential Area Pump Stations. King County, 2015. https://www.kingcounty.gov/~/media/depts/dnrp/wtd/about/ESJ/2015-06_ESJ-Pump-Station-Review.ashx?la=en

In 2013, WTD also investigated an evenly distributed sample of wastewater treatment and conveyance facilities to determine any possible inequities in the utility's practices, as it pertains to design, odor, and maintenance of the regional wastewater system. The initial review included a subset of pump stations and suggested that there may be a correlation between higher income and higher quality of design as well as a possible correlation between higher income and increased quality of maintenance.[85]

6.2.3 Wastewater treatment capacity constraints

Overall, treatment plant capacity is governed by both flow (the amount of liquid) and loading (solids and dissolved organic matter). Flow is affected by both population and wet weather events. For WTD's system, the capacity of the pipelines conveying wastewater to the treatment plants limits the amount of wet weather peak flow that reaches the plants. Existing and projected peak flows are not the primary cause of capacity constraints for most of the processes within the regional treatment plants, but peak flow is a major factor for sizing and timing of the upgrades in the conveyance system.

In 2019, the County completed a wastewater treatment plant flows and loadings study to assess the existing and potential future capacity of each major treatment process within the three regional wastewater treatment plants and the timing of when that capacity would be exceeded. As part of this study, WTD updated flow and loading projections through 2060.[86]

WTD determined that, based on existing conditions, approximately 10 processes at the three regional treatment plants are projected to be at, or exceed capacity within, the next 10 years and all three regional treatment plants will need significant expanded treatment capacity in the 2030s. WTD currently has projects underway to address three of the near-term capacity limitations and has initiated an effort to identify specific projects for other near-term capacity limitations.

6.2.4 Wastewater technology

The wastewater treatment industry is continually experiencing advances in science and technology as well as regulatory changes that correspond to these advances. As such, King County is committed to being at the forefront of wastewater treatment trends. The Technology Assessment and Innovation Program (TAIP) is a dedicated group within WTD that ensures that the division takes full advantage of wastewater industry innovations.[87] TAIP provides technical services to stimulate innovation, build a sustainable and resilient future, advance resource recovery, and maximize the cost-effectiveness of WTD services. TAIP helps WTD be strategic about evaluation and decision-making related to WTD's technology and innovation opportunities. TAIP also strives to anticipate regulatory changes that may affect WTD's permits and operations.

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[85] Equity and Social Justice Review of Facilities. King County, 2013. https://www.kingcounty.gov/~/media/depts/dnrp/wtd/about/ESJ/2013-11_ESJ-Facilities-Review.ashx?la=en

[86] Treatment Plant Flows and Loadings Summary Report. Brown and Caldwell, 2019.

[87] Technology Assessment and Innovation Program Strategic Plan. King County, 2018. https://www.kingcounty.gov/~/media/services/environment/wastewater/resource-recovery/plans/1711_KC-WTD-TAIP-2018-2037-Strategic-Plan-rev.ashx?la=en

To stay current with technological and regulatory changes, TAIP monitors and evaluates the following:

- Improved treatment processes and efficiencies
- Process controls and treatment reliability
- Reducing the environmental footprint of wastewater treatment and its byproducts
- Improvements in safety

6.2.5 Staffing

WTD employs approximately 700 people, almost half of which comprise operations staff that run the County's regional wastewater conveyance and treatment facilities 24 hours a day, 7 days a week. As it is for other utilities in major metropolitan areas, retaining plant operations staff, in particular, represents a challenge for WTD. Primarily beause of the region's strong economy and low employment rate, staff turnover has increased.

Staff retention at West Point, in particular, is an ongoing issue because the cost of living in the surrounding area is high, which results in long commutes for employees, who often transfer from West Point to other facilities once eligible.[88] Additionally, in the next 4 years, approximately 20% of WTD's entire workforce will be eligible for retirement, further exacerbating the problem.

To attract new employees, WTD has implemented a number of recruitment strategies including hosting career fairs and networking opportunities, offering high school and college internships and an Operator-in-Training Program, and aligning with the King County WorkSource's Work-to-Hire program that contracts with higher-education organizations to introduce youth to wastewater careers and provide work study placements and job training opportunities to disadvantaged youth. The County has also taken strides to diversify its workforce by targeting specific demographics such as women in trades and people of color. To date, diversity in employment applications, hiring, and promotions has steadily increased across the board at WTD.

6.3 Wet weather management

Wet weather management involves flows into three different collection systems: combined sewer systems, separated sewer systems, and MS4s. Wet weather flows are intentionally captured by combined sewer systems and MS4s, and unintentionally captured in the separated sewer system in the form of I/I. The remaining surface runoff that is not captured in a pipe and instead directly enters receiving waters is referred to as "nonpoint flow."

The County operates a combined sewer system, a separated sewer system, and an MS4, each of which is regulated and permitted by Ecology. WTD is responsible for managing the County's combined sewer system and separated sewer system, including wet weather flows to those systems, while King County's Water and Land Resources Division is responsible for managing wet weather flows in the County's MS4.

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[88] West Point Treatment Plant Independent Assessment. July 2017. https://www.kingcounty.gov/~/media/depts/dnrp/wtd/system/WP/restoration/170718-WPt-Ind-Assmt-Report-FINAL.ashx?la=en

6.3.1 Combined sewage management

When large storms occur, CSOs may result at any of the County's 39 CSO outfalls. Each outfall discharges into one of the regional water bodies, including Lake Washington, Lake Union, the Lake Washington Ship Canal, the Duwamish River, Elliott Bay, or Puget Sound. Figure 21 shows the location and status of the County's CSO locations. King County has greatly reduced the occurrence of overflows from its CSOs since the 1960s by implementing projects to increase the conveyance or storage capacity of the combined system. However, 20 out of the County's 39 CSO locations are currently categorized as uncontrolled (that is, they average greater than one overflow per year).[89] Of these uncontrolled CSOs, six are being monitored to determine their control status and four have projects underway. For the remaining CSOs, projects are in planning stages. Table 3 presents the status of King County's uncontrolled CSO locations.

[89] CSO Control Program Update. King County, 2018. https://www.kingcounty.gov/~/media/services/environment/wastewater/cso/docs/program-updates/2018_CSO-control-program-update-secure.ashx?la=en

Figure 21. Combined sewer overflow locations and status (as of 2018)

To comply with the federal Consent Decree, the County is required to reduce the number of overflows at these locations to bring each under control by 2030.[90] Many of the remaining uncontrolled CSOs discharge into the Duwamish Waterway, which the surrounding community depends on for recreational activities such as swimming, boating, and fishing.

Table 3. Status of King County uncontrolled CSOs (as of 2018)

CSO location name	Yearly overflow frequency (20-year average)
Undergoing monitoring[a]	
63rd Ave. SW	1.4
Barton Street Pump Station	1.6
Denny Way Regulator Station	8.9
Hanford #1	10.6
Harbor Ave. Regulator Station	1.6
S Magnolia	20.6
Projects underway	
11th Ave. NW[b]	14.7
3rd Ave. W[b]	6.8
Brandon St. Regulator Station[c]	16.2
S Michigan St. Regulator Station[c]	11.4
Planning underway[d]	
Belvoir Pump Station[e]	1.5
Chelan Ave. Regulator Station	5.3
Hanford #2 Regulator Station	16.2
King St. Regulator Station	13.2
Kingdome Regulator Station	6.7
Lander St. Regulator Station	15.6
Montlake Regulator Station	7.7
Terminal 115	1.8
University Regulator Station	6.8
W Michigan St. Regulator Station	4.6

[a] CSO locations undergoing operational changes or further monitoring to determine control status.
[b] Construction of project for CSO control complete by end of 2025.
[c] Construction of project for CSO control complete by end of 2022.
[d] To comply with the Consent Decree, planning is underway for CSO control by end of 2030.
[e] Belvoir is under supplemental compliance, with planning underway to determine a preferred alternative for control.

