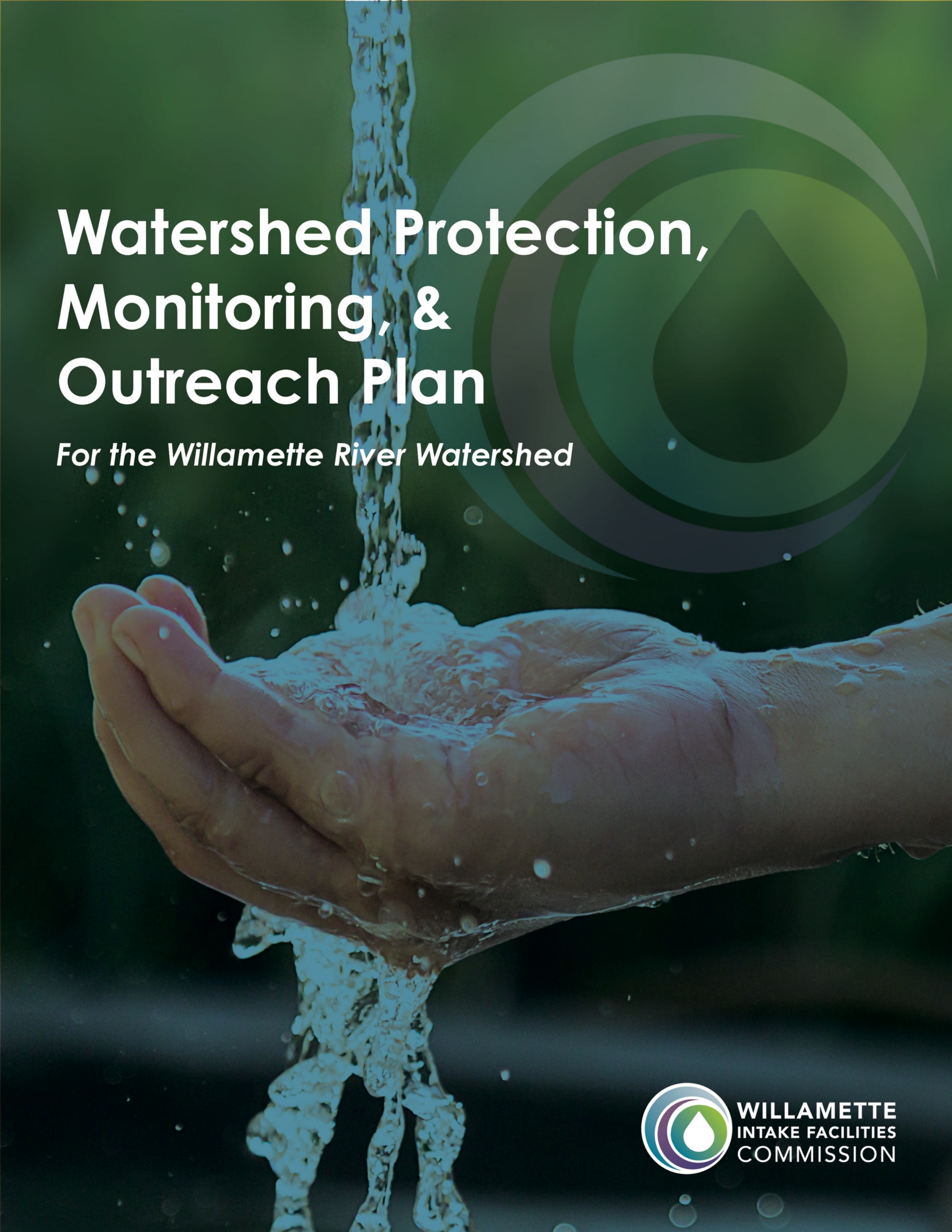
Watershed Protection, Monitoring, & Outreach Plan

For the Willamette River Watershed



WILLAMETTE
INTAKE FACILITIES
COMMISSION

Prepared for
Willamette Intake Facilities Commission

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LIST OF ACRONYMS AND ABBREVIATIONS

AFO	Animal Feeding Operation
Area Plans	Water Quality Management Area Plans developed by ODA
BiOp	Biological Opinions
BMP	best management practice
CAFOs	Confined Animal Feeding Operations
COC	contaminants of concern
CRWP	Clackamas River Water Providers
CSO	Combined Sewer Overflow
cyanoHAB	cyanobacteria harmful algal bloom
DBP	disinfection byproducts
DO	dissolved oxygen
DWSRF	Drinking Water State Revolving Fund
ELISA	Enzyme-Linked Immunosorbent Assay
EQIP	Environmental Quality Incentives Program
ESA	Endangered Species Act
EWEB	Eugene Water and Electric Board
FPR	Feature Potency Ratio
FPS	Feature Potency Score
FTE	Full Time Equivalent
HHSL	human health-based screening level
Intake Facilities	Willamette Intake Facilities overseen by the WIF Commission
JWC	Joint Water Commission
LOI	Letter of Intent
MeHg	methylmercury
MPSF	minimum perennial streamflow
MVVG	Mission, Vision, Values and Goals
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service

O&M	operations and maintenance
ODA	Oregon Department of Agriculture
ODOT	Oregon Department of Transportation
OEM	Office of Emergency Management
OHA	Oregon Health Authority
OWEB	Oregon Watershed Advancement Board
OWRD	Oregon Water Rights Department
PCBs	polychlorinated biphenyls
PCS	Potential Contaminated Sources
PFAS	per- and polyfluoroalkyl substances
Plan	*Watershed Protection, Monitoring, and Outreach Plan*
PPCPs	pharmaceuticals and personal care products
RCPP	Regional Conservation Partnership Program
SCADA	Supervisory Control and Data Acquisition
SDWRLF	Safe Drinking Water Revolving Loan Fund
SOC	synthetic organic compound
SWCD	Soil and Water Conservation District
THg	total mercury
TMDL	Total Maximum Daily Load
TVWD	Tualatin Valley Water District
UCMR3	Third Unregulated Contaminant Monitoring Rule
UCMR5	Fifth Unregulated Contaminant Monitoring Rule
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WIF Partners	the Tualatin Valley Water District and the cities of Wilsonville, Sherwood, Hillsboro, Tigard, and Beaverton
WIF	Willamette Intake Facilities
WMCPs	Water Management and Conservation Plans

WRWC	Willamette River Water Coalition
WRWTP	Willamette Water Treatment Plant
WTP	Water Treatment Plant
WVP	Willamette Valley Project
WWSS	Willamette Water Supply System

Executive Summary

This *Watershed Protection, Monitoring, and Outreach Plan* (hereafter referred to as the Plan) was developed for the Willamette Intake Facilities (WIF) Commission. The WIF Commission's goal is to responsibly secure a safe and reliable drinking water supply for the Tualatin Valley Water District (TVWD) and the cities of Wilsonville, Sherwood, Hillsboro, Tigard, and Beaverton, while serving as trusted stewards of the Willamette River watershed. **The goal of this Plan is to protect source water quality by prioritizing projects and initiatives through identifying risks from potential sources of contamination and opportunities to mitigate these risks.**

The Plan was developed in accordance with the ANSI/AWWA G300 Standard for Source Water Protection. The Plan first provides an overview of the Willamette River Basin, including the history of the Willamette River as a drinking water source, with respect to both natural resources and human use. This includes historical trends and current conditions of population, land use, hydrology, water quality, aquatic life, and municipal use in and near the basin. The impacts of reservoirs and dam operations, especially the United States Army Corps of Engineers (USACE) Willamette Valley Project (WVP), are also discussed as they relate to Willamette River hydrology, water quality, and aquatic life. This section also describes how, for the purposes of this Plan, the Willamette River Basin was divided into regions to focus the discussion of relative risk posed to water quality in the Willamette River at the Intake Facility. The Plan focuses primarily on the Tier 1 (high priority) region (Middle Willamette and Yamhill Subbasins approximately 35 miles upstream of the Intake Facilities), while also considering the full Willamette River Basin.

The results of data and risk analyses are then discussed with a focus on the Tier 1 region, including the factors that affect flow and temperature, and ultimately water quality, at the Intake Facilities, including drivers that originate both within and upstream of the Tier 1 region. A notable driver within the Tier 1 region is the tributary flow from the Yamhill River, the only major tributary within the Tier 1 region. In the Tier 2 and Tier 3 regions, management of the WVP makes a noticeable impact on flow and temperature regimes with implications for harmful algal blooms, which may be exacerbated by climate change. This section also presents baseline water quality conditions as illustrated by trends in previous water quality monitoring studies within the Tier 1 region. Available studies suggest that, although there are water quality concerns in tributaries, water quality in the mainstem Willamette River upstream of the Intake Facilities is good. However, assessments of risk from potential point and nonpoint sources of contaminants within the Tier 1 region identified relatively high risks from Confined Animal Feeding Operations (CAFOs) near the mainstem, facilities with water quality permits in Newberg, railroad and road crossings over streams, and a fuel pipeline that crosses the Willamette River upstream of the Intake Facilities. Potential for erosion, particularly within agricultural land in the Tier 1 region, is another risk to water quality, particularly after an extreme event such as wildfire or flooding.

This Plan proposes a multi-pronged approach of watershed protection, water quality monitoring, and outreach to manage these risks and maintain or improve the high-quality source water. Watershed protection strategies address the high-risk sources through efforts such as an emergency response plan, land management programs, and establishing key partnerships. The monitoring plan will target constituents of concern associated with the high-risk sources, including algal blooms, hydrocarbons, nutrients. The monitoring plan will also address contaminants of emerging concern and standard source water parameters. The communication and outreach portion of the Plan lays the groundwork for successful engagement of potential partners and designates the WIF Commission as a regional collaborator and leader in source water protection. The WIF Commission will seek funding opportunities to implement and maintain the activities outlined in this Plan and evaluate progress.

This Plan is intended to be a living document. The strategies and recommendations outlined herein should be assessed annually, and the Plan should also be updated every five years to incorporate any major changes that may be needed as the Plan is implemented.

1 Introduction

The Willamette Intake Facilities (WIF) Commission is responsible for oversight of the management and operation of the Willamette Intake Facilities (Intake Facilities). The WIF Intergovernmental Agreement was entered into by Tualatin Valley Water District (TVWD) and the cities of Wilsonville, Sherwood, Hillsboro, Tigard, and Beaverton (WIF Commission 2021). The members of the WIF Commission are local governments authorized to own, operate, and maintain municipal water supply systems. The cities and TVWD are referred to herein as the WIF Partners. The WIF Commission understands that there are many competing interests in the Willamette River Basin (interchangeably referred to as the Willamette River watershed) and must work effectively to address a multitude of impacts and needs associated with water rights, watershed protection, stakeholder collaboration, and Intake Facilities operations. Its mission is to responsibly secure a safe and reliable drinking water supply for partner communities while serving as trusted stewards of the Willamette River watershed. Protecting the health of the Willamette River is an essential responsibility of this generation and future generations and is an essential need for the wellbeing of the region. Many organizations, agencies, and partners must work together to protect the health and water quality of the Willamette River.

In 2021, the WIF Commission publicly affirmed its vision to become a trusted steward of the Willamette River watershed with the adoption of its Mission, Vision, Values and Goals (MVVG) Strategic Framework (WIF Commission 2021). The WIF Commission further clarified the vision with the following statements in the MVVG Strategic Framework: "We apply science, innovation, and advocacy for resilient and clean water stewardship. We improve awareness, provide education, and build support for watershed protection. We advocate at all levels for investment and policy to protect drinking water source quality." The full MVVG strategic framework (WIF Commission 2021) is highlighted throughout this document and is provided as Appendix 1-A.

The goal of this *Watershed Protection, Monitoring, and Outreach Plan* (Plan) is to protect source water quality by prioritizing projects and initiatives through identifying risks and opportunities. This Plan will protect source water both now and in the future, and will enable WIF Commission to provide partner agencies with safe, reliable drinking water for their communities. This Plan focuses primarily on the Middle Willamette and Yamhill Subbasins immediately upstream of the Intake Facilities, while also considering the full Willamette River Basin and its far-reaching impacts (Figure 1).

WIF COMMISSION STRATEGIC FRAMEWORK, WATER QUALITY PROTECTION PILLAR:

"We engage in addressing existing, emerging, and potential risks that may impact water quality at the Intake Facility ahead of treatment."

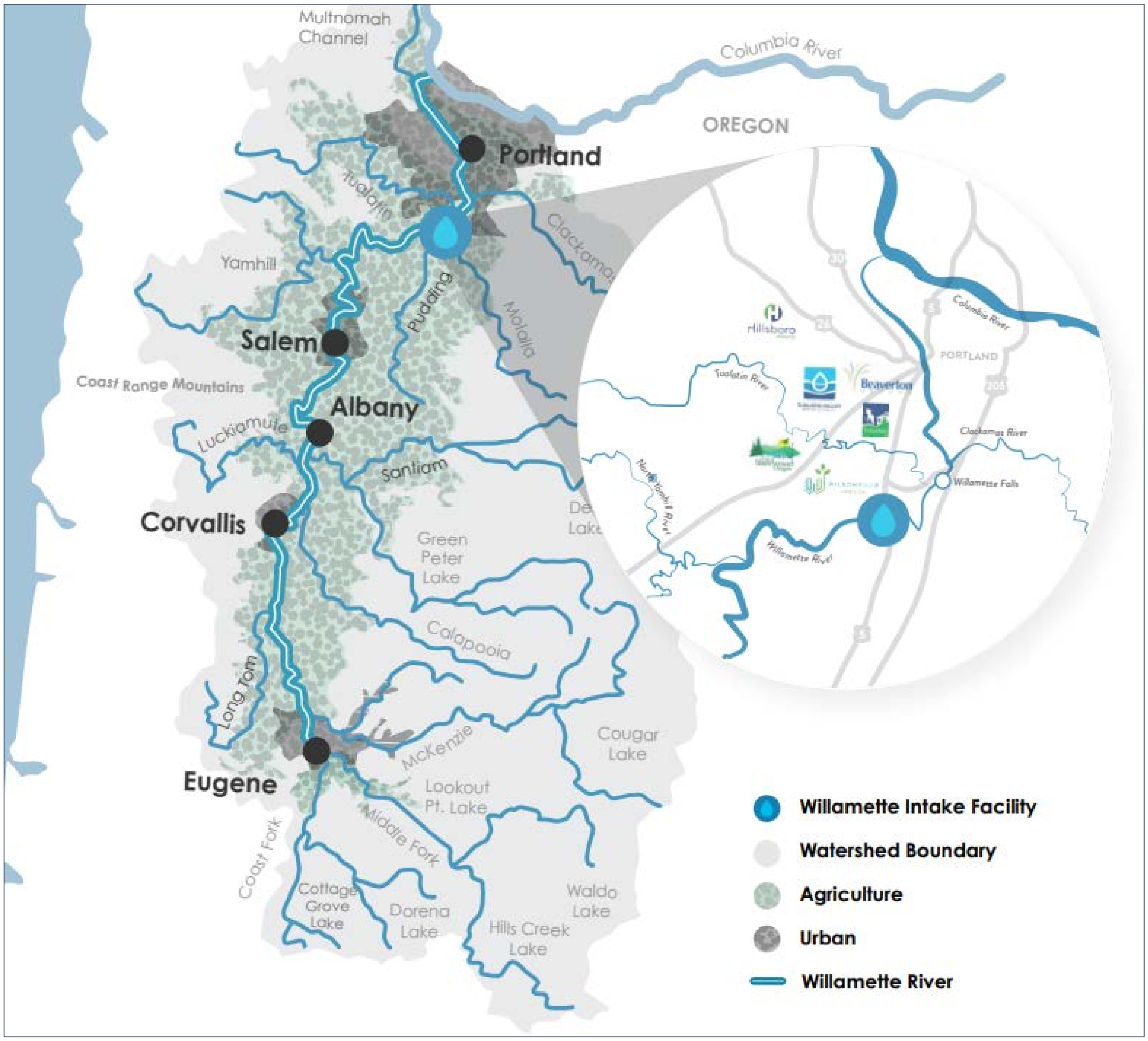

Figure 1: Scope of the Watershed Protection, Monitoring, and Outreach Plan (reproduced from WIF Commission 2021a)

This Plan addresses the six main elements of a successful source water protection program as outlined by the ANSI/AWWA G300 Standard for Source Water Protection (AWWA 2014). This Plan characterizes the source water and source water protection area, sets source water protection goals, unifies the vision for stakeholder involvement, outlines action plans, and proposes methods for implementation and periodic evaluation of the entire program. This Plan is intended to be a living document. The strategies and recommendations outlined herein should be assessed annually, and the Plan should also be updated every five years to incorporate any major changes that may be needed as the Plan is implemented. Additional guidance on adaptive management is provided in Section 9.

2 Watershed Overview

The Willamette River flows from south to north, from its headwaters near Eugene to the confluence with the Columbia River, as shown in Figure 1. The Willamette River drains a 11,500-square-mile region in northwestern Oregon, accounting for 12% of the total area of the state (Robbins 2021). The Willamette River Basin contains the Willamette Valley (Figure 2), the lowland areas surrounding the river where urban and agricultural land uses dominate, and the majority of the basin's population resides. This region is bounded by the Cascade Range to the east, the Calapooya Mountains to the south, and the Oregon Coast Range to the west (Robbins 2021). The Willamette Valley is home to over two-thirds of Oregon's population, including its largest city (Portland) and its capital (Salem).

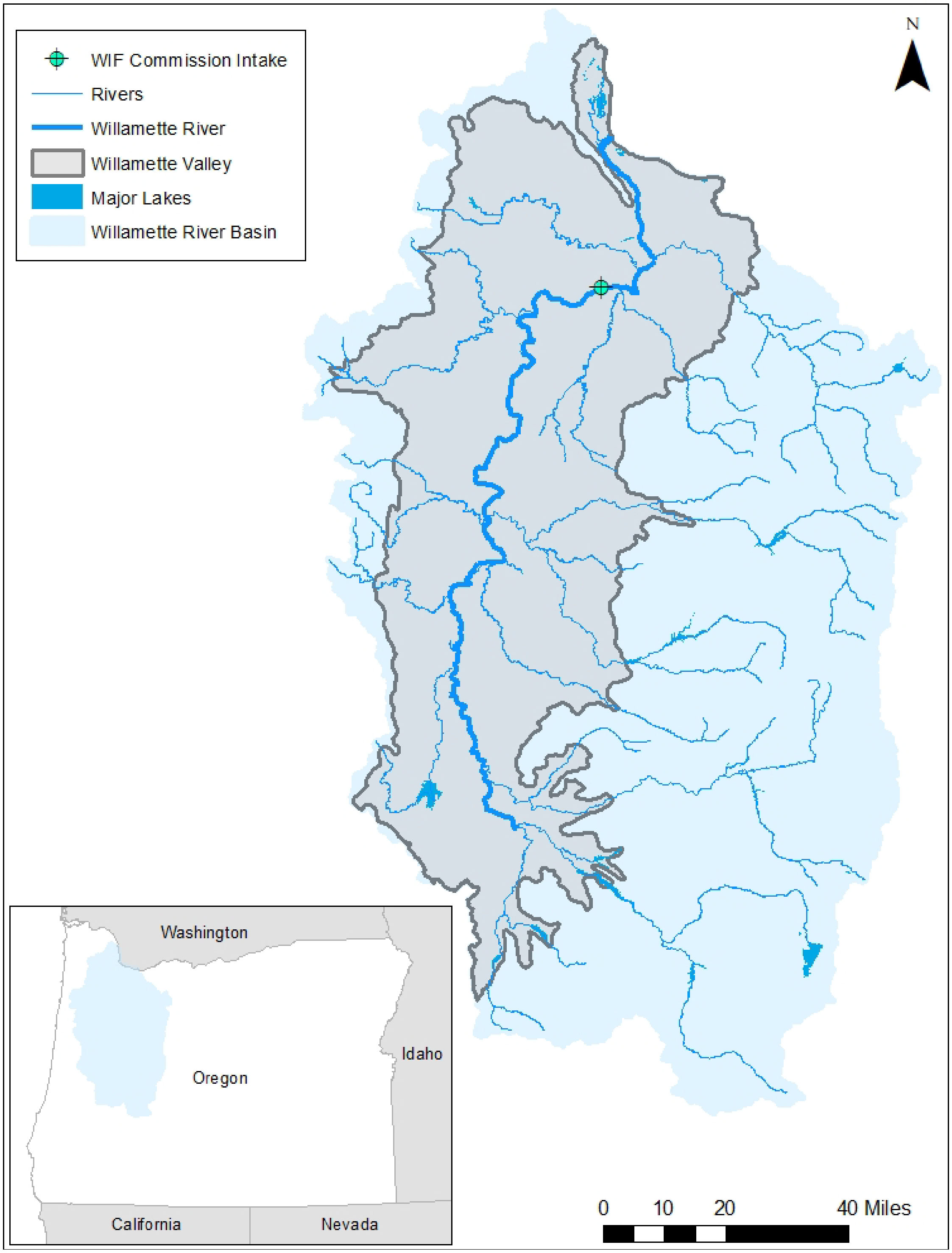

Figure 2: Extent of the Willamette Valley within the Willamette River Basin

2.1 History of the Willamette River as a Drinking Water Source

> **WIF COMMISSION STRATEGIC FRAMEWORK, WATER QUALITY PROTECTION GOAL #4:**
>
> *"Lead outreach and education on the Willamette River Basin history and current and future needs for protection."*

Use of the Willamette River as a drinking water source over time has depended primarily on the quality of water in the Willamette River, the quantity of Willamette River water allowed for municipal supply, and the availability of other water sources. Activities in the basin are diverse and the history of the river itself is complex. Some communities along the upper reach of the Willamette River, including the City of Corvallis, have successfully used the river as a drinking water source on and off for over 100 years. However, for many years the idea of using the downstream reaches of the Willamette River for drinking water was not considered. Decades of harmful industrial practices had polluted the middle and lower reaches of the Willamette River so severely that it was not viewed as a resource that could be used for drinking water. Restoration and cleanup efforts of the past 70 years have improved the water quality substantially, and portions of the Middle and Lower Willamette River and its tributaries have now been used as viable drinking water sources for several communities within the Willamette River Basin. For example, the City of Wilsonville has been successfully using the Willamette River as its primary water source for over 20 years.

Figure 3 illustrates major trends and events over the last 200 years. The following sections describe the changing conditions of the Willamette River Basin, Willamette Valley, and Willamette River with respect to human use.

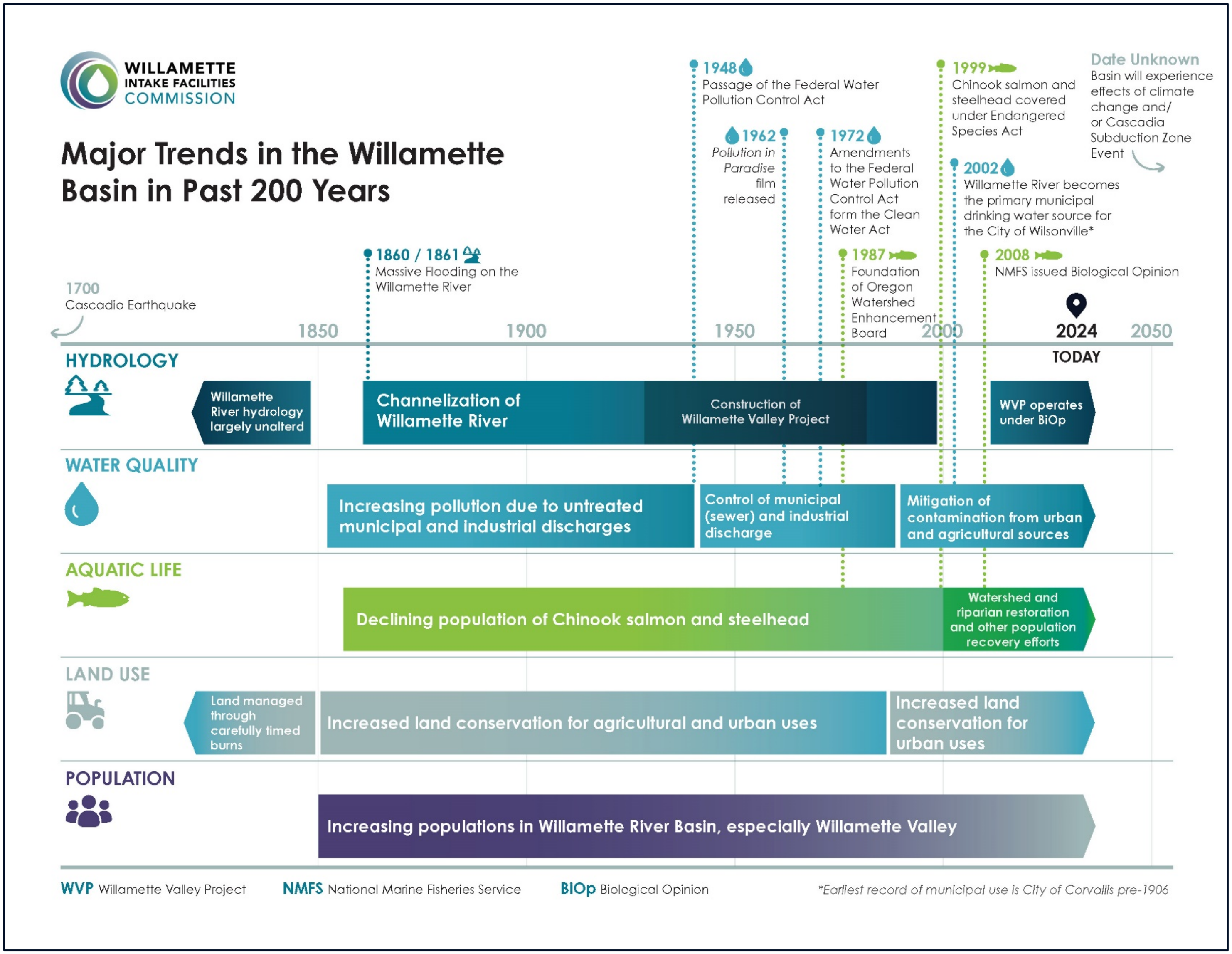

Figure 3: A Visual, Select History of the Willamette River

2.1.1 Population

For thousands of years, the native Kalapuya people, including the Calapooia, Luckiamute, Yamhill, and Clackamas bands, inhabited the Willamette River Basin (Sinclair 2005). Native peoples' relationships with and practices on the land and river involved only minor alterations and were relatively ecologically stable (Robbins 2021). Early Euro-Americans arrived in the Willamette Valley in the 1700s (Sinclair 2005). More settlers came to Oregon starting in the 1830s, and in large numbers starting in the 1840s and continuing to the end of the 19th century (Robbins 2021). European diseases diminished native populations (Macnaughtan 2021), and Euro-American settlements along the Willamette River displaced native people as well as their traditional land management practices (Sinclair 2005). Eventually, native people in the basin were forcibly removed from their ancestral lands to reservations, namely the Grande Ronde reservation west of Salem (Macnaughtan 2021).

The population in the Willamette Valley, especially in cities including Eugene, Albany, Corvallis, Salem, Springfield, and Portland, continues to grow. The 10 counties that are wholly or partially within the Willamette River watershed (Lane, Linn, Benton, Polk, Marion, Yamhill, Washington, Clackamas, Multnomah, and Columbia) are home to approximately 3 million people, out of the total Oregon population of 4.2 million (US Census Bureau 2021). More information about population trends is provided in Appendix 2-A.

2.1.2 Land Use

During the latter half of the 19th century, Euro-American settlers planted crops, built towns, and modified the Willamette River for use as a transportation corridor (Portland Bureau of Environmental Services n.d.). Between 1850 and 1990, the landscape changed considerably from the original coniferous forests, prairies, and oak savannas. Much of the change occurred in the regions closest to the river. By 1990, 42% of the Willamette Valley was used for agriculture and 11% was developed, while the Willamette River Basin overall was 19% agricultural and 5% developed (Enright, et al. 2002).

Today, the Willamette River Basin outside of the Willamette Valley remains predominantly forested. More recent changes in land use have continued to occur, primarily in the Willamette Valley, where agriculture now accounts for 45% of land, forest accounts for 34%, and developed land accounts for 13% (Wilson and Sorenson 2012). Land conversion to agriculture has slowed in favor of urban development as Oregon's population continues to increase (Morlan, et al. 2010). Developed land extents are limited by urban growth boundaries (Metro n.d.). Although urban growth boundaries can and have been expanded over time, this law protects farms and forests from urban sprawl. More information about land use is provided in Appendix 2-A.

2.1.3 Hydrology

As populations and cities grew during the 19th century, settlers invested in urban and agricultural infrastructure along the Willamette River corridor. The Willamette River is prone to flooding following storm events, and severe floods in 1860 and 1861 emphasized the perceived need to control the river (Payne, et al. 2002). Channel armoring methods, including dikes and revetments, wing deflectors, and levees, were implemented to channelize the water. The first dams were built along the Willamette River mainstem in the 1940s, following authorization of the Flood Control Act and subsequent approval of funding for the first seven dams in 1938 (Binus 2006).

The Willamette Valley Project (WVP) eventually grew to include 13 dams along the mainstem and major tributaries of the river. The WVP was completed in 1969 and is operated by the United States Army Corps of Engineers (USACE) in accordance with various federal and state mandates. To achieve the primary purpose of reducing winter peak floods and augmenting summer flows (USACE 2022b), dam operations necessarily have a significant impact on flow in the Willamette River. The hydrology of the Willamette River is discussed further in Section 3.1 and in even more detail in Appendices 2-A and 2-B.

2.1.4 Water Quality

The discharge of untreated municipal and industrial wastes directly to the Willamette River and its tributaries in the late 19th and early 20th centuries contributed to degradation of water quality in the middle and lower reaches of the river. By the 1920s, the majority of cities discharged untreated domestic and industrial waste into the Willamette River mainstem or its tributaries (Robbins 2021).

Cleanup of the Willamette River in the 20th century began with the passage of the Federal Water Pollution Control Act in 1948, which then required primary treatment (removal of material that will readily settle out by gravity) for municipal wastes discharged into the river. Starting in the 1960s, mandates focused on the water quality impacts from canneries, paper mills, and other industrial point sources (Portland Bureau of Environmental Services n.d.) and water quality began to improve. Amendments to the Federal Water Pollution Control Act in 1972 (hereafter referred to as the Clean Water Act) required a National Pollutant Discharge Elimination System (NPDES) Permit for discharge of wastewater to surface waters (United States Environmental Protection Agency [USEPA] 2021a). The Clean Water Act also required states to develop Total Maximum Daily Loads (TMDLs), which are plans to improve water quality in polluted waterways based on numerical water quality standards. By the 1970s, the Willamette River had gained notoriety nationwide for its substantially improved water quality.

However, starting in the 1990s, more advanced laboratory equipment and sampling methods uncovered that though the most visible pollution had been eliminated from the Willamette River, the river continued to experience high levels of contamination from industrial, agricultural, and urban nonpoint sources (Robbins 2021). Additional measures were then enacted by the State of Oregon, such as the 1997 Oregon Plan for Salmon and Watersheds and funding of watershed councils, which are local community groups that implement watershed enhancement projects. The combination of activities resulting from federal and state environmental laws have contributed to substantial improvements in water quality.

Today, the Willamette River is used as a drinking water source by multiple communities, all of which successfully meet applicable standards for safe drinking water. The Lower Willamette River is subject to occasional health advisories but is considered safe for human contact recreation in most seasons (Oregon Department of Environmental Quality [DEQ] 2020). However, low levels of hundreds of contaminants still persist in the Willamette River. Present-day water quality is closely studied to support human use and ecological benefits. The water quality of the Willamette River is discussed further in Section 3 and in greater detail in Appendices 2-A and 2-B.

2.1.5 Aquatic Life

The Willamette River is home to 36 native and 33 nonnative fish species (Oregon State University 2012). Development in and around the river has had a negative impact on habitat for aquatic species. Channelization of the river has narrowed the floodplain and eliminated side channels, reducing shallow water habitat and refuges. The development of dams has created water quality, habitat, and passage concerns, especially for endangered species. Additionally, large dams trap approximately 50-60% of bed-material sediment, which has led to a decrease in active channel habitat (Wallick, et al. 2013).

Under the 1973 Endangered Species Act (ESA), federal agencies must consider the impact of decisions on protected species. Since the listing of Chinook salmon and steelhead as endangered species under the ESA in 1999, USACE has managed the WVP in consultation with the National Marine Fisheries Service (NMFS). USACE's biological assessments completed in 2000 and 2007 informed NMFS's Biological Opinions (BiOp), issued in 2008, which established minimum flow targets for the Willamette River mainstem from April through October (National Marine Fisheries Service 2008). The targets vary annually based on available WVP storage in mid-May, indicating the water year type; water years may be classified as Abundant, Adequate, Insufficient, or Deficit. The year's classification informs the required flow rate to be maintained at the Salem United States Geological Survey (USGS) gage. The BiOp also established minimum and maximum flow objectives below dams on tributaries to ensure adult fish access to existing spawning habitat below USACE dams, protect eggs deposited during spawning, and provide rearing habitat. The implications of the WVP operations under the current BiOp are discussed further in Section 3.1. Additionally, in 2022 the USACE released a draft Environmental Impact Statement on the operations and maintenance of the WVP, which proposes changes in dam operations and flow management (USACE 2022a). As part of this process, USACE has re-initiated consultation under the ESA on NMFS's 2008 BiOp, and a new BiOp will be issued by the end of 2024. The forthcoming BiOp is anticipated to set forth different flow targets and may include additional measures to protect listed fish species.

Additionally, there have been many efforts by local and state agencies over the last 40 years to restore habitat and water quality conditions in the Willamette River in support of populations of endangered fish species. Notable partners in these efforts include the Oregon Watershed Enhancement Board (OWEB) and various watershed councils for tributaries to the Willamette River.

2.1.6 Municipal Use

Early on, water providers using the Willamette River as a water source did so due to a lack of other nearby options. This was the case for the City of Corvallis, which used the Willamette River as its sole source before 1906. From 1915 until 1946, Corvallis used small streams, and after 1946, Corvallis again began using the Willamette River as a major source of drinking water. The Cities of Salem and Wilsonville obtained Willamette River water rights in the 1970s but did not immediately develop them (Appendix 2-A). One of the most influential factors allowing the use of the Willamette River as a municipal drinking water supply was the completion of the WVP in 1969. Control of the dams to store water during rainy months and release it in summer months has historically provided sufficient water quantity for water providers during late summer and improved water quality through pollutant flushing.

As water quality in the Willamette River improved, water providers turned to the Willamette River to meet water supply needs when various factors challenged their existing water sources. In the 1990s and 2000s, several water providers began recognizing issues with their current water supplies. Groundwater has become a less viable water source in the Willamette River Basin due to declining groundwater levels caused by population growth, capacity issues, increased demand, and groundwater quality concerns. For example, the City of Wilsonville addressed its declining aquifer levels by switching to the Willamette River as its primary water source upon completion of its *Willamette River Water Treatment Plan* in 2002. Additionally, climate change, resulting in longer and drier summers, has stressed groundwater resources and highlighted the need for alternate water supplies to increase resiliency.

The Willamette River has become a key resource to municipalities facing these challenges. More water providers have obtained or developed their Willamette River water right permits in recent years. Water providers both with and without Willamette River water rights have also formed agreements to share water resources and often have system connections to support each other's water demand needs. Examples of such partnerships include the Joint Water Commission (JWC) and the Willamette River Water Coalition (WRWC). The JWC is owned by the Cities of Hillsboro, Forest Grove, and Beaverton, as well as TVWD. The WRWC members are the City of Sherwood, City of Tigard, City of Tualatin, and TVWD.

However, water quantity in the Willamette River during the summer is a concern due to minimum flow requirements for fish persistence conditions that are in several water provider water rights. Water management on the Willamette River is primarily dependent on USACE's operation of the WVP, which is influenced by annual weather conditions and patterns. USACE is beholden to certain federal and state mandated storage and instream flow requirements that affect other water rights. Water right permit holders may be subject to reductions of permitted diversions based on streamflow levels in the Willamette River. In recent years, water providers using the Willamette River have needed to manage water rights and water supplies more actively.

In addition, the Willamette River has minimum perennial streamflows (MPSFs) with both natural flow and released stored water components that will likely be converted to instream water rights at some point in the future. Conversion of the MPSFs is not expected to significantly affect the reliability of WIF Partners' water rights, but partners are tracking the conversion process in the event that conversion could affect their reliability and have been participating in the Willamette River Basin Review (often called the "Reallocation Study"). Furthermore, water providers holding water rights for natural flow have benefitted from the USACE's management of uncontracted water to meet flow targets; however, if the stored water is released for a specific contract in the future or legally protected instream under an instream water right, then it may not be available for water providers that would rely on natural flow water rights. This potential limitation on natural flow rights appears unlikely to result in diversion restrictions greater or more frequent than those to which WIF Partners are already subjected. Additional information about WIF diversions is provided in Section 3.1 and covered in even more detail in Appendix 2-A.

WIF COMMISSION STRATEGIC FRAMEWORK, WATER SUPPLY STEWARDSHIP GOAL #1:

"Engage proactively with regulatory agencies on water supply needs and future demands."

2.1.7 Reservoirs and Dam Operations

Of the 371 dams in the Willamette River Basin, 25 are considered to be major dams. There are 11 hydropower dams, one multipurpose dam on the Tualatin River, and 13 multipurpose WVP dams (Northwest Power and Conservation Council 2022). These dams are owned both publicly and privately. Most of the dams are located on tributaries within the basin, rather than the Willamette River mainstem.

The Flood Control Acts of 1938 and 1950 authorized USACE to construct and operate the WVP. Congress initially authorized the projects for flood control, but the authorized project purposes have been amended over time to include hydropower, recreation, irrigation, fish and wildlife, navigation, municipal and industrial water supply, and water quality. These reservoirs are located on tributaries and are currently operated by USACE under the NMFS BiOp to help regulate water quality in the Willamette River. Water levels in the WVP Reservoirs are maintained at their lowest elevations in the winter months to allow for storage of precipitation and snow melt. During high flow events, outflows from the system of dams are coordinated to reduce peak flows and river stages downstream (USACE 2022c). The dams in the WVP regulate approximately 27% of surface area runoff in the Willamette River Basin, and since the dams were completed, they have cumulatively prevented more than $25 billion in flood damages to the Willamette Valley (USACE 2022b). They hold nearly 1.6 million acre-feet of water (USACE 2019). In the spring, USACE allows the reservoirs to fill. This stored water is then released in the summer months to improve water quality, produce hydropower, support fish and wildlife habitat, and provide irrigation water (USACE 2022c).

Historically, there has only been a contracting program for the use of stored water for irrigation. The use of stored water in the WVP for other beneficial uses, including municipal water supply, has been hindered by limitations in the State of Oregon water rights issued for the projects that only authorize water storage for irrigation and by the need to reallocate storage. Following the *Willamette Basin Review Feasibility Study* (USACE 2019), reallocation of water storage in the WVP for other needs, including municipal, industrial, and fish and wildlife, was approved in 2020 (Congress 2020). The State of Oregon water rights authorizing storage of water in WVP reservoir will need to be modified to allow for the use of stored water to meet municipal and industrial and fish and wildlife needs. Municipal water providers throughout the basin have been investing considerable resources toward the reallocation of storage space in the WVP reservoirs and associated changes to the water rights to enable municipal access to stored water.

2.2 Delineation of Tiered Regions

For the purposes of this Plan, the Willamette River Basin was divided into three regions based on the potential to influence water quality at the Intake Facilities (Figure 4). The highest impact region (Tier 1) is directly upstream of the Intake Facilities and is considered the emergency response region, where a spill or contamination event would need to be rapidly communicated to water providers and mitigated and where drinking water quality could be affected within a matter of hours. The delineation of Tier 1 extends 35 miles upstream of the Intake Facilities on the Willamette River mainstem and includes lower reaches of the North and South Yamhill River. This delineation was informed by both the 8-hour travel time upstream of the Intake Facilities under high flow conditions and the 2-day travel time during low-moderate flow conditions, as well as the locations of nearby population centers in Newberg and McMinnville. Tier 1 is predominantly within Yamhill County, although a large portion is in Marion County and a smaller but notable portion is within Clackamas County. The Tier 1 region can also be characterized as being contained withing the hydrologic boundaries of the Yamhill Subbasin and the Middle Willamette Subbasin. The composition of Tier 1 area by county and subbasin is provided in Table 1.

The second, longer-term management region (Tier 2) contains risks to water quality that may affect the Willamette River at the Intake Facilities to a lesser extent, and that would allow for substantially more time to prepare a response. Depending on flow conditions, the travel time from the upper reach of the Willamette River within the Tier 2 region to the Intake Facilities may range from approximately 2 to 10 days. The final tier (Tier 3) extends to the entire Willamette River Basin and considers risks that may slowly impact the overall basin water quality. More information about the tiers and delineation methods is provided in Appendix 2-B.

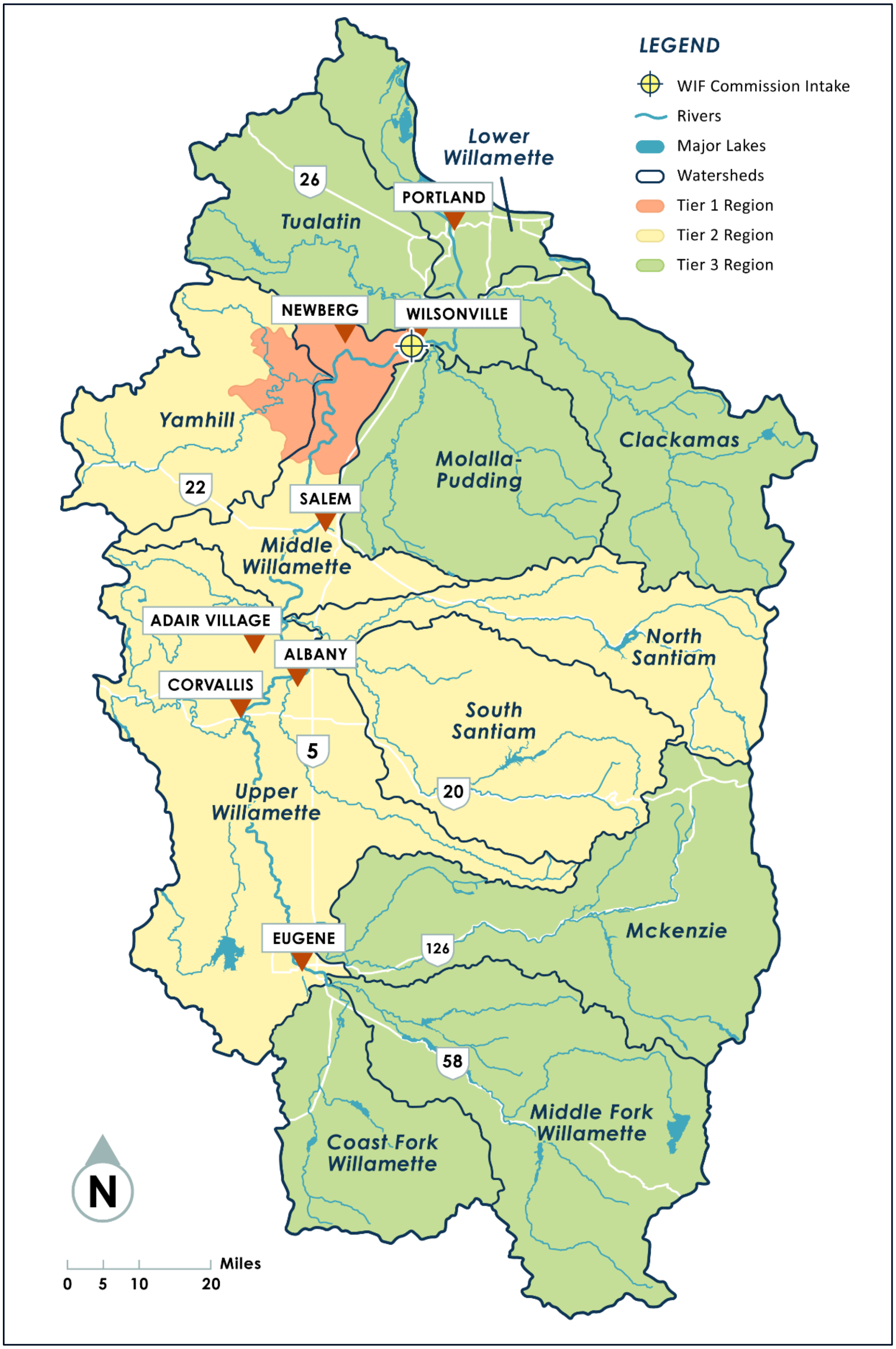

Figure 4: Tiered Regions of the Willamette River Basin

Table 1: Composition of Tier 1 Area by County and Subbasin

County	Percent of Tier 1 Area
Yamhill County	65.1%
Marion County	30.4%
Clackamas County	4.0%
Polk County	0.3%
Washington County	0.2%

Subbasin	Percent of Tier 1 Area
Middle Willamette	63.7%
Yamhill	36.3%

3 Water Availability and Source Water Quality

This section summarizes analytical flow and water quality studies for the Willamette River to characterize the source water. Additional information about each parameter discussed in this section is available in Appendix 2-B.

WIF COMMISSION STRATEGIC FRAMEWORK, WATER QUALITY PROTECTION GOAL #5:

"Give members of the WIF Commission resources to enable them to serve as water quality experts and representatives of WIF Commission interests."

3.1 Flow

The Willamette River originates south of Eugene and is fed by tributaries from 12 subbasins. Groundwater discharge is a large component of streamflow in the volcanic, highly permeable High Cascade region, while streamflow in other regions of the Willamette River Basin is largely dominated by precipitation runoff (Conlon, et al. 2005). Discharge in the Willamette River is typically low in the summer with swells in the spring and fall. The swell in the fall/winter season is caused by increased precipitation, while the high flows in spring are influenced by both precipitation and snow melt.

3.1.1 At the Intake

The primary indicator for flow rates immediately upstream of the Intake Facilities is the USGS gage at Newberg (14197900), which has over 20 years of data. A hydrograph analysis of historical flow data at this gage suggests that while wet season flow rates are quite variable given high precipitation events associated with winter storms, the average summer baseflows tend to be fairly consistent, which is mainly due to WVP storage releases (Figure 5). On average, the highest flow rates in the river occur during the winter months of December and January due to storm events. Large rainfall events increase loading of pollutants from stormwater discharges and may result in higher instream concentrations of some pollutants. There is a noticeable dip in flow during early spring, followed by a slight rise in flow rates for the months of March and April when temperatures warm and snowmelt from the upper reaches of the Willamette River Basin contributes significant water volume. The summer season from July through October exhibits an extended trough of low flow with little variability across water years. The average summer flow is approximately 7,500 cubic feet per second. During these months, less flow is available for diluting potential water quality contaminants from non-stormwater discharges such as wastewater treatment plant effluent and irrigation runoff.

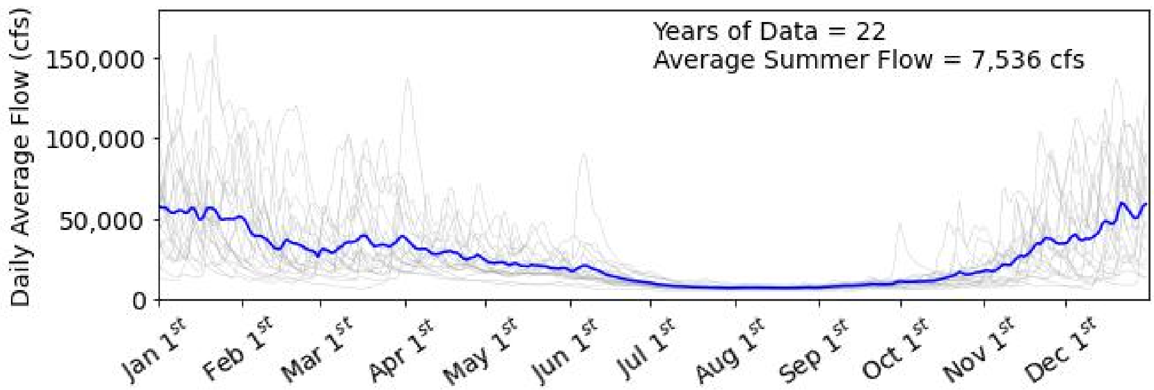

Figure 5. Average Annual Hydrograph (blue) and Supporting Years (gray) for USGS Gage at Newberg (14197900)

Other than the Willamette River mainstem itself, the greatest tributary contributor to flow at the Intake Facilities in the Tier 1 region is the Yamhill River. Analyses performed in support of this Plan estimated that the Yamhill River contributes approximately 10% of the total flow to the Willamette River mainstem at the Intake Facilities during any given season (Appendix 2-B). This means that source water protection in the Yamhill River Basin is important in addition to the Willamette River mainstem and other major tributaries.

Another significant tributary to the Willamette River is the Santiam River in the Tier 2 region, especially in the late spring and early fall. The unique hydrology in the Santiam River Basin is possible due to the operations of the WVP dams on the North and South Santiam Rivers. The Santiam River Basin is also a water supply source for the City of Salem. Therefore, the Santiam River Basin is a priority watershed for scientific investigation and management partnerships. However, the majority of flow in the Willamette River mainstem is sourced from the Coast Fork and Middle Fork Willamette River tributaries, upstream of the Tier 2 region.

3.1.2 Impact of WVP

The impact of the WVP dams can be observed both in tributaries where the dams are located and along the Willamette River mainstem. The long-term flow records at USGS gages along the mainstem Willamette River in the Tier 2 region were analyzed to compare the historical and current flow regimes. Visual and tabular results from this analysis are provided in Appendix 2-B. This analysis demonstrated the overall trend in flow before and after the completion of some of the largest WVP dams in 1953. For example, the average flow at Salem during summer months has increased after the construction of the dam projects. The overall average monthly flows have increased by 65%, with July being the lowest increase at 13% and September being the largest increase at 114%.

Additionally, due to the large contribution of flow by the Santiam River to the Willamette River mainstem, it is essential to understand the tributary flows of the Santiam River, as well as the effect of the WVP dams on the North and South forks. On the North Santiam River, the Big Cliff and Detroit Dams operate storage volume in the Detroit Reservoir to dampen winter storms, store spring runoff, and augment summer and early fall flow rates. Analysis of flow data at the

USGS gage just downstream (14181500) of the dam before and after 1953 confirmed this. The Big Cliff and Detroit Dams provide a major boost to late summer flows in the North Santiam River, specifically in August through October, and help dampen winter high flows. The USGS flow gage downstream of Foster Dam on the South Santiam River (14187200) reflects similar post-dam tributary hydrology.

Overall, the following trends that are characteristic of the impacts of the WVP were observed:

- The historical trends show a slight dip in flows in early March, likely associated with the period between winter storms and spring snowmelt, while the springtime flows in the recent record are relatively constant during those weeks. This change may be because the WVP dams store springtime flows.
- The late spring flows in the recent record exhibit a cliff in mid-June that is not present in the historical record. This may be associated with the minimum flow objectives at Salem, for which the threshold decreases significantly on June 15.
- The average summer flow rates are much higher in the recent period than in the historical record prior to 1953, once again likely due to the influence of the WVP operations and NMFS's BiOp (National Marine Fisheries Service 2008).

These findings corroborate that the WVP operations have, in meeting the conditions of the BiOp, affected the flow regimes in the Willamette River mainstem. These measures protect water quantity for both humans and native fish species. However, maintenance or changes in operations of the dams may present risks as far downstream as the Intake Facilities. In particular, the aging infrastructure of the WVP dams may increase the need for maintenance that would disrupt dam operations and result in periods of run-of-the-river flows. Studies have found these risks to be manageable. The WVP dams are a system in which operations at other dams will respond to the changing conditions downstream (Tullos, Walter and Vache 2020). Additionally, management changes that are made in response to climate change will likely reduce potential impacts to the current flow regimes, as discussed in Section 4.5.

3.1.3 Implications for Water Supply

The higher summer flows due to the dams benefit the fish as well as the water providers drawing from the Willamette River. Currently, WIF Partners' permissible diversion rates are limited by the Oregon Water Rights Department (OWRD) approvals of their Water Management and Conservation Plans (WMCPs). Hillsboro and WRWC partners must individually request access to water under their permits to remove limitations on permissible diversion rates. Additionally, limits on permissible diversion rates apply to WRWC, Beaverton, and Hillsboro water right permits. When instream flows do not meet the fish persistence target flows identified for the Salem gage, either diversion is prohibited, as in the case of Beaverton, or permissible diversions are reduced in proportion to the percentage by which the flow target is missed up to a certain percentage, as is the case for Hillsboro and WRWC. Wilsonville's diversion is not limited by flow targets at the Salem gage. Additional information about flow targets is provided in Appendix 2-A.

Historically, permissible diversion rates by WIF Partners have been minimally affected from October through March based on instream flows. Between April and September, flow targets are frequently not met for some WIF Partner water rights due to low instream flows. The flow targets vary slightly for different entities, but flows recorded at the Salem gage show that, in extreme years, the most restrictive of flow targets have been missed for most of the April through September season. However, while the maximum permissible diversion may be reduced due to missing instream flow targets, this will not always directly impact actual withdrawals due to several factors, including demand.

To explore the concept of flow targets, a flow frequency analysis was conducted for daily average flow rates at the USGS gage at Salem. As done in the analyses presented in prior sections, only data after 1954 were used. Flows were compared to fish persistence target flows at the Salem gage used in water rights permits held by the City of Beaverton and the City of Hillsboro as an example. Flow targets for Beaverton and Hillsboro are the same but are slightly different than the WRWC flow targets. This exercise revealed that fish persistence flow targets are missed less than 5% of the time for September through March. Fish persistence target flows are missed approximately 20-50% of the time for the periods from April-June, with June 1-15 being the period where target flows are missed most frequently. For July-September, where water demand is often highest, target flows are missed less than 10% of the time. This analysis applies to average conditions and not to a single year. Also, the results of this analysis are relative indicators and do not directly represent diversion restrictions for any of the WIF Partners. Plots showing the full results of this analysis are provided in Appendix 2-B.

Considering the reallocation process of WVP storage, the possible conversion of MPSFs to instream flow water rights, and other USACE actions to protect stored water releases, there is significant uncertainty in how water rights holders will be affected. However, based on the location of the WIF diversion downstream of the Salem gage, it appears unlikely that protection of stored water releases would result in diversion restrictions greater or more frequent than those to which WIF Partners are already subject.

3.2 Temperature

Elevated water temperatures in the Willamette River and tributaries are a water quality concern both for aquatic life and drinking water providers. Water temperature is important to endangered species and is also a key factor in various water quality conditions that can affect drinking water treatment and quality. Rising stream temperatures occur naturally from solar radiation and are generally the highest in the summer when solar radiation is high and corresponding streamflow is low (DEQ 2006). Anthropogenic activities such as discharging warm wastewater, decreasing riparian shade, and impounding or diverting water from the main channel can also lead to high stream temperatures. The Willamette River Basin temperature TMDL, established in 2006, sets heat load allocations and reductions for anthropogenic activities to meet water temperature standards within the basin. These standards vary based on use designations, including categories such as salmon rearing and spawning (DEQ 2006). However, the DEQ is under court order to replace temperature TMDLs for the Willamette River and major tributaries approved between 2004 and 2010 by February 28, 2025 (DEQ 2022a).

3.2.1 At the Intake

Water temperatures in the Willamette River Basin follow seasonal trends. As noted previously, water temperatures are typically highest in the summer months when there is the most solar radiation and streamflow is low. This can be observed from USGS gauge data. Of particular interest to this Plan is the USGS monitoring location at Newberg (14197900). Average, minimum, and maximum daily mean temperatures at this location are shown in Figure 6.

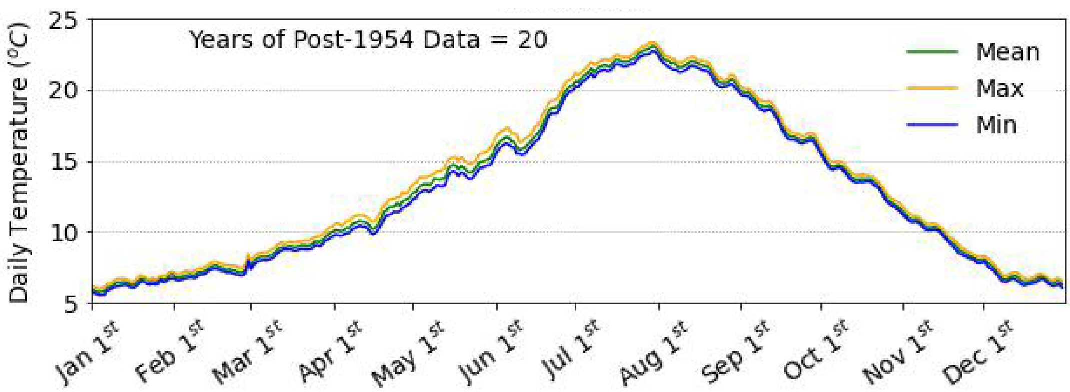

Figure 6. Seasonal Temperature Trends on the Willamette River Mainstem at Newberg

Temperature TMDL criterion vary in each subbasin, but regardless of the established criterion, streams generally exceed their assigned criterion from early summer into the fall (DEQ 2006). Historical DEQ water temperature data and thermistor data collected for the 2006 TMDL demonstrate that Willamette River water temperatures exceed biologically based criteria during the April through October period (DEQ 2006). In the Tier 1 region downstream of river mile 50 (approximately the Yamhill River and the City of Newberg), spawning and rearing are not designated uses; therefore, a relatively non-stringent numeric criterion of 20 °C for salmonid migration applies. The critical period for this reach is from June through September, when river temperatures are often warmer than the biologically based numeric criterion (DEQ 2006). As shown in Figure 6, average daily maximum temperatures at the Newberg USGS gage during this time of the year exceed 20 °C. However, the criterion applies to the 7-day average of the daily maximum temperature. Additionally, while this criterion is an indicator of both poor environmental conditions to support fish species and poor overall water quality to supply drinking water, the criterion is primarily designed to support fish life cycles. Exceedances of this criterion may not be directly detrimental to drinking water treatment processes, finished water quality, or other associated industrial water uses and treatment processes.

3.2.2 Impact of WVP

Water is stored behind many of the WVP dams while streamflow is high, then released during the summer. These releases help to regulate stream temperature as well as to dilute pollutants, improving water quality within the basin. Specifically, water released during the summer comes from low reservoir depths, which cools the water temperature downstream, while thermal stratification breaks down in the late summer, allowing warmer water to be released in the fall (DEQ 2006). This process regulates stream temperature but must be closely monitored to ensure proper temperatures are maintained for fish habitat and spawning.

This effect can be observed in the spatial and seasonal trends in water temperature along the Willamette River mainstem from upstream to downstream, USGS water temperature data were analyzed at Harrisburg (14166000), Albany (14174000), and Salem (14191000). Only data collected after 1954 were used to isolate trends following completion of several major WVP dams. Daily minimum and maximum water temperature were averaged across years to obtain average seasonal trends. Plots showing the results of this analysis are available in Appendix 2-B. This analysis revealed an interesting spatial trend. The summer high water temperatures at Albany appear to be slightly warmer than those at the downstream Salem gage, with daily maximum temperatures of 22 °C at Albany and closer to 20 °C further downstream at Salem. This is contrary to the general trend of warmer river temperature downstream. The lower peak summer temperatures at Salem compared to Albany are likely due in large part to colder water from the four WVP dams on the North and South Santiam Rivers entering the Willamette River between the Albany and Salem gages.

The WVP also has a significant impact on the water temperature simply by affecting the amount of flow in the Willamette River. In the summer months, there is an inverse relationship between flow and temperature, with flow reductions resulting in water temperature increases. The temperature of lower flows will be more readily affected by air temperature, which during the summer months will have a warming effect. Modeling analysis for the creation of the TMDL shows that a 20% flow reduction produces river mouth temperatures that are 0.5 °C warmer in the Middle Fork Willamette River and 0.3 °C warmer in the McKenzie River (DEQ 2006). The inverse relationship between flow and water temperature in the summer was also observed by correlating the average daily flow versus average daily maximum temperature for each month at Salem (14191000) and Albany (14174000) gages. Plots showing the results of this analysis are provided in Appendix 2-B. This correlation analysis shows that maximum water temperature and flow in spring and summer months have a negative relationship. In March to November, as average flow increases, the maximum temperature decreases. The statistical significance of the correlation during these months suggests a close relationship between average daily flow and maximum daily water temperature. Trends for June through September showed especially little variability considering that over 20 years of daily data were used. There are many factors in addition to WVP operations that impact these trends, including seasonal precipitation and air temperature. Also, the seasonal relationship between flow and water temperature becomes less clear in the fall. This may be due to increased variation in weather conditions during those months. Additionally, the effect of reservoirs during these months varies as reservoirs often store heat in the summer months and releasing this flow can increase water temperatures downstream, although this depends greatly on the depth from which this flow is released. Monthly correlation coefficients for all months are provided in Appendix 2-B.

3.2.3 Implications for Source Water Quality

Water released during the summer from low reservoir depths contributes to cooler water temperature in the Santiam River and, in turn, the Willamette River mainstem downstream. Operational changes on the Santiam River dams, such as installing selective withdrawal facilities that could allow warmer water to be released, could influence this trend in the future. However, it is unclear how large of an effect the Santiam River temperature trends have on temperature trends at the Newberg gage and, subsequently, at the Intake Facilities.

Separately, long-term analysis of water temperature in the Willamette River at the USGS Harrisburg gage (14166000) confirms an expected trend: the average water temperatures in months April through October are increasing over the years. Based on the linear regression analysis performed at this gage, July and August months have experienced the largest increase in water temperature (0.33°C per decade). A similar, but less substantial, upward trend can be observed in the other months as well. However, this gage is far upstream of the Intake Facilities and many factors affect the water temperature before it reaches the intake. Plots showing the results of this linear regression analysis are provided in Appendix 2-B.

The WVP dam operations dampen the trend of increasing water temperatures by increasing summer average flows and releasing cold water from dams to cool summer temperature. However, long-term temperature trends are of relevance to the WIF Commission in consideration of the impacts of warming summer temperatures on source water quality.

3.3 Other Water Quality Constituents

This section summarizes analytical water quality studies and trends for specific parameters.

3.3.1 Bacteria

The Willamette River Basin TMDL for bacteria was established in 2006 (DEQ 2006). The Willamette River Basin bacterial TMDL focuses on *E. coli* concentrations and covers the entire Willamette River and all tributaries, although many tributaries have achieved different statuses over time. Concentrations of *E. coli*, a species within the category of fecal coliform bacteria, are used as an indicator of bacterial concentrations in the Willamette River Basin. The most common strains of *E. coli* do not cause illness, but their presence indicates sources that are likely to include other pathogens that do cause human illness. The most common source of bacteria in the Willamette River is contaminated runoff. Therefore, contamination of the Willamette River is highest when rainfall, and therefore river flow, is high. This is typically October through March (DEQ 2006). Sources of *E. coli* are less common in the summer months, leading to lower *E. coli* concentrations despite having less flow in the river to dilute contaminants.

While bacteria have generally been of high concern in the Willamette River Basin due to historical trends, the level of concern for this pollutant at the Intake Facilities is lower due to both the location of the Intake Facilities and improvements in management of sources upstream. Bacterial loading in the Willamette River mainstem has historically come primarily from point sources such as Combined Sewer Overflows (CSOs) and stormwater discharges sources. Prior to 2001, the City of Corvallis had CSOs during rainfall events, but a new wastewater treatment facility addressed this issue (DEQ 2006). Another significant historical source of CSOs on the Willamette River is the City of Portland; however, this source is both far downstream of the Intake Facilities and has also seen a significant decrease in CSOs over time.

The Intake Facilities location is also advantageous relative to loading from tributaries. Where the Intake Facilities is located at river mile 38.7, most of the water that enters the Willamette River mainstem has already entered upstream of this point. The majority of this flow comes from the Coast Fork and Middle Fork Willamette, McKenzie, and North and South Santiam Rivers, which have bacterial concentrations well below the water quality criteria (DEQ 2006). Even though there are significant bacterial inputs from smaller tributaries upstream of the Intake Facilities, there is also significant streamflow entering that provides assimilative capacity and brings down the overall concentration. For example, a review of water quality data for the Yamhill River revealed exceedances at monitoring locations and no definitive trend of improvement (ODA 2017). However, dilution allows water quality above Willamette Falls to stay consistently below the bacteria criteria established in the Willamette River bacteria TMDL (DEQ 2006). While there are tributaries that substantially increase the average *E. coli* concentration in the Lower Willamette River mainstem, namely the Molalla-Pudding and Tualatin River Subbasins, these are downstream from the Intake Facilities.

There is not substantial recent monitoring data for bacteria available in the vicinity of the Intake Facilities. This does not present a data gap at this time, as bacteria have not been identified as high-risk to water quality at the Intake Facilities. However, this should be re-evaluated if additional information becomes available.

3.3.2 Mercury

The Willamette River Basin mercury TMDL was reestablished in 2021 (DEQ 2022a). It covers the entire Willamette River and most of its tributaries. Sources of mercury in the Willamette River Basin are atmospheric deposition originating from sources outside Oregon, soil erosion, historical mining activity, sediment resuspension, and municipal and industrial water discharges (DEQ 2019a). Mercury takes various forms in the environment, but methylmercury (MeHg) is the most bioaccumulative form of mercury in fish tissue and the most toxic for human consumption. The TMDL was developed to meet the human health criterion for mercury and therefore focuses primarily on MeHg concentrations in fish tissue (DEQ 2019a). However, MeHg is only a subset of the total mercury (THg) in the Willamette River Basin.

While mercury is of high concern in the Willamette River Basin overall, it is currently thought that the primary threat posed to human health is through consumption of fish that have bioaccumulated MeHg over several years, which is the approximate time it takes to accumulate enough MeHg to exceed the fish-tissue criterion (Tetra Tech 2019). Based on the latest assessments of MeHg and THg data, mercury has not been identified as high-risk to water quality at the Intake Facilities. However, this should be re-evaluated if additional information becomes available.

3.3.3 Phosphorus

Phosphorus is a component of fertilizer that may travel to waterways from the application site due to storm events, excessive irrigation, or erosion. This nutrient is typically a limiting factor to the growth of aquatic weeds and algae in rivers. Combined with warm water temperatures, sunlight, and low summer flows, phosphorus can encourage excessive algal growth, which in turn worsens water quality. The impacts of algal blooms are further discussed in Section 3.3.4.

The Yamhill River Subbasin established a TMDL for phosphorus in 1989 (DEQ 1989). The Oregon Department of Agriculture (ODA) has worked with the Soil and Water Conservation Districts (SWCDs) for Yamhill and Polk counties to report water quality trends in the basin. In the 2017 *Yamhill Agricultural Water Quality Management Plan*, trends suggest that phosphorus levels in the Yamhill River at Dayton have been improving (ODA 2017).

Although data are not available at Newberg after 2003, phosphorus levels have been recorded at Wheatland Ferry multiple times per year from 1992 to 2022. This gage is further upstream, but still within the Tier 1 region and may serve as an indicator for water quality at the Intake Facilities. However, phosphorus monitoring in the Tier 1 region may not be a high priority for the WIF Commission as trends on the Yamhill River are improving. Additionally, as discussed in the next section, the related concern of algal blooms is currently not prominent on the Willamette River mainstem in the area of the Intake Facilities. The potential future impact of phosphorus on the risk of excessive algal growth in the Newberg Pool may cause phosphorus to present a higher concern at that time, and the importance of acquiring recent monitoring data closer to the Intake Facilities may need to be revisited. This is further discussed in Section 4.5.

3.3.4 Algal Blooms

Cyanobacteria, also known as blue-green algae, can grow into cyanobacteria harmful algal blooms (cyanoHABs) in certain environmental conditions when ponds, rivers, and impoundments are warm, slow moving, and nutrient-rich. CyanoHABs can release a variety of cyanotoxins that are harmful to human and aquatic organisms and ecosystem health and threaten drinking water quality and recreational use of water bodies. Though some drinking water treatment methods, including ozonation and filtration through granular activated carbon used by the WIF Partners, are effective at removing cyanotoxins, conventional drinking water treatment systems may not be able to treat more severe blooms (USEPA 2021b), and frequent treatment for blooms can increase drinking water treatment costs regardless of treatment methods.

Reservoirs, with slow moving water that can heat more easily, are especially susceptible to cyanoHABs. In the Willamette River Basin, cyanoHABs are known to occur in a number of tributary reservoirs, from which cyanotoxins may be transported downstream to the Willamette River mainstem. Between 2005 and 2018, cyanoHABs were reported in 10 of the 13 reservoirs associated with the WVP, along with two other reservoirs operated by the Eugene Water and Electric Board (EWEB) and the City of Eugene (DEQ 2022b). All locations where cyanoHABs were reported in the Willamette River Basin from 2005 to 2018 are shown in Figure 7. CyanoHABs have also been documented on the Willamette River near Portland, including as recently as 2023 (although this data point is not included on the map given its downstream location in relation to the Intake Facilities). Notably, there were no reports within the Tier 1 area, and only at a few locations in the Tier 2 area. These are Detroit Lake (North Santiam River Basin), Fern Ridge Lake on the Long Tom River (Upper Willamette River Basin), and Golden Gardens Pond in the City of Eugene (Upper Willamette River Basin). Of these, Detroit Lake had cyanoHABs reported during the greatest number of years (four).

CyanoHABs that occur in tributaries and far upstream of the Intake Facilities along the Willamette River mainstem have the potential to transport cyanotoxins downstream. For example, in 2018, Salem issued a drinking water advisory due to cyanotoxins originating in Detroit Lake, which persisted for nearly a month (Oregon Water Science Center 2018). Similar blooms that historically have occurred in reservoirs on the McKenzie River could cause similar advisories for Eugene. Cyanotoxins are relatively persistent in the environment but do experience some photodegradation. Dilution as toxins move downstream will likely reduce threats to water quality at the Intake Facilities, though monitoring for cyanotoxins when there are active cyanoHABs upstream would be prudent.

Oregon Health Authority (OHA) has developed regulations that require drinking water systems using surface water sources susceptible to cyanoHABs to routinely test for two cyanotoxins that these blooms produce and notify the public about the test results. For water systems not subject to the cyanotoxin monitoring rules that serve surface water and have had algae issues in the past, OHA recommends voluntarily testing for cyanotoxins and notifying the public about the results (Oregon Health Authority 2022a). To preempt cyanoHABs, USGS, EWEB, USACE, and the City of Salem partnered to perform continuous water quality monitoring in Detroit Lake and Cougar Reservoir to monitor parameters that affect and induce cyanoHABs as well as proxies for measuring algae and algal activity directly. These parameters included temperature, conductance, turbidity, chlorophyll, blue-green pigment phycocyanin, dissolved oxygen (DO), pH, and fluorescing dissolved organic matter. These parameters were monitored throughout the vertical profile of the lakes from September 2019 to April 2020 (USGS 2020). Additionally, DEQ has monitored chlorophyll-a at three sites on the Yamhill River, including the North and South Yamhill Rivers, and four sites on the Willamette River mainstem between Salem and Wilsonville. The length of record and frequency of sampling varies between sites, but generally consists of a few samples per year between 1992 and 2021. These and other data can be used to monitor reservoir conditions to predict likely bloom events when cyanotoxin sampling might be important.

Overall, monitoring performed thus far suggests that bloom events are of relatively low concern in the mainstem Willamette River upstream of the Intake Facilities. The cyanotoxin detection in Salem, Oregon, in May 2018 was at the Detroit Lake Reservoir and not in the mainstem Willamette River. A preliminary cyanotoxin detection by Wilsonville in June 2018 was determined to be a false positive based on subsequent verification sample testing. While there have been cyanotoxin detections in the Willamette River in the Portland area downstream of Ross Island Lagoon, this is due to location-specific factors that exist substantially downstream of the Intake Facilities and below Willamette Falls.

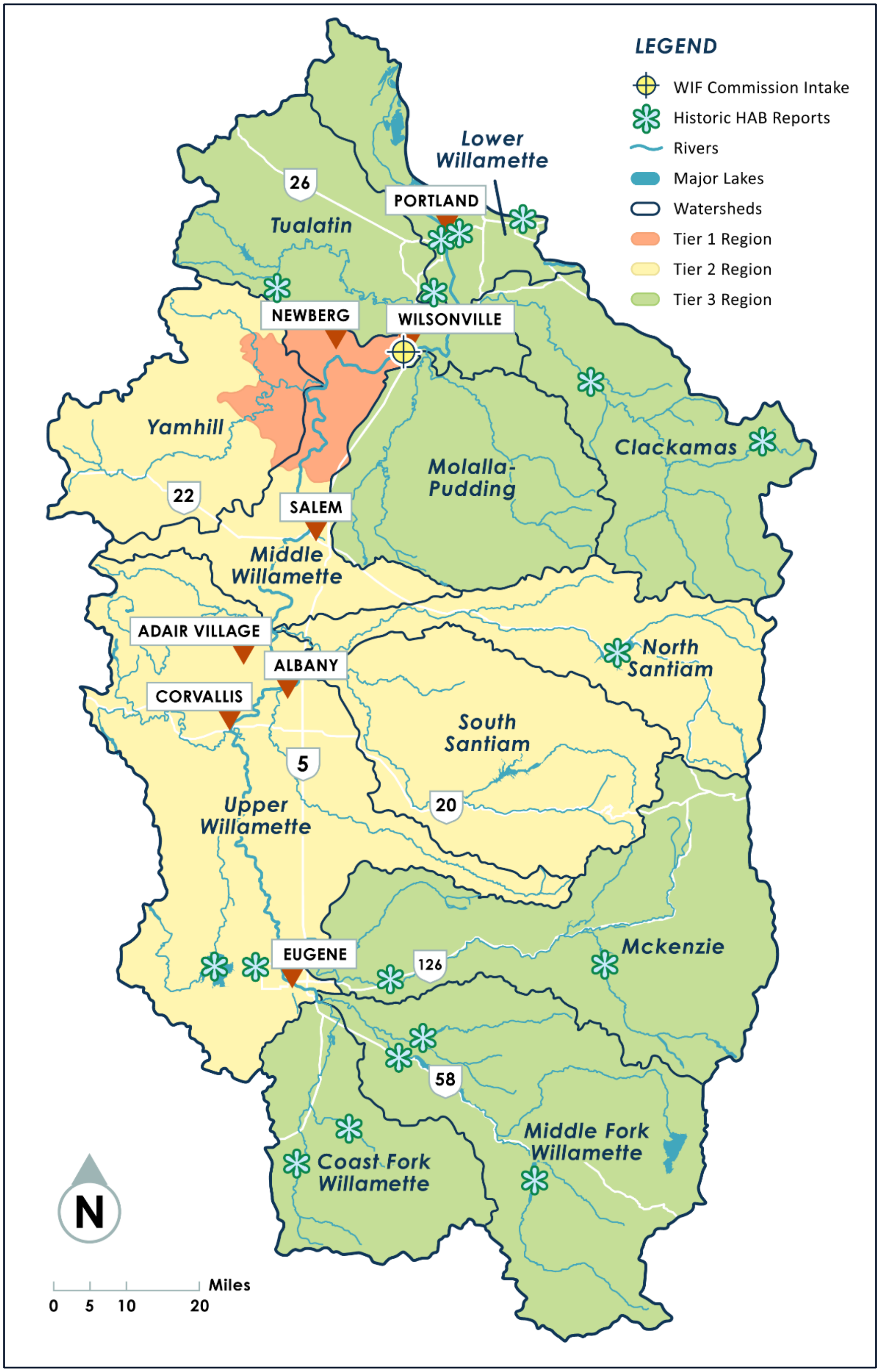

Figure 7: Cyanobacteria Harmful Algal Bloom Reports in the Willamette River Basin from 2005–2018

3.3.5 Dissolved Oxygen and pH

There are several subbasins upstream of the Intake Facilities with TMDLs for DO and/or pH. The Coast Fork Willamette Subbasin TMDL, approved in 1996, includes DO and pH (DEQ 1995). Rickreall Creek in the Middle Willamette Subbasin established a TMDL for DO in 1994 (DEQ 1993). The Yamhill River phosphorus TMDL also established a pH standard of 6.5–8.5 to support water quality (ODA 2017). These TMDLs generally relate to excessive algal growth, discussed in Section 3.3.4, which can contribute to high pH and low DO. Additionally, native fish species need DO and moderate pH levels to support many biologic processes. Low DO concentrations can also lead to anoxic conditions which can result in the release of nutrients from the sediment bed.

A 2017 analysis of water quality monitoring data for three sites in the Yamhill River Subbasin suggested that exceedances of the DO water quality standard are either stable or improving over time, depending on the site (ODA 2017). The data also indicated that no pH exceedances were observed at two of the three sites, although the third site had multiple exceedances caused by high pH values. However, no pH exceedances have been detected at that site since 2015. Available data on the Willamette River mainstem consists primarily of pH and DO measurements at the DEQ site near Newberg, extending from 1992 to 2003. There is more recent data available at Wheatland Ferry, which is relatively far upstream of the Intake Facilities but still located within Tier 1. As this site is relatively far upstream of the Intake Facilities and upstream of the confluence with the Yamhill River, data at this site are insufficient to characterize pH and DO near the Intake Facilities. At this time, pH and DO have not been identified as posing high risk to relevant drinking water treatment processes at the Intake Facilities but are useful indicators of overall watershed health and long-term source water trends.

3.3.6 Metals

Many metals occur naturally, and thus detection of metals is common in waterways. However, human activity may increase the frequency and magnitude of metal concentrations. Thus, Oregon has existing water quality criteria for many metals, and these are included in DEQ's ongoing monitoring efforts. Between April 2008 and May 2010, DEQ collected seasonal water samples at seven locations in the Middle Willamette River Basin, including one site on the Yamhill River at Dayton and several locations on the Middle Willamette River mainstem (DEQ 2015). DEQ also conducted additional sampling in 2015-2016 and issued a Statewide Water Quality Toxics Assessment Report summarizing the results of both studies (DEQ 2020). These studies indicated that concentrations of copper and iron exceeded applicable aquatic life criterion on the Yamhill River. The 2008-2010 sampling also found concentrations of iron that exceeded the aquatic life benchmark on the Willamette River at Canby (downstream of the Intake Facilities), but this was not found in 2016 sampling at Hebb Park Boat Ramp nearby. Additionally, the criterion for iron was established to protect aquatic life and exceedances do not pose a risk to human health (DEQ 2020).

Recent sampling programs on the Willamette River mainstem near the Intake Facilities have been limited. At the Wheatland Ferry site, data for some metals are available from 1992 to 2022, with samples collected approximately a few times per year. As this site is relatively far upstream of the Intake Facilities and upstream of the confluence with the Yamhill River, data at this site are insufficient to characterize metals concentrations near the Intake Facilities. DEQ also currently collects samples downstream of the Intake Facilities near Canby; however, it is unknown whether this location is an adequate proxy for the Intake Facilities. Nevertheless, water quality sampling for the Wilsonville Willamette River Water Treatment Plant (WRWTP) have resulted in no detections, or detections at levels well below regulatory levels[1] for inorganic substances, including metals (City of Wilsonville 2023). Therefore, working with DEQ and other partners to conduct additional metals sampling closer to the Intake Facilities may be valuable but is not considered high priority at this time.

3.3.7 Pesticides and Petroleum Products

Pesticides and petroleum products fall into the category of synthetic organic compounds (SOCs). SOCs are not common in the Willamette River. Prior analyses for the WRWTP of 30 SOCs and 50 volatile organic chemicals[2] resulted in no detections (Tualatin Valley Water District and City of Hillsboro 2019). However, pesticide compounds were detected in the Yamhill River as part of the 2015 DEQ Toxics Assessment. The assessment examined both current use and banned (or legacy) herbicides and insecticides. Legacy pesticides are very persistent and bioaccumulate up the food chain, making them a concern for humans. Additionally, research shows that even low levels of pesticides, including current use pesticides, in aquatic environments may affect fish and other aquatic organisms (DEQ 2015).

A total of 14 current use pesticide compounds were detected during DEQ's monitoring of the Middle Willamette River and Yamhill River Basins from 2008-2010 (DEQ 2020). Diuron, atrazine, and simazine were detected specifically at the Yamhill River site at Dayton. Two current use pesticides, diuron and pentachlorophenol, exceeded the applicable USEPA aquatic life benchmark and DEQ water quality criterion for human health, respectively, at the Yamhill River sampling location. An updated assessment in 2016 used new analytical methods with a lower detection limit. The 2016 sampling effort resulted in exceedances for three legacy pesticides and detections of more current use pesticides at the Yamhill River site, although no exceedances occurred for the current use pesticides sampled (DEQ 2020). Exceedances for current use pesticides were also not observed at the Middle Willamette River mainstem sampling locations. Working with DEQ and other partners to conduct additional sampling for current and legacy pesticides may be valuable, however it is not considered high priority at this time.

Potential sources of pesticides are most commonly nonpoint discharges from agricultural land uses, while petroleum products more often originate from point sources. This alters how the relative risks from these SOCs are managed. Point sources of SOCs are discussed further in Section 4.1. Nonpoint sources of SOCs are discussed in Section 4.2.

[1] Most regulated inorganic parameters were not detected in the Willamette River source water. Nitrate and barium were the typical inorganics detected and were well below regulatory levels.

[2] Volatile organic chemicals are a subset of SOCs.

3.3.8 Contaminants of Emerging Concern

Per- and polyfluoroalkyl substances (PFAS) are a family of substances known as “forever chemicals” for their persistence in the environment. There are thousands of types of PFAS, which are used in a variety of household and industrial processes and products, and PFAS have been linked to a range of health issues. Their ubiquity and resistance to degradation in the environment make PFAS chemicals a growing concern for drinking water providers. Though PFAS compounds are not currently regulated nationwide, the USEPA has listed two of the most common types of PFAS as hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and is moving towards regulating them in drinking water. On March 14, 2023, USEPA announced proposed National Primary Drinking Water Regulations for six PFAS compounds (USEPA 2023). Prior to this, the USEPA Third Unregulated Contaminant Monitoring Rule (UCMR3) under the Safe Drinking Water Act required public water systems in the United States to monitor for six PFAS substances in finished drinking water from 2013 to 2015 (USEPA 2021b). None of the PFAS compounds tested in UCMR3 were detected in drinking water samples (i.e., at the tap after treatment) in the Willamette River Basin (Hu, et al. 2016). Source waters were not sampled as part of UCMR3. However, DEQ statewide screenings have detected no PFAS compounds in the Willamette River. The USEPA Fifth Unregulated Contaminant Monitoring Rule (UCMR5) now requires public water systems in the United States to monitor for 29 PFAS substances in finished drinking water from 2023 to 2025 (USEPA 2021b). This UCMR5 monitoring includes the six PFAS chemicals targeted in the proposed regulation and all WIF partners have begun or will begin this monitoring within the required timeframe.

Microplastics are very small pieces of plastic (smaller than 5 millimeters) that result from the breakdown of products in the environment. Data on microplastic occurrence is limited and highly varied due to lack of monitoring standards, and even less data are available related to the potential health hazards associated with microplastics. Current understandings suggest that the risks microplastics present in drinking water include physical particles, particularly nanoparticles, toxics, and microbial pathogens as part of biofilms, but studies disagree as to the degree of hazard these present (World Health Organization 2019). Drinking water treatment processes are considered very effective at physically removing microplastics, though more research is needed on drinking water treatment implications regarding the chemicals and biofilms associated with microplastics. Microplastics were found in every Oregon water body tested as part of the Environment Oregon Microplastics Survey (Meiffren-Swango 2021), including the Willamette River at Eugene, Corvallis, and Salem, Detroit Lake in the Santiam River, the McKenzie River at Springfield, and the North Fork Middle Willamette River at Oakridge. No data were available regarding microplastic presence in drinking water samples in Oregon. Microplastics are not currently regulated nationwide, but some states, including California, are moving forward with developing testing methods that may lead to national regulations in the future.

Pharmaceuticals and personal care products (PPCPs) encompass thousands of chemicals used for personal care or personal heath. These chemicals can enter waterways through ingestion and excretion into municipal or household sewer systems or through improper disposal. This class of contaminant is challenging to monitor, regulate, and treat due to the sheer variety of chemicals that it contains. Several pharmaceutical products were sampled by DEQ in 2016. The Yamhill River location had the highest number of unique detections (DEQ 2020). However, only two of the compounds detected in 2016 have established criteria and the measured concentrations were substantially below the criteria. Although the Yamhill River contributes approximately 10% of the flow at the Intake Facilities, there is likely low risk to water quality at the Intake Facilities from PPCPs in the Yamhill River due to the low concentrations detected.

For the contaminants of emerging concern discussed above—PFAS chemicals, microplastics, and PPCPs—it is important to monitor guidance from regulatory agencies such as OHA and USEPA and remain up to date on best practices being used by water providers. Staying apprised of the latest research on these contaminants through webinars and conferences for universities and organizations such as the American Water Works Association (AWWA) is also important for remaining up to date on the status of these contaminants. The rapidly changing availability of information and guidance regarding emerging contaminants of concern requires that the WIF Commission invest in frequent education opportunities for staff and partners on these topics to inform future monitoring and outreach efforts.

4 Risk Assessment

This section presents an overview and analysis of risks associated with various sources of pollutants to the Willamette River that have the potential to adversely impact water quality at the Intake Facilities. This section also addresses the potential effects of factors such as erosion, natural disasters, and climate change.

4.1 Potential Contamination Sources

Point sources of pollutants are identifiable locations of contaminants that can be directly traced to receiving waters. To understand potential point sources of contamination that may pose risks to the Intake Facilities, an inventory of Potential Contamination Sources (PCS) was developed and combined with analysis of travel time and toxicity to evaluate water quality risk at the Intake Facilities. The analysis was conducted using the framework shown in Figure 8. Analyses shaded green were accomplished during Phase 1. In Phase 2, a more quantitative analysis of risk was performed. The refined analyses completed in Phase 2 are shaded orange. Cells shaded grey, which include risk factors associated with duration of a contaminant plume at the Intake Facilities (i.e., how slowly or quickly a plume moves past the Intake Facilities), were removed from consideration due to the following factors:

1. Redundancy with other framework component analyses
2. System redundancy considering the WIF Partners' partnerships with other water agencies and available groundwater resources
3. Intended use of the results of this analysis (outreach and stakeholder engagement), which do not depend on plume duration
4. Incompatibility with Phase 1 risk scores, which were used where data gaps remain

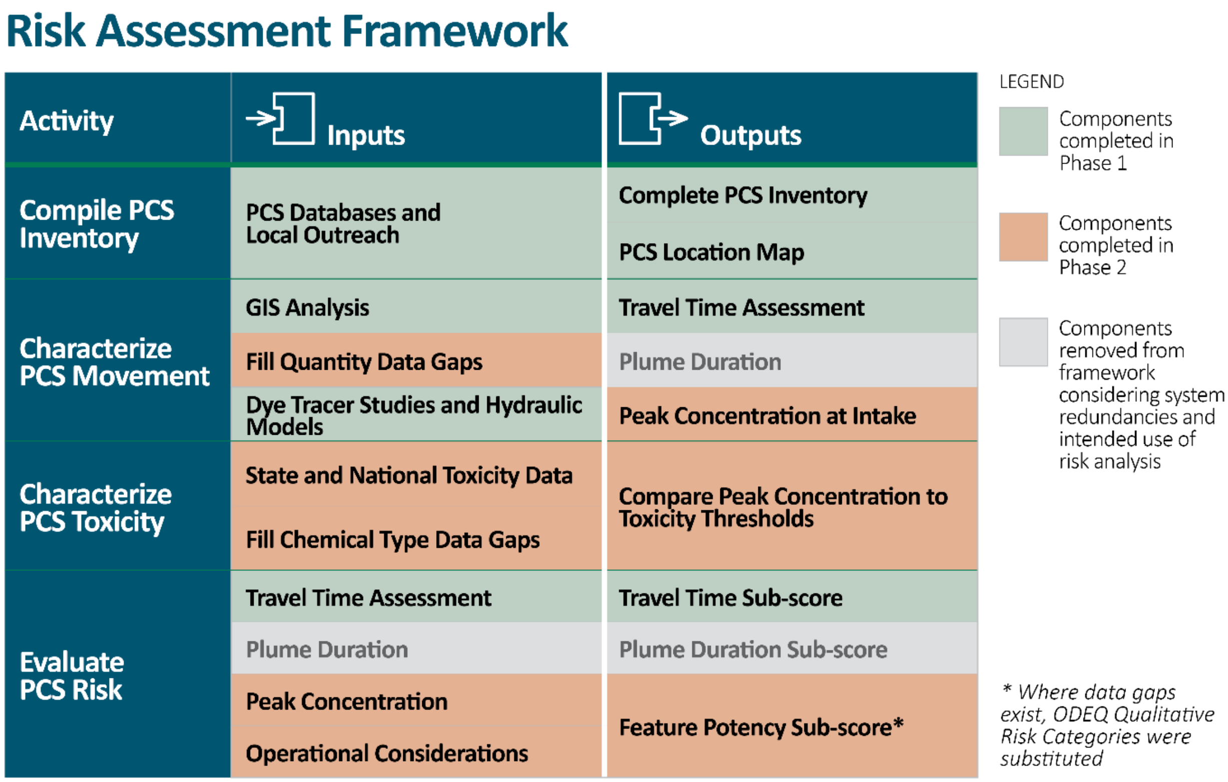

Figure 8: Overall Risk Assessment Framework

An overview of the process used to implement this framework and the key results are provided in the following sections. More detailed descriptions of the framework, methods, and intermediate and final products for Phases 1 and 2 of the risk analysis are available in Appendices 2-B and 2-C, respectively.