[90] Consent Decree. United States v. King County, Washington. https://www.epa.gov/sites/production/files/documents/kingcountywashington-cd.pdf

The City of Seattle also operates a combined system, which flows into the County's combined sewer pipes for conveyance to the regional wastewater treatment plants. Because of that interconnectedness, changes to the City's combined system can also affect the County's system. The City owns 85 CSO locations that are distinct from the County's CSOs and is responsible for separately managing and reporting on those locations.[91]

6.3.2 Combined sewer facilities and control

Approaches to controlling CSOs include optimization, conveyance, separation, green stormwater infrastructure (GSI), storage, and treatment. Conveyance, separation, storage, and treatment are typically referred to as "grey" infrastructure, whereas GSI technologies are referred to as "green" infrastructure. Each is described in further detail in the following subsections.

6.3.2.1 Optimization

WTD has continually optimized conveyance system operations for more than 30 years to maximize overall system performance while maintaining reliability standards. System optimization includes managing the operation of the combined sewer system to maximize existing capacity and minimize overflows.

Continual improvements in operational procedures have contributed to significant reductions in CSOs within the County's combined sewer system. Because optimization approaches have been pursued aggressively by the County over the last several decades, there may be few significant opportunities for optimization remaining in the existing system.

6.3.2.2 Conveyance

CSO control using conveyance includes pipeline and pump station capacity upgrades. This approach increases capacity in a part of the system to convey peak wet weather flows to another part of the system. An example could be increasing conveyance from one area that is overburdened to a portion of the interceptor that has capacity. This can balance flows and decrease CSOs. When increasing conveyance capacity, WTD must also consider the available capacity in downstream conveyance and treatment facilities to ensure that additional flows can be managed and treated adequately. The County completed a number of conveyance upgrades for CSO control in the 1970s; few remaining opportunities for this approach are available.

6.3.2.3 Separation

Stormwater runoff that is generated during a rainfall event can enter the combined sewer system from a variety of sources, including private property and a public right-of-way (ROW), such as a road surface. Approaches that prevent some or all of this stormwater from entering the combined sewer system are referred to as "separation approaches." Separation approaches include the following:

- Full separation, which prevents all stormwater runoff from a given area from entering the combined system, typically by constructing a new separated sewer system and using the existing combined pipelines to convey only stormwater to the MS4.
- Partial separation, which disconnects a portion of stormwater from the combined sewer system to lower peak flows, typically focusing on constructing new parallel pipes to

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[91] Controlling combined sewer overflows. King County, 2016. https://www.kingcounty.gov/services/environment/wastewater/cso/about/working-together.aspx

convey stormwater runoff from streets to the MS4, but keeping roofs and foundations connected to the combined system.

- Opportunistic separation, which takes advantage of locations where stormwater flows can be easily rerouted from the combined system to an existing stormwater pipe or outfall.

The County pursued separation approaches extensively in the 1960s and 1970s, and continues to consider these approaches where appropriate. The County's most recent CSO Control Program Update concluded that CSO control through separation is currently cost-prohibitive relative to other methods.[92]

6.3.2.4 Green stormwater infrastructure

GSI includes a variety of "green" construction elements that can store, infiltrate, and/or treat wet weather flows before they enter the combined sewer system or MS4, potentially reducing CSOs or stormwater impacts to surface water. Examples of these facilities include bioswales, green roofs, permeable pavement, and rainwater-harvesting systems. GSI as a CSO control approach is often paired with separation, collecting stormwater runoff that would normally go to the combined system. It can also be used as a component of separated stormwater management. GSI can be installed when a site or roadway is newly constructed or updated, or can be integrated as retrofits within developed parts of the system.

In addition to preventing stormwater from entering the combined sewer system, GSI has other social and environmental benefits, such as adding additional green space in urban areas. However, GSI implementation is limited to areas that are suitable for infiltration, and is not feasible in locations with dense soils, high groundwater, or on steep slopes that could represent landslide hazards. Within King County, areas with those characteristics represent a sizable proportion of the land area in some CSO basins, limiting the use of GSI as a CSO control tool.

Several large-scale GSI facilities are located throughout the city of Seattle, including the County's completed Barton GSI Project in West Seattle's Westwood and Sunrise Heights neighborhoods, which controls CSOs into Puget Sound.[93] In partnership with SPU, WTD has also administered the RainWise program since 2010.[94] This program provides rebates to homeowners living in specific combined sewer areas for installing rain gardens and cisterns on their property. RainWise helps to slow, detain, or retain stormwater, which reduces the volume and timing of combined sewer flows and sources of pollution into the combined system.

6.3.2.5 Storage

Storage infrastructure decreases CSOs by capturing excess wet weather flow volume that can be stored for a time and then released back to the combined sewer system when downstream conveyance and treatment capacity become available. Once stormwater has entered the combined sewer system, storage can be used at or near CSO relief points to reduce the volume and frequency of CSOs.

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[92] CSO Control Program Update. King County, 2018. https://www.kingcounty.gov/~/media/services/environment/wastewater/cso/docs/program-updates/2018_CSO-control-program-update-secure.ashx?la=en

[93] Barton CSO control. King County, 2020. https://www.kingcounty.gov/depts/dnrp/wtd/capital-projects/completed/barton-cso-gsi.aspx

[94] Be RainWise. King County, 2017. https://kingcounty.gov/services/environment/wastewater/cso/rainwise.aspx

There are two basic ways to store excess flow: in-line storage, where storage occurs within the pipes that also convey combined sewage, and offline storage, where storage occurs in tanks (primarily below ground) or tunnels that are constructed adjacent to the combined sewer system. King County currently manages its wastewater collection system to optimize and maximize in-line storage before CSO events (in many ways, the large pipes that make up the combined system act as a network of in-line storage tunnels). Looking forward, the County is considering additional use of offline storage for future CSO control in either buried concrete tanks, large-diameter pipes, or tunnels.

The County has four offline storage tanks: Murray, North Beach, Rainier Valley, and South Magnolia. A major new offline storage tunnel, the Ship Canal Water Quality Facility, is a joint project of King County and SPU and is currently under construction.[95] The project includes a 2.7-mile-long tunnel, with a diameter of 18 feet, 10 inches, that will extend from Wallingford to Ballard in Seattle. The tunnel will improve water quality regionally by keeping more than 75 million gallons, on average, of combined sewage from flowing into the Lake Washington Ship Canal, Salmon Bay, and Lake Union each year.

6.3.2.6 Treatment

Dedicated wet weather treatment stations (WWTSs) are intermittently operated treatment facilities that treat large volumes of combined sewage to a water quality standard that meets or exceeds regulatory requirements for solids and disinfection, and then discharges the treated water to nearby waterways based on requirements of an NPDES permit. The County operates four dedicated WWTSs, including Alki, Henderson/Martin Luther King Jr. Way, Elliott West, and Carkeek. A fifth WWTS (Georgetown) is currently being constructed to control CSOs from the Brandon and South Michigan Street CSO basins.[96]

WWTSs are typically constructed at a centralized location, such as a CSO, major pump station, or wastewater treatment plant, to treat a significant portion of peak wet weather flows within a CSO basin. This can reduce or eliminate the need for additional conveyance facilities in a basin. Because they are very expensive to construct and operate, these facilities are often the selected means of CSO control when the volume of excess combined sewage is too large for a storage option or a combination of storage and GSI.

6.3.3 Infiltration and inflow management

I/I is rainwater, surface water, and groundwater that flows directly and indirectly into separated sewers. Infiltration occurs when groundwater enters the sewer because of defective or damaged pipes and connections; inflow occurs when unallowed sources, such as roof drains, foundation drains, and improper storm sewer connections, enter the sewer.

Figure 22 shows pathways for I/I to enter the sewer system.[97] King County Code 28.84.050 requires that the design of new sewers by local agencies be such that the I/I will not exceed 3.06 cubic feet per acre in any 30-minute period.[98]

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[95] Ship Canal Water Quality Project. EnviroIssues, 2020. https://spushipcanal.participate.online/

[96] CSO treatment facilities. King County, 2017. https://www.kingcounty.gov/depts/dnrp/wtd/system/cso-facilities.aspx

[97] Conveyance System Improvement Program Update 2007. King County, 2007. https://your.kingcounty.gov/dnrp/library/wastewater/csi/ProgramUpdate/0706CSI-Plan.pdf

[98] Title 28 Metropolitan Functions. King County, 2017. https://www.kingcounty.gov/council/legislation/kc_code/38_Title_28.aspx

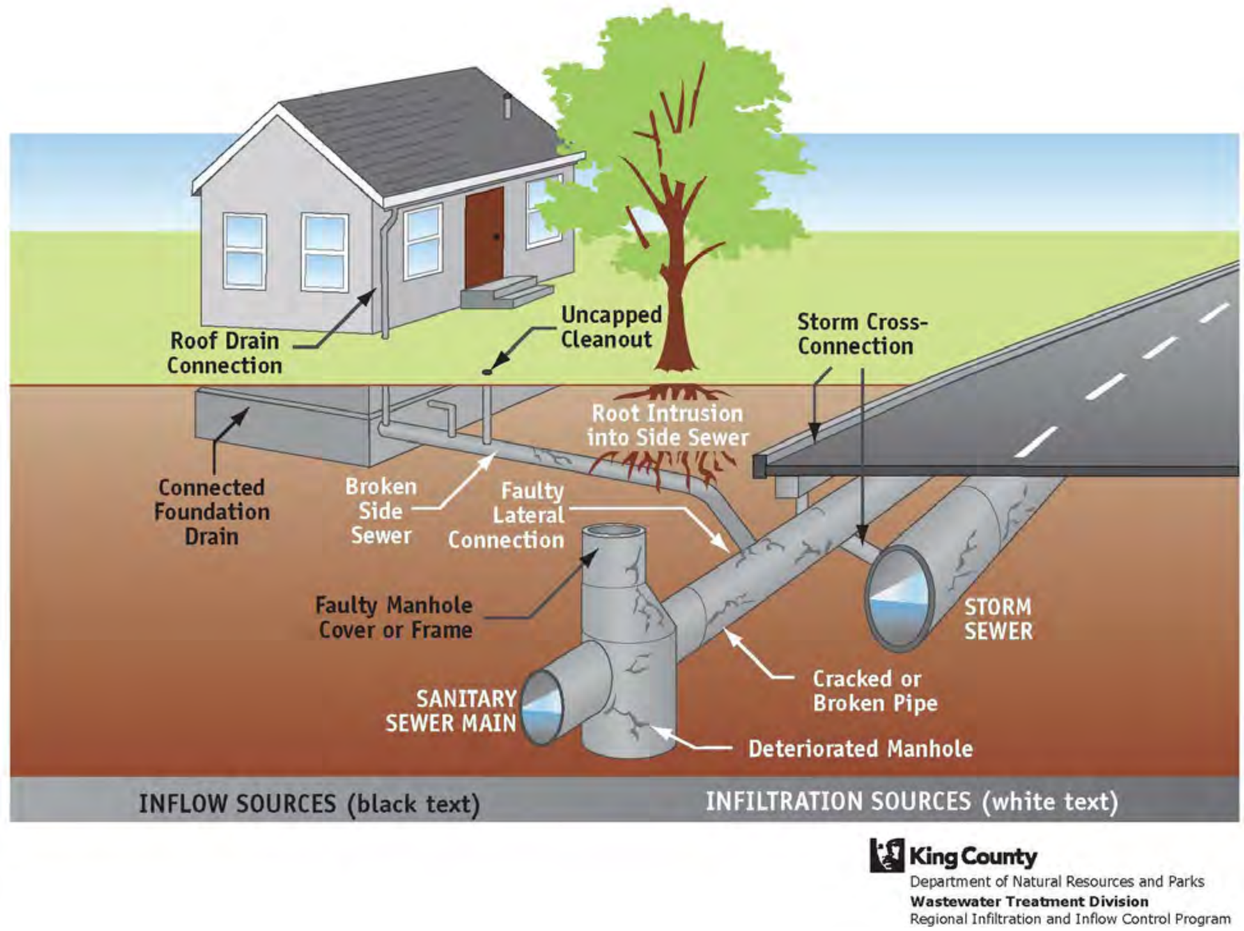

Figure 22. Infiltration and inflow sources

The County estimates that, under peak wastewater flow conditions, as much as 75% of the peak flow in the separated sewer system is rain-derived I/I.[99, 100] These excessive I/I flows impact both capital and operational costs. Large quantities of I/I result in higher capital program costs by accelerating the need and scale of capacity improvement projects. Operational costs are increased because of the need to convey and treat higher rates of flow. The additional capital costs associated with increasing the capacity of the collection system, pump station, and wastewater treatment plants to handle excessive I/I flows are currently spread across all customers through WTD's sewer rates.

Based on national I/I surveys and historical King County I/I reports, a significant portion of the I/I in the separated sewers originates on private property. An estimated 25% of the annual wastewater system volume treated at WTD's wastewater treatment plants can be attributed to I/I. In addition, I/I contributions are expected to increase over time.

[99] King County. Pilot Project Report. October 2004.

[100] King County Metro. Wastewater 2020 Plus Infiltration/Inflow Existing Conditions. February 1994.

WTD's Conveyance System Improvement Program assesses the capacity of the regional separated sewer system with projected 20-year peak flows.[101] This information is used to plan and size future capacity-related improvement projects. WTD also has an I/I Control Program that focuses on portions of the separated sewer system experiencing flow capacity shortages.[102] The I/I Control Program has developed data to assess specific locations where pursuing I/I reduction projects might be more cost-effective than increasing pipe and/or pump station capacity. The I/I Control Program is conducting complementary regional planning work to evaluate concepts to reduce I/I throughout the separate sewer system over decades, particularly in private side sewers.

6.4 Sustainability and climate change

Sustainability and climate change are particularly important focus areas for WTD. The following subsections describe King County's goals and activities in these areas.

6.4.1 Sustainability

Sustainability is pervasive throughout King County and WTD operations. Sustainability is defined as the long-term viability, health, and robustness of environmental, social, and economic systems.[103] For WTD, this means

- healthy, natural environments.
- equity, social justice, and vibrant communities.
- cost-effective capital investments, operations, and maintenance.
- resilience to future disruptions and climate adaptation.