The final step was a vulnerability analysis applicable to both the Willamette Water Supply System (WWSS) water treatment plant (WTP) and WRWTP given their shared use of the Intake Facilities. This provided an assessment of the ability of the processes under design for the WWSS WTP and currently in use by the WRWTP to effectively treat identified contaminants of concern (COCs). An overview of the results of this analysis are provided in this section. Additional information pertaining to the vulnerability analysis is available in Appendix 2-D.

4.1.1 PCS Risk Analysis—Phase 1

In Phase 1, a geodatabase of Drinking Water Protection PCSs compiled by DEQ (DEQ 2022b) was leveraged to identify sites and facilities with elevated risks to surface water quality due to possible or historic accidental releases or point discharges (e.g., outfalls) of contaminants. A list of the risk categories for surface water considered in this risk assessment is provided in Appendix 2-B.

This initial PCS feature dataset was then spatially confined to Tier 1 hazards (within an estimated 8-hour travel time window) of the Intake Facilities based on analysis from a source water assessment conducted by DEQ for the City of Wilsonville (DEQ 2019b). A risk analysis was conducted on this refined list to assign a risk score to each PCS based on

1. an updated assessment of total travel time to the Intake Facilities; and
2. qualitative risk to surface water ranking, based on DEQ's Drinking Water Protection Potential Contamination Sources geodatabase.

Travel time from a PCS feature to the Intake Facilities was determined as the summation of applicable travel pathways including underground or overland flow, tributary flow, and mainstem flow. More information about the methodology used to determine travel times from each PCS feature to the Intake Facilities is provided in Appendix 2-B.

The travel time for each Tier 1 PCS was ranked on a scale of 1 to 4, and this score was added to the qualitative risk score, which assigned a value of 1 to 3 based on the risk classification assigned to the site in the DEQ geodatabase. With the added scores, each PCS feature can range from 1 to 7. In this scoring system, high values are associated with higher risk while low value indicate relatively lower risk. The specific criteria used to assign rankings to each site are shown in Table 2.

Table 2: Numeric Risk Sub-Scores Assigned Based on Surface Water Risk Ranking and Travel Time

Category	Numeric Sub-score Risk Value
Surface Water Risk Ranking	
High	3
Medium	2
Low	1
Travel Time (hours)	
0-10	4
10-20	3
20-40	2
40-250	1
250+	0 [1]

Note:
[1] A score of "0" was assigned during Phase 1 analysis to aid in computation of relative risk between sites. During Phase 2, sites with minimal risk were handled differently, as discussed in Section 4.1.2.

A map of the overall Phase 1 risk scores for each PCS feature in the Tier 1 region is shown in Figure 9. Sites with an overall risk score of 6 or 7 were considered high-risk. These sites were mostly located on or near the Willamette River mainstem and around the city of Newberg. Only these Phase 1 high-risk features were included in the refinement process performed during Phase 2.

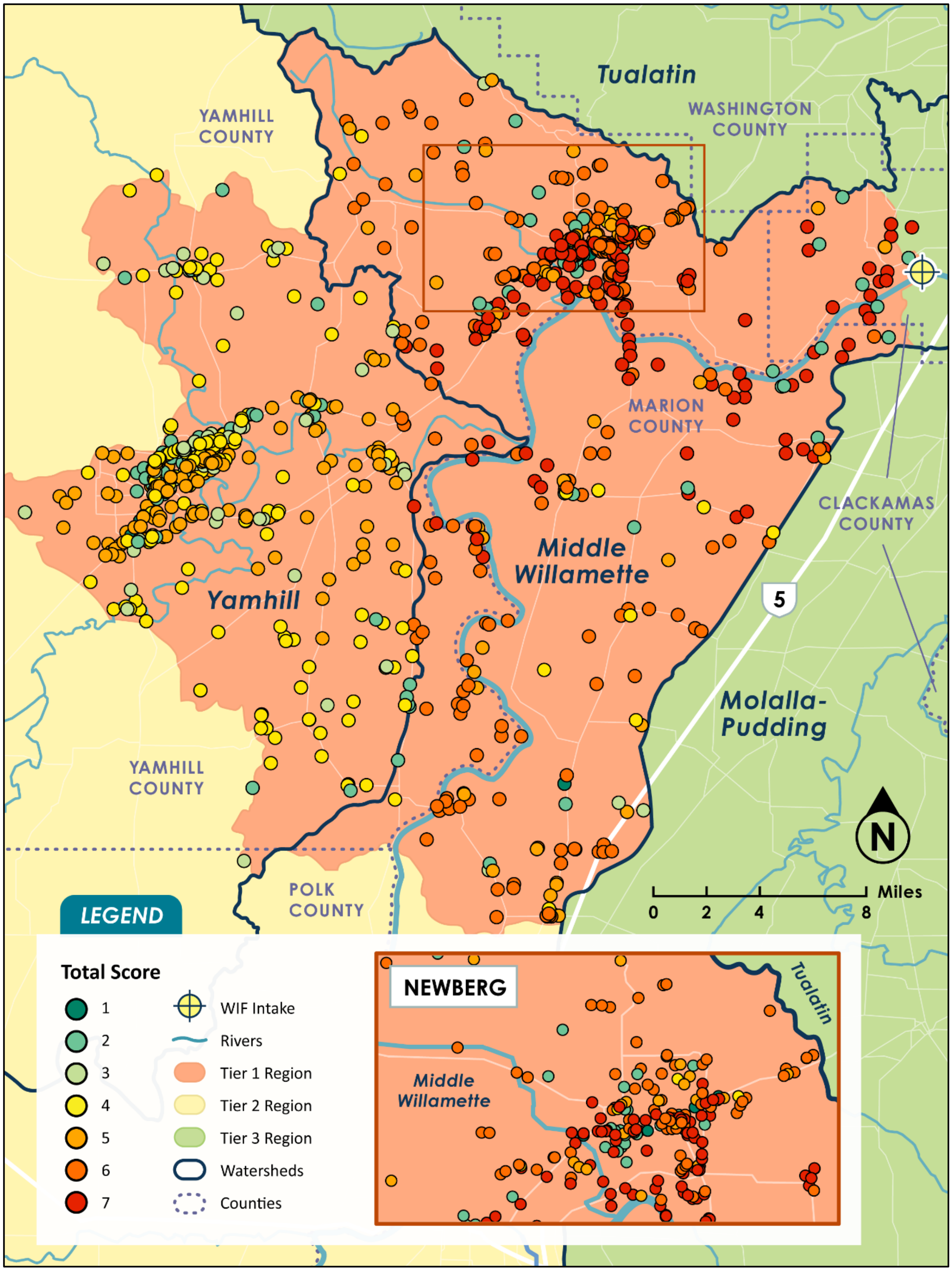

Figure 9. Relative Overall Risk to Surface Water at the Intake Facilities for PCS Features within Tier 1

4.1.2 PCS Risk Analysis—Phase 2

Phase 2 implemented a refined process to more quantitatively assess the hazards posed by high-risk PCS features and sites identified in the Phase 1 analysis, discussed in Section 4.1.1. This refined analysis applied site specific data describing COCs stored on-site and their quantities to focus the assessment of risk at the Intake Facilities.

The first step was to verify the presence of the high risk PCS features identified in Phase 1 through additional desktop screening exercises. Features found to be erroneously included or no longer presenting an acute threat to drinking water (e.g., the site is closed) were excluded from further consideration.

The next step was to assemble the information needed to both estimate peak COC concentrations at the Intake Facilities for each PCS site and evaluate the relative toxicity of this concentration. The following variables or inputs were identified as critical:

1. A list of hazardous chemicals at each PCS site
2. Information on the mechanism of release (e.g., a spill from a tanker truck at a stream crossing, a leak from an aboveground storage tank)
3. The volume of contaminant that could potentially be released in an acute[3] event
4. The threshold concentration for adverse health effects caused by each contaminant

To assemble this information, specific COCs and likely release quantities for each PCS site or feature were identified based on publicly available data from local and state agencies. The methods and considerations for filling in these key attributes varied by PCS category (e.g., Dry Cleaners, Mining Permits, CAFOs).

The threshold concentration for health effects caused by each contaminant identified at the PCS sites was obtained from state, regional, and national standards, regulations, and guidance documents. A list of published human health-based screening levels (HHSLs) for chronic exposure was compiled and used to assign the most conservative threshold value to each contaminant. COCs considered non-toxic based on their mixture composition or their tendency to volatilize or degrade were flagged to result in negligible risk in subsequent steps of the analysis.

After COC information was compiled and HHSLs were tabulated, each PCS site was classified into one of three categories:

1. <u>Update risk score:</u> There was enough data to calculate an updated toxicity score based on a comparison of likely COC concentrations at the Intake Facilities to human health limits.

[3] "Acute event" refers to chemical releases that happen at a single location and at a specific point in time (i.e., a spill) and that reach the stream network relatively rapidly. These events differ from nonpoint contaminants, which may not be traceable to a single point of origin, and from more chronic chemical exposure pathways, which occur over longer periods such as slow leaks or groundwater transport.

2. Do not update risk score: There was either not enough data to quantify or identify the COC, or these values were identified, but no HHSLs or toxicity information were found.
3. Remove from consideration: Research into the site indicated that the risk was minimal due to operational or other circumstances. For example, some dry-cleaning sites that were initially classified as high risk were found to have no historical use of industrial solvents.

For the PCS sites classified as "Update risk score," chemical transport and dispersion were then calculated to estimate downstream concentrations at the Intake Facilities resulting from a potential contaminant release event at each PCS site. Four discharge scenarios in the Willamette River were analyzed to classify risk under varied conditions. The different scenarios were assessed to identify the river condition likely to generate the highest risk to surface water quality at the Intake Facilities based on COC concentration at the Intake Facilities and COC travel time.

Finally, the estimated concentrations of individual COCs at the Intake Facilities were compared to the corresponding HHSL. Each downstream COC concentration was divided by its respective HHSL to calculate a Feature Potency Ratio (FPR)—a measure of how many times greater the contaminant concentration at the Intake Facilities is than a conservative human health toxicity threshold. The FPR was then used to assign a quantitative Feature Potency Score (FPS) for each COC at each PCS site according to the logic in Table 3. Because the peak concentration of the COC at the Intake Facilities depends on the flow scenario, FPRs and FPSs were calculated for each PCS site for each of the four flow scenarios analyzed.

Table 3: Feature Potency Score Criterion Based on Feature Potency Ratio

	Normalized Feature Potency Score (FPS)		
	High Risk (3)	**Medium Risk (2)**	**Low Risk (1)**
Feature Potency Ratio (FPR)	FPR greater than or equal to 100	FPR between 10 and 100	FPR greater than 1 and less than or equal to 10

The FPS for each COC at each PCS site supports assessment of the relative risks posed by major PCS sites near the Intake Facilities. Sites with an FPR less than 1 (indicating peak concentrations below the most conservative available HHSL) were designated “Minimal Risk” and were not assigned an FPS. These sites do not entirely lack hazards to the WIF, but rather pose considerably lower risks than other PCS sites. Minimal risk PCS sites may still present challenges to WIF stakeholders in the event of a release, and many sites contain a mix of minimal-risk and high-risk contaminants, which should be considered when assessing the overall hazard profile of each site.

Overall, the FPSs were used, where available, to replace Surface Water Risk Rankings (Table 2) for many PCS features. As both FPS and Surface Water Risk Rankings used a scale of 1 to 3, once added to the Travel Time score (from 1 to 4), the maximum overall risk score for a PCS feature remained 7. Total risk scores were calculated for each flow scenario. The total number of PCS features now identified as high risk to surface water quality across the flow scenarios analyzed are organized by PCS category and provided in Appendix 2-C. The results indicate that lower flow conditions in the Willamette River pose greater risk to the Intake Facilities due to potential for higher contaminant concentrations in a release event. However, overall risk is not eliminated during periods of high flow because contaminant travel times decrease, decreasing reaction time. Many PCS sites in the region contain a variety of hazardous features, and the refined analysis illustrates that while certain PCS features may only present significant risk during low-flow conditions, many features show a similar level risk across flow scenarios. The refined risk scores can be used to better prioritize risks to the Intake Facilities and provide an understanding of which specific risks are associated with which facilities. The results from this analysis are compiled in an annotated Excel Workbook for use in active management of potential contamination risks and releases. Each ranked PCS feature is identified by site name, site identification number, coordinates, and PCS type.

Figure 10 shows the sites with FPS of 3 (the maximum score for FPS) based on the Phase 2 analysis. Comparing this figure to Figure 9 reveals that refining the analysis to focus on sites with the potential to result in high chemical concentration at the Intake Facilities removes sites located farther away from the Intake Facilities, resulting in only a few PCS sites in the Yamhill River Subbasin, with the highest risk locations primarily in the vicinity of the mainstem Willamette River. This is because of the potential for dilution and dispersion of releases from sites located further upstream. Sites with an overall risk ranking of 7 (the maximum score for overall risk) based on the Phase 2 analysis are shown in Figure 11. This additional refinement to focus on sites with both a high feature potency score and short travel time, indicating the need for a rapid response, highlights three primary types of PCS sites:

- CAFOs near the mainstem Willamette River. CAFO sites are distributed throughout the Tier 1 area and represent the most widely distributed PCS type shown in Figure 11.
- Water Quality Permits in the Newberg area. Newberg is the population center located most immediately upstream of the Intake Facilities, and the Newberg area has a concentration of high priority sites.
- Route stream crossings and bridges. Figure 11 indicates that crossings at roadways in the Newberg area and along the mainstem Willamette River are a notable category of PCS sites. There is also a notable concentration of hazardous substance information system sites along the same routes, highlighting the importance of railway and road crossings.

The refined risk analysis shown in Figure 10 and Figure 11 informs the priority areas and watershed protection strategies discussed in Section 5.

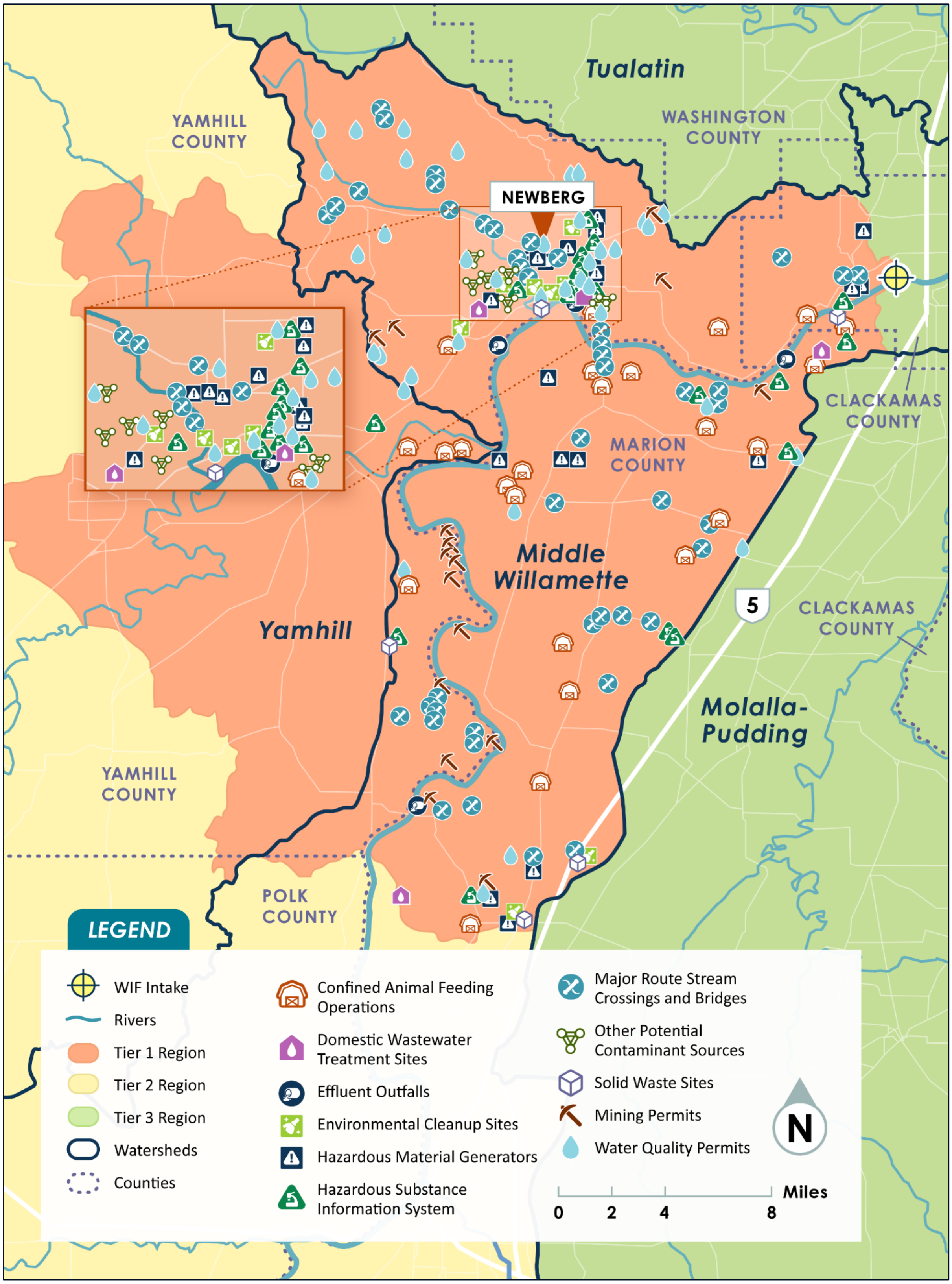

Figure 10. PCS Locations with a Feature Potency Score of 3 Based on Phase 2 Analysis

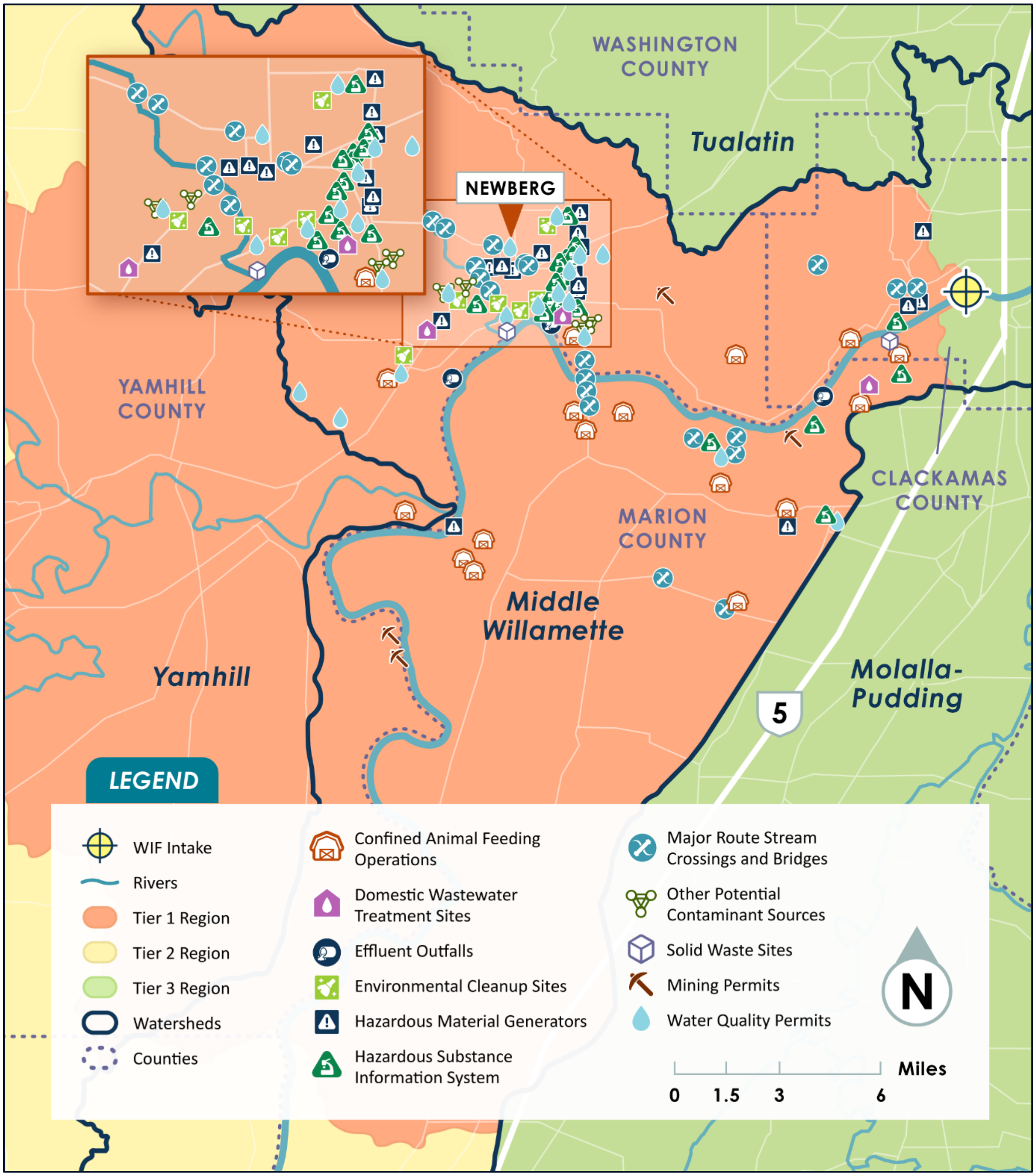

Figure 11. PCS Locations with an Overall Risk Score of 7 Based on Phase 2 Analysis

4.1.3 Additional PCSs

Through the risk analysis refinement process and insights gained from the WIF Partners, additional potential contaminant sources surfaced that were not considered in the original risk assessment framework. One such source is a Kinder Morgan pipeline that runs roughly adjacent to Interstate 5 from Portland to Eugene (Kinder Morgan 2019). The 8-inch, direct-pumping line transports gasoline and diesel fuels including conventional gas, USEPA ultra-low sulfur diesel (ULSD) biodiesel, and ethanol. The average and maximum capacity of this pipeline have not been published. The pipeline crosses the Willamette River just west of Interstate 5 near Wilsonville, approximately one-third of a mile upstream of the Intake Facilities. Although the pipeline has both automated and manual shut-off valves, which can limit the magnitude of a spill, a spill would still pose substantial risk to the Intake Facilities. In the event of an accidental release from this pipeline at or near the Willamette River crossing, a contaminant plume consisting of petroleum products would have a relatively short travel time to the Intake Facilities, and therefore minimal opportunity for dilution and dispersion. Additionally, there are many factors that would make it difficult to quickly characterize a spill event and the impact to the Intake Facilities, including the density and buoyancy of the petroleum product, the depth of the intake, and flow conditions and hydraulics in the Willamette River.

Additionally, a desktop-level assessment of railways within the Tier 1 area showed a relatively higher density of PCS sites located on rail lines compared to other areas within the Tier 1 area. This is due in part to the railways servicing the population centers of Newberg and McMinnville, but also shows a “chemical corridor” along the railways, which may have a relatively higher density of high-risk facilities. Interstate commerce laws and reporting requirements make characterizing the types and quantities of chemicals of concern being transported more difficult, and therefore it is more difficult to assess the likelihood and risk of accidental releases along railways.

Both features should be considered in source water protection planning efforts related to outreach, monitoring, and emergency planning.

4.1.4 Vulnerability to PCSs

The high-risk PCS types identified in the risk analysis were assessed in conjunction with the treatment processes for the WWSS WTP and WRWTP to demonstrate that these plants are resilient to potential contaminants and conditions, and to identify additional monitoring needs. The contaminant classes that would likely occur for each of the high-priority PCS categories identified in the risk analysis are summarized in Table 4.

Table 4: Matrix of Contaminant Classes by Potential Source of Contamination

PCS Category	Pathogens	Turbidity	Disinfection Byproduct Precursors	Synthetic Organics	Inorganics	Aesthetic Contaminants	Emerging Contaminants
Dry Cleaners				X			
Mining Permits		X		X	X	X	
Confined Animal Feeding Operations	X	X	X	X		X	X
Water Quality Permits	X	X	X	X	X	X	X
Boating Access Sites				X			
Route Crossings				X			X
Hazardous Material Generators				X	X		
AST/ HSIS				X	X		
Other Potential Contamination Sources			X	X			
Solid Waste Sites	X	X	X	X	X	X	X
Environmental Cleanup Sites				X	X		

The processes designed and under construction for the WWSS WTP builds off the City of Wilsonville WRWTP's successful treatment of the Willamette River supply for more than 20 years and uses similar treatment processes. The WWSS WTP will manage water risks through the application of multiple barriers, providing a comprehensive strategy using diverse management methods and processes to remove or reduce contaminants in drinking water. This approach recognizes that no single treatment process or technology can eliminate all contaminants in drinking water. Instead, a series of treatment barriers are used to provide multiple, redundant layers of protection against each type of potential contaminant. Table 5 provides a summary of the classes of constituents addressed by each major process for the WWSS WTP.

Table 5: Treatment Barriers Provided by WWSS WTP (WWSS Commission)

Constituent	Ballasted Flocculation	Intermediate Ozonation	Biological Filtration	Ultraviolet Disinfection	Chlorine Disinfection
Turbidity/Particles	X		X		
Pathogens	X[1]	X	X	X	X
Taste and Odors		X	X		
Trace Organics		X	X		
Emerging Contaminants[2]		X	X	X	

Notes:
[1] Coagulation/flocculation does provide some pathogen removal per USEPA (2010).
[2] The Emerging Contaminants considered here are PFAS and cyanotoxins

Overall, the vulnerability assessment concluded that the processes for the WWSS WTP are appropriate and robust, ensuring high quality drinking water to customers in the region. Water quality sampling at the WRWTP (City of Wilsonville 2023) suggests that both the current source water quality and the technology under construction for WWSS WTP will allow the plant to effectively treat pathogens, remove turbidity, and manage disinfection byproducts (DBPs) well below regulatory levels. Inorganic contaminants such as nitrate, metals, and materials that cause taste or odor in water are also unlikely to pose a major risk to WWSS WTP based on previous water quality sampling at the WRWTP (City of Wilsonville 2023). Additionally, PFAS and cyanotoxins do not currently pose a risk to water quality at the Intake Facilities and subsequent WTPs. However, the risk from these contaminants of emerging concern should continue to be evaluated into the future.

Ultimately, as with many drinking water supplies, the risk of contamination from organic chemicals, particularly petroleum products, are the primary vulnerabilities for the plants. Although synthetic organic chemicals have not previously been detected at the WRWTP (Tualatin Valley Water District and City of Hillsboro 2019) and the treatment processes employed at both the WWSS WTP and WRWTP are capable of removing trace levels of organics, there are significant potential sources of these pollutants upstream of the Intake Facilities. This risk is manageable through source water protection measures and emergency response planning.

More detailed findings from the vulnerability assessment are available in Appendix 2-D. Recommendations for source water monitoring based on this vulnerability assessment are discussed further in Section 6.

4.2 Agricultural and Forest Land

As discussed in Section 2.1.2, agricultural and forested land comprise the majority of the area in the Willamette Valley. Similarly, these two land uses make up the vast majority of the area in both the Tier 1 and Tier 2 regions based on statewide land use data (Oregon Geographic

Information Council 2022). As shown in Table 6, Tier 1 is primarily agricultural, while Tier 2 is primarily forested. The spatial distribution of these land uses is shown in Figure 12.

Table 6: Land Use Percent Composition of Tier 1 and Tier 2 Regions

Land Use Category	Tier 1	Tier 2
Forest	11.1%	58.7%
Agricultural	76.8%	29.9%
Industrial	1.0%	0.7%
Residential	2.7%	1.9%
Commercial / Institutional	2.6%	2.7%
Rural / Other	5.8%	6.2%

Agricultural and forested land are potential nonpoint sources of many contaminants of concern, including bacteria, nutrients and other factors that influence algal blooms, and pesticides.

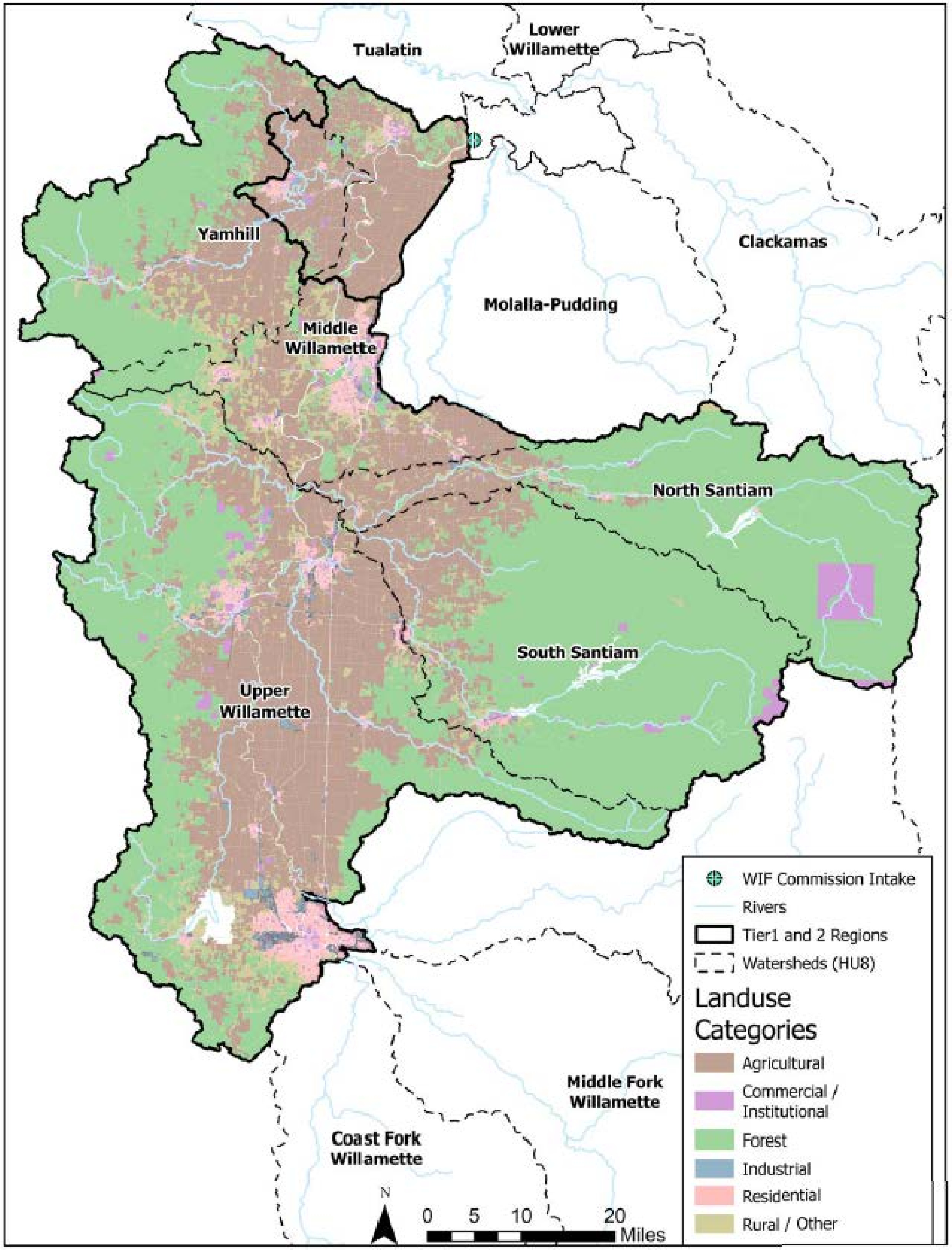

Figure 12: Land Use Distribution in Tier 1 and Tier 2 Regions

4.3 Landslides and Erosion

Landslides and soils vulnerable to erosion can pose a threat to water quality through the transport of excess sediment and pollutants associated with sediments. Many areas of the Willamette River Basin are susceptible to landslides due to non-cohesive soils, steep slopes, and regional hydrology, including periods of intense rainfall, freeze-thaw cycles, and rapid snowmelt. With a few exceptions in the Tier 2 region, the presence of scarps and scarp flanks (very steep slopes and undisturbed material around the slope, respectively), is limited to areas in the upper reaches of the Willamette River Basin or downstream of the Intake Facilities. Within the Tier 1 area, there is limited landslide hazard indication, though there are some localized areas of landslide deposits and historical landslides as well as small scarps in the vicinity of the Intake Facilities. Because most landslide activity takes place in the upper reaches of the Willamette River watershed, along tributaries to the Willamette River mainstem, or downstream of the Intake Facilities, the risks to water quality at the Intake Facilities associated with excess sediment due to landslides are limited. Additionally, the presence of the WVP reservoirs downstream of areas with elevated landslide activity may help to mitigate the effects of these landslides due to sedimentation.

Soil susceptibility to erosion is influenced by many factors, including soil type and erodibility, slope, the length of the slope, vegetative cover and erosion control practices, and rainfall intensity. Figure 13 maps soil erodibility factors, known as “K-values” within the Tier 1 region. K-values are depicted based on a scale from cool (low K-values) to warm (high K-values) colors. The higher the K-value, the more susceptible the soil is to erosion; K-values of 0.35 to 0.4 and higher are considered highly erodible soils. Large portions of the Tier 1 area consist of highly erodible soils, especially along the Willamette River mainstem where agricultural lands predominate. Therefore, other factors contributing to soil erosion, such as vegetative or other cover, as well as consistent implementation of agricultural and construction best management practices, will become important factors in mitigating sediment in runoff.

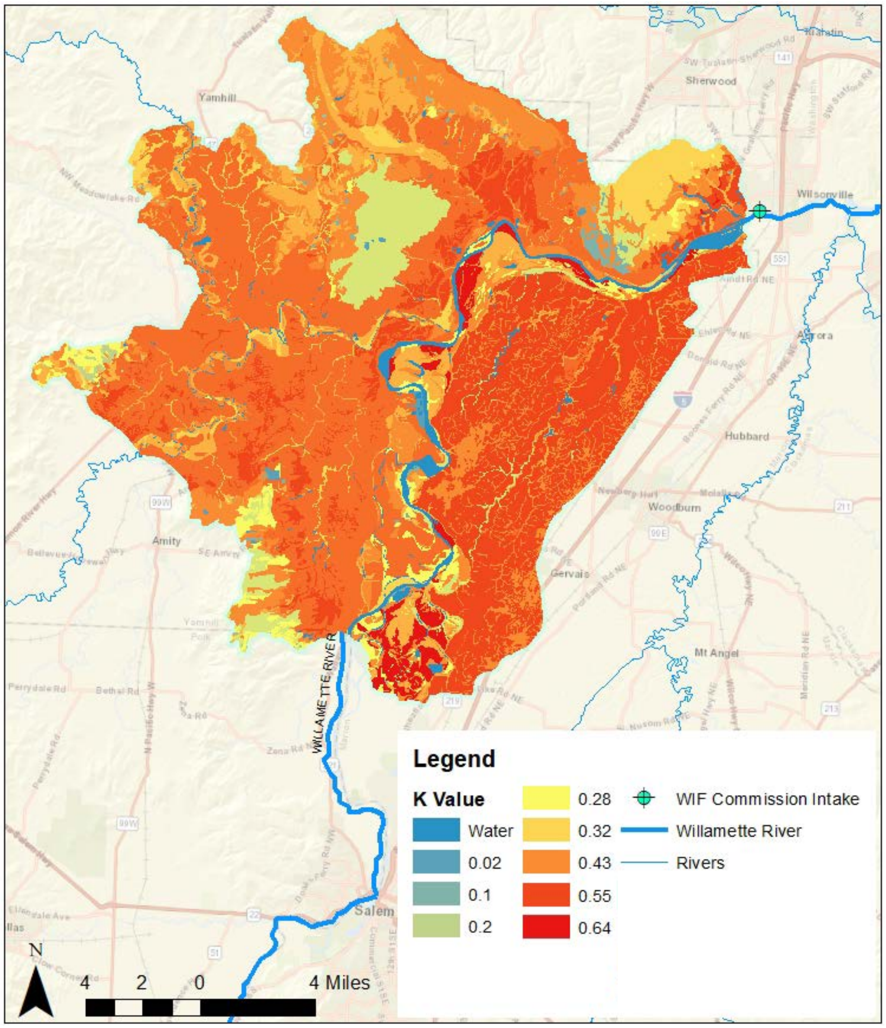

Figure 13. Soil Erodibility (K-Value) of Sediments within Tier 1 Region

4.4 Extreme Weather Events

Extreme weather events are known to occur in the Willamette River Basin. Typical extreme events include heavy rainfall, flooding, snowmelt, drought, extreme temperatures, and wildfires (Stanford, et al. 2014). The designs of WWSS WTP and WRWTP are sufficiently robust that source water quality changes from extreme events would effectively be managed by the WTPs. However, this topic requires continual consideration as the frequency and severity of extreme weather events will be exacerbated by climate change, as discussed in Section 4.5.

Heavy precipitation events can result in water quality challenges through the mobilization and disturbance of contaminants in the watershed from surface erosion, stormwater discharges, and sewer overflows. These events typically result in increases in raw water turbidity and pathogen loads. Floods can also damage, inundate, or overwhelm upstream infrastructure that may result in the transport of chemicals into source water supplies.

High air temperatures can increase water temperatures and result in multiple issues in the source water. The rate of formation of DBPs is dependent on temperature. High temperature extremes can increase the speed at which DBPs are formed within the treatment plant and throughout the distribution system. Other heat-associated challenges include increased risk of algae blooms, taste and odor changes, and increased proliferation of bacteria and pathogens in the source water.

Wildfires occur every summer in Oregon, and risks to surface water can persist long after the fires are extinguished. Threats include increased susceptibility to flooding and erosion caused by loss of vegetation, increased risk of landslides and debris flows, and decreased reservoir capacity from sedimentation. Water quality may be degraded by elevated risk of harmful algal blooms due to elevated nutrient loading and degraded water quality at intakes, including increased turbidity, nutrients, organic matter, metals, chemicals from fire suppressants, and byproducts from fires in developed areas (e.g., due to burning of building materials). Additionally, runoff from burn scars can result in volatile organic compounds, such as benzene, being mobilized into drinking water sources (Oregon Health Authority 2022b). Notably, the east half of the Willamette River Basin has much higher fire risk than the west, as shown in Figure 14. Fires in these areas may impact water quality in tributaries to the Willamette River in the Tier 2 and Tier 3 regions. Fire risk within the Tier 1 region is relatively low.

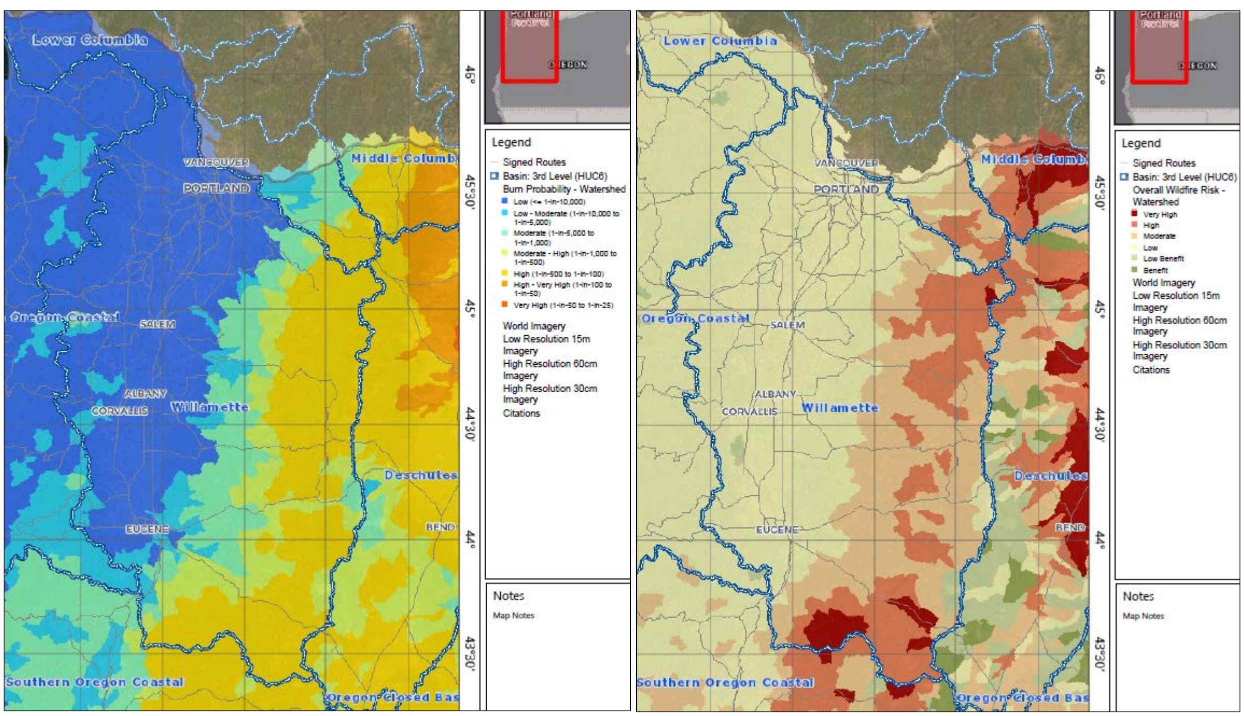

Figure 14: Burn Probability (left) and Overall Fire Risk (right) by Watershed in the Willamette River Basin (Oregon Explorer 2022)

4.5 Climate Change

Climate change is a threat multiplier will likely result in increasingly challenging conditions in the Willamette River. While the specific changes in the Willamette River Basin are uncertain, there are consistent trends across multiple studies (warmer temperatures, less snowfall, more extreme precipitation, higher wildfire risk) that are expected to impact water quality in the Willamette River.

Due to increased air temperatures, more precipitation is expected to fall as rain, resulting in less accumulation of snowpack and earlier snowmelt (Tullos, Walter and Vache 2020). Because the Willamette Basin is a highly managed system, there is potential for the reservoirs to be managed to mitigate the resulting reduced summer streamflow due to climate change. Tullos et. al found that operators could begin refilling reservoirs earlier in the season to help offset the predicted reduction of snowmelt under severe climate change scenarios (Tullos, Walter and Vache 2020). Overall, the study found that operational objectives (storage, flood control, and target streamflow) of the WVP will not be dramatically compromised by climate change.

Climate change impacts on temperature could mean a significant increase in Willamette River water temperatures. Increases in Willamette River water temperature could be as high as 4 °C on average under an extreme climate scenario (Chang, Watson and Strecker 2018). As with streamflow, there is potential for the reservoirs to be managed to mitigate the impacts of climate change on water temperature in the Willamette River, at least to some extent, by releasing cooler water from the bottom of the reservoirs during key periods (Section 3.2.2). However, because of the long travel times from the reservoirs to the Intake Facilities, the mitigating effect of cold-water releases would be muted, and the impact of air temperature increases due to climate change on Willamette River water temperatures will remain a concern.

Climate change is anticipated to exacerbate the prevalence of algal blooms in reservoirs, including the reservoirs in the Willamette River Basin, which are already experiencing blooms as discussed in Section 3.3.4. Cyanobacteria grow more quickly in warm water, which can lead to more cyanotoxins releases. Additionally, warmer air temperatures can result in stronger stratification of reservoirs, which limits mixing and encourages algae growth (USEPA 2022). While harmful algal blooms have been noted primarily in WVP reservoirs to date, it is possible that blooms could form in the Newberg pool in the future. Though ozonation and granular activated carbon treatments used by the WRWTP and future WWSS WTP are effective at removing cyanotoxins (USEPA 2021b), increased algal blooms could increase the costs of water treatment and become a greater concern for public perception of drinking water quality.

Additionally, trends in drought events and increased temperatures are expected to increase the severity and frequency of wildfires in Oregon. Wildfire dynamics are affected by many factors, including climate conditions, land management, human activity, ecosystem health, and expansion of non-native invasive grasses. From 1984 through 2018, the annual area burned in Oregon increased considerably. Over the next 50 to 100 years, total area burned and fire frequency are projected to continue to increase due to warmer and drier summer conditions. The result could be a two- to nine-times increase in land area burned by forest wildfires (Oregon

State University 2012). There are many efforts underway to reduce the risk from wildfires in the Willamette River Basin.

Due to the potential threats discussed above, it is important to stay apprised of the latest research on climate change impacts in the Willamette River Basin and Oregon as a whole. This topic of climate risk mitigation and management is frequently discussed in webinars and conferences by local universities and organizations. The rapidly changing availability of information and guidance regarding climate concerns requires that the WIF Commission invest in frequent education opportunities for staff and partners on these topics to inform future monitoring, watershed protection, and outreach efforts.

5 Watershed Protection

This section focuses on high priority areas for watershed protection and types of watershed protection projects, drawing on the results the analyses discussed in Sections 2–4.

5.1 Priority Areas for Protection

This section identifies areas within the Tier 1 region for prioritizing watershed protection efforts. In identifying priority areas, key considerations were proximity to the Intake Facilities, density of PCS sites, and potential partnerships for identifying, funding, and executing these efforts.

5.1.1 Route Crossings

The high concentration of relatively high-risk PCS sites along railways and major roads, both within the Newberg area and further downstream on the mainstem Willamette River, indicates the importance of these locations as potential sites of spills and accidental releases. Interstate commerce laws and reporting requirements make characterizing the types and quantities of chemicals of concern being transported more difficult, and therefore it is equally difficult to assess the likelihood and risk of accidental releases along railways. However, this highlights the importance of working with local and regional partners to develop an emergency response plan to quickly identify the necessary information about the release and implement a coordinated response. Communication with the Oregon Department of Transportation (ODOT) regarding emergency response protocols for spills and crashes near bridges is recommended. ODOT is also an agent for the Federal Railroad Administration and inspects track, railroad cars and equipment, hazardous materials, and operating practices. Finally, ODOT has a database of crash statistics that could be analyzed to identify high crash areas near stream crossings. Additional discussion about emergency response coordination is included in Section 5.2.1.

5.1.2 CAFOs

As highlighted in Figure 11, CAFOs are a significant category of high-risk PCS sites within the Tier 1 area. CAFOs are regulated in collaboration between DEQ and ODA. There is an existing program through the Natural Resources Conservation Service (NRCS) (United States Department of Agriculture [USDA] 2023b) providing financial assistance for implementing best management programs at Animal Feeding Operations (AFOs, which include CAFOs), including in the Tier 1 area. One high priority for preserving water quality in the Tier 1 area is collaborating with the Clackamas, Marion, and Yamhill SWCDs, which include portions of the Tier 1 area and supporting existing programs focused at reducing the water quality impacts of CAFOs. Coordination with ODA to maintain awareness of relevant regulation and ensure communication with stakeholders is also recommended.

5.1.3 Yamhill Subbasin

The Phase 1 risk analysis identified a significant number of PCSs in the Yamhill River Subbasin. While the refined Phase 2 risk analysis indicated that the PCS sites in the Yamhill River Subbasin are not high priority for emergency response, it is still an important area for reduction of nonpoint source contamination and overall water quality in the Willamette River downstream of the confluence with the Yamhill River. The Yamhill River is the major tributary most immediately upstream of the Intake Facilities, and as discussed in Section 3.3.1, had exceedances of criteria for bacteria and no definitive trend towards improvement (ODA 2017). Developing partnerships with groups such as the Yamhill Soil and Water Conservation District and Greater Yamhill Watershed Council to support and expand existing programs is recommended. Such programs include supporting erosion control practices, improving riparian shading and streambank protection along properties with a stream, and promoting wildfire prevention activities and awareness.

5.1.4 Tier 1 Areas at Greater Risk for Erosion

A large portion of the Tier 1 areas has a soil erodibility factor (K-factor) greater than 0.4, indicating substantial potential for erosion (Figure 12). The latest City of Wilsonville Source Water Assessment (DEQ 2019b) likewise found substantial erosion potential in the immediate upstream vicinity of the Intake Facilities location. The areas immediately upstream of the Intake Facilities are heavily agricultural. While ODA is responsible for plan development to control pollution from agricultural activities, working with the Clackamas, Marion, and Yamhill SWCDs to support these programs is recommended. The extent of the county boundaries corresponding to these SWCDs are shown in Figure 15. A more detailed analysis using the Revised Universal Soil Loss Equation (RUSLE), a USDA tool that considers slope length, steepness, land cover and agricultural best management practices (BMPs), could identify properties with particular erosion risk.

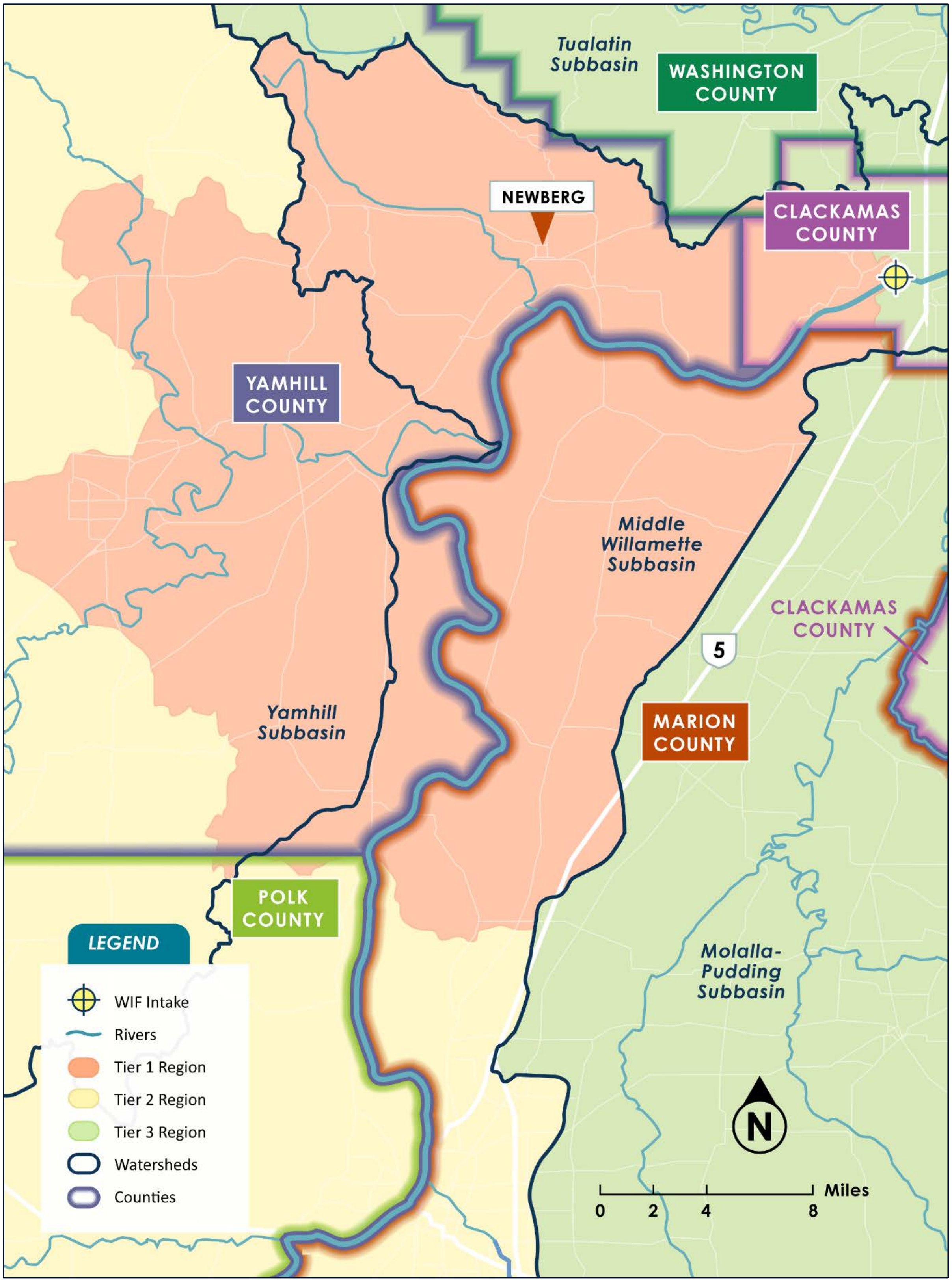

Figure 15: County and Subbasin Boundaries within Tier 1 Region

5.2 Watershed Protection Strategies

This section outlines watershed protection strategies focused on specific types of risks to water quality, including mitigation of point-source PCS risks, BMPs for agricultural land to protect and improve water quality, and forest land management activities.

5.2.1 Emergency Response Plan

Quickly identifying and obtaining information regarding spills of hazardous materials within the Tier 1 area is an important aspect of source water protection. For example, a petroleum spill may require temporarily shutting off withdrawals at the Intake Facilities location as an enhanced precaution. Section 6 discusses monitoring for identifying petroleum at the Intake Facilities and upstream. Having an emergency response plan will also be important in the event of a wildfire in the vicinity of the Intake Facilities. Development of an emergency response plan is also recommended and should include the following elements:

WIF COMMISSION STRATEGIC FRAMEWORK, EFFECTIVE WIF OPERATIONS GOAL #1:

"Develop and maintain Emergency Response Plans and guide shared ownership with priority stakeholders."

- Outreach to emergency response partners to develop notification and response protocols regarding the pipeline
- Additional tabletop emergency response exercises to identify appropriate actions given hypothetical spills at bridge crossings of major roads and heavy rail, pipeline leaks, or wildfires
- Development of an incident management team and standard operating procedures for spills and wildfire events

The Emergency Response Plan will facilitate efficient response coordination, information sharing, and identification of needed resources and management actions.

5.2.2 Agricultural Land

The Willamette Valley is heavily agricultural, including large sections of the watershed immediately adjacent to the mainstem Willamette River. As discussed in Section 4.2, the Tier 1 area is 77% agricultural based on statewide land use data (Oregon Geographic Information Council 2022). Therefore, prioritizing BMPs on agricultural land is important for an overall watershed protection program.

ODA is required under the Agricultural Water Quality Management Act of 1993 to prevent and control water pollution from agricultural activities. ODA developed Water Quality Management Area Plans (Area Plans) throughout the state, including for the Lower Willamette, Middle Willamette, and Yamhill River areas, which cover portions of the Tier 1 area. The plans include requirements for maintaining vegetation, avoiding discharge of excess soil, manure, fertilizer or other wastes, and other erosion control and runoff prevention practices.

In addition to programs required under the Area Plans, there are existing incentive programs administered by ODA and SWCDs, including the following:

- The NRCS Environmental Quality Incentives Program (EQIP), which provides funding for voluntary conservation activities on farmland including erosion control, no-till planting, nutrient management, and cover cropping. As mentioned in Section 5.1.2, there is a specific EQIP program focused on CAFOs in the Willamette Basin, including Yamhill, Clackamas, and Marion Counties (within the Tier 1 area).
- The NRCS Regional Conservation Partnership Program (RCPP), which provides funding for conservation activities by farmers, ranchers, and forest landowners. Projects in eight critical areas are funded under the RCPP Critical Conservation Areas program and receive 50% of the total RCPP budget. One of these areas is known as Western Waters and includes the Willamette River Basin.

Serving as a regional leader and collaborator in source water protection and assisting SWCDs and watershed councils in connecting landowners to funding opportunities is a high priority for the WIF Commission. Additionally, the WIF Commission should track changes to regulations and permits associated with agricultural land in the Tier 1 area.

5.2.3 Septic System Management

Septic systems are potential sources of nutrients and bacteria to streams in the Willamette River Basin. Over time, poorly maintained septic systems have the potential to increase the risk from algal blooms and to degrade water quality. Counties have existing programs to identify and repair failing septic systems. For example, Clackamas County has a Septic and On-site Wastewater Program that regulates the installation, repair, and maintenance of septic systems. Working with the counties in the Tier 1 area, in particular Clackamas, Yamhill, and Marion Counties, to identify septic system locations and support the programs to repair failing septic systems is recommended.

5.2.4 Forest Land

While the Tier 1 area is largely agricultural, protection activities on forest land are also important. As discussed in Section 4.2, forest land makes up 11% of the Tier 1 area. Furthermore, the Tier 2 area is 59% forest land. The Western portion of the Yamhill River Subbasin, for example, is largely forested. Forest management activities can affect water quality in a variety of ways, including harvesting techniques and chemical applications.

Wildfires present specific water quality challenges. These include elevated turbidity, which can increase the likelihood of producing DBPs, elevated nutrient loads resulting in higher likelihood of algae blooms, and volatile organic carbon from water runoff from burned areas (Oregon Health Authority 2022b). Additionally, while the class of firefighting foam widely used for wildfires and structural fires generally do not contain PFAS chemicals, PFAS-containing foam may be used if there is liquid fuel in the structure or wildfire region-such as gas stations, or oil cans (New Hampshire Department of Environmental Services 2023). Therefore, partnerships with organizations promoting healthy forest management, including SWCDs, Watershed Councils, the Oregon Small Woodlands Association, and Oregon State University Extension Service are recommended. Such partnerships will also be useful for emergency response in the event of a wildfire (Section 5.2.1).

5.2.5 Public Outreach and Education

Supporting existing education programs both monetarily and with staff time is recommended. This could include education programs targeted for landowners, the general public, or K-12 students. Initial educational resources for the general public and students about the basic tenants of source water protection could be made available on the WIF Commission website. As the WIF Commission implements the Strategic Communication and Outreach Plan over time, additional opportunities for focused outreach and education will be identified. For example, many watershed councils and SWCDs have existing education programs that the WIF Commission could support. The Strategic Communication and Outreach Plan is summarized in Section 7 and available in full in Appendix 1-B. The WIF Commission should also invest in education of staff to equip them to engage in future public outreach as needed, especially where subject matter is rapidly evolving such as for contaminants of emerging concern and climate change.

5.2.6 Key Partnerships

Key partnerships for short-term water protection efforts are identified below:

- County emergency management departments for Clackamas, Yamhill, and Marion Counties (these counties make up the Tier 1 area, except for very small portions of Washington and Polk Counties)
- County Sheriff offices
- Fire and Rescue districts
- Oregon Office of Emergency Management
- Oregon DEQ
- ODOT
- Confederated Tribes of Grand Ronde
- Confederated Tribes of Siletz
- Confederated Tribes of Warm Springs
- Yamhill SWCD

WIF COMMISSION STRATEGIC FRAMEWORK, WATER QUALITY PROTECTION GOAL #3:

“Promote information exchanges amongst stakeholders, tracking relevant data on emerging issues such as contaminants, natural hazards, and regulatory changes.”

- Other SWCDs, particularly the Clackamas and Marion SWCDs, which include portions of the Tier 1 area
- ODA
- Oregon Association of Nurseries
- Oregon Hazelnut Association
- Oregon Department of Forestry
- Commercial Timber (Stimson Lumber, Weyerhaeuser, Hampton Lumber)
- Oregon Small Woodlands Association
- Oregon State University Extension Service, including the Agriculture and Natural Resources Extension, Forestry and Natural Resources Program, 4-H Youth Development Program, and Fire Program
- Greater Yamhill Watershed Council
- Other Watershed Councils
    - There is not a watershed council covering the Tier 1 area outside the Greater Yamhill Watershed Council. However, maintaining relationships with the Pudding River Watershed Council and Molalla River Watch (for tributaries entering the mainstem just downstream of the Intake Facilities) and watershed councils in the Salem-Keizer area is recommended for connecting to overall Willamette River Basin watershed protection programs.

6 Watershed Monitoring

This section presents an overview of the proposed watershed monitoring plan to understand and proactively manage source water quality over time. The monitoring plan includes a summary of objectives, the parameters of interest, and sampling locations.

6.1 Monitoring Objectives

The objectives of the watershed monitoring plan include the following:

- Serve as one component of the WIF Commission's multi-barrier approach to delivering safe drinking water.
- Support ongoing partnerships with watershed stakeholders to promote awareness and stewardship of a healthy watershed through targeted actions.
- Assess source water quality to monitor water quality trends.
- Allocate resources cost-effectively by prioritizing and phasing recommended monitoring strategies.

WIF COMMISSION STRATEGIC FRAMEWORK, WATER QUALITY PROTECTION GOAL #4:

"Invest in monitoring technologies and communication networks with upstream and downstream agencies and private partners to detect and provide early incident notifications."

6.2 Parameters of Interest

This monitoring plan focuses on parameters that will provide the most value for WTP operations in the near and long-term. The suggested parameters included in the monitoring plan are listed in Table 7. The parameters are separated by "drivers" to indicate the motivation for their inclusion as well as their collection method (i.e., online, in-situ versus grab samples). Discussion of the respective collection methods is addressed in Section 6.4. Baseline water quality parameters are listed to establish the foundation of a source water monitoring program. Additional parameters are included to monitor associated risks to the watershed and WTPs, including algae and cyanobacteria, petroleum spills, and pollution associated with organic and inorganic compounds. Further discussion on these parameters of interest can be found in Appendix 2-E**.**

Table 7: Monitoring Parameters of Interest

Driver	Parameter	Collection Method
Baseline water quality	Temperature	Online, in-situ
	Conductivity	
	DO	
	pH	
	Turbidity	
Algae and cyanobacteria risk	Chlorophyll-a	
	Phycocyanin	
Petroleum spill risk	Hydrocarbon	
Organics, DBP formation risk	UV254	
Algae and cyanobacteria risk	Algal enumerations	Grab samples
	Cyanotoxins	
Fecal contamination risk (e.g., CAFOs, septic systems)	*E. coli*	
Agricultural runoff	Total nitrogen	
	Nitrate	
	Total phosphorus	
	Phosphate	
	Pesticides	
Emerging contaminant	PFAS	

6.3 Sampling Locations and Frequency

Based on the objectives and key risks outlined above, the following locations are recommended for monitoring: 1) the Intake Facilities, and 2) an upstream location in the Willamette River at Newberg. The monitoring plan can be implemented in a phased approach. For the first phase, establishing monitoring equipment at the intake should be prioritized to complement real-time water treatment plant operations and decisions. Several logistical options exist for monitoring source water quality directly at the intake, as discussed in Section 6.4. A secondary monitoring location upstream, potentially near the existing USGS gage at Newberg (Gage 14197900), could be a meaningful addition to help characterize watershed scale changes and trends, as well as providing advance notification of upstream water quality conditions. Further discussion around the recommended monitoring plan is included in Section 6.4**.** The recommended parameters, sampling location, and sampling frequency are listed in Table 8. A visual summary of this information, combined with the drivers and recommended collection methods from Table 7, is provided in Figure 16.

Table 8: Monitoring Locations of Interest

Parameter	Location	Frequency
Temperature	Intake, upstream	Continuous, 15 minute intervals
Conductivity	Intake, upstream	
DO	Intake, upstream	
pH	Intake, upstream	
Turbidity	Intake, upstream	
Chlorophyll-a	Intake, upstream	
Phycocyanin	Intake, upstream	
Hydrocarbon	Intake	
UV254	Intake	
Algal enumerations	Intake	Weekly from May to October 31
Cyanotoxins	Intake	Every two weeks from May to October 31
PFAS	Intake, upstream	Baseline sampling, monthly for one year and following storm events
Pesticides	Intake, upstream	
E. coli	Intake, upstream	
Total nitrogen	Intake, upstream	
Nitrate	Intake, upstream	
Total phosphorus	Intake, upstream	
Phosphate	Intake, upstream	

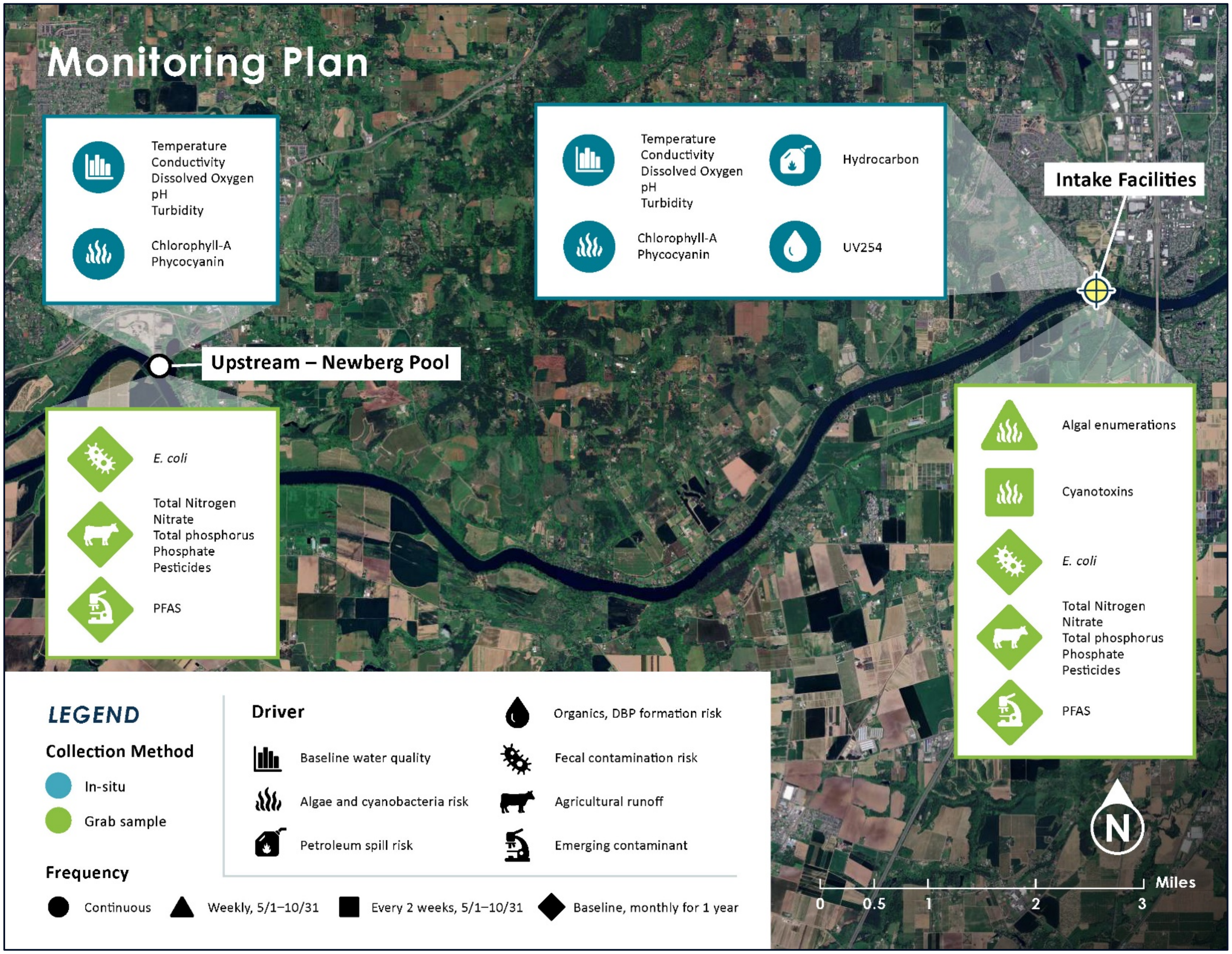

Figure 16: Schematic of Recommended Monitoring Locations, Parameters, Method, Frequency, and Drivers

6.4 Technology and Methods

The recommendations for the monitoring outlined in Table 8 are separated by online/in-situ and grab sample methods, discussed as follows.

6.4.1 Online/In-situ at the Intake

It is recommended that the online/in-situ parameters of interest listed in Table 8 are monitored at the intake location. Online sampling allows for continuous, automatic sampling to assist with real-time decision making. The recommendations from Table 8 were evaluated against the existing infrastructure at the WRWTP Raw Water Vault and the planned infrastructure at the WWSS Raw Water Facilities to determine if existing assets could be leveraged first. Gaps that exist include dissolved oxygen, chlorophyll-a, and phycocyanin monitoring, as noted in Table 9.

Table 9: Intake Monitoring Gap Analysis

Parameter	Included in WWSS RWF Design	Included in Existing WRWTP RW Vault	Gap
Temperature	Yes (Endress+Hauser)	Yes	No
Conductivity	Yes (Endress+Hauser)	N/A	No
DO	N/A	N/A	Yes, Gap
pH	Yes (Endress+Hauser)	Yes (Emerson Rosemount)	No
Turbidity	Yes (Endress+Hauser)	Yes (Hach Surface Scatter and Turbidimeter)	No
Chlorophyll-a	N/A	N/A	Yes, Gap
Phycocyanin	N/A	N/A	Yes, Gap
Hydrocarbon	N/A	Yes (Turner Designs TD-4100XD)	No
UV254	Yes (RealTech M3000)	N/A	No

It should be noted that the parameters identified that are not accounted for in either the WWSS or WRWTP (DO, chlorophyll-a, phycocyanin) sampling are not required for regulatory compliance. However, these parameters can often serve as early indicators of source water change that could cause treatment plant upsets. Spikes in concentration of dissolved or suspended organic matter can lead to reduced DO levels, which can be indicative of increased municipal, agricultural, or industrial discharges or spills. In contrast, diurnal variations in DO that include unusually high DO levels can indicate increased algal activity and can serve as an early warning for harmful algal blooms. Low DO levels caused by excessive organic wastes or die-off of algae blooms can result in anoxic conditions that could result in fish kills. Chlorophyll-a and phycocyanin are typically surrogate parameters that are often included as part of a monitoring approach to trigger more detailed analysis using microscopy or cyanotoxin sampling.

If additional instrumentation is desired, online/continuous monitoring could be achieved through installing in-situ probes at a fixed elevation and location or on a monitoring buoy. The WWSS Raw Water Facilities building design includes space for additional monitoring equipment, feed lines, and a raw water quality panel for source water monitoring at the intake. Continuous monitoring is preferred to occur closer to the intake either using new sample lines or a monitoring buoy in order to better characterize in-situ source water conditions. In either case, the equipment can be connected to plant Supervisory Control and Data Acquisition (SCADA) system for data management and analysis if preferred.

The instruments for monitoring the parameters of interest are available from vendors such as YSI/Xylem, Hach, and In-Situ Systems. Depending on the vendor selected, monitoring probes can be grouped together and placed in multi-parameter sondes, or probes can remain separate in the river. If preferred, sample feed lines can feed flow cells and flow-through units for sampling. However, in-situ sensors are typically preferred for more consistent representation of the raw water sample. Table 10 describes example instruments recommended for monitoring the parameters of interest, comparing different instrument types from YSI, Hach, and In-Situ Systems. Each vendor package accommodates for future modularity, allowing instruments to be added or removed over time as needs evolve.

For data management, each vendor supplied example includes a SCADA interface system, allowing for the monitoring equipment at the intake to be tied into WTP SCADA for easier operational tracking. If a SCADA connection is not desired, the monitoring equipment can remotely connect to a telemetry unit and data can be stored in a vendor-managed cloud-based data management platform. A vendor data management platform could additionally host WTP SCADA and laboratory data if integration of all data is desired in a hosted system.

One additional option is coordinating with USGS to deploy and manage monitoring equipment at the intake. This is discussed further in Section 6.7.1.

Table 10: Example Monitoring Equipment

<table>
<tr><th></th><th>Parameter</th><th>Temperature</th><th>Conductivity</th><th>Dissolved Oxygen</th><th>pH</th><th>Turbidity</th><th>Chlorophyll-a</th><th>Phycocyanin</th><th>Hydrocarbon</th><th>UV254</th><th>SCADA Interface System</th></tr>
<tr><td rowspan="3">YSI</td><td>Monitoring instrument</td><td colspan="7">Multiparameter Sonde</td><td colspan="2">Individual Probe</td><td>N/A</td></tr>
<tr><td>Sample type</td><td colspan="9">In-situ</td><td>N/A</td></tr>
<tr><td>Example</td><td colspan="7">EXO2</td><td>Cyclops-7F</td><td>NiCaVis 701 IQ NI</td><td>Campbell CR6</td></tr>
<tr><td rowspan="3">Hach</td><td>Monitoring instrument</td><td colspan="5">Individual Probe</td><td colspan="2">Spectro-photometer</td><td colspan="2">Individual Probe</td><td>N/A</td></tr>
<tr><td>Sample type</td><td colspan="5">In-situ</td><td colspan="2">Laboratory instrument</td><td colspan="2">In-situ</td><td>N/A</td></tr>
<tr><td>Example</td><td>DPD1R1</td><td>D3725E2T</td><td>LDO sc Model 2</td><td>DPD1R1</td><td>Solitax t-line sc</td><td>DR6000 UV VIS</td><td>DR6000 UV VIS</td><td>FP360 sc</td><td>UVAS plus sc UV Sensor</td><td>SC1000, SC45000, and adapters</td></tr>
<tr><td rowspan="3">In-Situ Systems</td><td>Monitoring instrument</td><td colspan="7">Multiparameter Sonde</td><td>N/A</td><td>Online analyzer</td><td>N/A</td></tr>
<tr><td>Sample type</td><td colspan="7">In-situ</td><td>N/A</td><td>Flow-through Unit</td><td>N/A</td></tr>
<tr><td>Example</td><td colspan="7">MPX4</td><td>N/A</td><td>Chem-Scan Mini Analyzer</td><td>7300 Monitor</td></tr>
</table>

6.4.2 Grab Samples at the Intake

Grab samples provide a snapshot in time for specific water quality parameters. They are collected manually and typically analyzed in a laboratory. As part of the ongoing monitoring, it is recommended that algal enumerations are performed from grab samples taken in the photic (near-surface) zone, near the Intake Facilities. These samples should be collected weekly during the growing season (May 1–October 31). Enumerations can be completed in-house, tailoring methodology to available time while ensuring value of data, or by an external laboratory. Turnaround time for an external laboratory can hinder data usefulness. An in-house FlowCam could assist with automating the enumeration process. Enumerations should be completed to the genus level with units of colony-forming units (CFU) per milliliter or cells per milliliter. Enumeration frequency may be reduced once the biological succession is understood and correlated to sonde-derived water quality parameters.

In addition to analyzing the phytoplankton community, grab samples should be regularly analyzed for cyanotoxins. OHA requires cyanotoxin sampling for microcystin and cylindrospermopsin at least once every two weeks during the growing season from May 1-October 31 (Oregon Health Authority 2023a). It is recommended that the USEPA Method 546: Determination of Total Microcystins and Nodularins in Drinking Water and Ambient Water by Adda Enzyme-Linked Immunosorbent Assay (ELISA) only be used as a screening tool for microcystins and nodularin in raw water. The ELISA method is both quicker and less expensive than other methods, but it can lead to false positives in finished water (Aranda-Rodriguez, et al. 2015). It is recommended that Method 544: Determination of Microcystins and Nodularin in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS) be used for finished water samples and to confirm positive results from the ELISA method for raw samples. Additionally, OHA has a recreational cyanobacteria monitoring program, reporting source water exceedances above the state's recreational advisory levels (Table 11). There could be collaborative opportunities to provide additional monitoring locations and the associated datasets, and to share resources. The WRWTP lab currently performs routine cyanotoxin monitoring and there is a possibility the WWSS WTP could collaborate on cyanotoxin monitoring. This is currently in discussion with OHA and should be closely monitored.

Table 11: OHA Cyanotoxin Recreational Advisory Levels (Oregon Health Authority 2023b)

Cyanotoxin	Recreational Advisory Level (µg/L)
Microcystin	8
Cylindrospermopsin	15
Anatoxin-a	15
Saxitoxin	8

Notes:
µg/L - micrograms per liter

Lastly, a baseline screening is recommended to understand current system concentrations for other contaminants including PFAS, pesticides, pathogens (e.g., *E. coli*), and nutrients. The results of the baseline sampling would inform if regular additional sampling is needed. It is recommended that grab samples are collected at or near the Intake Facilities monthly, with additional grab samples collected after storm events, for at least one year: The purpose of the additional samples following storm events is to understand watershed runoff contributions to concentrations of the baseline screening parameters.

- PFAS: To better help quantify potential background concentrations of PFAS outside of the current UCMR5 required PFAS monitoring, method USEPA 533 can be leveraged to measure 25 PFAS compounds, including 11 short chain compounds.
- Pesticides: To help quantify baseline pesticide concentrations, analytical method USEPA 505 could be used to test for organohalide pesticides and polychlorinated biphenyls (PCBs).
- CAFOs: To help quantify potential impacts from the CAFOs, it could be beneficial to sample for fecal indicators (i.e., *E. coli* or thermotolerant coliforms) and endocrine disrupting parameters. Method USEPA 1604 can be used to test for thermotolerant coliforms. This procedure can be performed in-house if an incubator above 38°C is available, following the filtration paper method of USEPA 1604
- Nutrients: To help quantify background nutrient concentrations, it is recommended to sample total nitrogen, nitrate, total phosphorous, and phosphate. Note that total nitrogen is determined as the sum of total Kjeldahl nitrogen (TKN), nitrate (NO_3), and nitrite (NO_2). DEQ currently performs grab samples for these parameters at locations along the Willamette River, including one 0.66 miles downstream of the Intake Facilities (Figure 17). It is recommended that this baseline screening effort collects samples at the Intake Facilities and compares them to the downstream DEQ dataset. If minimal difference is observed, then DEQ data could potentially be relied upon for general nutrient trending. If there are wide differences indicating a strong influence from a downstream source, then supplementary grab samples may be needed. Regardless, there could be potential opportunity for collaboration with DEQ, consistent with Section 5.2.6 (Key Stakeholders).

Figure 17: Existing DEQ Sample Location

6.4.3 Monitoring Upstream

Additional recommendations are focused on installing a monitoring buoy upstream of the Intake Facilities in the Newberg Pool and near the USGS gage (14197900). The objective of an additional upstream monitoring buoy is to help characterize watershed scale changes and trends as well as potentially serve as an early indicator for potential source water impacts.

For a monitoring buoy, it is recommended that the in-situ/online water quality parameters from Table 7 are included. Additional instruments can be added as needed. The same YSI instruments listed in Table 10 are applicable to remote buoy deployment, aside from the SCADA interface system. A buoy would require telemetry for data transmittal. YSI does provide a cellular data hosting platform for an annual fee. The deployment location for the proposed monitoring buoy will need to be refined. A buoy in the river is possible but may require coordination with state and federal agencies regarding permitting. Additional safety measures may need to be taken to ensure the protection of a remote field device as well.

Prior to installing an upstream monitoring station, grab samples/hand sonde measurements could be gathered. In place of permanent equipment, staff could collect monthly samples of the baseline water quality parameters, chlorophyll-a, and phycocyanin with hand sondes. This could help establish the water quality database and confirm the need for permanent online sensors.

6.5 Operation and Maintenance

Water quality sensors require regular maintenance and calibration to ensure accurate, reliable data collection. The steps below provide an overview of operations and maintenance (O&M) needed to keep monitoring equipment working properly. Depending on the equipment, maintenance schedules can range from weekly to every six months.

- Cleaning: It is important to keep the equipment clean to prevent any biofouling, dirt, or river debris from interfering with the sensor measurements.
- Calibration: Calibrating sensors using a standard solution or by comparing the instrument's readings to those of a calibrated reference instrument ensures that they are providing accurate measurements.
- Checking cables and connectors: The cable and connectors should be checked for any damage or wear and tear that could affect the sensor performance.
- Sensor replacement: Manufacturers recommend replacement of water quality sensors periodically (e.g., every 2–4 years). Refer to specific product user manual for Recommended Replacement Time.

All manufacturer recommended maintenance schedules should be followed. For the first few months of implementation, it is recommended the instrumentation be cleaned and checked weekly as well as after large storm events to assess fouling and equipment health. This maintenance schedule could decrease in frequency depending on findings. Calibration checks should also be performed monthly at first but could decrease in frequency if minimal drift is noticed.

Lastly, the vendors selected above offer a field services team to help with the installation and commissioning of the equipment as well as troubleshooting. If the monitoring equipment is installed via partnership with USGS, then USGS would be responsible for equipment maintenance.

6.6 Data Management

The monitoring plan will generate large volumes of data and it is imperative that data management best practices are followed. As the plan evolves and new locations or instruments are included or removed, it is recommended that data storage, data types, and data organization is reviewed. If data sources expand beyond the plant SCADA, such as implementing a remote buoy with an online data service, there may be a desire for integrating all data sources into a common platform. Additionally, there may be benefits in compiling plant SCADA output with lab data into a common platform to facilitate data visualization and analyses or potential auto-report generation.

If it is desired to share source water monitoring instrumentation resources between the WRWTP and the WWSS WTP, it is important to account for data sharing between the facilities. It is recommended that discussions continue in determining the data sharing agreements and data management interfaces. A web-based data viewing platform from a third party vendor is a potential solution to consolidate multiple SCADA output for shared viewing. Additionally, it is recommended to continue working towards enhanced communications and data sharing amongst the various partners, especially to assist with emergency response.

6.7 Existing Programs and Partnerships

The monitoring strategy includes a discussion on building off existing programs and partnerships to implement the proposed plan.

6.7.1 Incorporation with USGS Efforts

There is an opportunity to involve key partners prior to implementing the proposed monitoring plan. The USGS is closely involved with monitoring water quantity and quality within the Willamette River Basin. The basin was identified as an Integrated Water Science Basin by USGS, with the goal to better understand the nexus between human and ecological demands. Due to these shared interests, continued coordination with USGS could be beneficial to the long-term success of this monitoring plan as well as better understanding of changing water quality within the Willamette River Basin.

One option is to coordinate with USGS to deploy and manage the monitoring equipment. For the immediate-term recommendations, USGS could deploy equipment at the Intake Facilities in place of plant-operated equipment. Additionally, for the near-term upstream recommendations, monitoring equipment could be co-located with the existing USGS gage (14197900) at Newberg. In USGS/utility partnerships, USGS is typically able to bear about 25-40% of the total costs. USGS would maintain the equipment and ensure data validation, while making the monitoring data publicly accessible. If the USGS can add on to the existing gage station, this could simplify permitting challenges and the implementation timeline. It is expected that a USGS/WIF Commission partnership could take roughly 6 months to 1 year from planning to implementation of the monitoring equipment. One potential challenge with this option is data integration with plant and laboratory data, but customizable solutions could be pursued if interested.

6.7.2 Key stakeholders

Stakeholder involvement is a critical component to source water protection and its continued success. Stakeholder actions have the ability to further improve the watershed, providing an overall benefit of improving water quality. Prior efforts have identified local and regional stakeholders (Appendix 2-A). It is recommended that communication continues with stakeholders and collaborative opportunities are identified. As it pertains to the monitoring plan recommendations, an implementation team could be organized, involving stakeholders and across-organization team members to review information, share results, and establish goals.

6.8 Future Recommendations

The monitoring plan recommendations outlined above should help assess source water quality, identify trends and changes to water quality, and inform operational decisions. Continuous sustained monitoring is important to ensure the monitoring plan continues to meet the WIF Commission's objectives. The following are future recommendations for consideration:

- **Establish Thresholds or Triggers**: The collected data should be regularly assessed, at least quarterly, to identify trends and changes to water quality. From this assessment, correlations or thresholds may become evident that impact operational decisions. Examples could include turbidity thresholds that inform coagulation dose changes or chlorophyll-a concentrations to trigger additional monitoring.
- **Evaluate Progress**: Once the plan is implemented, it is recommended to establish routine review points and milestones for capturing progress. An implementation team could be organized, involving stakeholders and across-organization team members to review information, share results, and establish goals. For example, routine review points could include evaluating and tracking metrics regarding monitoring plan budgets and costs, maintenance times, level of effort required by the operations team, and data gaps.
- **Enhanced Monitoring**: It is recommended that the parameters from the key parameters of interest list (Table 7) are included in the initial implementation effort. The monitoring plan can be extended to include additional parameters, if new drivers become apparent or increased frequency, if concentration variability needs to be better understood. For example, if taste and odors become a reoccurring challenge, algal enumeration data could be correlated to the specific genera responsible for specific taste and odor compounds. This targeted correlation could inform management and treatment decisions. Additionally, if a new contaminant of interest emerges, additional monitoring may be warranted.
- **Future Updates**: It is recommended that this plan is reviewed annually and that a summary report is also prepared annually. Consider updating the monitoring plan and strategies every 5 years as the plan is implemented and progress is evaluated over time. However, the monitoring plan should be updated more frequently if large perturbations, such as extreme weather events or hazardous events, occur. Future updates should also consider the status of contaminants of emerging concern including PFAS chemicals, microplastics, and PPCPs and others, based on guidance from regulatory agencies and best practices being used by water providers. It is recommended to continue referencing the AWWA G300 standard on source water protection for future updates.

7 Strategic Communication and Outreach Plan

An important part of the MVVG strategic framework is identifying stakeholder engagement activities to support in meeting those goals (Appendix 1-A). Since the MVVG document was adopted, the WIF Commission has been investing in its stakeholder engagement strategy through interviews with partner agency staff, their respective commissioners, and external stakeholders. Key stakeholder groups that the WIF Commission has begun to engage include regional water providers, elected officials, state agencies, non-governmental organizations, and the agricultural and tribal communities.

The Communications & Stakeholder Engagement Plan (found in Appendix 1-B) outlines the process the WIF Commission has already undertaken to build a strong foundation for its stakeholder engagement. It also outlines recommended measures to address key water quality risks including pollution from spills and accidental releases, agricultural run-off and pesticides, septic systems, and wildfire events, while advancing initiatives like public information and partnerships.

High priority engagement measures include 1) promoting information sharing about emergency preparedness amongst operators, other water provider staff, and local emergency response agencies and organizations; 2) prioritizing meetings with water providers and county and state agencies to identify collaboration opportunities around water quality monitoring; and 3) working with local agricultural and watershed groups to promote pollution prevention practices amongst landowners. Further, it is recommended that the WIF Commission continue to keep in contact with Tribal communities about source water protection to share information and identify partnership opportunities.

Overall, one of the most significant, strategic recommendations is for the WIF Commission to step into the role of a regional leader and collaborator in source water protection amongst water providers and potentially other stakeholder groups. Through the Commission's discussions with water providers, it is clear there is a need to be filled to facilitate the sharing of monitoring data, funding opportunities, and more. Positioning the WIF Commission as a leader and collaborative resource supports the strategies identified in Section 5.2. These strategies focus on working with partners with existing emergency response programs and landowner relationships to identify source water protection projects within priority areas and to connect grant and loan opportunities with projects ready for implementation. It is recommended the WIF Commission address the need for this identified leadership gap.

The proposed engagement activities are broken down into phases. Those in Phase 1 are recommended activities for the first year of Plan implementation. The information gathered, and the partnerships formed, in Phase 1 will necessarily shape the timing and type of activities performed in subsequent phases. Phasing is discussed in Section 8.3.2. This is also reflected in the Communications & Stakeholder Engagement Plan that is attached in Appendix 1-B of this document.

8 Implementation Plan

This section provides guidance on implementation of the Watershed Protection, Monitoring, and Outreach Plan in the near and short term. Guidance includes cost estimates, funding mechanisms, timing of activities by priority, and metrics to track progress during implementation.

8.1 Cost Estimates

8.1.1 Labor and Full Time Equivalents

The case study analysis conducted in Phase 2 (Appendix 2-E) included reviews of the source water protection programs for two Oregon utilities, EWEB and the Clackamas River Water Providers (CRWP). EWEB's source protection program, as documented in its 2017 technical report, uses 2.5 full-time equivalents (Eugene Water & Electric Board 2017). CRWP has two staff members (a Water Resources Manager and a Public Outreach and Education Coordinator) dedicated to implementing source water protection strategies. It is recommended that the WIF Commission consider one FTE focused on source water protection in the near term and evaluate the future need for a second FTE.

8.1.2 Emergency Response Program

Annual non-labor costs for an emergency response program can be approximated at $50,000 per year based on comparable programs from EWEB and CRWP. Initially, this would include activities such as development of spill response protocol, tabletop exercises, and partner outreach and coordination. As the program develops, this would also include acquisition of spill response equipment such as booms, additional coordination with partners, tabletop exercises, and potentially field emergency response drills.

8.1.3 Agricultural BMP Support and SWCD Collaboration

Annual non-labor costs for collaboration with SWCD partners and pursuing NRCS funding to support water quality programs on agricultural land are estimated at $50,000. In the immediate term (1–2 years), this would include activities such as convening meetings with local, county, and state agencies focused on land management, providing matching funds for grants, and supporting partners with existing programs based on their needs. As the collaboration relationships develop, this work may shift to involve more direct support on preparation of grant applications and supporting expansion or piloting of new programs.

8.1.4 Septic System Program

Annual non-labor costs for engagement with county septic system programs are estimated at $10,000 per year. This program is recommended for the 2–5 year timeframe. WIF activities focused on septic systems would include convening meetings with existing county programs to identify collaboration opportunities, providing funds to existing county programs or directly to outreach efforts, and connecting landowners or agricultural groups to county-level programs.

8.1.5 Public Education

Annual non-labor costs for supporting existing and future public education programs are estimated at $25,000. Initially, funds may be used to develop public education materials for the WIF Commission website and to promote the use of the website. Education materials could be on topics such as the following examples:

- Existing source water protection programs
- Landowner practices such as pesticide and fertilizer usage, pet waste cleanup, septic programs, and land management

Over time, the funds may be leveraged to participate in and support existing education programs from entities such as watershed councils and SWCDs.

8.1.6 Monitoring Costs

The estimated cost associated with the monitoring plan is separated by phase. The Immediate-term (1–2 year) costs are shown below in Table 12**,** and include capital, reoccurring subscription costs, and annual O&M estimates for the next 1, 5, and 10 years. Unburdened labor rates were used to estimate only O&M costs associated with the maintenance tasks listed in Section 6.5. Potential burdened labor costs were excluded given that these estimates have been developed only for initial planning purposes. However, this makes an accurate, full cost comparison between WIF Commission owned and operated equipment and a USGS collaboration difficult to execute given the labor time involved in O&M costs for a WIF Commission deployed monitoring site. A 30% contingency was applied to the total estimated costs as well. This phase only includes monitoring equipment at the plant intake and is estimated to cost between $200,000–$910,000 over the next 10 years, if all monitoring probes from Table 10 are purchased. The costs do not yet include the installation method of the sensors at the Intake Facilities as this has not been confirmed. Additionally, it was assumed that all samples could be analyzed at the WWSS WTP, so additional sample costs from external labs were not included. Detailed cost estimates and assumptions can be found in Appendix 1-C.

Table 12: Intake Facilities—Immediate Implementation (1–2 Fiscal Year) Cost Estimate Comparison, in 2023 Dollars

		Capital Equipment Purchase Cost	Subscription Costs	Annual O&M Costs	Contingency	Total Project Cost
In-Situ Systems Quote	1 year	$42,000	$0	$7,000	$15,000	**$64,000**
	5-year cumulative	$70,000	$0	$20,000	$27,000	**$117,000**
	10-year cumulative	$116,000	$0	$37,000	$46,000	**$199,000**
YSI Quote	1 year	$72,000	$1,000	$7,000	$24,000	**$104,000**
	5-year cumulative	$120,000	$5,000	$20,000	$44,000	**$189,000**
	10-year cumulative	$200,000	$10,000	$37,000	$74,000	**$321,000**
Hach Quote	1 year	$141,000	$30,000	$7,000	$54,000	**$232,000**
	5-year cumulative	$188,000	$150,000	$20,000	$108,000	**$466,000**
	10-year cumulative	$266,000	$299,000	$37,000	$181,000	**$783,000**
USGS[1]	1 year	$0	$70,000	$0	$21,000	**$91,000**
	5-year cumulative	$0	$350,000	$0	$105,000	**$455,000**
	10-year cumulative	$0	$700,000	$0	$210,000	**$910,000**

Note:

[1] USGS collaboration would result in USGS ownership of equipment. All other quotes listed result in WIF Commission ownership of equipment.

Near-term (2–5 years) costs are shown below in Table 13**,** and include capital, reoccurring subscription costs, and annual O&M estimates for the next 1, 5, and 10 years. Potential labor costs were excluded given that these estimates have been developed for initial planning purposes; however, this makes an accurate, full cost comparison between WIF Commission owned and operated equipment and a USGS collaboration difficult to execute given the labor time involved in O&M costs for a WIF Commission deployed monitoring site. Consistent with Table 11, a 30% contingency was applied to the total estimated costs. This phase only includes monitoring equipment for an upstream buoy and is estimated to cost around $155,000–$730,000 over the next 10 years, if all monitoring probes from Table 10 are purchased and implemented starting in year 4. These costs would be additive to the prior phase costs. There is no year 1 cost for this phase since it is assumed this would begin in the near-term (2–5 years). Additionally, it was assumed that all samples could be analyzed at the WWSS WTP, so additional sample costs from external labs were not included. Detailed cost estimates and assumptions can be found in Appendix 1-C.

Table 13: Upstream Location—Near-term (2–5 Fiscal Years) Cost Estimate Comparison, in 2023 Dollars

		Capital Equipment Purchase Cost	Subscription Costs	Annual O&M Costs	Contingency	Total Project Cost
In-Situ Systems Quote	1 year	$0	$0	$0	$0	**$0**
	5-year cumulative	$18,000	$1,000	$20,000	$12,000	**$50,000**
	10-year cumulative	$64,000	$3,000	$53,000	$36,000	**$155,000**
YSI Quote	1 year	$0	$0	$0	$0	**$0**
	5-year cumulative	$92,000	$2,000	$20,000	$35,000	**$148,000**
	10-year cumulative	$172,000	$7,000	$53,000	$70,000	**$301,000**
USGS[1]	1 year	$0	$0	$0	$0	**$0**
	5-year cumulative	$0	$210,000	$0	$63,000	**$273,000**
	10-year cumulative	$0	$560,000	$0	$168,000	**$728,000**

Note:
[1] USGS collaboration would result in USGS ownership of equipment. All other quotes listed result in WIF Commission ownership of equipment.

8.2 Funding Mechanisms

WIF COMMISSION STRATEGIC FRAMEWORK, WATER QUALITY PROTECTION GOAL #2:

"Acquire grants, loans, and funding in support of source water protection plan implementation."

- **Oregon Office of Emergency Management.** Funding through the Office of Emergency Management (OEM) could be used to prepare for hazards, which could include spills and wildfire. These grants include the Emergency Management Performance Grant, Homeland Security Grant Program and Hazard Mitigation Assistance Grant. The EWEB plan (Eugene Water & Electric Board 2017) notes that the organization has received grants from Homeland Security and OEM for emergency response planning, among other funding sources.
- **Oregon Watershed Enhancement Board**. The Oregon Watershed Enhancement Board (OWEB) provides a variety of funding opportunities which could be accessed by WIF Commission members or, potentially, partner organizations external to the WIF Commission (Oregon Watershed Enhancement Board 2023), including the following:
    - Restoration Grants: Grants intended to protect watershed functions or restore altered watershed functions.
    - Land Acquisition Grants: Entities including local government agencies are eligible to apply for OWEB funding to acquire land from willing sellers to use for maintaining or restoring habitat.

    - Stakeholder Engagement Grants: These grants may be used to communicate and engage with landowners regarding feasibility and benefits of restoration projects.
    - Small Grants Program: Small grants offered through OWEB provide up to $15,000 for restoration projects on private lands, such as streamside revegetation or reducing upland erosion by modifying agricultural practices.
    - Operating Capacity: Operating Capacity grants are awarded to support the operating costs of watershed organizations. These may be used by watershed councils and Soil and Water Conservation Districts. The grants are intended to allow for stakeholder engagement and restoration activities outside of the organizations existing capacity (Oregon Watershed Enhancement Board n.d.). The groups eligible for these grants are potential partners external to the WIF Commission.
    - Monitoring Grants: These grants could be used to fund a wide range of watershed related monitoring activities, including surveys of water quantity, water quality, vegetation, macroinvertebrates, fish, or invasive species.
    - Technical Assistance Grants: There are two types of technical assistance grants administered through OWEB. Technical Design and Engineering grants support the technical design of a restoration project. Resource Assessment and Planning grants fund development of an implementation plan for restoration projects.
    - Partner Technical Grants: These grants support existing partnerships in efforts that lead to implementation of conservation actions. The grants are intended to fund the development of a new or enhanced strategic action plan or support the capacity and level of performance of an existing project. The grants can last up to 3 years and have a maximum value of $150,000.
    - Organization Collaboration Grants: This program offers grants to support new or expanded collaborations to achieve ecological outcomes. The program supports the evaluation of the organizational structure of collaborating organizations, or the merger/consolidation of organizations. These grants cannot exceed $75,000.
- **Clean Water State Revolving Fund, Oregon DEQ and USEPA.** The Clean Water State Revolving Fund provides low-interest (below-market rate) loans for water infrastructure projects. Projects can include nonpoint source pollution management, stormwater program enhancements, watershed pilot projects, and other activities relevant to watershed protection.
- **Nonpoint Source Implementation 319 Grants.** Oregon DEQ administers this grant program for watershed-based mitigation of nonpoint source pollutants (including sediment, pesticides, and nutrients). The funding comes from the USEPA Clean Water Act section 319 grants to the state. A watershed-based plan must be developed and approved prior to implementation of projects associated with these funds.

- **Water Project Grants and Loans.** OWRD administers grants for evaluating, planning, and developing water projects that must have benefits for all of three categories: economic, environmental, or social/cultural. Projects include conservation and streamflow protection or restoration, as well as storage and distribution projects.
- **Drinking Water Provider Partnership Grants.** This program, a partnership between the Geos Institute, USDA Forest Service, DEQ, Washington Department of Health, USEPA, United States Bureau of Land Management, Freshwater Trust, and WildEarth Guardians, provides grants for habitat conservation and restoration in municipal watersheds in the Northwest United States (Oregon and Washington). Projects funded in 2023 included creek restoration, watershed management, and floodplain enhancement. In 2020, there were 13 funded projects totaling $400,000 in grant funding.
- **Five Star and Urban Waters Restoration Grant Program, USEPA and National Fish and Wildlife Foundation**. This program is focused on environmental education and training through wetland and stream restoration projects. Funding amounts ranged from $250,000 to $50,000 in 2023.
- **Environmental Education Grants Program, USEPA.** This program funds projects focused on environmental stewardship and awareness. Applicants must represent a local education agency, state education or environmental agency, college or university, 501(c)(3) non-profit organization, noncommercial educational broadcasting agency or tribal education agency. As such, the WIF Commission would need to collaborate with a partner to access this grant program.
- **Supplemental Environmental Projects**. Oregon DEQ allows payments for projects benefiting the environment or public health to offset up to 80% of the total for civil penalties assessed by DEQ for violations of regulations (DEQ 2023). Example project types include stream-bank restoration, construction of bioswales for filtration of stormwater, and environmental education. The DEQ website (DEQ 2023) provides additional information and a list of contacts for potential projects.
- **United States Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) Programs.** The USDA-NRCS is a key funder of conservation and water quality programs on private agricultural and forest land. While the WIF Partners could not apply for the funding directly, NRCS programs could be an important source of funding for improved water quality practices in the Willamette Basin.
    - Environmental Quality Incentives Program (EQIP): EQIP provides financial and technical assistance directly to agricultural and forest landowners to address a wide range of natural resource priorities, including improved water quality. Ongoing programs through EQIP include the following:
        - Erosion control in Orchards in Marion, Polk, Washington, and Yamhill counties (USDA 2023a).

Lower Willamette and North Coast AFOs: This program is focused on efforts to reduce erosion and transport of elevated nutrients (phosphorus and nitrogen) to surface water from AFOs in Clackamas, Clatsop, Columbia, Marion, Multnomah, Polk, Tillamook, Washington, and Yamhill Counties (USDA 2023b).

McKenzie Watershed Degraded Riparian Habitat: This program focuses on improving water quality on the McKenzie River in Lane County by working with landowners to implement programs such as establishment of vegetation, weed control, and improving nutrient management (USDA 2023c).

Middle Willamette Water Quantity and Soil Quality: This program is intended to address source water depletion and inefficient use of irrigation water in Marion County (USDA 2023d).

Yamhill Partnership for Water Quality: This program is intended to address transport of sediment, nutrients, and pathogens to surface water, and source water depletion in Yamhill County (USDA 2023e).

  - Regional Conservation Partnership Program (RCPP): RCPP provides funding for conservation activities by farmers, ranchers, and forest landowners (USDA 2023f). Projects in eight critical areas are funded under the RCPP Critical Conservation Areas program and receive 50% of the total RCPP budget. One of these areas is known as Western Waters and includes the Willamette River Basin (USDA 2020). Projects outside these areas are also eligible for funding through RCPP. RCPP funded projects include land management, conservation easements, and public works or watershed-based projects. Projects are funded up to $10,000,000.

- The **Safe Drinking Water Revolving Loan Fund (SDWRLF)**, also known as the Drinking Water State Revolving Fund (DWSRF), is a partnership program between Business Oregon and the OHA and is funded by the USEPA. The SDWRLF recently received new funding from the Infrastructure Investment and Jobs Act (IIJA). The program has a January 15 deadline for the current call for Letters of Intent (LOIs). LOIs are ranked, and top-scoring communities are then provided a one-year window to submit an application. The SDWRLF includes the following categories, including:
  - <u>Drinking Water Source Protection Fund (DWSPF) projects</u>: The DWSPF is a program funded by the SDWRLF program focused on source water protection. Eligible projects include: enhanced delineation of drinking water source areas, enhanced assessment involving an inventory or evaluation of contaminant sources, source water protection planning, and implementation of source water protection strategies, such as public education, best management practices, and pollution prevention projects. Projects are funded with loans of up to $100,000 or grants of up to $50,000 (Oregon Health Authority 2023c).

- o Infrastructure projects: Eligible projects include new water sources, treatment, transmission (or repair/replacement of these elements of water supply), instrumentation and measurement, safety improvements (e.g., seismic or security upgrades), and projects which add to the reliability of critical assets (Oregon Health Authority 2023d). These projects are funded with loans with repayment terms up to 30 years. Projects greater than $6 million require additional levels of approval. While this category of project is not directly related to source water protection, a monitoring technology project may be applicable here.

8.3 Timeline

8.3.1 Emergency Response Program

We recommend development of an emergency response plan in the next 1–2 years. As described in Section 5.2, activities should include outreach to emergency response partners, development of an incidence response team and standard operating procedures, and additional tabletop exercises regarding response planning.

8.3.2 Outreach

The recommendations for outreach are detailed in Appendix 1-B. Outreach efforts the WIF Commission seeks to prioritize are identified in Appendix 1-B as Phase 1 outreach activities. These activities will include foundational information gathering and will shape subsequent phases. Activities in Phase 1 outreach activities include 1) convening information-sharing meetings with water providers, 2) emergency preparedness activities, and 3) relationship building with agricultural-related stakeholders. During Phase 1, it is also recommended the WIF Commission focus on building its position as a regional leader and collaborator in source water protection, with a priority focus on stakeholders in the Tier 1 area. In subsequent phases, the WIF Commission should take an increasingly active role in coordinating grant applications along with key partners and connecting landowners with grant funding and programs for implementing restoration activities.

8.3.3 Monitoring

It is recommended that the monitoring plan be implemented in two phases (immediate and near-term) with the intention to allocate resources cost-effectively.

Immediate implementation (1–2 fiscal years) recommendations include sampling efforts at the Intake Facilities. Implementation recommendations are further separated by online/in-situ and grab sample methods as discussed in Section 6.4. The timeline for online/in-situ monitoring depends greatly on the method chosen for installation of the sensors and data transmission. If the sensors are deployed on a monitoring buoy and data is transmitted telemetrically, implementation may be feasibly immediately. However, if new infrastructure is built to house the sensors and connect them to the Intake Facilities, the implementation schedule may need to be extended.

Near-term implementation (2–5 fiscal years) recommendations are focused on installing a monitoring buoy upstream of the Intake Facilities near the Newberg Pool and USGS gage (14197900).

8.4 Key Performance Indicators

This section lists metrics that the WIF Commission should track to measure progress toward the recommendations provided in this Plan. These recommendations are consistent with industry standards and include metrics from the American Water Works Association Source Water Protection Performance Metrics guidance document (American Water Works Association 2021). The indicators are organized according to the goals outlined in the WIF Commission strategic plan (Appendix 1-A). These indicators include both internal and external metrics.

8.4.1 Grants, Loans, and Funding

Internal metrics include the following:

- Hours (or FTEs) spent applying for grants and loans or administering grants and loans received
- Grant or loan applications submitted

External metrics include the following:

- Grant or loan dollars leveraged through partnership relationships for source water protection activities
- Grant or loan dollars matched

8.4.2 Enhanced Emergency Preparedness and Response

Internal metrics include the following:

- Hours (or FTEs) focused on emergency response planning
- Is there a formal Emergency Response Plan in place?

External metrics include the following:

- Is there active coordination with local and state emergency response agencies?
- Number of tabletop exercises and field drills per year

8.4.3 Information Exchange on Emerging Issues

Internal metrics include the following:

- Hours (or FTEs) focused on engaging on legislative matters

- Hours (or FTEs) focused on tracking changes in land use, forestry practices, and water quality permits
- Dollars spent for direct expenses to engage on these issues

External metrics include the following:

- New federal, state, or county programs, or changes to existing programs, identified to support source water protection efforts

8.4.4 Outreach and Education

The metrics in this section apply to outreach and education efforts overall. Additional qualitative and quantitative metrics pertaining to specific measures in the communication plan and specific stakeholder groups are provided in Appendix 1-B.

Internal metrics include the following:

- Hours (or FTEs) focused on outreach and education
- Materials produced or updated for use in outreach efforts

External metrics include the following:

- Stakeholder points of contact
- Stakeholder meetings convened
- Stakeholder response rates
- Number of landowners engaged through partner organizations with WIF Commission support
- Projects implemented through partner organizations with WIF Commission support
- Total area of watershed improvement projects implemented through partner organizations with WIF Commission support

8.4.5 Monitoring Technology

Internal metrics include the following:

- Hours (or FTEs) focused on water quality monitoring and data analysis
- Dollars spent on monitoring technology and data management systems

External metrics include the following:

- Number of monitoring stations
- Quantity of data produced

- Percent of sampling events meeting data quality objectives
- Water quality data trends, including:
  - Turbidity
  - Fecal indicators (*E. coli* or thermotolerant coliforms)
  - Nutrients (nitrogen and phosphorus)
  - Chlorophyll-a fluorescence
  - Dissolved oxygen
  - pH
  - PFAS
- Are data sharing agreements in place?

9 Adaptive Management

This Watershed Protection, Monitoring, and Outreach Plan is intended to be a living document. The strategies and recommendations outlined herein should be assessed annually, identifying whether progress has been made on the key performance indicators. Activities that would support this annual assessment include review of the monitoring plan and preparation of a monitoring report summary.

WIF COMMISSION STRATEGIC FRAMEWORK, WATER QUALITY PROTECTION GOAL #1:

"Develop and maintain a state and regionally supported source water protection plan."

The Watershed Protection, Monitoring, and Outreach Plan should also be updated every five years to incorporate any major changes that may be needed as the Plan is implemented. Updates should consider new or resolved water quality risks, additional monitoring or emergency response programs, availability of new monitoring technologies, additional funding opportunities, and partnership opportunities. The monitoring plan may be updated outside of this schedule if large perturbations, such as extreme weather events or hazardous events, occur.

10 References

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WILLAMETTE INTAKE FACILITIES COMMISSION

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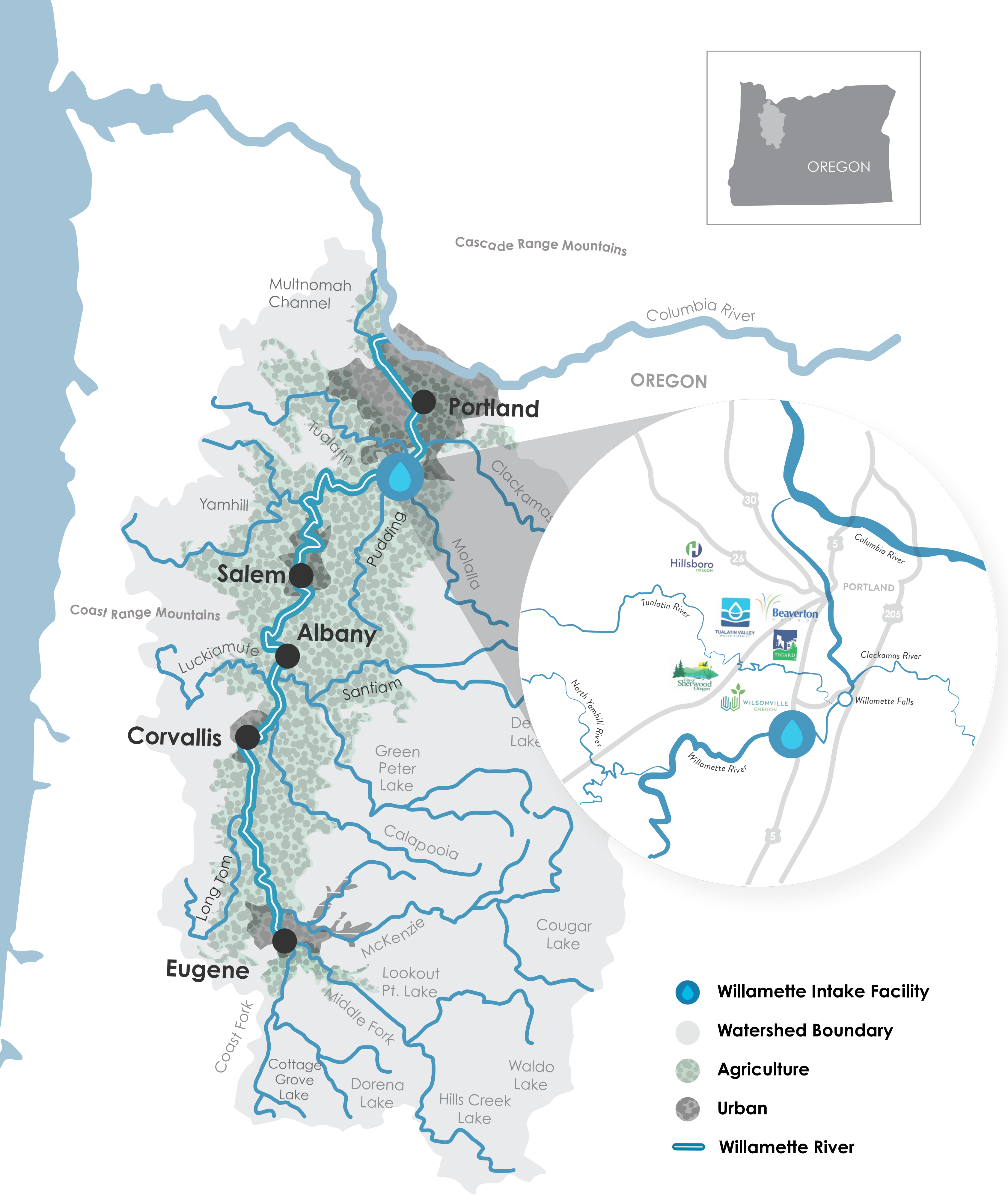
Appendix 1-A

The Willamette Intake Facility Commission

Strategic Framework: Mission, Vision, Values & Goals

Developed by the Willamette Intake Facility Commission (WIF Commission) Mission, Vision, Values & Goals Working Group in 2020-21 and adopted by the WIF Commission Board in Summer 2021. The WIF Commission is a coalition of Mid-Willamette River drinking water agencies.



OVERVIEW

Willamette River Watershed

The Willamette River is the heart of our area, supplying water to support people, agriculture, industry, forest land, native plants, fish, wildlife habitat, and more. It defines our region and the communities we call home and is a natural treasure of Oregon.

The Willamette River is the largest watershed in Oregon and the 13th largest river in the nation by volume. The Willamette River spans 190-mile stretch and begins near the City of Eugene and ends at the confluence of the Columbia River in North Portland. One of its sources is Waldo Lake, which is recognized as one of the purest water bodies in the world. It is uniquely and entirely contained by the Cascade Mountain Range to the east and the Coast Range to the west.

The Willamette River basin has 13 tributaries that feed into the main stem river. The Willamette Valley area is home to 70 percent of Oregon's population and more than one million acres are devoted to agriculture in the Willamette Basin.

Protecting the health of the Willamette River is an essential responsibility of this and future generations and is an essential need for the wellbeing of our region. Many organizations, agencies, and partners work together to protect the health and water quality of our river. The Willamette River Intake Facility Commission is proud to be amongst these leaders with a mission to provide an expanded drinking water supply to the Tualatin Valley Water District, and the cities of Wilsonville, Sherwood, Hillsboro, Tigard, and Beaverton.

Through the commitments made in the Mission, Vision, Values and Goals outlined within, we celebrate our mission and purpose to deliver quality drinking water for our communities.

FORWARD

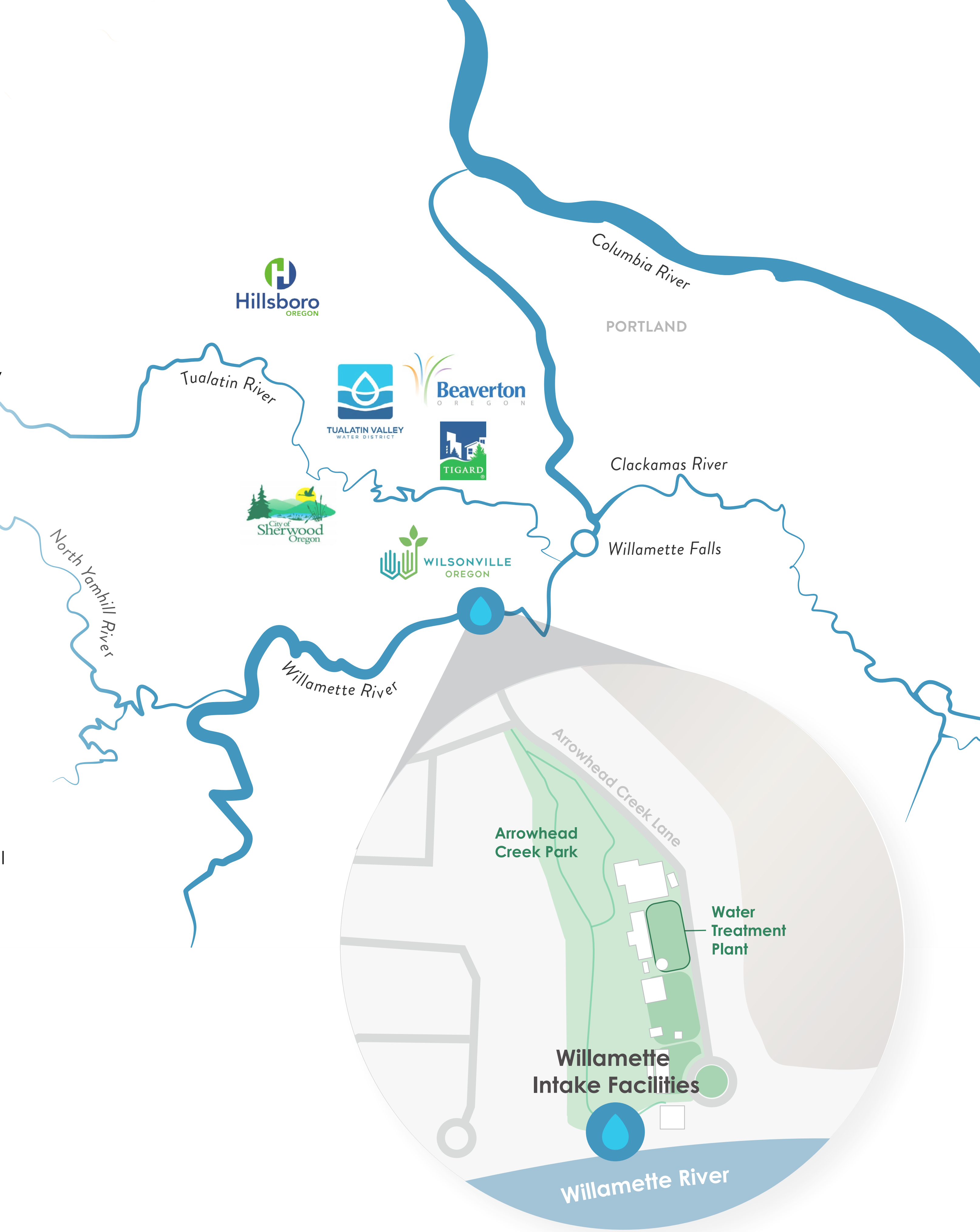
WIF Commission

The WIF Commission is responsible for oversight of the management and operation of the Willamette Intake Facilities (Intake Facilities). The Intake Facilities are a critical component serving the Willamette River Water Treatment Plant now and the Willamette Water Supply System in the future. The Intake Facilities draw water from the Willamette River for treatment at the Willamette River Water Treatment Plant through a multi-step treatment facility and delivery to the cities of Wilsonville and Sherwood. In the future, the Intake Facilities will also provide water supply to the Willamette Water Supply System for treatment at its state-of-the-art treatment facility and delivery to the service areas of TVWD and the cities of Hillsboro and Beaverton.

The WIF Commission has established a strong model for shared ownership of a critical water supply asset, the Intake Facilities, vital to the drinking water supply for the region. The WIF Commission is a partnership formed under ORS Chapter 190 between: the Tualatin Valley Water District, and the cities of Wilsonville, Sherwood, Hillsboro, Tigard, and Beaverton.

The WIF Commission must work effectively to address a multitude of impacts and needs associated with the water rights, watershed protection, stakeholder collaboration, and Intake Facilities operations.

The WIF Commission Mission, Vision, Values and Goals were developed in 2020-21 by a WIF Commission Working Group. The Working Group was composed of members of the Commission Management, Operations, and Finance Committees. The framework defined within serves as the core framework for annual planning and effective decision making.



click on an element to learn more

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Key Elements of Our Strategic Framework

Mission

To responsibly secure a safe and reliable Willamette River drinking water supply for our communities.

CONTENTS MISSION VISION VALUES PILLARS GOALS

Vision

To become a trusted steward of the Willamette River watershed.

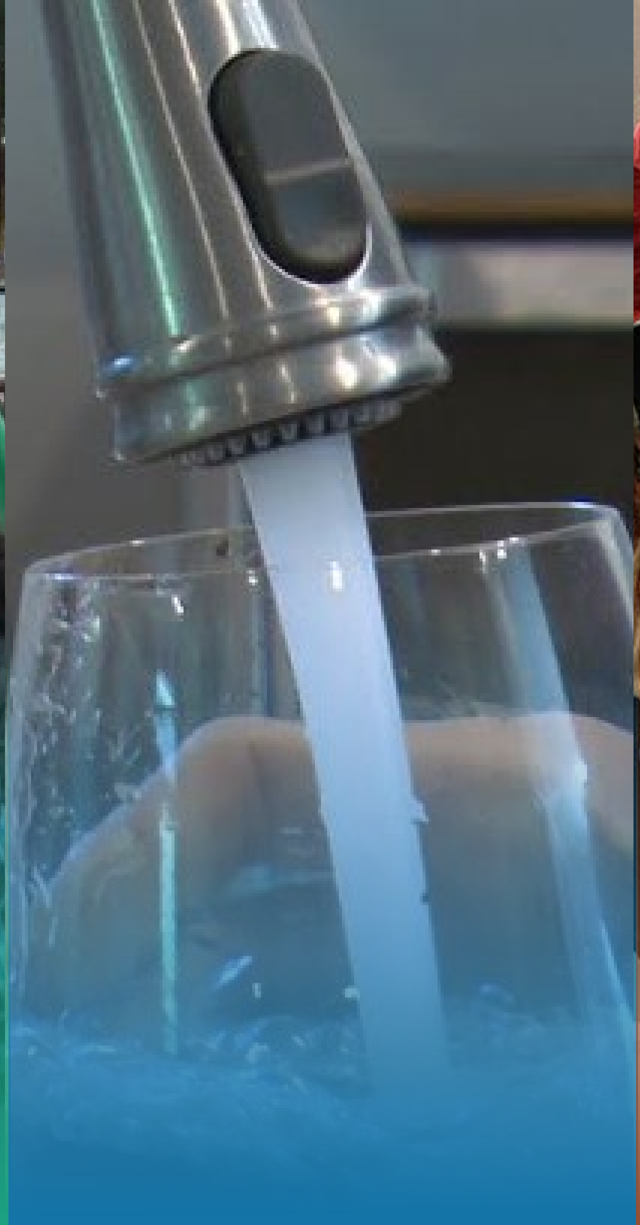
- ✓ We apply science, innovation and advocacy for resilient and clean water stewardship.
- ✓ We improve awareness, provide education and build support for watershed protection.
- ✓ We advocate at all levels for investment and policy to protect drinking water source quality.

Values

To conduct business in a manner that is unified, responsible and reliable.

Unified

We are devoted to creating cooperative and inclusive decision-making environments where WIF Commission partners input is respected.



Responsible

We are dedicated to cost-effective and responsible water management.

Reliable

We are committed to data-driven and science-based decision making.

The Three Pillars

The strategic pillars hold up the Mission and Vision and give focus to the goals.

Water Quality Protection

We **engage in addressing existing, emerging and potential risks** that may impact water quality at the intake facility ahead of treatment.

Water Supply Stewardship

We pursue **access to reliable water supply** to meet the needs of the region and participating agencies.

Effective WIF Operations

We are dedicated to effective utility management to **deliver consistent operations and quality service** to our communities.

Water Quality Protection

We **engage in addressing existing, emerging and potential risks** that may impact water quality at the intake facility ahead of treatment.

Goals

1. Develop and maintain a **state and regionally supported source water protection plan.**
2. **Acquire grants, loans, and funding** in support of source water protection plan implementation.
3. **Promote information exchange amongst stakeholders,** tracking relevant data on emerging issues such as contaminants, natural hazards, and regulatory changes.
4. **Lead outreach and education** on the Willamette River Basin history and current and future needs for protection.
5. Give members of the WIF Commission resources to enable them to **serve as water quality experts and representatives** of WIF Commission interests.
6. Invest in **monitoring technology and communication networks** with upstream and downstream agencies and private partners to detect and provide early incident notifications.

Water Supply Stewardship

We pursue **access to reliable water supply** to meet the needs of the region and participating agencies.

Goals

1. **Engage proactively with regulatory agencies** on water supply needs and future demands.
2. **Foster relationships with the State and Federal agencies** to proactively address water supply shortage scenarios and develop cooperative agreements.
3. Periodically collect **water demand forecasting information** from partner agencies to support operational planning and decision making.
4. **Engage proactively with dissenting or potentially opposing stakeholders**.
5. Develop **curtailment plans that enhance preparedness** for water scarcity scenarios and are adopted by the Board.

Effective WIF Operations

We are dedicated to effective utility management to **deliver consistent operations and quality service** to our communities.

Goals

1. Develop and maintain **Operations, Curtailment, and Emergency Response Plans** and guide shared ownership with priority stakeholders.
2. Ease **decision making on prioritized investments** using strategic asset management and Capital Improvement Program best practices.
3. Preserve a **cooperative team dynamic** among WIF members through regular knowledge exchange workshops and retreats.

TUALATIN VALLEY WATER DISTRICT | WILSONVILLE OREGON | Hillsboro OREGON | Beaverton OREGON | City of Sherwood Oregon | TIGARD

Developed by the Willamette Intake Facility Commission (WIF Commission) Mission, Vision, Values & Goals Working Group in 2020-21 and adopted by the WIF Commission Board in Summer 2021. The WIF Commission is a coalition of Mid-Willamette River drinking water agencies.

Contact Us: (503) 941.4551 WIF@TVWD.org

Appendix 1-B

WILLAMETTE INTAKE FACILITIES COMMISSION

Communications & Stakeholder Engagement Plan

2023–2024

The Watershed Protection, Monitoring, & Outreach Project

TUALATIN VALLEY WATER DISTRICT
Hillsboro OREGON
Beaverton OREGON
City of Sherwood Oregon
WILSONVILLE OREGON
TIGARD

Contents

Introduction

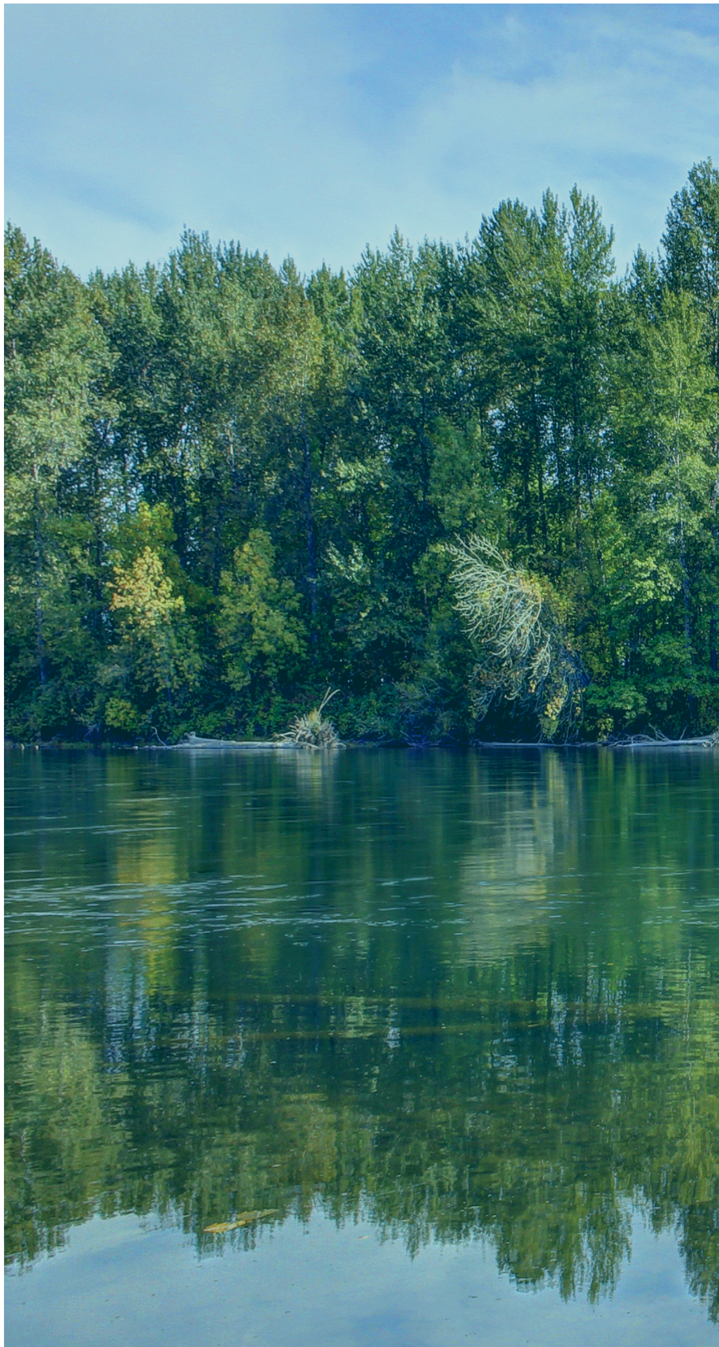
Effective communications and stakeholder engagement invites interested parties to provide meaningful input that can shape public issues they care about. This input helps leaders and decision-makers better understand the perspectives, opinions, and concerns of its stakeholders. For purposes of this document, ***Stakeholder*** is defined as *an individual or organization with an interest or concern in source water protection, drinking water, water quality, or related issues.*

Stakeholder input can offer previously unknown insights to decision-makers that are key to project success. Creating a strong and consistent project narrative can help stop the spread of misinformation amongst stakeholders before it starts. In terms of this initiative, stakeholder engagement provides a myriad of valuable opportunities for the Willamette Intake Facilities Commission (Commission or WIF Commission) to form relationships and glean information that promote the protection and preservation of the Willamette River Watershed.

In the following pages, we outline the processes the WIF Commission has undergone to identify, prioritize, and engage stakeholders; key elements of the Commission's visual brand to elevate its mission; and high-level strategies to continue stakeholder engagement. The purposes of this document are listed below.

1. *This is a living document and will change as more information is uncovered and current circumstances evolve.*
2. *This is a record of past stakeholder activities and recommended engagement strategies to support the overall goals in the WIF Commission strategic plan.*
3. *This promotes consistency in the understanding of who, when, how, and with which messaging communications will occur.*

This is an internal document. Some content may be shared externally as deemed appropriate by the Commission.



Background Information

The Commission is a forward-thinking partnership between six agencies: the cities of Hillsboro, Wilsonville, Tigard, Sherwood, and Beaverton, and the Tualatin Valley Water District (TVWD). **The Commission's mission is to responsibly secure a safe and reliable Willamette River drinking water supply for its communities.** Source water protection is the first step to promoting high-quality water at the tap.

The Commission is responsible for oversight of the management and operation of the Willamette Intake Facilities (Intake Facilities). The Intake Facilities draw water from the Willamette River for treatment at the Willamette River Water Treatment Plant. Treated drinking water is then delivered to approximately 40,000 residents in Wilsonville and Sherwood.

In the future, the intake facilities will also send water to the Willamette Water Supply System for treatment at its state-of-the-art facility and deliver it to another 400,000 customers. This will offer TVWD and the cities of Hillsboro and Beaverton (and potentially other water suppliers in the future) access to another water supply designed to meet future demand and offer security in the case of a large-scale emergency such as an earthquake.

The Need

With a shifting climate, dwindling surface water supplies, and a growing region, we know that thoughtfully managing our water resources is more critical than ever.

The Willamette River is the heart of the region, supplying water to support people, agriculture, industry, forest land, wildlife, recreation, and more. Seventy percent of Oregonians live in the Willamette Valley and more than one million acres are devoted to agriculture in the Willamette Basin. The Willamette River defines the region and is a natural treasure. Its vitality is key to the health of our communities. Protecting and preserving it is a responsibility that the WIF Commission is proud to share.

Funding for the WIF Commission

Funding comes from the six partner agencies: TVWD, Hillsboro, Beaverton, Wilsonville, Sherwood, and Tigard. The WIF Commission is exploring other funding options (including grants and loans) to supplement the WIF partners' investments that support this initiative.

To learn more about the WIF Commission visit
tvwd.org/district/page/willamette-intake-facilities-commission

Mission, Vision, Values, & Goals

Mission, Vision, Values, & Goals

In 2020, the WIF Commission developed its mission, vision, values, and goals (MVVG) in a robust strategic planning process. Elements of the MVVG are referenced in this document and continually inform the stakeholder engagement approaches undertaken by the Commission. See Appendix 1-A to view the full Strategic Plan.

Mission

To responsibly secure a safe and reliable Willamette River drinking water supply for our communities.

Vision

To become a trusted steward of the Willamette River watershed.

- *We apply science, innovation, and advocacy for resilient and clean water stewardship.*
- *We improve awareness, provide education, and build support for watershed protection.*
- *We advocate at all levels for investment and policy to protect drinking water source quality.*

Pillars

These are the three Pillars that uphold the Mission and Vision of the WIF Commission's Strategic Plan.

WATER QUALITY PROTECTION

We **engage in addressing existing, emerging, and potential risks** that may impact water quality at the intake facility ahead of treatment.

WATER SUPPLY STEWARDSHIP

We pursue **access to reliable water supply** to meet the needs of the region and participating agencies.

EFFECTIVE WIF OPERATIONS

We are dedicated to effective utility management to **deliver consistent operations and quality service** to our communities.

Stakeholder Analysis

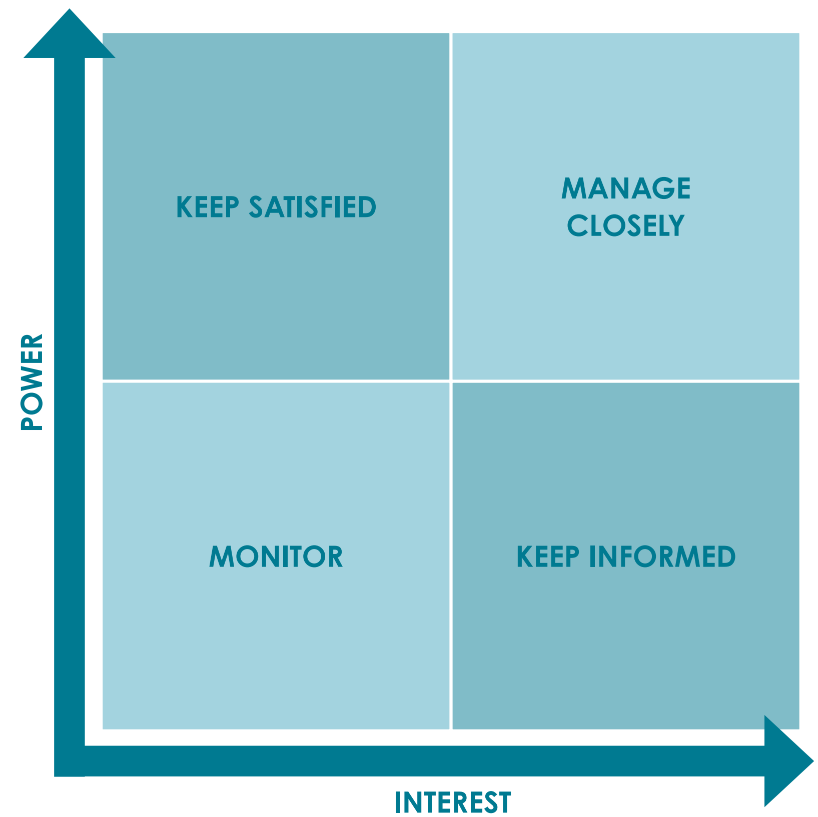
The Stakeholder Mapping Process

After the Commission established its MVVG, the partners embarked on a stakeholder mapping analysis to determine the level of engagement for each stakeholder group based on their interest and level of influence.

Stakeholder mapping is a widely used tool to define, understand, and manage stakeholder groups. The Commission undertook a three-step approach in the mapping process:

1. *They brainstormed all stakeholders with an interest in the project objective.*
2. *They clarified the interest and influence level of each stakeholder group.*
3. *The WIF Commission identified the areas of interests and concerns for each stakeholder group during this process.*

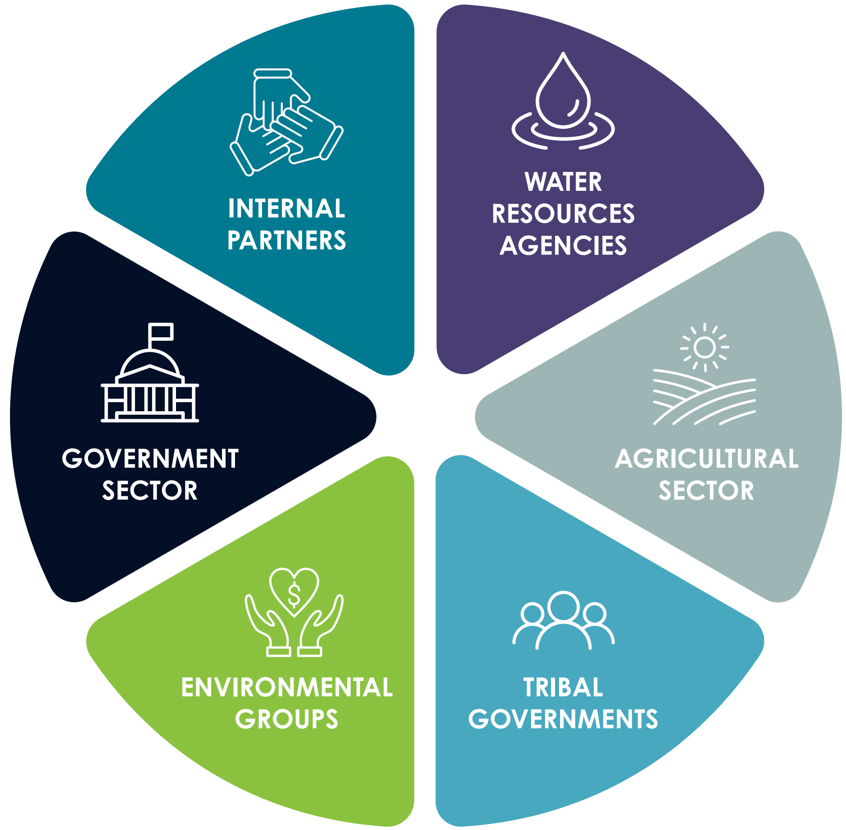
The outcome was a comprehensive list of stakeholders, in addition to insights on how to best partner with them and meet their needs and interests. The Commission will continue to seek out partnerships with other entities that share a common interest in protecting and preserving the Willamette River watershed.



This chart helped guide the stakeholder mapping process.

Stakeholder Identification

A stakeholder is an individual or organization with an interest or concern in source water protection, drinking water, water quality, or related issues. Stakeholders can be both internal—those working within the organization—or external. Through thorough vetting, the WIF Commission identified the stakeholders below as high priority at this juncture. Stakeholders will change as the WIF Commission develops.



Water Resources Agencies

- City of Adair Village
- City of Corvallis
- Eugene Water & Electric Board
- City of Newberg
- City of Salem
- Metropolitan Wastewater Management Commission
- Portland Bureau of Environmental Services
- City of Albany

Government Agencies

- Oregon Department of Environmental Quality
- U.S. Geological Survey
- Oregon Watershed Enhancement Board
- Oregon Health Authority
- Oregon Water Resources Department
- U.S. Army Corps of Engineers
- Oregon Dept of Fish & Wildlife

Agricultural Sector

- Oregon Farm Bureau
- Oregon Association of Nurseries
- Associated Oregon Hazelnut Industries
- Oregon Department of Agriculture
- Yamhill Soil & Water Conservation District
- Natural Resource Conservation Service
- Oregon State University Extension

Environmental Groups

- Trout Unlimited
- Willamette Partnership
- Willamette Riverkeeper
- Tualatin Riverkeepers

Internal Partners

- Commissioners from each WIF Partner Agency
- WIF Commission Partner Agency Staff

Tribal Governments

- Confederated Tribes of Grande Ronde
- Confederated Tribes of Siletz
- Confederated Tribe of Warm Springs

It is recommended the public, media, elected officials, and others outside this list are engaged as the Commission's capacity grows.

Preparing for Stakeholder Engagement

To prepare for engaging external stakeholders, the Commission conducted interviews with the Partner Agencies' staff and each respective Commissioner. The goals of these conversations were to get feedback on: 1) what success looks like in terms of stakeholder engagement; 2) what challenges and opportunities exist in terms of engaging stakeholders about source water protection in the Willamette River; and 3) source water protection priorities. Here are the questions that were asked of each group in virtual discussions held in late 2022.

Agency Staff Questions

- *What would successful relationships with key stakeholders look like?*
- *Are any key stakeholders missing from the list?*
- *What are effective ways to engage key stakeholders over the life of this program?*
- *What challenges do you see in terms of engaging key stakeholders?*
- *What are your priorities relative to source water protection/ stakeholder engagement?*

Commissioner Questions

- *What concerns do you have regarding protecting the Willamette River as a drinking water supply?*
- *What concerns do you hear from your community about water quality/source water risks in the Willamette River?*
- *What opportunities do you see to protect the Willamette River for drinking water?*
- *Which types of stakeholders should the WIF engage with to protect the watershed?*
- *What challenges do you foresee re: stakeholder engagement?*
- *What is your level of anticipated engagement?*

What We Learned

The conversations with the Partner Agencies' staff and each respective Commissioner revealed five key themes. These themes inform the recommendations for strategies later in this Plan.

1

PARTNERSHIP BUILDING

This initiative presents opportunities for building long-lasting and trusting relationships, coalition building, and coordination with state and federal agencies to explore funding opportunities.

2

WATER RIGHTS AND FUNDING

Water rights for each partner agency is important to recognize and be sensitive to, and securing funding helps motivate organizations to be engaged.

3

STRATEGIES AND TACTICS

Stakeholders will benefit from concise, tailored messaging. Given limited time and resources, building on existing resources and meetings, in addition to WIF-hosted meetings for information sharing, will promote success.

4

WATER QUALITY AND PRESERVATION

Water quality monitoring, response to water contamination (eg. from a spill), agricultural run off or dumping, and pollution from recreation were areas of concern to be addressed.

5

OTHER TOPICS

Stakeholders including agriculturalists, recreators, landowners on the river, farmers, and the media should be engaged strategically when appropriate.

Master Messaging

Master messaging refers to high-level, branded key points that communicate the most important aspects of an initiative. They relay the core functions of the WIF Commission, including who we are, what we do, and who we serve. The key messaging below is outlined in a Frequently Asked Questions format. Master messaging is a tool to be used to promote consistent messaging, writing, and speaking as it pertains to the WIF Commission's work. The messages below will be updated as the WIF Commission evolves, and as stakeholder relationships and circumstances grow and change.

Frequently Asked Questions

Background

The WIF Commission is a unique and forward-thinking partnership between six agencies: TVWD and the cities of Hillsboro, Wilsonville, Tigard, Sherwood, and Beaverton. **The WIF Commission's mission is to responsibly secure a safe and reliable Willamette River drinking water supply for its communities.**

The Commission owns, manages, and operates the Intake Facilities, which draw water from the Willamette River for treatment at the Willamette River Water Treatment Plant. Treated drinking water is currently delivered to approximately 40,000 customers in Wilsonville and Sherwood.

In 2026, the Intake Facilities will also serve the new Willamette Water Supply System for treatment at its state-of-the-art facility (WWSS Water Treatment Plant,) and deliver drinking water to another 400,000 customers. This will give TVWD and the cities of Hillsboro and Beaverton an additional source of **water supply** to meet future demand and provide resiliency for the region in the event of a large-scale emergency, such as an earthquake.

The WIF Commission's vision is to become a trusted steward of the Willamette River watershed. In that vein, we are undertaking the development of the *Watershed Protection, Monitoring, and Outreach Plan* (the Project). As the name suggests, the Project will eventually include a suite of activities that aim to further protect and preserve the Willamette River as a drinking water source for the region.

Frequently Asked Questions

1. **What does *Source Water* Protection mean?**
Source water refers to sources of water (such as rivers, streams, lakes, reservoirs, springs, and groundwater) that provide water to public drinking water supplies and private wells. Source water protection includes a wide array of actions and activities aimed at safeguarding, maintaining, and/or improving the quality and/or quantity of sources of drinking water. These can be actions directly at the source or within its contributing area, like a watershed or aquifer. Types of activities depend on the type of source being protected (e.g., groundwater, reservoir, or river). (EPA, 2023.)

2. **What is the Watershed Protection, Monitoring, and Outreach Project?**
The Project aims to support and enhance the ongoing protection and preservation of the Willamette River as a drinking water source for the region. The WIF Commission will undertake a variety of long- and short-term activities to achieve this goal. Protection activities will center around the following themes:
    - Engage in outreach and education initiatives and partnership-building
    - Promote information exchange amongst stakeholders to track data on issues such as pollutants, hazards, and policy changes
    - Acquire grants, loans, and other funding for source water protection projects
    - Invest in monitoring technology and communications networks to identify emergencies and contamination events within the Willamette River, protecting public health.

3. **Why is this Project needed?**
Safe drinking water is a result of effective treatment and well managed distribution systems, but it is also dependent upon high-quality sources of water. Source water protection is one of the first critical barriers to drinking water contamination(AWWA, 2023). The potential for contamination grows as urbanization and industrial development expand. Other challenges like a shifting climate, reduced surface and groundwater supplies, and a growing Willamette Valley region require us to take steps now to help secure enough water to support our growing communities and to be prepared in the case of an emergency event.

4. **Is it safe to use the Willamette River as a drinking water source?**
Yes. The City of Wilsonville has been using the Willamette River as a drinking water source since 2002, and the City of Sherwood since 2011. Extensive testing conducted on the Willamette River has shown it to be a high quality and highly treatable source for drinking water. Annual water quality reports from both cities show their drinking water meets or exceeds state and federal water quality standards.

5. **What are the benefits of protecting the Willamette River as a drinking water source?**
As the region experiences irregular storm events, prolonged dry seasons, a growing community, and shrinking groundwater supplies, new water supplies are needed to ensure a resilient future. Securing the Willamette River as a drinking water source offers several benefits to the region:
    - Excellent finished water quality
    - A more seismically resilient supply
    - Ownership and control of the supply by local agencies and cities
    - Year-round reliability
    - A healthier natural ecosystem for the benefit of all river users

Frequently Asked Questions

6. **Who funds this Project?**
   The Project is funded by the WIF Commission's six agency partners: TVWD, and the cities of Hillsboro, Wilsonville, Tigard, Sherwood, and Beaverton. The WIF Commission is also exploring other funding options to support the WIF Commission's initiatives.

7. **Where will protection and enhancement activities be performed?**
   While we aim to preserve and enhance the health of the entire Willamette River Basin, many activities associated with this Project will be specifically focused on the stretch of river between Wilsonville and Salem, which is nearest to the Willamette Intake Facility located at Wilsonville.

8. **Which cities receive drinking water from the Willamette currently?**
   The City of Wilsonville has been using the Willamette River as a drinking water source since 2002, and the City of Sherwood since 2011. **Extensive testing of the Willamette River has shown it to be a safe drinking water source.** TVWD and the cities of Hillsboro and Beaverton are slated to begin receiving water in 2026 via the new Willamette Water Supply System.

9. **How will the Project benefit public health?**
   We're committed to supporting a healthy Willamette River. The Commission will identify existing, emerging, and potential risks that may impact water quality prior to treatment. Through increased partner communications and monitoring technology, we can identify a contamination event more efficiently and earlier, promoting the health of our communities. Protecting the river as a drinking water source will also help to keep it enjoyable for all users and protect the health of the natural environment.

10. **Doesn't DEQ already set standards for water quality in the Willamette River?**
    For decades, DEQ has done extensive source water protection work to promote high-quality drinking water in Oregon. We know that it is challenging for one organization to do it alone. The health of the Willamette River is everyone's responsibility. Through this Project, we will support DEQ's vital efforts to maintain a safe and reliable water supply.

11. **How is this related to the Willamette Water Supply System (WWSS)?**
    The Willamette Water Supply System is slated for completion in 2026. It is a drinking water infrastructure system that will provide treated water from the Willamette River to TVWD, Hillsboro, and Beaverton with a seismically resilient water supply designed to meet future demand and provide an additional drinking water supply in case of an emergency event. The WWSS will provide an additional source of safe water to more than 400,000 customers. This Project directly addresses the quality of the source water for these customers.

Frequently Asked Questions

Specific for Stakeholder Groups

1. **Will source water protection activities prevent what I can do on my property?**
   We want to learn from, listen to, and collaborate with other interested stakeholders, including property owners and rivers users. The health of the Willamette River is key to the wellbeing of our region. The WIF Commission is a resource for property owners, helping to equip them with information about how to best protect the river's health.

2. **Will there be limits to what recreation activities can be done on the Willamette?**
   We understand there is a careful balance required between promoting the health of the river and the interests of recreationalists who enjoy its benefits. We're committed to working closely with recreationists to listen, learn, and collaborate on mutually beneficial source water protection efforts.

3. **How will this impact drinking water providers?**
   Clean source water benefits all drinking water providers. The WIF Commission hopes to collaborate with drinking water providers to find innovative solutions to protect the Willamette River and safeguard a sustainable water future for our region and customers.

4. **How will this Project impact the agriculture community?**
   We are committed to building strong partnerships with the agricultural community and engaging in continuous communication as the Project takes shape to identify mutually beneficial land and agricultural management practices. Together we can protect the Willamette River for agriculture and safeguard a sustainable water future for our region.

5. **How will source water protection activities impact the tribal community?**
   Salmon, in particular, have great cultural, economic, and recreational significance in the Willamette Valley. Maintaining the health and vitality of the Willamette River positively impacts the entire natural ecosystem, including various fish species that some communities rely on for sustenance. We are committed to partnering with the tribal community to learn, listen, and find innovative solutions to promote the river's vitality for decades.

6. **Will source water protection activities raise customers' drinking water rates?**
   Protection of drinking source water is a core function and operational expense of all water providers as contaminants must be either prevented or treated for drinking water. Impacts to drinking water rates will be determined as source water protection initiatives are identified. Protecting source water from contamination helps reduce treatment costs and may avoid or defer the need for complex treatment.

7. **Are there funding opportunities available from the WIF Commission?**
   At this time funding opportunities have not been developed. The WIF Commission is committed to seeking out grants, loans, and other funding for source water protection initiatives and implementation. The Commission would like to learn more about funding needs of stakeholders/potential partners in order to advance shared goals aimed at safeguarding, maintaining, and improving the quality and/or quantity of sources of drinking water where funding could be leveraged.

For more information, please visit Willamette Intake Facilities Commission, Tualatin Valley Water District Oregon at **tvwd.org.**

Brand Identity

Effective brands inspire trust and confidence, and reflect your mission, vision, and core values. The following section is designed to ensure consistent use of the Commission's brand across communication materials. This promotes alignment in brand use across partner agencies.

Brand Identity

Logo

The logo is a symbol of our identity, a creative illustration of our commitment to holistic watershed health. The logomark showcases our collaboration efforts that center around the watershed. The colors and gradients give a modern represention of the natural Pacific Northwest region colors.

This logo also has all-black, all-white and reverse color options dependent on the background where it's being used.

COLOR

BLACK

REVERSE

WHITE

Color Palette

The use of color on communication materials should be limited to the approved brand colors using the primary palette and accent colors.

Colors are listed in several color forms. CMYK is used for print, RGB are used for digital, and HEX numbers are used for web, email, video, and any other on screen use.

PRIMARY

R0 G122 B145	R71 G168 B191	R158 G181 B181	R3 G15 B38
C87 M39 Y34 K5	C68 M16 Y20 K0	C39 M19 Y26 K0	C90 M80 Y54 K71
HEX: #007A91	HEX: #47A8BF	HEX: #9EB5B5	HEX: #030F26

ACCENTS

R138 G194 B64	R74 G61 B115
C51 M2 Y100 K0	C83 M86 Y27 K13
HEX: #8AC240	HEX: #4A3D73

Brand Identity

Typography

Century Gothic is used on all branded collateral such as recruiting materials, social media, website, and outreach materials. *Calibri* can be used for all Microsoft templates, such as Word, PowerPoint and Excel. This font is a system default font so every computer will show the same design.

You can use this Communications Plan as an example for how to use the fonts in an appropriate heirachy.

Century Gothic

Century Gothic Regular
AaBbCc123

Century Gothic Italic
AaBbCc123

Century Gothic Bold
AaBbCc123

Century Gothic Bold Italic
AaBbCc123

Calibri

Calibri Regular
AaBbCc123

Calibri Italic
AaBbCc123

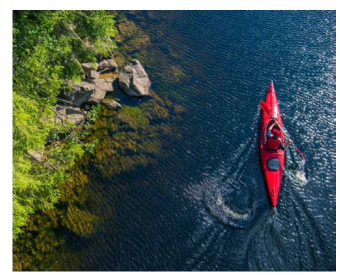
Calibri Bold
AaBbCc123

Calibri Italic
AaBbCc123

Iconography and Photography

Custom iconography can be used to make materials more inviting. The icons were all created in two different color tones that can be swapped out based on the design.

A photo library of stock photos has been created for staff use. We emphasize showing bright, colorful imagery that pairs with the color palette. We recommend showing people, recreation, agriculture, and the other areas that reflect the various benefits of the Willamette River.



Engagement Strategies

Engagement Strategies

Water Quality Protection is one of three pillars upholding the Commission's Mission and Vision, as referenced on page 3 of this document. The six goals below support the realization of the Water Quality Protection Pillar. The stakeholder engagement strategies proposed on the following page are informed by these goals, in addition to the technical risks, needs, and opportunities outlined earlier in this document.

Develop and maintain a state and regionally supported source water protection plan.

Promote information exchange amongst stakeholders, tracking relevant data on emerging issues such as contaminants, natural hazards, and regulatory changes.

Enable WIF Commission members to serve as water quality experts and represent the Commission's interests.

Acquire grants, loans, and funding in support of source water protection plan implementation.

Lead outreach and education on the Willamette River Basin history and current and future needs for protection.

Invest in monitoring technology and communication networks to detect and provide early incident notifications.

Engagement Strategies

Several key components of the source water protection plan have been identified already in the technical sections of this document. These are listed below. The engagement strategies proposed in Table 1 align with these key components to address and advance them.

1. *Emergency Response (spills, wildfires, etc.)*
2. *Knowledge Sharing*
3. *Water Quality Monitoring*
4. *Funding Opportunities*
5. *Septic System Management*
6. *Agricultural Pollution Prevention*
7. *Legislative Advocacy*
8. *Education & Engagement*

Table 1. Willamette Intake Facilities Engagement Strategies

Activities outlined in Phase 1 are anticipated to commence during year one. The information and feedback gathered during Phase 1 will shape subsequent phases. The strategies and timeframes below may necessarily change with shifts in stakeholder interests, dynamics, and needs and with the WIF Commission's capacity.

Stakeholder Group	Components of Source Water Protection Plan	Supporting Measures	Phases	Example Performance Indicators
Water Resources Agencies	• Emergency Response • Knowledge and Data Sharing • Monitoring Systems/ Protocols • Legislative Advocacy Opportunities • Funding Opportunities	1. Hold in-person or virtual meetings to serve as a regional leader and collaborator in source water protection for knowledge and information sharing.	Phase 1	• How many meetings with this group has the Commission led each year? How many water resources agencies are engaged through these meetings? • Is there active communication about emergency preparedness? Is there a formal coordination plan in place for emergency response? • Have there been formal collaborations on funding opportunities? If so, how many dollars have been leveraged through these partnerships? • What are the data needs of water resources agencies? Has the Commission helped to fill data gaps over time?
		2. Promote information sharing about emergency preparedness amongst operators and other staff.	Phase 1	
		3. Identify information sharing systems about monitoring data.	Phase 1	
		4. Identify opportunities to partner on funding proposals.	Phase 3	

Engagement Strategies

Stakeholder Group	Components of Source Water Protection Plan	Supporting Measures	Phases	Example Performance Indicators
County and State Agencies	• Emergency Response • Knowledge Sharing • Monitoring Systems/ Protocols • Septic System Management • Funding Opportunities • Legislative Advocacy	1. Lead discovery meetings with county and state agencies to identify key collaboration opportunities.	Phase 1	• How many meetings with this group has the Commission led each year? How many county or state agencies are engaged through these meetings? • Is there active communication about emergency preparedness? Is there a formal coordination plan in place for emergency response? • Have there been formal collaborations on funding opportunities? If so, how many dollars have been leveraged through these partnerships?
		2. Create schedule to keep in contact with county and state agencies.	Phase 1	
		3. Promote information sharing about emergency preparedness with county and state emergency response agencies.	Phase 1	
		4. Identify ways to partner on funding opportunities – or to stay apprised of them.	Phase 3	
		5. Develop a plan for monitoring efforts, water quality, and data sharing across agencies.	Phase 1	
		6. Collaborate regarding programs and resources for septic system maintenance.	Phase 2	
		7. Engage in legislative advocacy efforts collaboratively to promote source water protection.	Phase 3	
Agricultural Groups	• Agricultural Pollution Prevention • Septic System Management • Legislative Advocacy	1. Lead discovery meetings with agricultural groups to identify key collaboration opportunities.	Phase 1	• How many meetings with this group has the Commission led each year? How many agricultural stakeholders are engaged through these meetings? • How much source water protection-related information is coming from the Commission and getting to landowners via partners? • What is the level of landowner awareness around source water protection activities landowners can perform? Has the awareness changed over time?
		2. Create schedule to keep in contact with agricultural groups.	Phase 1	
		3. Explore legislative advocacy opportunities via partnerships.	Phase 3	
		4. Collaborate to educate and encourage septic system maintenance with landowners.	Phase 1	
		5. Collaborate to incentivize/educate on septic system maintenance with landowners.	Phase 1	
Tribal Communities	• Knowledge Sharing	1. Continue to develop contacts within Tribal communities, hold conversations, and understand desired level of communication.	Phase 1	• How many times annually has the Commission connected with key Tribal communities? • Has their interest in engaging in the Commission's activities shifted over time? • Have partnership opportunities for certain activities formally been established with a Tribe?
		2. Create schedule to keep in contact with Tribal communities to solicit their input about source water protection collaboration.	Phase 1	

Engagement Strategies

Stakeholder Group	Components of Source Water Protection Plan	Supporting Measures	Phases	Example Performance Indicators
Non-Governmental Organizations	• Information Sharing • Education Opportunities	1. Create schedule to keep in contact with NGO groups.	Phase 2	• How many NGOs have reached out to the Commission for leadership or resources? • Is this group clear about how they can partner with the Commission? Do they understand how to access the Commission as resource?
		2. Collaborate on youth, adult, and landowner education opportunities.	Phase 3	
Public Outreach	• Education for Youth, Adults, and Landowners.	1. Open house series in Washington County associated with new WWSS integration to encourage stewardship.	Phase 3	• Does the website and social media include information about source water protection and WIF Commission messaging? How often is this content viewed? • How many adults/youth are being reached annually related to source water protection from Commission activities? Is there a measurement mechanism in place? • How many academic institutions or academics has the Commission engaged annually about source water protection?
		2. Collaborate with NGOs and schools on youth and adult stewardship education.	Phase 3	
		3. Bolster WIF Commision's online presence.	Phase 3	
		4. Identify opportunities to partner with academic institutions to use the Commission's source water protection work as model for information sharing and convening.	Phase 3	
		5. Create Annual Report/summary of activities for transparency to stakeholders.	Phase 3	
		6. Identify partners to cross promote the Commission's messaging.	Phase 3	
Elected Official Outreach	• Legislation and Advocacy	1. Identify relevant regional elected officials. Create schedule to keep in contact with their representatives.	Phase 3	• How many elected officials has the Commission engaged with annually? • What is their position on source water? Has it changed over time?
		2. Send briefing packet to staffers when plan is released.	Phase 3	

Appendix A

Stakeholder List

Organization Name	Organization Type	Stakeholder Type
Associated Oregon Hazelnut Industries	Nongovernmental Organization	Policy Advocacy
Audubon Society of Portland (and other Oregon chapters)	Nongovernmental Organization	Watershed/ Environmental Protection
Benton Soil and Water Conservation District	State Government	Natural Resource Manager
Bureau of Land Management	Federal Government	Natural Resource Manager
Canby Utility	Municipal Utility	Water Resources Agencies - Other
Center for Resources and Environmental Sicence & Technologies (CREST)	Education/Research Institution	Watershed/ Environmental Protection
Center for Sustainable Economy	Nongovernmental Organization	Policy Advocacy
City of Adair Village	Municipal Utility	Water Resources Agencies - Willamette
City of Albany	Municipal Utility	Discharger
City of Corvallis	Municipal Utility	Water Resources Agencies - Willamette
City of Cottage Grove	Municipal Utility	Water Resources Agencies - Other
City of Creswell	Municipal Utility	Water Resources Agencies - Willamette
City of Durham	Municipal Utility	Customer
City of King City	Municipal Utility	Customer
City of Milwaukie	Municipal Utility	Water Resources Agencies - Other
City of Newberg	Municipal Utility	Water Resources Agencies - Other
City of Portland Bureau of Environmental Services	Municipal Utility	Discharger
City of Portland Water Bureau	Municipal Utility	Water Resources Agencies - Other
City of Salem	Municipal Utility	Discharger
City of Salem	Municipal Utility	Water Resources Agencies - Other
City of Tualatin	Municipal Utility	Water Resources Agencies - Other
Clackamas County Soil and Water Conservation District	State Government	Natural Resource Manager
Clackamas River Water Providers	Municipal Coalition	Water Resources Agencies - Other
Clackamas Water Environment Services	Municipal Utility	Discharger
Clean Water Services	Municipal Utility	Discharger

Stakeholder List

Organization Name	Organization Type	Stakeholder Type
Confederated Tribes of Grand Ronde	Tribal Government	Natural Resource Manager
Confederated Tribes of Warm Springs	Tribal Government	Natural Resource Manager
East Multnomah Soil and Water Conservation District	State Government	Natural Resource Manager
Eugene Water and Electric Board	Municipal Utility	Water Resources Agencies - Other
Joint Water Commission	Municipal Utility	Water Resources Agencies- Other
Kinder Morgan	Private Business	Facility Operator
Lake Oswego-Tigard Partnership	Municipal Coalition	Water Resources Agencies- Other
League of Oregon Cities	Municipal Coalition	Policy Advocacy
Linn Soil and Water Conservation District	State Government	Natural Resource Manager
Manufacturing Council of Oregon	Trade Association	Policy Advocacy
Marion Soil and Water Conservation District	State Government	Natural Resource Manager
Metro	State Government	Natural Resource Manager
Metropolitan Wastewater Management Commission (MWMC)	Municipal Coalition	Discharger
Native Fish Society	Nongovernmental Organization	Watershed/ Environmental Protection
Natural Resource Conservation Service	Federal Government	Technical/Financial Assistance Provider
Nesika Wilamut	Nongovernmental Organization	Watershed/ Environmental Protection
Network of Oregon Watershed Councils	Nongovernmental Organization	Watershed/ Environmental Protection
NOAA Fisheries	Federal Government	Natural Resource Manager
Northwest Environmental Advocates	Nongovernmental Organization	Policy Advocacy
Oregon Association of Clean Water Agencies	Nongovernmental Organization	Policy Advocacy
Oregon Association of Nurseries	Nongovernmental Organization	Policy Advocacy
Oregon Department of Geology and Mineral Industries	State Government	Natural Resource Manager
Oregon Dept of Agriculture	State Government	Regulatory Agency
Oregon Dept of Environmental Quality	State Government	Regulatory Agency
Oregon Dept of Forestry	State Government	Regulatory Agency
Oregon Farm Bureau	Nongovernmental Organization	Policy Advocacy
Oregon Farm Service Agency	Federal Government	Technical/Financial Assistance Provider
Oregon Federal Legislators	Federal Government	Policy Advocacy
Oregon Fish & Wildlife Service	State Government	Natural Resource Manager

Stakeholder List

Organization Name	Organization Type	Stakeholder Type
Oregon Health Authority	State Government	Regulatory Agency
Oregon State Legislators	State Government	Policy Advocacy
Oregon Water Resources Dept	State Government	Natural Resource Manager
Oregon Water Utility Council	Nongovernmental Organization	Policy Advocacy
Oregon Watershed Enhancement Board	State Government	Technical/Financial Assistance Provider
Oregon Watershed Enhancement Board	State Government	Natural Resource Manager
Oregon Department of Transportation		
OSU Mid Willamette Valley Small Farms Program	Education/Research Institution	Technical/Financial Assistance Provider
Polk Soil and Water Conservation District	State Government	Natural Resource Manager
Regional Water Providers Consortium	Municipal Coalition	Water Resources Agencies - Other
Special Districts Association of Oregon	Municipal Coalition	Policy Advocacy
Tree For All	Nongovernmental Organization	Watershed/ Environmental Protection
Trout Unlimited	Nongovernmental Organization	Watershed/ Environmental Protection
Tualatin Riverkeepers	Nongovernmental Organization	Watershed/ Environmental Protection
Tualatin Soil and Water Conservation District	State Government	Natural Resource Manager
United States Environmental Protection Agency	Federal Government	Regulatory Agency
United States Geological Survey	Federal Government	Natural Resource Manager
Upper Willamette Soil & Water Conservation District	State Government	Natural Resource Manager
US Army Corps of Engineers	Federal Government	Natural Resource Manager
Water Environment Federation	Nongovernmental Organization	Policy Advocacy
WaterWatch Oregon	Nongovernmental Organization	Policy Advocacy
Wild Salmon Center	Nongovernmental Organization	Watershed/ Environmental Protection
Willamette Partnership	Nongovernmental Organization	Watershed/ Environmental Protection
Willamette River Water Coalition	Municipal Coalition	Water Resources Agencies - Willamette
Willamette Riverkeeper	Nongovernmental Organization	Watershed/ Environmental Protection
Willamette Water Supply Program	Municipal Coalition	Water Resources Agencies - Willamette
Yamhill Soil and Water Conservation District	State Government	Natural Resource Manager
Emergency Management Departments	County Government	Emergency Response Partner
Commercial Timber	Private Business	Landowner

WILLAMETTE INTAKE FACILITIES COMMISSION

Prepared by Water Systems Consulting

Appendix 1-C

Summary of Vendor Quotes

YSI - Vendor Quote October 2023

Parameter	Monitoring Instrument	Sample Type	Example	Cost	Notes
Temperature	Multiparameter Sonde	In-situ	EXO2	$ 21,000.00	
Conductivity	Multiparameter Sonde	In-situ		$ -	
Dissolved Oxygen	Multiparameter Sonde	In-situ		$ -	
pH	Multiparameter Sonde	In-situ		$ -	
Turbidity	Multiparameter Sonde	In-situ		$ -	
Chlorophyll-a	Multiparameter Sonde	In-situ		$ -	
Phycocyanin	Multiparameter Sonde	In-situ		$ -	Included with above
Hydrocarbon	Individual Probe	In-situ	Cyclops-7F	$ 10,000.00	
UV254	Individual Probe	In-situ	NiCaVis 701 IQ NI (YSI/Xylem)	$ 30,000.00	
SCADA Interface System	N/A	N/A	Campbell CR6	$ 10,000.00	
Data hosting	N/A	N/A	N/A	$ 1,000.00	annually
Total				**$ 72,000.00**	

Buoy System - Basic, for sonde	N/A	N/A	EMM68 EXO	$ 20,000.00	
Cellular Telemetry Unit	N/A	N/A	N/A	$ 10,000.00	
Data hosting	N/A	N/A	N/A	$ 1,000.00	annually
Same as above	Probes/Sonde	In-situ	Above	$ 61,000.00	
Total				**$ 92,000.00**	

Buoy System - Complex, for all devices	N/A	N/A	EMM700 EXO	$ 60,000.00	

Hach - Vendor Quote October 2023

Parameter	Monitoring Instrument	Sample Type	Example	Cost	Notes
Temperature	Individual Probe	In-situ	DPD1R1	$ 1,357.00	
Conductivity	Individual Probe	In-situ	D3725E2T	$ 1,477.00	
Dissolved Oxygen	Individual Probe	In-situ	LDO sc Model 2	$ 2,996.00	
pH	Individual Probe	In-situ	DPD1R1	$ -	Included with Temp Probe
Turbidity	Individual Probe	In-situ	Solitax t-line sc	$ 5,506.00	
Chlorophyll-a	Spectrophotometer	Lab-instrument	DR6000 UV VIS	$ 13,665.00	

Phycocyanin	Spectrophotometer	Lab-instrument	DR6000 UV VIS	$ -	Included with Chlorophyll-a Spectrophotometer
Hydrocarbon	Individual Probe	In-situ	FP360 sc	$ 25,987.00	
UV254	Individual Probe	In-situ	UVAS plus sc UV Sensor	$ 25,383.00	
SCADA Interface System	N/A	N/A	SC1000, SC45000, and adapters	$ 48,524.05	
Data hosting service	N/A	N/A	RIO SAMPSVC, DIMPRT-CNFG, RIO-GS-L	$ 15,900.00	
Data hosting subscription	N/A	N/A	RIO Subscription	$ 29,875.00	annually
Total				**$ 170,670.05**	

In-SItu - Vendor Quote October 2023

Parameter	Monitoring Instrument	Sample Type	Example	Cost	Notes
Temperature	Multiparameter Sonde	In-situ	MPX4	$895.00	
Conductivity	Multiparameter Sonde	In-situ		-	Included with Temperature
Dissolved Oxygen	Multiparameter Sonde	In-situ		$1,095.00	
pH	Multiparameter Sonde	In-situ		$795.00	
Turbidity	Multiparameter Sonde	In-situ		$1,095.00	
Chlorophyll-a	Multiparameter Sonde	In-situ		$1,995.00	
Phycocyanin	Multiparameter Sonde	In-situ		$1,995.00	
Hydrocarbon	N/A	N/A	N/A	N/A	N/A
UV254	Online analyzer	Flow-through Unit	ChemScan Mini Analyzer	$20,000.00	
Multiparameter Sonde Unit	Multiparameter Sonde	N/A	MPX4	$5,790.00	
SCADA Interface System	N/A	N/A	7300 Monitor	$1,895.00	
Other instrumentation	N/A	N/A	N/A	$6,030.00	
Total				**$41,585.00**	

Buoy System	N/A	N/A	BOB-TB-v1	$2,750.00	
Cellular Telemetry Unit	N/A	N/A	VuLink	$1,010.00	
Data hosting	N/A	N/A	HydroVu	$420.00	Annually
Same as above	N/A	N/A	Aqua TROLL 700	$11,865.00	
Other instrumentation	N/A	N/A	N/A	$1,454.75	
Total				**$17,499.75**	

Detailed Cost Assumptions

Assumptions

1	$ 30.00	Assumed average operator rate
2	0.30	Assumed 30% contingency
3	9.00	Devices
4	$ 70,000.00	Annual fee to USGS for monitoring equipment at upstream location, provided by USGS

Maintenance Schedule - Yr 1

Task	Hours	Frequency/Yr	Total Hours	Cost	Notes
Sensor Cleaning	1	52	52	$ 1,560.00	
Calibration	1	12	108	$ 3,240.00	Assume calibrating all devices each time
Checking	1	52	52	$ 1,560.00	
Replacement	4	0.5	2	$ 60.00	
Total			**214**	**$ 6,420.00**	
Buoy Maintenance				$ 12,840.00	Assume twice as much effort, due to remote location

Maintenance Schedule - Yr 2+

Task	Hours	Frequency/Yr	Total Hours	Cost	Notes
Sensor Cleaning	1	26	26	$ 780.00	
Calibration	1	6	54	$ 1,620.00	
Checking	1	26	26	$ 780.00	
Replacement	4	0.5	4	$ 120.00	Assume replace 2 sensors/yr
Total			**110**	**$ 3,300.00**	
Buoy Maintenance				$ 6,600.00	Assume twice as much effort, due to remote location

YSI - Detailed Cost Breakdown

YSI - Intake

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Equipment Purchase Cost	$ 72,000.00	$-	$ 16,000.00	$ 16,000.00	$ 16,000.00	$ 16,000.00	$ 16,000.00	$ 16,000.00	$16,000.00	$16,000.00
Subscription Costs	$ 1,000.00	$ 1,000.00	$ 1,000.00	$ 1,000.00	$ 1,000.00	$ 1,000.00	$ 1,000.00	$ 1,000.00	$ 1,000.00	$ 1,000.00
Annual O&M Costs	$ 6,420.00	$ 3,300.00	$ 3,300.00	$ 3,300.00	$ 3,300.00	$ 3,300.00	$ 3,300.00	$ 3,300.00	$ 3,300.00	$ 3,300.00
Contingency	$23,826.00	$1,290.00	$6,090.00	$6,090.00	$6,090.00	$6,090.00	$6,090.00	$6,090.00	$6,090.00	$6,090.00
Total Project Cost	$103,246.00	$5,590.00	$26,390.00	$26,390.00	$26,390.00	$26,390.00	$26,390.00	$26,390.00	$26,390.00	$26,390.00

YSI - Upstream

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Equipment Purchase Cost	$ -	$ -	$ -	$ 92,000.00	$-	$ 16,000.00	$ 16,000.00	$ 16,000.00	$16,000.00	$16,000.00
Subscription Costs	$ -	$ -	$ -	$ 1,000.00	$ 1,000.00	$ 1,000.00	$ 1,000.00	$ 1,000.00	$ 1,000.00	$ 1,000.00
Annual O&M Costs	$ -	$ -	$ -	$ 12,840.00	$ 6,600.00	$ 6,600.00	$ 6,600.00	$ 6,600.00	$ 6,600.00	$ 6,600.00
Contingency	$ -	$ -	$ -	$31,752.00	$2,280.00	$7,080.00	$7,080.00	$7,080.00	$7,080.00	$7,080.00
Total Project Cost	$0.00	$0.00	$0.00	$137,592.00	$9,880.00	$30,680.00	$30,680.00	$30,680.00	$30,680.00	$30,680.00

YSI Intake - Costs Summarized

	Year 1	Year 5 - Cumulative	Year 10 - Cumulative
Capital Equipment Purchase Cost	$ 72,000.00	$ 120,000.00	$ 200,000.00
Subscription Costs	$ 1,000.00	$ 5,000.00	$ 10,000.00
Annual O&M Costs	$ 6,420.00	$ 19,620.00	$ 36,120.00
Contingency	$ 23,826.00	$ 43,386.00	$ 73,836.00
Total Project Cost	$103,246.00	$ 188,006.00	$ 319,956.00

Rounded

	Year 1	Year 5 - Cumulative	Year 10 - Cumulative
Capital Equipment Purchase Cost	$72,000	$120,000	$200,000
Subscription Costs	$1,000	$5,000	$10,000
Annual O&M Costs	$7,000	$20,000	$37,000
Contingency	$24,000	$44,000	$74,000
Total Project Cost	$104,000	$189,000	$321,000

YSI Upstream - Costs Summarized

	Year 1	Year 5 - Cumulative	Year 10 - Cumulative
Capital Equipment Purchase Cost	$ -	$ 92,000.00	$ 172,000.00
Subscription Costs	$ -	$ 2,000.00	$ 7,000.00
Annual O&M Costs	$ -	$ 19,440.00	$ 52,440.00
Contingency	$ -	$ 34,032.00	$ 69,432.00
Total Project Cost	$0.00	$ 147,472.00	$ 300,872.00

Rounded

	Year 1	Year 5 - Cumulative	Year 10 - Cumulative
Capital Equipment Purchase Cost	$0	$92,000	$172,000
Subscription Costs	$0	$2,000	$7,000
Annual O&M Costs	$0	$20,000	$53,000
Contingency	$0	$35,000	$70,000
Total Project Cost	$0	$149,000	$302,000

Hach - Detailed Cost Breakdown

Hach - Intake

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Equipment Purchase Cost	$ 140,795.05	$-	$ 15,643.89	$ 15,643.89	$ 15,643.89	$ 15,643.89	$ 15,643.89	$ 15,643.89	$ 15,643.89	$15,643.89
Subscription Costs	$ 29,875.00	$ 29,875.00	$ 29,875.00	$ 29,875.00	$ 29,875.00	$ 29,875.00	$ 29,875.00	$ 29,875.00	$ 29,875.00	$29,875.00
Annual O&M Costs	$ 6,420.00	$ 3,300.00	$ 3,300.00	$ 3,300.00	$ 3,300.00	$ 3,300.00	$ 3,300.00	$ 3,300.00	$ 3,300.00	$ 3,300.00
Contingency	$53,127.02	$9,952.50	$14,645.67	$14,645.67	$14,645.67	$14,645.67	$14,645.67	$14,645.67	$14,645.67	$14,645.67
Total Project Cost	$ 230,217.07	$43,127.50	$63,464.56	$63,464.56	$63,464.56	$63,464.56	$63,464.56	$63,464.56	$63,464.56	$63,464.56

Hach Intake - Costs Summarized

	Year 1	Year 5 - Cumulative	Year 10 - Cumulative
Capital Equipment Purchase Cost	$ 140,795.05	$ 187,726.73	$ 265,946.21
Subscription Costs	$ 29,875.00	$ 149,375.00	$ 298,750.00
Annual O&M Costs	$ 6,420.00	$ 19,620.00	$ 36,120.00
Contingency	$ 53,127.02	$ 107,016.52	$ 180,244.86
Total Project Cost	$230,217.10	$ 463,738.25	$ 781,061.07

Rounded

	Year 1	Year 5 - Cumulative	Year 10 - Cumulative
Capital Equipment Purchase Cost	$141,000	$188,000	$266,000
Subscription Costs	$30,000	$150,000	$299,000
Annual O&M Costs	$7,000	$20,000	$37,000
Contingency	$54,000	$108,000	$181,000
Total Project Cost	$232,000	$466,000	$783,000

In-Situ - Detailed Cost Breakdown

In-Situ - Intake

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Equipment Purchase Cost	$ 41,585.00	$-	$ 9,241.11	$ 9,241.11	$ 9,241.11	$ 9,241.11	$ 9,241.11	$ 9,241.11	$ 9,241.11	$ 9,241.11
Subscription Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Annual O&M Costs	$ 6,420.00	$ 3,300.00	$ 3,300.00	$ 3,300.00	$ 3,300.00	$ 3,300.00	$ 3,300.00	$ 3,300.00	$ 3,300.00	$ 3,300.00
Contingency	$14,401.50	$990.00	$3,762.33	$3,762.33	$3,762.33	$3,762.33	$3,762.33	$3,762.33	$3,762.33	$3,762.33
Total Project Cost	$62,406.50	$4,290.00	$16,303.44	$16,303.44	$16,303.44	$16,303.44	$16,303.44	$16,303.44	$16,303.44	$16,303.44

In-Situ - Upstream

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Equipment Purchase Cost	$ -	$ -	$ -	$ 17,499.75	$-	$ 9,241.11	$ 9,241.11	$ 9,241.11	$ 9,241.11	$ 9,241.11
Subscription Costs	$ -	$ -	$ -	$ 420.00	$ 420.00	$ 420.00	$ 420.00	$ 420.00	$ 420.00	$ 420.00
Annual O&M Costs	$ -	$ -	$ -	$ 12,840.00	$ 6,600.00	$ 6,600.00	$ 6,600.00	$ 6,600.00	$ 6,600.00	$ 6,600.00
Contingency	$ -	$ -	$ -	$9,227.93	$2,106.00	$4,878.33	$4,878.33	$4,878.33	$4,878.33	$4,878.33
Total Project Cost	$0.00	$0.00	$0.00	$39,987.68	$9,126.00	$21,139.44	$21,139.44	$21,139.44	$21,139.44	$21,139.44

In-Situ Intake - Costs Summarized

	Year 1	Year 5 - Cumulative	Year 10 - Cumulative
Capital Equipment Purchase Cost	$ 41,585.00	$ 69,308.33	$ 115,513.89
Subscription Costs	$ -	$ -	$ -
Annual O&M Costs	$ 6,420.00	$ 19,620.00	$ 36,120.00
Contingency	$ 14,401.50	$ 26,678.50	$ 45,490.17
Total Project Cost	$62,406.50	$ 115,606.83	$ 197,124.06

Rounded

	Year 1	Year 5 - Cumulative	Year 10 - Cumulative
Capital Equipment Purchase Cost	$42,000	$70,000	$116,000
Subscription Costs	$0	$0	$0
Annual O&M Costs	$7,000	$20,000	$37,000
Contingency	$15,000	$27,000	$46,000
Total Project Cost	$64,000	$117,000	$199,000

In-SItu Upstream - Costs Summarized

	Year 1	Year 5 - Cumulative	Year 10 - Cumulative
Capital Equipment Purchase Cost	$ -	$ 17,499.75	$ 63,705.31
Subscription Costs	$ -	$ 840.00	$ 2,940.00
Annual O&M Costs	$ -	$ 19,440.00	$ 52,440.00
Contingency	$ -	$ 11,333.93	$ 35,725.59
Total Project Cost	$0.00	$ 49,113.68	$ 154,810.90

Rounded

	Year 1	Year 5 - Cumulative	Year 10 - Cumulative
Capital Equipment Purchase Cost	$0	$18,000	$64,000
Subscription Costs	$0	$1,000	$3,000
Annual O&M Costs	$0	$20,000	$53,000
Contingency	$0	$12,000	$36,000
Total Project Cost	$0	$51,000	$156,000

USGS - Detailed Cost Breakdown

USGS - Intake	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Equipment Purchase Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Subscription Costs	$70,000.00	$ 70,000.00	$ 70,000.00	$70,000.00	$ 70,000.00	$70,000.00	$ 70,000.00	$ 70,000.00	$70,000.00	$70,000.00
Annual O&M Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Contingency	$21,000.00	$21,000.00	$21,000.00	$21,000.00	$21,000.00	$21,000.00	$21,000.00	$21,000.00	$21,000.00	$21,000.00
Total Project Cost	$91,000.00	$91,000.00	$91,000.00	$91,000.00	$91,000.00	$91,000.00	$91,000.00	$91,000.00	$91,000.00	$91,000.00

USGS - Upstream	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Equipment Purchase Cost	$ -	$ -	$ -							
Subscription Costs	$ -	$ -	$ -	$70,000.00	$ 70,000.00	$70,000.00	$ 70,000.00	$ 70,000.00	$70,000.00	$70,000.00
Annual O&M Costs	$ -	$ -	$ -							
Contingency	$ -	$ -	$ -	$21,000.00	$21,000.00	$21,000.00	$21,000.00	$21,000.00	$21,000.00	$21,000.00
Total Project Cost	$ -	$ -	$ -	$91,000.00	$91,000.00	$91,000.00	$91,000.00	$91,000.00	$91,000.00	$91,000.00

USGS - Intake Summarized	Year 1	Year 5 - Cumulative	Year 10 - Cumulative
Capital Equipment Purchase Cost	$0	$0	$0
Subscription Costs	$70,000	$350,000	$700,000
Annual O&M Costs	$0	$0	$0
Contingency	$21,000	$105,000	$210,000
Total Project Cost	$91,000	$455,000	$910,000

Rounded	Year 1	Year 5 - Cumulative	Year 10 - Cumulative
Capital Equipment Purchase Cost	$0	$0	$0
Subscription Costs	$70,000	$350,000	$700,000
Annual O&M Costs	$0	$0	$0
Contingency	$21,000	$105,000	$210,000
Total Project Cost	$91,000	$455,000	$910,000

USGS - Upstream Summarized	Year 1	Year 5 - Cumulative	Year 10 - Cumulative
Capital Equipment Purchase Cost	$0	$0	$0
Subscription Costs	$0	$140,000	$490,000
Annual O&M Costs	$0	$0	$0
Contingency	$0	$42,000	$147,000
Total Project Cost	$0	$182,000	$637,000

Rounded	Year 1	Year 5 - Cumulative	Year 10 - Cumulative
Capital Equipment Purchase Cost	$0	$0	$0
Subscription Costs	$70,000	$140,000	$490,000
Annual O&M Costs	$0	$0	$0
Contingency	$21,000	$42,000	$147,000
Total Project Cost	$91,000	$182,000	$637,000

Appendix 2-A

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Technical Memorandum

Date: 30 June 2022

To: Christina Walter, Joel Cary, Joelle Bennett, and David Kraska, Tualatin Valley Water District

From: Jacob Krall, Jamie Feldman, Jo Lewis, Lindsey Spencer, and Rob Annear, Geosyntec Consultants
Suzanne de Szoeke and Adam Sussman, GSI Water Solutions
Susan Schlangen and Amy Stevens, Water Systems Consulting (WSC)

Subject: Willamette Watershed History, Characterization, and Stakeholders

1. INTRODUCTION

The information provided in this technical memorandum (Memo) is part of a larger effort to develop the Willamette Intake Facilities (WIF) Commission's *Watershed Protection, Monitoring, and Outreach Plan* (Source Water Protection Plan). This Memo presents findings for the first component of the Source Water Protection Plan, including the history of the Willamette watershed, characterization of the watershed, and summary of local and regional stakeholders. Work on additional components of the Source Water Protection Plan will be documented in subsequent memos.