WTD models leadership in sustainable development every day; biogas from the wastewater treatment process is turned into clean energy, wastewater solids (poop and food) are cleaned and recycled into a nutrient-rich soil builder for plants, green building practices are incoporated into construction projects, and a grant program helps communities improve water quality and promotes equity and social justice. Together, the environmental, social, and economic sustainability practices of WTD support thriving, resilient neighborhoods, and communities throughout the Puget Sound region.

6.4.1.1 Sustainability rating system

King County uses various rating systems to verify sustainable performance on projects. The Green Building Ordinance, adopted by the King County Council and signed by the County Executive in December 2013, ensures that the planning, design, construction, remodeling, maintenance, and operations of any County-owned or -financed capital project are consistent with the latest green building and sustainable development practices.[104]

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[101] Conveyance System Improvement Program Update 2017. King County, 2017. https://www.kingcounty.gov/~/media/services/environment/wastewater/csi/docs/1805_Final-CSI-2017-Program-Update-rev.ashx?la=en

[102] Regional Infiltration and Inflow Control Program. King County, 2019. https://www.kingcounty.gov/services/environment/wastewater/ii.aspx

[103] Sustainability. King County, 2018. https://www.kingcounty.gov/depts/dnrp/wtd/sustainability.aspx

[104] Green Building and Sustainable Development Ordinance. King County, 2016. https://kingcounty.gov/depts/dnrp/solid-waste/programs/green-building/county-green-building/green-building-ordinance.aspx

The Green Building Ordinance directs County departments to incorporate the use of the Leadership in Energy and Environmental Design (LEED) green building rating system, and establishes a Green Building Team to provide education and guidance to County departments. As of 2014, all eligible new construction projects are required to strive for LEED Platinum certification, and all eligible major renovation and remodeling projects are required to achieve LEED Gold certification.

The County developed its own Sustainable Infrastructure Scorecard in 2014, using basic concepts of the LEED rating system, adapted to more appropriately apply to infrastructure projects in the County.[105] King County policy is to have all projects that are not eligible or are limited in their ability to achieve LEED certification apply the Sustainable Infrastructure Scorecard and strive to achieve a Platinum level.

6.4.2 Climate change mitigation via greenhouse gas emissions reduction

King County has a long track record of innovation and leadership to reduce GHG emissions and prepare for climate change impacts. King County's 2015 SCAP covers five goal areas where the County will deliver services to support countywide GHG emissions reductions.[106] The goal areas and specific goals pertaining to WTD are as follows:

- Goal area 1: transportation and land use. Increase the efficiency of fleet vehicles and minimize their GHG emissions.
- Goal area 2: buildings and facility energy. Reduce energy use in County facilities and operations and produce and consume more renewable energy.
- Goal area 3: green building. County-owned buildings and infrastructure will be built, maintained, and operated consistent with the highest green building and sustainable development practices.
- Goal area 4: consumption and materials management. The County will minimize operational resource use, maximize reuse and recycling, and choose products and services with low environmental impacts.
- Goal area 5: forests and agriculture. The County will protect and support healthy, productive farms and privately owned forests that maximize biological carbon storage, promote public health, and are resilient to changing climate conditions.

King County is working to achieve carbon neutrality across all government operations and services. These efforts are described further in Section 6.5.

[105] Sustainable infrastructure scorecard. King County, 2018. https://kingcounty.gov/depts/dnrp/solid-waste/programs/green-building/county-green-building/scorecard.aspx

[106] Strategic Climate Action Plan. King County, 2015. https://your.kingcounty.gov/dnrp/climate/documents/2015_King_County_SCAP-Full_Plan.pdf

6.4.3 Climate change preparedness for sea level rise and changes in precipitation

King County has made efforts to plan and prepare for the likely impacts of climate change on County-owned facilities, services, infrastructure, and natural resources, and to provide services that support the region and build resilience, including the following:[107]

- Assessing impacts of climate change on local rainfall patterns and flooding
- Planning for climate change impacts on wastewater, stormwater, emergency management, public health, roads, flood risk reduction, and salmon recovery
- Improving regional coordination on climate change preparedness, including engaging partners and the public

Priority actions for WTD include:[108]

- Assessing climate impacts on rainfall patterns
- Assessing impacts on wastewater conveyance and treatment
- Planning for SLR impacts on coastal zones
- Expanding use of recycled water

6.5 Resource recovery

In the wastewater treatment industry, "resource recovery" refers to the separation or recovery of materials or energy from waste to produce fuel, heat, water, soil amendments, and nutrients for reuse. WTD is increasing its focus on resource recovery throughout its operations. As part of WTD's vision of being "an innovative and resilient clean water enterprise revolutionizing the recovery of valuable resources for sustainable communities," its resource recovery programs produce biosolids, recycled water, and energy from the wastewater treatment process.[109] Resource recovery at WTD also promotes sustainable practices and wastewater treatment technology innovation. In all, resource recovery at WTD comprises the following programs: Biosolids, Energy, Recycled Water, TAIP, and Sustainability.

6.5.1 Biosolids

Biosolids are the organic-rich solids from the wastewater treatment process after they have been treated and stabilized to reduce pathogens. Depending on the level of treatment, biosolids can be classified as Class A (99 to 100% pathogen reduction, suitable for use by the general public without permits) or Class B (95 to 99% pathogen reduction, suitable for use on permitted sites only).

Since 2012, the County uses Class B biosolids, marketed as Loop®, as fertilizer to reduce carbon emissions, reduce the amount of non-renewable synthetic fertilizer used, and return nutrients to the environment. The majority of the County's biosolids, approximately 90%, are trucked roughly 200 miles to one of two farming programs in eastern Washington to be used as

[107] Strategic Climate Action Plan. 2015 Annual Report. https://your.kingcounty.gov/dnrp/climate/documents/2015-annual-report-scap-06-2016.pdf

[108] Strategic Climate Action Plan. 2017 Biennial Report. https://your.kingcounty.gov/dnrp/climate/documents/2017-SCAP-Biennial-Report.pdf

[109] Resource Recovery. King County, 2019. https://www.kingcounty.gov/services/environment/wastewater/resource-recovery.aspx

an agricultural fertilizer. Application in eastern Washington is preferred because the dry climate there allows for year-round beneficial use (as opposed to only seasonal use west of the Cascade Mountains).

Every year, more than two dozen farmers in Washington apply Loop® to more than 10,000 acres of farmland. To protect nearby water bodies and the land, biosolids are applied in precise agronomic rates calculated by university soil scientists to provide sufficient nutrients for the benefit of the soils, but not so much that excess nutrients run off into nearby streams or lakes.

Historically, biosolids have also been used to develop a Class A compost product used in community gardens, sold as GroCo™ compost, and as a fertilizer on forestlands in eastern King County to support commercial growth of trees. Similar to agricultural uses, forestland application is based on rigorous evaluation to ensure that agronomic rates are being applied. However, these uses have declined in recent years.[110, 111]

6.5.2 Energy

WTD's energy program focuses on the generation of renewable energy from resources recovered during the wastewater treatment process as well as the conservation of energy at WTD facilities. To guide WTD's activities, the 2018 WTD Energy Plan identified specific energy goals and targets, including the following:[112]

- Holistically integrate energy awareness across WTD.
- Increase energy efficiency in WTD facilities by 7.5% by 2020 and by 10% by 2025 from the 2014 baseline.
- Produce and use renewable energy at a rate of 70% of WTD facility energy consumption by 2020 and 85% by 2025.
- Achieve carbon neutrality in operations and purchasing by 2025.

The majority of renewable energy generated by WTD derives from biogas. Biogas is a mixture of methane, carbon dioxide, and other constituents produced during the anaerobic digestion of wastewater solids. Since 1966, WTD has been capturing and beneficially using its biogas. To meet process and space heating needs, biogas produced at each of WTD's wastewater treatment plants is used to provide heat, in either hot water boilers or cogeneration systems.

At West Point, biogas is burned in large engines to drive the wastewater treatment plant's influent pumps and in the cogeneration engines to generate electricity. Both systems also recover heat to meet the wastewater treatment plant's heating needs. In 2014, the cogeneration system at West Point sold 16,900 megawatt-hours of renewable electricity to Seattle City Light (SCL).[113] Each

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[110] King County Biosolids Strategic Plan 2018-2037. King County, 2018. https://www.kingcounty.gov/~/media/services/environment/wastewater/resource-recovery/plans/1711_KC-WTD-Biosolids-2018-2037-Strategic-Plan-rev2.ashx?la=en

[111] Loop® biosolids. King County, 2018. https://www.kingcounty.gov/services/environment/wastewater/resource-recovery/loop-biosolids.aspx

[112] Energy Plan. King County, 2018. https://www.kingcounty.gov/~/media/services/environment/wastewater/resource-recovery/plans/1802_KC-WTD-Energy-Plan.ashx?la=en

[113] Final Report for West Point Treatment Plant Biogas Utilization Study. Brown and Caldwell, 2016.

year, the engines that power the influent pumps save approximately 4,000 kilowatt-hours (kWh) of electricity that would be required if electric motors were used instead.[114]

The biogas produced at South Plant is treated to remove carbon dioxide and produce renewable natural gas to be exported to the Puget Sound Energy (PSE) natural gas system. The renewable natural gas is used to replace diesel fuel in commercial vehicles, capitalizing on a federal program designed to power more transportation with domestic renewable energy. The availability, use, and sale of biogas reduces the amount of energy that WTD needs to purchase and reduces WTD's carbon footprint. It is also cost-effective; renewable natural gas sales in 2017 yielded $6 million in revenue. South Plant also operates a cogeneration system that uses gas turbines, but this system is currently used only as a backup to provide electrical system stability during winter storms and additional heat as needed.[115, 116]

In addition to generating renewable energy from biogas and heat recovery, the County has made significant investments in improving the energy efficiency of the wastewater facilities it operates. Of the County's government facilities, WTD is the largest consumer of energy. As Figure 23 shows, the majority of that energy is electricity, of which WTD consumes 17 megawatts (MW) on average. The remainder is the renewable biogas produced at the wastewater treatment plants, natural gas and propane used as backup energy supplies, and diesel used for hauling biosolids to application sites.

WTD has invested significantly in energy conservation efforts to promote energy efficiency. These investments include performing energy audits and training staff to operate systems efficiently and seek out opportunities for improvement. The effect has been a net reduction in normalized energy consumption between 2007 and 2012.[117]

Efforts to reduce the carbon footprint of WTD's operations has included targeting renewable energy supplies for WTD's major facilities. West Point and many of the West Section off-site facilities receive electricity from SCL, which largely sources its power supply from hydroelectric facilities. In 2005, SCL achieved carbon neutrality.[118]

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[114] West Point Treatment Plant Raw Sewage Pump Station Evaluation. CH2M, 2018.

[115] South Plant Digester Gas Utilization Study. King County, 2014. https://www.kingcounty.gov/~/media/services/environment/wastewater/resource-recovery/docs/SP_Gas_Utilization_Final_Report.ashx?la=en

[116] Cogeneration. King County, 2019. https://www.kingcounty.gov/services/environment/wastewater/resource-recovery/Energy/renewable/cogen.aspx

[117] 2017 Energy plan. King County, 2018. https://www.kingcounty.gov/services/environment/data-and-trends/indicators-and-performance/kingstat/2017/performance-measures/environment/energy-plan.aspx

[118] Carbon Neutral. SCL, 2019. https://www.seattle.gov/light/enviro/carbonneutral.htm

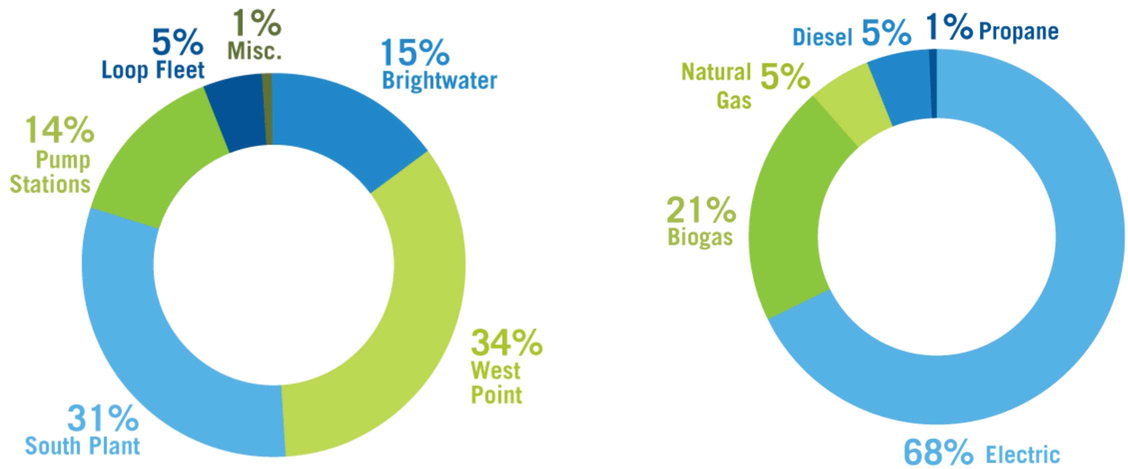

Figure 23. Energy use by location (left) and fuel type (right)

South Plant and most of the East Section off-site facilities receive electricity from PSE. PSE sources its power supply from a mixture of mostly hydroelectric, natural gas, and coal sources, but the County has partnered with PSE in the Green Direct wind power program. When the project begins operation, the County will purchase wind from the project to meet 98% of government electricity use in PSE service territory. This will cut the County's direct GHG emissions by 20%.[119] Lastly, Brightwater receives electricity from Snohomish Public Utility District No. 1, which sources 90% of its power supply from hydroelectric facilities, with the bulk of the remainder from nuclear power.[120]

As a result of these efforts, the King County Department of Natural Resources and Parks reached carbon neutrality in 2016.[121] The 2015 SCAP requires WTD and the Solid Waste Division to be carbon neutral for both purchasing and operations by 2025. WTD expects to meet this target. It is already carbon neutral for operations and is currently refining its methodology for calculating and reducing purchasing-related GHG emissions.

6.5.3 Recycled water

Recycled water (also referred to as "reclaimed water") is highly treated water from the wastewater treatment process that can be used to reduce demand on potable and non-potable water sources. WTD has distributed reclaimed water for 20 years and currently produces Class A non-potable reuse water. All of WTD's wastewater treatment plants produce non-potable water for on-site uses (washdown water, lawn irrigation, and so on).

The County also markets recycled water from South Plant, Brightwater, and Carnation for uses beyond wastewater treatment plant needs, such as irrigation for sports fields, golf courses, and farms and as a wetland restoration supplement (in the case of recycled water from the

[119] Executive Constantine: The proposed settlement of the Puget Sound Energy rate case lays the groundwork for cleaner energy in King County. King County, 2017. https://www.kingcounty.gov/elected/executive/constantine/news/release/2017/September/15-pse-rate-settlement.aspx

[120] Power Supply. SnoPUD, 2019. https://www.snopud.com/PowerSupply.ashx?p=1105

[121] DNRP carbon neutral. King County, 2019. https://www.kingcounty.gov/depts/dnrp/about/beyond-carbon-neutral.aspx

Carnation Treatment Plant). In total, an average of 2 MGD of recycled water was produced in 2017, with the majority (85%) used on-site at the wastewater treatment plants.[122] Together, the program's efforts support water supply resilience, help address climate change, and reduce wastewater effluent discharges.