1.1. Background

Water providers in the Willamette Basin have formed agreements to share water resources and often have system connections to meet water demands. Examples of such partnerships include the Joint Water Commission (JWC), the Willamette River Water Coalition, and the WIF Commission.

The WIF Intergovernmental Agreement was entered into by Tualatin Valley Water District (TVWD) and the cities of Wilsonville, Sherwood, Hillsboro, Tigard, and Beaverton. All members are local governments authorized to own, operate, and maintain municipal water supply systems (WIF Commission, 2021a). The cities and TVWD are sometimes referred to as the WIF partners. Collectively, the WIF Commission understands that there are many competing interests in the Willamette River basin and must work effectively to address a multitude of impacts and needs associated with water rights, watershed protection, stakeholder collaboration, and Intake Facilities operations. Its mission is to responsibly secure a safe and reliable drinking water supply for Partner communities while being stewards of the Willamette River watershed. Protecting the health of the Willamette River is an essential responsibility of this and future generations and is an essential need for the wellbeing of the region. Many organizations, agencies, and partners must work together to protect the health and water quality of the Willamette River.

In 2021, the WIF Commission publicly affirmed its vision to become a trusted steward of the Willamette River watershed with the adoption of its Mission, Vision, Values and Goals (MVVG)

Strategic Framework (WIF Commission, 2021b). The Commission further clarified the vision with the following statements: "We apply science, innovation, and advocacy for resilient and clean water stewardship. We improve awareness, provide education, and build support for watershed protection. We advocate at all levels for investment and policy to protect drinking water source quality."

1.2. Purpose and Function of the Watershed Protection, Monitoring, and Outreach Plan

This Memo summarizes the results of the Watershed Assessment Task of the overall Source Water Protection Plan project. The purpose of the Watershed Assessment Task is to summarize Willamette River watershed history, characteristics, and stakeholders. This Watershed Assessment will then be used to inform the Data and Risk Analysis Task of the Watershed Protection, Monitoring, and Outreach Plan, which will be documented in a subsequent memorandum.

Overall, the goal of the Watershed Protection, Monitoring, and Outreach Plan is to identify risks and opportunities to allow for prioritization of projects and initiatives to protect source water quality, both now and in the future, and provide partner agencies with safe, reliable drinking water for their communities. The plan focuses primarily on the mid-Willamette basin immediately upstream of the intake facility, while also considering the full Willamette Basin and its far-reaching impacts (***Figure 1***).

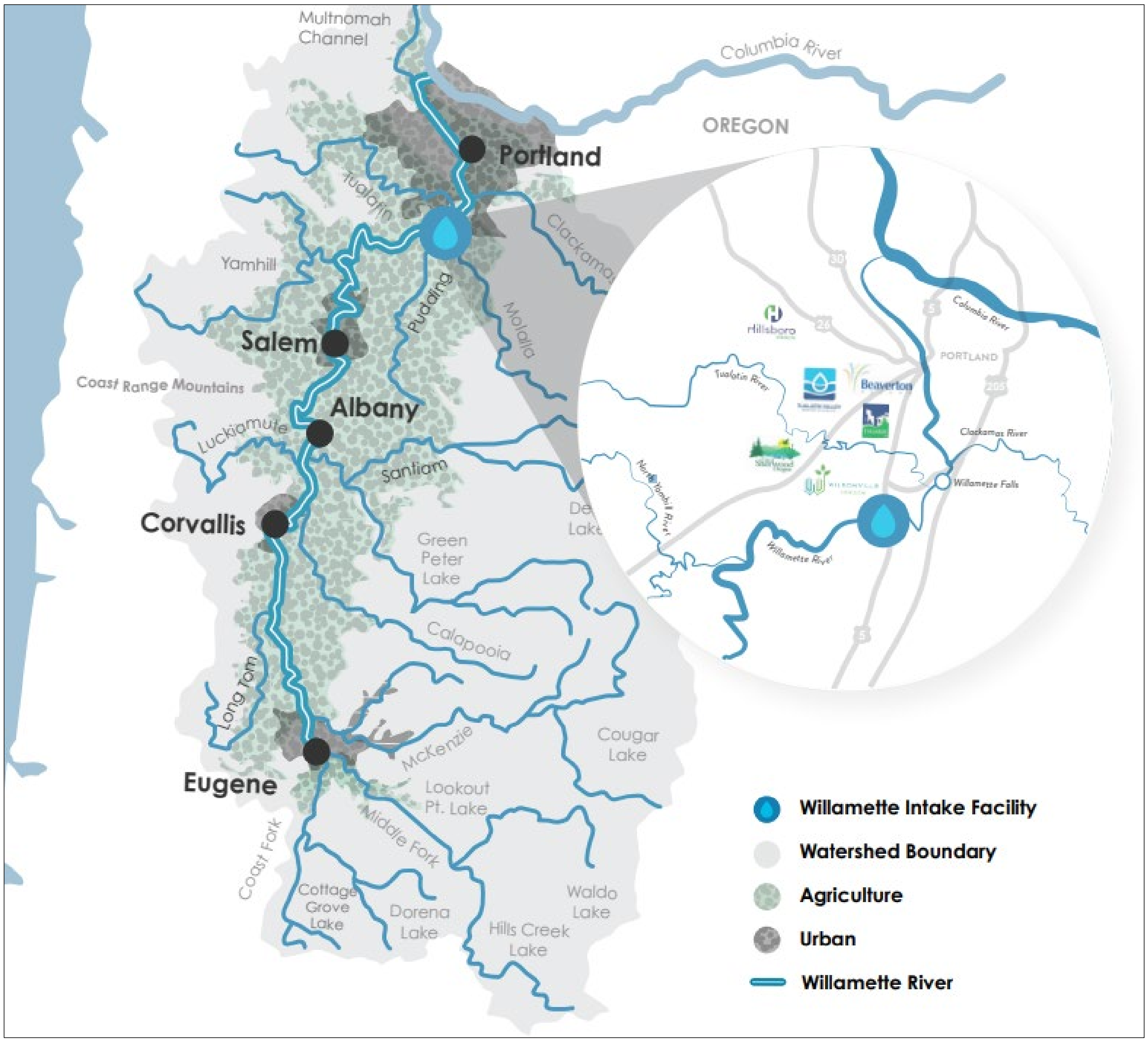

Figure 1: Scope of the Source Water Protection Plan. Reproduced from WIF Commission, 2021b.

Source water protection is a critical component of providing quality drinking water to customers, and an effective Source Water Protection Plan serves multiple purposes: it can help utilities more proactively and cost-effectively meet drinking water standards, identify emerging areas of concern, reduce treatment costs, and prevent taste and odor issues. It results in strengthened stakeholder relationships, promotes environmental efforts, and better prepares the stakeholder community when emergencies, such as wildfires and harmful algal blooms occur. As such, it is an important part of the mission of drinking water utilities.

1.3. Overview of the Willamette River

The Willamette River drains a 11,500 square mile region in northwestern Oregon, accounting for 12% of the total area of the state (Robbins, 2021). The Willamette River Basin contains the Willamette Valley (***Figure 2***), the lowland areas surrounding the river where urban and agricultural land uses dominate, and the majority of the basin's population resides. This region is bounded by the Cascade Range to the east, the Calapooya Mountains to the south, and the Oregon Coast Range to the west (Robbins, 2021). The Willamette Valley is home to over two-thirds of Oregon's population, including its largest city (Portland) and its capital (Salem).

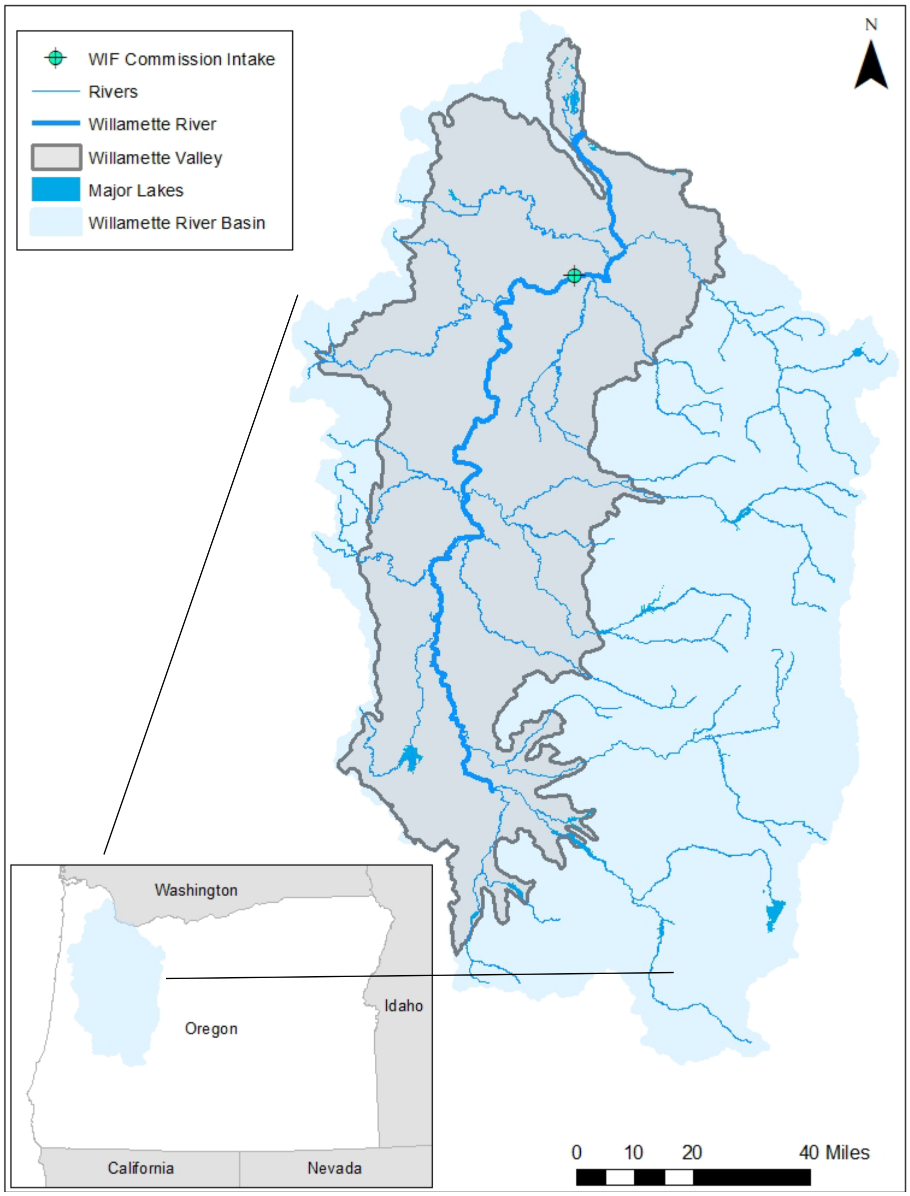

Figure 2: Extent of the Willamette Valley within the Willamette River Basin.

Activities in the basin are diverse and the history of the river itself is complex. For many years, the idea of using the river for drinking water was not considered. Decades of harmful industrial practices had polluted the river so severely that it was not viewed as a resource that could be used for drinking water. Restoration and cleanup efforts of the past thirty years have improved the water quality substantially, and the Willamette River and its tributaries are now used as viable drinking water sources for many communities within the Willamette River Basin.

2. WATERSHED HISTORY

This section provides context for the current state of the Willamette River Basin by providing a history of the watershed through the lens of human perception of and interaction with the river. An overview of key scientific investigations within the basin provides insight to the watershed characteristics that stakeholders hold with high priority and what data gaps may persist.

The following sub-sections discuss how humans have viewed and interacted with the Willamette River since pre-European settlement and how those perceptions have changed with conditions in the basin with a particular focus on hydrology and water quality.

2.1. Changing Perceptions

For thousands of years, the native Kalapuya people, including the Calapooia, Luckiamute, Yamhill, and Clackamas bands, inhabited the Willamette Basin (Sinclair, 2005). They used frequent and carefully timed burns to manage the land in the Willamette Valley for hunting, foraging, and agriculture, keeping much of the land as early successional prairie and oak savannas (Bureau of Environmental Services [BES], n.d.). The Willamette River, thought to mean "green river" (Sinclair, 2005), was used extensively by native people for fishing and navigation. Overall, native peoples' relationships with and practices on the land and river involved only minor alterations and were relatively ecologically stable (Robbins, 2021).

Early Euro-Americans arrived in the Willamette Valley in the 1700s mainly seeking beaver pelts (Sinclair, 2005). More settlers came to Oregon starting in the 1830s, and in large numbers starting in the 1840s and continuing to the end of the 19th century (Robbins, 2021). Settlers planted crops, built towns, and modified the Willamette River for use as a transportation corridor (BES, n.d.). European diseases diminished native populations (Macnaughtan, 2021), and Euro-American settlements along the Willamette River displaced native people as well as their traditional land management practices (Sinclair, 2005 and Robbins, 2021). Eventually, native people in the basin were forcibly removed from their ancestral lands to reservations, namely the Grande Ronde reservation west of Salem (Macnaughtan, 2021).

Euro-American settlers in the Willamette Valley built towns and eventually cities, cultivated crops, and raised livestock in the latter half of the 19th century. They viewed the Willamette River as important for transportation of people and resources, especially for shipping wheat crops to Portland (BES, n.d.). "Snags," or large woody debris, were removed to deepen the river channel and remove obstructions for navigation. A canal and locks were built at Willamette Falls in 1873 to improve river transport to and from Portland (Robbins, 2021).

As populations and cities, including Eugene, Albany, Corvallis, Salem, Springfield, and Portland, grew and settlers invested in urban and agricultural infrastructure along the Willamette River corridor, perceptions of the river changed in two important ways:

First, the Willamette River was seen as a convenient way to dispose of urban and industrial wastes. By the 1920s, the majority of cities discharged untreated domestic and industrial waste into the Willamette River mainstem or its tributaries (Robbins, 2021). The water quality impacts of this practice are discussed in Section 2.2.2.

Second, the unboundedness of the river channel, with its meanders, braids, and frequent floods, was seen as an unpredictable nuisance and danger. In particular, severe floods in 1860 and 1861 emphasized the perceived need to control the river (Payne, 2002). Channel armoring methods, including dikes and revetments, wing deflectors, and levees, were implemented in an attempt to channelize the water. The first dams were built along the Willamette River mainstem in the 1940s, following authorization of the Flood Control Act and subsequent approval of funding for the first seven dams in 1938 (Binus, 2006). The Willamette Valley Project eventually grew to include 13 dams along the mainstem and major tributaries of the river, which were celebrated for providing flood control, flow predictability, recreational opportunities, and pollutant flushing in the late summer months. In total, there are approximately 370 dams within the Willamette River Basin owned and operated by various public and private agencies which provide flood and flow control, irrigation, and other services (Payne, 2002). Further information on the Willamette Valley Project dams is provided in Section 3.5.

Starting in the 1960s and 1970s, perceptions of the river shifted again in recognition of the water quality impairments in the river due to the vast amounts of pollution discharged through urban, industrial, and agricultural activities. Legislation in these decades centered on addressing point sources of pollution including municipal sewage and industrial process water treatment facilities (Robbins, 2021). With more advanced understanding of water quality concerns in the 1990s, it became clear that while addressing point sources of pollution had significantly cleaned the Willamette River, invisible industrial, agricultural, and urban pollutants from the watershed were still pervasive and showing a measurable impact on aquatic species (Robbins, 2021).

Two federal laws play a central role in regulating activities on the Willamette River:

- The Federal Water Pollution Control Act (1948), later amended and renamed the Clean Water Act (CWA) in 1972, gives the United States Environmental Protection Agency (EPA) authority to approve water quality standards for a wide range of pollutants. The CWA also provides a framework allowing the Oregon Department of Environmental Quality (ODEQ) to regulate point source discharges under the National Pollutant Discharge Elimination System (NPDES) program, and provides for ODEQ to impose additional requirements through the Section 401 certification process, among other provisions.

- The Endangered Species Act (ESA, 1973) provides protection for listed species. Willamette River Chinook Salmon and steelhead are listed species. Under the ESA, federal agencies must consider the impact of decisions on these species. Biological Opinions by National Oceanic and Atmospheric Administration (NOAA) Fisheries and the U.S. Fish and Wildlife Service assessed potential impacts of the Willamette Valley Project as part of an ESA consultation process.

State regulations such the Oregon Forest Practices Act, which regulates logging in riparian areas and municipal standards, including development standards for areas near the Willamette River, are also important in protecting the water quality of the River.

The ten counties that are wholly or partially within the Willamette River watershed (Lane, Linn, Benton, Polk, Marion, Yamhill, Washington, Clackamas, Multnomah, and Columbia) are home to approximately 3 million people, out of the total Oregon population of 4.2 million (US Census Bureau, 2021). The Willamette Valley has the largest agricultural production of any part of the state, and it also provides many recreational opportunities for residents. Current efforts to improve water quality in the Willamette River emphasize watershed management strategies to mitigate or eliminate non-point sources of pollution. The continued operation of the Willamette Valley Project is highly debated, with many stakeholder groups calling for major changes in the way the dams are operated, primarily to benefit aquatic life and endangered species (see Section 3.7). In short, residents of the Willamette River basin recognize the many social benefits the watershed provides and seek to manage those resources in a way that can be sustained into the future. Factors that complicate this management, such as fully distributed water rights allocations, impact of dams on fish passage, and climate change, are described in Section 3.

2.2. Changing Conditions

Changing views of the Willamette River and the Basin ultimately influence changes in the condition of the river and its watershed over time as populations interact with the river in manners which reflect their perceptions. The following subsections describe how the perceptions discussed in Section 2.1 impacted and continue to influence hydrology, water quality, and watershed trends in the Willamette River Basin. A visual summary of the hydrologic, anthropologic, and ecologic history of the watershed is provided in ***Figure 3*** .

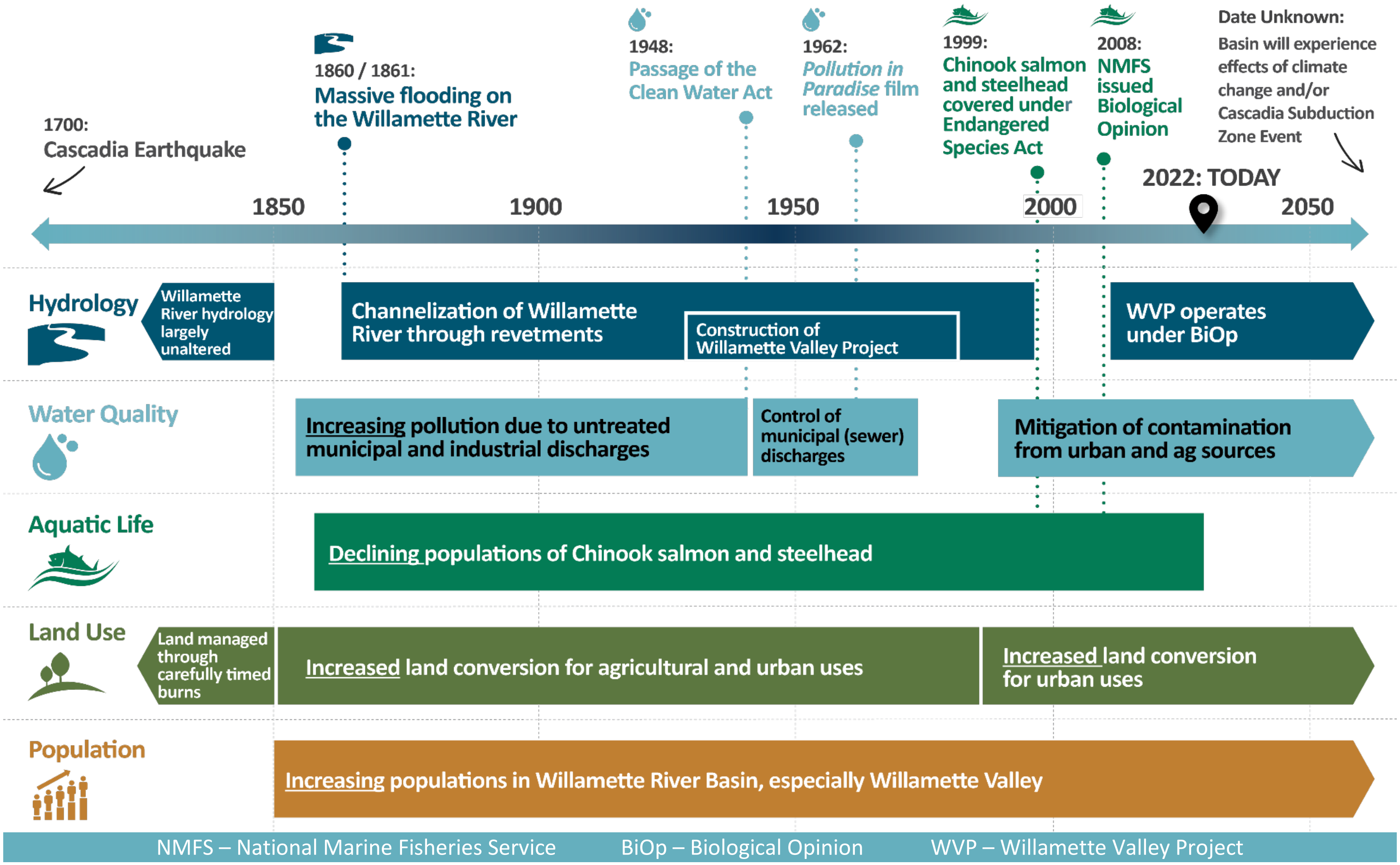

Figure 3: A visual, select history of the Willamette River.

2.2.1. Hydrology

The upper and middle reaches of the Willamette River were historically largely unbounded with many braided channels which meandered over time. The river frequently inundated its floodplain with spring snowmelt. The lower Willamette, from present-day City of Newberg to its confluence with the Columbia River, was historically more limited in its lateral movement by its basalt channel geology (Sinclair, 2005). Though native people frequently interacted with the river and used it extensively for navigation and fishing, it was rarely altered except due to the building of small, temporary weirs and traps for fishing (Robbins, 2021).

As settlers built towns and cities within the Willamette River's floodplains throughout the latter half of the 19th century, the view of the river as a primary navigation and shipping route led to the channelization of the river into one main channel for most of its mainstem length. As mentioned previously, this was initially accomplished through removing large woody debris from the river to deepen the channel and remove obstructions. Other activities, described below, subsequently reinforced this channelization.

The perceived danger and unpredictability of the frequent inundation of the Willamette River's floodplains led to channel armoring by landowners to protect their land from erosion. However, this practice is incompatible with the natural tendencies of rivers—especially the Willamette River in its upper reaches—to meander, flood, and deposit sediment. Over time, the extents of the revetments came to comprise approximately 25% of the length of the Willamette River mainstem, with nearly 65% of revetments located at meander bends or other historically dynamic sections of the river (Pacific Northwest Ecosystem Research Consortium [PNW-ERC], 2002). These revetments further contribute to the channelization of the Willamette River, as well as influence some natural functions of the river, including sediment deposits and hyporheic (groundwater) exchange at the riverbed. These are discussed in more detail in Section 3.3.

Figure 4[1] shows the marked channelization of the Willamette River and the loss of braids and side channels between the Cities of Eugene and Newberg from 1850 to 1995 (Sinclair, 2005). These maps were compiled from reports of high-water marks (1850) and USACE surveys. This same data was used in ***Figure 5*** to graphically depict the proportion of the channel width comprised of main or primary river, side channels, alcoves, and islands. Overall, the Willamette River has lost many of its meandering features, especially in its upper reaches.

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[1] Note that ***Figure 4,*** which is taken directly from Sinclair (2005), shows the Middle Reach of the Willamette River beginning at Albany, Oregon, and ending at Newberg, Oregon. The boundaries between the various reaches of the River are not universally agreed upon. For example, the boundary from the Upper to Middle Willamette River is sometimes taken to be Albany, Oregon, sometimes the confluence with the Santiam River just north of Albany, and sometimes at Salem, Oregon. However, for the remainder of this memorandum, the Middle Willamette River will mean the reach from the confluence with the Santiam River just north of Albany, Oregon, to Willlamette Falls at Oregon City, Oregon, with the Lower Willamette River being downstream of the Falls, and the Upper Willamette River meaning the reach upstream of the confluence with the Santiam River.

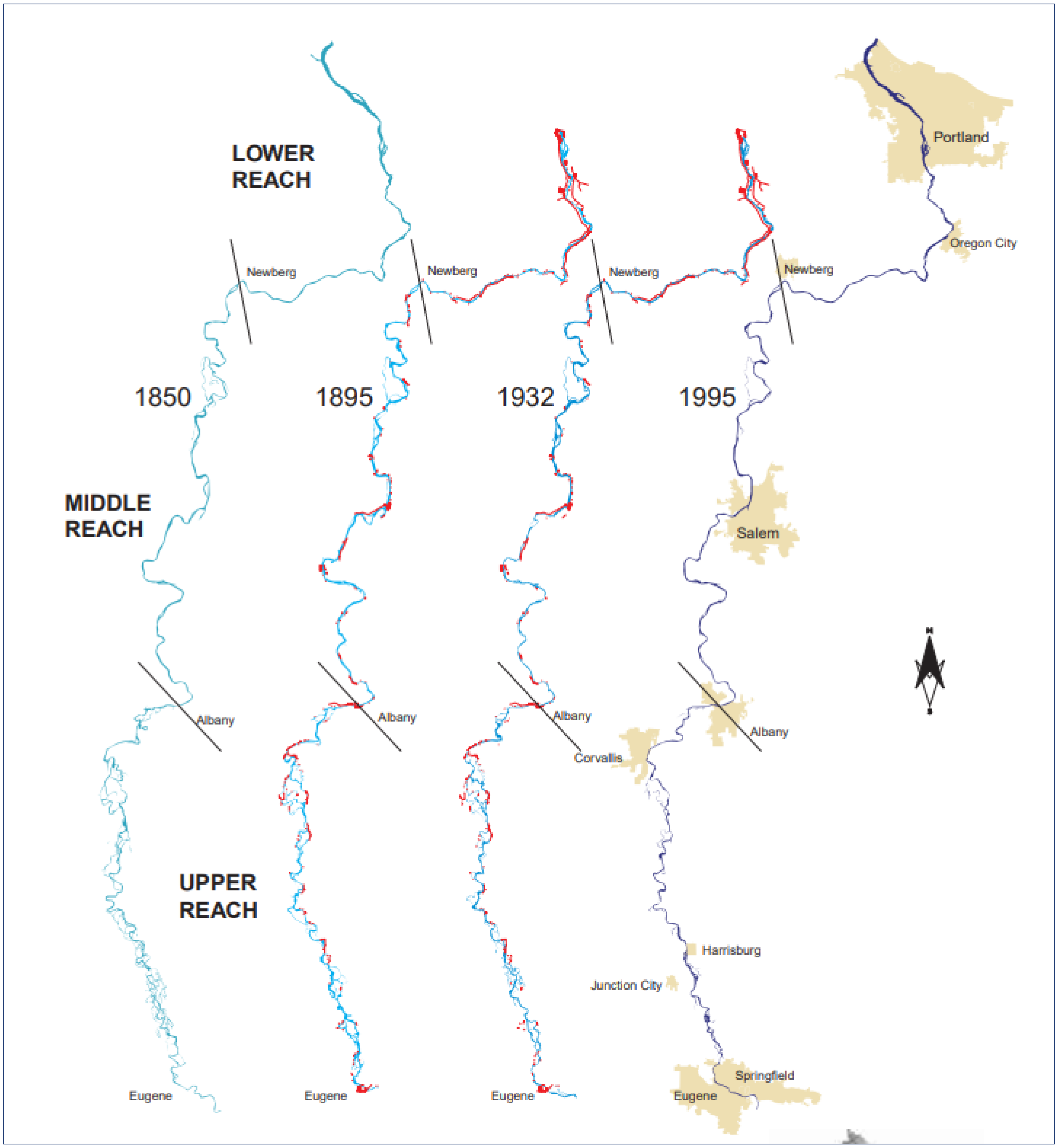

Figure 4. Channelization of the Willamette River from 1850 to 1995. Near-river roads and railroads are shown in red (1895 and 1932); urban growth boundaries are shown in tan (1995). Reproduced from PNW-ERC 2002.

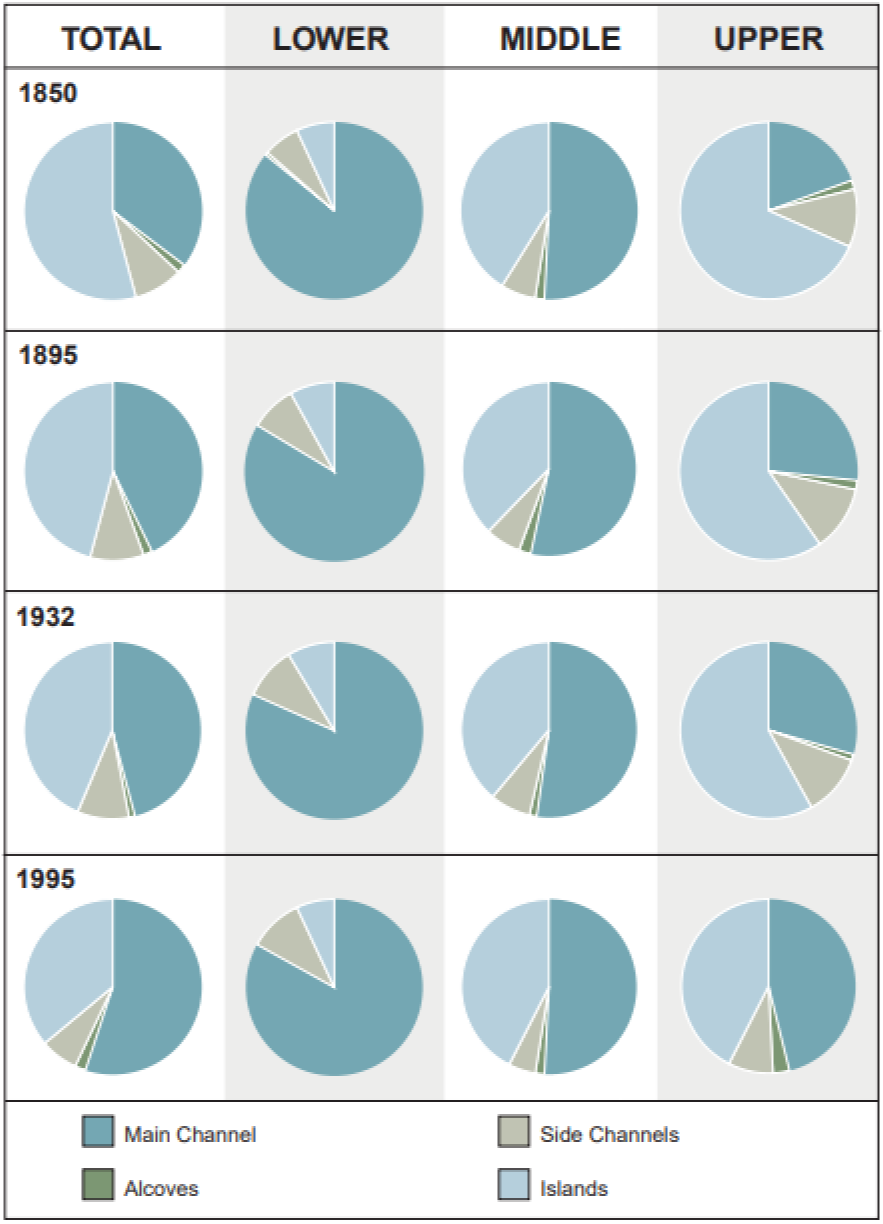

Figure 5. Proportion of channel composed of main river, side channels, alcoves, and islands from 1850 to 1995. Reproduced from PNW-ERC 2002.

The implementation of the Willamette Valley Project, finished in the 1970s, also contributed to the channelization of the river. The construction of dams along the tributaries of the Willamette River helped protect urban and agricultural infrastructure by mitigating flooding and provided predictable flows. These dams are currently still managed for flood control, water availability, recreational opportunities, protection of aquatic life, and hydropower generation (see Section 3.5).

2.2.2. Water Quality

As described in Section 2.1, the increased discharge of untreated municipal and industrial wastes directly to the Willamette and its tributaries in the late 19th and early 20th centuries contributed to degradation of water quality in the river. By the early 20th century, the Willamette River was recognized by Willamette Valley residents as “filthy”, “ugly”, and “an open sewer” and was believed to be unfit for human interaction (EPA, 1976). A 1962 film called *Pollution in Paradise* highlighted the toxic state of the river (Robbins, 2020).

Cleanup of the Willamette River in the 20th century occurred in two main phases. Municipal sewer discharges continued without regulation until the passage of the Federal Water Pollution Control Act in 1948 (later amended and renamed the Clean Water Act, see Section 2.1), which then required primary treatment (removal of material that will readily settle out by gravity) for municipal wastes discharged into the river. Starting in the 1960s, mandates focused on the water quality impacts from canneries, paper mills, and other industrial point sources (BES, n.d.) and water quality began to improve. By the 1970s, the Willamette River had gained notoriety nationwide for its substantially improved water quality.

However, starting in the 1990s, more advanced laboratory equipment and sampling methods uncovered that though the most visible pollution had been eliminated from the Willamette River, the river continued to experience high levels of contamination from industrial, agricultural, and urban non-point sources (Robbins, 2021). Studies found petroleum products, toxic chemicals, and metals from urban and former industrial areas and pest and nutrient concerns in more rural sections of the river (Robbin, 2021). Studies also found contaminants not only in the water column, but in other environmental media such as bottom sediments and aquatic life (ODEQ, 2020).

Today, the Willamette River is considered safe for human contact recreation in most seasons, though low levels of hundreds of contaminants persist (ODEQ, 2020). Present-day water quality is closely studied to support human use and ecological benefits (as discussed in Section 3.4). Health advisories for the consumption of fish from the river reflect the general trend of increasing levels of contamination further downstream in the watershed, especially the reach from the City of Portland to the mouth of the Willamette River at its confluence with the Columbia River (Oregon Health Authority [OHA], 2022).

The Willamette River is used as a drinking water source by multiple communities, all of which successfully meet applicable standards for safe drinking water. The Willamette River as a drinking water source is further discussed in Section 3.4.2.

2.2.3. Watershed Trends

Human interactions with the land that drains to the Willamette River has also changed with time. It is important to reiterate here the distinction between the extents of the Willamette River Basin and the Willamette Valley, which are distinct in the context for describing changes in watershed trends (***Figure 2***).

Settlement of the land within the Willamette River Basin began in earnest around 1850 as settlers moving west were drawn to the basin's temperate climate and fertile soils, especially along the Willamette Valley. Prior to this, native people managed land through intentional burns, and thus much of the valley landscape was comprised of prairies and oak savannas which were used for hunting, foraging, and agriculture. In the latter half of the 19th century, as the practice of fire management was lost, more dense forest growth replaced the savannas and prairies. Today, less than 12% of lower elevation prairies and savannas remain (Sinclair, 2005).

Between 1850 and 1990, landscapes changed considerably, with much of the change occurring in the regions closest to the river. The composition of the Willamette Basin and the Willamette Valley by land uses in 1990 is shown in ***Figure 6*** (Enright et al., 2002). Note the differences between the Willamette Basin, which is primarily forested, and the Willamette Valley, which has experienced much more human influence by conversion to urban and agricultural uses.

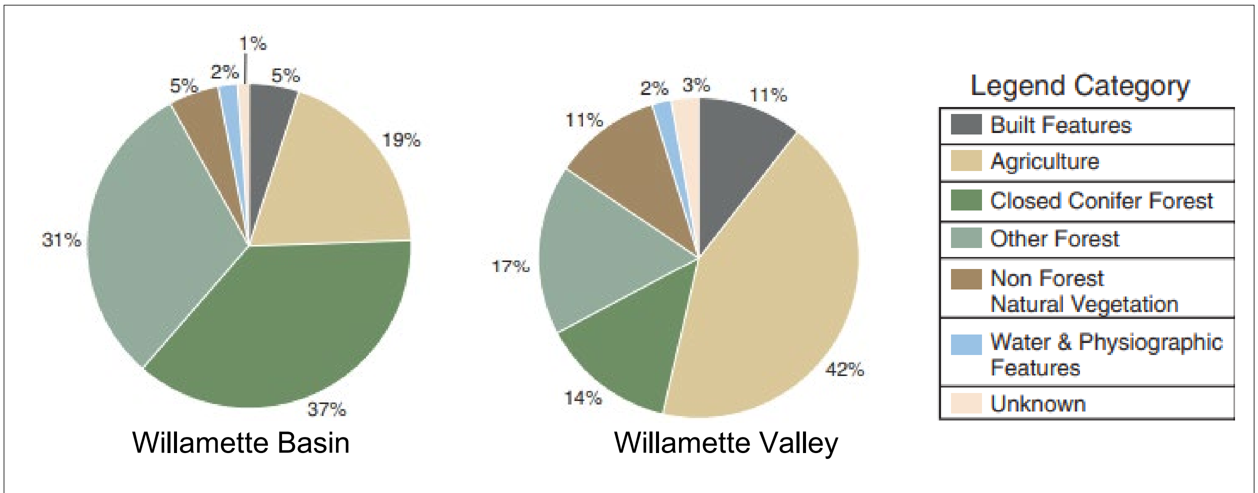

Figure 6. Land cover distribution within the Willamette River Basin (left) and the Willamette Valley (right). Reproduced from Enright et al., 2002

Oregon's land use regulations have contributed to the preservation of natural areas or areas that mimic natural services. For example, urban growth and residential boundaries have helped preserve some of the fields and forested areas throughout the basin, and cultivating pasture and hay provides similar ecosystem functions to prairie lands. The slow pace of rural subdivision of parcels has kept road density relatively low (Oregon Explorer, 2014).

Today, much of the upper reaches of the watershed are still heavily forested (PNW-ERC, 2002). Recent changes in land use have occurred primarily in the Willamette Valley, trending away from land conversion to agriculture and more towards urban development as Oregon's population continues to increase (Morlan et al., 2010). ***Figure 7*** shows the causes of the loss of wetlands in the Willamette Valley from 1982 – 1994, and again from 1994 - 2005. Notably, most of the land conversion between 1982 and 1994 was for agricultural purposes, while between 1994 and 2005 land conversion primarily served urban and rural development. A more comprehensive description of current land use and landscapes is provided in Section 3.2.1.

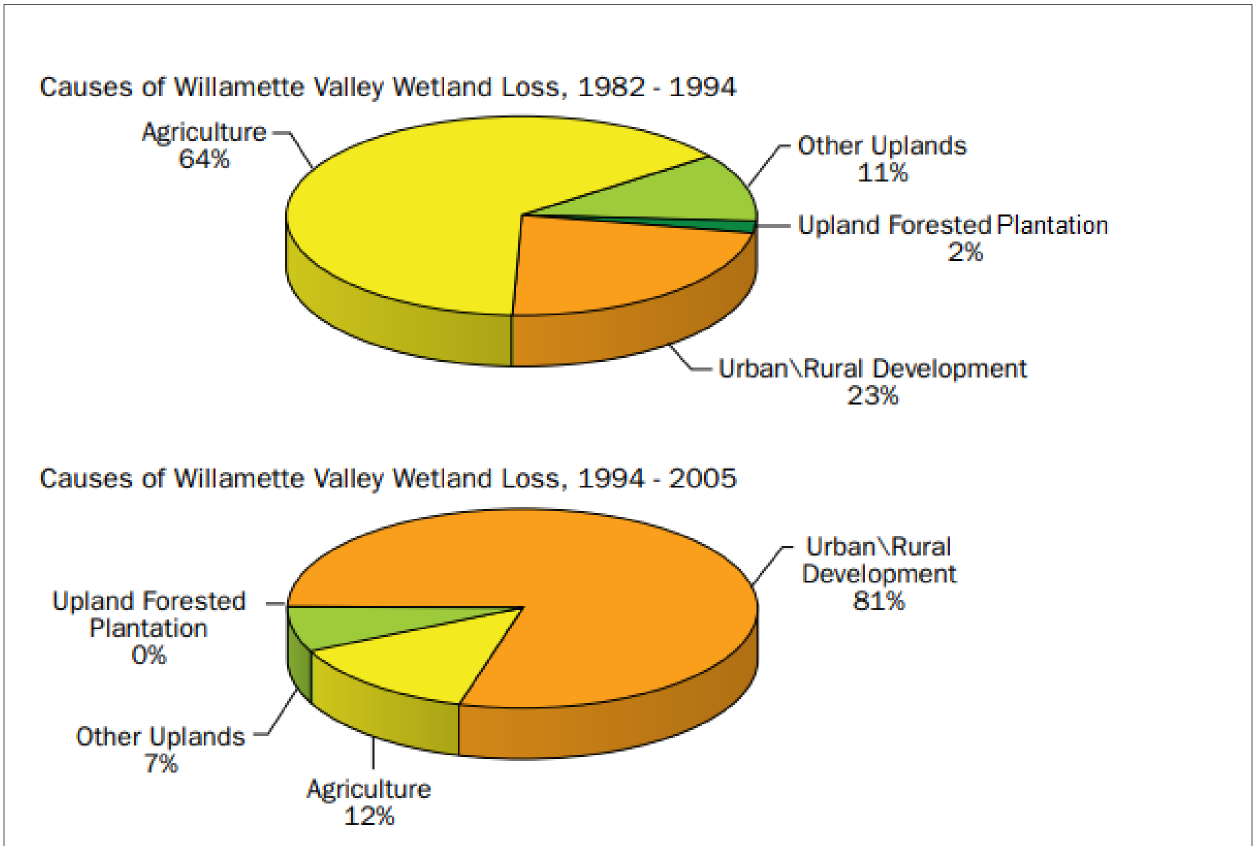

Figure 7. Causes of wetland loss in the Willamette Valley 1982 - 1994 compared to 1994 - 2005. Modified from Morlan et al., 2010.

2.2.4. Human Use

Use of the Willamette River as a drinking water source over time has depended primarily on the quality of water in the Willamette River, the quantity of Willamette River water allowed for municipal supply, and the availability of other water sources. The changing conditions described in the sections above influence these three factors and the resulting use of the Willamette River as a municipal drinking water source. This section briefly describes the history of the Willamette River as a municipal water source; refer to Appendix A for a more complete overview.

While some water providers were early adopters of the Willamette River as a water supply, many water providers only began seriously considering the Willamette River as a water source once water quality began to improve. One of the most influential factors allowing the use of the Willamette River as a municipal drinking water supply was the completion of the Willamette Valley Project in the 1970s. Control of the dams to store water during rainy months and release it in summer months provides sufficient water quantity for water providers during late summer and improved water quality through pollutant flushing. Additionally, legislative measures since the 1960s have improved water quality in the Willamette River. Namely, amendments to the Federal Water Pollution Control Act in 1972 (hereafter referred to as the Clean Water Act) required a National Pollutant Discharge Elimination System (NPDES) Permit for discharge of wastewater to surface waters (EPA, 2021). The Clean Water Act also required states to develop Total Maximum Daily Loads (TMDLs), which are plans to improve water quality in polluted waterways based on numerical water quality standards. Additional measures were then enacted by the State, such as the 1997 Oregon Plan for Salmon and Watersheds and funding of watershed councils, which are local community groups that implement watershed enhancement projects. The combination of the activities resulting from federal and state environmental laws have contributed to substantial improvements in water quality.

As water quality in the Willamette improved, water providers turned to the Willamette River to meet water supply needs when various factors challenged their existing water sources. Some water providers had been able to rely on groundwater, surface water from natural flows and stored water releases in tributaries of the Willamette River, and wholesale water purchases from nearby communities. However, in the 1990s and 2000s, a number of water providers began recognizing issues with their current water supplies. Groundwater has become a less viable water source in the Willamette River Basin as population growth causes groundwater levels to decline, capacity issues to meet demand, and groundwater quality concerns. Additionally, climate change, resulting in longer and drier summers, has stressed groundwater resources and highlighted the need for alternate water supplies to increase resiliency.

The Willamette River has become a key resource to municipalities facing these challenges. More water providers have obtained or developed their Willamette River water rights permits in recent years. For example, the City of Wilsonville addressed its declining aquifer levels by developing its pre-existing Willamette River water right. The City of Wilsonville switched to using the Willamette River as its primary water source upon completion of its Willamette River Water Treatment Plant in 2002, a switch that was done in partnership with TVWD given both water providers owned the land where the Willamette River Water Treatment Plant was built. Additionally, the City of Sherwood relied upon groundwater rights until reliability became a concern due to declining groundwater levels, causing it to switch exclusively to the Willamette River in 2015. Water providers have also formed agreements to share water resources and often have system connections to support each other's water demand needs. Examples of such partnerships include the Joint Water Commission (JWC), the Willamette River Water Coalition (WRWC), and the Willamette Intake Facilities (WIF) Commission.

Figure 8 shows public drinking water providers which currently draw from the Willamette River mainstem or its tributaries.

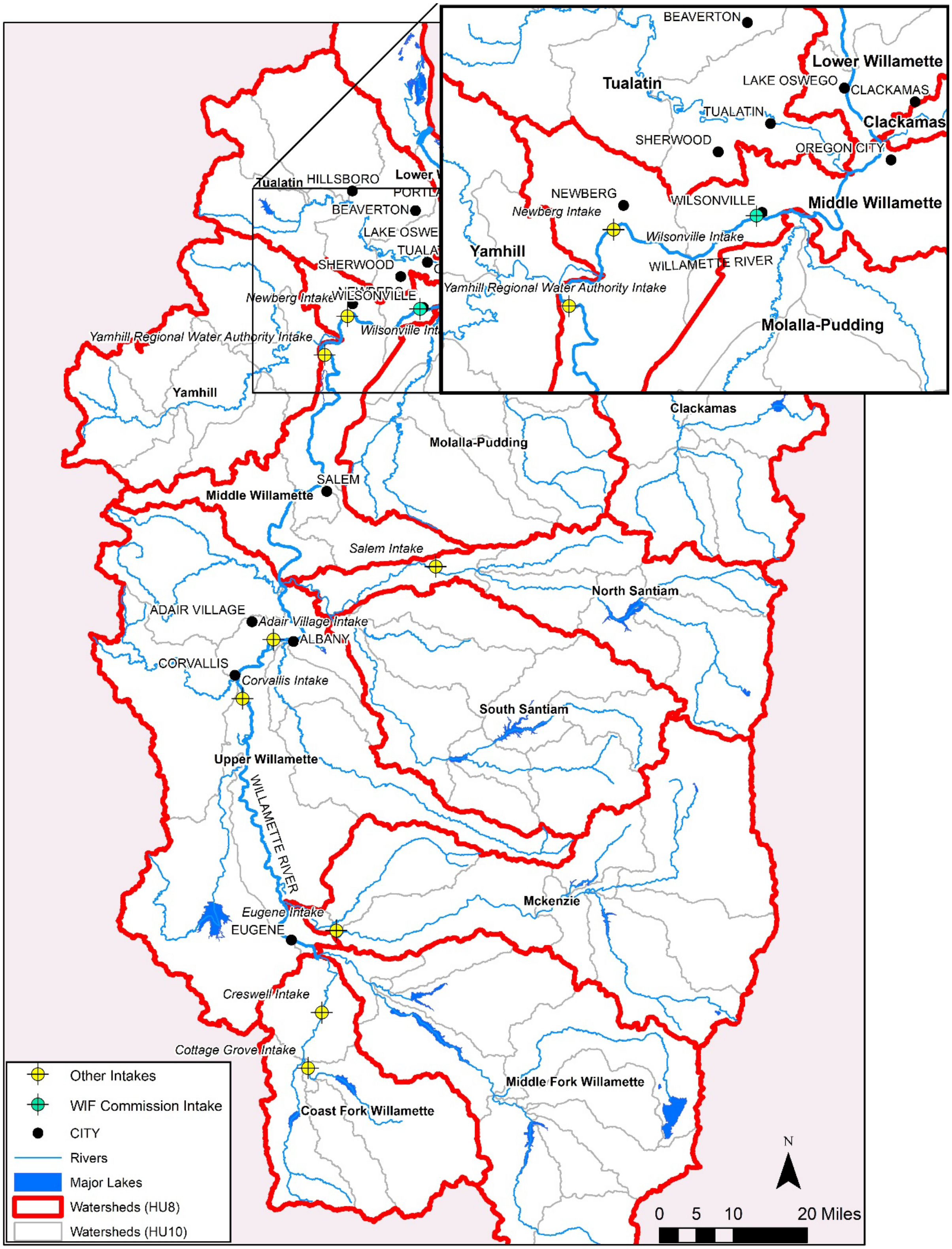

Figure 8: Select water users in the Willamette River Basin upstream of the WIF Commission Intake

However, water quantity in the Willamette River during the summer is a concern due to minimum flow requirements for fish persistence conditions. In recent years, water providers utilizing the Willamette River have needed to manage water rights and water supplies more actively. The Oregon Water Resources Department (OWRD) has required water providers to prepare Municipal Water Management and Conservation Plans (WMCPs) for permit issuance (OWRD, 2015). WMCPs must include, among other requirements, water conservation measures and plans for future water needs. If a water provider does not develop all the water under its permit by the permit's completion date, the water provider must request an extension. After the extension is approved, the water provider must update its WMCP. To be able to use any of the undeveloped portion of the permit, the WMCP must include a request for access to the undeveloped portion of the permit after demonstrating a need for more water. OWRD will indicate in the Final Order approving the WMCP how much of the undeveloped portion of the permit can be developed. Consequently, water providers pay careful attention to water use, conservation measures, and future water needs.

Overall, population growth, groundwater decline, climate change resulting in longer and drier summers, a desire for more control over water sources, and the need for multiple water supplies have been major drivers motivating water suppliers in the Lower Willamette River Basin to look towards the Willamette River as a water supply source in recent years.

2.3. Key Investigations

Several key investigations have been conducted within the Willamette Valley that centered on specific features of the basin. The investigations and reports below are referenced in Section 3 where appropriate. Note that these are not the only important investigations and reports referenced in this Memo, but they are listed in this section to emphasize their prominence in the scientific community within the Willamette River Basin. Brief summaries of these reports and citations are provided below:

- *Willamette Water 2100, OSU.* The Willamette Envision model was developed to evaluate how climate change, population growth, economic growth, and reservoir operations will change the availability and the use of water in the Willamette River Basin from 2010 to 2099. The study is documented on a website referred to as OSU, 2012.

- *Fish Deformities in the Newberg Pool, OSU.* Frequent observations of fish deformities in the Willamette River, especially in the region known as the Newberg Pool, incited a multi-year study of the phenomenon by researchers at OSU. The inter-disciplinary research team presented their findings to the public in at the Wilsonville Library on June 30, 2004. The summary of these findings is referred to as OSU, 2004.

- *Willamette Basin Review Feasibility Study: Final Integrated Feasibility Report and Environmental Assessment, USACE.* The Portland District of the USACE and the OWRD jointly sponsored a feasibility study to determine if and how space in the reservoirs can be reallocated during the spring and summer to provide stored water for 1) municipal and industrial water supply, 2) agricultural irrigation, and 3) fish and wildlife uses. This report documents current water uses in the basin, provides projections of water needs for these three project purposes, and develops a combined conservation storage reallocation and water management plan that would provide the most public benefit within the policies and regulations of the Corps and the state of Oregon. Referred to as USACE, 2019.

- *Willamette River Basin Atlas, PNW-ERC.* Based on the problem statement that continued population growth will exacerbate the competition for land, water, and other natural resources in the basin, the Willamette River Basin Atlas research program characterized the basin using a broad spectrum of base data and then studied the likely effects of three different trajectories of landscape change in the basin. This book is referred to as PNW-ERC, 2002.

3. WATERSHED CHARACTERIZATION

3.1. Basin Overview

The Willamette River originates at the confluence of the Coast Fork of the Willamette River (originating in the Coast Range), the Middle Fork of the Willamette River, and the McKenzie River. It flows north for 187 miles before ending at its confluence with the Columbia River just north of Portland, Oregon (***Figure 9***). The Willamette Basin contains 12 subbasins and drains nearly 11,500 square miles in northwestern Oregon, which accounts for 12% of the total state area. The basin is home to nearly 3 million people, over two thirds of Oregon's total population of 4.2 million (U.S. Census Bureau, 2021). The basin includes Oregon's capital, Salem, and its largest city, Portland.

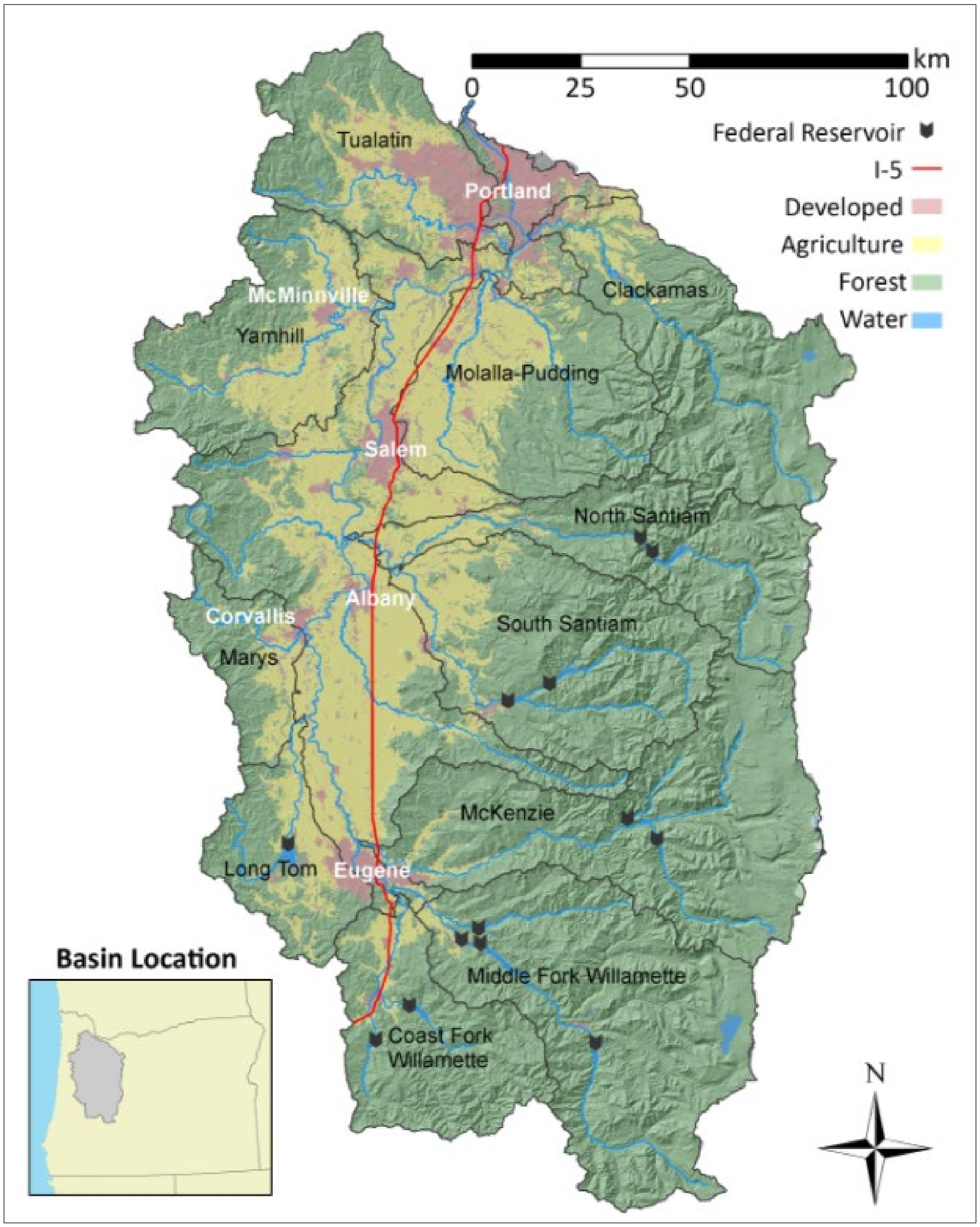

Figure 9. A map of the Willamette Basin. Reproduced from Jaeger et al., 2017.

3.2. Landscape and Land Use

The Willamette Valley is bound to the west by the sedimentary and metamorphic mountains of the Coast Range and to the east by the basaltic Cascades (Wilson, 2012). Coniferous forests cover much of the basin, while agriculture and developed land are concentrated in the Willamette Valley. Therefore, this section focuses primarily on the Willamette Valley.

3.2.1. Land Use

Land use in the Willamette Valley largely consists of agriculture, forest, and developed land (***Figure 10***). Agriculture accounts for 45.1% of land use, forest accounts for 33.5% of land use, and developed land accounts for 12.5% of land use (Wilson, 2012). These three land cover classes represent over 90% of land use in the Willamette Valley. Developed land extents are limited by urban growth boundaries, which Oregon law designates as area supported by urban services such as roads, water and sewer systems, parks, schools and fire and police protection (Metro, n.d.). Although urban growth boundaries can and have been expanded over time, this law protects farms and forests from urban sprawl. The protected agricultural land in the Basin is quite versatile, with more than 170 different crops grown in the Willamette Valley (OSU, 2012).

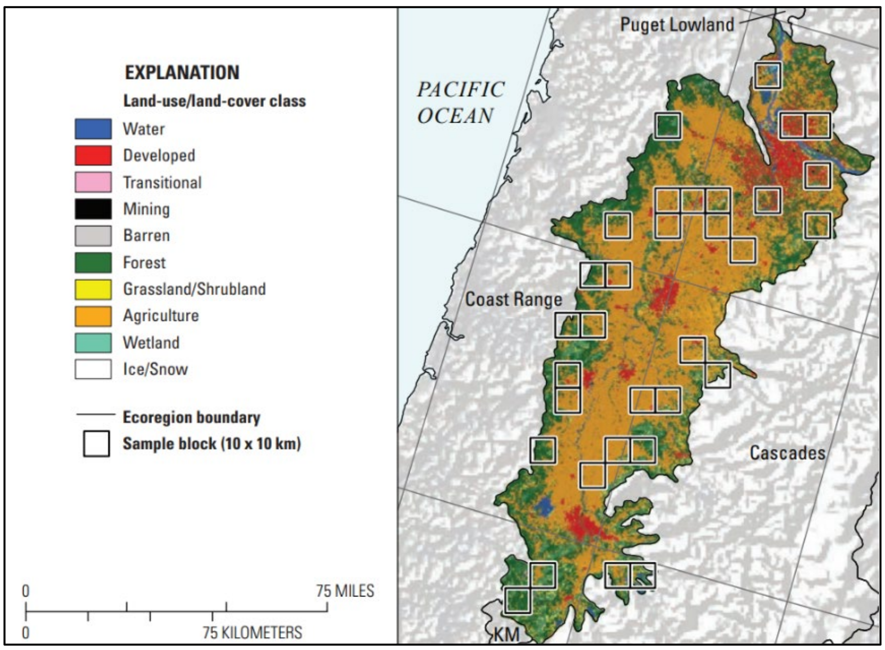

Figure 10. Land use in the Willamette Valley. Reproduced from Wilson, 2012.

3.2.2. Population, Demographics, and Socioeconomic Conditions

Urban areas in the Willamette Valley have seen steady growth over time. According to the 2020 census, Multnomah, Washington, and Clackamas Counties grew by 10%, 13%, and 12%, respectively, since the previous census. Polk, Linn, and Benton Counties also experienced growth of over 10% (Stites, 2021). All six of these high-growth counties are within the Willamette Basin.

3.3. Hydrology

3.3.1. Surface Water

The Willamette River originates south of Eugene and is fed by tributaries from 12 subbasins. Groundwater discharge is a large component of streamflow in the volcanic, highly permeable High Cascade region, while streamflow in other regions of the Willamette Basin is largely dominated by precipitation runoff (Conlon, 2005). Discharge in the Willamette is typically low in the summer with swells in the spring and fall (***Figure 11***). The swell in the fall/winter season is caused by increased precipitation, while the high flows in spring are influenced by both precipitation and snow melt. The river is prone to flooding following storm events.

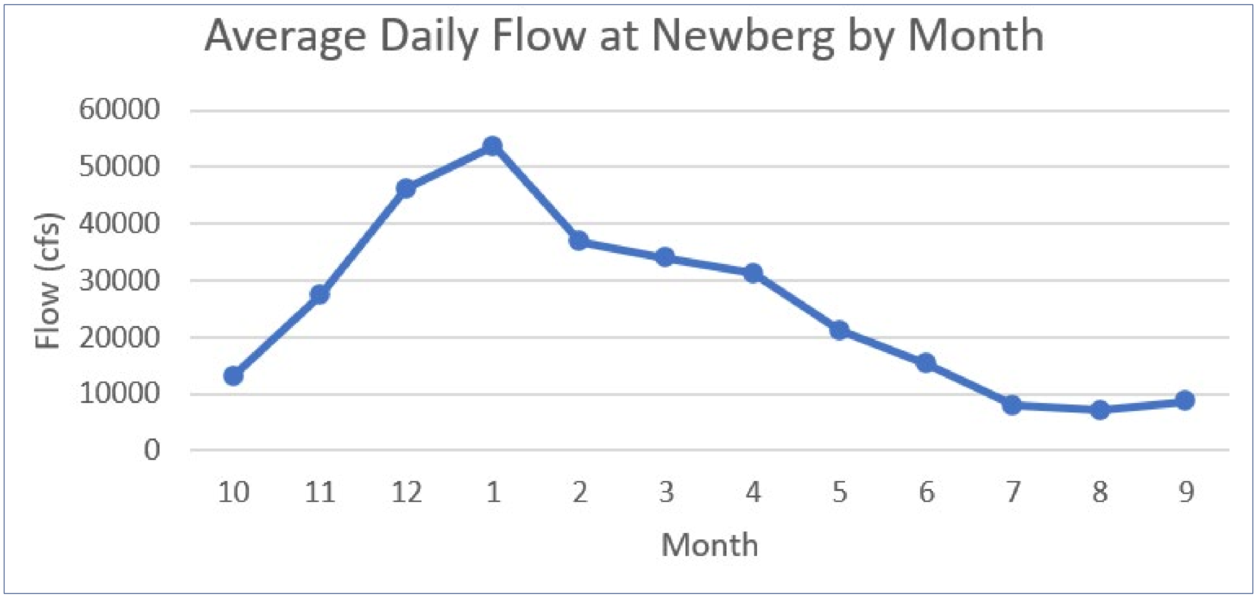

Figure 11: Average daily flow, averaged by month, for 20-year period of record from water year 2001-2021 at Newberg (USGS Gage 14197900)

The upper section of the Willamette between its origin and Albany, Oregon, known as the upper Willamette River[1], is where the river experiences its steepest grade. The elevation of the river's source is 438 feet above sea level and the river gradually drops to roughly 200 feet above sea level in Albany. Between Albany and Oregon City, in the middle Willamette[1], the river experiences a lesser grade. Due to both the lesser grade in this reach of the river and the influence of Willamette Falls in Oregon City, water tends to pool in the stretch between river miles 30 and 50. This area is known as the Newberg Pool and is frequently used for recreation. At Oregon City, the river drops approximately 40 feet at Willamette Falls. Downstream of the falls, in the lower Willamette, the river has very minimal grade and is affected by semidiurnal tides from the Pacific Ocean via the Columbia River. The final elevation of the river at its mouth is 10 feet above sea level.

More than 96 miles of revetments have been constructed on the Willamette. While 96 miles makes up approximately 26% of the total length of streambanks (187 stream miles, and two banks, or 374 miles), 65 percent of meander bends are revetted (Oregon Explorer, 2007). This has greatly restricted the river's ability to adjust its channel. This, along with the lack of side channels, has simplified the river and diminished both the quantity and quality of aquatic habitats.

3.3.2. Subsurface Flow

Subsurface flow in the Willamette Basin plays an important role in the basin's hydrology. Groundwater recharge mostly comes from infiltration of precipitation, meaning recharge happens mostly in the winter months. This leads to a seasonal high groundwater level in the late winter.

Available soil water decreases in the mid- to late summer, due to irrigation use and lack of recharge.

In the High Cascades, groundwater is discharged into streamflow which ultimately feeds into the Willamette River. In the Willamette Valley (***Figure 2***), the direction of flow between the Willamette and adjacent aquifers is dependent on river stage (Conlon, 2005). When the river stage is low, groundwater will flow from aquifers into the river. When the river stage is high, water will flow from the river into adjacent aquifers. However, channel armoring along the Willamette has greatly reduced the river's ability to interact with groundwater (Oregon Explorer, 2007).

3.3.3. Water Balance

Water in the Willamette Basin largely comes from precipitation and groundwater. Some water is lost to evapotranspiration, municipal and industrial water use, and agriculture, while the remaining water flows into the Columbia River. A graphic describing the sources and sinks of water can be found in ***Figure 12***. Water lost to agriculture is mostly used in the spring and summer when streamflow is low. Because of this, water used for agriculture is typically taken from groundwater. Irrigation is the largest use of groundwater in the Willamette Basin, accounting for 240,000 acre-feet of withdrawals, or 81% of annual groundwater withdrawals (Conlon, 2005). The thickness of the lines in the figure represents the relative amounts of water.

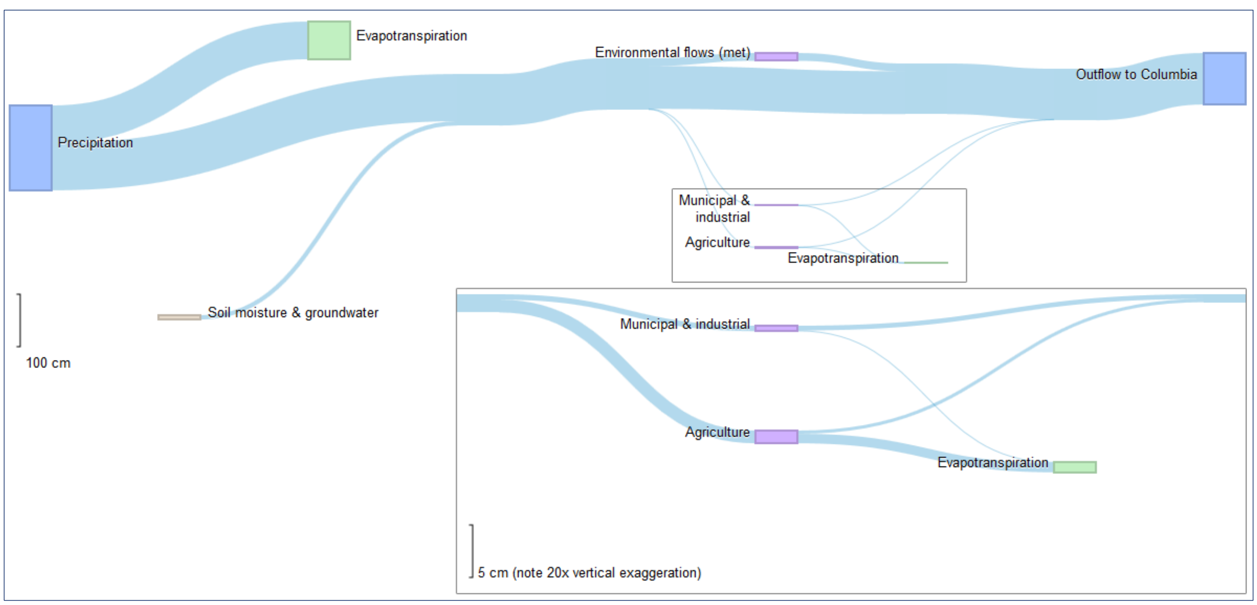

Figure 12. Visualization of annual water budget for the Willamette River. The thickness of the lines in the figure represents the relative amount of water. 1 cm = 235,000 acre-feet. Reproduced from OSU, 2012.

Precipitation is typically greatest in the fall and winter. Precipitation levels decline throughout the spring and are very low throughout the summer. Groundwater recharge is largely due to infiltrating precipitation, so recharge follows similar seasonal trends. Runoff is also greatest when precipitation amount is high. Conversely, evapotranspiration is highest in the spring and summer, then decreases in the fall and winter. Seasonal trends in the water budget can be seen in ***Figure 13***.

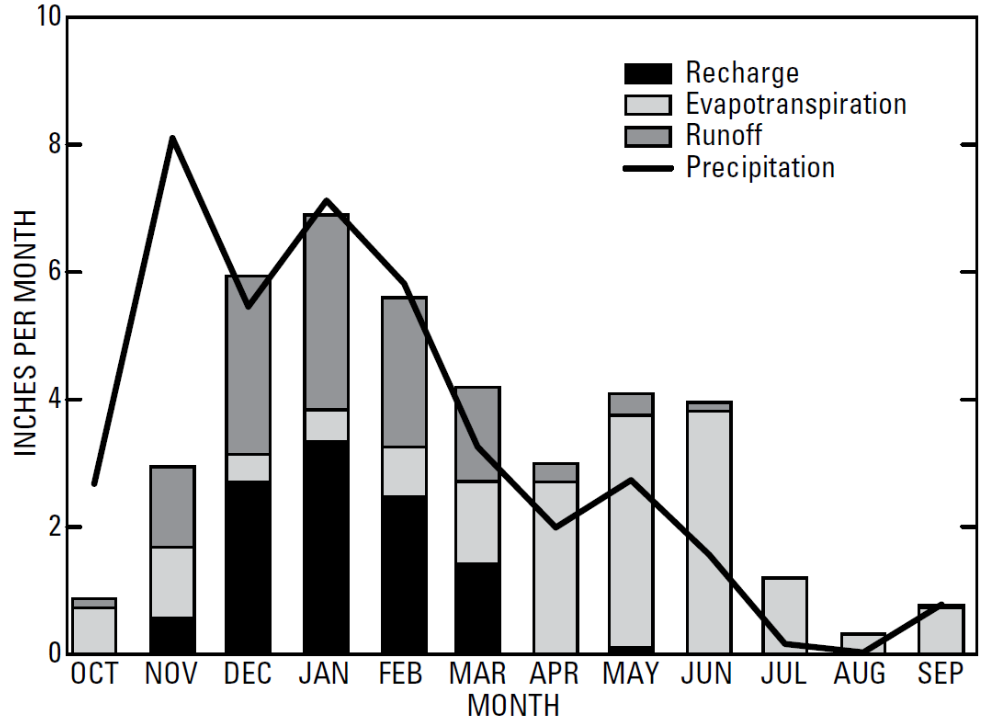

Figure 13. Simulated monthly water budget in the central Willamette Basin for water year 2000. Reproduced from Conlon, 2005.

3.4. Water Quality

3.4.1. Ambient Water Quality

The Willamette and most of its major tributaries have impaired water quality. According to section 303(d) of the Clean Water Act, states are required to develop lists of impaired waters. These lists are commonly referred to as the 303(d) list. The Willamette River mainstem and all of its subbasins are, or previously have been, 303(d) listed. Once a waterbody is 303(d) listed, a total maximum daily load (TMDL) must be established for the waterbody to be removed from the list. The EPA has approved TMDLs for all subbasins in the Willamette Basin, although additional 303(d) listings may exist for parameters not addressed in approved TMDLs (ODEQ, 2012a).

A TMDL was established for the Willamette Basin in 2006 and addresses bacteria, mercury, and temperature (ODEQ, 2006). The mercury TMDL was revised in 2019 and approved in 2021. The temperature TMDL is currently in the process of being replaced due to a court order. In addition to the Willamette Basin TMDL, several subbasins have TMDLs in place. These were approved between 1992 and 2008. The Molalla-Pudding is one of these subbasins and its TMDL is also in the process of being replaced. Additional information is provided in Section 3.4.3.

The bacteria, mercury, and temperature issues covered in the Willamette Basin TMDL are the sources of a variety of water quality concerns in the Willamette River. The main stem Willamette River is listed as impaired for aesthetic quality, fish and aquatic life, livestock watering, and private and public domestic water supply across its entire reach (EPA, 2020). The river is also impaired for water contact recreation downstream of the Clackamas River confluence but is in good condition upstream of the confluence, including at the location of the WIF intake near Wilsonville (EPA, 2020).

3.4.2. Drinking Water Quality and Existing Plans

In Oregon, Source Water Assessments (SWAs), developed by ODEQ and the Oregon Health Authority (OHA), and Drinking Water Protection Plans (DWPPs), developed voluntarily by drinking water providers and approved by ODEQ, contain valuable information related to potential contaminants of concern for drinking water sources. SWAs and DWPPs already developed for water providers in the Willamette Basin can provide a foundation to understanding water quality threats to source waters at the WIF intake location. This section summarizes the core concerns of SWAs and DWPPs from communities within the Willamette Basin upstream of the WIF intake; see Appendix B for a more detailed summary.

The following DWPPs and SWAs were reviewed (***Table 1***):

Table 1. Jurisdictions and Water Sources of Water Quality Assessments in the Willamette River Basin.

Jurisdiction	Document Reviewed	Water Source	Source Type
Adair Village	SWA	Willamette River	Surface
Cottage Grove	DWPP	Row River	Surface
Creswell	DWPP	Coast Fork Willamette / Groundwater	Surface / Groundwater
Eugene Water and Electric Board	DWPP	McKenzie River	Surface
Junction City	DWPP	Groundwater	Groundwater
Hubbard	DWPP	Groundwater	Groundwater
Springfield	DWPP	Groundwater	Groundwater
Veneta	DWPP	Groundwater	Groundwater
Corvallis	SWA	Willamette River, North and South Forks of Rock Creek, and Griffith Creek	Surface
Salem	SWA	North Santiam River	Surface
Wilsonville	SWA	Willamette River	Surface
DWPP – Drinking Water Protection Plan SWA – Source Water Assessment			

Common themes include potential risks to drinking water source quality from:

- Agriculture, including sediments, nutrients, pesticides, and other chemicals from irrigated crops and pathogens and other chemicals from livestock operations.
- Transportation, including sediments, fuels, hazardous substances, and landscaping chemicals.
- Industry, including fuels, other chemicals, increased downstream temperatures, and metals.
- Residential areas, including nutrients, pathogens, metals, and other chemicals, and nutrients and other chemicals from septic systems.
- Urban stormwater, including nutrients, heavy metals, pharmaceuticals, fuels, pathogens, and other chemicals.

Water providers with surface water sources also highlight forestry, mining, wood, pulp, and paper mills, recreation (including boating, water sports, hiking, and camping) and waste management streams (including landfills, biosolids management, and application of recycled water) as water quality concerns.

Only a handful of cities, including Corvallis, Adair Village, and Wilsonville source drinking water from the Willamette River and have completed SWAs (***Table 1***). These cities use a similar series of treatment methods: coagulation, sedimentation, filtration, and disinfection, with Wilsonville utilizing ozone as an additional step for oxidation (City of Adair Village, Oregon, 2019; City of Corvallis, Oregon, n.d.; Wilsonville, Oregon, 2021)). Water quality concerns for these three intakes include agriculture, transportation, industrial and commercial uses, recreation, residential, and municipal use. Forestry practices are also a concern in Corvallis and Adair Village, and to a lesser extent for Wilsonville. Resulting pollutants of concern include sediment, nutrients, toxics, volatile organic compounds (VOCs), pathogens, pharmaceuticals, temperature, organic matter, gasoline and diesel, polychlorinated biphenyls (PCBs), and heavy metals. All facilities successfully treat the water to meet or exceed requirements for safe drinking water. See Appendix B for a full summary of water quality concerns by water provider.

The water quality concerns highlighted by SWAs and DWPPs in the Willamette Basin represent water quality concerns that may be considered by the WIF Commission in the development of this Source Water Protection Plan. Further investigations of water quality concerns are performed in the water quality data analysis in the upcoming Task 3 Memo.

3.4.3. Pollutants of Concern and Sources

The Willamette River Basin has TMDLs for mercury, bacteria, and temperature (ODEQ, 2022). The mercury TMDL was reestablished in 2021, while the bacteria and temperature TMDLs were established in 2006. As previously mentioned, DEQ is under court order to replace temperature

TMDLs approved between 2004 and 2010 due to a U.S. District Court finding that a previous aspect of Oregon's temperature criteria, known as the Natural Thermal Potential (which allowed for a less strict temperature requirement where the biologically based criteria could not be met even under natural conditions), was unlawful (ODEQ, 2022). As a result of this, temperature TMDLs for the Willamette River and major tributaries must be replaced by February 28, 2025 (ODEQ, 2022).

The entire Willamette River and most tributaries are covered by the Willamette Watershed mercury TMDL (***Figure 14***). Sources of mercury in the Willamette Basin are atmospheric deposition, erosion of native soils, historical mining activity, sediment resuspension, and municipal and industrial water discharges (ODEQ, 2019). Mercury takes various forms in the environment, but methyl mercury is the most bioaccumulative form of mercury in fish tissue and the most toxic for human consumption (ODEQ, 2019).

Figure 14: Map of reaches impaired for mercury in the Willamette River. Reproduced from ODEQ, 2019.

The Willamette Basin bacterial TMDL focuses on *E. coli* concentrations and covers the entire Willamette River and all tributaries, although many tributaries have achieved different statuses over time (***Figure 15***). Bacterial loading comes from point sources such as Combined Sewer Overflows (CSOs) and storm water discharges and a small amount comes from nonpoint sources. Prior to 2001, the City of Corvallis had CSOs during rainfall events, but a new wastewater treatment facility has addressed this issue. About 70% of the flow in the Willamette River at Salem comes from the Coast Fork and Middle Fork Willamette, McKenzie, and North and South Santiam Rivers, which have bacterial concentrations well below the water quality criteria (ODEQ, 2006). This helps dilute bacterial concentrations in the Willamette River mainstem. In the middle reach, the river is impacted by runoff from rural residential and agricultural land as well as by occasional sanitary sewer spills and overflows. Inflow from the Molalla-Pudding and Tualatin subbasins increases the average *E. coli* concentration in the Willamette River mainstem, both of which are downstream from the WIF Commission intake. In the lower reach, CSOs and urban runoff add to the already heightened *E. coli* concentrations from the upper and middle reaches (ODEQ, 2006). The City of Portland has substantially reduced CSOs, resulting in decreased bacterial loading to the Willamette.

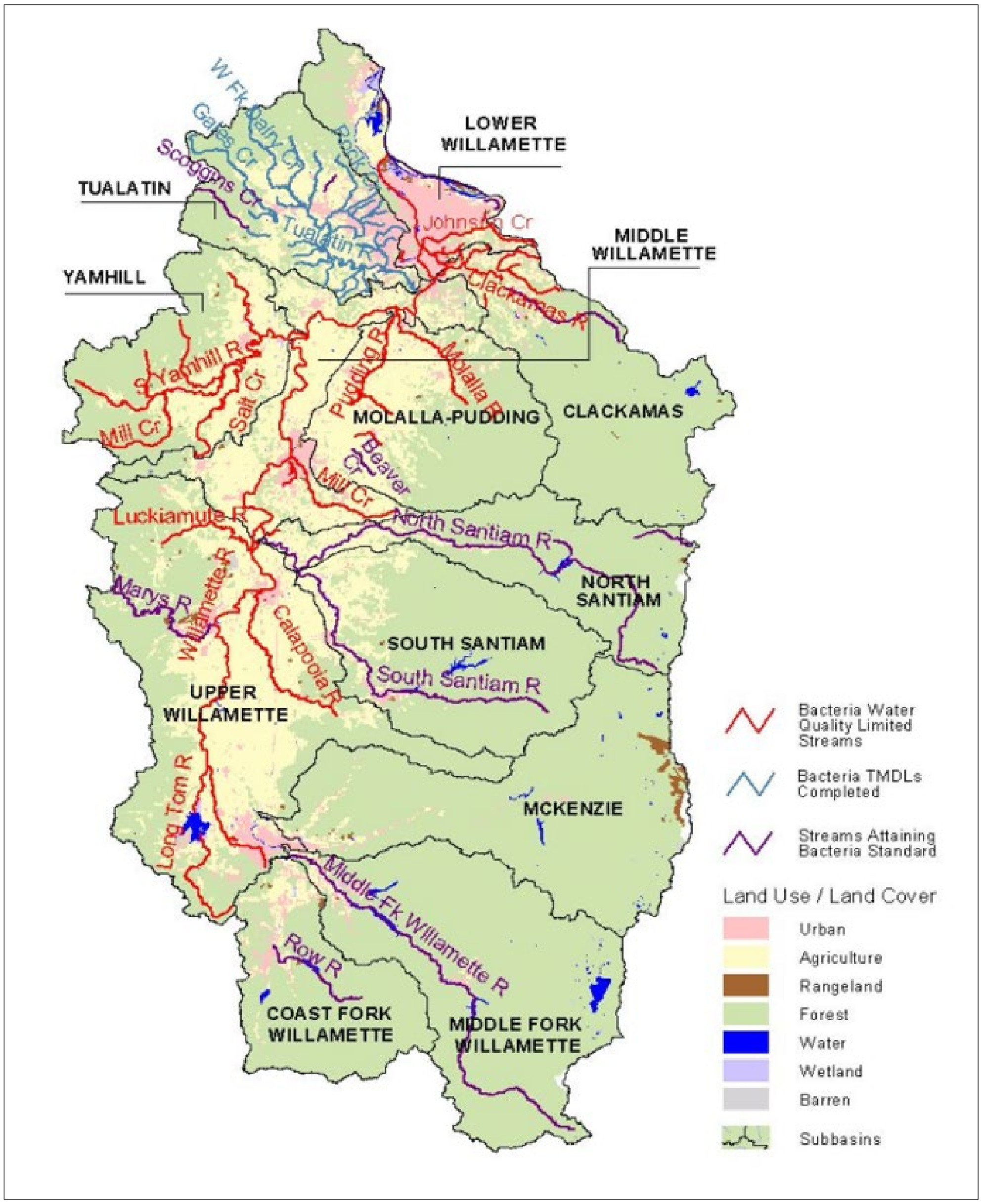

Figure 15: Map of reaches impaired for bacteria in the Willamette Basin. Reproduced from ODEQ, 2006.

Elevated water temperatures in the Willamette River and tributaries are also a water quality concern (***Figure 16***). Rising stream temperatures occur naturally from solar radiation and are generally the highest in the summer when solar radiation is high and streamflow is low (ODEQ, 2006). Anthropogenic activities such as discharging warm wastewater, decreasing riparian shade, and impounding or diverting water from the main channel can also lead to high stream temperatures, though heat loading from solar radiation exceeds anthropogenic loads by an order of magnitude (ODEQ, 2006). However, anthropogenic activities that decrease effective shade increase the amount of solar radiation reaching the river, so both natural and anthropogenic sources of heat loading are important to consider.

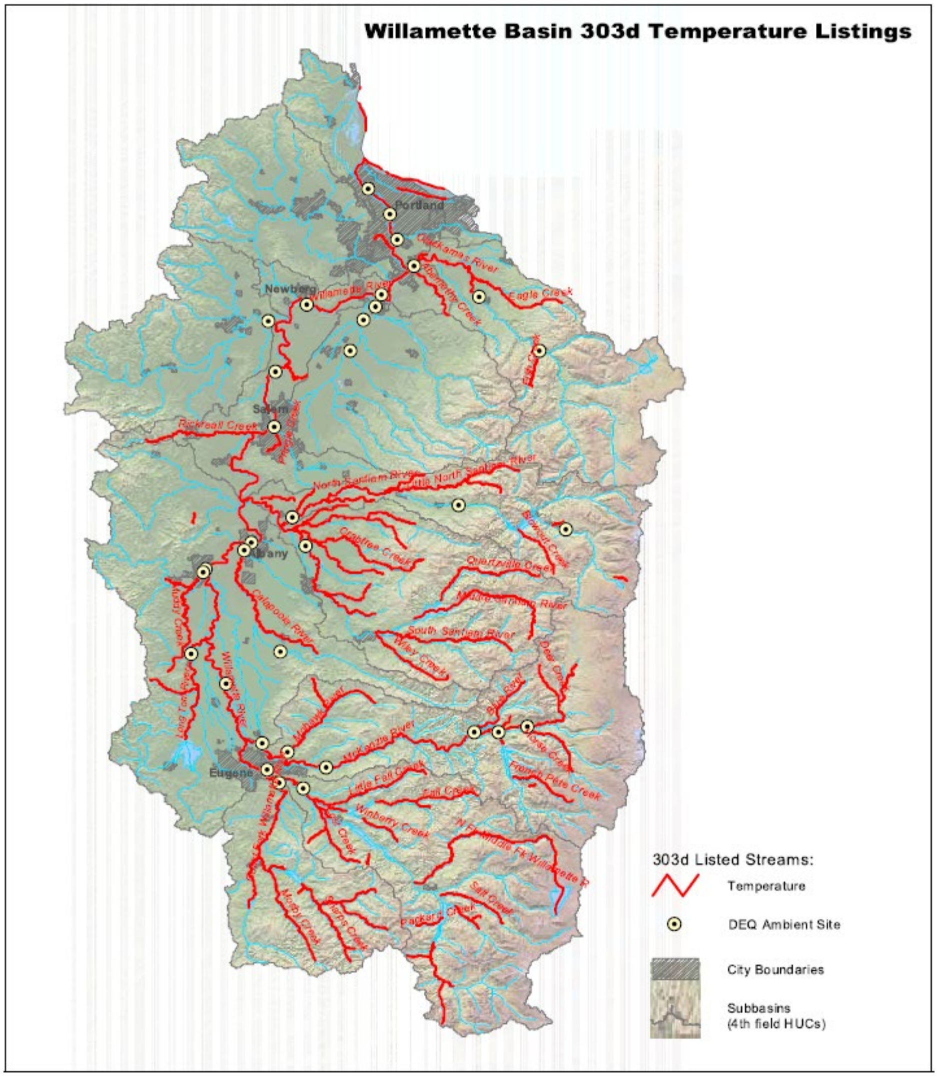

Figure 16: Map of reaches impaired for temperature in the Willamette Basin. Reproduced from ODEQ, 2006.

Communities and public utilities in the Willamette Basin have developed TMDL implementation plans to comply with ODEQ's regulations. These plans hold communities accountable for maintaining water quality in the Willamette River. Plans typically include a variety of public involvement and education, stormwater and infrastructure operations and maintenance, development standards, structural controls, and monitoring measures. Actions being taken by the City of Portland to reduce water temperatures in the Lower Willamette include implementing programs to protect riparian buffers and corridors, restoring riparian buffers, revegetating streambanks, and creating cold water refugia (City of Portland, 2017). The City of Newberg is working to maintain existing stream vegetation, increase effective shade, and conduct stream assessments (City of Newberg, 2021). Clean Water Services (CWS), who manage wastewater and stormwater in the Tualatin subbasin, are implementing flow enhancement and riparian shade programs, as well as a water quality trading program, to manage water temperature in compliance with the TMDL (CWS, 2016). These activities and more help to manage water temperature in the Willamette Basin on a community level.

Additional water quality concerns in the Willamette basin include dissolved oxygen, pH, toxics (Dieldrin and DDT), and phosphorus in addition to mercury, bacteria, and temperature (ODEQ, 2006). These pollutants are addressed by TMDLs in several subbasins. The Coast Fork Willamette TMDL, approved in 1996, includes dissolved oxygen and pH (ODEQ, 1995). Rickreall Creek in the Middle Willamette subbasin established TMDLs for dissolved oxygen, chlorine, and temperature in 1994 (ODEQ, 1993). The Molalla-Pudding TMDL was established in 2008 and includes temperature, bacteria, pesticides, nitrate, and metals (ODEQ, 2008). In 2012, the Tualatin subbasin revised previously established TMDLs for pH, chlorophyll *a*, and dissolved oxygen (ODEQ, 2012b). The previous TMDLs, established in 2001, also included bacteria and toxics (ODEQ, 2001). The Yamhill subbasin established a TMDL for phosphorus in 1992 (ODEQ, 1989). Of all of these TMDLs, the Willamette Basin and Molalla-Pudding Subbasin TMDLs are currently being replaced. Additional potential pollutants of concern and sources identified for specific regions are discussed Appendix B.