7.0 Maintaining and funding the regional wastewater system

Preserving and paying for the regional wastewater system are crucial elements of WTD's overall operations. Ensuring the longevity and integrity of its wastewater infrastructure, practicing sound financial management, and keeping rates fair and equitable are core values of WTD as a utility. These values are part of King County government's overall mission to provide fiscally responsible regional services. This section presents an overview of WTD's asset management and utility finanacing operations.

7.1 Asset management

King County provides a key service that is the efficient operation of wastewater infrastructure with a goal of uninterrupted service. To do this, the County must make informed decisions related to infrastructure operations, maintenance, renewal, and resilience. Asset management is a tool the County uses to focus resources on critical assets to reduce the risk of service interruption in a cost-effective manner.

The County also evaluates and addresses the ability of the wastewater system to withstand events like earthquakes or severe storms that may impact operations, and how quickly critical systems can be brought back online as necessary. This is known as "resilience."

7.1.1 Historical infrastructure upgrades

Development of the regional wastewater system largely began in 1958 with the adoption of the Comprehensive Sewage Plan.[123] Under this plan, four wastewater treatment plants were constructed by 1963, and the Alki Treatment Plant was taken over from the City of Seattle. Since then, WTD has converted the Alki, Carkeek Park, and Richmond Beach treatment plants to WWTSs, expanded West Point and South Plant for additional treatment capacity and secondary treatment upgrades, constructed new WWTSs at Elliott West and Henderson/Norfolk, and constructed a new regional treatment plant (Brightwater).

Table 4 presents a list of major WTD system upgrades and the corresponding year they were commissoned in chronological order.[124]

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[122] Facts about the WTD System. King County, 2019. https://www.kingcounty.gov/depts/dnrp/wtd/system/facts.aspx

[123] 1958 Comprehensive Sewage Plan. King County, 2016. https://www.kingcounty.gov/depts/dnrp/wtd/about/history/1958-plan.aspx

[124] History of our mission. King County, 2016. https://www.kingcounty.gov/depts/dnrp/wtd/about/history.aspx

Table 4. Major WTD system upgrades	
Year	**Major system upgrade**
1958	Alki Treatment Plant construction
1962	Carkeek Park Treatment Plant construction
1963	Richmond Beach Treatment Plant construction
1965	South Plant construction
1966	West Point construction
1973	South Plant enlargement 1
1986	South Plant enlargement 2
1994	Carkeek Treatment Plant conversion to Wet Weather Treatment Station
1996	West Point expansion
1997	West Seattle Tunnel and Pump Station commissioning
2001	South Plant enlargement 3
2001	Alki Treatment Plant conversion to Wet Weather Treatment Station
2005	Elliott West Wet Weather Treatment Station commissioning
2005	Henderson/Norfolk Wet Weather Treatment Station commissioning
2011	Brightwater construction

7.1.2 Renewal of aging infrastructure

As previously mentioned, the regional wastewater system owned and operated by King County was established in the 1960s. Some facilities were in place before 1960 and acquired as components of the system. Improvements and expansions since 1960 have added to the number of facilities and assets to be managed (see Table 4). The current system, comprised of over 55,000 assets (equipment, instruments, control devices, and conveyance pipelines) as well as the buildings that house them, requires planning, inspection, maintenance, repair, and replacement. It would cost well over $20 billion to build King County's existing wastewater infrastructure from the ground up today.

A significant portion of the County's wastewater infrastructure portfolio has aged such that its condition puts individual assets at an increased risk of failure. The region's wastewater infrastructure will continue to age, and rehabilitation and replacement needs are anticipated to increase significantly in the coming decades. This results in an ongoing need for year-to-year investments as well as large reinvestment needs in the system at certain points in the future. These ongoing investment needs represent repair and replacment of aging facilities to ensure reliable operations.

The investments have been, and will continue to be, part of annual system matinenance. The amount of these investments on an annual basis would be expected to increase as the system ages. The large reinvestment needs will be full replacement of some of the regions wastewater infrastrucure. Because wastewater infrastructure (like other types of major infrastructure such as roadways and bridges) have long life cycles, greater than 50 years in many cases, replacement occurs in large sums at periods of time. This results in the need for large investments as major components of the wastewater system reach the end of useful life.

7.1.3 Asset management program

WTD established a formal asset management program with the creation of its first Strategic Asset Management Plan (SAMP) in 2005. Although WTD had been practicing asset management techniques before this, the formal program identified goals and strategies WTD sought to pursue. The County's SAMP is updated every 5 years. The 2018 Strategic Asset Management Plan Update provides a current overview of the goals, objectives, strategies, and priorities of WTD's asset management program.[125] The current asset management program goals include striving to improve available data on WTD assets, using condition and financial information to make decisions that minimize system risk, and communicating and aligning asset management activities with County staff and other stakeholders.

7.1.4 Risk management

Risk management relies on strategies to minimize impacts to customers, the environment, and utility finances that may be caused by failing infrastructure because of either deterioration or events such as earthquakes. WTD uses a mix of the following risk management strategies for different types of infrastructure:

- The most critical off-site (pump stations and so on) and treatment facility assets are monitored based on age and expected life. As assets get closer to their end-of-life date, asset managers and reliability engineers review the asset's condition as well as

[125] 2018 Strategic Asset Management Plan Update. King County, 2018. https://www.kingcounty.gov/~/media/depts/dnrp/wtd/pubs/plans/1812_SAMP-Update-2018.ashx?la=en

operating conditions to determine what action should be taken. Other assets are inspected and maintained based on schedules. Operations and process control monitoring also flag assets that are not performing as designed.

- Gravity conveyance system assets are routinely inspected, and structural defects that are found are reviewed to determine the appropriate action. Severe defects are directed to capital project prioritization and funding processes, while minor defects are addressed by contractors under the direction of WTD staff.
- A force main corrosion control program is in place and projects that are identified are prioritized using a risk matrix. These projects are also directed to capital project prioritization and funding processes.
- Some asset types have no condition-based risk management strategy, including buildings, roofing and other structures, some force mains, and conveyance piping within the treatment facilities.

7.1.5 Resiliency and redundancy

Over the last few years, WTD has increased its focus on system resilience and its ability to continue to deliver services or to quickly recover in the event of an emergency. In the County's wastewater service area, the main natural hazard threats include earthquakes, soil liquefaction, landslides, extreme weather events, climate, flooding, and tsunamis. In particular, WTD has taken a proactive approach to address risks from natural disasters. A resiliency assessment and master planning effort resulted in the development of Recommendations to Enhance the Resiliency and Recovery of King County's Regional Wastewater Treatment Facilities.[126]

To determine risks to the wastewater system and associated improvements to protect and mitigate the effects of a disaster, WTD evaluated the various probabilities and consequences of failure because of these natural hazards. WTD conducted an overall system assessment that yielded the following four risk categories:

- Life safety: Where would life safety be compromised if the buildings collapsed?
- Public health: While the overflow of sewage to water bodies is an environmental concern (see bullet below), where would failure result in the backup of sewage into streets, ditches, or houses/property? Where could wastewater pipeline collapses result in sewage backup and public health issues?
- Consequent damage: Where could WTD assets be damaged by failures of other infrastructure, or cause damage to other critical infrastructure if the WTD assets failed?
- Environmental: Where are vulnerable facilities and pipelines where failure could cause discharge into environmentally sensitive receiving waters throughout the system?