3.4.4. Reservoirs

The USACE operates the 13 Willamette Valley Project dams in the Willamette Basin, which create 13 reservoirs that hold nearly 1.6 million acre-feet of water (USACE, 2019). These reservoirs are not located on the Willamette River mainstem but regulate tributaries which in turn help regulate water quality in the Willamette. Beyond the Willamette Valley Project, there are 371 total dams in the Willamette River Basin (Payne, 2002). Combined, these dams can store over 2.7 million acre-feet of water (Payne, 2002). Water is stored in many of these reservoirs while streamflow is high, then released during the summer. These releases help to regulate stream temperature as well as to dilute pollutants, improving water quality within the basin. Specifically, water released during the summer comes from low reservoir depths, which cools the water temperature downstream, while thermal stratification breaks down in the late summer, allowing warmer water to be released in the fall (ODEQ, 2006). An example of this can be seen in ***Figure 17***. This process regulates stream temperature but must be closely monitored to ensure proper temperatures are maintained for fish habitat and spawning.

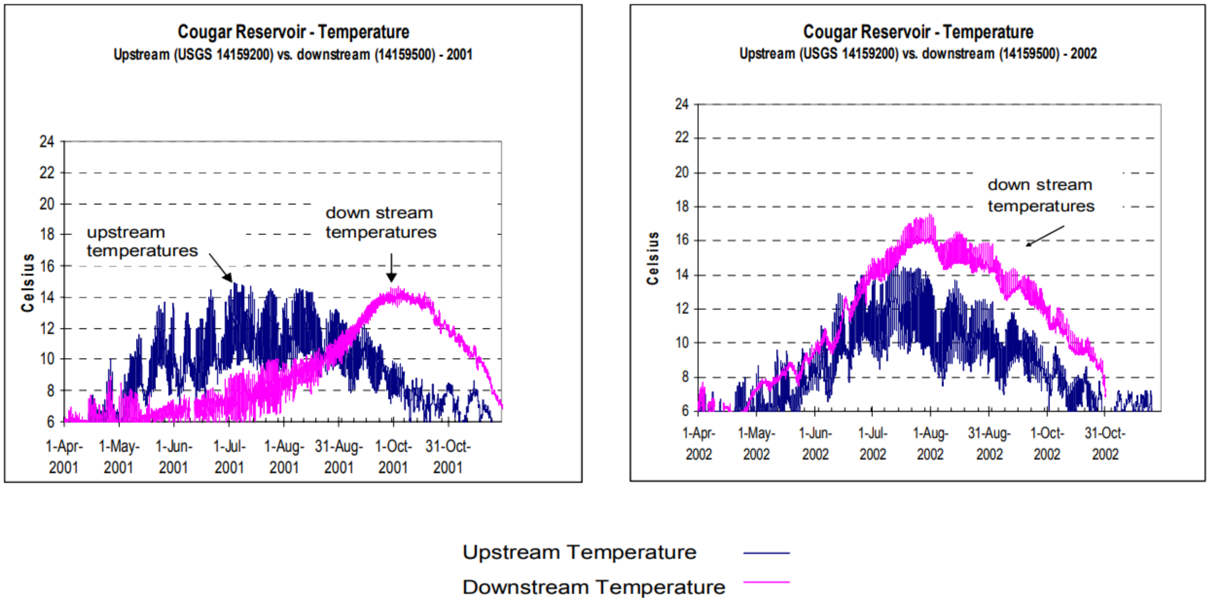

Figure 17. Water Temperatures in 2001 and 2002 collected upstream and downstream of Cougar Reservoir. In 2001 the dam functioned normally, whereas in 2002 it was down due to maintenance. Reproduced from ODEQ, 2006.

Of the dams in the Willamette River Basin, the Willamette Falls Hydroelectric Project is of particular significance because it is the only dam on the Willamette River mainstem. The Willamette Falls Project is located at river mile 26.5 and generates 16.680 MW of power (FERC, 2005). This dam and the reduced grade of the river upstream of it are jointly responsible for the creation of the Newberg Pool. While not technically a reservoir, the Newberg Pool is a notable water body within the Willamette Basin. It is defined by the stretch of the Willamette between river miles 30 and 50. The Newberg Pool is relatively wide and slow moving and is a popular location for recreation and is more heavily regulated for recreation than upstream segments of the river. Partially for this reason, it has been closely monitored for water quality concerns in the past.

One of these concerns is that fish in the Newberg Pool have been noted to have more prevalent levels of skeletal deformities than fish in upstream locations (Curtis, 2007). A study was performed by Oregon State University to investigate the causes of this phenomenon. It was determined that the deformities were being caused by a parasite with a more prevalent population in the Pool, and water quality in the Newberg Pool did not significantly differ from water quality at upstream locations at detectable levels (OSU, 2004). The question then remains why there was a higher incidence of fish infections in the Newberg pool than elsewhere in the Willamette basin. The research panel speculated that this may be due to the ecology of either the parasite-laden snails or the fish themselves (OSU, 2004). For example, the possibility was offered that the Newberg Pool provides a better habitat for the snails in which the parasites dwell. In tandem, fish experts found that the fish species and the time and location of fish spawning, which may differ in the Newberg

Pool, are strong indicators for rates of deformities. Overall, there are likely several environmental factors that contribute to the fish deformity phenomenon in the Newberg Pool.

3.5. Dams and Dam Operations

Of the 371 dams in the Willamette Basin, 25 are considered to be major dams: 11 hydropower dams, one multipurpose dam on the Tualatin River, and the 13 multipurpose Willamette Valley Project dams (Northwest Power and Conservation Council, 2022). These dams are owned both publicly and privately. Most of the dams are located on tributaries within the basin, rather than the Willamette River mainstem. The Willamette Valley Project reservoirs are all located on tributaries (***Figure 18***).

Figure 18: Willamette Valley Project dams. Reproduced from USACE, 2022a.

The Willamette Valley Project reservoirs were built primarily to reduce flooding, although they also provide power, recreation, and irrigation water. To achieve their primary purpose of reducing winter peak floods and augmenting summer flows (USACE, 2022a), the dam operations necessarily have a significant impact on flow in the Willamette River. Water levels in the Willamette Valley Project Reservoirs are maintained at their lowest elevations in the winter months to allow for storage of precipitation. During high flow events, outflows from the system of dams are coordinated to reduce peak flows and river stages downstream (USACE, 2022b). The dams in the Willamette Valley project regulate approximately 27% of surface area runoff in the Willamette Basin, and since the dams were completed, they have cumulatively prevented more than $25 billion in flood damages to the Willamette Valley (USACE, 2022a). In the spring, USACE allows the reservoirs to fill. As discussed previously, this stored water is then released in the summer months to improve water quality, produce hydropower, support fish and wildlife habitat, and provide municipal and irrigation water (USACE, 2022b). The specific management strategies that inform the operation of the Willamette Valley Project are discussed in more detail in Section 3.8.

Eight of the dams associated with the Willamette Valley Project generate hydroelectricity, while the remaining hydroelectricity generating dams in the Basin are licensed by the Federal Energy Regulatory Commission (FERC). At maximum capacity, these dams can generate nearly 500 MW (USACE, 2022a).

3.6. Climate

As a result of the Cascade Range to the east, the Willamette Valley experiences frequent rain in the fall and winter. The Cascade Range receives heavy snowfall with regions of permanent snowfields and glaciers (PNW-ERC, 2002). The Coast Range receives much lighter snowfall but heavier rains (PNW-ERC, 2002). The Willamette Basin receives approximately 80% of annual precipitation between October and March, and less than 5% in July and August (Conlon, 2005). These wet winters help to swell streamflow, recharge soil moisture and groundwater, and create snowpack in the Cascades (OSU, 2012). Average monthly precipitation in Corvallis, located in the Willamette Valley, and at Tombstone Pass, located in the Cascades, can be seen in ***Figure 19***. Precipitation amount increases with elevation, with annual precipitation of 40-50 inches in the Willamette Valley and nearly 200 inches near the crest of the Coast and Cascade Ranges (PNW-ERC, 2002).

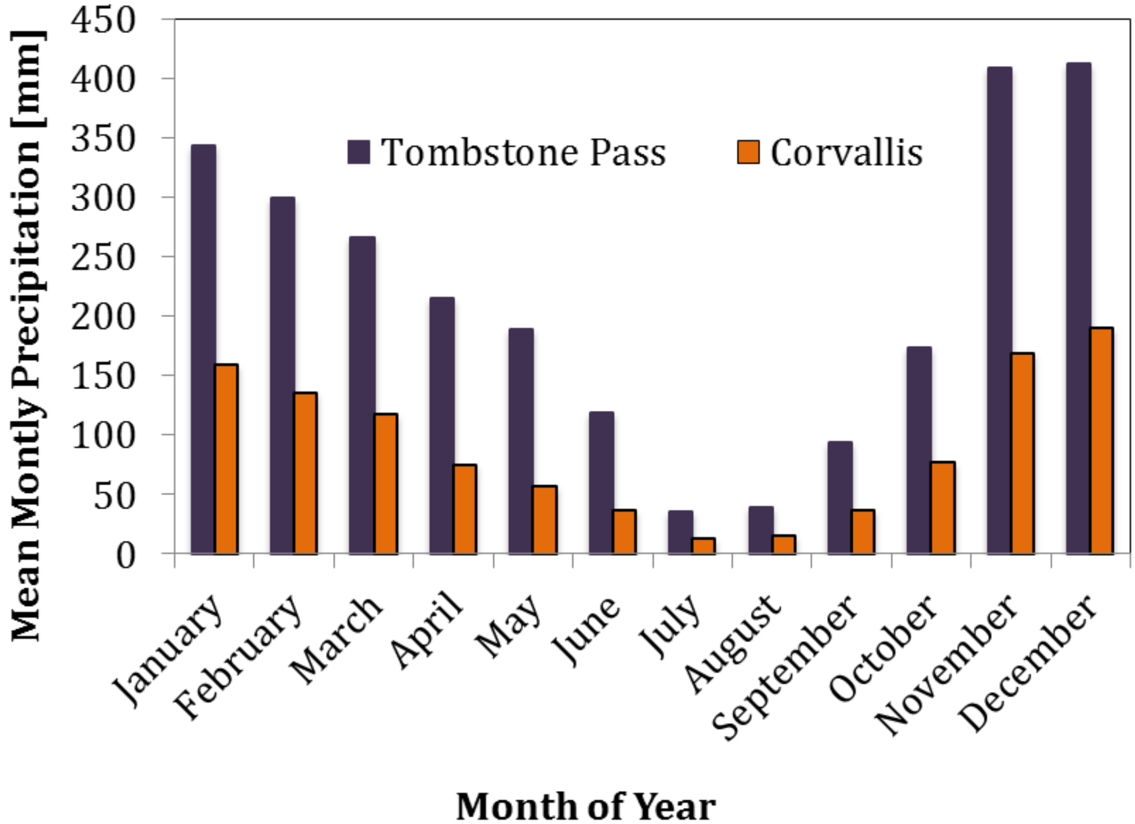

Figure 19. Mean monthly precipitation in the Willamette Basin. Reproduced from OSU, 2012.

3.6.1. Water Availability Projections

The Willamette River is used for a variety of water uses, all controlled by water rights issued by OWRD. Surface water in the Willamette Basin is fully allocated in most areas (PNW-ERC, 2002). A map of available water in the Basin can be seen in ***Figure 20***. If more water is needed in the future, such as for growing urban areas, or if less water is available, such as because of climate change, more junior water rights will not be satisfied.

Current municipal water rights may reach capacity in the Portland metropolitan area in the year 2040, and in the City of Salem in 2070 (OSU, 2012). However, based on currently underutilized water rights and those under development, urban water rights are likely capable of meeting the overall growth in urban water demand (Jaeger et al., 2017). In contrast, agricultural land use and associated water use are projected to decline slightly (OSU, 2012). In addition to this, climate change is expected to cause irrigation to start and end earlier in the year, when water is more available (OSU, 2012). Therefore, having sufficient water for irrigation is not a major concern when evaluating future water availability.

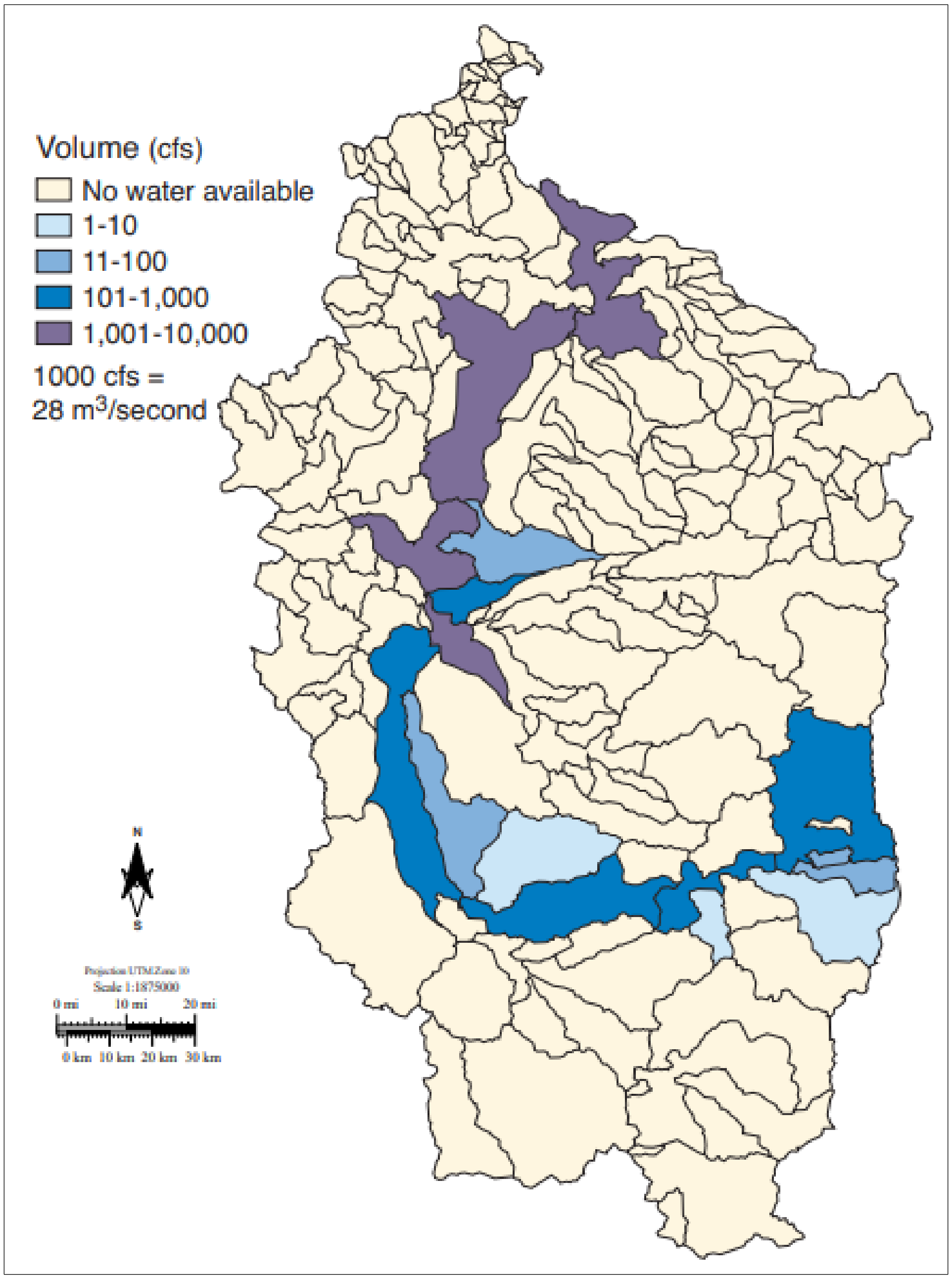

Figure 20. Surface water availability during August Reproduced from PNW-ERC, 2002.

3.6.2. Wildfires

Every summer Oregon battles wildfires, with some years bringing significant damage to forests and in some cases rural communities within the Willamette Basin (***Figure 21***). As climate change continues to damage ecosystems, wildfires will continue to be a threat. Less snowpack and hotter, drier summers are projected to lead to a two- to nine-times increase in land area burned by forest wildfires (OSU, 2012). This increase in wildfires will likely cause changes in forest types as well as a decrease in mature forests available for harvest.

Figure 21: 2020 fire perimeters (Oregon Explorer, 2020).

Additionally, risks to surface water can persist long after the fires are extinguished due to increased susceptibility to flooding and erosion caused by loss of vegetation, increased risk of landslides and debris flows, and decreased reservoir capacity from sedimentation. Water quality may be degraded by elevated risk of harmful algal blooms due to elevated nutrient loading and degraded water quality at intakes, including increased turbidity, nutrients, organic matter, metals, chemicals from fire suppressants, and byproducts from fires in developed areas (e.g., due to burning of building materials). Regional burn probability and overall fire risk have been summarized on a watershed scale by the Oregon Department of Forestry (***Figure 22***). Notably, the east half of the Willamette Basin has much higher fire risk than the west. To mitigate the risks of wildfires, many counties in the Basin upstream of the WIF Intake, including Marion, Linn, and Lane counties (Marion County, 2017; Linn County, 2007; Lane County, 2020), have undertaken the development of Community Wildfire Protection Plans (CWPPs).

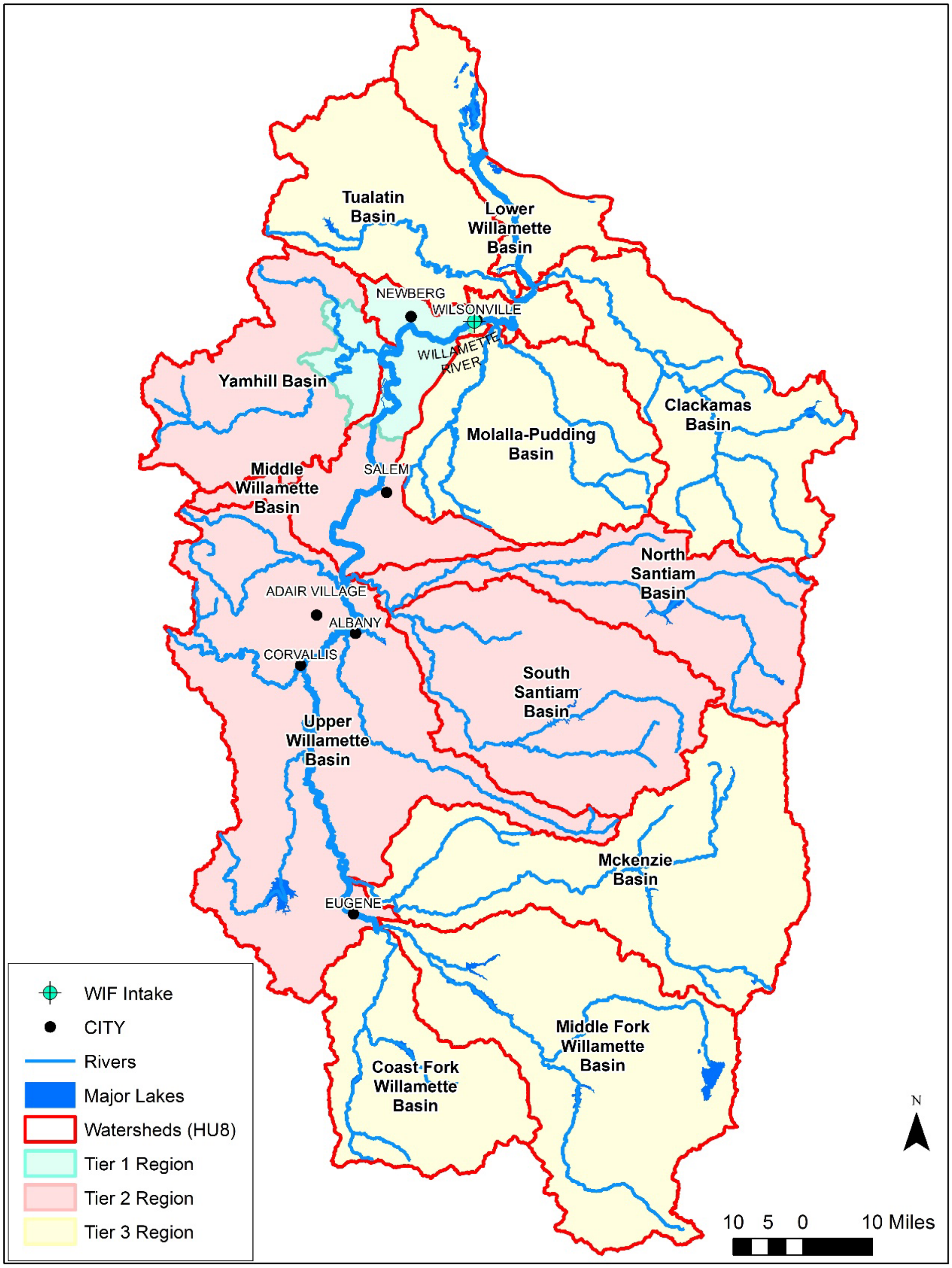

Figure 1. Tiered regions of the Willamette River Basin

2.1. Identification of Relevant Flows

To identify the flow rates of interest for travel time analysis, long term flow monitoring data was analyzed at two locations on the Willamette River mainstem above the WIF Commission Intake. These monitoring stations, United States Geological Survey (USGS) gages 14197900 and 14191000, are located at Newberg and Salem respectively (***Figure 2***). Each gage station contains at least 20 years of average daily discharge data from 2002 to 2022. The USGS gage station at Wilsonville was not used as data was only available up until 1973.

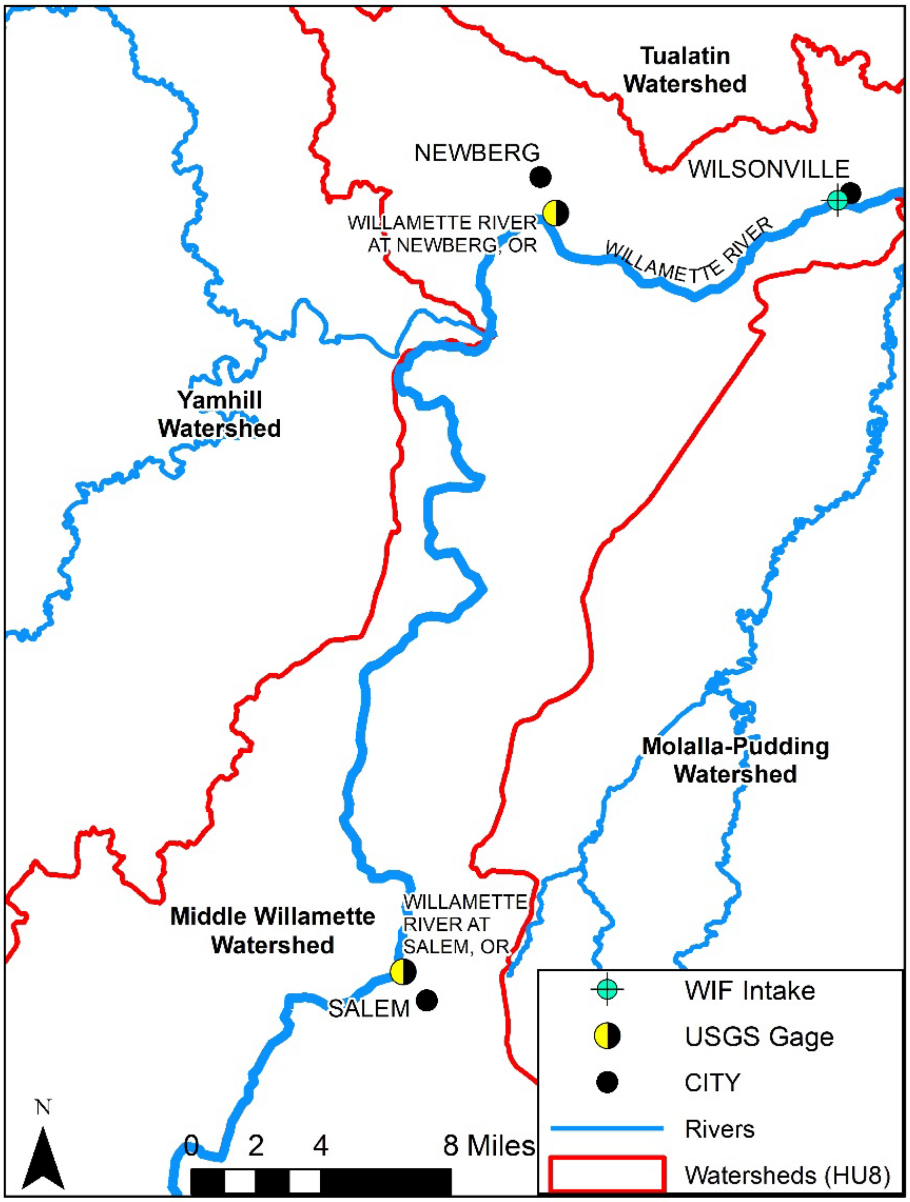

Figure 2. Locations of USGS gages used for flow analysis to inform Tier 1 delineation

The flow statistics at these gages were generated based on the history of record at the stations to identify very low flows or very high flows, which may be critical to assessing risks. Very high flows are important as travel times will be shortest and therefore response times for water quality emergencies will be the most limited. While travel times will be longer during very low flows, these flow rates may also be of concern as less volume is present to provide dilution of contaminants, and therefore high concentrations of pollutants may occur. Low flows are also most relevant for water temperature impacts and potential harmful algal blooms. To capture the ranges of both high and low flows, the 10th and 90th percentile statistics were calculated for dry and wet months, respectively, as well as for the annual data. These results are presented in ***Table 1***. The flow values at Newberg are generally higher than those at Salem as the Yamhill River flows into the Willamette between the two locations.

Table 1. Willamette River Flow statistics at Salem and Newberg USGS gages.

Flow Statistic	Flow at Salem (14191000)	Flow at Newberg (14197900)
90th percentile January flow	85,540 cfs	98,250 cfs
90th percentile annual flow	48,200 cfs	57,500 cfs
10th percentile annual flow	7,025 cfs	7,044 cfs
10th percentile August flow	5,748 cfs	5,940 cfs
cfs – cubic feet per second		

Corresponding flow rates at the WIF Commission Intake were then estimated from the statistics at Newberg and Salem by scaling the flows according to the ratio in drainage areas. The drainage area to the Salem gage is approximately 7,280 square miles while the drainage areas to Newberg and Wilsonville are very similar (8,350 and 8,400 square miles, respectively). Thus, the ratio used to scale flows from Salem to Wilsonville was 1.15 and the ratio used to scale flows from Newberg to Wilsonville was close to 1. Ultimately, the scaled flows from the Newberg gage were used to estimate statistically significant flow rates at the WIF Commission Intake. These flow values are provided in ***Table 2***.

Table 2. Estimated flow statistics at the WIF Commission Intake.

Flow Statistic	Estimated Flow at Intake
90th percentile January flow	98,800 cfs
90th percentile annual flow	57,800 cfs
10th percentile annual flow	7,100 cfs
10th percentile August flow	6,000 cfs
cfs – cubic feet per second	

To obtain a conservative estimate of the Tier 1 region of interest, an approximation of the 90th percentile January flow statistics was used in the travel time analysis, as discussed in Section 4.1.

2.2. Summary of Identified Regions for Risk Analysis

2.2.1. Tier 1: Travel Time for Rapid Responses

Travel times in the middle Willamette River mainstem reaches have been characterized in prior studies as described in this section. The temperature Total Maximum Daily Load (TMDL) developed by the Oregon Department of Environmental Quality (ODEQ) describes the slowing effect of the Newberg Pool on travel times, estimating that low flow travel time through the pool (river mile [RM] 56 to 26.5) is about four days, partially due to the Willamette Falls Project dam (ODEQ, 2006). Temperature modeling performed by the USGS found similarly long travel times. The results of this study suggested that flow starting in Salem (RM 85) would take approximately three days to travel to the WIF Commission Intake (RM 38.7) during low-to-moderate flows (Rounds, 2007). Travel times are shorter during high flows but are still long enough to substantially limit the distance that flow can travel in a given period of time. For example, assuming a flow of 100,000 cubic feet per second (cfs) (corresponding to approximately the 90th percentile January flows), a velocity of 5 feet per second (ft/s) may be estimated based on 2022 monitoring data at the Newberg USGS gage. Under these conditions, an 8-hour travel time would allow flow to travel approximately 27 miles. This limits the 8-hour travel time upstream of the WIF Commission Intake to a point near Fairfield at RM 66.

Delineation of the Tier 1 region was informed by the travel time analysis described above, as well as considerations for the locations of nearby population centers in Newberg and McMinnville and other conservative assumptions. The resulting Tier 1 drainage region extends approximately 35 miles upstream of the WIF Commission Intake on the Willamette River mainstem (RM 73.7) and includes the Yamhill River tributary up to RM 17.8 on the South Yamhill River and to RM 14.8 on the North Yamhill River. These extents align with delineated watershed units (HU12) defined by the Bureau of Land Management (BLM) (BLM, 2004). Accidental releases and point discharges within this region are likely to impact water quality at the intake, with only a relatively short period available for contaminant dispersion and response at the WIF Commission Intake (***Figure 3***).

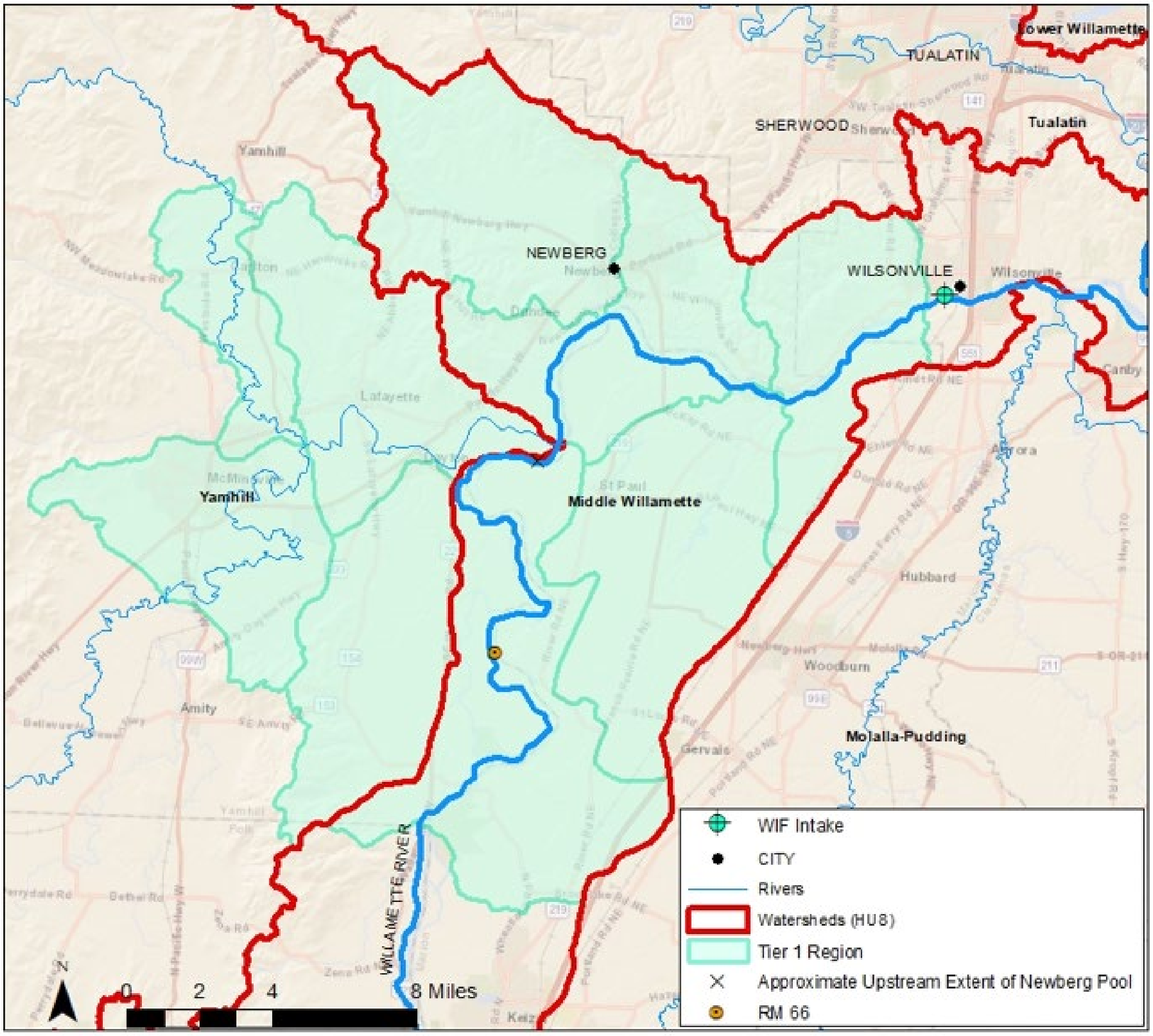

Figure 3. Tier 1 region.

2.2.2. Tier 2: Region for Secondary Management and Analysis of Temperature

The Tier 2 region encompasses the Middle Willamette, Upper Willamette, Yamhill, North Santiam and South Santiam subbasins, which contain features that affect water quality in the Middle Willamette River from subbasins and tributaries upstream of the Tier 1 region. These include major cities such as Salem, Corvallis, and Eugene, reservoirs such as Detroit Lake on the North Santiam River, and agricultural areas such as the Yamhill and Middle Willamette agricultural management areas. The features within the Tier 2 region are unlikely to cause water quality events requiring immediate responses for most contaminant types. Instead, these potential pollutant sources should be monitored for seasonal disturbances to water quality and mitigated through long-term relationships with the communities in this region. The exception is water temperature, as this water quality parameter does not necessarily respond to the same dilution or degradation principles as chemicals where the area of greatest concern is typically the point of discharge. For example, the impact of a withdrawal on water temperature may not be largest at the point of the withdrawal. Thus, the Tier 2 region was also delineated with the intention of examining water temperature and its far-reaching influencers including reservoirs, stream side shading, withdrawals, and point sources. The Tier 2 region and its extent relative to the Tier 1 region are shown in ***Figure 4***.

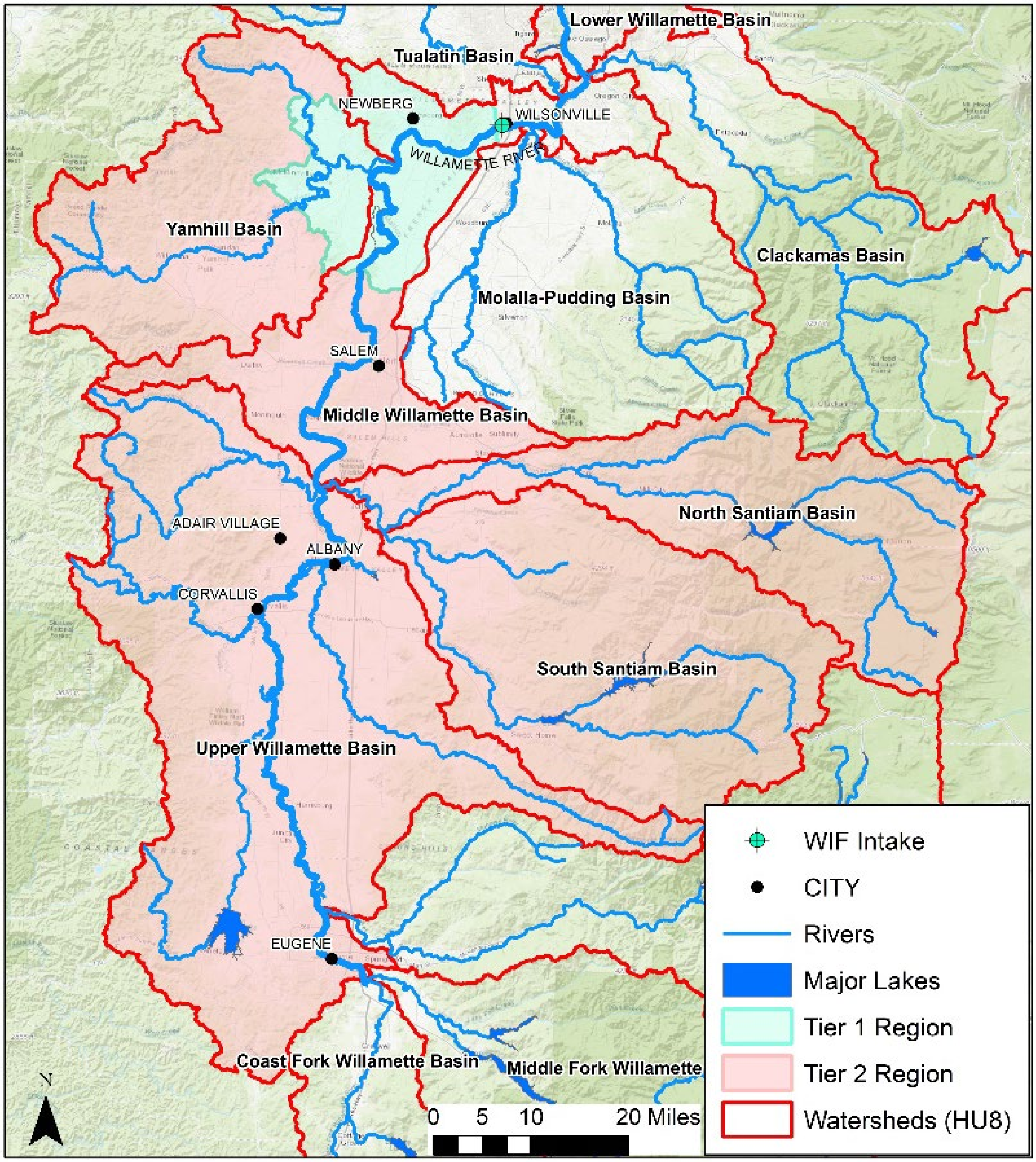

Figure 4. Tier 2 region.

2.2.3. Tier 3: Additional Considerations for Full Willamette River Basin

The Tier 3 region comprises the rest of the Willamette River Basin not encompassed by the Tier 1 or Tier 2 regions, including drainage area downstream of the intake. Potential risks in this region are unlikely to directly affect the water quality at the WIF Commission Intake. However, the WIF Commission should stay apprised of the observed and expected scientific trends on a watershed scale to inform potential new threats or priorities. These basin-wide concerns may include climate change, large scale trends in agriculture, silviculture, land use, and development, population growth, potential modifications to dam and reservoir management, and planned policy changes such as the Willamette Reallocation Project. The extent of the Tier 3 region relative to the Tier 1 and 2 regions is shown in ***Figure 1***.

3. SUMMARY OF HISTORIC AND CURRENT DATA

This section summarizes the flow and water quality monitoring data available in the Tier 1 and Tier 2 regions, with a focus on the Tier 1 region as data allows. The datasets evaluated include flow, water temperature, mercury, bacteria, phosphorus, harmful algal blooms, dissolved oxygen, pH, metals, pesticides, and emerging contaminants. The largest focus was given to the parameters that are most likely to significantly affect source water quality at the intake based on the level of concern within the Basin. These include flow, temperature, mercury, and bacteria. As discussed in the "Willamette Watershed History, Characterization, and Stakeholders" Memo, there are Willamette Basin TMDLs for temperature, mercury, and bacteria. These are water quality parameters that have been identified as reaching levels in the rivers that are harmful to both humans and aquatic species. Additional parameters considered, such as phosphorus, harmful algal blooms, and pesticides, have TMDLs in smaller subbasins within the Willamette or have been identified as potential water quality risks by communities in specific parts of the Tier 1 or Tier 2 regions.

The information provided in each subsection includes the monitoring locations, periods of record, and descriptive analysis of the data. Analysis consists of spatial, seasonal, and long-term trends as data allow. Where applicable, analysis of water quality parameters may also include correlations to flow. Some analysis provided is summarized from previous studies in the basin, as significant analysis has been done by regional and local stakeholders as well as government agencies. Additional analyses were performed to fill analytical gaps in the literature and focus the discussion on the Tier 1 and Tier 2 regions. Additional analyses primarily utilized data available from USGS gages, although data from the Oregon Water Resource Department (OWRD) gages and other monitoring records may be included prior to submission of the final draft of this Memo. Where data was too limited to perform the desired analysis, this is noted along with recommendations to fill these data gaps. Finally, it should be noted that the analysis presented in this draft memo is in preliminary stages and may be modified or added to prior to submission of the final draft. In most cases, this is indicated within the following subsections.

3.1. Flow

Analyzing historic and present-day flow in the Willamette Basin is an important part of understanding water availability trends, both seasonally and over multiple years. Flow also has a substantial impact on water quality parameters including temperature. Therefore, this subsection is dedicated to understanding flow along the reaches within the Tier 1 and Tier 2 regions.

3.1.1. Tier 1

There are over 100 USGS flow gages in the Willamette River Basin. Of these, only three are located within the Tier 1 region (***Figure 5***). One of these is on the Willamette River mainstem at Newberg and two are on the South Yamhill River. The Newberg gage (14197900) has flow data from 2001-2022. The gages on the South Yamhill, 14194000 and 14194150, have data from 1940-1991 and 1994-2022, respectively. Although there is no USGS gage on the North Yamhill River within the Tier 1 region, a Tier 2 gage on the North Yamhill River (14197000) has historic data and was assessed to estimate relative flow contributions.

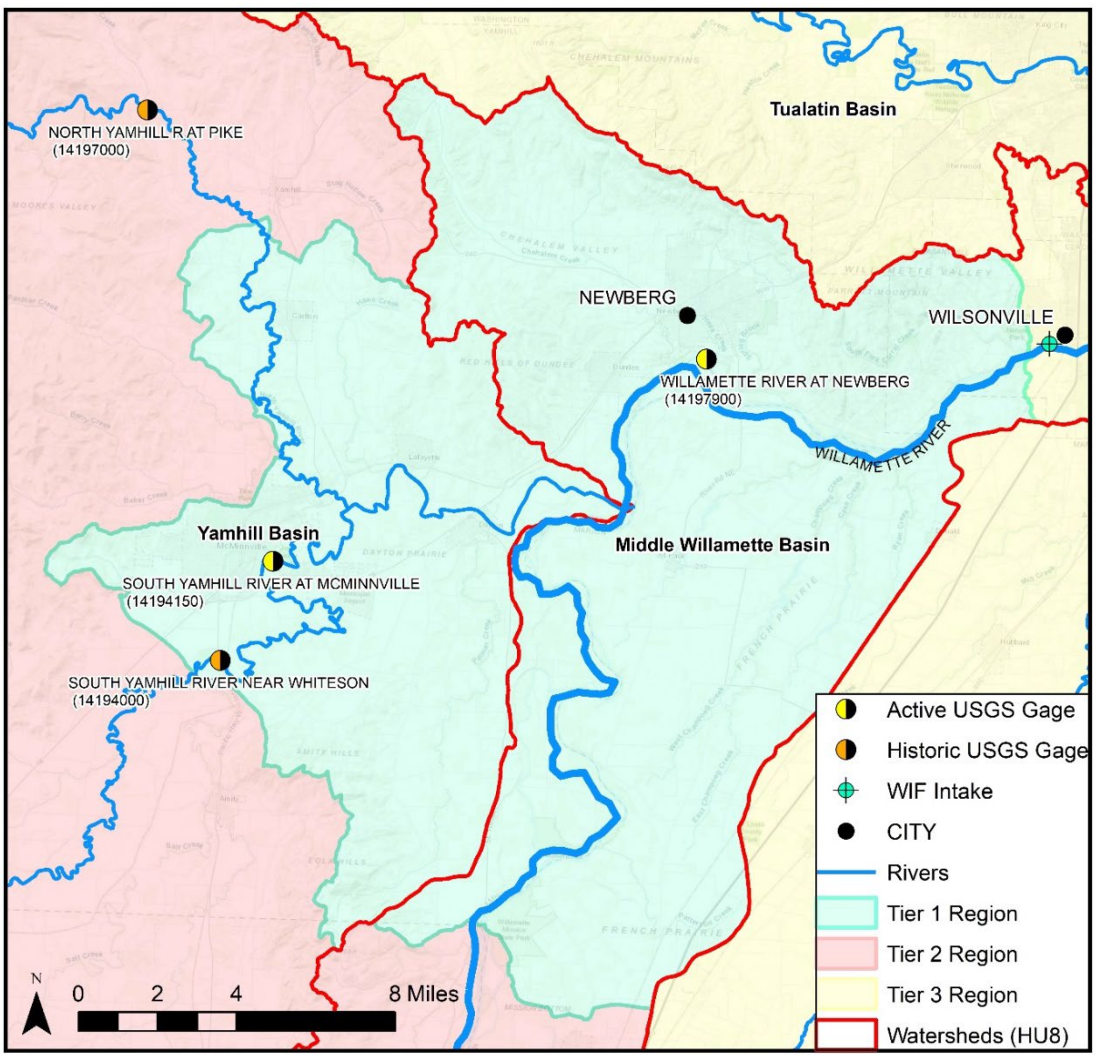

Figure 5. USGS flow gage locations and status in the Tier 1 region.

As described in Section 2.1., the primary indicator for flow rates near the WIF Commission Intake is the USGS gage at Newberg (14197900). A hydrograph analysis of historical flow data at this gage is shown in ***Figure 6***. This analysis suggests that while wet season flow rates are quite variable, as shown by the data from the individual supporting years in gray, an average seasonal trend does emerge (in blue). Summer flows from July through October are predictably low, with relatively consistent flow rates throughout the summer and little variability across water years. The highest flow rates in the river occur during the winter months of December and January due to storm events. There is a noticeable dip in flow during early spring, followed by a slight rise in flow rates for the months of March and April when temperatures warm and snowmelt from the upper reaches of the Willamette Basin contributes significant water volume.

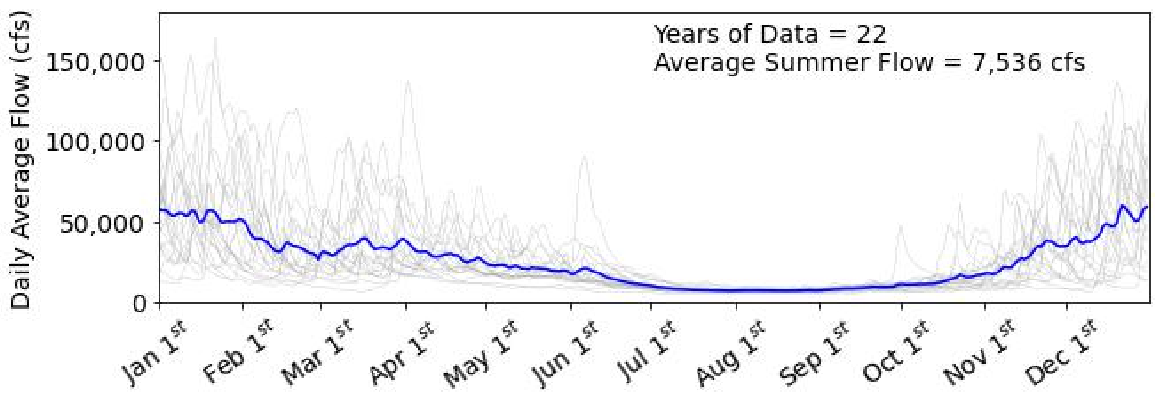

Figure 6. Average annual hydrograph (blue) and supporting years (gray) for USGS gage at Newberg (14197900)

Other than the Willamette River mainstem itself, the greatest tributary contributor to flow at the WIF Commission Intake in the Tier 1 region is the Yamhill River. As there is no active USGS gage on the mainstem of the Yamhill, an approximation of the contributions from the Yamhill River may be estimated from the active South Yamhill River gage (14194150) and the inactive North Yamhill River gage (14197000). The South Yamhill gage exhibits a similar seasonal trend as the Newberg gage, although the South Yamhill River does not receive an obvious boost in streamflow during the spring as the drainage area is relatively low in elevation and does not typically maintain winter snowpack (***Figure 7***). Far less flow on average was recorded at the North Yamhill River gage compared to the South Yamhill River gage, although the seasonal trends are very similar. By comparing the combined annual average hydrographs of the North and South Yamhill River gages to that of the gage at Newberg, it can be estimated that the Yamhill River contributes approximately 1/10th of the total flow to the Willamette River mainstem at the WIF Commission Intake during any given season. This means that source water protection in the Yamhill Basin is important as well as on the Willamette River mainstem and other major tributaries.

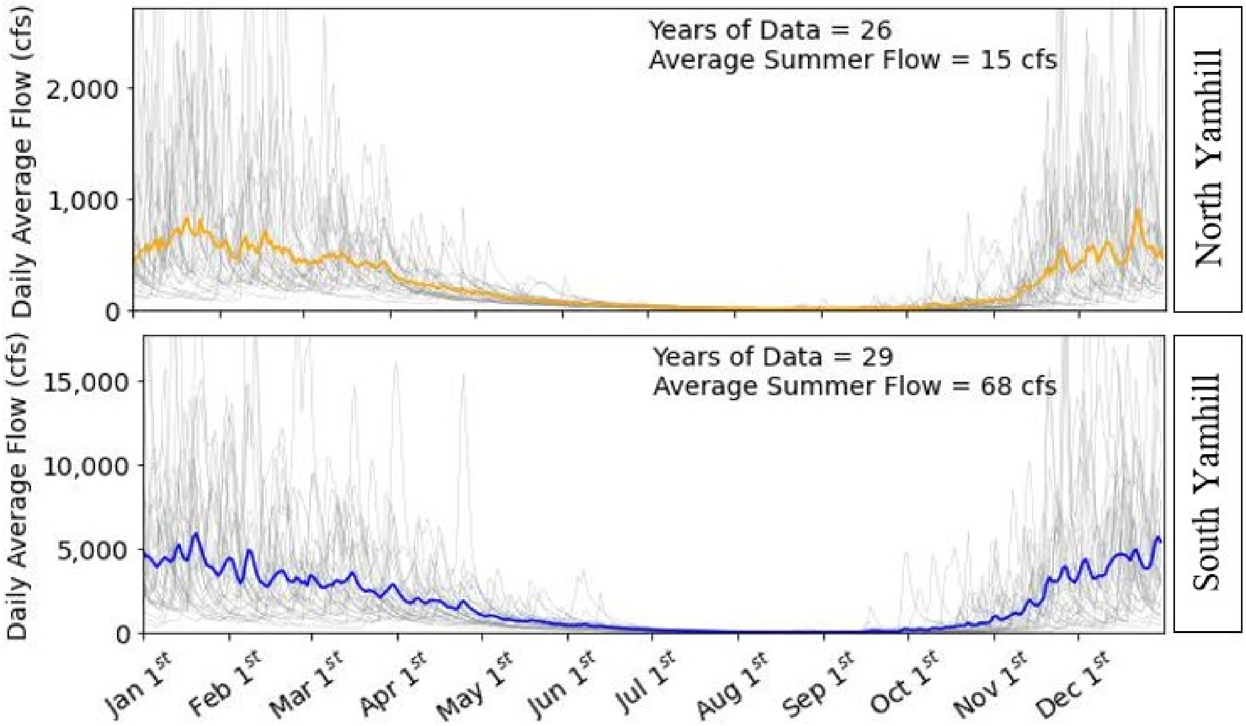

Figure 7. Annual average hydrographs and supporting years for historic USGS gage on North Yamhill (top) and active USGS gage on South Yamhill (bottom).

3.1.2. Tier 2

There are 36 USGS flow gages in the Tier 2 region, for a total of 39 flow gages in the Tier 1 and Tier 2 regions combined. The time periods of record of the 39 flow gages are provided in ***Table 3***. Of the 36 flow gages in the Tier 2 region, 23 have sufficient recent data for analysis. Combined with the two gages analyzed in the Tier 1 region, there are a total of 25 gages with at least 10 years of recent daily average flow data. These are shown with yellow labels in ***Figure 8***.

Table 3. Summary of USGS gages in the Tier 1 and Tier 2 regions. Inactive gages are greyed out.

Station ID	Station Name	Start Date	End Date	Years of Data
14166000	WILLAMETTE RIVER AT HARRISBURG, OR	10/1/1944	4/17/2022	78
14166500	LONG TOM RIVER NEAR NOTI, OREG.	10/1/1935	4/17/2022	87
14167000	COYOTE CREEK NEAR CROW, OREG.	7/1/1940	9/29/1987	47
14169000	LONG TOM RIVER NEAR ALVADORE, OREG.	10/1/1939	4/17/2022	83
14170000	LONG TOM RIVER AT MONROE, OR	11/13/1920	4/17/2022	102
14171000	MARYS RIVER NEAR PHILOMATH, OR	10/1/1940	4/17/2022	82
14172000	CALAPOOIA R AT HOLLEY OREG	10/1/1935	9/30/1990	55
14173500	CALAPOOIA RIVER AT ALBANY, OR	10/1/1940	9/30/1990	50
14174000	WILLAMETTE RIVER AT ALBANY, OR	1/1/1900	4/17/2022	122
14178000	NO SANTIAM R BLW BOULDER CRK, NR DETROIT, OR	1/1/1907	4/17/2022	115
14179000	BREITENBUSH R ABV FRENCH CR NR DETROIT, OR.	6/1/1932	4/17/2022	90
14180300	BLOWOUT CREEK NEAR DETROIT, OR	10/1/1998	4/17/2022	24
14181500	NORTH SANTIAM RIVER AT NIAGARA, OR	12/1/1908	4/17/2022	114
14181750	ROCK CREEK NEAR MILL CITY, OR	9/30/2005	1/4/2009	4
14182500	LITTLE NORTH SANTIAM RIVER NEAR MEHAMA, OR	10/1/1931	4/17/2022	91
14183000	NORTH SANTIAM RIVER AT MEHAMA, OR	7/1/1905	4/17/2022	117
14184100	NORTH SANTIAM R AT GREENS BRIDGE, NR JEFFERSON, OR	10/1/1964	4/17/2022	58
14185000	SOUTH SANTIAM RIVER BELOW CASCADIA, OR	9/1/1935	4/17/2022	87
14185900	QUARTZVILLE CREEK NEAR CASCADIA, OREG.	8/1/1963	4/17/2022	59
14187000	WILEY CREEK NEAR FOSTER, OR	10/1/1947	4/17/2022	75
14187200	SOUTH SANTIAM RIVER NEAR FOSTER, OR	7/19/1973	4/17/2022	49
14187500	SOUTH SANTIAM RIVER AT WATERLOO, OREG.	7/1/1905	4/17/2022	117
14188610	SCHAFER CREEK NEAR LACOMB, OR	7/15/1993	4/17/2022	29
14188800	THOMAS CREEK NEAR SCIO, OR	10/1/1962	4/17/2022	60
14189000	SANTIAM RIVER AT JEFFERSON, OR	10/1/1907	4/17/2022	115
14189500	LUCKIAMUTE RIVER NEAR HOSKINS, OREG.	5/1/1934	9/29/1978	44
14190000	LUCKIAMUTE R AT PEDEE OREG	10/1/1940	9/29/1970	30
14190500	LUCKIAMUTE RIVER NEAR SUVER, OR	8/1/1905	4/17/2022	117
14190700	RICKREALL CREEK NEAR DALLAS, OREG.	10/1/1957	9/29/1978	21
14191000	WILLAMETTE RIVER AT SALEM, OR	10/1/1909	4/17/2022	113
14192000	MILL CREEK AT SALEM, OREG.	10/1/1940	9/29/1978	38
14192500	SOUTH YAMHILL RIVER NEAR WILLAMINA, OREG.	5/1/1934	9/29/1993	59
14193000	WILLAMINA CREEK NEAR WILLAMINA, OR	6/1/1934	9/29/1991	57
14194000	SOUTH YAMHILL RIVER NEAR WHITESON, OREG.	7/1/1940	9/29/1991	51
14194150	SOUTH YAMHILL RIVER AT MCMINNVILLE, OR	10/1/1994	4/17/2022	28
14194300	NORTH YAMHILL RIVER NEAR FAIRDALE, OREG.	10/1/1958	9/29/1991	33
14196000	HASKINS CREEK BLW RESERVOIR, NR MCMINNVILLE, OR	10/1/1967	12/8/2008	41
14197000	NORTH YAMHILL R AT PIKE, OREG.	10/1/1948	9/29/1973	25
14197900	WILLAMETTE RIVER AT NEWBERG, OR	10/1/2001	4/17/2022	21

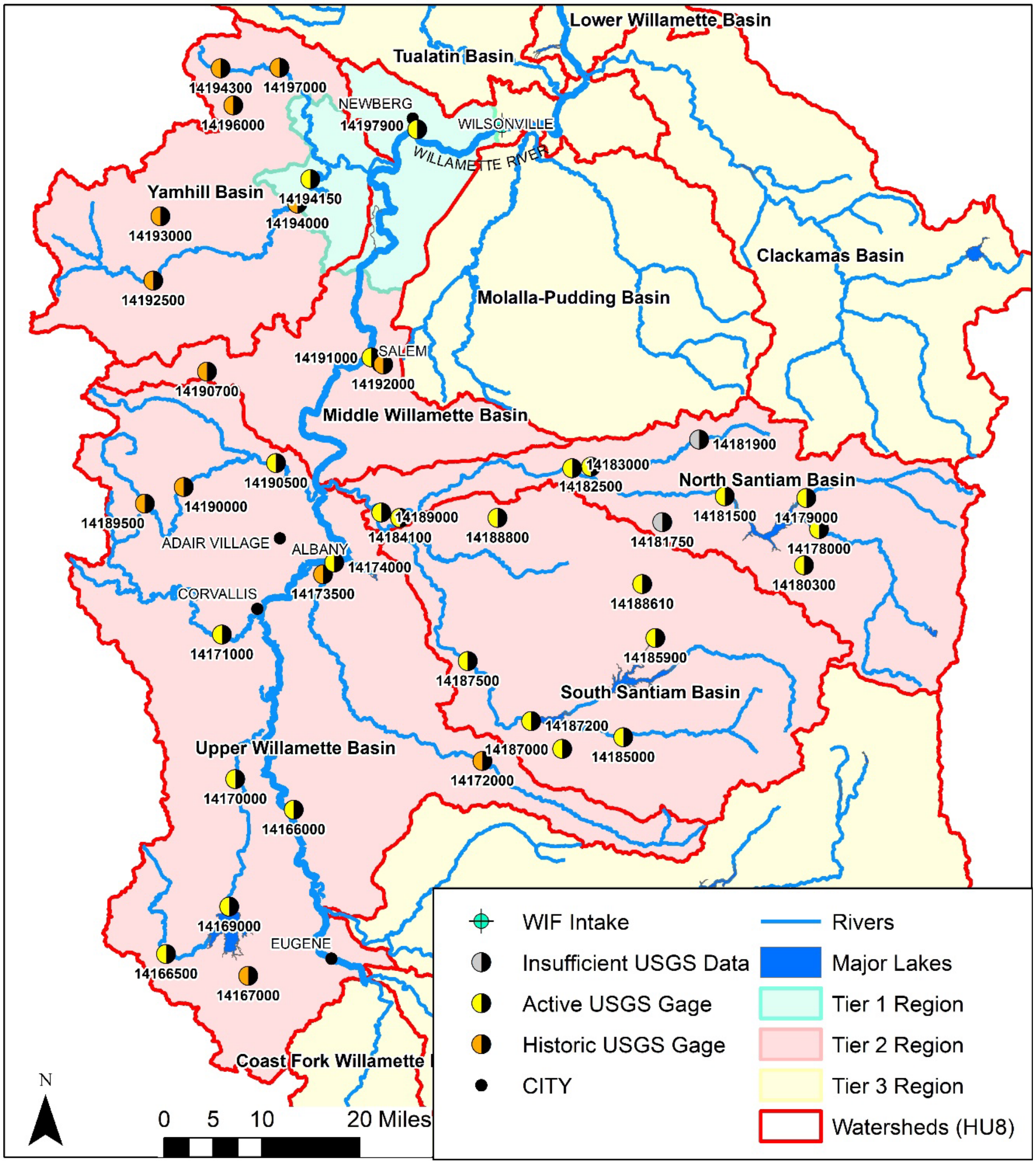

Figure 8. USGS gages in Tier 1 and Tier 2 regions.

3.1.2.1. Long Term Trends

The most downstream USGS gage in the Tier 2 region is near Salem (14191000). The long-term flow record at this gage was analyzed to compare the historical and current flow regimes. ***Figure 9*** shows the monthly average flows from 1923 to 2022 for the summer and fall months, which had the most noticeable differences in trend. It also demonstrates the overall trend in flow before and after the completion of some of the largest Willamette Valley Project (WVP) dams in 1953, as shown by the horizontal lines. The monthly average flow plot in June exhibits a wide range of flow variation, which makes it difficult to establish a pattern throughout the available period. Nevertheless, the average flow for the other months shown in the plots appears to have increased after the completion of the dam project. This behavior is more apparent while the flow is low. ***Table 4*** quantifies the overall average of monthly flow before and after 1953 for summer and fall at the Salem gage. The overall average monthly flows have increased by 65%, with July being the lowest increase at 13% and September being the largest increase at 114%. Flows during the month of June appear to have decreased slightly since 1953. This is likely due to high variability in rainfall during this month, which affects when WVP dams begin programmatic control of discharges. Furthermore, the flows are typically much lower later in the summer, so the WVP dams generally continue to store water in June.

Table 4. Average monthly flows at the Salem gage

Month	Before 1953	After 1953
June	14,429 cfs	13,876 cfs
July	6,648 cfs	7,530 cfs
August	4,125 cfs	6,963 cfs
September	4,168 cfs	8,931 cfs
October	8,085 cfs	13,071 cfs

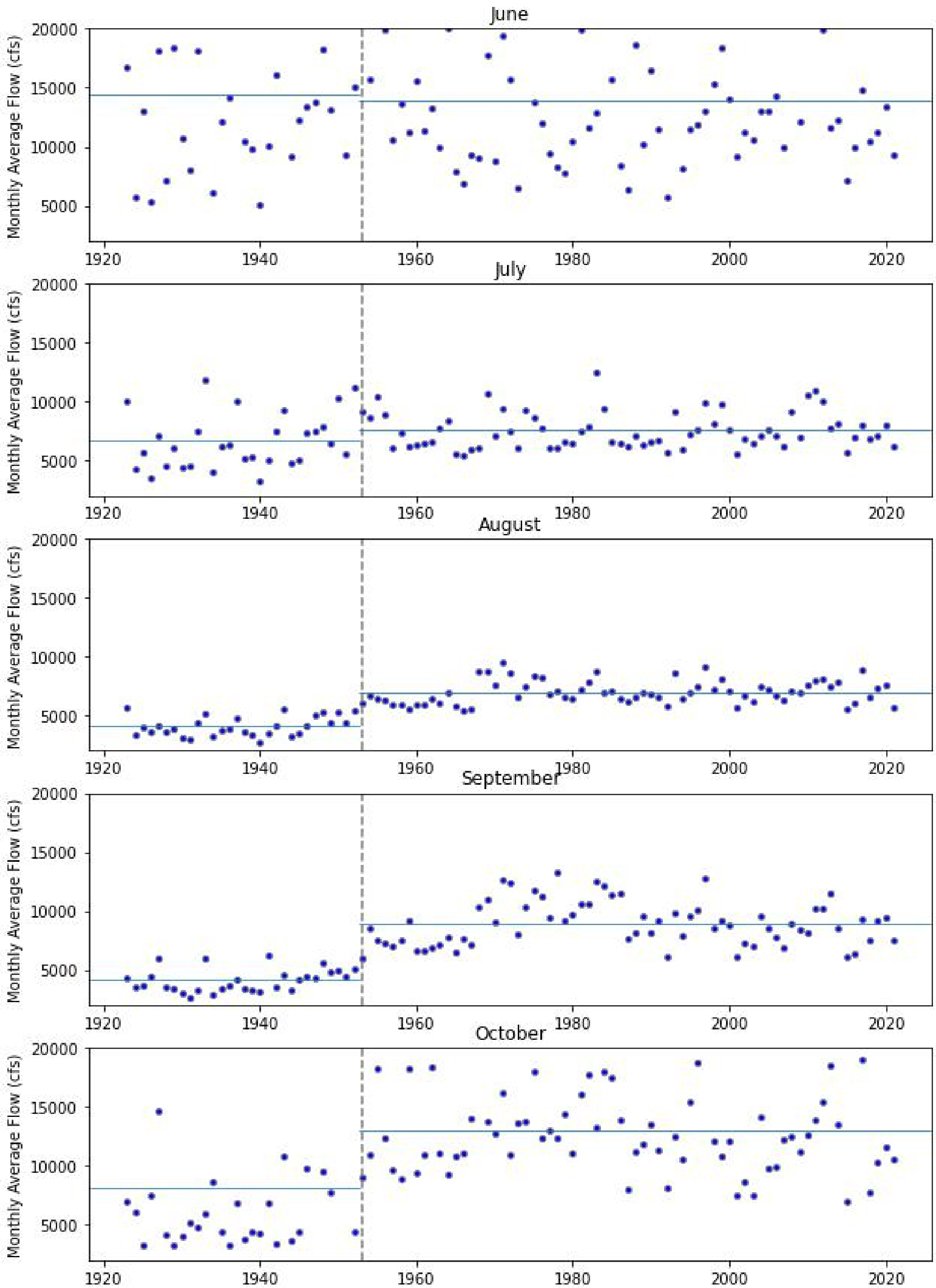

Figure 9. Average flows from 1923 to 2022 at the Salem gage (14191000) for summer and fall months

3.1.2.2. Seasonal Trends

Seasonal flow along the Willamette River mainstem in the Tier 2 region, from upstream to downstream, can be characterized in more detail by the gages at Harrisburg (14166000), Albany (14174000), and Salem (14191000), in that order. As each of these gages have about a century of data, the datasets were divided by the year 1954, when several of the WVP dams were completed, in analysis to capture the effects of the dam operations on average flow rates. The average annual hydrographs pre-1954 (top, yellow) and post-1954 (bottom, blue) from these three mainstem gages are shown in ***Figure 10***. Data from the individual supporting years is shown in gray.

These plots show current seasonal trends (shown in blue) are extremely similar along the length of the Willamette River mainstem. As expected, the magnitude of both the wet season flow rates and summer low flows increase downstream, although the overall shape of the pulses observed at Harrisburg during the wet season are also observed at Salem. Similarly, the summer season exhibits an extended trough of low flow which then rises slowly starting in September along the whole Willamette River mainstem. As expected, this indicates that less flow is available for diluting potential water quality contaminants.

The pre-1954 data at these same gages (shown in yellow) indicate that slightly different seasonal trends could be observed on the Willamette River mainstem today had the WVP and other major anthropogenic changes not been made to the basin. The historical annual average flow regime during the wet season has a different shape than that in the more recent record. The following differences can be observed:

- The historical trends show a slight dip in flows in early March, likely associated with the time period between winter storms and spring snowmelt, while the springtime flows in the recent record are relatively constant during those weeks. As discussed in the "Willamette Watershed History, Characterization, and Stakeholders" Memo, this change may be due to the fact the WVP dams store springtime flows.
- The late spring flows in the recent record exhibit a cliff in mid-June that is not present in the steadily decreasing springtime flows in the historical record. This may be associated with the minimum flow objectives at Salem, for which the threshold decreases significantly on June 15th.
- The average summer flow rates are much lower along the Willamette River mainstem in the historical record than in the recent time period, once again likely due to the influence of the WVP operations and NOAA's National Marine Fisheries (NMFS) Biological Opinion (NMFS, 2008). This is further discussed in Section 4.2.2.

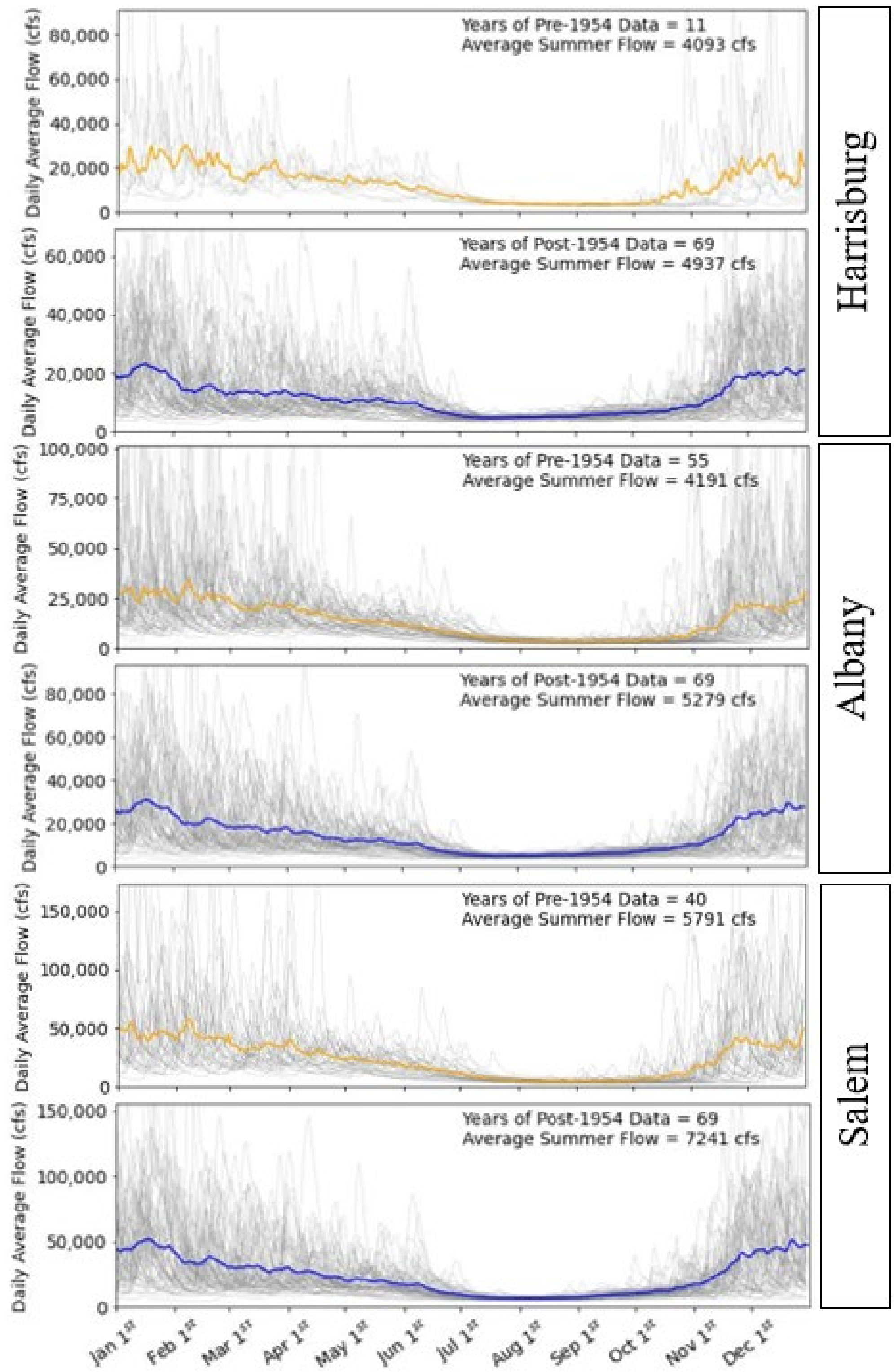

Figure 10. Average annual hydrographs pre-1954 (yellow) and post-1954 (blue) for the Willamette River mainstem at Harrisburg (top), Albany (middle), and Salem (bottom)

These findings are significant to source water protection as they suggest that the WVP operations have, in meeting the conditions of the Biological Opinion, affected the flow regimes in the Willamette River mainstem. The higher summer flows due to the dams benefit the fish as well as the water providers drawing from the Willamette, as many water rights contain fish persistence conditions. These conditions, which are further discussed in the Watershed History, Characterization, and Stakeholders Memo, require that withdrawals are curtailed when flows are below a certain threshold. Although the WVP reduces the frequency that flows drop below this threshold during the summer months, some WIF Commission Partners may still expect to experience occasional curtailment events based on individual permit conditions. This is further explored in a Section 3.1.2.3, which presents the results of a flow frequency analysis.

The seasonal contributions to the Willamette River from major tributaries in the Tier 2 region, in order from upstream to downstream, are best characterized by the gages closest to the respective confluences on the Long Tom River (14170000), Mary's River (14171000), Calapooia River (14173500), Santiam River (14189000), and Luckiamute River (14190500). The same 1954 temporal threshold was applied to the data to characterize the recent and historic hydraulics of the rivers separately. The post-1970 plots are provided in ***Figure 11***. It should be noted that, as shown in ***Figure 8***, there is no active gage on the Calapooia River. Instead, historical gage data on the Calapooia at Albany (14173500) was used to characterize flow from this tributary, therefore the annual hydrograph for this tributary is supported by fewer years of data compared to the others.

Figure 11 shows the vast majority of tributary flow to the Willamette River in the Tier 2 region comes from the Santiam River (14189000), especially in the late spring and early fall. This hydrology in the Santiam basin is possible due to the operations of the WVP dams on the North and South Santiam Rivers. The Santiam basin is also a water supply source for the City of Salem. Therefore, the Santiam basin is an important area within Tier 2 for establishing source water protection partnerships, and for the WIF Commission Partners to monitor.

It should also be noted that the impact of the Fern Ridge dam is clearly visible in the high flow plateau in the late summer at the Long Tom River gage (14170000). The impacts of the WVP dams on the tributaries to the Willamette are further explored in Section 4.2.2

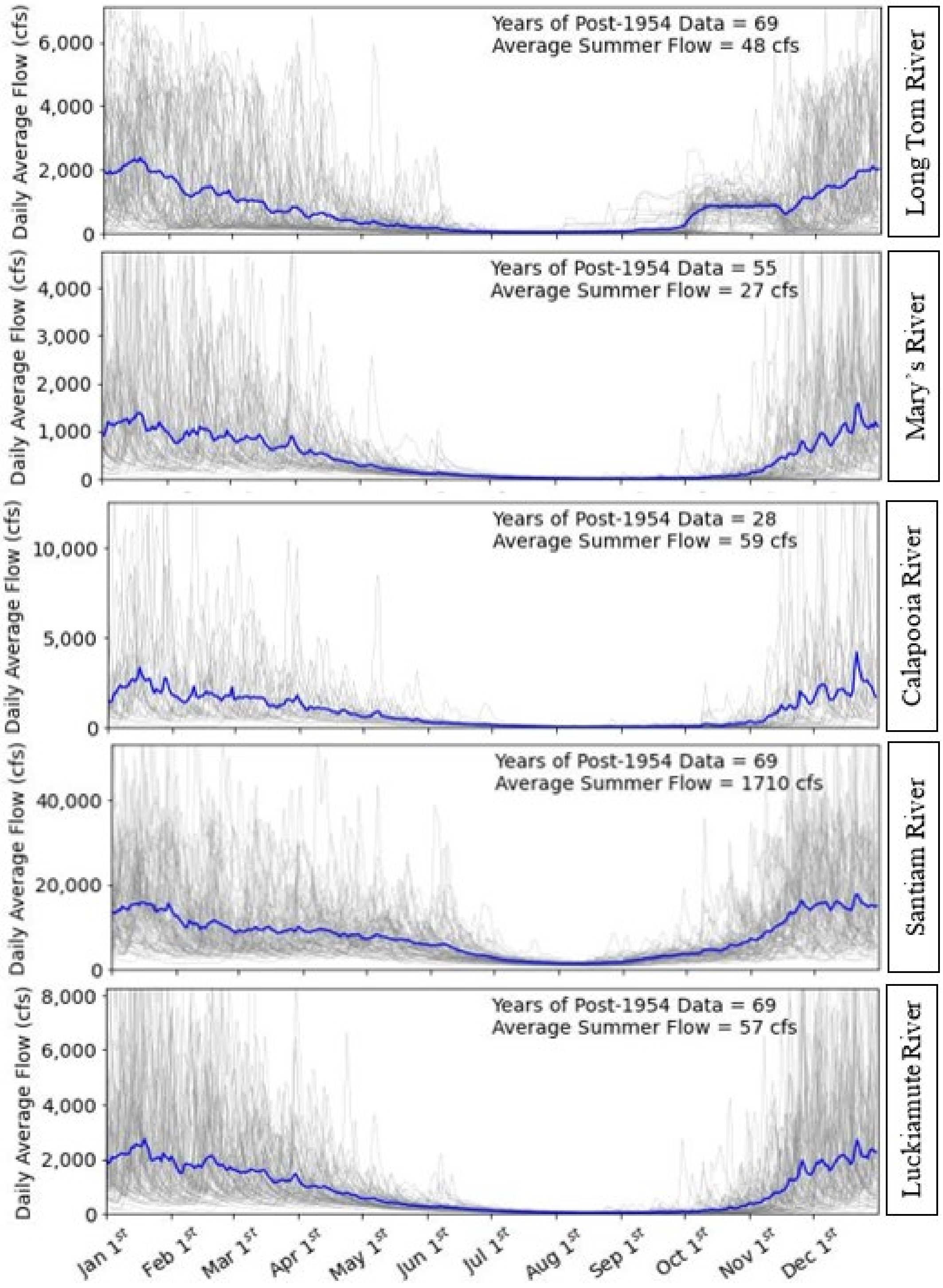

Figure 11. Annual average hydrographs post-1954 for major tributaries. In order from top to bottom: Long Tom River, Mary's River, Calapooia River, Santiam River, and Luckiamute River.

In summary, the USGS flow data on the Willamette River mainstem indicates that the WVP dams have increased average summer flows in the mainstem since they began operation. This seasonal trend is supported into the future by the NMFS BiOp and represents a potential benefit to holders of water right with fish persistence conditions during that season. Additional details about these findings and how they pertain to the water rights held by the WIF Commission Partners will be provided in the final draft of this Memo. Furthermore, the data available for the tributaries within the Tier 2 region demonstrate that the Santiam River is the largest contributor of flow to the Willamette in the region. This makes it a priority watershed for scientific investigation and management partnerships. However, it should be noted that the majority of flow in the Willamette River mainstem is sourced from the Coast Fork and Middle Fork Willamette River tributaries upstream of the Tier 2 region.

3.1.2.3. Flow Frequency Analysis

In general, a flow frequency analysis can be conducted to determine the percentage of time that streamflow at a given location is below a given threshold. For this analysis, a flow frequency analysis was conducted for daily average flow rates at the USGS gage at Salem. As done in the analyses presented in prior sections, only data after 1954 were used. Flows were compared to fish persistence target flows used in water rights permits held by the City of Beaverton and the City of Hillsboro. These fish persistence target flows are part of the curtailment conditions, which limit the amount of water that can be legally diverted for some water rights at low flow conditions. The fish persistence target flows considered in this analysis are summarized in ***Table 5***.

Table 5. Fish persistence target flows at Salem and applicable date ranges.

Dates	**Fish Flow Targets Measured at Salem (cfs)**
July 1 – October 31	5,630
November 1 – March 31	6,000
April 1 – April 15	15,000
April 16 – April 30	17,000
May 1 – May 31	15,000
June 1 – 15	12,600
June 16 – 30	8,500

Figure 12 shows a daily flow frequency plot for each month, with two plots for April and June due to the differing fish persistence target flows for the two halves of those months. The figure shows that, as expected, flows are lower and less variable in the summer months, with higher and more variable flows in the winter. Fish persistence flow targets are missed less than 5% of the time for January, February, March, September, October, November, and December.

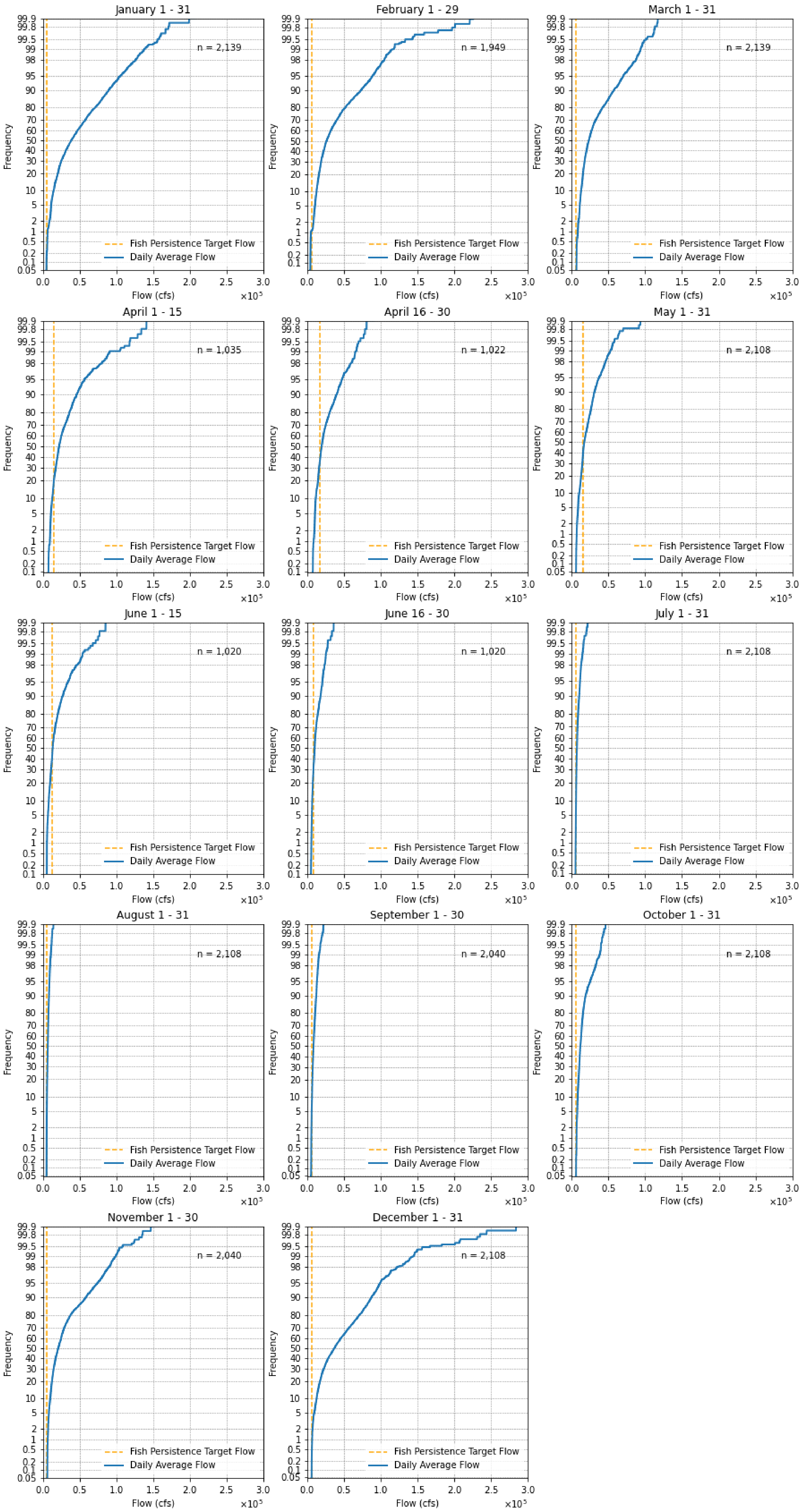

Figure 12. Flow frequency curves for daily average flows at the USGS gage at Salem.

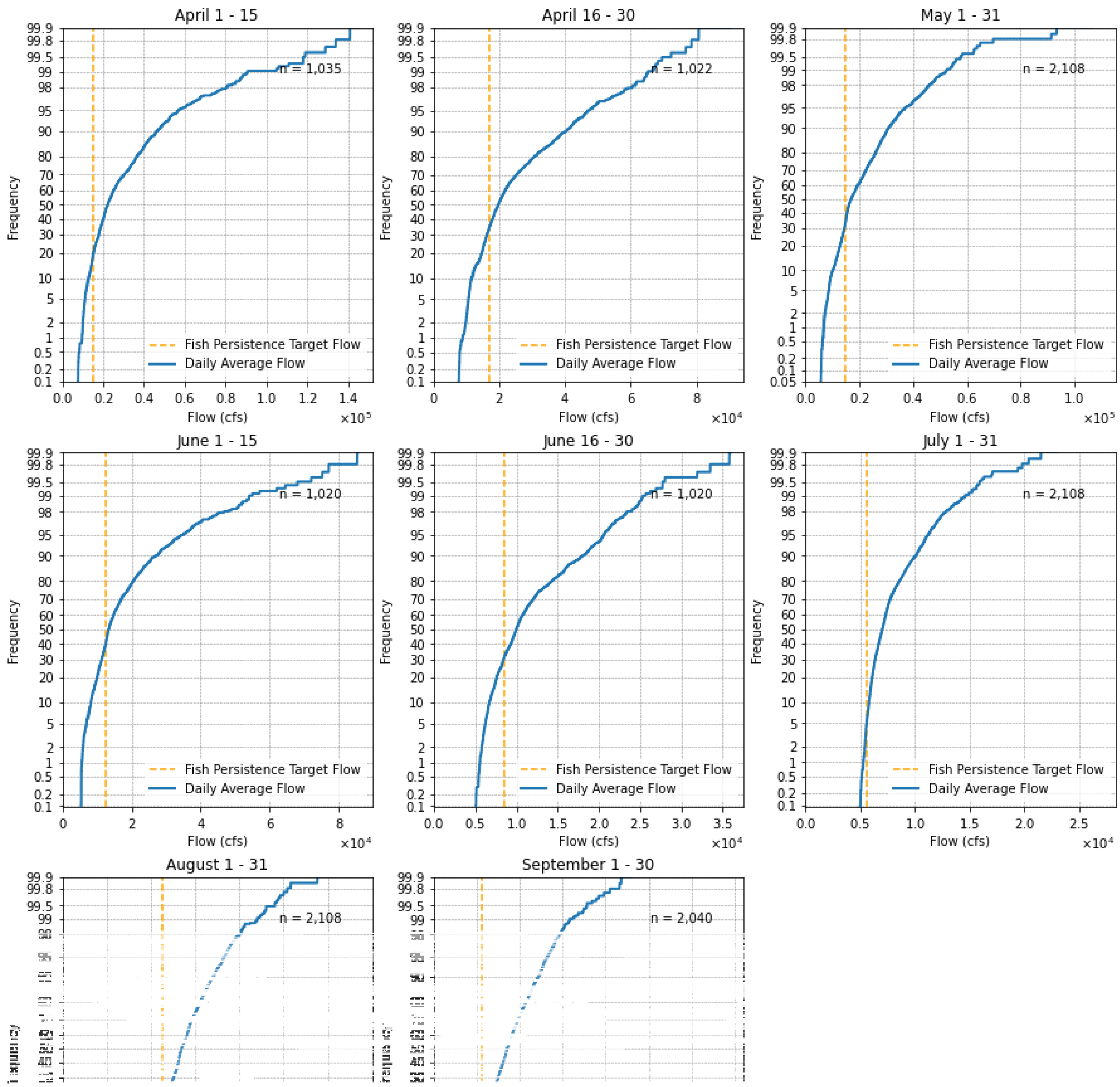

Figure 13. Flow frequency curves for daily average flows at the USGS gage at Salem for April-September.

3.2.Water Temperature

Water temperature is an important water quality concern throughout the Willamette Basin. Water temperature is critically important to endangered species and is also a key factor in various water quality conditions that can affect drinking water treatment and quality. The Willamette Basin temperature TMDL, established in 2006, sets heat load allocations and reductions to meet water temperature standards within the basin. These standards vary based on use designations, including categories such as salmon rearing and spawning (ODEQ, 2006). The development of the temperature TMDL involved data collection, analysis, and overall characterization of the water temperature in the Basin. Additionally, it provides metrics to assess the severity of the issue over time in different areas of the Basin. Therefore, it is a valuable resource for understanding this component of water quality.

The 2006 Water Temperature TMDL was developed using continuous temperature data, flow volume (gage data and instream measurements), channel morphology surveys, effective shade measurements, and extensive numerical modeling using CE-QUAL-W2 (ODEQ, 2006). Stream surveys were conducted by ODEQ in the summers of 2000, 2001, and 2002 (ODEQ, 2006). These surveys focused on near-stream land cover classification and measurements, channel morphology measurements, and stream shade measurements. Continuous water temperature data was collected with thermistors at a variety of sites in the Willamette Basin in 2000, 2001, and 2002 (ODEQ, 2006). These locations are summarized in ***Table 6***. While the 2006 Water Temperature TMDL currently establishes load reductions to meet water temperature standards in the basin, the temperature TMDL is in the process of being replaced. Additional data have been collected since 2006 and will be incorporated into the development of the updated TMDL. Where applicable, these recent data will also be incorporated into this analysis.

Table 6. Continuous water temperature data collection sites for the development of the 2006 TMDL, with subbasins outside of the Tier 1 and Tier 2 regions grayed out. Reproduced from ODEQ, 2006.

Subbasin Name	Number of Sites	Agencies
Clackamas	3	BLM
Coast Fork Willamette	21	BLM, ODEQ
Lower Willamette	24	ODEQ, USGS
McKenzie	27	ODEQ, USGS
Middle Fork Willamette	36	ODEQ, USGS
Middle Willamette	14	ODEQ, USGS, City of Salem
Molalla-Pudding	2	ODEQ
North Santiam	42	ODEQ, USGS, BLM
South Santiam	105	ODEQ, USGS, BLM
Tualatin	1	ODEQ
Upper Willamette	86	ODEQ, USGS, BLM
Yamhill	1	ODEQ

The sites summarized in ***Table 6*** include several USGS gage stations. Of particular interest to this Plan are the USGS monitoring locations that have collected both temperature and flow data in the Tier 1 and Tier 2 regions. The available long-term USGS gages that monitor both parameters in the Tier 1 and Tier 2 regions are shown in ***Figure 14***. Several of these gages are no longer active, so the primary gages relevant to this analysis are at Newberg (14197900), Salem (14191000), Albany (14174000), and Harrisburg (14166000), as well as the gages on the North and South Santiam Rivers. A summary of available temperature data at these and other sites is included in Appendix A.

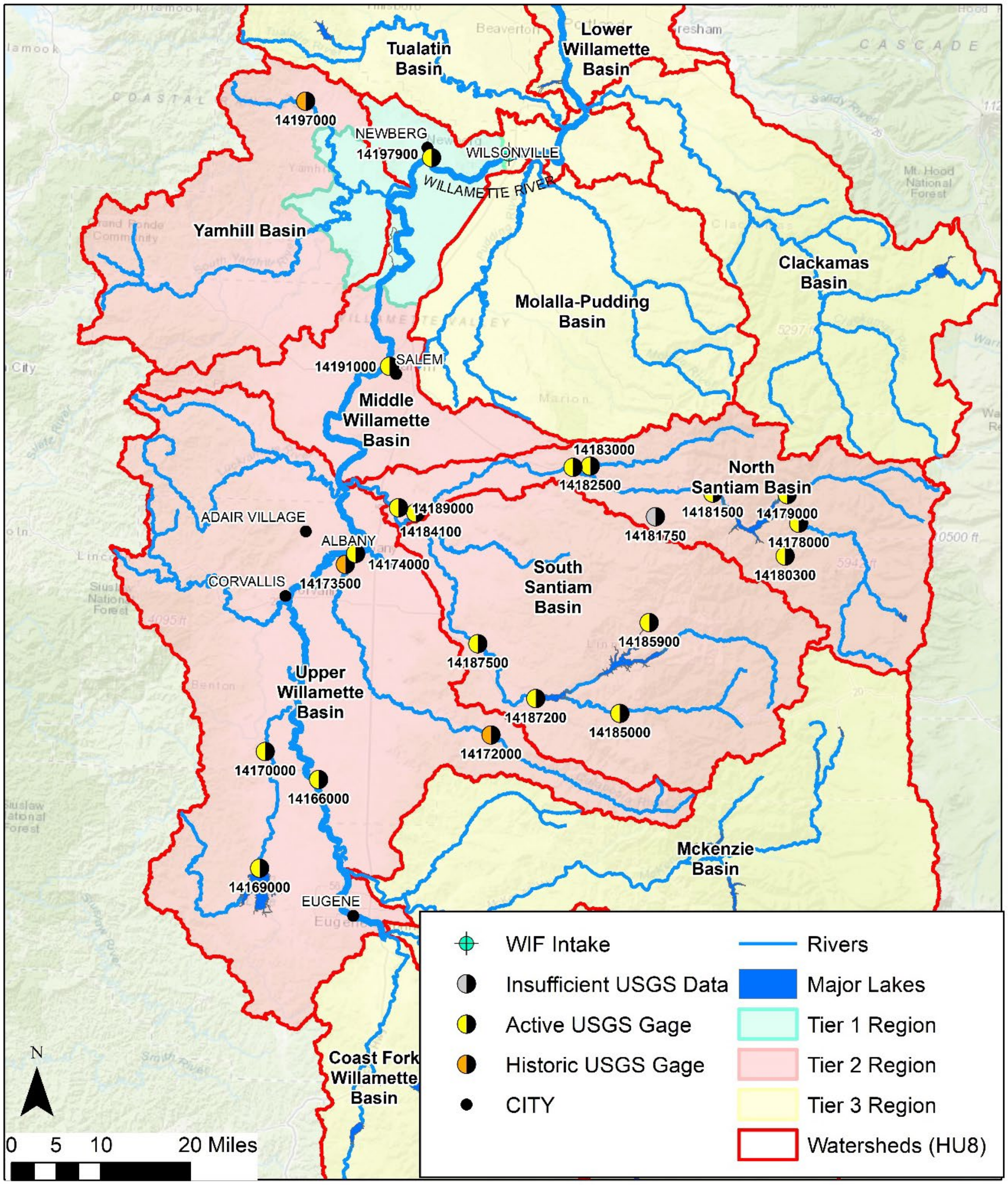

Figure 14. USGS gages with both flow and temperature data in the Tier 2 region.

The variety of ground surface elevations within the Willamette Basin create a spatial trend for water temperatures. In general, the coldest maximum temperatures have been recorded in higher elevation streams, while the warmest values have been recorded at low elevations (ODEQ, 2006). Streams in the high elevation Cascades stayed cooler than 16 °C throughout the year (ODEQ, 2006). Streams in the Coast Range and the mid-elevation Cascades warmed to over 16 °C in the summer, and streams and rivers on the valley floor were often well above 20 °C (ODEQ, 2006).

Figure 15 shows how water warms as it moves downstream in the Willamette River mainstem. Conversely, the greater summer river volume downstream and increase in heat loading capacity mean that the river cannot dissipate heat as readily as a smaller stream. This results in minimum temperature values increasing in a downstream direction (ODEQ, 2006).

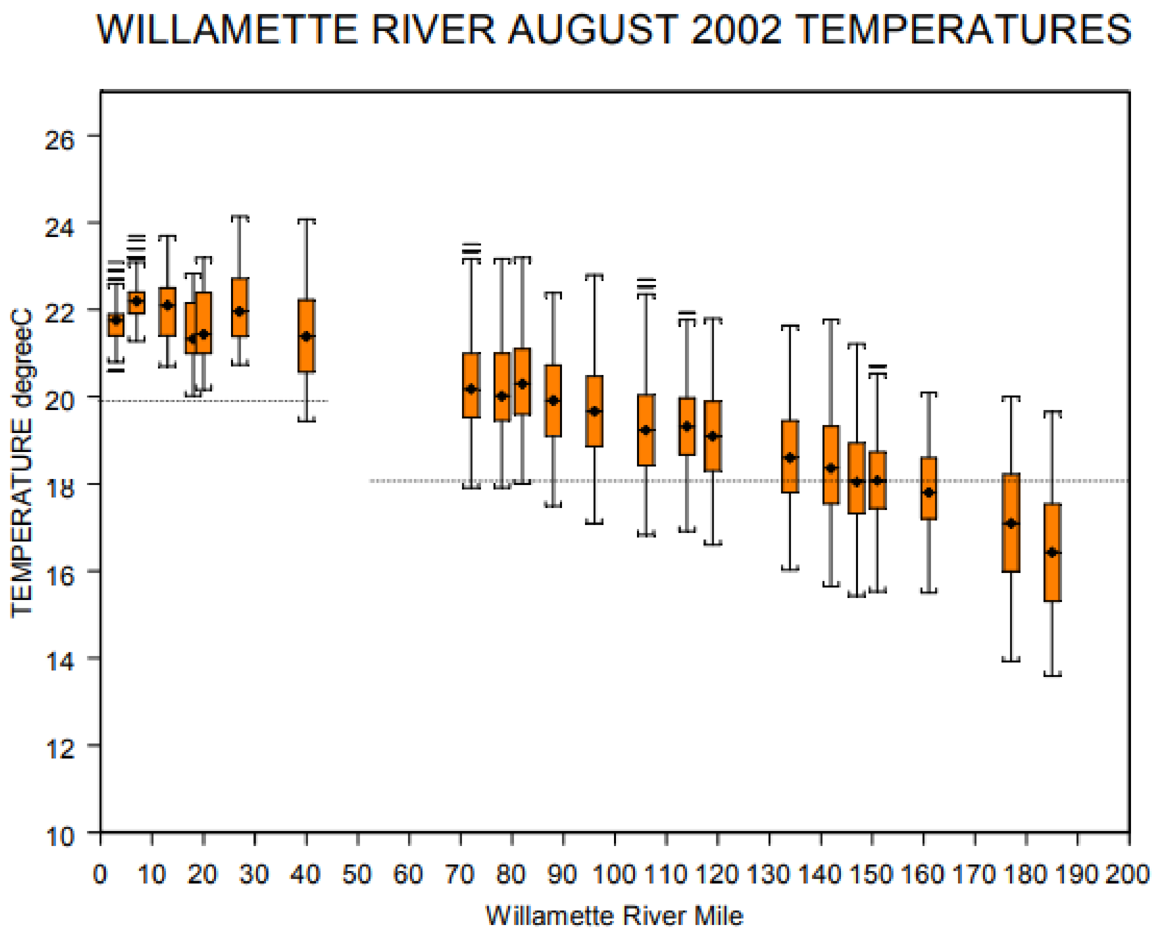

Figure 15. Water temperatures in the Willamette River in August 2002. Reproduced from ODEQ, 2006

3.2.1 Seasonal Trends

Water temperatures in the Willamette Basin also follow seasonal trends. Water temperatures are typically highest in the summer months when there is the most solar radiation and streamflow is low. Temperature TMDL criterion vary in each subbasin, but regardless of the established criterion, streams generally exceed their assigned criterion from early summer into the fall (ODEQ, 2006). Historical ODEQ water temperature data and thermistor data collected for the 2006 TMDL demonstrate that Willamette River water temperatures exceed biologically based criteria during the April through October period (ODEQ, 2006). In the Tier 1 region downstream of RM 50 (approximately the Yamhill River and the City of Newberg), spawning and rearing are not designated uses, therefore, a relatively non-stringent numeric criterion of 20 °C for salmonid migration applies. The critical period for this reach is from June through September when river temperatures are often warmer than the biologically based numeric criterion (ODEQ, 2006). As shown in ***Figure 16***, average daily mean temperatures at the Newberg USGS gage during this time of the year exceed 20 °C. However, it should be noted that the criterion applies to the 7-day average of the daily maximum temperature, a metric not displayed in the figure. Additionally, as aforementioned, the criterion is designed to support fish life cycles, and exceedances of these criteria may not be directly detrimental to drinking water treatment processes or finished water quality.

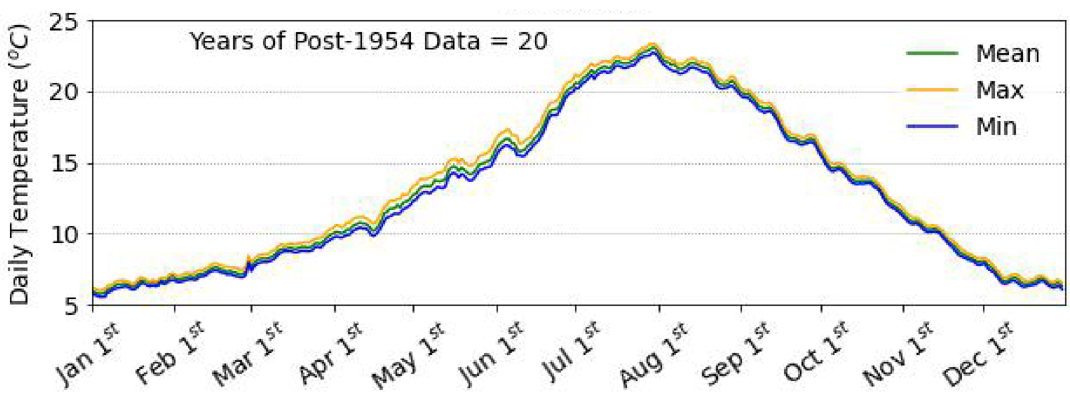

Figure 16. Seasonal temperature trends on the Willamette River mainstem at Newberg.

To further explore both the spatial and seasonal trends in water temperature along the Willamette River mainstem from upstream to downstream, USGS water temperature data were analyzed at Harrisburg (14166000), Albany (14174000), and Salem (14191000). Similar to the analysis performed for flow data, the data were split into a post-1954 data set to isolate more recent historical trends. Daily minimum and maximum water temperature were averaged across years to obtain average seasonal trends. Where sufficient daily average water temperature measurements were available (more than three years of data), these trends were plotted as well. Even where sufficient daily average temperature records were available, many daily average temperature records are not as consistent as the daily maximum or minimum temperature records, occasionally causing daily average temperatures to fall outside the range between the minimum and maximum trend lines. The seasonal trends at the three gages along the Willamette River mainstem are provided in ***Figure 17***, in order from upstream to downstream.

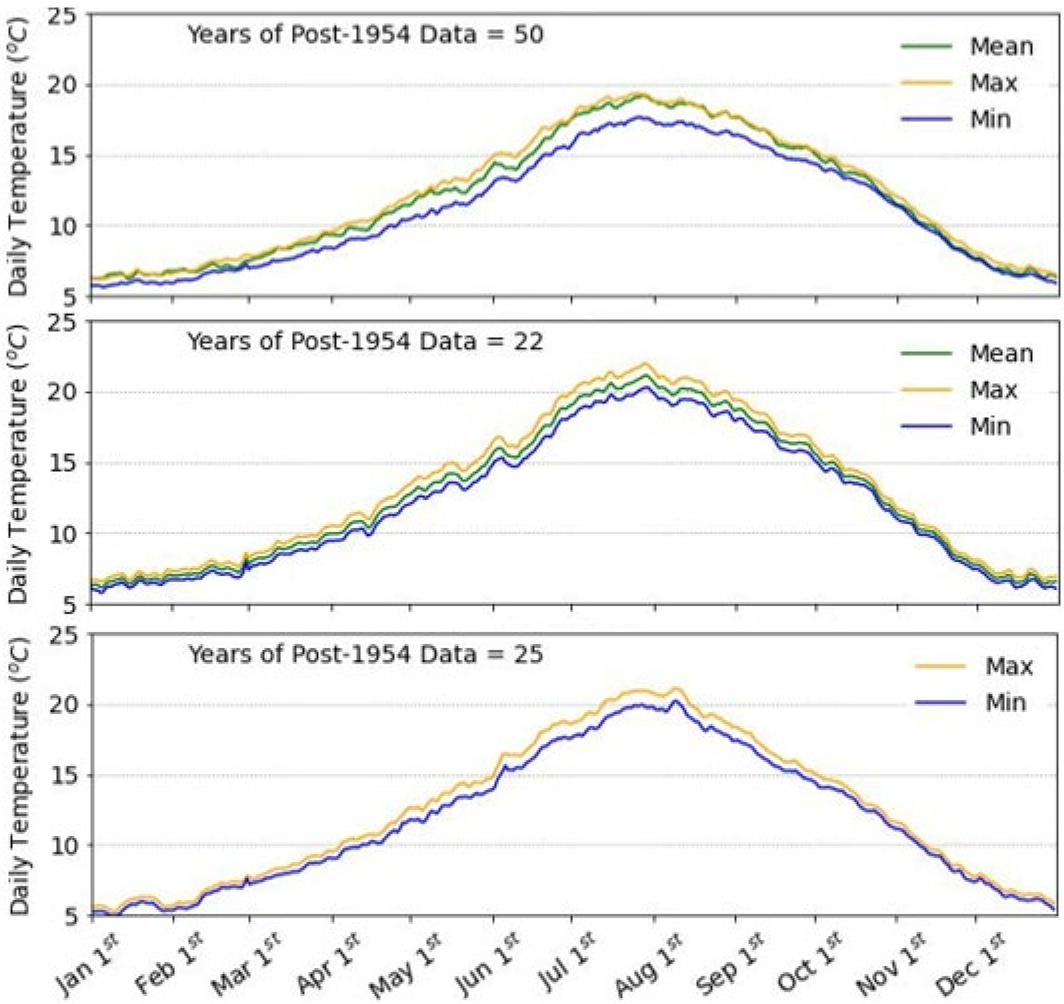

Figure 17. Seasonal temperature trends on the Willamette River mainstem at Harrisburg (top), Albany (middle), and Salem (bottom).

The seasonal analysis shown in ***Figure 17*** reveals an interesting spatial trend. The summer high water temperatures at Albany appear to be slightly higher than those at the downstream Salem gage, with daily maximum temperatures of 22 °C at Albany and closer to 20 °C further downstream at Salem. The lower peak summer temperatures at Salem compared to Albany are likely due in large part to colder water from the Santiam River entering the Willamette River between the two gages, as shown by the seasonal trend for the Santiam River gage (14189000) in ***Figure 18***, for which the summer maximum daily water temperatures closely resemble those at Salem. Operational changes on the Santiam River dams, such as installing selective withdrawal facilities that could allow warmer water to be released, could influence this trend in the future. However, it is unclear how large of an effect the Santiam River temperature trends have on temperature trends at the Newberg gage and, subsequently, at the intake.

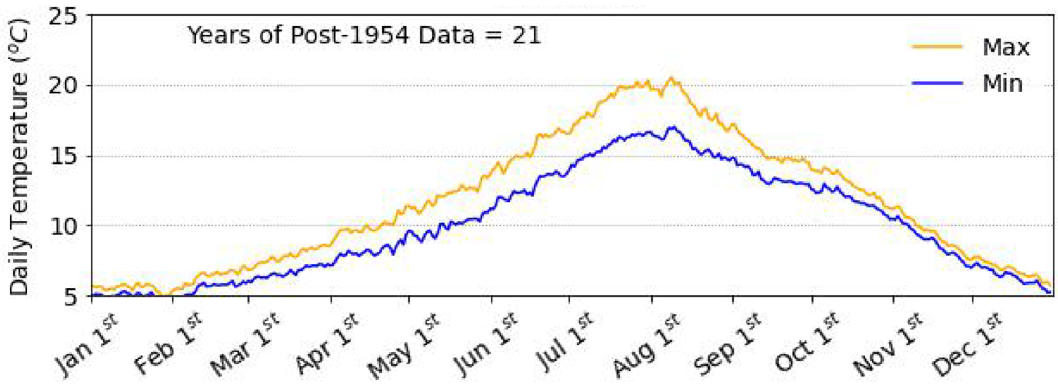

Figure 18. Seasonal temperature trend on the Santiam River at Jefferson.

3.2.2 Correlation Analysis

The amount of flow in the Willamette River also has a significant impact on the water temperature. In the summer months, there is an inverse relationship between flow and temperature, with flow reductions resulting in water temperature increases. Modeling analysis for the creation of the TMDL shows that a 20% flow reduction produces river mouth temperatures that are 0.5 °C warmer in the Middle Fork Willamette and 0.3 °C warmer in the McKenzie (ODEQ, 2006). Another approach to understand the relationship between flow and water temperature is to visualize them in a scatter plot for each month. ***Figure 19*** and ***Figure 20*** show the average daily flow versus average daily maximum temperature for each month at Salem (14191000) and Albany (14174000) gages, respectively, for the available data in the recent time period.

In addition to the trend visualization, Spearman Rank Correlation coefficient was also calculated for each month to quantify the strength of the non-linear relationships between maximum water temperature and flow; this coefficient is shown in ***Figure 19*** and ***Figure 20*** as ρ. Spearman Rank Correlation is the non-parametric version of the Pearson coefficient which ranges between –1 to +1, which represent perfect negative and positive correlations between the ranks, respectively. This correlation analysis shows the maximum water temperature and flow in spring and summer months have a negative relationship. For the plots from March to November, as discharge increases (x-axis), the maximum temperature decreases (y-axis). In these figures, the tighter the data point scatter and the higher the Spearman Rank Correlation coefficient, the closer the relationship is between flow and maximum daily water temperature.

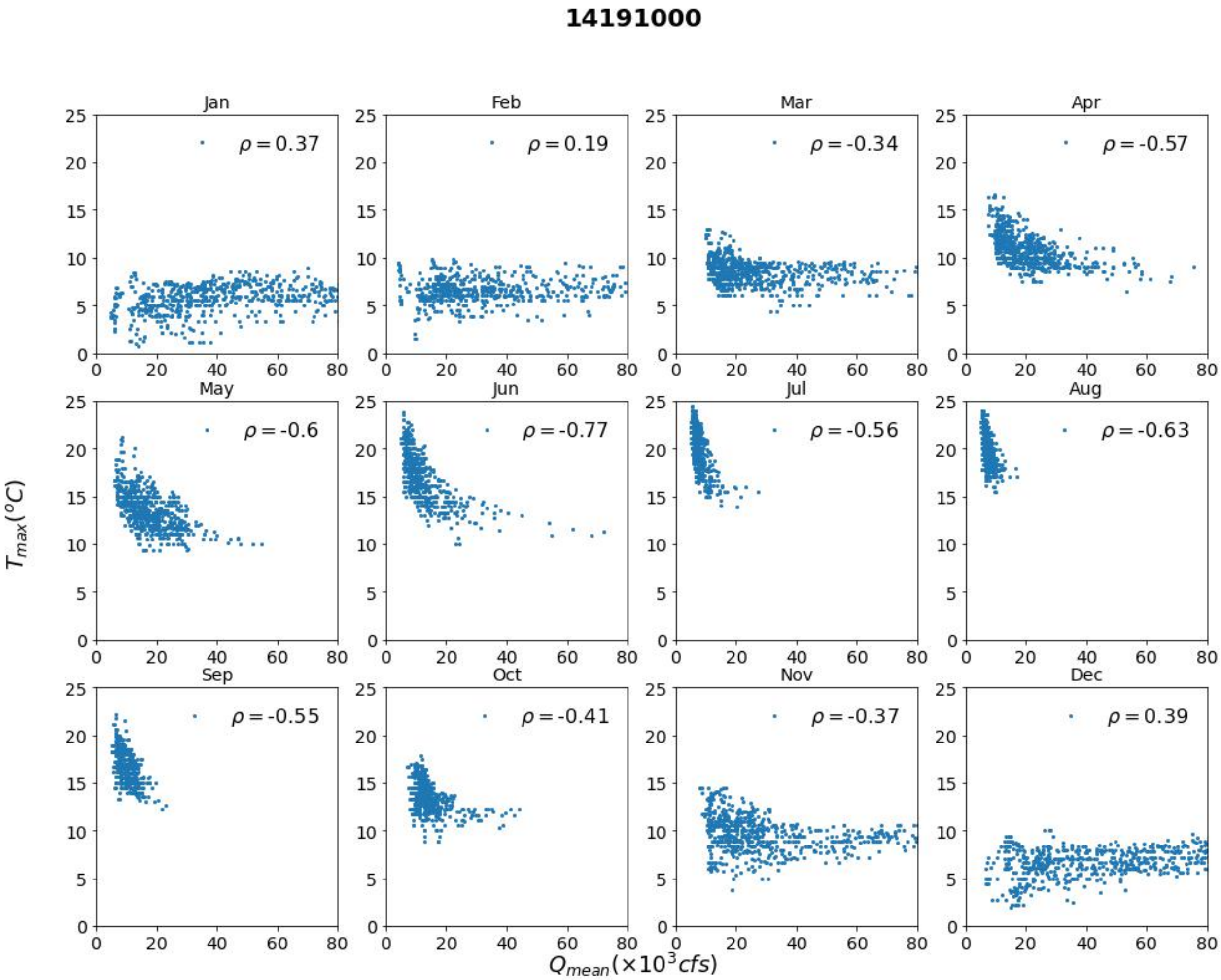

Figure 19. Willamette River flow and water temperature correlations at the USGS Salem gage (14191000).

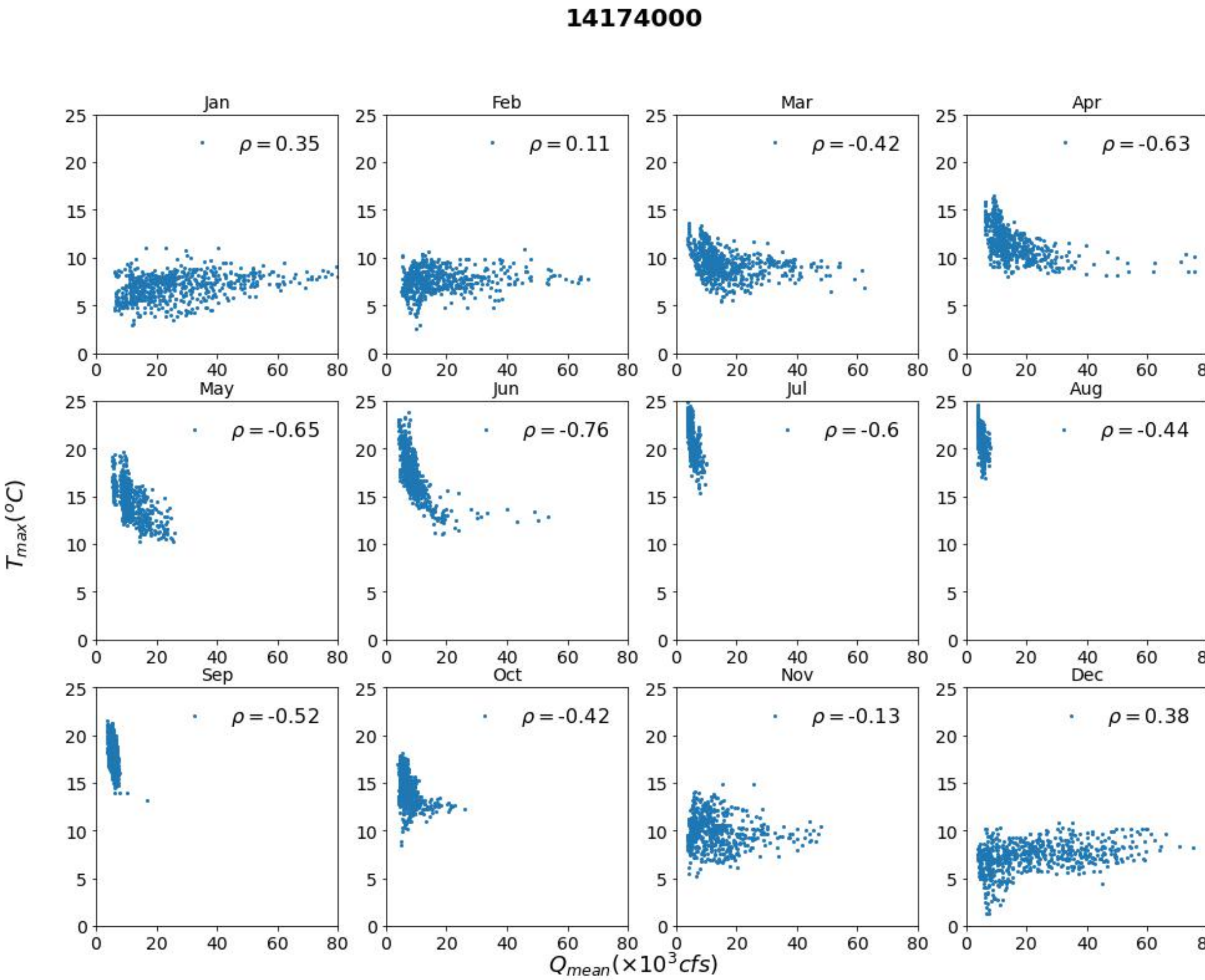

Figure 20. Willamette River flow and water temperature correlations at the USGS Albany gage (14174000).

The seasonal relationship between flow and water temperature becomes less clear in the fall. Reservoirs often store heat in the summer months and releasing this flow can increase water temperatures downstream (ODEQ, 2006). This relationship is further explored in Section 4.2.2.

3.2.3 Long Term Trends

Finally, long-term analysis of water temperature in the Willamette River confirms an expected trend: the average water temperatures are increasing over the years. ***Figure 21*** and ***Figure 22*** show the time series of the average daily maximum, minimum and mean water temperature for the Willamette River at the USGS Harrisburg gage (14166000) in months April through October. To better capture the possible trend, a linear regression analysis was performed on the daily maximum water temperature data, which is shown with dashed gray line. The slope of each trend line and a measure of the goodness of fit (R^2) are also shown in each figure. Based on the linear regression analysis, July and August months have experienced the largest increase in water temperature

(0.33ºC per decade). A similar upward trend but a smaller slope can be observed in the other months as well.

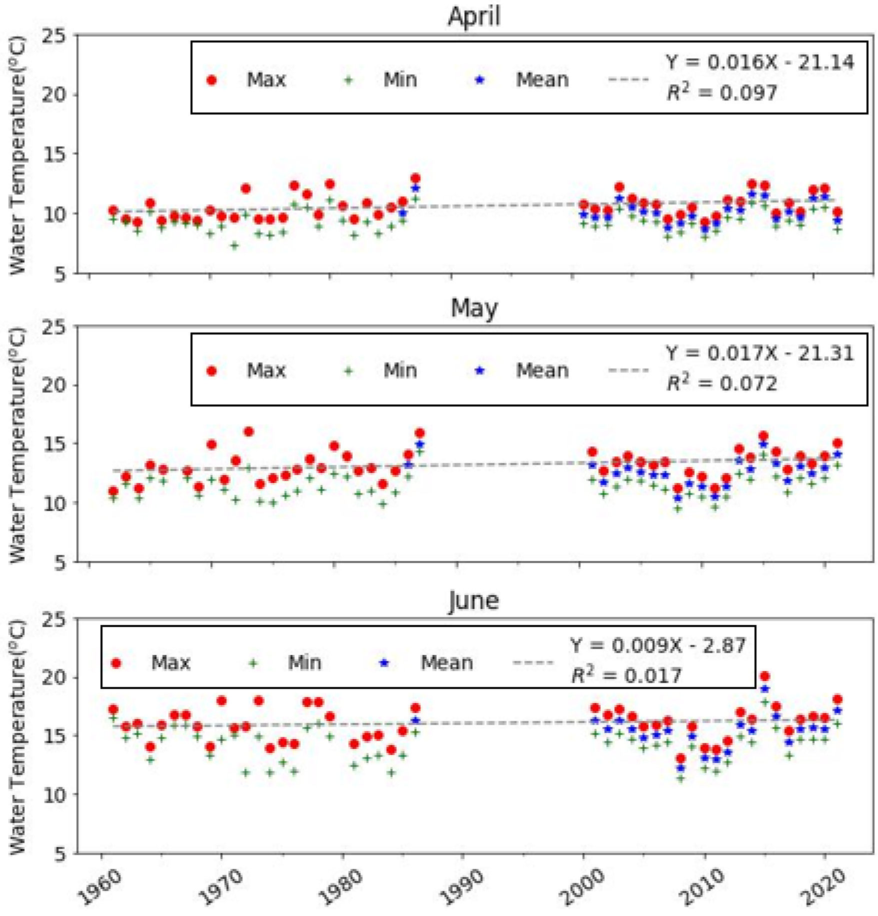

Figure 21. Mean monthly temperature statistics for spring and early summer months on the Willamette at Harrisburg

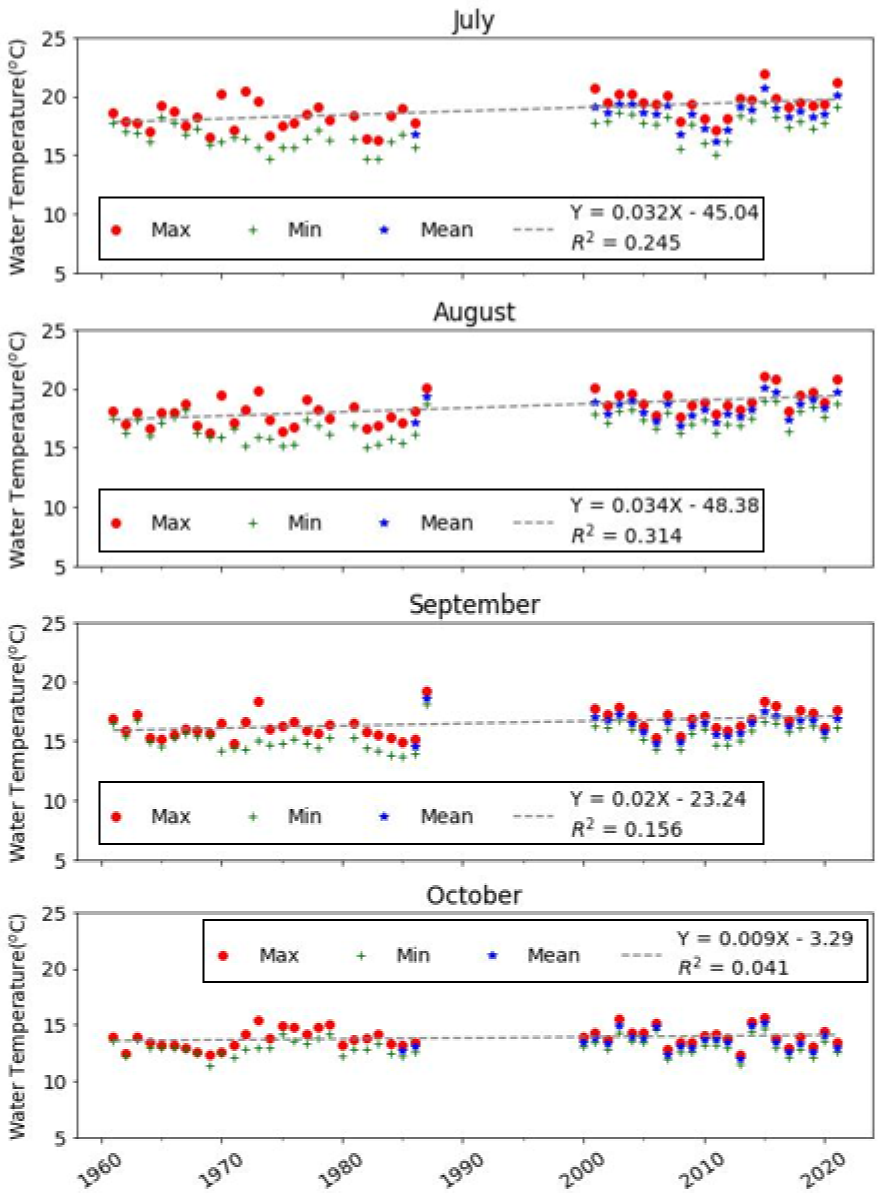

Figure 22. Mean monthly temperature statistics for late summer and fall months on the Willamette at Harrisburg

The long-term trend of increasing summer temperature in the Willamette River mainstem may be influenced by a number of factors. One of the largest is likely a warming climate. However, it is also likely that the WVP dam operations dampen this trend and by increasing summer average flows and releasing cold water from dams to cool summer temperature. Regardless, long-term temperature trends are of relevance to the WIF Commission in consideration of the impacts of warming summer temperatures on source water quality. This is further discussed in Section 4.3.1.2.

In summary, the temperature data described in this section reveal that summer months are a critical period for river temperature in both the Tier 1 and Tier 2 regions. The TMDL documented that reaches in both regions often exceed biological criteria during this time, which is an indicator for both poor environmental conditions to support fish species and poor overall water quality to supply drinking water. The data analysis provided confirms and characterizes these trends. It also indicates that, as flow and temperature are inversely correlated during summer months, WVP operations alleviate some of these concerns in the Tier 2 region by releasing water and thereby cooling water temperatures downstream. Additional analysis further describing temperature trends in the Tier 1 region will be included in the final draft of this Memo.

3.3. Mercury

The United States Environmental Protection Agency (USEPA) and ODEQ finalized the revised Willamette Basin Mercury TMDL in February of 2021. Most mercury enters the Willamette Basin from atmospheric deposition and originates from sources outside of Oregon. Once mercury has been deposited on the landscape, erosion and runoff allow it to enter waterbodies. Methylmercury (MeHg) is the organic form of mercury and is converted from its inorganic form by anaerobic bacterial processes that occur in aquatic systems. Methylmercury bioaccumulates in fish and is a neurotoxin in humans (ODEQ, 2019). The TMDL was developed to meet the human health criterion for mercury and therefore focuses primarily on methylmercury concentrations in fish tissue (ODEQ, 2019). However, methylmercury is only a subset of the total mercury (THg) in the Willamette Basin and the ratio between them must also be considered. To analyze the presence of mercury in the basin, many datasets with varying sampling mediums and dates were used (***Table*** *7*).

Table 7. Summary of mercury data sources for the creation of the Willamette Basin mercury TMDL. Reproduced from Tetra Tech, 2019.

Dataset	Data Provider	Sampling Medium	Sample Dates
2006 TMDL Fish Data	ODEQ	Fish tissue	7/8/2003-9/2/2003
2008 Fish Sample Records	ODEQ	Fish tissue	8/20/2008-10/28/2008
ARRA Willamette Mercury Monitoring Project	ODEQ	Water column, fish tissue, sediment	8/23/2010-10/1/2010
Black Butte Mine Storm Sampling	USEPA	Water column	1/7/2013-1/19/2017
Cottage Grove Analytical Reports	ODEQ	Fish tissue	6/2/2005-8/8/2005
Cottage Grove Reservoir Monitoring	USEPA	Water column	3/8/2013-1/19/2017
ODEQ Laboratory LASAR Database	ODEQ	Water column, fish tissue, sediment	8/14/2002-3/30/2009
ODEQ Toxics Monitoring Program	ODEQ	Fish tissue	8/20/2008-10/1/2010
USEPA R10 Columbia River Basin Mercury Database	USEPA	Fish tissue	7/8/1969-12/7/2010*
NLA Lake Fish Tissue Mercury Data	USEPA	Fish tissue	4/16/2014-10/17/2014

Dataset	Data Provider	Sampling Medium	Sample Dates
Portland Harbor Superfund Mercury Data	USEPA	Water column and fish tissue	6/25/2002-9/5/2008
USGS Mercury Data for Cottage Grove Lake and Coast Fork Willamette	USEPA	Water column and sediment	7/13/1992-9/30/2014*
USGS Willamette River Mercury Sampling	USGS	Fish tissue and water column	7/8/2011-8/26/2011
*Water column and sediment total mercury (THg) data prior to 2002 were not used in the TMDL analyses.			

Upon analysis of these data, it was found that the Coast Fork, Tualatin, and Lower Willamette subbasins have higher median mercury levels than other subbasins (Tetra Tech, 2019). The Coast Fork subbasin had by far the highest concentrations of both THg and dissolved methylmercury (dMeHg). This is likely due to the presence of the former Black Butte Mine just south of Cottage Grove, Oregon. However, including values from this subbasin in these analyses did not significantly bias the estimates and were therefore included in the analyses (Tetra Tech, 2019).

Reservoirs have been known to affect mercury levels, specifically the ratio of MeHg to THg, within waterbodies. However, analysis of existing data shows that the ratio of methylmercury to total mercury does not significantly vary with respect to space within the Willamette Basin (Tetra Tech, 2019). This indicates that reservoirs within the basin do not have a significant impact on the ratio of MeHg to THg (Tetra Tech, 2019).

Bioaccumulation of methylmercury in fish tissue is a long-term process related to the consumption of prey containing methylmercury. It takes several years for fish to accumulate enough MeHg to exceed the fish-tissue criterion (Tetra Tech, 2019). Because bioaccumulation of MeHg is a long-term process, it does not display seasonal trends. However, the ratio of dissolved MeHg to THg does appear to have slight seasonal variation. The ratio is higher in the warm summer months when biological activity is greater, due to an average increase in dMeHg and a decrease of THg concentrations in the summer (Tetra Tech, 2019). MeHg produced during summer periods of high biological activity is believed to be derived from THg loads accrued during the previous year. However, available data are not sufficient to investigate this hypothesis (Tetra Tech, 2019).

3.4. Bacteria

Water quality impairments due to bacteria are common in the Willamette Basin, especially in smaller creeks that drain urban and agricultural land. For example, water quality trends and exceedances at monitoring locations in the Yamhill Basin indicate that, overall, bacteria (*E. coli*) levels are either showing no trend or, at one site, may be worsening (***Table 8***).

Table 8. Bacteria trends at monitoring locations in the Yamhill Basin. Reproduced from Oregon Department of Agriculture (ODA), 2017.

Monitoring Locations	Yamhill River at Dayton			North Yamhill at Poverty Bend Road			South Yamhill River at Hwy 99W McMinnville		
Pollutants	**Trend**			**Trend**			**Trend**		
Bi Review Year	*** 2015**	**** 2017**	**2019**	*** 2015**	**** 2017**	**2019**	*** 2015**	**** 2017**	**2019**
***E. coli* (Bacteria)**	↑	NT	-	NT	↓	-	NT	NT	-
Pollutants	**Number of Exceedances per Number of Samples**			**Number of Exceedances per Number of Samples**			**Number of Exceedances per Number of Samples**		
***E. coli* (Bacteria)**	6/149	-		8/119	-		3/109	-	

Trend: ↑ - Improving ↓ - Declining NT – No Trend (-) Data Not Available
* 10 Year Water Quality Index (DEQ) from data collected 2006-2015. The Oregon Water Quality Index (OWQI) analyzes a defined set of water quality variables and produces a score describing general water quality.
** September 2017 Water Quality Status and Trends Analysis for ODA's Biennial Review (DEQ) from data collected 2000 – 2017

The 2002 303(d) list identified RM 0 to RM 149 of the Willamette River as impaired for water contact recreation during fall, winter, and spring (ODEQ, 2006). The river is not listed as water quality limited in summer. Concentrations of *E. coli* are used as an indicator of bacterial concentrations in the Willamette Basin. *E. coli* are a species within the category of fecal coliform bacteria. The most common strains of *E. coli* do not cause illness, but their presence indicates sources that are likely to include other pathogens that do cause human illness (ODEQ, 2006). ***Table 9*** describes the samples used in the Willamette River bacteria model created to inform the development of the bacteria TMDL. Almost all of the *E. coli* data available at the Newberg ODEQ monitoring site (10342) were collected prior to 2003. If bacteria are identified as high-risk to water quality at the intake, the lack of recent *E. coli* monitoring data at Newberg may present as a major data gap. Furthermore, there is a negligible amount of *E. coli* data available at Wilsonville. However, as discussed in this section, the level of concern for the WIF Commission due to bacteria may be decreasing and therefore significant additional monitoring data for this parameter may not be necessary.

Table 9. Samples used in the development of the Willamette River bacteria model, locations outside of the Tier 1 and Tier 2 region are grayed out. Reproduced from ODEQ, 2006.

Sampling Site	River Mile (RM)	ODEQ Site Number	Fall-Winter-Spring *E. coli* samples (count)
SP&S Bridge	7	10332	28
Hawthorne Bridge	13.2	10611	61
Canby Ferry	34.4	10339	28
Newberg	48.6	10342	61
Wheatland	71.9	10344	26
Salem	84.0	10555	60
Albany	119.3	10350	60
Corvallis	131.4	10352	57
Harrisburg	161.2	10355	58
Springfield	185.3	10359	23

The most common source of bacteria in the Willamette River is contaminated runoff. When precipitation comes in contact with contaminated substances, that runoff can carry bacteria into local bodies of water. Some cities also utilize combined sewers, where sewage and stormwater are carried in the same system. During storm events, a combination of runoff and untreated sewage is discharged to a water body. These events are known as combined sewer overflows (CSOs). Because these routes of exposure rely on runoff, contamination of the Willamette River is highest when rainfall, and therefore river flow, is high. This is typically October through March (ODEQ, 2006). Sources of *E. coli* are less common in the summer months, leading to lower *E. coli* concentrations despite having less flow in the river to dilute contaminants (ODEQ, 2006).

Another variable in bacterial concentrations in the Willamette River Basin is the sampling location within in the Basin. Most water enters the Willamette River mainstem upstream of RM 48, so even though there are significant bacterial inputs from tributaries, there is also significant streamflow entering (ODEQ, 2006). This provides assimilative capacity and brings down the overall concentration. From RM 48 to the Willamette Falls, land use becomes more urban and more significant bacteria inputs enter the river. However, water quality above Willamette Falls consistently stays below the bacteria criteria established in the Willamette River bacteria TMDL (ODEQ, 2006). CSOs occur most frequently in the Portland area, leading to higher bacterial concentrations in the lower portion of the river than the upper and middle portions. In addition to these spatial trends, seasonal trends are stronger at some locations than at others. For example, summer bacteria concentrations at Newberg are lower than at Salem (***Figure 23***).

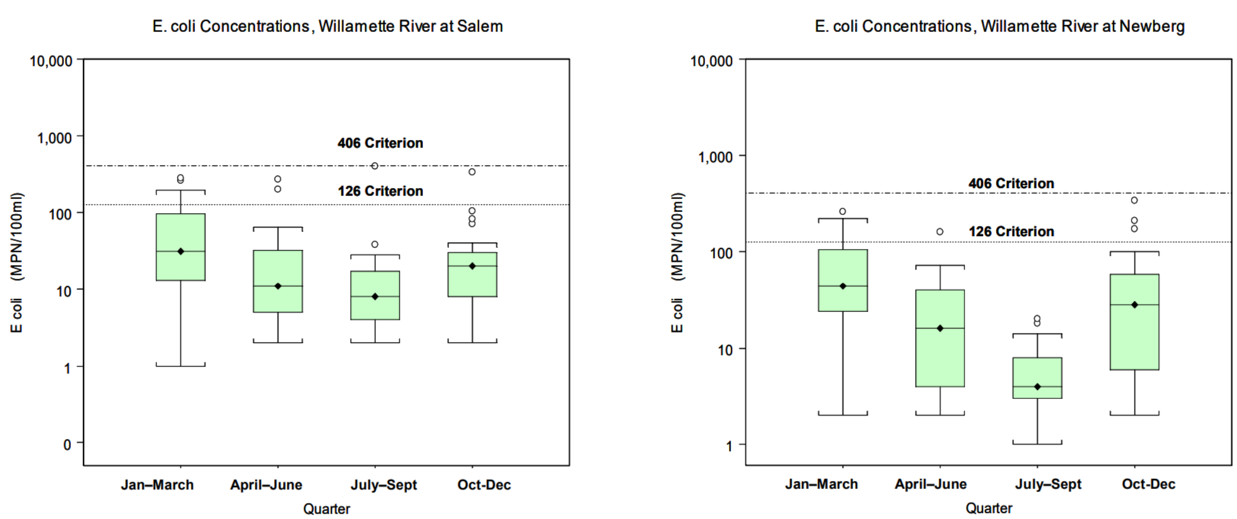

Figure 23. E. coli concentrations from the Willamette River at Salem and Newberg. Horizontal criterion lines correspond to criteria established in the Willamette River bacteria TMDL (126 MPN/100mL monthly log-mean; 406 MPN/100mL single-sample maximum) Reproduced from ODEQ, 2006.

Historically, CSOs also occurred in Corvallis around RM 131. In 2001, Corvallis replaced their combined sewer system with separate stormwater and sewer systems (ODEQ, 2006). Since replacing their sewers, there have not been any overflow events into the Willamette River. The City of Portland still uses combined sewers, however a legal agreement between Portland and ODEQ in 1991 has led to a significant decrease in CSOs over time (ODEQ, 2006). With these adjustments, bacterial loading in the Willamette River due to CSOs has decreased over time. Therefore, the data suggests that, while bacteria is of high concern due to historic trends, the level of concern for the WIF Commission may be decreasing due to both the location of the intake and improvements in management of sources upstream.

3.5. Additional Parameters

Several additional water quality constituents are of relevance to the Tier 1 and Tier 2 regions, although Willamette-Basin-wide TMDLs have not been established for these. These parameters include nutrients, algae, and toxics, and are addressed briefly in the following sections. Data for several of these parameters has been collected during ODEQ sampling programs at various sites in the Tier 1 region. The locations and names of these sites are provided in ***Figure 24***.

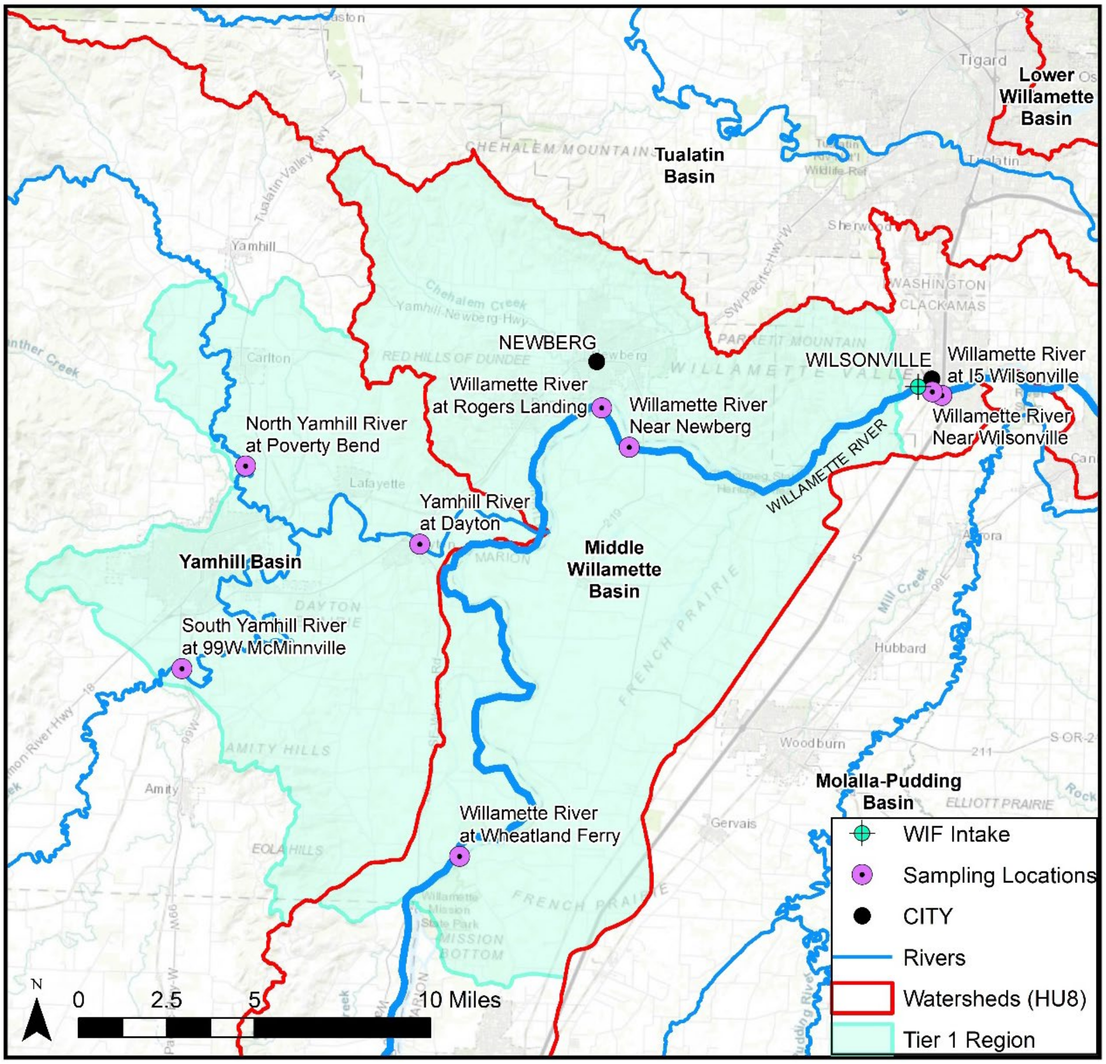

Figure 24. ODEQ water quality sampling locations in the Tier 1 region

3.5.1. Phosphorus

Phosphorus is a component of fertilizer that may travel to waterways from the application site due to storm events, excessive irrigation, or erosion. This nutrient is a limiting factor to the growth of aquatic weeds and algae in rivers, and thus presents a water quality concern in the Yamhill subbasin. Combined with warm water temperatures, sunlight, and low summer flows, phosphorus can encourage excessive algal growth, which in turn worsens water quality. The impacts of algal blooms are further discussed in Section 3.5.2.

The Yamhill subbasin established a TMDL for phosphorus in 1998 (ODEQ, 1989). Since that time, the Oregon Department of Agriculture (ODA) has worked with the Yamhill and Polk Soil and Water Conservation Districts (SWCDs) to report water quality trends in the basin. In the 2017 Yamhill Agricultural Water Quality Management Plan, trends in phosphorous were summarized from previous ODEQ assessments of data at three sites on the Yamhill. These analyses suggest that phosphorus levels in the Yamhill River at Dayton have been improving based on two different analyses of water quality data from 2000-2017 (***Table 10***).

Table 10. Phosphorus trends at monitoring locations in the Yamhill Basin. Reproduced from ODA, 2017.

Monitoring Locations	Yamhill River at Dayton			North Yamhill at Poverty Bend Road			South Yamhill River at Hwy 99W McMinnville		
Pollutants	Trend			Trend			Trend		
Bi Review Year	* 2015	** 2017	2019	* 2015	** 2017	2019	* 2015	** 2017	2019
Phosphorus	↑	↑	-	NT	NT	-	↑	NT	-

Trend: ↑ - Improving ↓ - Declining NT – No Trend (-) Data Not Available
* 10 Year Water Quality Index (DEQ) from data collected 2006-2015. The Oregon Water Quality Index (OWQI) analyzes a defined set of water quality variables and produces a score describing general water quality.
** September 2017 Water Quality Status and Trends Analysis for ODA's Biennial Review (DEQ) from data collected 2000 – 2017

Additional data from relevant ODEQ monitoring sites, including those on the Yamhill and the Willamette River site near Newberg, are summarized in Appendix A. In addition to the three ODEQ sites on the Yamhill River, data are also available at two sites on the Willamette River mainstem in the Tier 1 region (near Newberg and at Wheatland Ferry). Although data are not available at Newberg after 2003, phosphorus levels have been recorded at Wheatland Ferry multiple times per year from 1992 to 2022. This gage is further upstream, but still within the Tier 1 region and may serve as an indicator for water quality at the intake. However, it may be expected that phosphorus monitoring in the Tier 1 region will not be of high concern for the WIF Commission as trends on the Yamhill are improving and, as discussed in the following section, the related concern of algal blooms is more prominent in the Tier 2 region. Potential future impact of phosphorus on risk of excessive algal growth in the Newberg Pool may cause phosphorus to present a higher concern at that time, and the importance of acquiring recent monitoring data closer to the intake may need to be revisited.

3.5.2. Algal Blooms

Cyanobacteria, also known as blue-green algae, can grow into cyanobacteria harmful algal blooms (cyanoHABs) in certain environmental conditions when ponds, rivers, and impoundments are warm, slow moving and nutrient-rich. CyanoHABs can release a variety of cyanotoxins that are harmful to human and aquatic organisms and ecosystem health and threaten drinking water quality and recreational use of water bodies. Though some drinking water treatment methods, including ozonation and filtration through granular activated carbon, are effective at removing cyanotoxins, conventional drinking water treatment systems may not be able to treat more severe blooms (USEPA 2021), and frequent treatment for blooms can increase drinking water treatment costs regardless of treatment methods.

Reservoirs, with slow moving water that can heat more easily, are especially susceptible to cyanoHABs. In the Willamette River Basin, cyanoHABs occur in tributary reservoirs such as Detroit Lake (North Santiam River), Blue River reservoir (McKenzie basin), and Cougar reservoir

(McKenzie basin), where cyanotoxins may be transported downstream to the Willamette River mainstem. CyanoHABs have been reported since 2005 in ten of the thirteen reservoirs associated with the WVP, along with two other reservoirs operated by the Eugene Water and Electric Board and the City of Eugene. These cyanoHAB reports since 2005 upstream of the WIF Commission Intake are summarized in ***Table 11***, and all cyanoHAB reports in the Willamette Basin from 2005 through 2018 are shown in ***Figure 25***.

In 2018, Salem issued a drinking water advisory due to cyanotoxins originating in Detroit Lake, which persisted for nearly a month (Oregon Water Science Center, 2018). Similar blooms which historically have occurred in reservoirs on the McKenzie River could cause similar advisories for Eugene.

CyanoHABs that occur in tributaries and far upstream of the WIF Commission Intake along the Willamette River mainstem have the potential to transport cyanotoxins downstream. Cyanotoxins are relatively persistent in the environment but do experience some photodegradation. Dilution as toxins move downstream will likely reduce threats to water quality at the WIF Commission Intake, though monitoring for cyanotoxins when there are active cyanoHABs upstream may be prudent.

Table 11. Harmful algal bloom reports since 2005 upstream of WIF Commission Intake. Source: ODEQ ArcGIS

Subbasin	Location	Years with CyanoHAB Reporting	Authority
Coast Fork Willamette	Dorena Lake	2008, 2009, 2010, 2011, 2012, 2013, 2018	WVP
	Cottage Grove Lake	Not Reported	WVP
Long Tom River	Fern Ridge Reservoir	2012, 2013	WVP
McKenzie River	Blue River Lake	2010	WVP
	Cougar Reservoir	2011	WVP
	Walterville Pond	2012, 2013, 2014	EWEB
Middle Fork Willamette	Hills Creek Lake	2005, 2006, 2007, 2008, 2009	WVP
	Lookout Point Lake	2005	WVP
	Fall Creek Lake	2011	WVP
	Dexter Reservoir	2008, 2009, 2010, 2011, 2012, 2013	WVP
Santiam River	Detroit Reservoir	2007, 2015, 2017, 2018	WVP
Willamette	Golden Gardens Pond	2010	City of Eugene
CyanoHAB – Cyanobacteria Harmful Algal Bloom WVP – Willamette Valley Project EWEB – Eugene Water and Electric Board			

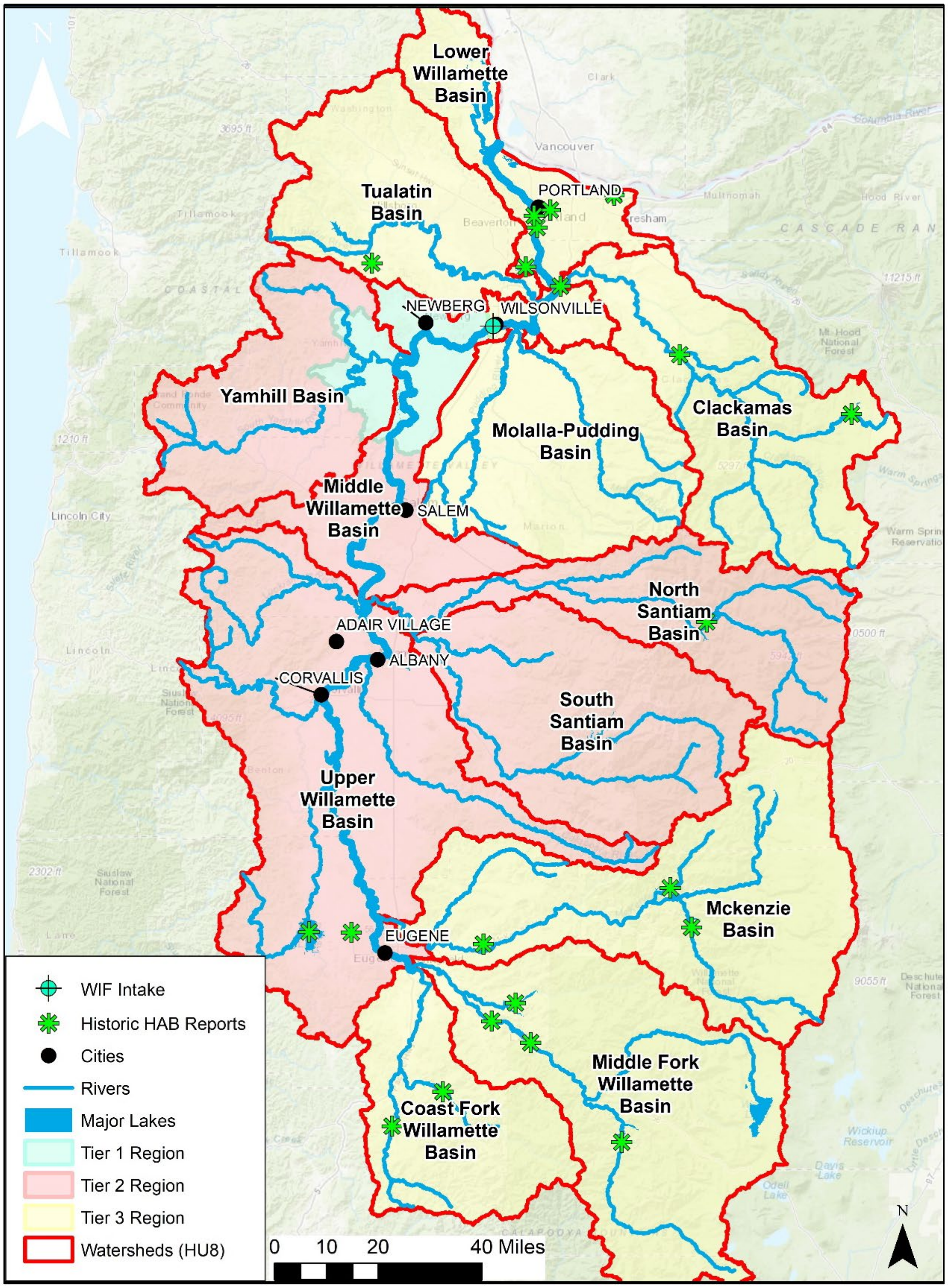

Figure 25. Cyanobacteria Harmful Algal Bloom reports in the Willamette Basin from 2005 - 2018. Source: ODEQ ArcGIS.

Oregon Health Authority (OHA) has developed regulations that require drinking water systems using surface water sources susceptible to cyanoHABs to routinely test for two cyanotoxins that these blooms produce and notify the public about the test results. OHA is encouraging water systems not subject to the cyanotoxin monitoring rules that serve surface water and have had algae issues in the past to voluntarily test for cyanotoxins and notify the public about the results (OHA, 2022). For example, there is a robust monitoring program for cyanoHABs within the Clackamas River Basin through a partnership between Portland General Electric and the Clackamas River Water Providers (CRWP, 2021). Additionally, USGS, EWEB, U.S. Army Corp of Engineers (USACE), and the City of Salem partnered to perform continuous water quality monitoring in Detroit Lake and Cougar Reservoir to monitor parameters that affect and induce cyanoHABs as well as proxies for measuring algae and algal activity directly. These parameters included temperature, conductance, turbidity, chlorophyll, blue-green pigment phycocyanin, dissolved oxygen, pH, and fluorescing dissolved organic matter. These parameters were monitored throughout the vertical profile of the lakes from September 2019 to April 2020 (USGS, 2020).

Figure 26 shows data for water temperature and total chlorophyll, which are indicators of algal biomass, from September 2019 to April 2020 over the depth of Detroit Lake up to 240 ft below the water's surface (USGS, 2020). As surface waters warm and the water column stratifies in September and October, chlorophyll peaks in mid-October, indicative of an increase in the presence of algae. These and other data can be used to monitor reservoir conditions to predict likely bloom events when cyanotoxin sampling might be important. ODEQ has monitored chlorophyll a at three sites on the Yamhill River, including the North and South Yamhill, and four sites on the Willamette River mainstem between Salem and Wilsonville. The length of record and frequency of sampling varies between sites, but generally consists of a few samples per year between 1992 and 2021.

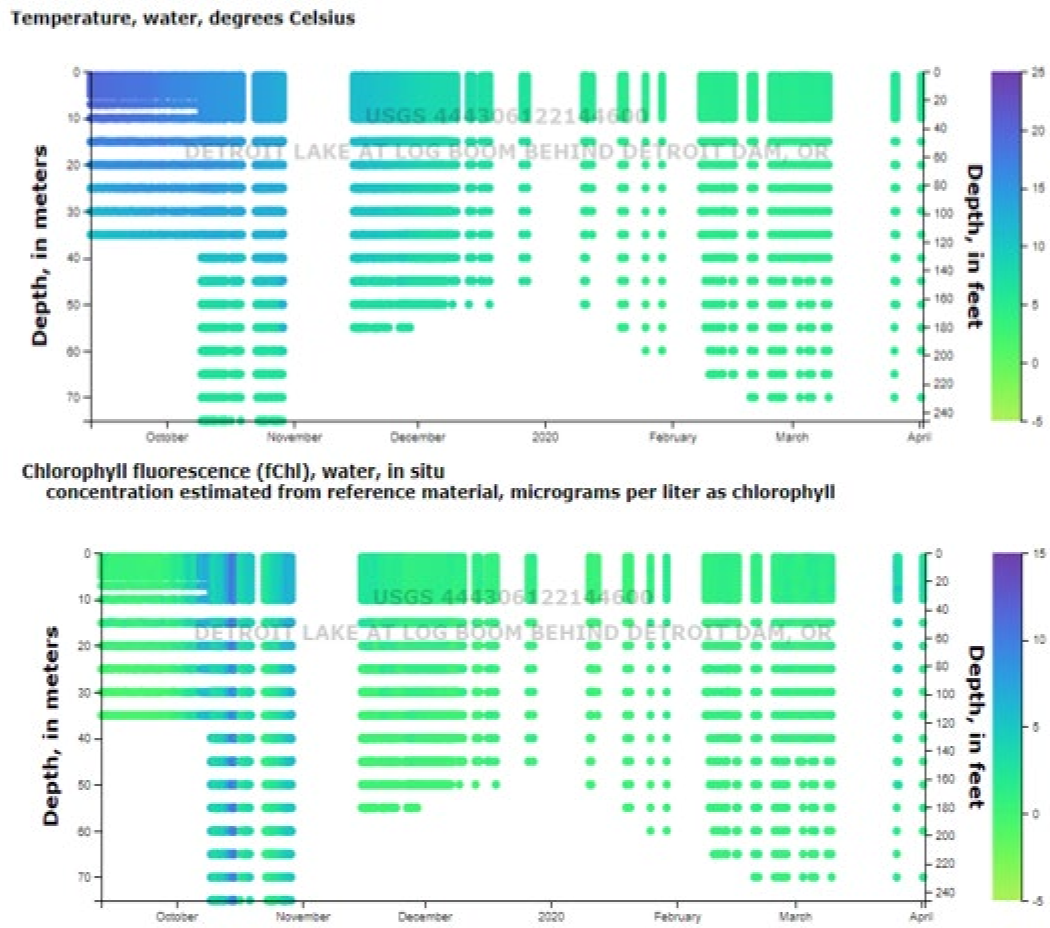

Figure 26. Seasonal trends in algal indicators for Detroit Lake (USGS, 2020). The darker blue indicates higher temperature (top) and higher concentration of chlorophyll (bottom).

3.5.3. Dissolved Oxygen and pH

Excessive algal growth, which was discussed in Section 3.5.2., can contribute to high pH and low dissolved oxygen (DO). Native fish species need dissolved oxygen for successful spawning and moderate pH levels are required to support many biologic processes including metabolism and reproduction. The Yamhill phosphorus TMDL established a pH standard of 6.5-8.5 to support water quality (ODA, 2017). In addition, low DO concentrations can lead to anoxic conditions which can release nutrients from the sediment bed of the river, which may occur in the Newberg pool.

Water quality monitoring of three sites in the Yamhill subbasin suggests DO concentrations may be improving over time. However, the trends for pH are less promising, with analysis indicating that no trend was observed at two of the three sites, and that pH may be worsening at the third (***Table 12***).

Table 12. Dissolved oxygen and pH trends at monitoring locations in the Yamhill Basin. Reproduced from ODA, 2017.

Monitoring Locations	Yamhill River at Dayton			North Yamhill at Poverty Bend Road			South Yamhill River at Hwy 99W McMinnville		
Pollutants	Trend			Trend			Trend		
Bi Review Year	* 2015	** 2017	2019	* 2015	** 2017	2019	* 2015	** 2017	2019
pH	NT	↓	-	NT	NT	-	NT	NT	-
Dissolved Oxygen	NT	↑	-	↑	NT	-	↑	NT	-
Pollutants	Number of Exceedances per Number of Samples			Number of Exceedances per Number of Samples			Number of Exceedances per Number of Samples		
Bi Review Year	2017	2019		2017	2019		2017	2019	
pH	3/252	-		0/219	-		0/128	-	
Dissolved Oxygen	39/189	-		23/124	-		14/110	-	

Trend: ↑ - Improving ↓ - Declining NT – No Trend (-) Data Not Available

* 10 Year Water Quality Index (DEQ) from data collected 2006-2015. The Oregon Water Quality Index (OWQI) analyzes a defined set of water quality variables and produces a score describing general water quality.

** September 2017 Water Quality Status and Trends Analysis for ODA's Biennial Review (DEQ) from data collected 2000 – 2017

Some additional data are available on the Willamette River mainstem and are summarized in Appendix A. Available data consist primarily of pH and DO measurements at the ODEQ site near Newberg, as well as substantial DO data available at Wheatland Ferry. There is also limited pH and DO data at the Rogers Landing site. The records at the Newberg site extend from 1992 to 2003 and contain samples taken approximately every month. The Wheatland Ferry data span from 1992 to 2022 with samples every one to three months. The small amount of data at Rogers Landing span from 2002 to 2011 and only a few samples recorded per year. Altogether, there is limited current data close to the intake, with the latest sufficient data located relatively far upstream at Wheatland Ferry. This may represent a data gap if pH and DO are identified as posing high risk to relevant drinking water treatment processes.

3.5.4. Metals

Many metals occur naturally, and thus detection of these metals is common in waterways. However, human activity may increase the frequency and quantity of metal detections. Thus, Oregon has existing water quality criteria for many metals, and these are included in ODEQ's ongoing monitoring efforts. Between April 2008 and May 2010, ODEQ collected seasonal water samples at seven locations in the Mid-Willamette River basin with one site in Yamhill at Dayton (station number 10363). To capture seasonal use patterns and hydrologic differences, collection of water samples took place six times over the course of two years (ODA, 2017). In 2015, ODEQ issued its first Statewide Water Quality Toxics Assessment Report, which included conclusions based on this data (ODEQ, 2015).

The metals sampled included copper, lead, arsenic, cadmium, barium, and manganese. Eleven metals were detected in the Mid-Willamette River Basin with at least one detected at all sites (ODEQ, 2015). The eleven metals monitored were detected in the Yamhill River. Copper and iron exceeded applicable aquatic life criterion at the Yamhill River site. Lead exceeded aquatic life criterion as well, although these data only include results for total lead while the criterion is expressed as dissolved. Therefore, this comparison is conservative. Total chromium also potentially exceeded aquatic life criterion at the Yamhill River site. Similar to lead, total chromium was measured while the criterion is expressed at chromium VI, making this comparison conservative. Although exceedances occurred during specifically spring and fall sampling events, several metals were consistently detected across seasons at all sites.

An updated assessment was issued in 2020 and included the findings of the 2008-2010 sampling as well as additional sampling from 2015-2016 (ODEQ, 2020). 17 metals were included in the 2016 analysis and at least 11 of the metals were found at each monitoring site.

In total, ODEQ metals data exist at the three sites on the Yamhill River and two sites on the Willamette River mainstem in the Tier 1 region (the site near Newberg and the site at Wheatland Ferry). These data are summarized in Appendix A. As discussed above, the majority of samples at these sites were obtained during the 2008-2010 and 2015-2016 time periods. However, the Newberg site was not included in those sampling programs and the data for that site were collected prior to 2001. At the Wheatland Ferry site, data for some metals are available from 1992 to 2022, with samples collected approximately a few times per year. As this site is relatively far upstream of the intake and upstream of the confluence with the Yamhill River, data at this site are insufficient to characterize metals concentrations near the intake. Thus, because of the limited number of samples at relevant locations and the lack of continued sampling over long periods of time to determine trends, there is incomplete understanding of the baseline condition in the Tier 1 region for metals concentrations. Working with ODEQ and other partners to conduct additional metals sampling closer to the intake may be valuable.

3.5.5. Pesticides

Pesticide compounds studied as part of the 2015 ODEQ Toxics Assessment included both current use and banned (or legacy) herbicides and insecticides. Legacy pesticides are very persistent and bio-accumulate up the food chain, making them a concern for humans. Additionally, research shows that even low levels of pesticides, including current use pesticides, in aquatic environments may affect fish and other aquatic organisms (ODEQ, 2015).

A total of 14 current use pesticide compounds were detected during ODEQ's monitoring of the Mid-Willamette River and Yamhill River basins from 2008-2010 (ODEQ, 2015). At least two current use pesticides were detected at every site in this portion of the basin. Herbicides were the most common group of pesticides detected. Diuron was detected at every site and the herbicides, atrazine, and simazine, occurred specifically at the Yamhill River site at Dayton. Two compounds, diuron and pentachlorophenol, exceeded the applicable USEPA aquatic life benchmark and ODEQ water quality criterion for human health, respectively, at the Yamhill River sampling location. Both exceedances occurred during a spring sampling event, however, diuron was detected across seasons at this location (ODEQ, 2015).

The 2016 assessment used new analytical methods with a lower detection limit. Potentially as a result of the new methods, the 2016 sampling effort resulted in detections of three legacy pesticides. Detections of current use pesticides also increased in the 2016 sampling effort (ODEQ, 2020).

In total, pesticide sampling data in the Tier 1 region are only available at the ODEQ sites on the Yamhill at Dayton and on the Willamette River mainstem at Wheatland Ferry (Appendix A). Even more so than metals there is a limited amount of data available, particularly for identifying long-term trends, as the ODEQ sampling has been conducted irregularly and at locations far upstream of the intake. Working with ODEQ and other partners to conduct additional sampling for current and legacy pesticides may be valuable.

3.5.6. Contaminants of Emerging Concern

Contaminants of emerging concern (CECs) are any synthetic or naturally occurring contaminants that have not been historically and are not commonly monitored but have a real or perceived threat to human health. Due to limited occurrence data and epidemiological studies, CECs and their adverse effects are often not as well understood; monitoring methods may be under development or not well-refined, and regulatory guidance or mandates regarding CECs may not be fully developed. While these challenges can make understanding the level of risk posed by CECs difficult, it is important to consider them and potential future impacts to source water protection. CECs in the Willamette River Basin include per- and polyfluoroalkyl substances (PFAS), microplastics, and pharmaceuticals, which are discussed briefly below.

3.5.6.1. PFAS

PFAS are a family of substances known as “forever chemicals” for their persistence in the environment. There are thousands of types of PFAS, which are used in a variety of household and industrial processes and products, including non-stick cookware, cosmetics, personal care products, clothing, and firefighting foams. Their ubiquity and resistance to degradation in the environment make PFAS chemicals a growing concern for drinking water providers. Though PFAS compounds are not currently regulated nationwide, the USEPA has listed two of the most common types of PFAS, perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS), as hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and is moving towards regulating them in drinking water (Environmental Working Group [EWG], 2021). Several states nationwide have already set statewide drinking water standards and goals.

The USEPA Third Unregulated Contaminant Monitoring Rule (UCMR3) under the Safe Drinking Water Act required public water systems in the United States to monitor for six PFAS substances (PFOS, PFOA, perfluorononanoic acid [PFNA], perfluorohexanesulfonic acid [PFHxS], perfluoroheptanoic acid [PFHpA], and perfluorobutanesulfonic acid [PFBS]) from 2013 to 2015 (USEPA 2021). None of the PFAS compounds tested in UCMR3 were detected in drinking water samples (i.e., at the tap after treatment) in the Willamette River Basin (Hu et al. 2016); source waters were not sampled as part of UCMR3. Several military sites in the Willamette River Basin have been linked to PFAS contamination of groundwater drinking water supplies, including Anderson Readiness Center and McNary Field in Salem, the Lebanon Motor Pool National Guard Site, and Lane County Armed Forces Reserve Center in Springfield (EWG, 2021).

As attention towards PFAS compounds increases, drinking water providers will likely need to monitor for an increasing variety of these chemicals; the Fifth Unregulated Contaminant Monitoring Rule (UCMR5) will require monitoring of 29 new PFAS substances from 2023 to 2025 in finished drinking water. They will also need to adopt or maintain treatment processes such as filtration through granular activated carbon, anion exchange systems, or membrane filtration to remove PFAS to regulated levels once nationwide standards are established, which may increase treatment costs. While there is no federal drinking water standard for PFAS, in 2016, the USEPA set a non-regulatory advisory level of 70 parts per trillion (ppt) for two PFAS compounds, known as PFOS and PFOA and the Oregon Health Authority (OHA) set a combined health advisory level of 30 ppt for four PFAS compounds (PFOS, PFOA, PFNA, and PFHxS) in 2021 (OHA, 2021).

3.5.6.2. Microplastics

Microplastics are very small pieces of plastic (<5 mm) which result from the breakdown of products in the environment. Data on microplastic occurrence is limited and highly varied due to lack of monitoring standards, and even less data is available related to the potential health hazards associated with microplastics. Current understandings suggest that the risks microplastics present in drinking water include physical particles, particularly nanoparticles, toxics, and microbial pathogens as part of biofilms, but studies disagree as to the degree of hazard these present (WHO, 2019). Drinking water treatment processes are considered very effective at physically removing microplastics, though more research is needed on drinking water treatment implications regarding the chemicals and biofilms associated with microplastics.

Microplastics were found in every Oregon water body tested as part of the Environment Oregon Microplastics Survey (2021), including the Willamette River at Eugene, Corvallis, and Salem, Detroit Lake in the Santiam River, the McKenzie River at Springfield, and the North Fork Middle Willamette River at Oakridge. No data were available regarding microplastic presence in drinking water samples in Oregon. Microplastics are not currently regulated nationwide, but states including California are moving forward with developing testing methodologies which may lead to national regulation in the future.

3.5.6.3. Pharmaceuticals and Personal Care Products

Pharmaceuticals and personal care products (PPCPs) encompass thousands of chemicals used by people for personal care or personal heath and can include over the counter and prescription drugs, cosmetics, cleaning products, and more. These chemicals can enter waterways through ingestion and excretion into municipal or household sewer systems or through improper disposal. This class of CEC is challenging to monitor, regulate, and treat due to the sheer variety of chemicals that it contains. Several pharmaceutical products were sampled by ODEQ in 2016. The Yamhill River location had the highest number of unique detections (ODEQ, 2020). However, only two of the compounds detected in 2016 have established criteria (acetaminophen and diethyl phthalate) and the measured concentrations were substantially below the criterion. Although the Yamhill River contributes approximately $1/10^{th}$ of the flow at the intake, there is likely low risk to water quality at the intake from PPCPs in the Yamhill River due to the low concentrations detected.

It is important to monitor guidance from regulatory agencies such as OHA and USEPA and remain up to date on best practices being used by water providers. Webinars and conferences through organizations such as the American Water Works Association (AWWA) are also important for staying up to date on the status of CECs.

4. RISK ANALYSIS

This section presents an overview and analyses of risks associated with various sources of pollutants to the Willamette River that have the potential to adversely impact water quality at the WIF Commission Intake. Many of these pollutants are discussed in Section 3 in terms of water quality observed in the Willamette River and its tributaries, but do not characterize the potential sources of the pollutants. Broadly, sources of these pollutants within the Willamette River Basin include both nonpoint and point sources.

Pollutants from nonpoint sources do not originate from any one identifiable location, but rather accumulate from the land surface and are transported to water bodies via rainfall or snow melt either directly or through erosion. Additionally, nonpoint sources of pollutants can be exacerbated by basin-wide concerns such as climate change and population growth.

Conversely, point sources of pollutants are identifiable locations of contaminants that can be directly traced to receiving waters. For potential point sources of contamination, a geodatabase of Drinking Water Protection Potential Contamination Source (PCS) Risk from point sources can be assessed through the framework shown in ***Figure 27***. First, an inventory of potential contamination sources (PCSs) may be compiled through available local, state, and national databases and verified or augmented through local outreach and knowledge. The PCSs may be mapped to understand where risks are distributed throughout the relevant watershed area. Then, an assessment can be performed to characterize how contaminants from each PCS feature might move through the watershed to the drinking water intake. A GIS spatial assessment to determine the lengths of relevant flow pathways informs the appropriate travel time equations for each PCS feature; travel time equations may be taken from literature, local dye tracer studies, or relevant hydrologic models of the system. The peak concentration of the contaminant plume at the intake and the time it takes the contaminant plume to pass the intake (i.e., the time during which elevated levels of contaminant may be experienced at the intake [“plume duration”]) may be assessed using dispersion equations from local dye tracer studies and known or assumed quantities of contaminants that are likely to be released from PCS features. Peak concentrations of the contaminant plume at the intake can be compared to state and national toxicity thresholds and standards to characterize the relative toxic potency of a contaminant release. Outputs from assessments of PCS movement and toxicity can be combined to characterize the overall risk of releases from PCS features; these assessments may be repeated for different flow regimes to encompass the range of risks that may be associated with low and high flows. For example, during low flows, travel times may be longer, which would provide more time for emergency response at the intake, but less dispersion would increase peak concentrations at the intake; the opposite would be true for high flows. Operational considerations of the drinking water treatment facility may inform other factors affecting risk, including the amount of treated water stored by the water provider, water usage trends, treatment processes used in the treatment facilities, and availability of alternative or redundant sources of water.

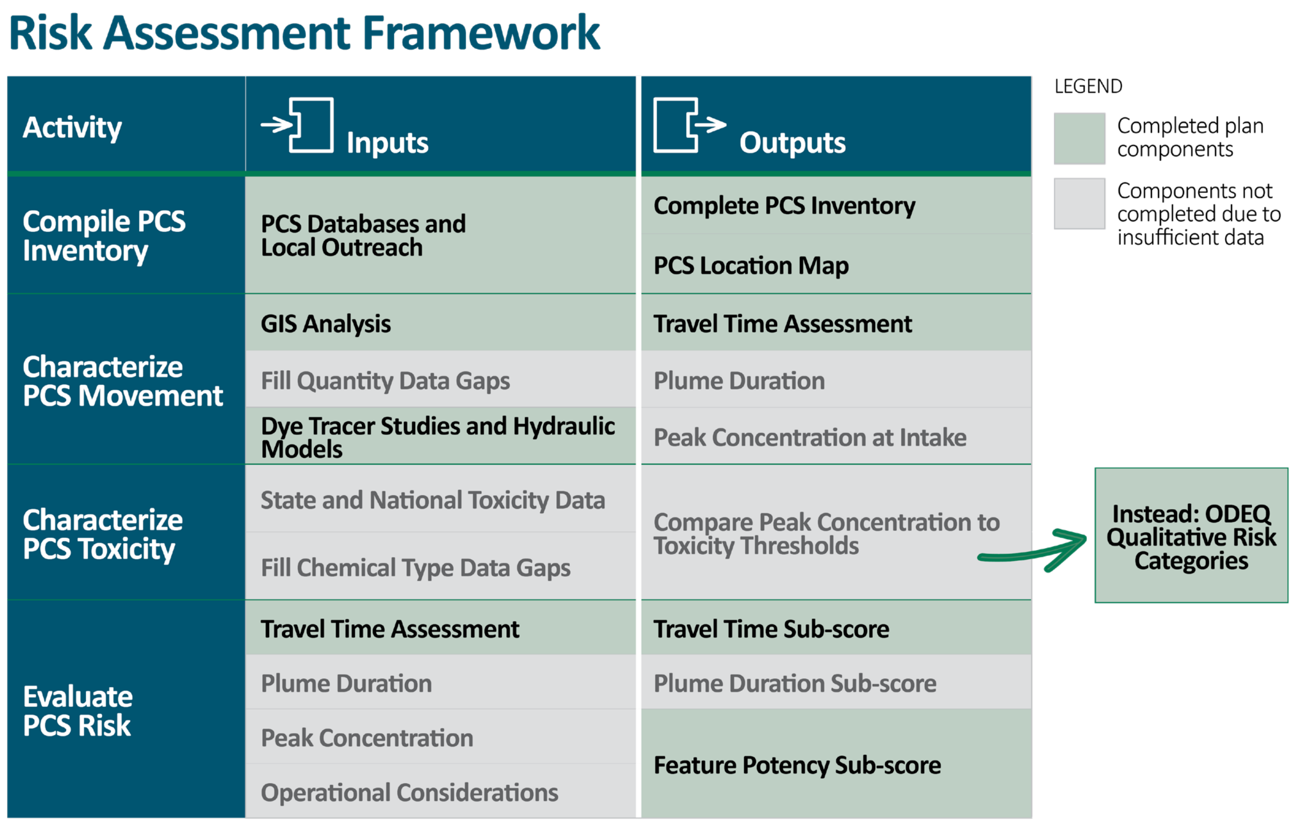

Figure 27. Framework for risk analysis

For potential point sources of contamination within the Willamette River Basin, a geodatabase of Drinking Water Protection Potential Contamination Sources compiled by ODEQ (ODEQ ArcGIS) was leveraged to identify sites and facilities with elevated risks to surface water quality due to possible or historic accidental releases or point discharges (e.g. outfalls) of contaminants. *Table 12* shows the risk categories considered in this risk assessment and the likely type of risk, which affects the appropriate travel pathways discussed in Section 4.1.3. Risk categories indicating no further action required or that may be superseded by other, more recent datasets (e.g., "Leaking Underground Storage Tanks – No Further Action" and "Original Source Water Assessment

Potential Contaminant Sources [2005]", which was superseded by a 2018 update) were excluded from the risk assessment. 303(d) listings were also excluded. Where information was available, facilities and sites with statuses indicating that a threat was no longer present (e.g., "Cleanup Complete" or similar) were excluded from the risk assessments. More information about each dataset is available at the embedded links in ***Table 13***.

Table 13. Drinking Water Protection Potential Contamination Source Categories

Risk Category	**Type of Risk**
Potential Contaminant Sources (2015-2022)	Surface
Dry Cleaners	Surface
Confined Animal Feeding Operations	Surface
Environmental Cleanup Sites with Known Contamination	Surface
Hazardous Material Generator Sites	Surface
Hazardous Substance Information System	Surface
Hazardous Substance Information System – Aboveground Storage Tank	Surface
Leaking Underground Storage Tanks	Subsurface
Mining Permits	Surface
Oil and Gas Wells (Permitted Only)	Surface
Updated Source Water Assessments Potential Contaminant Sources (2018)	Surface
Solid Waste Sites	Surface
Underground Storage Tanks	Subsurface
Water Quality Domestic Wastewater Treatment Sites	Surface
Water Quality Permits - Active	Surface
Surface Water Potential Contaminant Sources	Surface
Harmful Algal Bloom (HAB) Advisories (through 2018)	Surface
Boating Access Sites (2016)	Surface
Major Route Stream Crossings and Bridges (2013)	Surface
Water Quality Effluent Outfalls (2009)	Surface
Historic Fire Perimeters (2021)	Surface

4.1. Tier 1

The focus of the Tier 1 region risk assessment was on point sources of contamination, including accidental releases and point discharges of contaminants. Mentioned in Section 2.2.1, travel times to the WIF Commission Intake within the Tier 1 region are relatively short, which limits plume dispersion, increasing the peak pollutant concentration found at the intake, and provides a relatively short amount of time for emergency response protocols to be enacted following the report of an accidental release. Therefore, it is important to inventory and characterize the relative risk of point sources of contamination within the Tier 1 region.

Nonpoint sources of pollution discussed as part of the Tier 2 and Tier 3 risk assessments are also relevant to Tier 1.

4.1.1. Summary of Risks Identified in the Wilsonville Source Water Assessment

A source water assessment was originally conducted on behalf of the City of Wilsonville in 2002 (MWH, 2002). An 8-hour travel time window of 7.85 river miles upstream of the intake was estimated based on velocity at a previously active USGS gauge at Wilsonville at a typical flow rate (28,585 cfs). This 8-hour travel time area covered 34.4 square miles (MWH, 2002). Risks identified included high-erosion potential areas, high permeability and high runoff potential soils, and PCS locations identified by ODEQ including environmental cleanup sites, underground storage tanks, dry cleaners, Water Pollution Control Facilities, National Pollutant Discharge Elimination System (NPDES) permitted facilities, Solid Waste Management sites and Underground Injection Control (UIC) sites.

ODEQ conducted an updated source water assessment for the City of Wilsonville in 2019 (ODEQ, 2019) using a similar approach but an updated database of PCS locations. The ODEQ analysis estimated the 8-hour travel time area as slightly larger (46.2 square miles) based on the Extended Unit Runoff Method (ODEQ, 2019). The updated analysis included 46 agricultural/forest, 222 commercial/industrial, 51 residential/municipal, and 331 miscellaneous PCS locations (ODEQ, 2019).

4.1.2. Inventory of Potential Contamination Sources

Table 14 inventories the relative number of PCS features in each category for the entire Tier 1 region and the population centers of the Cities of Newberg, McMinnville, and Yamhill located within the Tier 1 region. Note that multiple features (e.g., storage tank, outfall, etc.) may be present at one site.

Table 14. Inventory of PCS Features and Sites within Tier 1 Region.

PCS Category	Tier 1 Region	City of Newberg	City of McMinnville	City of Yamhill
Other Potential Contaminant Sources	15	0	0	0
Dry Cleaners	12	5	6	0
Confined Animal Feeding Operations	47	0	0	1
Environmental Cleanup Sites	32	7	13	0
Hazardous Material Generators	112	37	44	0
Hazardous Substance Information System	289	55	99	6
Aboveground Storage Tanks	101	20	30	3

PCS Category	Tier 1 Region	City of Newberg	City of McMinnville	City of Yamhill
Leaking Underground Storage Tanks	107	27	33	4
Mining Permits	45	0	1	0
Permitted Oil and Gas Wells	0	0	0	0
Source Water Assessments PCSs	0	0	0	0
Solid Waste Sites	13	2	2	0
Underground Storage Tanks	27	8	12	2
Domestic Wastewater Treatment Sites	7	1	0	1
Water Quality Permits	146	27	38	1
Surface Water Potential Contaminant Sources	0	0	0	0
Historic Harmful Algal Bloom Advisories	0	0	0	0
Boating Access Sites	7	1	0	0
Major Route Stream Crossings and Bridges	98	4	5	1
Effluent Outfalls	14	0	2	0
Historic Fire Perimeters	0	0	0	0
Total	**1,072**	**194**	**285**	**19**

The Tier 1 PCS features are shown by PCS category in ***Figure 28***. This figure displays the spatial distribution of PCS features and associated category types within the Tier 1 region. For example, many PCS category types are associated primarily with urban areas such as dry cleaners, hazardous material generators, and underground storage tanks. Other PCS categories are distributed more broadly across the more rural areas of the Tier 1 area, including confined animal feeding operations (CAFOs) and mining activities. Transportation routes which cross the Willamette River and its tributaries are also largely found outside of urban areas.

The following sections build upon this PCS inventory for the Tier 1 region to further characterize the features in terms of travel time to the WIF Commission Intake and relative risk to surface water quality.