As a result of this assessment, WTD has prioritized a number of potential risk mitigation measures (potential projects) and response and recovery strategies that would strengthen WTD's infrastructure resilience and recovery if and when a natural disaster or hazard occurs. Conceptual cost estimates suggest the level of investment for resiliency mitigation in WTD's system is around $190 million from 2019 to 2024.

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[126] Recommendations to Enhance the Resiliency and Recovery of King County's Regional Wastewater Treatment Facilities. King County, 2018. https://www.kingcounty.gov/~/media/services/environment/wastewater/mwpaac/docs/2018/2018_05_23_KC_Resiliency_500report_April-2018.ashx?la=en

In addition to the systemwide assessment, the West Point Treatment Plant Half-Century Assessment also reviewed certain vulnerabilities and factors impacting resiliency including redundancy, emergency bypass capabilities, and power reliability.[127] This assessment found the following:

- Redundancy is generally not a concern during average flows and loads because the equipment is sized for peak flows and loads and treatment plant staff can usually schedule planned maintenance during less vulnerable periods. However, during peak flows, lack of redundancy could pose a risk if a process unit or piece of equipment fails unexpectedly.
- Existing emergency bypass systems rely on power; the appropriate action of gates, instruments, and controls; and operator actions to function properly and flawlessly in situations of high flow and potential extreme hazard. The interactions of these mechanical and control functions are complex and subject to component failure, leaving the treatment plant vulnerable to flooding.

West Point depends on utility power for all of its pumping and treatment functions, except for raw sewage pumping, although there is a project underway to convert these pumps to run on electricity (a risk asessment regarding conversion from gas to electricity is included as part of the project). West Point has suffered from power system instability; 104 power failures to West Point were reported between 2001 and 2017, occasionally requiring an emergency bypass of the plant.[128] WTD is currently working with SCL to identify opportunities to improve the power reliability at West Point, including both improvements SCL can make to the power supply infrastructure and improvements WTD can make to the power infrastructure on-site.

7.2 Utility financing

This section describes utility financing. The first part of the section presents a general description of how utilities fund facility development and operations, including national trends in utility financing. The second part of this section presents a brief overview of WTD financing.

7.2.1 National utility financing overview

Wastewater utilities rely on a combination of funding from local, state, and federal sources. Generally, local ratepayer charges provide the bulk of funding, and this share has been increasing over time. State and federal grants and low-interest loans provide the balance of funding. As Figure 24 shows, the increase in average annual U.S. wastewater service charge per household has been far greater than the Consumer Price Index.

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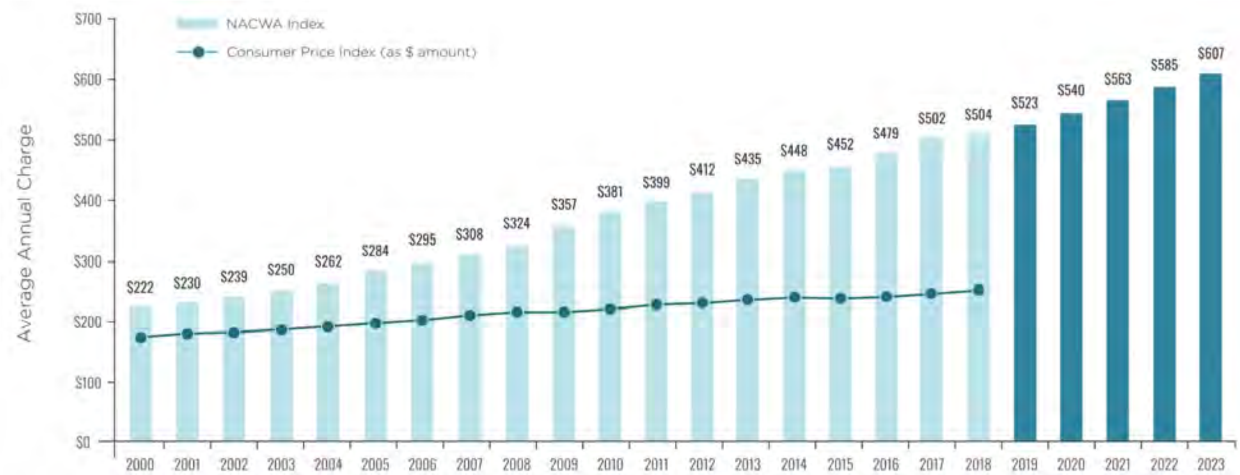
[127] Half-Century Assessment of the West Point Treatment Plant. King County, 2017.

[128] Seattle City Light power disruption leads to emergency bypass at West Point, systems restored quickly. King County, 2019. https://www.kingcounty.gov/depts/dnrp/newsroom/newsreleases/2019/July/19-west-point-bypass-outage.aspx



Note: dark blue bars represent forecasted average annual charge.

Figure 24. Average annual U.S. wastewater service charge per household

The federal share of spending on wastewater utilities has consistently declined for several decades (see Figure 25).[129] Historically, non-local grants and loans have funded many large capital projects. Nationally, from 1956 to 1976, capital costs were slightly greater than operations and maintenance (O&M) costs. Over time, the proportion of spending on O&M expenses relative to capital expenses has increased, driving the burden of funding toward ratepayers. Nationally, since 2017, capital expenses represent 28% and O&M expenses represent 72% of total expenses. As annual O&M costs increase as a share of overall expenses, financing becomes less important and annual revenue generated through wastewater rates and capacity charges become relatively more important.