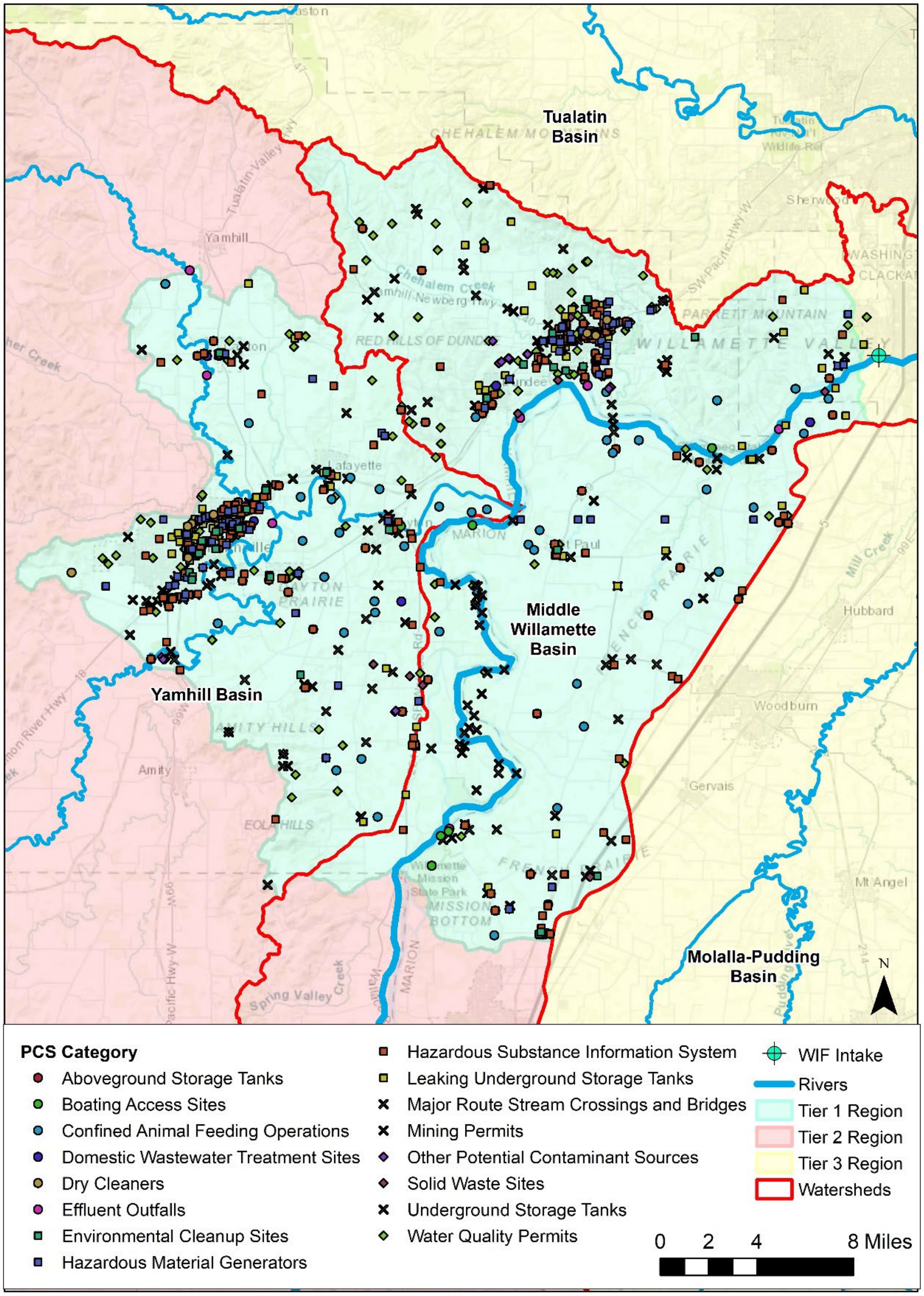

Figure 28. PCS features in the Tier 1 region by category of PCS category type.

4.1.3. Travel Time Methodology

Travel times from each PCS feature to the WIF Commission Intake were estimated piecewise using flow pathways appropriate to the PCS feature. These flow pathways include overland flow, underground flow, flow in a tributary, and flow along the Willamette River mainstem. Storm drainage features were not considered in this analysis. The methodology used to estimate the travel times is described below. Note that these generally describe travel times to the peak of a potential contaminant plume, not the leading edge of the plume.

Total travel time (TT) from a PCS feature to the WIF Commission Intake is a summation of the applicable travel pathways (Equation 1), described in subsequent sections:

Equation 1:

$$TT_{peak} = [TT_{underground} \; or \; TT_{overland}] + TT_{tributary} + TT_{mainstem}$$

Where: TT_{peak} is the total travel time from the PCS feature to the peak of a contaminant plume as it passes the WIF Commission Intake

$TT_{underground}$ is the travel time for the underground flow pathway (as applicable)

$TT_{overland}$ is the travel time for the overland flow pathway (as applicable)

$TT_{tributary}$ is the travel time for the tributary flow pathway

$TT_{mainstem}$ is the travel time for the mainstem flow pathway

4.1.3.1. Overland Flow

The following spatial datasets were used to estimate overland flow path lengths and travel times from each PCS feature within the Tier 1 region:

- Digital Elevation Model (Oregon State Service Center for GIS [SSCGIS])
- Statewide Land Use Data Standard (Oregon Geographic Information Council [OGIC], 2022)
- Hydrologic Soil Group (USDA NRCS, 2019a)
- Representative Slope (USDA NRCS, 2019b)

The overland flow distance for each PCS feature was computed using the Digital Elevation Model (DEM) as input. The flow distance algorithm uses the D8 flow direction method in which the direction of flow is determined by the direction of steepest descent from each DEM pixel to one of its eight neighbors. The result of the geoprocessing procedure is a value per cell in the DEM representing the minimum downslope distance following flow paths to a target feature. This calculation was conducted to determine the distance until the flow path intercepted the nearest tributary, mainstem, or the intake. Distance values for each PCS feature were extracted from each of the resulting flow distance raster files.

Overland flow travel times ($TT_{overland}$) were calculated using the SCS curve number method (Purdue Engineering, n.d.) as defined by Equation 2.

Equation 2:

$$TT_{overland} = \frac{\left(Distance_{overland}{}^{0.8}\right)\left[\left(\frac{1000}{CN} - 10\right) + 1\right]^{0.7}}{1{,}140\left(S^{0.5}\right)}$$

Where: CN is the curve number, estimated according to land use and soil type, as defined in ***Table 15***. Land use designations in the OGIC dataset were associated with the general land use categories defined by TR-55.

S is the land slope (%), estimated using the representative slope class defined by the USGS Web Soil Survey (USDA NRCS, 2019b)

$Distance_{overland}$ is the overland flow path length, estimated as described above

Table 15. Estimated Curve Number (CN) based on land use designation and Hydrologic Soil Group

Land Use Designation	**Hydrologic Soil Group**							
	A	**A/D**	**B**	**B/D**	**C**	**C/D**	**D**	**Not Available**
Commercial Improved	89	92	92	93.5	94	94.5	95	95
Commercial Unimproved or Vacant	49	66.5	69	76.5	79	81.5	84	84
Forest Land Improved	30	53.5	55	66	70	73.5	77	77
Forest Land Residential / Manufactured Structure	42	61.5	62.5	71.75	75	78	81	81
Forest Land Unimproved or Vacant	39.5	60	62	71.25	74.5	77.5	80.5	80.5
Farmland or Farm/Range Land Improved	64	74.5	75	80	82	83.5	85	85
Farmland or Farm/Range Land Residential / Manufactured Structure:	59	72	72.5	78.75	81	83	85	85
Farmland or Farm/Range Land Unimproved or Vacant	56.5	70.5	72	78.25	80.5	82.5	84.5	84.5

Land Use Designation	Hydrologic Soil Group							
	A	A/D	B	B/D	C	C/D	D	Not Available
Government Improved	89	92	92	93.5	94	94.5	95	95
Government Unimproved or Vacant	69	79.25	80.5	85	86.5	88	89.5	89.5
Industrial Improved	81	87	88	90.5	91	92	93	93
Industrial Unimproved or Vacant	65	76.75	78.5	83.5	85	86.75	88.5	88.5
Institution Improved	89	92	92	93.5	94	94.5	95	95
Institution Unimproved or Vacant	69	79.25	80.5	85	86.5	88	89.5	89.5
Miscellaneous Improved	89	92	92	93.5	94	94.5	95	95
Miscellaneous Unimproved or Vacant	49	66.5	69	76.5	79	81.5	84	84
Residential Multi-Family Improved	77	84.5	85	88.5	90	91	92	92
Residential Manufactured Structures Improved	77	84.5	85	88.5	90	91	92	92
Residential Single-Family Improved	77	84.5	85	88.5	90	91	92	92
Residential Unimproved or Vacant	51.5	68	69.5	77	79.5	82	84.5	84.5
Rural Tract Improved	49	66.5	69	76.5	79	81.5	84	84
Rural Tract Residential / Manufactured Structure	54	69.5	70	77.5	80	82.5	85	85
Rural Tract Unimproved or Vacant	51.5	68	69.5	77	79.5	82	84.5	84.5
Pavement	98	98	98	98	98	98	98	98
River	1	1	1	1	1	1	1	1
Source: https://engineering.purdue.edu/mapserve/LTHIA7/documentation/scs.htm								

4.1.3.2. Underground Flow Path

The following spatial datasets were used to estimate underground flow path lengths and travel times ($TT_{underground}$) from subsurface PCS features within the Tier 1 region:

- Digital Elevation Model (SSCGIS)
- Hydrologic Soil Group (USDA NRCS, 2019a)
- Representative Slope (USDA NRCS, 2019b)

For PCS features categorized as underground storage tanks or leaking underground storage tanks, the overland flow path between the PCS feature and the nearest mapped tributary or Willamette River mainstem was assumed as a proxy for the underground travel distance of a potential contaminant plume. Absent a thorough understanding of groundwater movement in the region, this was assumed to be a sufficient estimate.

Underground travel times for subsurface PCSs were calculated by dividing the flow path distance by the seepage velocity as shown in Equation 3.

Equation 3:

$$TT_{underground} = \frac{Distance_{overland}}{Velocity_{seepage}}$$

Where the seepage velocity is defined by Equation 4.

Equation 4:

$$Velocity_{seepage} = \frac{q}{n} = \frac{-K\frac{dh}{dx}}{n}$$

Where: q is the unit discharge

n is porosity, estimated according to soil type as defined in ***Table 16***

K is hydraulic conductivity, estimated according to soil type as defined in *Table 15*

dh/dx is the fluid gradient, assumed here to be the representative slope (USGS NRCS, 2019b)

Table 16. Estimated hydraulic conductivity and porosity values based on Hydrologic Soil Group

	Hydrologic Soil Group							
	A	**A/D**	**B**	**B/D**	**C**	**C/D**	**D**	**Not Available**
Hydraulic Conductivity, K (in/hr.)[1]	5.67	5.67	1.42	1.42	0.14	0.14	0.06	5.67
Porosity[2]	0.44	0.44	0.49	0.49	0.4	0.4	0.47	0.4
[1] NRCS, 2007 [2] Minnesota Pollution Control Agency, 2016								

4.1.3.3. Tributary Flow Path

The following spatial datasets were used to estimate tributary path lengths and travel times from surface PCS features within the Tier 1 region:

- Hydrologic Unit (HU12) Watershed Boundary Dataset (BLM, 2004)
- USGS National Hydrography Dataset (USGS, 2006)

Travel distances along mapped tributaries (USGS, 2006) were computed individually from the most downstream overland or underground flow path's (Sections 4.1.3.1 and 4.1.3.2) interception point with a tributary. The main tributary within the Tier 1 region is the Yamhill River, consisting of both the North and South forks. There are also several smaller tributaries, including Champoeg Creek, Chehalem Creek, Corral Creek, Coffee Lake Creek, Lambert Slough, Palmer Creek, and Hawn Creek.

A USGS dye tracer study (Lee, 1995) provides data relating discharge in the Yamhill and South Yamhill rivers to the time to peak of the dye plume. Thus, an average velocity over these tributary lengths can be back-calculated and a regression curve relating velocity to tributary discharge developed. It should be noted that the dye tracer studies were only performed under two flow regimes per study reach, and therefore the resulting regression curves are likely highly approximate outside of the range of flows observed in Lee (1995). ***Figure 29*** shows the linear regressions that relate average tributary velocity to tributary discharge for both the Yamhill and South Yamhill Rivers. Regression equations are provided in the figure, where V is the average segment velocity and Q is the tributary discharge.

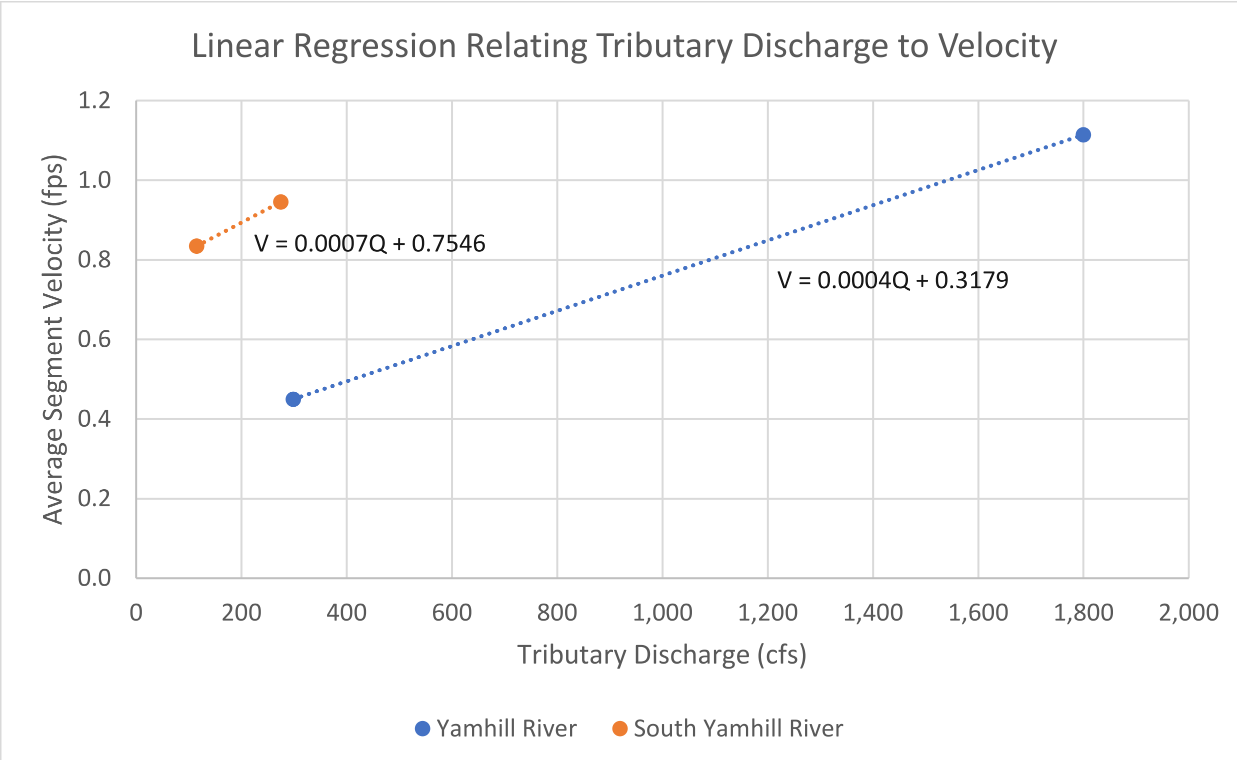

Figure 29. Relationship of tributary discharge to average tributary velocity on the Yamhill and South Yamhill Rivers.

Absent other hydrologic data for the smaller tributaries within the Tier 1 region, PCS features were located within HU12 watershed boundaries (BLM, 2004), which were then associated with either the Yamhill or South Yamhill tributary hydrology based on proximity as shown in ***Table 17***. The study flow rates for the Willamette River mainstem were then scaled by a ratio of the drainage area of each HU12 watershed area to the overall drainage area to the WIF Commission Intake to determine flow rates for the smaller tributaries. Then, using the flow-velocity regression equations derived from dye tracer studies and scaled flow rates, average velocities for each smaller tributary were calculated.

The flow path length along each tributary ($Distance_{tributary}$) was divided by the appropriate tributary velocity ($Velocity_{scaled}$) to determine the travel time within each watershed (Equation 5).

Equation 5:

$$TravelTime_{tributary} = \frac{Distance_{tributary}}{Velocity_{scaled}}$$

Table 17. Representative discharge and velocity for tributaries in HU12 watersheds within the Tier 1 region.

Subbasin	Associated Tributary	Drainage Area (sqm)	Study Flow Rate (Willamette River Mainstem) (cfs)							
			98,800		57,800		7,100		6,000	
			Flow (cfs)	Velocity (ft/s)	Flow (cfs)	Velocity (ft/s)	Flow (cfs)	Velocity (ft/s)	Flow (cfs)	Velocity (ft/s)
Champoeg Creek	South Yamhill	44.5	524	1.12	306	0.97	38	0.78	32	0.78
Chehalem Creek	South Yamhill	40.8	479	1.09	280	0.95	34	0.78	29	0.77
Hess Creek-Willamette River	South Yamhill	37.1	436	1.06	255	0.93	31	0.78	27	0.77
Corral Creek-Willamette River	South Yamhill	28.1	330	0.99	193	0.89	24	0.77	20	0.77
Coffee Lake Creek-Willamette River	South Yamhill	23.2	273	0.95	160	0.87	20	0.77	17	0.77
Lambert Slough-Willamette River	South Yamhill	52.8	622	1.19	364	1.01	45	0.79	38	0.78
South Yamhill River	South Yamhill	31.2	367	1.01	214	0.90	26	0.77	22	0.77
Palmer Creek	Yamhill	33.3	391	0.47	229	0.41	28	0.33	24	0.33
Hawn Creek-Yamhill River	Yamhill	35.6	419	0.49	245	0.42	30	0.33	25	0.33
Lower North Yamhill River	Yamhill	15.9	187	0.39	109	0.36	13	0.32	11	0.32

4.1.3.4. Willamette River Mainstem Flow Path

The following spatial datasets were used to estimate the Willamette River mainstem path lengths and travel times from surface PCS features within the Tier 1 region:

- USGS National Hydrography Dataset (USGS, 2006)

Travel distances along the Willamette River mainstem were computed individually from the most downstream flow path or tributary segment's interception point with the mainstem to the WIF Commission Intake.

Travel times on the Willamette River mainstem were analyzed using the CE-QUAL-W2 model for the Middle Willamette River (Salem to Willamette Falls) originally developed and calibrated by Annear et al. (2004) and used by ODEQ for the 2006 TMDL (ODEQ, 2006).

The CE-QUAL-W2 model was run with adjusted upstream boundary inflows matching the four study flow rates at the Salem gage (see ***Table 17*** and Section 2.1), with an assumed injection of a theoretical dye tracer at Salem (RM 85). Study flow rates at the Salem gage were used instead of flow rates at the WIF Commission Intake because the model accounts for tributary flow contributions between Salem and the intake location. Tributary flows were not modified from the original model. For each study flow rate, the time, in hours, to the peak of the dye tracer plume was identified for 31 locations along the Willamette River mainstem, with the most downstream location being the WIF Commission Intake (RM 38.7). The distance upstream of the intake was calculated for each of the 31 locations, as well as the travel time from the location to the WIF Commission Intake at each of the four study flow rates as shown in ***Figure 30***.

The travel time along the Willamette River mainstem from each PCS point to the WIF Commission Intake was estimated by linearly interpolating between the travel times of the two closest of the 31 locations.

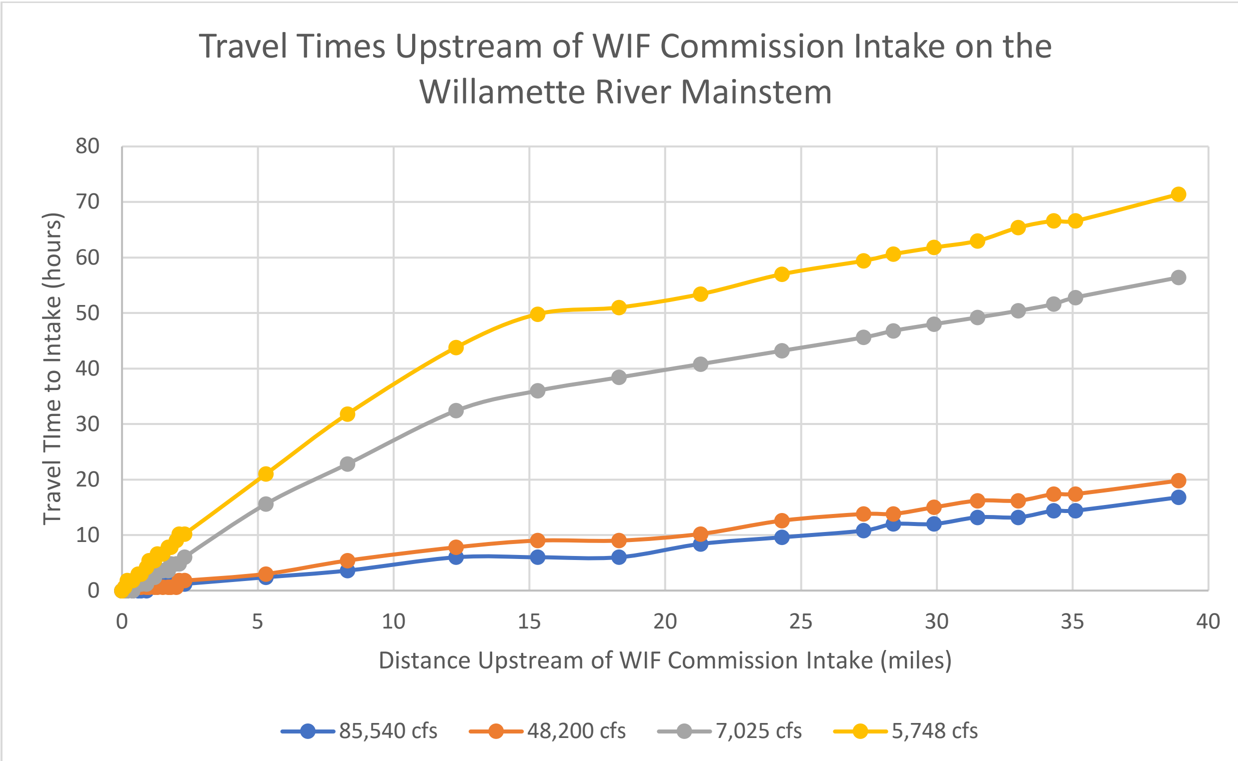

Figure 30. Travel times upstream of the WIF Commission Intake on the Willamette River mainstem for the four study flow rates (Cite table above). The study flow rates in this figure are for the Willamette River at Salem.

Figure 31 shows the relative travel times for PCS features within the Tier 1 region for the highest study flow rate (98,800 cfs). Note that all PCS features with travel times greater than 250 hours are subsurface PCS features such as underground storage tanks. As expected, PCS features with faster travel times are located closer to the WIF Commission Intake and along the mainstem or tributaries, while PCS features that are high in the Tier 1 region watershed or are far away from tributaries have longer travel times.

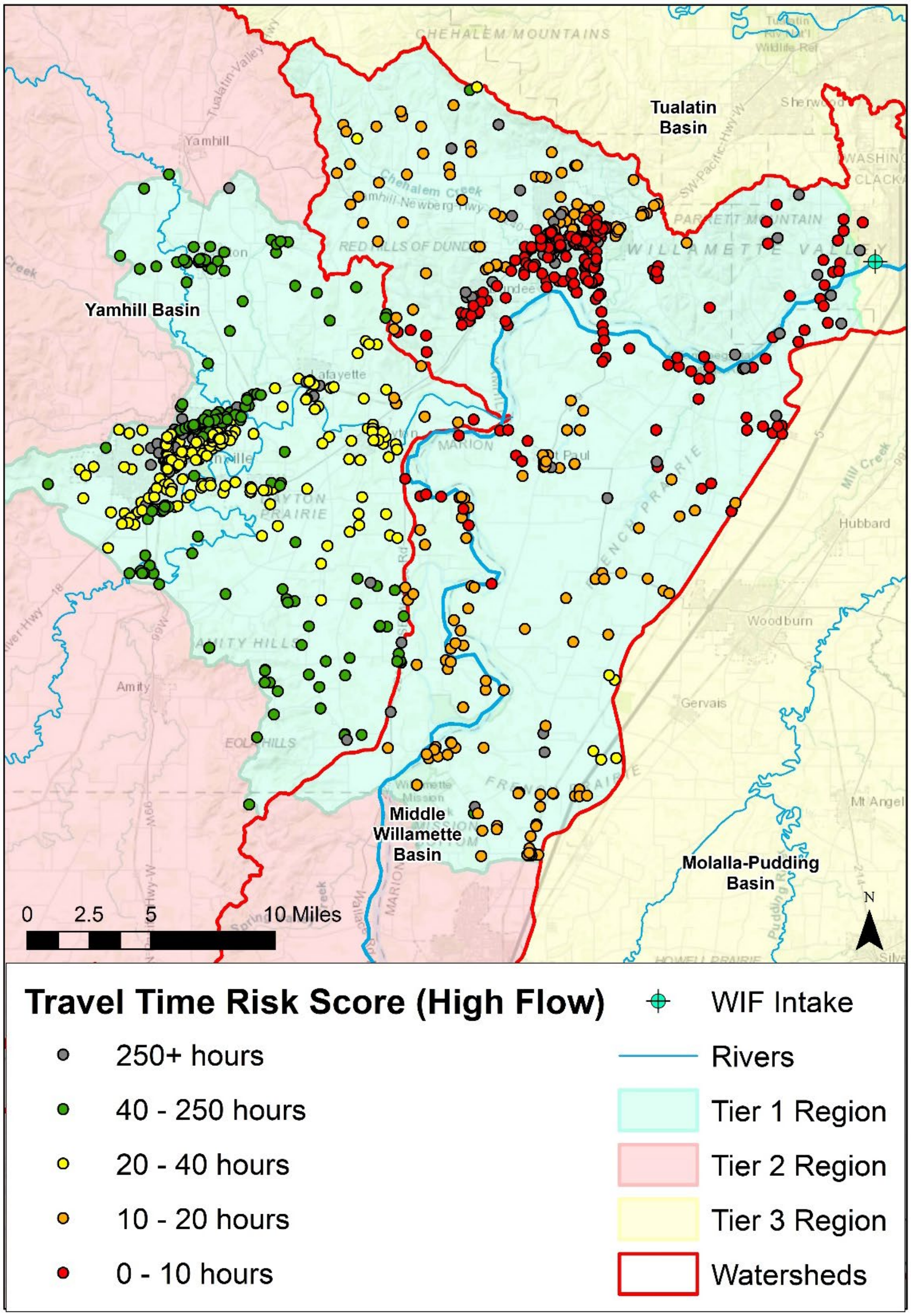

Figure 31. Relative risk to surface water as classified by travel time to the WIF Commission Intake for PCS features within Tier 1. Assumes flow rate in the Willamette River mainstem at the WIF Commission Intake of 98,800 cfs.

4.1.4. Toxicity of Selected PCS Features

The ODEQ Drinking Water Protection Potential Contamination Sources geodatabase does not include specific contaminants of concern (COCs) or the quantity of COCs for each PCS feature or site identified. This precludes estimation of COC concentrations at the WIF Commission Intake under the study flow rates and qualification of the relative toxicity of the COC to human health standards as described in the Risk Assessment Framework described in ***Figure 27***. The PCS features and categories could be used with national databases to better characterize likely COCs associated with PCS features and to evaluate the relative toxicity of each COC relative to human health standards. This could be further refined through the estimation or inventory of COC quantities associated with each PCS feature, which could in turn allow the peak concentration of the contaminant plume at the intake to be calculated.

The geodatabase does provide qualitative rankings for each PCS feature for surface water risk categorically as High, Medium, or Low. These rankings broadly consider the type of PCS, the COCs likely associated with the site, and the transport characteristics of likely contaminants. In lieu of COC data, these rankings were used as proxies for toxicity.

Table 18 shows the number of PCS features within the Tier 1 region categorized by the surface water risk category. Notably, the solid waste sites, CAFOs, domestic wastewater treatment facilities, boating access sites, route crossings (roadways and bridges), effluent outfalls, environmental cleanup sites, and hazardous-material-generating PCS features are classified as high risk to surface waters. Similarly, the dry cleaners and leaking underground storage tanks were classified as medium risks, and the underground storage tanks were classified as low risks.

Table 18. Number of high-, medium-, and low- surface water risk PCS features within the Tier 1 region per PCS category

PCS Category	Surface Water Risk Ranking		
	High	**Medium**	**Low**
Other PCSs	11	3	1
Dry Cleaners	0	12	0
Mining Permits	26	19	0
Solid Waste Sites	13	0	0
CAFOs	47	0	0
Domestic Wastewater Treatment	7	0	0
Water Quality Permits	139	5	2
Boating Access Sites	7	0	0
Route Crossings	98	0	0
Effluent Outfalls	14	0	0
Environmental Cleanup Sites	32	0	0
Hazardous Material Generator	112	0	0
Hazardous Substance Information System	81	132	74
Aboveground Storage Tanks	33	52	15
Leaking Underground Storage Tanks	0	107	0
Underground Storage Tanks	0	0	27
Totals[1]	**620**	**330**	**119**
[1] Three PCS features were not assigned surface water risk rankings in the ODEQ database			

The PCS features are mapped in ***Figure 32*** according to their relative risk to surface water as classified in the ODEQ database. Notably, a proportionally higher number of PCS features found within population centers are categorized as low or medium risk (see inset maps for Newberg and McMinnville), while PCS features outside of the population centers tend to be categorized as higher risk.

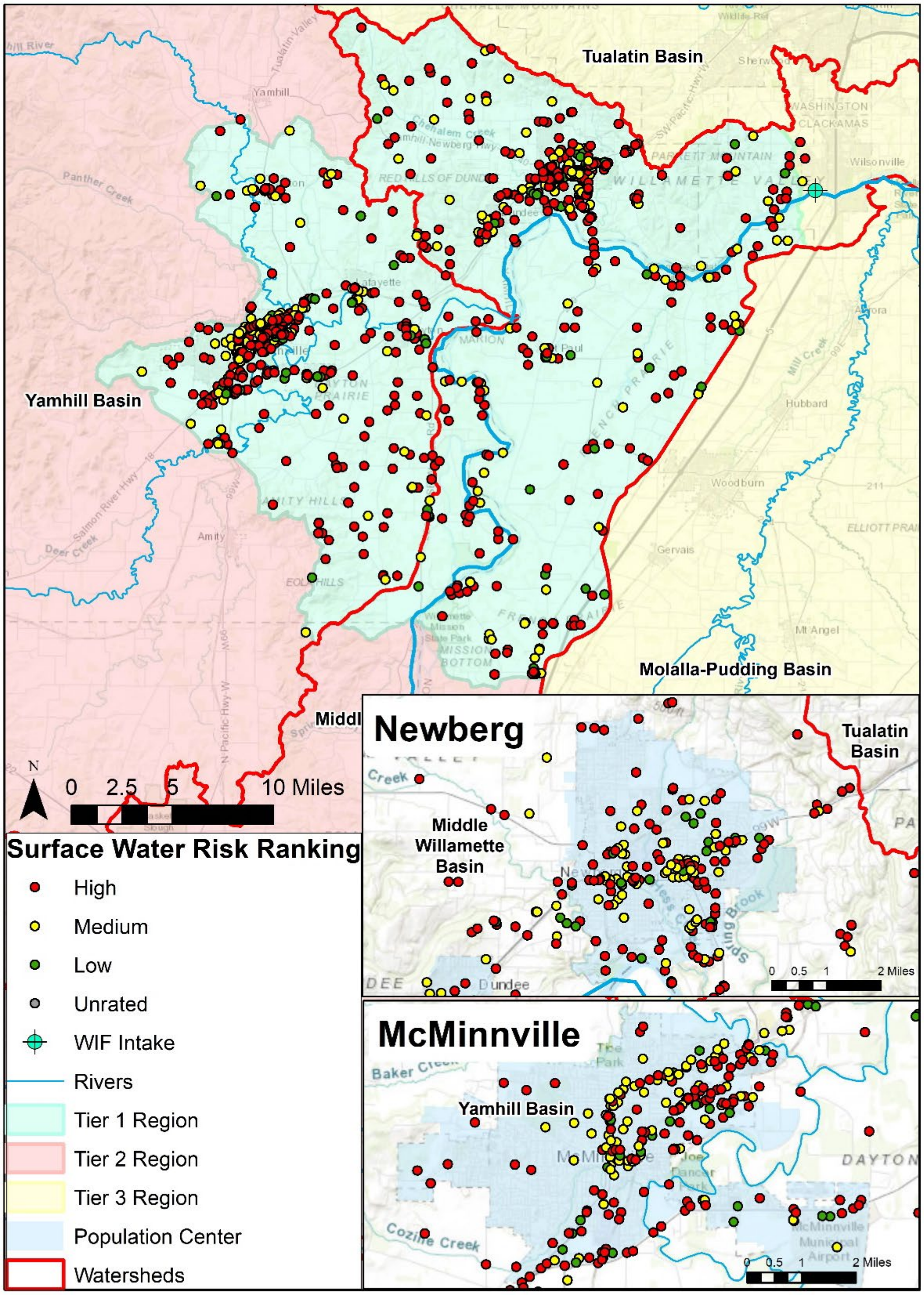

Figure 32. Relative risk to surface water as classified by ODEQ Drinking Water PCS database for PCS features within Tier 1.

4.1.5. Methodology for Evaluating PCS Risk

Risk to surface water quality at the WIF Commission Intake for each PCS can be evaluated based on travel times to the intake, risk to water quality, or both as summarized in ***Figure 27***. ***Figure 31*** and ***Figure 32*** in the previous sections show the relative risk of PCS features in the Tier 1 region based on surface water risk rankings (assigned by the ODEQ database) and travel time, respectively, but separately.

A simple numerical ranking system of sub-scores was developed to help characterize overall combined risk, where higher numbers indicate higher risk to drinking water. The numerical values were assigned to travel times, in hours, at the highest study flow (85,540 cfs) and surface water risk rankings; these appear in ***Table 19***. Travel time categories were based loosely on distribution statistics for surface risk PCS features at the highest study flow, meaning that there are roughly the same number of PCSs in each risk value category and thus this ranking system provides a useful metric for relative comparison.

Table 19. Numeric risk value sub-scores assigned based on surface water risk rankings and travel times

Category	Numeric Sub-score Risk Value
-- Surface Water Risk Ranking --	
High	3
Medium	2
Low	1
-- Travel Time (hours) --	
0-10	4
10-20	3
20-40	2
40-250	1
250+	0

These sub-scores were added (i.e., weighted equally between two sub-scores) to create an overall risk score, from 1 – 7 which factors in both the travel time and relative consequence of each PCS feature. These are mapped in ***Figure 33***.

High risk scores (overall risk score of 6 or 7) tend to be located along the Willamette River mainstem, with a high concentration within and around the City of Newberg. Most of the medium risk scores (overall risk score of 3, 4, or 5) are generally clustered along tributaries and in the City of McMinnville. Lower risk scores (overall risk score of 1 or 2) are generally located higher elevations (and hence further away) in the Tier 1 region or represent subsurface features. A summary of the number of PCSs with each risk score in each category is provided in ***Table 20***. Additionally, a list of the high risk PCSs in the Tier 1 region is provided in Appendix B.

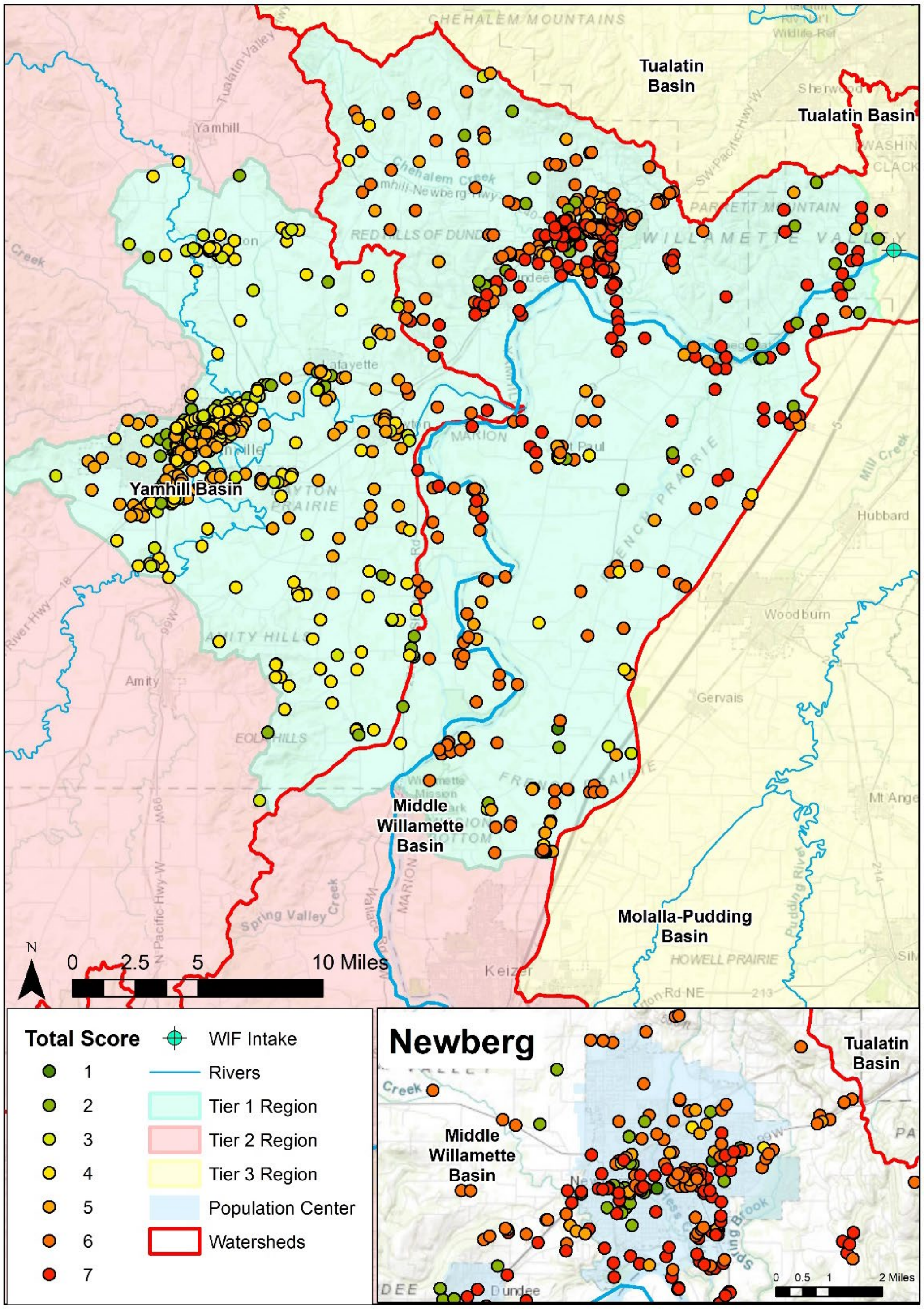

Figure 33. Relative overall risk to surface water at the WIF Commission Intake for PCS features within Tier 1.

Table 20. Number of PCSs by category and risk score

PCS Feature Category Type	Overall Risk Score						
	1	**2**	**3**	**4**	**5**	**6**	**7**
	Low		**Medium**			**High**	
Other PCSs	0	0	2	4	0	5	4
Dry Cleaners	0	0	3	4	0	5	0
Mining Permits	0	0	4	10	7	19	5
Solid Waste Sites	0	0	0	2	2	5	4
CAFOs	0	0	0	8	10	9	20
Domestic Wastewater Treatment	0	0	0	1	3	0	3
Water Quality Permits	0	1	1	31	33	47	33
Boating Access Sites	0	0	0	0	1	3	3
Route Crossings	0	0	0	20	26	34	18
Effluent Outfalls	0	0	0	4	3	1	6
Environmental Cleanup Sites	0	0	0	5	13	7	7
Hazardous Material Generator	0	0	0	25	33	13	41
Hazardous Substance Information System	0	14	68	68	67	48	22
Aboveground Storage Tanks	1	2	23	21	22	22	10
Leaking Underground Storage Tanks	0	106	1	0	0	0	0
Underground Storage Tanks	27	0	0	0	0	0	0
Total	28	123	102	203	220	218	176

This risk analysis could be refined to include more of the analyses included in the Risk Assessment Framework described in ***Figure 27***. A more thorough investigation of the PCS features and sites identified in the ODEQ PCS database may produce an inventory of specific COCs, contaminant quantities held or likely discharged onsite, and factors affecting the likelihood of a release. Filling these data gaps would allow the qualification of the relative toxicity of prevalent COCs to state and national human health standards. Other factors that may be considered include the treatability of prevalent COCs by treatment processes at WIF Commission Partner drinking water treatment facilities, and onsite preventative measures and response protocols for accidental releases. Refinement of the risk analysis can also incorporate the use of national databases on contaminants and toxicity information. These and other investigations and refinements to the risk assessment will be addressed in future Source Water Protection Plan tasks.

4.2. Tier 2

4.2.1. Inventory of Potential Contamination Sources

The Willamette River mainstem includes the cities of Salem, Corvallis, Albany, Eugene, and Springfield. These urban areas are important when considering the number and types of PCSs in the Tier 2 region. However, travel times from these cities to the WIF Commission Intake are long enough (on the order of days to weeks) to provide sufficient response time for water providers in case of an accidental release and substantial dispersion of contaminants. This also reduces the peak concentrations experienced at the WIF Commission Intake. This section provides a high-level overview of the types and relative number of potential contamination source categories but does not assign risk factors to each PCS feature as was done for Tier 1 PCSs in Section 4.1.

Table 21 shows the number of PCS features located within these urban growth areas. The cities of Corvallis and Albany, and Eugene and Springfield, are considered as paired due to their proximity. There are relatively more PCS features located within the Salem and Eugene/Springfield urban areas than within Corvallis/Albany urban areas, which is to be expected given the relative populations sizes.

The types and proportion of PCS features in these urban areas are not drastically different from the urban areas within the Tier 1 region, including the cities of Newberg and McMinnville, or the Tier 1 region with the following exceptions:

- The city of Salem contains a higher proportion of PCS features that include leaking underground storage tanks (23.4%) compared to other Tier 2 urban areas (< 14%) and the Tier 1 region (<10%).

- The urban areas in the Tier 2 region contain a lower proportion of PCS features that are mining permits (< 1%) compared to the Tier 1 region (4.2%), but similar proportions to the cities of Newberg and McMinnville (< 0.5%).

- The urban areas in the Tier 2 region contain a lower proportion of PCS features that are water quality permits (< 8.5%) compared to Tier 1 urban areas (> 13%) and the Tier 1 region (13.6%).

- The urban areas in the Tier 2 region contain a higher proportion of PCS features that are major route crossings and bridges (> 7.5%) compared to Tier 1 urban areas (< 2.1%), but similar proportions to the Tier 1 region (9.1%).

Table 21. Inventory of PCS Features and Sites within Population Centers of Tier 2 Region.

PCS Category	**City of Salem**	**Cities of Eugene and Springfield**	**Cities of Corvallis and Albany**
Other Potential Contaminant Sources	36	0	18
Dry Cleaners	33	43	18
Confined Animal Feeding Operations (CAFOs)	0	1	2
Environmental Cleanup Sites	87	95	58
Hazardous Material Generators	274	356	146
Hazardous Substance Information System	507	679	334
Aboveground Storage Tanks	150	180	80
Leaking Underground Storage Tanks	461	151	104
Mining Permits	16	6	2
Permitted Oil and Gas Wells	0	0	0
Source Water Assessment PCS	13	0	17
Solid Waste Sites	18	26	4
Underground Storage Tanks	72	73	37
Domestic Wastewater Treatment Sites	1	1	3
Water Quality Permits	149	162	53
Surface Water Potential Contaminant Sources	0	0	0
Historic Harmful Algal Bloom Advisories	4	3	0
Boating Access Sites	4	4	5
Major Route Stream Crossings and Bridges	149	201	148
Effluent Outfalls	3	7	5
Historic Fire Perimeters	0	0	0
Total	**1,977**	**1,988**	**1,034**

4.2.2. Influence of WVP Reservoirs

Several of the USACE WVP dams are within the Tier 2 region. These include Big Cliff and Detroit reservoirs on the North Santiam River, Foster and Green Peter reservoirs on the South Santiam River, and Fern Ridge reservoir on the Long Tom River. These are large projects, each of which may be expected to impact flow and water quality downstream due to their seasonal storage and release operations. Most of the remaining WVP dams are upstream of the Tier 2 region, including Lookout Point, Fall Creek, and Dexter reservoirs on the Middle Fork Willamette, Dorena and Cottage Grove reservoirs on the Coast Fork Willamette, and Blue River and Cougar reservoirs on the McKenzie River. Although these dams are outside of the Tier 2 region, they have significant impacts on these major tributaries. Their effects can also be observed at the USGS gages on the Willamette River mainstem at Harrisburg, Albany, and even as far downstream as Salem (ODEQ, 2006). However, for the purposes of this risk analysis, only the WVP dams in the Tier 2 region are discussed in detail. The locations of the WVP dams are provided relative to the locations of USGS gages in ***Figure 34***. The following sections describe the influence of the WVP dams on the flow and temperature in the rivers in the Tier 2 region based on long term monitoring data from the USGS gages. The following sections also touch on additional water quality parameters where information is available.

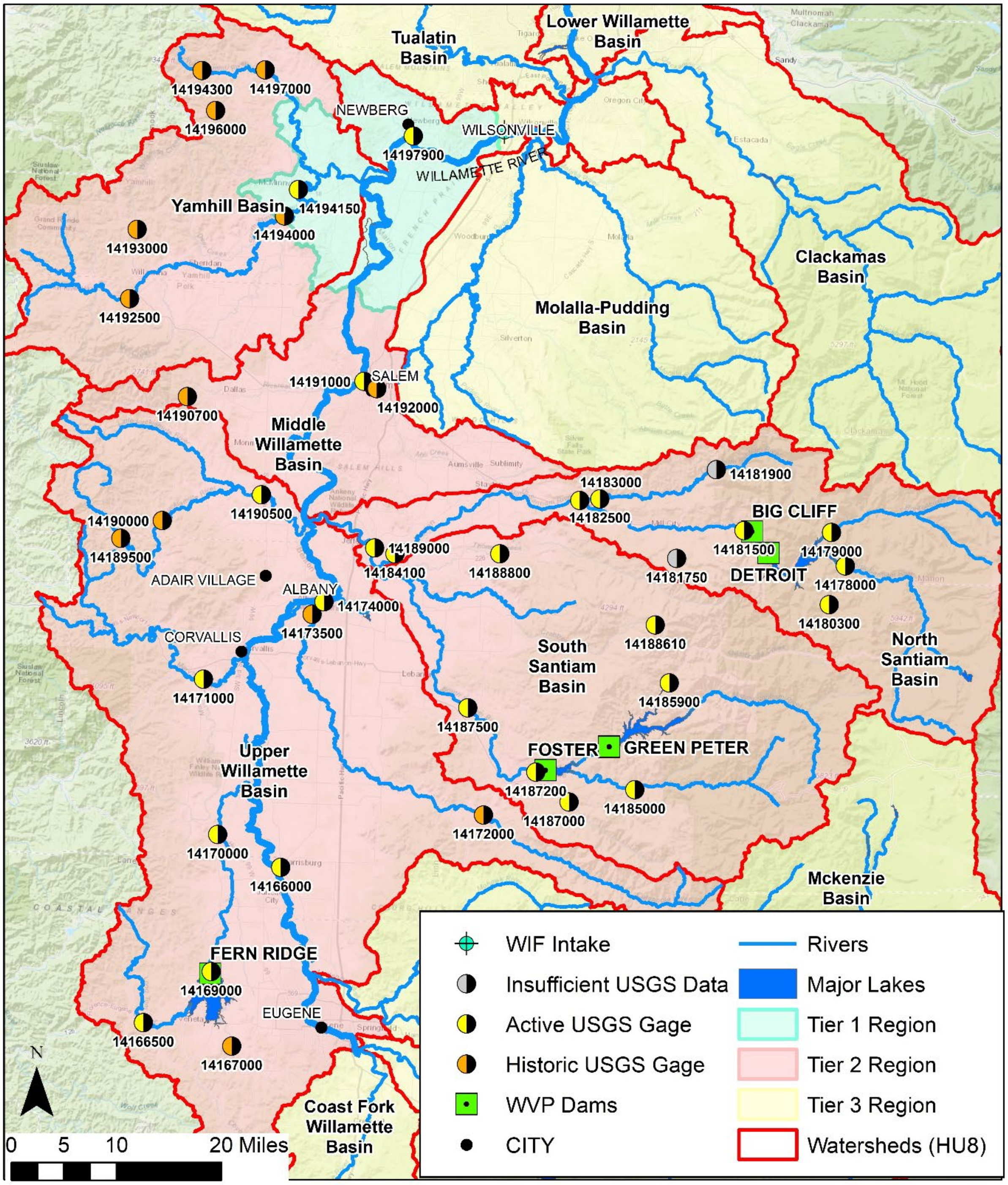

Figure 34. Locations of WVP dams relative to USGS gages in the Tier 1 and Tier 2 regions.

4.2.2.1. Flow

Due to the large contribution of flow by the Santiam River to the Willamette River mainstem, it is essential to understand the tributary flows of the North and South Santiam Rivers, as well as the effect of their respective WVP dams. The overall effect of these dams can be seen by comparing the seasonal average monthly flow rates at the Santiam River gage (14189000) before and after the Detroit and Big Cliff dams were completed in 1953. Numerical comparisons are provided in ***Table 22*** and visualized in ***Figure 35***. These representations of the flow data show that the dams are effective at reducing peak winter flows and increasing late summer and fall flows, specifically in August through October.

Table 22. Monthly average flows (in cfs) on the Santiam River before and after the completion of the Detroit Dam

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-1953	13,779	14,255	10,735	9,388	8,125	4,866	2,007	827	1,144	3,330	10,970	12,819
Post-1953	14,593	10,632	9,324	8,631	7,018	4,481	1,923	1,496	2,731	4,863	11,157	15,361

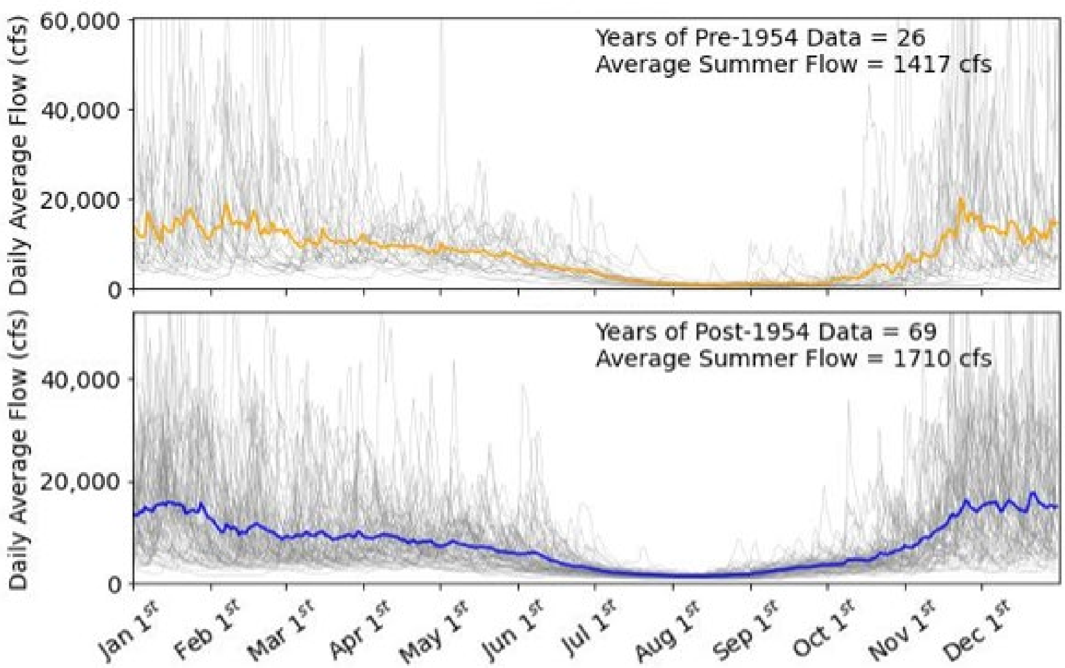

Figure 35. Seasonal flow trends on the Santiam River before (top) and after (bottom) completion of the Detroit Dam

On the North Santiam River, the Big Cliff and Detroit dams operate storage volume in the Detroit Reservoir to dampen winter storms, store spring runoff, and augment summer and early fall flow rates. The effect of these operations on flow in this tributary is best captured by the USGS gage just downstream (14181500) of the dam. This flow data was analyzed before and after 1953 to measure the influence of the dams on the average annual hydrology of the North Santiam River, as shown in ***Figure 36***. Here, it is again clear that the Big Cliff and Detroit dams provide a major boost to late summer flows in the North Santiam River and help dampen winter high flows.

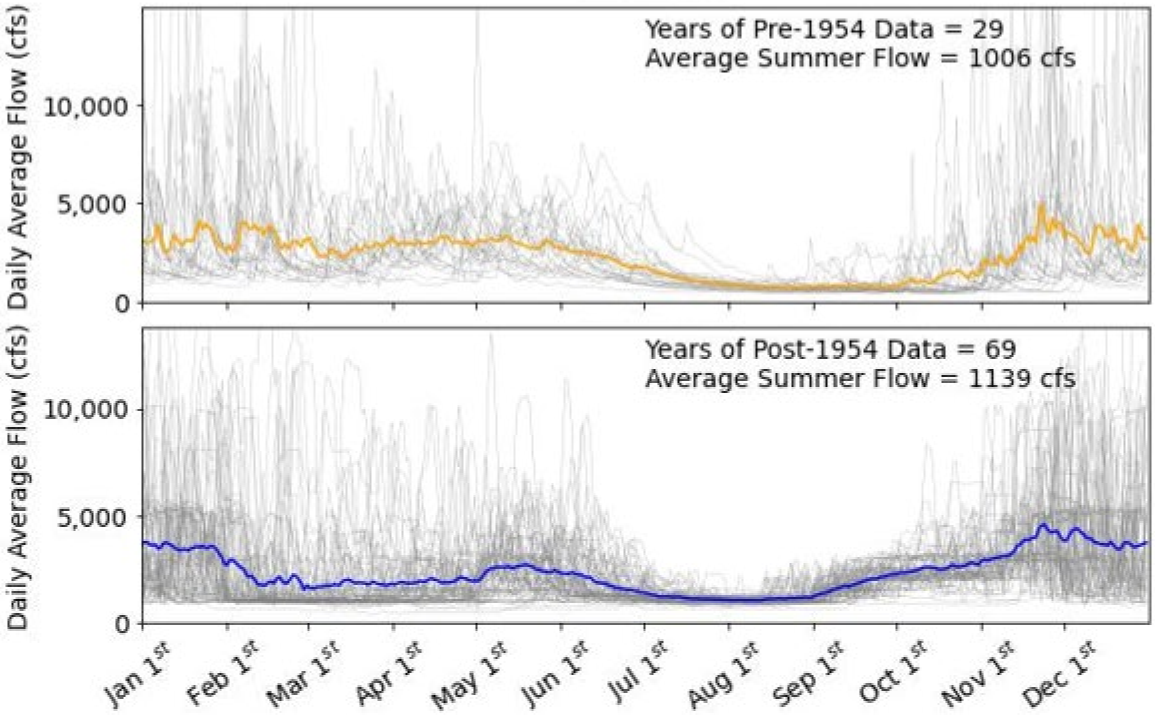

Figure 36. Seasonal flow trends on the North Santiam River below the Big Cliff and Detroit dams before (top) and after (bottom) completion of the dams

The USGS flow gage downstream of Foster Dam on the South Santiam (14187200) similarly captures the influence of the dam on that tributary hydrology. However, the Foster and Green Peter dams were completed in 1966 and 1967, respectively, and the USGS gage was not installed until 1972. Thus, no pre-WVP is available for comparison to the more recent seasonal trend shown in ***Figure 37***.

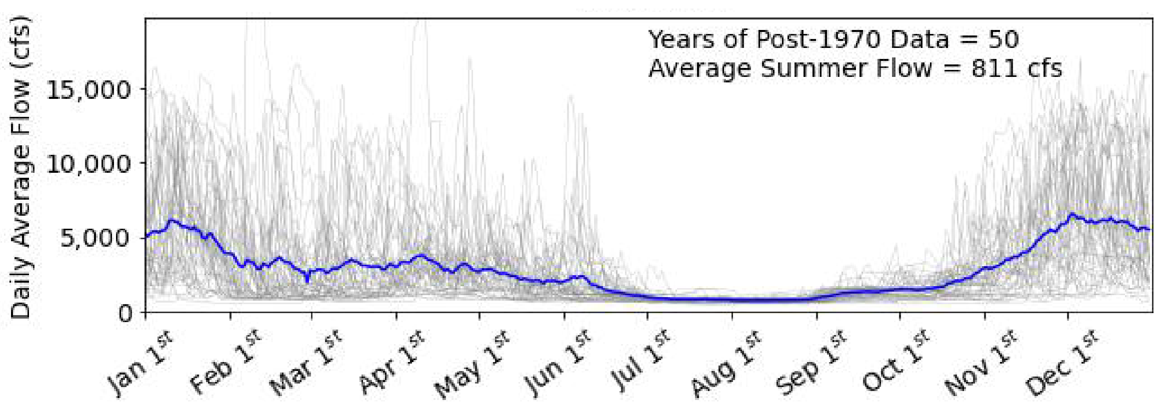

Figure 37. Seasonal flow trend on the South Santiam River after completion of the Foster and Green Peter dams

Overall, it may be expected that the operations of the WVP dams – particularly on the North Santiam River but also the South Santiam River – are of relevance to source water quantity. They contribute to the mitigation of both storm events in the winter and low baseflow in the summer on the Willamette River flow at Salem and Newberg. As discussed in the "Willamette Watershed History, Characterization, and Stakeholders" Memo, and in the following sections, these measures protect water quality for both humans and native fish species. However, maintenance or changes in operations of the dams may present risks as far downstream as the WIF Commission Intake. In particular, the aging infrastructure of the WVP dams may increase the need for maintenance that would disrupt dam operations and result in periods of run-of-the-river flows. It should therefore be noted that studies have found these risks to be manageable. The WVP dams are a system in which operations at other dams will respond to the changing conditions downstream (Tullos et. al, 2020). Additionally, management changes that are made in response to climate change will likely reduce potential impacts to the current flow regimes, as discussed in Section 4.3.1.1.

4.2.2.2. Water Temperature

The WVP reservoirs modify the water temperature regime of the Willamette River in several ways. In the summer, large volumes of water are released which are often substantially cooler than natural water temperatures. This phenomenon has been observed for the Cougar Dam (upstream of the Tier 2 region) as shown in ***Figure 38*** (ODEQ, 2006). Flow augmentation also creates higher flow velocities, shorter travel times through the mainstem river system reaches, and less exposure to natural heating and cooling processes (ODEQ, 2006). Additionally, having a greater volume of water in the river increases the heat loading capacity. These factors contribute to cooler maximum daily temperatures in the Willamette River mainstem during the summer than may be observed without the WVP operations.

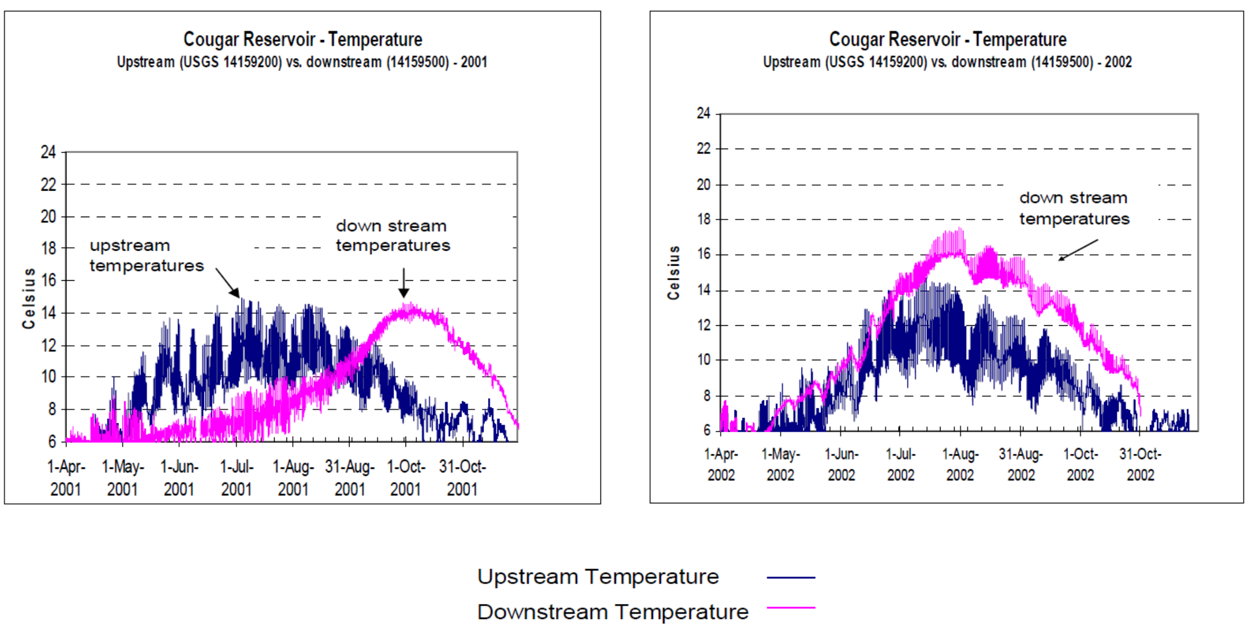

Figure 38: River temperatures upstream and downstream of the Cougar dam for 2001 (left), during which the dam was operated as normal, and 2002 (right), during which no water was stored behind the dam. Reproduced from ODEQ, 2006.

This trend may not extend into the fall, however, as the reservoirs often store heat in the summer months, and releasing this flow and stored heat can increase temperatures downstream (ODEQ, 2006). This trend can be observed on the North and South Santiam Rivers directly downstream of the Big Cliff and Foster dams at USGS gages 14181500 and 14187200, respectively (***Figure 39***). The plots show trends in data collected after the Big Cliff and Foster dams were completed in 1953 and 1968, respectively. USGS water temperature data are not available before the implementation of the dams. The plots in ***Figure 39*** show that the summer temperatures released are quite low, generally less than 12 °C, and the reservoirs release relatively warmer water in the fall, especially at Big Cliff and Detroit dams on the North Santiam. It should also be noted that the shapes of these curves are very similar to the trend for temperature downstream of the Cougar Reservoir in 2001 (shown above in ***Figure 38***).

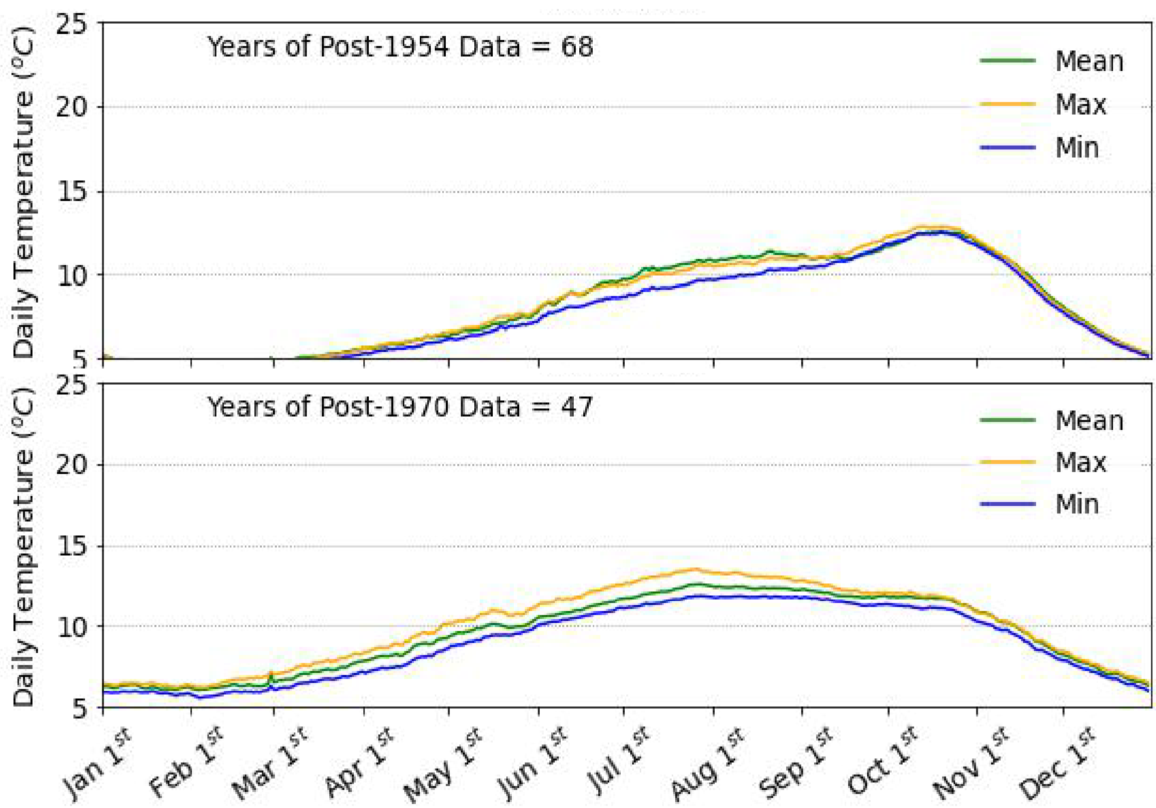

Figure 39. Seasonal temperature trends on the North (top) and South (bottom) Santiam Rivers

In addition to impacts on seasonal water temperature trends, studies have shown that the WVP dams directly affect water temperature variability on multi-day and weekly timescales. In particular, a wavelet analysis performed by National Ocean and Atmosphere Administration (NOAA) Fisheries found the large multi-purpose dams in the Willamette Basin reduce variability in water temperature regimes at small temporal scales such as 2-, 4-, and 8-day scales (Steel and Lange, 2007). This reduction in variability can also be observed in the difference between the short-term temperature swings upstream and downstream of Cougar Reservoir, even in years when the dam is not operational (***Figure 38***). Reduction in variability at these time scales represents a potential threat to the diversity and productivity of macroinvertebrate and fish communities which are adapted to those natural patterns. The lack of mitigation strategies geared directly toward this issue poses as risk to aquatic ecosystems, although this is unlikely to directly impact water quality for human use.

4.2.2.3. Other Water Quality Parameters

In general, the WVP reservoirs may be well-positioned to alleviate water quality concerns by allowing particulate-born contaminants to settle out and remain trapped in sediment behind the dams, or by releasing flows to dilute concentrations of pollutants downstream. However, it should be noted that some largely particulate-bound pollutants that also have a dissolved phase, such as phosphorus, may re-enter the water column and exacerbate other issues that could affect downstream water quality like algal blooms. As discussed in Sections 3.3. and 3.5.2., reservoirs may also be expected to influence water quality trends for mercury and algae.

Regarding mercury, Section 3.3. mentioned the observation that reservoirs in general have been known to affect mercury levels, specifically the ratio of MeHg to THg, within waterbodies. Examples of reservoir processes that can affect mercury are the trapping of ionic mercury associated with sediment, solubilizing particulate mercury under hypoxic conditions, and ionic mercury being converted to MeHg as a byproduct of bacterial activity. Factors that can affect these processes include fluctuations in water level, influent and legacy THg, the balance between settling losses and regeneration of sediment, and algal blooms which can induce hypoxic conditions. However, recent analysis of existing data shows that the ratio of methylmercury to total mercury does not significantly vary with respect to space within the Willamette Basin (Tetra Tech, 2019). This indicates that reservoirs within the basin, including the WVP reservoirs in the Tier 2 region, likely do not have a significant impact on the ratio of MeHg to THg (Tetra Tech, 2019). Therefore, additional analysis was not performed to address the influence of the WVP reservoirs with respect to mercury.

Algal blooms, on the other hand, are of high concern in some areas of the Tier 2 region, as discussed in Section 3.5.2. Reservoirs, with slow moving water that can heat and stratify more easily, are especially susceptible to cyanoHABs. In the Willamette Basin, cyanoHABs have occurred in tributary reservoirs such as Detroit Lake (North Santiam River) where cyanotoxins may be transported downstream to the Willamette River mainstem. In 2018, these concerns manifested in a drinking water advisory issued in the city of Salem due to cyanotoxins originating in Detroit Lake. Therefore, algal blooms may pose a risk to drinking water at the WIF Commission Intake due to the WVP reservoirs and the Newberg pool. In particular, the water quality monitoring in the Detroit Lake by the City of Salem should be of interest to the WIF Commission to track potential algal bloom events.

4.2.3. Landslides and Erosion

Landslides and soils vulnerable to erosion can pose a threat to water quality through the transport of excess sediment and pollutants associated with sediments.

The Willamette River Basin is conducive to landslides with its plentiful rainfall and experiences cycles during the winter and spring which are associated with landslide inception such as intense rainfall, freeze-thaw cycles, and rapid snowmelt. Where these factors combine with steep slopes, there is a higher likelihood of landslides. ***Figure 40*** shows a variety of indicators of landslide hazard in the Willamette River Basin (Statewide Landslide Information Database for Oregon [SLIDO], 2021). Deposits and historic landslide points indicate where landslides have occurred in the past, which could indicate where conditions exist that might produce landslides in the future. Note that most of these locations occur within the upper reaches of the watershed, outside of the extents of the Willamette Valley (see "Willamette Watershed History, Characterization, and Stakeholders" Memo, Figure 2). With a few exceptions of areas just south of Salem and around Eugene, the presence of scarps and scarp flanks (very steep slopes and undisturbed material around the slope, respectively), is limited to areas in the upper reaches of the Willamette River Basin or downstream of the WIF Commission Intake.

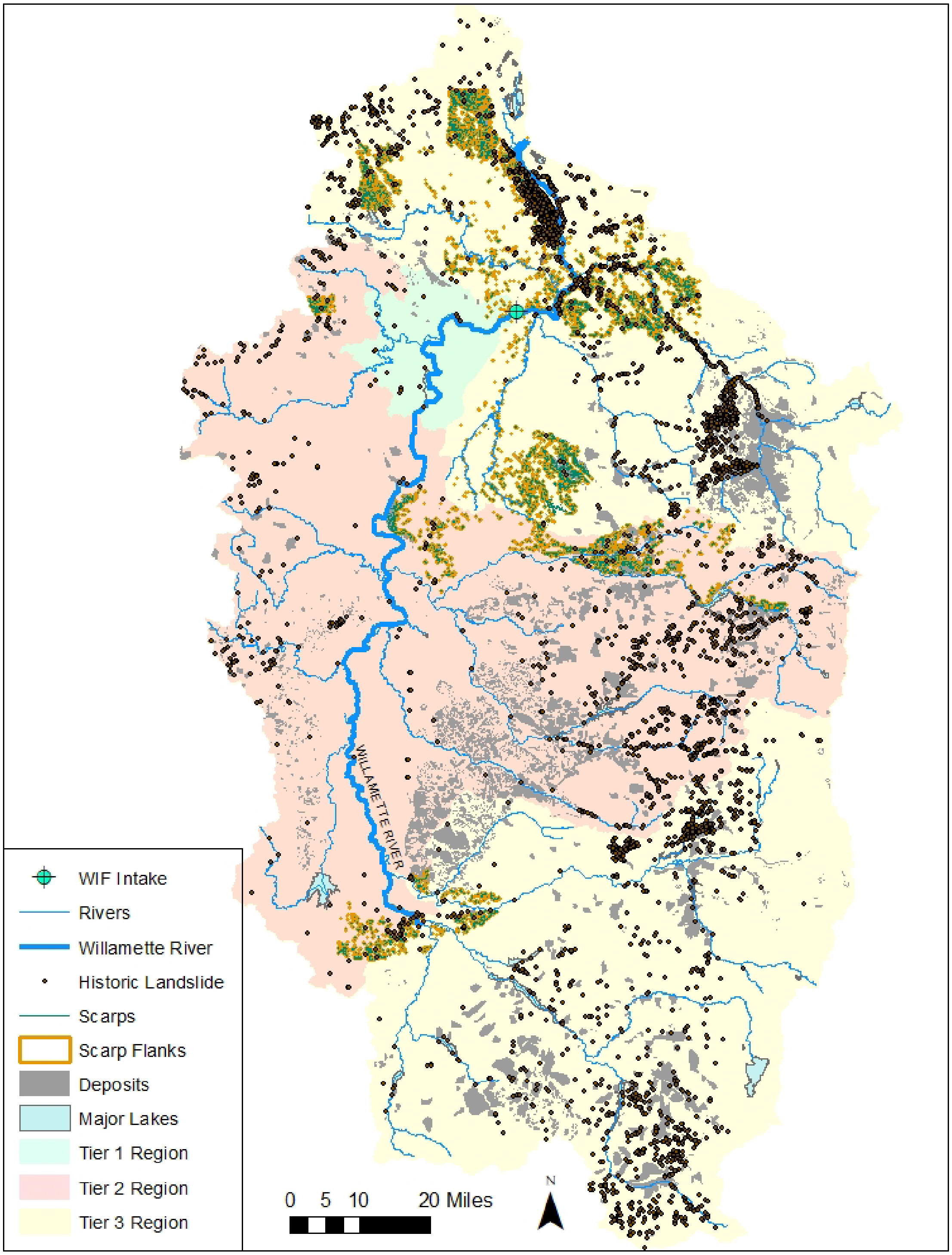

Figure 40. Landslide hazards within the Willamette River Basin

Within the Tier 1 area, there is limited landslide hazard indication, though there are some localized areas of landslide deposits and historic landslides as well as scarps immediately upstream of the intake (***Figure 41***).

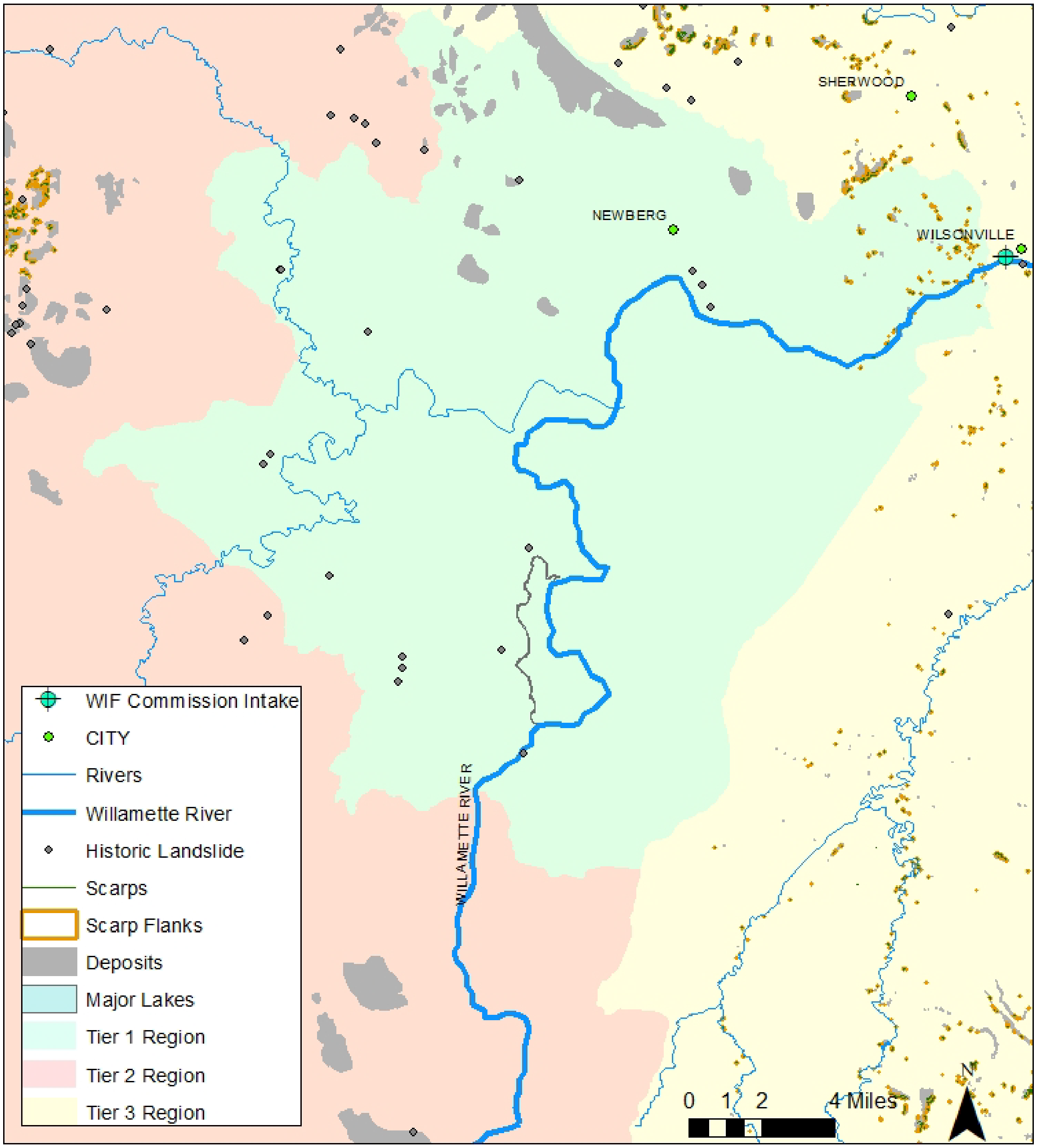

Figure 41. Landslide hazards within the Tier 1 Region

Because most landslide activity takes place in the upper reaches of the Willamette River watershed, along tributaries to the Willamette River mainstem, or downstream of the WIF Commission Intake, the risks to water quality at the WIF Commission Intake associated with excess sediment due to landslides are limited. Additionally, the presence of the WVP reservoirs downstream of areas with elevated landslide activity may help to mitigate the effects of these landslides due to sedimentation.

Soil susceptibility to erosion is influenced by many factors including soil type and erodibility, slope, the length of the slope, vegetative cover and erosion control practices, and rainfall intensity. ***Figure 42*** maps soil erodibility factors, known as "K-values" within the Tier 1 region. K-values are depicted based on a scale from cool (low K-values) to warm (high K-values) colors. The higher the K-value, the more susceptible the soil is to erosion; K-values of 0.35 to 0.4 and higher are considered highly erodible soils. ***Figure 42*** shows that large portions of the Tier 1 area consist of highly erodible soils, especially along the Willamette River mainstem. Therefore, other factors contributing to soil erosion, such as vegetative or other cover, will become important factors in mitigating sediment in runoff.

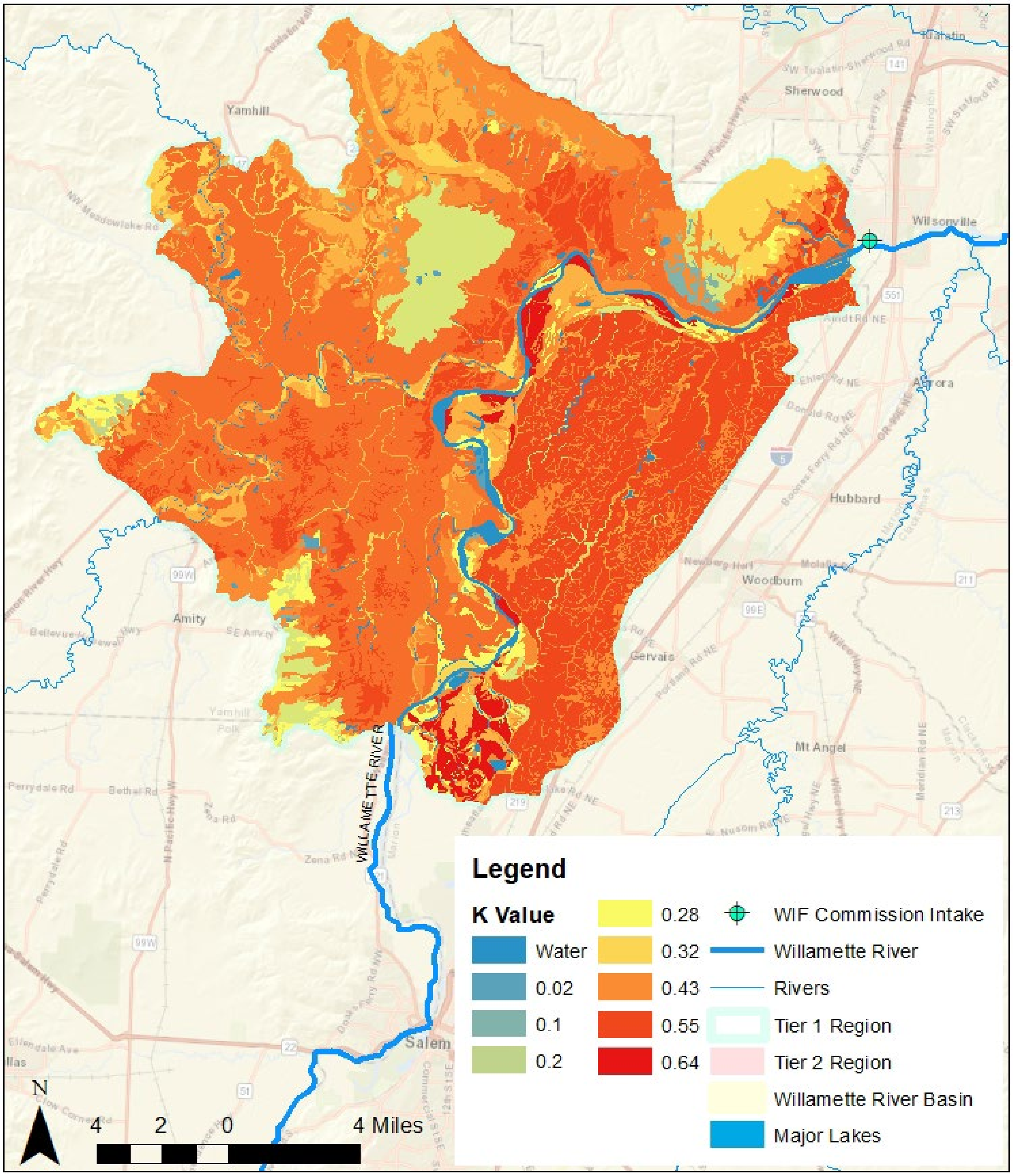

Figure 42. Soil erodibility (K-Value) of sediments within Tier 1 region

4.3. Tier 3

There are several Willamette-Basin-wide trends that instill concern amongst basin stakeholders regarding the long-term water quantity (risks to availability) and quality goals into the future. The first and foremost of these concerns tends to be climate change. There is a concern amongst many that warming conditions, whether they bring more or less precipitation, have the potential to put seasonal flow regimes in jeopardy and worsen water quality. Other concerns in the basin include the projected impacts of population growth, stemming from experience with the rapid increase in population over the last 100 years which led to degradation of water quality for native fish and recreation (as discussed in the "Willamette Watershed History, Characterization, and Stakeholders" Memo). These concerns are addressed in the following sub-sections.

4.3.1. Expected Impacts of Climate Change

As a result of climate change, air temperatures are expected to increase substantially over the 21st century in the Columbia River Basin, which includes the Willamette River Basin. A recent assessment predicted an increase of 3.0 °C above 1970-1999 average conditions under the Representative Concentration Pathway (RCP) 4.5 scenario, or 5.5 °C under the RCP8.5 scenario[2] (Rupp et. al, 2017). This increase in air temperature will have widespread impacts on the Willamette River Basin, as outlined in the following sections.

4.3.1.1. Streamflow

On an annual basis, overall precipitation in the Willamette River Basin is not expected to change significantly (Mote and Salathe, 2010). However, due to increased air temperatures, more precipitation is expected to fall as rain, resulting in less accumulation of snowpack and earlier snowmelt (e.g., Tullos et. al, 2020). Because the Willamette Basin is a highly managed system, there is potential for the reservoirs to be managed to mitigate the resulting reduced summer streamflow due to climate change. Tullos et. al (2020) found that climate change would reduce the ability to fill the reservoirs (increased storage deficit), and that there may be somewhat reduced ability to meet spring target flows set by the Willamette River Biological Opinion (BiOp), However, Tullos et. al (2020) found that summer BiOp target flows were unlikely to be impacted, and that beginning the refilling of the reservoirs earlier could ensure the reservoirs refilled under severe climate change scenarios. Overall, the authors found that operational objectives (storage, flood control, and target streamflow) of the WVP will not be dramatically compromised by climate change.

4.3.1.2. Water Temperature

In general, increases in air temperature have a direct impact on water temperature. Isaak et. al (2012) conducted a study of streams in the Pacific Northwest based on measured data from 1980-2009 and found strong correlations between air and water temperature. Isaak et. al (2012) found

[2] RCPs are emissions scenarios defined by the Intergovernmental Panel on Climate Change (IPCC). RCP4.5 is an intermediate scenario representing a decline in emissions beginning in 2045 and reaching half of 2050 levels by 2100. RCP8.5 is often taken to be a worst-case climate scenario, representing continued increase in emissions (IPCC, 2014)

that a 1 °C increase in air temperature tended to be associated with a 0.4-0.8 °C increase in water temperature. The authors did not explore the mechanistic reasons why the increase in water temperature is larger in some locations than others, but note that air temperature impacts multiple aspects of the heat budget of a river (e.g., direct heat transfer, increasing groundwater temperatures, etc.). Depending on local factors such as shading, channel slope, etc., the impacts of air temperature would have differing impacts on water temperature. However, even the low end of the range of impacts on water temperature would mean a significant increase in Willamette River water temperatures would be expected due to the increased air temperatures. Chang et. al (2018) found that the increase in Willamette River water temperature could be as high as 4 °C on average under an extreme climate scenario. As with streamflow, there is potential for the reservoirs to be managed to mitigate the impacts of climate change on water temperature in the Willamette River, at least to some extent, by releasing cooler water from the bottom of the reservoirs during key periods (see Section 4.2.2). However, because of the long travel times from the reservoirs to the Newberg Pool and WIF Commission Intake, the mitigating effect of cold-water releases would be muted, and the impact of air temperature increases due to climate change on Willamette River water temperatures will remain a concern even if summer flows do not decrease.

4.3.1.3. Algal Blooms

Climate change is anticipated to exacerbate the prevalence of algal blooms in reservoirs, including the reservoirs in the Willamette River Basin, which are already experiencing blooms as discussed in Section 3.5.2. Cyanobacteria grow more quickly in warmer water, which can lead to more cyanotoxins releases. Additionally, warmer air temperatures can result in stronger stratification of reservoirs, which limits mixing and encourages algae growth (USEPA, 2022). While harmful algal blooms have been noted primarily in WVP reservoirs to date, it is possible that blooms could form in the Newberg pool in the future. Though ozonation and granular activated carbon treatments used by the Willamette River Water Treatment Plant and future Willamette Water Supply System (WWSS) plant are effective at removing cyanotoxins (USEPA, 2021), climate change may result in algal blooms becoming a greater concern for public perception of drinking water quality and could increase the costs of water treatment.

4.3.2. Expected Impacts of Population Growth

The Willamette Water 2100 project assessed that between 2010 and 2100, the population of the Willamette Basin is expected to grow by over 3 million people (Jaeger et. al, 2017). Substantial increase in developed land is expected, particularly in the Portland metropolitan area. Water demand is expected to increase for cities (dependent on factors such as income growth, density development, and water price in addition to population) and remain relatively constant for agriculture (Jaeger et. al, 2017). Urban consumptive use of water in the Willamette Basin is small relative to agricultural use. Therefore, population growth is not expected to result in a dramatic reduction in water availability by 2100. The water quality impacts of population growth may include an increase in the number of urban PCS risks and potentially a reduction in PCS risks associated with non-developed land uses.

5. SUMMARY

The analyses presented in this Memo include summaries of flow and water quality data, as well as geospatial assessment of risks to surface water. The scope of these analyses and the subsequent discussions were driven by the boundaries of three regions referred to herein as Tier 1, Tier 2, and Tier 3.

The Tier 1 region extends approximately 35 river miles upstream of the Intake on the Willamette and Yamhill Rivers and includes the urban areas of Newberg, McMinnville, and Yamhill. The boundaries of this region were determined by estimating the distance associated with an 8-hour travel time during high flows along the Willamette River upstream of the WIF Commission Intake. In this region, existing flow data as well as data for several water quality parameters including bacteria, phosphorus, dissolved oxygen, pH, metals, and pesticides were evaluated. These investigations indicated that the Yamhill River contributes approximately $1/10^{th}$ of the total flow at the intake, and that water quality in the Yamhill River may occasionally be impaired for bacteria, pH, dissolved oxygen, phosphorus, several metals including copper and iron, and the pesticides diuron and pentachlorophenol. Most of these concerns occur during the spring season. Conclusions regarding temperature will be included in the final draft of this Memo assuming the data available at the stations listed in Appendix A are sufficient to support further analysis.

The risk analysis in the Tier 1 region evaluated the PCSs that may present a direct risk to water quality at the intake due to the ODEQ surface water risk rankings and the travel time from the PCS location to the intake. The risk analysis found that the PCSs with the highest risk scores were predominantly located immediately upstream of the Intake along the Willamette River mainstem and near Newberg. The PCSs themselves that were identified as high-risk, of which there are over 390, are listed in Appendix B.

The Tier 2 region extends from the upstream boundary of the Tier 1 region to the headwaters of the Willamette River mainstem below the confluence of the Coast Fork and Middle Fork Willamette Rivers. The Tier 2 region also includes the North and South Santiam River subbasins. The data summaries for Tier 2 focused on flow and temperature, with some consideration of other water quality concerns including bacteria, mercury, and algal blooms. Due to the WVP dams located within and directly upstream of the Tier 2 region, special attention was paid to the influence of these dam operations on river flow, temperature, and several other water quality parameters. The data analyses conducted in the Tier 2 region found that the Detroit and Big Cliff Dams on the North Santiam River affect seasonal flow trends by dampening winter high flows and boosting late summer and fall low flows. Additionally, the dams act to cool summer water temperatures, but may result in warmer temperatures in the fall. Finally, the dams may impact levels of contaminants by trapping sediment-bound pollutants, however they also create conditions for harmful algal blooms which have, in the past, degraded source water quality for drinking water at Salem.