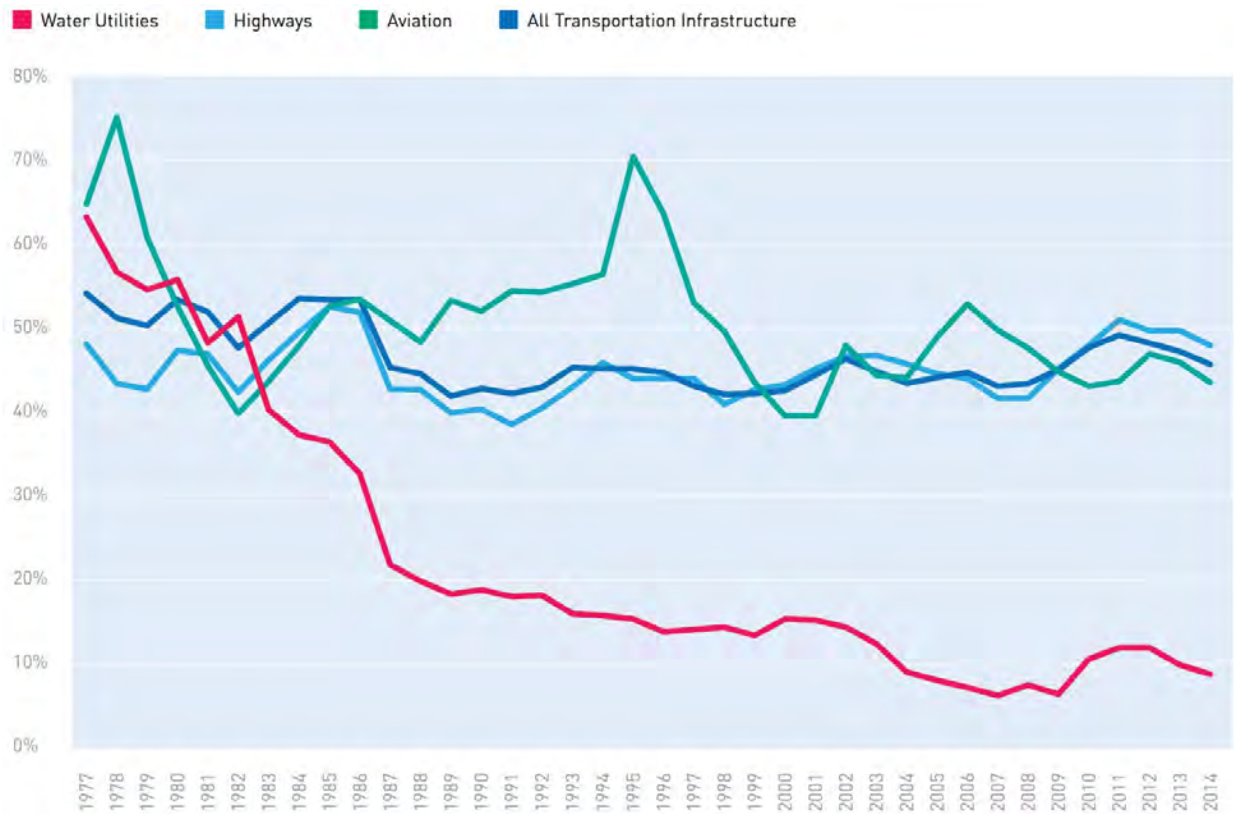


Figure 25. Federal contribution to total infrastructure spending as percentage of total (1977–2014)

[129] Public Spending on Transportation and Water Infrastructure, 1956 to 2017. Congressional Budget Office, 2018. https://www.cbo.gov/publication/54539

In general, utility rates are set based on projected revenue requirements, considering all expenses (capital and O&M), and other funding sources including reserves, grants, and borrowing. Borrowing first takes advantage of any below-market rate opportunities such as the State Revolving Fund. Other borrowing relies on bonds with repayment periods that are typically below 20 years, although there is some borrowing on longer timeframes to reflect the lifespan of capital projects that can extend to 50 years or more. Local spending on wastewater services is typically conducted at the city level, although counties and special districts nationally play important, but lesser roles.[130]

7.2.2 WTD finance overview

WTD manages a utility enterprise fund, meaning the activities performed by WTD are funded by user fees rather than tax revenue, and that fees are set to recover costs based on the service provided. WTD does not charge its customers directly for service (with the exception of capacity charges, which are discussed in Section 7.2.5 below). Rather, the County sets the rates and then charges the 34 component agencies that use the regional system, which, in turn, charge their customers. WTD's service responsibilities require a substantial and reliable stream of revenue to fund a range of operations. Revenues are collected and used to pay for capital improvements, administration, O&M, and financing.

7.2.3 Capital improvement plan costs

Costs associated with the improvement and expansion of the utility are known as "capital investments." Current WTD annual capital expenditures are approximately $250 million per year. These are dollars spent on capital investments. Some of these dollars are paid for using cash funds. King County also issues bonds to fund a portion of the capital improvement program. When available and awarded, WTD funds capital investments in part with low interest loans.

WTD is carrying and making payments on approximately $4 billion in outstanding debt. Given the capital-intensive nature of providing wastewater utility services and the need to issue bonds to meet the need, maintaining favorable credit ratings is fundamental to utility financial management. Favorable credit ratings lower the cost of borrowing and, as a result, the amount of annual debt service that must be funded by customer rates and charges. WTD currently maintains favorable credit ratings from credit rating agencies.

7.2.4 Operations and maintenance costs

Costs associated with the operation and maintenance of the utility are known as "operations and maintenance," or O&M costs. Current WTD annual O&M costs are approximately $170 million. These are dollars spent during the course of regular business, such as general and adminstrative expenses to operate the regional wastewater systems. WTD annual operating expenses have steadily climbed over time and they are expected to continue to do so.

WTD generally forecasts with an expected rate of inflation of 3%. Different types of expenses have increased above inflation rates, such as chemical costs. Actual annual rates of inflation have been less than 3% over the last decade.

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[130] Infrastructure Financing: A Guide for Local Government Managers. International City/County Management Association, 2017. https://icma.org/documents/infrastructure-financing-guide-local-government-managers

7.2.5 Rate structure

WTD is funded by ratepayers who invest in clean water programs and services through their monthly rate and capacity charge bills. WTD sets rates for households and other service recipients sufficient to provide the necessary funding for total annual expenses. Because WTD provides services wholesale rather than directly to ratepayers, WTD's options for service rates are limited to mechanisms uniformly available through its 34 local component agencies (for example, component agencies also provide services and have a share of the overall rate paid by ratepayers, additive to WTD charges). As of 2020, WTD's base monthly service rate is $45.33 per single-family household (averaging 850 cubic feet of water used per month).[131] Industrial customers are charged $45.33 for each 750 cubic feet of water used. This is an increase of 2.5% from the 2018 rate. Each component agency charges additional fees on top of WTD's rates to fund other costs.

The County has also charged a capacity fee for new connections since 1990, which covers the cost of implementing expansion projects. The County bills newly connected customers directly for this charge. As of 2020, this charge is $66.35 monthly, and, for new customers, lasts 15 years. This is an increase of 3% from the 2018 capacity charge. WTD estimates approximately 10,000 additional sewer connections annually over the near term.

In total, these charges come to approximately $544 annually for ratepayer households without a capacity charge and $1,340 annually with the capacity charge. Additional charges specific to each component agency are included with these costs on ratepayer bills. Currently, the additional local charges from component agencies to their customers range from approximately $144 to $564 per year per household. This rate structure impacts historically low-income residents and small businesses because the capacity charge does not fully cover additional costs of newly connected customers, and the remaining costs are distributed equally among ratepayers, posing a proportionally larger financial burden on low-income residents.

7.2.6 Affordability

The County continues to evaluate affordability challenges that its customers face. Evaluating these challenges includes assessing how affordability is defined and how the County can provide policies and programs that manage costs for low-income and disadvantaged communities, where, for example, the cost of decommissioning a septic system and the utility fees and connection charges associated with connecting to the wastewater system may prevent households from receiving adequate wastewater treatment. As a result, these communities may be exposed to pollution.

As of June 2019, several affordability options are available for King County ratepayers. The options include the following:

- Deferral of payment to be levied as a lien on a property when sold. Annually, the balance incurs 5% interest.
- Payment plan options that include paying more frequent, but smaller bills.
- Eligible low-income housing can qualify for a reduced capacity charge.

Financially, lower-income households in the region spend a far greater share of their income on housing and water/sewer services than other households. The percentage of household income

[131] Criteria for Sewage Works Design (Orange Book). Ecology, 2008. https://fortress.wa.gov/ecy/publications/documents/9837.pdf

spent on housing and wastewater utility services has traditionally been used as a measure of affordability, with thresholds of 30% and 1%, respectively, commonly used to note when costs become unaffordable. This approach has its disadvantages, however, because it is possible for utility costs to be “affordable” for the region as a whole, but unaffordable for lower-income households.[132] Case in point: For the region, the 40% of households with the lowest incomes exceed the 1% threshold for affordable wastewater services.

[132] Measuring Household Affordability for Water and Sewer Utilities. Teodoro, 2018. https://awwa.onlinelibrary.wiley.com/doi/full/10.5942/jawwa.2018.110.0002

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