The risk analysis for Tier 2 also consisted of inventories of PCSs in the population centers of Salem, Albany, and Eugene. Overall, similar numbers of PCSs were identified in the cities of Salem and Eugene, with fewer in Albany. The composition of the types of PCSs found in these cities vary. For example, Salem contains a higher proportion of leaking underground storage tanks (23.4%) compared to other population centers (< 14%). Additionally of note, the population centers in the Tier 2 region contain a lower proportion of PCS features that are water quality permits (< 8.5%) compared to Tier 1 population centers (> 13%). Also, the population centers in the Tier 2 region contain a higher proportion of PCS features that are major route crossings and bridges (> 7.5%) compared to Tier 1 population centers (< 2.1%), but similar proportions to the Tier 1 region as a whole (9.1%). Ultimately, the Tier 2 risk analysis characterized the risks to surface water from major cities along the Willamette and the WVP dams on major tributaries.

Finally, the Tier 3 region consists of the remainder of the watershed. This region includes areas downstream of the intake and the upstream-most major tributaries to the Willamette. Explorations of issues that affect these areas include the impacts of climate change and other long-term trends occurring in the basin. Risk analysis on this scale concluded that climate change, while likely to increase the percentage of precipitation that falls as rain in the basin and thus reduce snowpack and spring runoff, may not detrimentally impact winter high flows or summer low flows if operation of the WVP Dams can be adapted to meet this challenge. However, warming trends in summer air and river temperatures should be monitored. Risk analysis for Tier 3 also concluded that population growth is not expected to adversely affect water availability in the basin, although risks to water quality may increase as additional potential contaminant sources are established to support development.

In closing, the analyses provided in this Memo are intended to equip the Tualatin Valley Water District and its partners with the information needed to protect water quality at the WIF Commission Intake by prioritizing partnerships in key areas where risks may be high. This Memo will be followed by additional phases of the Source Water Protection Plan development during which exploratory and targeted stakeholder engagement will be pursued with these goals in mind.

6. RECOMMENDATIONS

The findings presented in this Memo leave several areas that would benefit from future consideration. These include parts of the analysis that may be expanded upon in greater detail to reveal new insights, as well as recommendations for potential partnerships and programs that may help the WIF Commission target high-priority pollutants and risks. These recommendations are mentioned throughout this Memo and are summarized below.

- Work with partners to conduct additional monitoring and sampling. These may include:
    - Engagement with USACE and USGS to continue anticipating trends in flow and water temperature based on climate conditions, reservoir operations, and other factors.

  - Engagement with USACE and USGS and other water providers to monitor additional reservoirs as needed for algal blooms.
  - Working with ODEQ and other partners to conduct additional metals and pesticide sampling, primarily in the Tier 1 region, with a focus on Newberg Pool.
- Refine relative toxicity of PCS features to further prioritize list of 395 high-risk PCSs. This effort may include:
  - Pairing PCS features and categories with national databases to better characterize likely COCs associated with PCS features and evaluate the relative toxicity of each COC relative to human health standards.
  - Estimation or inventory of COC quantities associated with each PCS feature, which could allow the peak concentration of the contaminant plume at the intake to be calculated.

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APPENDIX A

Existing Water Quality Data for Contaminants of Concern in the Tier 1 (Highlighted) and Tier 2 Regions Collected Over the Previous 30 Years

Agency	ID	Site Name	Water Temperature Records	Bacteria Records	Metals Records	Nutrient Records	Pesticide Records	Biological Indicators Records	Solids Records
ODEQ	11142	Long Tom River downstream of Fern Ridge Reservoir	4	4	N/A	N/A	N/A	N/A	N/A
USGS	14168000	Fern Ridge Lake	1,988	N/A	N/A	N/A	N/A	N/A	N/A
USGS	14170000	Long Tom River at Monroe, OR	4,895	N/A	N/A	N/A	N/A	N/A	N/A
USGS	14186200	Middle Santiam River below Green Peter Dam	17,778	N/A	N/A	N/A	N/A	N/A	N/A
ODEQ	28616	Middle Santiam below Green Peter Reservoir	2871	N/A	N/A	N/A	N/A	N/A	N/A
ODEQ	23805	Middle Santiam River upstream of Green Peter Reservoir	8968	N/A	N/A	N/A	N/A	DO – 1	N/A
USGS	14178000	North Santiam River near Detroit, OR	32,181	N/A	N/A	N/A	N/A	pH – 7486	N/A
ODEQ, SECOR	26751	North Santiam River at Detroit Lake Tailrace	5137	N/A	N/A	N/A	N/A	N/A	N/A
ODEQ	23788	South Santiam River downstream of Foster Dam	3991	7	N/A	N/A	N/A	N/A	N/A
ODEQ	23803	South Santiam River upstream of Foster Dam	4837	N/A	N/A	N/A	N/A	N/A	N/A
ODEQ	28615	South Santiam River above Foster Reservoir	999	N/A	N/A	N/A	N/A	N/A	N/A
ODEQ, SECOR	26756	Santiam River near Mouth	6247	N/A	N/A	N/A	N/A	N/A	N/A
ODEQ	10340	Willamette River at I5 Wilsonville	5,563	N/A	N/A	N/A	N/A	N/A	N/A
ODEQ	25990	Willamette River near Wilsonville	4	4	N/A	N/A	N/A	DO – 4 pH – 4 Chlorophyll a – 3	N/A
ODEQ	10342	Willamette River near Newberg	134	79	Aluminum – 111 Arsenic – 2 Barium – 3 Cadmium – 3 Chromium – 3 Copper – 3 Iron – 111 Lead – 2 Manganese – 111 Nickel – 3 Silver – 3 Zinc – 3	Total phosphorus – 132	N/A	DO – 134 pH – 132 Chlorophyll a - 61	N/A
ODEQ	26339	Willamette River at Rogers Landing	17	N/A	N/A	N/A	N/A	DO – 17 pH - 19	N/A
USGS	14197900	Willamette River at Newberg	23,653	N/A	N/A	N/A	N/A	N/A	N/A
ODEQ	10344	Willamette River at Wheatland Ferry	8,523	95	Aluminum – 68 Arsenic – 37 Barium – 28 Cadmium – 38 Chromium – 37 Cobalt – 12 Copper – 35 Iron – 75 Lead – 36 Manganese – 67 Nickel – 38 Silver – 38 Zinc – 38	Nitrate/nitrite – 156 Total Phosphorus – 156	Atrazine – 16 Dieldrin – 17 Diuron – 11 Pentachlorophenol – 14 Simazine – 16	Alkalinity – 168 BOD – 144 Chlorophyll a – 176 DO – 171	TSS – 166 Turbidity - 164
ODEQ	28255	Willamette River above WLTP Outfall	7,823	N/A	N/A	N/A	N/A	N/A	N/A
USGS	14192015	Willamette River at Keiser	26,393	N/A	N/A	N/A	N/A	N/A	N/A

Agency	ID	Site Name	Water Temperature Records	Bacteria Records	Metals Records	Nutrient Records	Pesticide Records	Biological Indicators Records	Solids Records
ODEQ	10555	Willamette River at Salem	293	160	Aluminum – 109 Arsenic – 46 Barium – 34 Cadmium – 46 Chromium – 43 Copper – 44 Iron – 109 Lead – 44 Manganese – 109 Nickel – 45 Silver – 46 Zinc – 46	Total phosphorus – 288	Atrazine – 13 Dieldrin – 11 Diuron – 8 Pentachlorophenol – 8 Simazine – 13	DO - 291 pH – 301 Chlorophyll a - 131	N/A
ODEQ	25988	Willamette River at Salem	4	4	N/A	N/A	N/A	DO – 4 pH – 4 Chlorophyll a – 3	N/A
ODEQ	28254	Willamette River above Rickreall Creek	7,150	N/A	N/A	N/A	N/A	N/A	N/A
ODEQ	10348	Willamette River at Buena Vista Ferry	5,668	N/A	N/A	N/A	N/A	N/A	N/A
USGS	14174000	Willamette River at Albany	27,717	N/A	N/A	N/A	N/A	N/A	N/A
USGS	14166000	Willamette River at Harrisburg	29,210	N/A	N/A	N/A	N/A	N/A	N/A
ODEQ	10929	North Yamhill River at Poverty Bend	207	122	Arsenic – 24 Barium – 12 Cadmium – 24 Chromium – 23 Copper – 22 Iron – 94 Lead – 23 Manganese – 94 Nickel – 24 Silver – 24 Zinc – 24	Total phosphorus – 205 Nitrate/nitrite - 207	N/A	DO – 208 pH – 219	TSS – 205
ODEQ	10948	South Yamhill River at 99W McMinnville	2720	119	Aluminum - 102 Arsenic – 23 Barium – 11 Cadmium – 23 Chromium – 22 Copper – 23 Iron – 102 Lead – 22 Manganese – 125 Nickel – 23 Silver – 23 Zinc – 23	Total phosphorus – 212	N/A	DO – 213 pH – 230 Chlorophyll a – 103	N/A

Agency	ID	Site Name	Water Temperature Records	Bacteria Records	Metals Records	Nutrient Records	Pesticide Records	Biological Indicators Records	Solids Records
ODEQ, SECOR	10363	Yamhill River at Dayton	6231	124	Manganese- 98 Copper – 42 Lead – 42 Arsenic – 43 Cadmium – 43 Barium – 31 Iron – 98 Chromium - 41	Nitrate/nitrite - 220 Total Phosphorus – 219	Dieldrin – 17 Diuron – 11 Atrazine – 16 Simazine – 16 Pentachlorophenol - 8	pH – 249	TSS –231

APPENDIX B

High-Risk Potential Contaminant Sources in the Tier 1 Region
Sorted by County, City, then Name of Site

Site ID	Name	County	City	Date	Latitude	Longitude	Category	Travel Time Sub-Score	Surface Risk Sub-Score	Total Score
1000212	MAYFIELD FARM LLC	CLACKAMAS	AURORA	8/14/2018	45.275556	-122.814167	Confined Animal Feeding Operations	4	3	7
186675	MAYFIELD FARM LLC	CLACKAMAS	AURORA	8/14/2018	45.275556	-122.814167	Confined Animal Feeding Operations	4	3	7
1000051	MAYFIELD FARM LLC	CLACKAMAS	AURORA	8/14/2018	45.275556	-122.814167	Confined Animal Feeding Operations	4	3	7
124572	NEW BUILDING FOR MCCARTHY MANUFACTURING	CLACKAMAS	N/A	10/31/2018	45.3102	-122.8475	Water Quality Permits	4	3	7
ORQ000014241	ODOC Coffee Creek Correctional Facility	CLACKAMAS	N/A	10/31/2018	45.3112	-122.8025	Hazardous Material Generators	4	3	7
112011	PACIFIC COMPOSTING FACILITY	CLACKAMAS	N/A	10/31/2018	45.2785	-122.8162	Solid Waste Sites	4	3	7
ORD987188521	T W D INC	CLACKAMAS	N/A	10/31/2018	45.2895	-122.8086	Hazardous Material Generators	4	3	7
OR0000031815	TROJAN ENTERPRISES INC	CLACKAMAS	N/A	10/31/2018	45.2899	-122.8051	Hazardous Material Generators	4	3	7
6096	Corral Creek, Grahams Ferry Rd	Clackamas	UNKNOWN	2013	45.29445	-122.814181	Major Route Stream Crossings and Bridges	4	3	7
6093	Corral Creek, Ladd Hill Rd	Clackamas	UNKNOWN	2013	45.301289	-122.846719	Major Route Stream Crossings and Bridges	4	3	7
6015	Corral Creek, Wilsonville Rd	Clackamas	UNKNOWN	2013	45.293181	-122.804489	Major Route Stream Crossings and Bridges	4	3	7
22655	FAIRDALE NURSERY	CLACKAMAS	WILSONVILLE	7/5/2019	45.2842	-122.8136	Aboveground Storage Tanks	4	3	7
22655	FAIRDALE NURSERY	CLACKAMAS	WILSONVILLE	7/5/2019	45.2842	-122.8136	Hazardous Substance Information System	4	3	7
123757	GRANDE POINTE AT VILLEBOIS	CLACKAMAS	Wilsonville	10/31/2018	45.3066	-122.8025	Water Quality Permits	4	3	7
120231	POLLYGON AT VILLEBOIS	CLACKAMAS	Wilsonville	10/31/2018	45.31	-122.7913	Water Quality Permits	4	3	7
62754	WIL-VIEW FARMS	CLACKAMAS	WILSONVILLE	8/14/2018	45.279722	-122.833889	Confined Animal Feeding Operations	4	3	7
24-0036	Butteville	Marion	Aurora	1/11/2018	45.250252	-122.855698	Mining Permits	4	3	7
96010	CENTURY MEADOWS SANITARY SYSTEM (CMSS)	MARION	AURORA	2009	45.262706	-122.843847	Effluent Outfalls	4	3	7
182160	E & M FARMS LLC	MARION	AURORA	8/14/2018	45.229639	-122.859083	Confined Animal Feeding Operations	4	3	7
1000135	FRAGRANT FARMS LLC	MARION	AURORA	8/14/2018	45.229639	-122.859083	Confined Animal Feeding Operations	4	3	7
122785	LOEN NURSERY INC	MARION	AURORA	7/5/2019	45.2687	-122.8116	Aboveground Storage Tanks	4	2	6
122785	LOEN NURSERY INC	MARION	AURORA	7/5/2019	45.2687	-122.8116	Hazardous Substance Information System	4	2	6
95388	MARION AG SERVICE INC	MARION	AURORA	7/5/2019	45.1909	-122.868	Aboveground Storage Tanks	4	2	6
95388	MARION AG SERVICE INC	MARION	AURORA	7/5/2019	45.1909	-122.868	Hazardous Substance Information System	4	2	6
95388	MARION AG SERVICE INC	MARION	AURORA	7/5/2019	45.1909	-122.868	Hazardous Substance Information System	4	2	6
63167	MILKY WAY DAIRY INC	MARION	AURORA	8/14/2018	45.202444	-122.879944	Confined Animal Feeding Operations	4	3	7
11070	NORTHWEST FLORICULTURE INC	MARION	AURORA	7/5/2019	45.2538	-122.848	Aboveground Storage Tanks	4	3	7
11070	NORTHWEST FLORICULTURE INC	MARION	AURORA	7/5/2019	45.2538	-122.848	Hazardous Substance Information System	4	3	7
183924	ROCK RIDGE FARMS LLC	MARION	AURORA	8/14/2018	45.260861	-122.828889	Confined Animal Feeding Operations	4	3	7
122564	Wilco Farmers	MARION	AURORA	7/5/2019	45.2261	-122.8409	Hazardous Substance Information System	4	2	6
100077	BROOKS SEWAGE TREATMENT PLANT	MARION	BROOKS	2009	45.093778	-123.041042	Effluent Outfalls	3	3	6
2339	GK MACHINE INC	MARION	DONALD	7/5/2019	45.2233	-122.8439	Aboveground Storage Tanks	4	3	7
2339	GK MACHINE INC	MARION	DONALD	7/5/2019	45.2233	-122.8439	Hazardous Substance Information System	4	3	7
2339	GK MACHINE INC	MARION	DONALD	7/5/2019	45.2233	-122.8439	Hazardous Substance Information System	4	3	7
63228	TWIN L FARM	MARION	GERVAIS	8/14/2018	45.1025	-122.976667	Confined Animal Feeding Operations	3	3	6
711	VIESKO REDI MIX	MARION	GERVAIS	7/5/2019	45.0953	-123.0318	Aboveground Storage Tanks	3	3	6
711	VIESKO REDI MIX	MARION	GERVAIS	7/5/2019	45.0953	-123.0318	Hazardous Substance Information System	3	3	6
ORQ000037611	LOWES OF KEIZER OR NO 2619	Marion	Keizer	10/31/2018	45.2245	-122.9986	Hazardous Material Generators	4	3	7
63169	MOISAN DAIRY	MARION	KEIZER	8/14/2018	45.048667	-123.014361	Confined Animal Feeding Operations	3	3	6
122187	PGE	MARION	KEIZER	7/5/2019	45.0746	-122.9725	Hazardous Substance Information System	3	3	6
24-0030	Viesko Pit	Marion	Keizer	1/11/2018	45.095676	-123.032036	Mining Permits	3	3	6

Site ID	Name	County	City	Date	Latitude	Longitude	Category	Travel Time Sub-Score	Surface Risk Sub-Score	Total Score
105034		MARION	N/A	10/31/2018	45.0492	-122.986	Solid Waste Sites	3	3	6
ORQ000031480		MARION	N/A	10/31/2018	45.0492	-122.986	Hazardous Material Generators	3	3	6
112115	AGRI-PLAS, INC.	MARION	N/A	10/31/2018	45.0734	-122.9569	Solid Waste Sites	3	3	6
112115	AGRI-PLAS, INC.	MARION	N/A	10/31/2018	45.0734	-122.9569	Solid Waste Sites	3	3	6
105813	BELL FARMS, INC.	MARION	N/A	10/31/2018	45.075	-122.9922	Water Quality Permits	3	3	6
101721	CENTURY MEADOWS SANITARY SYSTEM, INC.	MARION	N/A	11/1/2018	45.2656	-122.8253	Domestic Wastewater Treatment Sites	4	3	7
124580	DONALD INDUSTRIAL PARK	MARION	N/A	10/31/2018	45.2263	-122.8386	Water Quality Permits	4	3	7
24600	DONALD, CITY OF	MARION	N/A	10/31/2018	45.226	-122.8497	Water Quality Permits	4	3	7
ORQ000025684	ELDRIEDGE ELEMENTARY SCHOOL	MARION	N/A	10/31/2018	45.0691	-122.9798	Hazardous Material Generators	3	3	6
4335	HEINREICH BULLET PROPERTY	MARION	N/A	10/31/2018	45.0737	-122.9525	Environmental Cleanup Sites	3	3	6
124558	MARION AG	MARION	N/A	10/31/2018	45.1913	-122.8678	Water Quality Permits	4	3	7
124558	MARION AG	MARION	N/A	10/31/2018	45.1913	-122.8678	Water Quality Permits	4	3	7
105664	MORSE BROS.,INC.	MARION	N/A	10/31/2018	45.0597	-123.0053	Water Quality Permits	3	3	6
ORD180737835	MORSE BROS.,INC.	MARION	N/A	10/31/2018	45.0597	-123.0053	Hazardous Material Generators	3	3	6
110311	OREGON PARKS & RECREATION DEPARTMENT	MARION	N/A	10/31/2018	45.2543	-122.8997	Water Quality Permits	4	2	6
859	PACIFIC CUSTOM PRODUCTS	MARION	N/A	10/31/2018	45.05	-122.9863	Environmental Cleanup Sites	3	3	6
119486	SAINT PAUL (PALISADE RANCH) MINING FACILITY	MARION	N/A	10/31/2018	45.1602	-123.02	Water Quality Permits	3	3	6
84076	ST. PAUL, CITY OF	MARION	N/A	10/31/2018	45.2056	-122.9902	Water Quality Permits	3	3	6
106350	VIESKO REDI-MIX, INC.	MARION	N/A	10/31/2018	45.0906	-123.034	Water Quality Permits	3	3	6
ORD091298760	WESTERN FARM SERVICES	MARION	N/A	10/31/2018	45.0492	-122.9875	Hazardous Material Generators	3	3	6
4030	WESTERN FARM SERVICES	MARION	N/A	10/31/2018	45.0492	-122.9875	Environmental Cleanup Sites	3	3	6
112465	ZORN FARMS, INC.	MARION	N/A	10/31/2018	45.2456	-122.8869	Water Quality Permits	4	3	7
138629	COLEMAN RANCH INC	MARION	SAINT PAUL	8/14/2018	45.155167	-122.96475	Confined Animal Feeding Operations	3	3	6
63138	HAZENBERG DAIRY	MARION	SAINT PAUL	8/14/2018	45.258083	-122.946972	Confined Animal Feeding Operations	4	3	7
63168	MISSION LANE FARMS INC	MARION	SAINT PAUL	8/14/2018	45.219972	-122.987194	Confined Animal Feeding Operations	4	3	7
56179	NORTHWEST ASPHALT SEALING	MARION	SAINT PAUL	7/5/2019	45.2543	-122.9415	Aboveground Storage Tanks	4	2	6
56179	NORTHWEST ASPHALT SEALING	MARION	SAINT PAUL	7/5/2019	45.2543	-122.9415	Hazardous Substance Information System	4	2	6
5984	OREGON PARKS & REC	MARION	SAINT PAUL	7/5/2019	45.2487	-122.8915	Aboveground Storage Tanks	4	2	6
5984	OREGON PARKS & REC	MARION	SAINT PAUL	7/5/2019	45.2487	-122.8915	Hazardous Substance Information System	4	2	6
63177	OTT DAIRY	MARION	SAINT PAUL	8/14/2018	45.211667	-122.990556	Confined Animal Feeding Operations	4	3	7
174681	RICHTER RANCH INC	MARION	SAINT PAUL	8/14/2018	45.214	-122.993889	Confined Animal Feeding Operations	4	3	7
63184	SAR BEN FARMS INC	MARION	SAINT PAUL	8/14/2018	45.252722	-122.943389	Confined Animal Feeding Operations	4	3	7
63195	VEEMAN DAIRY LLC	MARION	SAINT PAUL	8/14/2018	45.258056	-122.92775	Confined Animal Feeding Operations	4	3	7
ORQ000037496	AMAZON.COMDEDC LLC PDX7	Marion	Salem	10/31/2018	45.2245	-122.9641	Hazardous Material Generators	3	3	6
36895	EGAN GARDENS	MARION	SALEM	7/5/2019	45.0617	-122.9821	Aboveground Storage Tanks	3	3	6
36895	EGAN GARDENS	MARION	SALEM	7/5/2019	45.0617	-122.9821	Hazardous Substance Information System	3	3	6
17670	KNIFE RIVER	MARION	SALEM	7/5/2019	45.059152	-123.013778	Aboveground Storage Tanks	3	3	6
17670	KNIFE RIVER	MARION	SALEM	7/5/2019	45.059152	-123.013778	Hazardous Substance Information System	3	3	6
24-0019	Mahoney Bar	Marion	Salem	1/11/2018	45.146095	-123.030296	Mining Permits	3	3	6
59631	MARION RESOURCE RECVY FAC LLC	MARION	SALEM	7/5/2019	45.0489	-122.985	Aboveground Storage Tanks	3	3	6
59631	MARION RESOURCE RECVY FAC LLC	MARION	SALEM	7/5/2019	45.0489	-122.985	Hazardous Substance Information System	3	3	6

Site ID	Name	County	City	Date	Latitude	Longitude	Category	Travel Time Sub-Score	Surface Risk Sub-Score	Total Score
1000164	CHAMPOEG CREEK FARM LLC	MARION	ST PAUL	8/14/2018	45.237237	-122.88727	Confined Animal Feeding Operations	4	3	7
5730	EHCO 1 NORTH	MARION	St. Paul	10/31/2018	45.2116	-122.9765	Environmental Cleanup Sites	3	3	6
2281	Mission Creek, Hwy 140	Marion	ST. PAUL	2013	45.208769	-122.968569	Major Route Stream Crossings and Bridges	3	3	6
124801	ST. PAUL HIGH SCHOOL GYM	MARION	St. Paul	10/31/2018	45.2141	-122.9754	Water Quality Permits	3	3	6
24-0004	Reed Pit	Marion	Tangent	1/11/2018	45.06118	-123.005005	Mining Permits	3	3	6
01557A	Case Creek, Broadacres Rd	Marion	UNKNOWN	2013	45.191281	-122.889369	Major Route Stream Crossings and Bridges	3	3	6
1557	Case Creek, Hwy 140	Marion	UNKNOWN	2013	45.1633	-122.917	Major Route Stream Crossings and Bridges	3	3	6
47C04	Case Creek, St Paul Hwy	Marion	UNKNOWN	2013	45.200331	-122.885439	Major Route Stream Crossings and Bridges	4	3	7
05113A	Champoeg Creek, Champoeg Rd	Marion	UNKNOWN	2013	45.245719	-122.881131	Major Route Stream Crossings and Bridges	4	3	7
5492	Champoeg Creek, french Prairie Rd	Marion	UNKNOWN	2013	45.163039	-122.9475	Major Route Stream Crossings and Bridges	3	3	6
9963	Champoeg Creek, Park Rd (Park Br)	Marion	UNKNOWN	2013	45.250569	-122.880969	Major Route Stream Crossings and Bridges	4	3	7
47C05	Champoeg Creek, St Paul Hwy	Marion	UNKNOWN	2013	45.209369	-122.911289	Major Route Stream Crossings and Bridges	4	3	7
Champoeg State	Champoeg State Park	Marion	Unknown	Mar-16	45.254717	-122.883883	Boating Access Sites	4	3	7
7887	Culvert, Hwy 1 at MP 265.49	Marion	UNKNOWN	2013	45.076183	-122.956847	Major Route Stream Crossings and Bridges	3	3	6
47C35	E.fk.champoeg Creek, Lebrun Rd	Marion	UNKNOWN	2013	45.140139	-122.9401	Major Route Stream Crossings and Bridges	3	3	6
2284	East Champoeg Creek, Hwy 140	Marion	UNKNOWN	2013	45.165539	-122.932511	Major Route Stream Crossings and Bridges	3	3	6
47C30	Mission Creek, Buyserie Rd	Marion	UNKNOWN	2013	45.232511	-122.9547	Major Route Stream Crossings and Bridges	3	3	6
5109	Mission Creek, Champoeg Rd	Marion	UNKNOWN	2013	45.250639	-122.898819	Major Route Stream Crossings and Bridges	4	3	7
47C09	Overflow Channel, Matheny Rd NE	Marion	UNKNOWN	2013	45.09345	-123.012889	Major Route Stream Crossings and Bridges	3	3	6
47C10	Overflow Channel, Matheny Rd NE	Marion	UNKNOWN	2013	45.093381	-123.029311	Major Route Stream Crossings and Bridges	3	3	6
47C32	Overflow Channel, Matheny Rd NE	Marion	UNKNOWN	2013	45.089831	-123.039731	Major Route Stream Crossings and Bridges	3	3	6
47C42	Patterson Creek. Waconda Rd NE	Marion	UNKNOWN	2013	45.074111	-122.9797	Major Route Stream Crossings and Bridges	3	3	6
72P33	Ryan Creek, Champoeg Park Rd	Marion	UNKNOWN	2013	45.250325	-122.880833	Major Route Stream Crossings and Bridges	4	3	7
San Salvador Ac	San Salvador Access Boat Ramp	Marion	Unknown	Mar-16	45.22219	-123.02738	Boating Access Sites	4	3	7
19761	Slough, Park Rd	Marion	UNKNOWN	2013	45.089069	-123.045086	Major Route Stream Crossings and Bridges	3	3	6
07850A	Waconda Rd NE over Hwy 1	Marion	UNKNOWN	2013	45.073494	-122.959492	Major Route Stream Crossings and Bridges	3	3	6
2283	West Champoeg Creek, Hwy 140	Marion	UNKNOWN	2013	45.165531	-122.943611	Major Route Stream Crossings and Bridges	3	3	6
Willamette Miss	Willamette Mission State Park Boat Ramp	Marion	Unknown	Mar-16	45.09263	-123.04166	Boating Access Sites	3	3	6
Mission Lake	Willamette Mission State Park Mission Lake Boat Ramp	Marion	Unknown	Mar-16	45.07813	-123.05189	Boating Access Sites	3	3	6
8157	Willamette River Oflow, Hwy 140 at MP 23.66	Marion	UNKNOWN	2013	45.264689	-122.943011	Major Route Stream Crossings and Bridges	4	3	7
8158	Willamette River Oflow, Hwy 140 at MP 23.89	Marion	UNKNOWN	2013	45.26145	-122.942589	Major Route Stream Crossings and Bridges	4	3	7
24-0008	Palisades Ranch	Marion	Wilsonville	1/11/2018	45.159649	-123.018402	Mining Permits	3	3	6
ORQ000037603	BUILDING	Marion	Woodburn	10/31/2018	45.2245	-122.859	Hazardous Material Generators	4	3	7
63118	COELHO DAIRY	MARION	WOODBURN	8/14/2018	45.188889	-122.898333	Confined Animal Feeding Operations	3	3	6
138820	COLEMAN RANCH INC	MARION	WOODBURN	8/14/2018	45.137111	-122.960667	Confined Animal Feeding Operations	3	3	6
54254	J MAR RACING INC	MARION	WOODBURN	7/5/2019	45.15827	-122.907722	Hazardous Substance Information System	3	3	6
99589	J MAR RACING INC	MARION	WOODBURN	7/5/2019	45.157131	-122.904353	Hazardous Substance Information System	3	3	6
101722	DUNDEE, CITY OF	N/A	Dundee	11/1/2018	45.281	-123.0133	Domestic Wastewater Treatment Sites	4	3	7
ORQ000037527	BDE MANUFACTURING TECHNOLOGIES	Washington	Hillsboro	10/31/2018	45.2245	-122.9121	Hazardous Material Generators	4	3	7
ORQ000037545	LOWES OF HILLSBORO OR NO 1558	Washington	Hillsboro	10/31/2018	45.2245	-122.9566	Hazardous Material Generators	3	3	6
36-0001	Marge Bollinger	Yamhill		1/11/2018	45.2869	-122.91106	Mining Permits	4	2	6

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995252	New Owner	YAMHILL		8/14/2018	45.227667	-123.027861	Confined Animal Feeding Operations	3	3	6
36-0019	Renne Pit	Yamhill		1/11/2018	45.291862	-122.910861	Mining Permits	4	2	6
104387	DOMAINE DROUHIN OREGON	Yamhill	Ashland	10/31/2018	45.2649	-123.0632	Water Quality Permits	4	3	7
36-0056	Renne Quarry Newberg Rock Pit	Yamhill	Aurora	1/11/2018	45.291916	-122.910904	Mining Permits	4	3	7
36-0037	Coffee Island Bar	Yamhill	Beaverton	1/11/2018	45.185246	-123.02169	Mining Permits	4	3	7
36-0061	Harney	Yamhill	Beaverton	1/11/2018	45.110103	-123.024989	Mining Permits	3	3	6
36-0052	Hildebrandt Property - Grand Island	Yamhill	Beaverton	1/11/2018	45.117298	-123.001144	Mining Permits	3	3	6
36-0054	Youngblood Pit	Yamhill	Beaverton	1/11/2018	45.192013	-123.024872	Mining Permits	4	3	7
11079	C and D LANDSCAPE CO	YAMHILL	DAYTON	7/5/2019	45.2378	-123.0653	Hazardous Substance Information System	3	3	6
23856	CARLTON PLANTS LLC	YAMHILL	DAYTON	7/5/2019	45.1568	-123.0541	Aboveground Storage Tanks	3	3	6
23856	CARLTON PLANTS LLC	YAMHILL	DAYTON	7/5/2019	45.1568	-123.0541	Hazardous Substance Information System	3	3	6
66399	DOMAINE DROUHIN OREGON INC	YAMHILL	DAYTON	7/5/2019	45.2656	-123.0556	Aboveground Storage Tanks	4	2	6
66399	DOMAINE DROUHIN OREGON INC	YAMHILL	DAYTON	7/5/2019	45.2656	-123.0556	Hazardous Substance Information System	4	2	6
93301	ELITE BATH INC	YAMHILL	DAYTON	7/5/2019	45.2044	-123.0587	Hazardous Substance Information System	4	3	7
36-0058	Hester Property	Yamhill	Dayton	1/11/2018	45.179992	-123.023094	Mining Permits	3	3	6
172732	MARCON FARMS #1 OWENS FACILITY	YAMHILL	DAYTON	8/14/2018	45.227667	-123.027861	Confined Animal Feeding Operations	3	3	6
172731	MARCON FARMS #2	YAMHILL	DAYTON	8/14/2018	45.228806	-123.01875	Confined Animal Feeding Operations	4	3	7
87511	MEISEL ROCK PRODUCTS	YAMHILL	DAYTON	7/5/2019	45.198	-123.0467	Hazardous Substance Information System	4	3	7
995253	New Owner	YAMHILL	DAYTON	8/14/2018	45.228806	-123.01875	Confined Animal Feeding Operations	4	3	7
172287	QUIMBY FARMS	YAMHILL	DAYTON	8/14/2018	45.230056	-123.047417	Confined Animal Feeding Operations	3	3	6
63738	SLEGERS INC	YAMHILL	DAYTON	8/14/2018	45.177222	-123.047333	Confined Animal Feeding Operations	3	3	6
5674		YAMHILL	Dundee	10/31/2018	45.2757	-123.0188	Environmental Cleanup Sites	4	3	7
121588	12TH & MAPLE WINE CO Buliding 5	YAMHILL	DUNDEE	7/5/2019	45.2733	-123.0156	Aboveground Storage Tanks	4	2	6
121588	12TH & MAPLE WINE CO Buliding 5	YAMHILL	DUNDEE	7/5/2019	45.2733	-123.0156	Hazardous Substance Information System	4	2	6
102501	12TH AND MAPLE WINE COMPANY	YAMHILL	DUNDEE	7/5/2019	45.2733	-123.0156	Aboveground Storage Tanks	4	2	6
102501	12TH AND MAPLE WINE COMPANY	YAMHILL	DUNDEE	7/5/2019	45.2733	-123.0156	Hazardous Substance Information System	4	2	6
125139	ALDER HILL SUBDIVISION	YAMHILL	Dundee	10/31/2018	45.2796	-123.0161	Water Quality Permits	4	3	7
25567	DUNDEE STP	YAMHILL	DUNDEE	2009	45.267568	-122.998951	Effluent Outfalls	4	3	7
112229	DUNDEE WWTP	YAMHILL	Dundee	10/31/2018	45.2693	-123.0002	Solid Waste Sites	4	3	7
125236	HWY99W PHASE A IMPROVEMENTS	YAMHILL	Dundee	10/31/2018	45.2778	-123.0109	Water Quality Permits	4	3	7
55212	M & W FIBERGLASS INC	YAMHILL	DUNDEE	7/5/2019	45.2723	-123.0234	Hazardous Substance Information System	4	3	7
174186	MANN FARMS LLC	YAMHILL	DUNDEE	8/14/2018	45.267778	-123.025556	Confined Animal Feeding Operations	4	3	7
100005	NW WINE COMPANY LLC	YAMHILL	DUNDEE	7/5/2019	45.2693	-123.0216	Aboveground Storage Tanks	4	2	6
100005	NW WINE COMPANY LLC	YAMHILL	DUNDEE	7/5/2019	45.2693	-123.0216	Hazardous Substance Information System	4	2	6
125786	KING'S LANDING	Yamhill	Hillsboro	10/31/2018	45.3287	-122.9791	Water Quality Permits	3	3	6
36-0005	Timmons Quarry	Yamhill	Maple Grove	1/11/2018	45.270802	-123.064003	Mining Permits	3	3	6
36-0016	Dorsey Pit	Yamhill	McMinnville	1/11/2018	45.197033	-123.037787	Mining Permits	4	2	6
36-0020	Freshauer Bar	Yamhill	McMinnville	1/11/2018	45.161098	-123.0083	Mining Permits	4	2	6
36-0049	Penland Farm	Yamhill	McMinnville	1/11/2018	45.196887	-123.025856	Mining Permits	3	3	6
36-0009	Rex Quarry	Yamhill	McMinnville	1/11/2018	45.316883	-122.913361	Mining Permits	3	3	6
36-0027	see 36-0016	Yamhill	McMinnville	1/11/2018	45.224201	-123.003303	Mining Permits	4	2	6

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36-0050	Wilson Pit	Yamhill	McMinnville	1/11/2018	45.188393	-123.025703	Mining Permits	3	3	6
ORQ000026707		YAMHILL	N/A	10/31/2018	45.307	-122.934	Hazardous Material Generators	3	3	6
116401	A TO Z WINEWORKS, LLC	YAMHILL	N/A	10/31/2018	45.3144	-122.92	Water Quality Permits	3	3	6
107990	ADELSHEIM VINEYARD, LLC	YAMHILL	N/A	10/31/2018	45.3383	-123.0483	Water Quality Permits	3	3	6
122556	ALEXANA WINERY	YAMHILL	N/A	10/31/2018	45.3022	-123.0747	Water Quality Permits	3	3	6
108426	ANDRUS, R. GARY	YAMHILL	N/A	10/31/2018	45.2566	-123.0463	Water Quality Permits	4	3	7
120212	APPASSIONATA VINEYARD PROPERTIES LLC	YAMHILL	N/A	10/31/2018	45.3416	-123.0205	Water Quality Permits	3	3	6
ORQ000026536	ARCO AM/PM	YAMHILL	N/A	10/31/2018	45.2838	-123.0052	Hazardous Material Generators	4	3	7
1761	BARGELT REFINISHING	YAMHILL	N/A	10/31/2018	45.29	-122.9968	Environmental Cleanup Sites	4	3	7
111513	BERGSTROM WINES LLC	YAMHILL	N/A	10/31/2018	45.3494	-123.0494	Water Quality Permits	3	3	6
125125	BERRY NOIR CO-PACKING, INC.	YAMHILL	N/A	10/31/2018	45.2806	-122.9448	Water Quality Permits	4	3	7
118946	BSX3 LLC	YAMHILL	N/A	10/31/2018	45.3	-123.0177	Water Quality Permits	3	3	6
124397	CALPORTLAND - NEWBERG	YAMHILL	N/A	10/31/2018	45.285	-122.95	Water Quality Permits	4	3	7
123283	CHEHALEM RIDGE	YAMHILL	N/A	10/31/2018	45.3275	-122.9252	Water Quality Permits	3	3	6
112394	CHEHALEM UPLANDS IND.	YAMHILL	N/A	10/31/2018	45.3175	-122.9113	Water Quality Permits	3	3	6
118188	CHEHALEM WINERY	YAMHILL	N/A	10/31/2018	45.3136	-122.9173	Water Quality Permits	3	3	6
109501	COLUMBIA EMPIRE FARMS, INC	YAMHILL	N/A	10/31/2018	45.2789	-123	Water Quality Permits	4	3	7
111269	CRABTREE ROCK COMPANY, INC	YAMHILL	N/A	10/31/2018	45.2719	-123.0253	Water Quality Permits	4	3	7
106982	DUCKPOND CELLARS	YAMHILL	N/A	10/31/2018	45.2916	-123	Water Quality Permits	3	3	6
124897	ECI FACILITY UPGRADE	YAMHILL	N/A	10/31/2018	45.1596	-123.0588	Water Quality Permits	3	3	6
112200	ECOLOGY COMPOSTING	YAMHILL	N/A	10/31/2018	45.1545	-123.0572	Solid Waste Sites	3	3	6
110728	ELMWOOD ENTERPRISES, INC.	YAMHILL	N/A	10/31/2018	45.2955	-122.9891	Water Quality Permits	4	2	6
ORQ000010777	FRED MEYER NEWBERG	YAMHILL	N/A	10/31/2018	45.3128	-122.9207	Hazardous Material Generators	3	3	6
125571	FREEMAN MANUFACTURING	YAMHILL	N/A	10/31/2018	45.2924	-122.9477	Water Quality Permits	4	3	7
ORQ000018903	Freeman Manufacturing LLC	YAMHILL	N/A	10/31/2018	45.2978	-122.9469	Hazardous Material Generators	4	3	7
ORD982654709	GATEWAY FORD, INC.	YAMHILL	N/A	10/31/2018	45.3128	-122.9207	Hazardous Material Generators	3	3	6
124858	GRACIE'S LANDING	YAMHILL	N/A	10/31/2018	45.3288	-122.9825	Water Quality Permits	3	3	6
34853	GRAY & COMPANY	YAMHILL	N/A	10/31/2018	45.1833	-123.05	Water Quality Permits	3	3	6
124810	HOLLIS RESERVOIR	YAMHILL	N/A	10/31/2018	45.3582	-123.0306	Water Quality Permits	3	3	6
104485	KAUER FARMS,INC; WILLAMETTE RIVER ORGANICS,INC; WILSON, WIL, BARBARA, STEVE & MARY DBA WILSON FARMS	YAMHILL	N/A	10/31/2018	45.1972	-123.0499	Water Quality Permits	4	2	6
108763	KREUTNER, TOM E.	YAMHILL	N/A	10/31/2018	45.3501	-123.0951	Water Quality Permits	3	3	6
ORQ000018226	Loren Berg Chevrolet Oldsmobile	YAMHILL	N/A	10/31/2018	45.3128	-122.9207	Hazardous Material Generators	3	3	6
ORQ000034739	M&W FIBERGLASS INC	YAMHILL	N/A	10/31/2018	45.2716	-123.0201	Hazardous Material Generators	4	3	7
108689	MEDICI, HAROLD J.	YAMHILL	N/A	10/31/2018	45.3333	-122.9594	Water Quality Permits	3	3	6
104469	MONTINORE VINEYARDS LIMITED	YAMHILL	N/A	10/31/2018	45.31	-123.06	Water Quality Permits	3	3	6
115992	NEWBERG TRANSFER STATION AND RECYCLING CENTER	YAMHILL	N/A	10/31/2018	45.2851	-122.9486	Water Quality Permits	4	3	7
104217	NEWBERG TRANSFER STATION AND RECYCLING CENTER	YAMHILL	N/A	10/31/2018	45.2851	-122.9486	Solid Waste Sites	4	3	7
121023	NW WINE COMPANY, LLC	YAMHILL	N/A	10/31/2018	45.2696	-123.0209	Water Quality Permits	4	3	7
1640	OLD NEWBERG DUMP	YAMHILL	N/A	10/31/2018	45.2889	-122.9787	Environmental Cleanup Sites	4	3	7
309	PARRETT MOUNTAIN TL 101	YAMHILL	N/A	10/31/2018	45.3016	-122.8942	Environmental Cleanup Sites	3	3	6

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119465	PENLAND FARM	YAMHILL	N/A	10/31/2018	45.1966	-123.0271	Water Quality Permits	4	3	7
113926	PENNER ASH WINERY	YAMHILL	N/A	10/31/2018	45.3339	-123.0911	Water Quality Permits	3	3	6
119211	RAUGUST, TIMOTHY	YAMHILL	N/A	10/31/2018	45.3335	-122.9584	Water Quality Permits	3	3	6
124832	RESIDENTIAL	YAMHILL	N/A	10/31/2018	45.2634	-123.0465	Water Quality Permits	4	3	7
123664	REX QUARRY	YAMHILL	N/A	10/31/2018	45.3168	-122.9134	Water Quality Permits	3	3	6
72615	SMURFIT NEWSPRINT CORPORATION	YAMHILL	N/A	10/31/2018	45.2891	-122.9611	Water Quality Permits	4	3	7
72615	SMURFIT NEWSPRINT CORPORATION	YAMHILL	N/A	10/31/2018	45.2891	-122.9611	Water Quality Permits	4	3	7
ORD009620378	SMURFIT NEWSPRINT CORPORATION	YAMHILL	N/A	10/31/2018	45.2891	-122.9611	Hazardous Material Generators	4	3	7
338	SMURFIT NEWSPRINT CORPORATION	YAMHILL	N/A	10/31/2018	45.2891	-122.9611	Environmental Cleanup Sites	4	3	7
82980	SOKOL BLOSSER WINERY, INC.	YAMHILL	N/A	10/31/2018	45.2508	-123.0494	Water Quality Permits	3	3	6
2746	SOUTH RIVER ROAD SLUDGE DISPOSAL SITE	YAMHILL	N/A	10/31/2018	45.2874	-122.9716	Environmental Cleanup Sites	4	3	7
117282	TRISAETUM WINERY	YAMHILL	N/A	10/31/2018	45.3494	-123.0756	Water Quality Permits	3	3	6
125200	VERITAS SCHOOL	YAMHILL	N/A	10/31/2018	45.3304	-122.9674	Water Quality Permits	3	3	6
119145	WILSON PIT	YAMHILL	N/A	10/31/2018	45.1885	-123.0255	Water Quality Permits	3	3	6
114988	WINE COUNTRY FARMS CELLARS	YAMHILL	N/A	10/31/2018	45.2661	-123.0653	Water Quality Permits	3	3	6
111022	YAMCO	YAMHILL	N/A	10/31/2018	45.288	-122.9126	Water Quality Permits	4	3	7
104036	YAMHILL COUNTY DEPT. OF PLANNING & DEVELOPMENT	YAMHILL	N/A	10/31/2018	45.2834	-122.9761	Solid Waste Sites	4	3	7
119314	YOUNGBLOOD MINING FACILITY	YAMHILL	N/A	10/31/2018	45.1923	-123.0228	Water Quality Permits	4	3	7
77859	3 D PLASTICS INC	YAMHILL	NEWBERG	7/5/2019	45.2994	-122.9516	Hazardous Substance Information System	4	3	7
ORD980738132	A DEC INC	YAMHILL	Newberg	10/31/2018	45.3154	-122.9468	Hazardous Material Generators	3	3	6
124987	A STORAGE PLACE - HANCOCK	YAMHILL	Newberg	10/31/2018	45.3016	-122.9538	Water Quality Permits	4	3	7
20623	A04	Yamhill	Newberg	27-Mar-20	45.29994	-123.015208	Other Potential Contaminant Sources	3	3	6
7031	ACTION EQUIPMENT CO INC	YAMHILL	NEWBERG	7/5/2019	45.3024	-122.9508	Hazardous Substance Information System	4	3	7
ORQ000010033	ACTION EQUIPMENT COMPANY INC	YAMHILL	Newberg	10/31/2018	45.2915	-122.9484	Hazardous Material Generators	4	3	7
ORQ000027490	ACTION EQUIPMENT COMPANY INC	YAMHILL	Newberg	10/31/2018	45.3029	-122.9536	Hazardous Material Generators	4	3	7
18668	A-DEC INC	YAMHILL	NEWBERG	7/5/2019	45.3154	-122.9539	Aboveground Storage Tanks	3	3	6
18668	A-DEC INC	YAMHILL	NEWBERG	7/5/2019	45.3154	-122.9539	Hazardous Substance Information System	3	3	6
119987	A-DEC, INC.	YAMHILL	Newberg	10/31/2018	45.3152	-122.9556	Water Quality Permits	3	3	6
ORQ000025142	AUSTIN PROPERTY	YAMHILL	Newberg	10/31/2018	45.3165	-122.9455	Hazardous Material Generators	3	3	6
84156	AutoZone #2214	YAMHILL	NEWBERG	7/5/2019	45.303418	-122.955751	Hazardous Substance Information System	4	2	6
ORQ000034144	AUTOZONE NO 2214	YAMHILL	Newberg	10/31/2018	45.3074	-122.9434	Hazardous Material Generators	4	3	7
ORQ000036044	BEAUDRYS CUSTOM WOODWORKING	YAMHILL	Newberg	10/31/2018	45.2951	-122.947	Hazardous Material Generators	4	3	7
49572	BRETTHAUER OIL CO	YAMHILL	NEWBERG	7/5/2019	45.3006	-122.9525	Aboveground Storage Tanks	4	3	7
49572	BRETTHAUER OIL CO	YAMHILL	NEWBERG	7/5/2019	45.3006	-122.9525	Hazardous Substance Information System	4	3	7
110391	BUFF AUTO CENTER	YAMHILL	Newberg	10/31/2018	45.3	-122.95	Water Quality Permits	4	3	7
ORD027691591	BUFF AUTO CENTER	YAMHILL	Newberg	10/31/2018	45.3	-122.95	Hazardous Material Generators	4	3	7
ORD981769086	CAPTAIN CRUNCH BODY AND PAINT	YAMHILL	Newberg	10/31/2018	45.3002	-122.9792	Hazardous Material Generators	4	3	7
92742	CARAVAN COFFEE	YAMHILL	NEWBERG	7/5/2019	45.292483	-122.952259	Hazardous Substance Information System	4	2	6
124855	CHEHALEM AQUATIC & FITNESS CENTER	YAMHILL	Newberg	10/31/2018	45.3073	-122.96	Water Quality Permits	3	3	6
02054A	Chehalem Creek, Hwy 1W	Yamhill	NEWBERG	2013	45.297619	-122.987628	Major Route Stream Crossings and Bridges	4	3	7
ORD061495115	CHEHALEM PARK & RECREATION DIST SHOP BDG	YAMHILL	Newberg	10/31/2018	45.2999	-122.9516	Hazardous Material Generators	4	3	7

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ORQ000021626	CHEHALEM PARK & RECREATION DIST SHOP BDG	YAMHILL	Newberg	10/31/2018	45.2999	-122.9516	Hazardous Material Generators	4	3	7
104334	CHEHALEM PARK & RECREATION DISTRICT	YAMHILL	Newberg	10/31/2018	45.3099	-122.9685	Solid Waste Sites	3	3	6
125643	CHEHALEM POINTE APARTMENTS	Yamhill	Newberg	10/31/2018	45.3108	-122.9644	Water Quality Permits	3	3	6
ORQ000002790	CIRCLE K STORE 05458 DBA BP OIL	YAMHILL	Newberg	10/31/2018	45.3067	-122.9458	Hazardous Material Generators	4	3	7
ORD048292858	CLIMAX PORTABLE MACHINE TOOLS INC	YAMHILL	Newberg	10/31/2018	45.2988	-122.9494	Hazardous Material Generators	4	3	7
ORQ000018515	Correas Furniture Refinishing	YAMHILL	Newberg	10/31/2018	45.3003	-122.9804	Hazardous Material Generators	4	3	7
36-0025	Crabtree Pit	Yamhill	Newberg	1/11/2018	45.274143	-123.054314	Mining Permits	3	3	6
36-0026	Crabtree Rock Company Inc.	Yamhill	Newberg	1/11/2018	45.272778	-123.025937	Mining Permits	4	2	6
ORQ000017004	Dennis C Nicola DDS Family Dentistry	YAMHILL	Newberg	10/31/2018	45.2995	-122.9748	Hazardous Material Generators	4	3	7
ORD987174448	DOT MAINTENANCE STATION	YAMHILL	Newberg	10/31/2018	45.3058	-122.9735	Hazardous Material Generators	4	3	7
17451	East Fork Chehalem Creek, Hwy 151	Yamhill	NEWBERG	2013	45.306817	-122.982233	Major Route Stream Crossings and Bridges	4	3	7
ORQ000026218	FINISH LINE INDUSTRIES INC.	YAMHILL	Newberg	10/31/2018	45.294	-122.947	Hazardous Material Generators	4	3	7
117630	FIRST STUDENT - NEWBERG	YAMHILL	Newberg	10/31/2018	45.2908	-122.953	Water Quality Permits	4	3	7
23894	First Student, Inc. #10457	YAMHILL	NEWBERG	7/5/2019	45.2918	-122.9533	Aboveground Storage Tanks	4	2	6
23894	First Student, Inc. #10457	YAMHILL	NEWBERG	7/5/2019	45.2918	-122.9533	Hazardous Substance Information System	4	2	6
112076	FMC TECHNOLOGIES INC.	YAMHILL	Newberg	10/31/2018	45.3056	-122.9749	Water Quality Permits	4	3	7
258	Former Newberg One Hour Dry Cleaning	Yamhill	Newberg	8/27/2018	45.302619	-122.957175	Dry Cleaners	4	2	6
24891	FRED MEYER STORES INC	YAMHILL	NEWBERG	7/5/2019	45.3058	-122.9442	Hazardous Substance Information System	4	2	6
ORD981767122	GEORGE FOX COLLEGE	YAMHILL	Newberg	10/31/2018	45.3029	-122.9689	Hazardous Material Generators	4	3	7
125941	GEORGE FOX UNIVERSITY	Yamhill	Newberg	10/31/2018	45.3051	-122.9623	Water Quality Permits	3	3	6
42806	GEORGE FOX UNIVERSITY	YAMHILL	NEWBERG	7/5/2019	45.302846	-122.970375	Aboveground Storage Tanks	4	2	6
42806	GEORGE FOX UNIVERSITY	YAMHILL	NEWBERG	7/5/2019	45.302846	-122.970375	Hazardous Substance Information System	4	2	6
ORD092288984	GEROME MANUFACTURING	YAMHILL	Newberg	10/31/2018	45.3032	-122.9795	Hazardous Material Generators	4	3	7
48	GEROME MANUFACTURING	YAMHILL	Newberg	10/31/2018	45.3032	-122.9795	Environmental Cleanup Sites	4	3	7
125355	GFU AUSTIN SPORTS COMPLEX	YAMHILL	Newberg	10/31/2018	45.3144	-122.9666	Water Quality Permits	3	3	6
121799	GLACIER NORTHWEST INC. DBA CALPORTLAND	YAMHILL	NEWBERG	7/5/2019	45.2855	-122.9498	Hazardous Substance Information System	4	2	6
ORD987197241	GRUMPYS CLEANERS	YAMHILL	Newberg	10/31/2018	45.303	-122.9526	Hazardous Material Generators	4	3	7
123628	HARCO BLDG B	YAMHILL	NEWBERG	7/5/2019	45.292948	-122.951799	Hazardous Substance Information System	4	2	6
26	HARCO MFG CO	YAMHILL	NEWBERG	7/5/2019	45.2921	-122.9495	Hazardous Substance Information System	4	3	7
125496	HAZELWOOD FARM SUBDIVISION	YAMHILL	Newberg	10/31/2018	45.3204	-122.968	Water Quality Permits	3	3	6
458	Hess Creek, Hwy 1W	Yamhill	NEWBERG	2013	45.300319	-122.967089	Major Route Stream Crossings and Bridges	4	3	7
994830	ILLAHEE TRAINING INC	YAMHILL	NEWBERG	8/14/2018	45.274889	-122.880889	Confined Animal Feeding Operations	4	3	7
20612	Impervious Surface	Yamhill	Newberg	26-Mar-20	45.29437	-122.994577	Other Potential Contaminant Sources	4	3	7
20619	Irrigated Agriculture	Yamhill	Newberg	27-Mar-20	45.292729	-123.005704	Other Potential Contaminant Sources	3	3	6
20620	Irrigated Agriculture	Yamhill	Newberg	37mar2020	45.290555	-123.011584	Other Potential Contaminant Sources	3	3	6
20624	Irrigated Agriculture	Yamhill	Newberg	29-Mar-20	45.280421	-122.944508	Other Potential Contaminant Sources	4	3	7
20625	Irrigated Agriculture	Yamhill	Newberg	29-Mar-20	45.279859	-122.945758	Other Potential Contaminant Sources	4	3	7
63429	JIFFY LUBE	YAMHILL	NEWBERG	7/5/2019	45.3073	-122.9421	Aboveground Storage Tanks	4	2	6
63429	JIFFY LUBE	YAMHILL	NEWBERG	7/5/2019	45.3073	-122.9421	Hazardous Substance Information System	4	2	6
ORQ000003392	JIFFY LUBE STORE 1466	YAMHILL	Newberg	10/31/2018	45.3076	-122.9415	Hazardous Material Generators	4	3	7
63732	KIL-MAR ACRES	YAMHILL	NEWBERG	8/14/2018	45.278361	-122.947333	Confined Animal Feeding Operations	4	3	7

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85914	KREATIVE IMAGES INC	YAMHILL	NEWBERG	7/5/2019	45.3009	-122.9552	Hazardous Substance Information System	4	2	6
ORD027691468	LEATHERS OIL CO. #40	YAMHILL	Newberg	10/31/2018	45.3003	-122.9778	Hazardous Material Generators	4	3	7
14844	LES SCHWAB TIRE CENTER	YAMHILL	NEWBERG	7/5/2019	45.3008	-122.9582	Hazardous Substance Information System	4	2	6
88778	M & S YARD SERVICE LLC	YAMHILL	NEWBERG	7/5/2019	45.288442	-122.989151	Hazardous Substance Information System	4	3	7
102894	NEWBERG - WYNOOSKI ROAD STP	YAMHILL	NEWBERG	2009	45.281143	-122.958483	Effluent Outfalls	4	3	7
ORD987184579	NEWBERG 1 HOUR DRY CLEANERS	YAMHILL	Newberg	10/31/2018	45.3035	-122.9541	Hazardous Material Generators	4	3	7
125322	NEWBERG AMBULATORY SURGERY CENTER	YAMHILL	Newberg	10/31/2018	45.3061	-122.9347	Water Quality Permits	3	3	6
ORD173276023	NEWBERG BODY & PAINT INC	YAMHILL	Newberg	10/31/2018	45.3003	-122.9689	Hazardous Material Generators	4	3	7
23156	NEWBERG CHEVROLET	YAMHILL	NEWBERG	7/5/2019	45.304	-122.9524	Hazardous Substance Information System	4	2	6
23156	NEWBERG CHEVROLET	YAMHILL	NEWBERG	7/5/2019	45.304	-122.9524	Hazardous Substance Information System	4	2	6
17505	NEWBERG CITY OF	YAMHILL	NEWBERG	7/5/2019	45.2878	-122.9535	Aboveground Storage Tanks	4	3	7
24399	NEWBERG CITY OF	YAMHILL	NEWBERG	7/5/2019	45.2848	-122.9601	Aboveground Storage Tanks	4	3	7
17505	NEWBERG CITY OF	YAMHILL	NEWBERG	7/5/2019	45.2878	-122.9535	Hazardous Substance Information System	4	3	7
24399	NEWBERG CITY OF	YAMHILL	NEWBERG	7/5/2019	45.2848	-122.9601	Hazardous Substance Information System	4	3	7
24399	NEWBERG CITY OF	YAMHILL	NEWBERG	7/5/2019	45.2848	-122.9601	Hazardous Substance Information System	4	2	6
626	NEWBERG LOT - HESS CREEK	YAMHILL	Newberg	10/31/2018	45.3133	-122.9599	Environmental Cleanup Sites	3	3	6
16056	NEWBERG NAPA AUTO PARTS	YAMHILL	NEWBERG	7/5/2019	45.302	-122.9598	Hazardous Substance Information System	4	2	6
63949	NEWBERG ROCK AND DIRT	YAMHILL	NEWBERG	7/5/2019	45.2897	-122.9119	Hazardous Substance Information System	4	3	7
OR0000969295	NEWBERG SD 29 JT MAINT SHOP	YAMHILL	Newberg	10/31/2018	45.2956	-122.9753	Hazardous Material Generators	4	3	7
ORD987190980	NEWBERG WWTP	YAMHILL	Newberg	10/31/2018	45.2858	-122.9515	Hazardous Material Generators	4	3	7
100988	NEWBERG, CITY OF	YAMHILL	Newberg	11/1/2018	45.2864	-122.9528	Domestic Wastewater Treatment Sites	4	3	7
20617	Nursery	Yamhill	Newberg	27-Mar-20	45.291973	-123.004993	Other Potential Contaminant Sources	4	3	7
122105	OAK GROVE APARTMENTS	YAMHILL	Newberg	10/31/2018	45.3038	-122.9444	Water Quality Permits	4	3	7
116700	OAK MEADOWS II	YAMHILL	Newberg	10/31/2018	45.3044	-122.9358	Water Quality Permits	3	3	6
120890	O'Reilly Auto Parts #4000	YAMHILL	NEWBERG	7/5/2019	45.304247	-122.956681	Hazardous Substance Information System	4	2	6
17053	PACIFIC PRIDE CARDLOCK	YAMHILL	NEWBERG	7/5/2019	45.30085	-122.952962	Hazardous Substance Information System	4	3	7
125711	PAGE LANDING	Yamhill	Newberg	10/31/2018	45.3132	-122.9748	Water Quality Permits	3	3	6
62300	PARR LUMBER COMPANY	YAMHILL	NEWBERG	7/5/2019	45.3017	-122.9526	Hazardous Substance Information System	4	2	6
50015	PATRICIA GREEN CELLARS	YAMHILL	NEWBERG	7/5/2019	45.347328	-123.093319	Aboveground Storage Tanks	3	3	6
50015	PATRICIA GREEN CELLARS	YAMHILL	NEWBERG	7/5/2019	45.347328	-123.093319	Hazardous Substance Information System	3	3	6
ORR000000125	PAUL HART PROPERTY	YAMHILL	Newberg	10/31/2018	45.3007	-122.9681	Hazardous Material Generators	4	3	7
17415	PGE	YAMHILL	NEWBERG	7/5/2019	45.3038	-122.9471	Aboveground Storage Tanks	4	3	7
17415	PGE	YAMHILL	NEWBERG	7/5/2019	45.3038	-122.9471	Hazardous Substance Information System	4	3	7
122035	PGE	YAMHILL	NEWBERG	7/5/2019	45.2915	-122.9478	Hazardous Substance Information System	4	3	7
122138	PGE	YAMHILL	NEWBERG	7/5/2019	45.2982	-122.9746	Hazardous Substance Information System	4	3	7
36871	PIERCE & SONS NURSERIES INC	YAMHILL	NEWBERG	7/5/2019	45.289787	-122.989018	Aboveground Storage Tanks	4	2	6
36871	PIERCE & SONS NURSERIES INC	YAMHILL	NEWBERG	7/5/2019	45.289787	-122.989018	Hazardous Substance Information System	4	2	6
109893	PPM TECHNOLOGIES HOLDINGS LLC	YAMHILL	NEWBERG	7/5/2019	45.3051	-122.9756	Aboveground Storage Tanks	3	3	6
109893	PPM TECHNOLOGIES HOLDINGS LLC	YAMHILL	NEWBERG	7/5/2019	45.3051	-122.9756	Hazardous Substance Information System	3	3	6
109893	PPM TECHNOLOGIES HOLDINGS LLC	YAMHILL	NEWBERG	7/5/2019	45.3051	-122.9756	Hazardous Substance Information System	3	3	6
ORQ000002501	PROVIDENCE NEWBERG HOSPITAL	YAMHILL	Newberg	10/31/2018	45.3041	-122.9617	Hazardous Material Generators	4	3	7

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125950	PROVIDENCE NEWBERG MEDICAL CENTER MOB II	Yamhill	Newberg	10/31/2018	45.3078	-122.9328	Water Quality Permits	3	3	6
ORQ000030699	RITE AID #5341	YAMHILL	Newberg	10/31/2018	45.311	-122.9468	Hazardous Material Generators	4	3	7
126023	RIVERRUN (A SUBDIVISION)	Yamhill	Newberg	10/31/2018	45.2861	-122.9763	Water Quality Permits	4	3	7
ORQ000031822	SAFEWAY STORE #2623	YAMHILL	Newberg	10/31/2018	45.311	-122.9468	Hazardous Material Generators	4	3	7
ORD009050691	SARTRON INC.	YAMHILL	Newberg	10/31/2018	45.3005	-122.9775	Hazardous Material Generators	4	3	7
ORQ000028132	SHELL OIL PRODUCTS US SAP#12456	YAMHILL	Newberg	10/31/2018	45.2998	-122.985	Hazardous Material Generators	4	3	7
118253	SHERWIN WILLIAMS CO	YAMHILL	NEWBERG	7/5/2019	45.3033	-122.9552	Hazardous Substance Information System	4	2	6
319	Snow White's Laundromat	Yamhill	Newberg	8/27/2018	45.302247	-122.953513	Dry Cleaners	4	2	6
125819	SOUTH PARK NEWBERG	Yamhill	Newberg	10/31/2018	45.2959	-122.9647	Water Quality Permits	4	3	7
72615	SP NEWSPRINT CO., LLC	YAMHILL	NEWBERG	2009	45.281359	-122.958603	Effluent Outfalls	4	3	7
72615	SP NEWSPRINT CO., LLC	YAMHILL	NEWBERG	2009	45.283395	-122.960369	Effluent Outfalls	4	3	7
72615	SP NEWSPRINT CO., LLC	YAMHILL	NEWBERG	2009	45.281023	-122.958626	Effluent Outfalls	4	3	7
12769	SPORTSMAN AIRPARK INC	YAMHILL	NEWBERG	7/5/2019	45.2948	-122.9539	Aboveground Storage Tanks	4	2	6
12769	SPORTSMAN AIRPARK INC	YAMHILL	NEWBERG	7/5/2019	45.2948	-122.9539	Hazardous Substance Information System	4	2	6
12769	SPORTSMAN AIRPARK INC	YAMHILL	NEWBERG	7/5/2019	45.2948	-122.9539	Hazardous Substance Information System	4	2	6
47	Spring Cleaners	Yamhill	Newberg	8/27/2018	45.308895	-122.946869	Dry Cleaners	4	2	6
90424	STEVES AUTO SERVICE INC	YAMHILL	NEWBERG	7/5/2019	45.3009	-122.9703	Aboveground Storage Tanks	4	2	6
90424	STEVES AUTO SERVICE INC	YAMHILL	NEWBERG	7/5/2019	45.3009	-122.9703	Hazardous Substance Information System	4	2	6
125354	STUDENT ACTIVITY CENTER	YAMHILL	Newberg	10/31/2018	45.3028	-122.9651	Water Quality Permits	4	3	7
5751	SUNSHINE CLEANER NEWBERT	YAMHILL	Newberg	10/31/2018	45.3034	-122.9576	Environmental Cleanup Sites	4	3	7
404	Sunshine Cleaners	Yamhill	Newberg	8/27/2018	45.303181	-122.958734	Dry Cleaners	4	2	6
783	Sunshine Cleaners Solvent Dist	Yamhill	Newberg	8/27/2018	45.303181	-122.958734	Dry Cleaners	4	2	6
ORD987191079	SUNSHINE DRYCLEANERS	YAMHILL	Newberg	10/31/2018	45.3032	-122.9562	Hazardous Material Generators	4	3	7
ORQ000017541	Suntron	YAMHILL	Newberg	10/31/2018	45.3089	-122.9468	Hazardous Material Generators	4	3	7
76457	TYLERS AUTOMOTIVE	YAMHILL	NEWBERG	7/5/2019	45.2867	-122.946	Hazardous Substance Information System	4	2	6
123016	United Pacific 5458	YAMHILL	NEWBERG	7/5/2019	45.3064	-122.9472	Hazardous Substance Information System	4	2	6
20621	Unknown Operation Forest	Yamhill	Newberg	27-Mar-20	45.291257	-123.010034	Other Potential Contaminant Sources	3	3	6
20614	Unknown Operations	Yamhill	Newberg	26-Mar-20	45.294381	-122.994274	Other Potential Contaminant Sources	4	2	6
ORD981773799	USHIO OREGON INC	YAMHILL	Newberg	10/31/2018	45.3175	-122.9582	Hazardous Material Generators	3	3	6
341	USHIO OREGON INC	YAMHILL	Newberg	10/31/2018	45.3175	-122.9582	Environmental Cleanup Sites	3	3	6
125433	VILLA ROAD IMPROVEMENTS	YAMHILL	Newberg	10/31/2018	45.3097	-122.9625	Water Quality Permits	3	3	6
33842	WASTE MANAGEMENT NEWBERG OPERATIONS	YAMHILL	NEWBERG	7/5/2019	45.286033	-122.946314	Aboveground Storage Tanks	4	3	7
33842	WASTE MANAGEMENT NEWBERG OPERATIONS	YAMHILL	NEWBERG	7/5/2019	45.286033	-122.946314	Hazardous Substance Information System	4	3	7
8760	WESTERN HELICOPTERS SVC	YAMHILL	NEWBERG	7/5/2019	45.2913	-122.9538	Aboveground Storage Tanks	4	3	7
8760	WESTERN HELICOPTERS SVC	YAMHILL	NEWBERG	7/5/2019	45.2913	-122.9538	Hazardous Substance Information System	4	3	7
8760	WESTERN HELICOPTERS SVC	YAMHILL	NEWBERG	7/5/2019	45.2913	-122.9538	Hazardous Substance Information System	4	2	6
6471	WESTROCK NW LLC	YAMHILL	NEWBERG	7/5/2019	45.2873	-122.9619	Aboveground Storage Tanks	4	3	7
6471	WESTROCK NW LLC	YAMHILL	NEWBERG	7/5/2019	45.2873	-122.9619	Hazardous Substance Information System	4	3	7
48951	WILCO FARMERS	YAMHILL	NEWBERG	7/5/2019	45.3008	-122.9566	Hazardous Substance Information System	4	2	6
125762	DUTCHMAN RIDGE	Yamhill	Pendleton	10/31/2018	45.3283	-122.9765	Water Quality Permits	3	3	6
36-0018	Renne Pit	Yamhill	St. Paul	1/11/2018	45.290253	-122.913811	Mining Permits	4	3	7

Site ID	Name	County	City	Date	Latitude	Longitude	Category	Travel Time Sub-Score	Surface Risk Sub-Score	Total Score
11598	Bryan Creek, County Rd 108	Yamhill	UNKNOWN	2013	45.332622	-123.033083	Major Route Stream Crossings and Bridges	3	3	6
11679	Bryan Creek, County Rd 4	Yamhill	UNKNOWN	2013	45.329742	-123.032528	Major Route Stream Crossings and Bridges	3	3	6
11650	Bryan Creek, Stone Rd	Yamhill	UNKNOWN	2013	45.319181	-123.025431	Major Route Stream Crossings and Bridges	3	3	6
11677	Chehalem Creek, Bayley Rd	Yamhill	UNKNOWN	2013	45.326281	-123.074069	Major Route Stream Crossings and Bridges	3	3	6
11767F	Chehalem Creek, Dayton Ave	Yamhill	UNKNOWN	2013	45.292619	-122.9829	Major Route Stream Crossings and Bridges	4	3	7
17450	Chehalem Creek, Hwy 151 at MP 5.73	Yamhill	UNKNOWN	2013	45.320572	-123.08605	Major Route Stream Crossings and Bridges	3	3	6
19153	Chehalem Creek, Hwy 151 at MP 9.66	Yamhill	UNKNOWN	2013	45.313539	-123.006431	Major Route Stream Crossings and Bridges	3	3	6
18143	Chehalem Creek, Sunnycrest Rd	Yamhill	UNKNOWN	2013	45.299969	-122.988789	Major Route Stream Crossings and Bridges	4	3	7
0P042	Culverts, Hwy 151 at MP 9.88	Yamhill	UNKNOWN	2013	45.312458	-123.002914	Major Route Stream Crossings and Bridges	3	3	6
Ediger Landing	Ediger Landing County Park Boat Ramp	Yamhill	Unknown	Mar-16	45.09075	-123.04635	Boating Access Sites	3	3	6
8155	Hess Creek, Hwy 140	Yamhill	UNKNOWN	2013	45.273139	-122.944089	Major Route Stream Crossings and Bridges	4	3	7
01496A	Lambert Slough, Grand Island Rd	Yamhill	UNKNOWN	2013	45.127731	-123.052039	Major Route Stream Crossings and Bridges	3	3	6
11655	Millican Creek, Kuehne Rd	Yamhill	UNKNOWN	2013	45.317381	-123.090689	Major Route Stream Crossings and Bridges	3	3	6
11794	Mosquito Creek, Dukes Landing Rd	Yamhill	UNKNOWN	2013	45.134386	-123.032203	Major Route Stream Crossings and Bridges	3	3	6
11787F	Mosquito Creek, Grand Island Loop	Yamhill	UNKNOWN	2013	45.125919	-123.033781	Major Route Stream Crossings and Bridges	3	3	6
11783	Mosquito Creek, Grand Island Rd	Yamhill	UNKNOWN	2013	45.12955	-123.035089	Major Route Stream Crossings and Bridges	3	3	6
11663	North Fork Chehalem Creek, County Rd 111	Yamhill	UNKNOWN	2013	45.3535	-123.060422	Major Route Stream Crossings and Bridges	3	3	6
11664	North Fork Chehalem Creek, County Rd 111	Yamhill	UNKNOWN	2013	45.355647	-123.061372	Major Route Stream Crossings and Bridges	3	3	6
Rogers Landing	Rogers Landing County Park Boat Ramp	Yamhill	Unknown	Mar-16	45.28595	-122.96915	Boating Access Sites	4	3	7
0M613	Sign Cantilever Br, Hwy 39 EB at MP 52.48	Yamhill	UNKNOWN	2013	45.235339	-123.064122	Major Route Stream Crossings and Bridges	3	3	6
0M612	Sign Cantilever Br, Hwy 39 WB at MP 52.48	Yamhill	UNKNOWN	2013	45.23535	-123.064003	Major Route Stream Crossings and Bridges	3	3	6
11789	Small Creek, Upper Island Rd	Yamhill	UNKNOWN	2013	45.117339	-123.011781	Major Route Stream Crossings and Bridges	3	3	6
11793	Small Stream, Dukes Landing Rd	Yamhill	UNKNOWN	2013	45.12885	-123.032219	Major Route Stream Crossings and Bridges	3	3	6
11882	Small Stream, Grand Island Loop	Yamhill	UNKNOWN	2013	45.121161	-123.011661	Major Route Stream Crossings and Bridges	3	3	6
8156	Willamette River, Hwy 140	Yamhill	UNKNOWN	2013	45.267561	-122.943369	Major Route Stream Crossings and Bridges	4	3	7
36-0060	Wilsonville Concrete Products Yamhill County Site	Yamhill	Wilsonville	1/11/2018	45.136592	-123.029495	Mining Permits	3	3	6

Appendix 2-C

Geosyntec consultants

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Technical Memorandum

Date: June 14, 2023

To: Christina Walter, Joel Cary, Joelle Bennett, and David Kraska, Tualatin Valley Water District

From: Jacob Krall, Jo Lewis, Josh Gottlieb, Paul de Vries, Tom Wanzek, Brian Webb, and James Peale, Geosyntec Consultants

Subject: Task 8.1: Risk Analysis Refinement

1. INTRODUCTION

This memorandum ("memo") summarizes the refinement of the Data and Risk Analysis for the Willamette Intake Facilities Commission, conducted as part of Phase 1 of the development of a Watershed Protection, Monitoring, and Outreach Plan (Source Water Protection Plan). This memo further quantifies the risks posed from the Potential Contamination Source (PCS) sites classified as high priority during Phase 1 to water quality at the Willamette Intake Facilities ("WIF intake"). Specific contaminants of concern (COCs) and likely release quantities for each PCS site were identified based on publicly available data from local and state agencies. Chemical transport and dispersion were estimated to determine downstream concentrations at the WIF intake resulting from a potential contaminant release. The estimated concentrations of individual COCs at the WIF intake were then compared to human health-based screening levels (HHSL) to determine a quantitative risk score for each COC at each PCS site, which supports assessment of the relative risks posed by major PCS sites near the intake facilities.

1.1. Background

The Data and Risk Analysis section in the previous memorandum "Willamette River Data and Risk Analysis" (Geosyntec, 2022) presented findings which included flow and water quality analyses, tiered zones of risk within the Willamette River watershed, and geospatial analysis of PCSs within the various risk zones. The results of this analysis were used to assign numeric risk scores to PCSs located in the zone of highest threat (Tier I) based on travel time from the PCS site to the WIF intake, and the Surface Water Risk ranking listed in the Oregon Department of Environmental Quality (DEQ) Drinking Water Protection Potential Contamination Sources geodatabase (DEQ ArcGIS Services, n.d.). The assigned risk scores ranged from 1-7, with PCSs scoring a 6 or 7 termed "high risk" sites. More detail on the results from this analysis is given in Section 2.

1.2. Memorandum Purpose and Context Within the Source Water Protection Plan

This memo describes the Phase 2 refinement process used to more quantitatively assess the hazards posed by high-risk PCS features and sites identified in the Phase 1 analysis. The investigation produced an inventory of specific COCs, contaminant quantities held or likely discharged onsite, and factors affecting the likelihood of a release. The travel time calculations conducted during Phase 1 (from PCS location to the WIF intake) were combined with an empirical chemical dispersion equation to estimate peak COC concentrations at the WIF intake resulting from accidental releases from the PCS sites.

The computations facilitated the quantification of the relative toxicity of COCs in relation to state and national human health standards, as retrieved from national and local databases. These updated risk scores for high-hazard facilities can be used to design more effective emergency response procedures and facilitate outreach to facility managers to help mitigate potential impacts to drinking water quality.

2. SUMMARY OF PHASE 1 RESULTS

This section provides a high-level overview of the analyses that were conducted as part of Phase 1 Risk Analysis for potential contaminant sources upstream of the WIF intake. More detailed description of the analyses and results can be found in the technical memorandum *Willamette River Data and Risk Analysis* (Geosyntec, 2022).

Figure 1 shows a framework for assessing risk to drinking water from PCSs upstream of an intake facility. Analyses shaded green in ***Figure 1*** were accomplished during Phase 1. Analyses shaded grey represent analyses that were not completed during Phase 1, which became the focus of Phase 2 and are summarized in Section 3. These included filling chemical type and quantity data gaps, calculation of peak concentrations and comparison of peak concentrations to toxicity thresholds.

In Phase 1, a geodatabase of Drinking Water Protection PCSs compiled by DEQ (DEQ ArcGIS Services, n.d.) was leveraged to identify sites and facilities with elevated risks to surface water quality due to possible or historic accidental releases or point discharges (e.g., outfalls) of contaminants. ***Table 1*** shows the risk categories considered in this risk assessment and the likely type of risk. More information about each dataset is available at the embedded links in ***Table 1***. Risk categories which had sites classified as “High Risk” were addressed in Phase 2 and are summarized in Section 3, with further detail in Section 4.

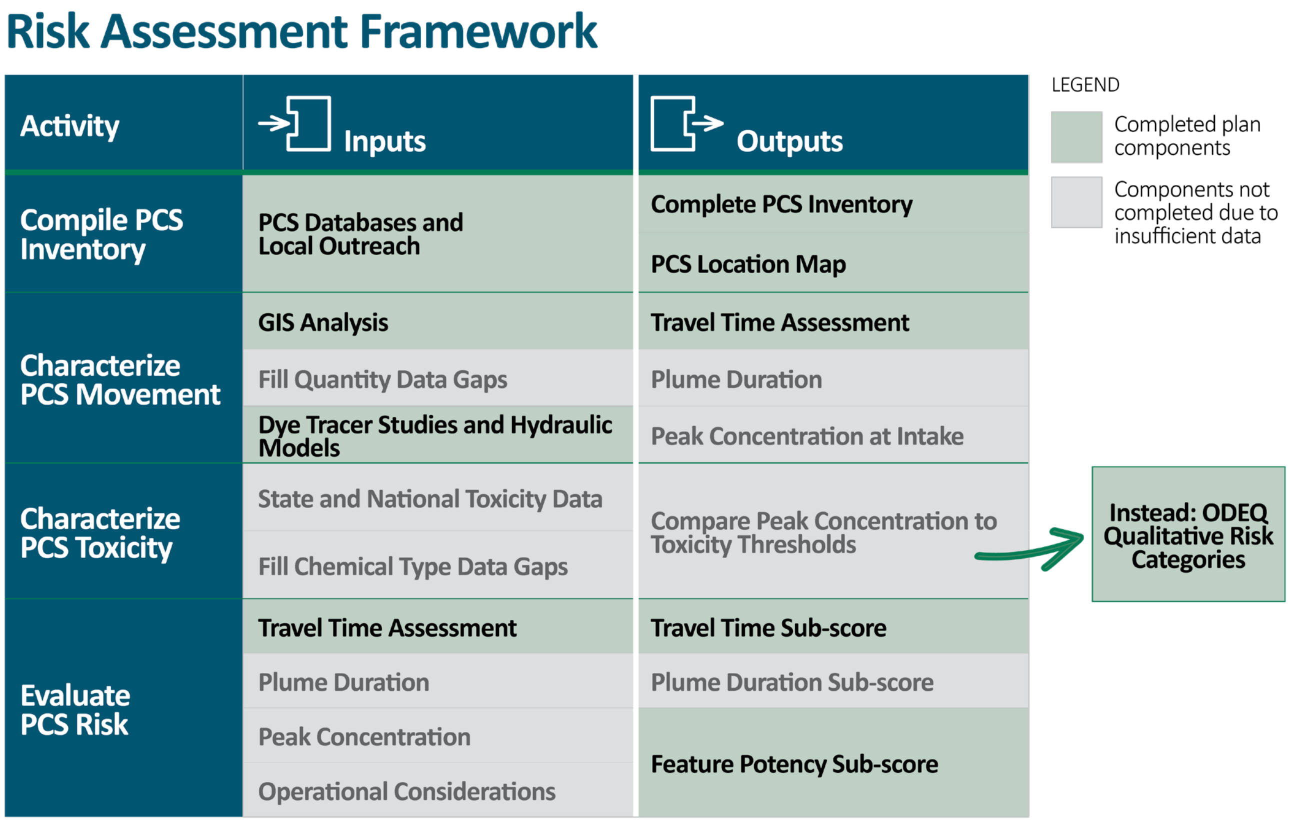

Figure 1. Framework for risk analysis

Table 1. High-Risk Drinking Water Protection Potential Contamination Source Categories

Risk Category	Type of Risk
Potential Contaminant Sources (2015-2022)	Surface
Dry Cleaners	Surface
Confined Animal Feeding Operations	Surface
Environmental Cleanup Sites with Known Contamination	Surface
Hazardous Material Generator Sites	Surface
Hazardous Substance Information System	Surface
Hazardous Substance Information System – Aboveground Storage Tank	Surface
Mining Permits	Surface
Oil and Gas Wells (Permitted Only)	Surface
Updated Source Water Assessments Potential Contaminant Sources (2018)	Surface
Solid Waste Sites	Surface
Water Quality Domestic Wastewater Treatment Sites	Surface
Water Quality Permits - Active	Surface
Surface Water Potential Contaminant Sources	Surface

Risk Category	Type of Risk
Boating Access Sites (2016)	Surface
Major Route Stream Crossings and Bridges (2013)	Surface
Water Quality Effluent Outfalls (2009)	Surface

This initial PCS list was then spatially confined to Tier 1 hazards (within an estimated 8-hour travel time window) of the WIF intake based on analysis from a source water assessment conducted by DEQ for the City of Wilsonville (DEQ, 2019). A list of Tier 1 PCS sites classified by feature types is shown in ***Table 2.***

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Table 2. Inventory of PCS Features and Sites within Tier 1 Region.

PCS Category	Tier 1 Region	City of Newberg	City of McMinnville	City of Yamhill
Other Potential Contaminant Sources	15	0	0	0
Dry Cleaners	12	5	6	0
Confined Animal Feeding Operations	47	0	0	1
Environmental Cleanup Sites	32	7	13	0
Hazardous Material Generators	112	37	44	0
Hazardous Substance Information System	289	55	99	6
Aboveground Storage Tanks	101	20	30	3
Leaking Underground Storage Tanks	107	27	33	4
Mining Permits	45	0	1	0
Solid Waste Sites	13	2	2	0
Underground Storage Tanks	27	8	12	2
Domestic Wastewater Treatment Sites	7	1	0	1
Water Quality Permits	146	27	38	1
Boating Access Sites	7	1	0	0
Major Route Stream Crossings and Bridges	98	4	5	1
Effluent Outfalls	14	0	2	0
Total	**1,072**	**194**	**285**	**19**

A risk analysis was conducted on this refined list to assign a risk score to each PCS based on:

1) Total travel time to the WIF intake (Geosyntec, 2022); and
2) Qualitative risk to surface water ranking, based on DEQ's Drinking Water Protection Potential Contamination Sources geodatabase.

The travel time for each Tier 1 PCS was ranked on a scale of 1-4, and this score was added to the qualitative risk score, which assigned a value of 1-3 based on the risk classification assigned to the site in the DEQ geodatabase. The specific criteria used to assign rankings to each site are shown in ***Table 3***.

Table 3. Numeric risk value sub-scores assigned based on surface water risk rankings and travel times

Category	Numeric Sub-score Risk Value
-- Surface Water Risk Ranking --	
High	3

Category	Numeric Sub-score Risk Value
Medium	2
Low	1
-- Travel Time (hours) --	
0-10	4
10-20	3
20-40	2
40-250	1
250+	0[1]

Sites with an overall risk score of 6 or 7 were considered high-risk. These sites were mostly located on or near the Willamette River mainstem and around the city of Newberg. The counts of these high-risk features by category are shown in ***Table 4.*** Only these previously identified high-risk features were included in this refinement process (described in sections 3-5).

[1] A score of "0" was assigned during Phase 1 analysis to aid in computation of relative risk between sites. However, all sites carry some level of risk, and low ranked sites were designated as "Minimal Risk" (rather than "0") during the Phase 2 analysis to reflect this.

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Table 4. Number of PCSs by category and risk score. Green cells list the categorical counts of high-risk features.

Potential Contaminant Source (PCS) Feature Category Type	Overall Risk Score						
	1	**2**	**3**	**4**	**5**	**6**	**7**
	Low		**Medium**			**High**	
Other PCSs	0	0	2	4	0	5	4
Dry Cleaners	0	0	3	4	0	5	0
Mining Permits	0	0	4	10	7	19	5
Solid Waste Sites	0	0	0	2	2	5	4
Confined Animal Feeding Operations	0	0	0	8	10	9	20
Domestic Wastewater Treatment	0	0	0	1	3	0	3
Water Quality Permits[2]	0	1	1	31	33	47	33
Boating Access Sites	0	0	0	0	1	3	3
Route Crossings	0	0	0	20	26	34	18
Effluent Outfalls	0	0	0	4	3	1	6
Environmental Cleanup Sites	0	0	0	5	13	7	7
Hazardous Material Generator	0	0	0	25	33	13	41
Hazardous Substance Information System	0	14	68	68	67	48	22
Aboveground Storage Tanks	1	2	23	21	22	22	10
Leaking Underground Storage Tanks	0	106	1	0	0	0	0
Underground Storage Tanks	27	0	0	0	0	0	0
Total	28	123	102	203	220	218	176

3. RISK ANALYSIS REFINEMENT METHODOLOGY OVERVIEW

Data gaps in the Risk Analysis Framework from Phase 1 (those cells shaded grey in ***Figure 1***) informed the focus of refinement analyses pursued in Phase 2. ***Figure 2*** shows an updated Risk Analysis Framework, with the refined analyses completed in Phase 2 and described in this memo shaded orange.

[2] Water quality permits include National Pollutant Discharge Elimination System and Water Pollution Control facilities permits issued by Oregon DEQ and the US EPA.

Cells shaded grey in Figure 3, which include risk factors associated with duration of a contaminant plume at the intake (i.e., how slowly or quickly a plume moves past the intake) were removed from consideration due to several factors including:

1) Duplicity with other framework component analyses

2) System redundancy considering the WIF Partners' partnerships with other water agencies and available groundwater resources

3) Intended use of the results of this analysis (outreach and stakeholder engagement), which do not depend on plume duration

4) Incompatibility with Phase 1 risk scores, which were used where data gaps remain

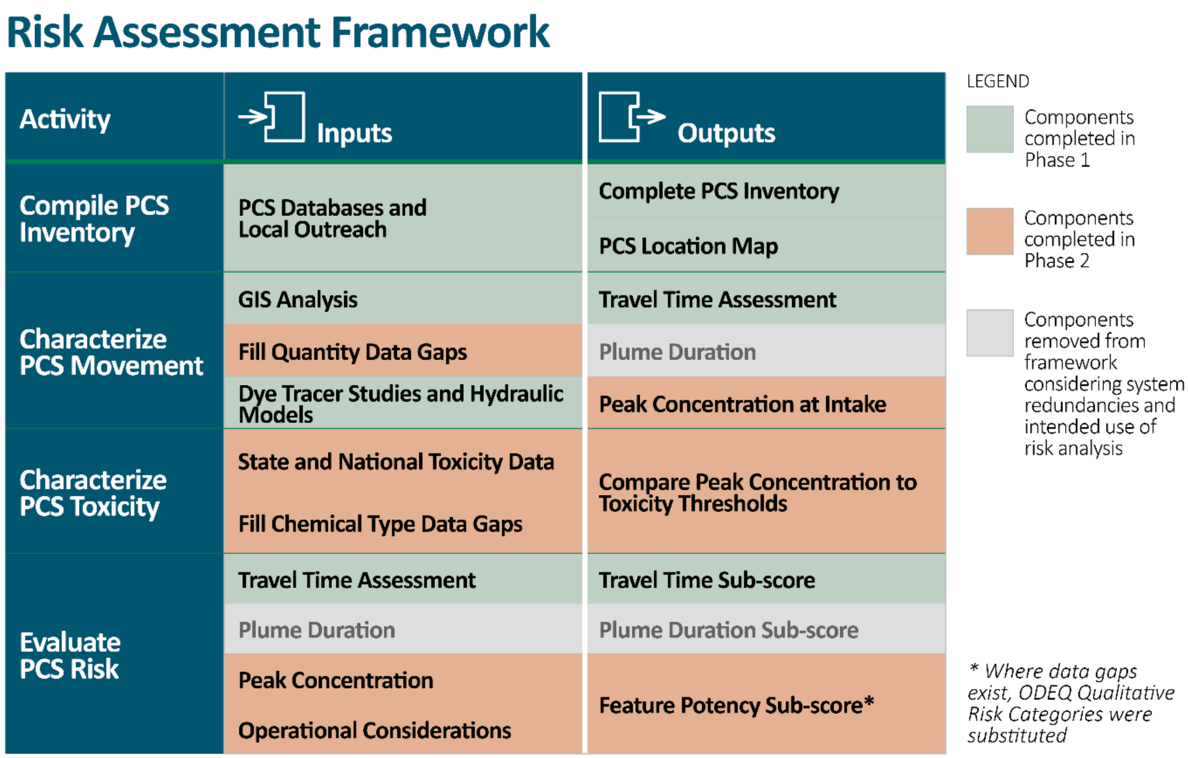

Figure 2. Updated Risk Assessment Framework (Phase 2)

The goal of refining the risk analysis conducted in Phase 1 was to apply site specific data describing COCs and their quantities in a more focused assessment of risk at the WIF intake. Contaminant quantities from PCS sites were used with a locally developed dispersion equation from a United States Geological Survey (USGS) study (USGS, 1995) to calculate the potential magnitude of peak concentrations at the WIF intake resulting from a potential release event at each PCS site. This peak concentration was compared to toxicity thresholds for the released contaminant, yielding a feature potency ratio – a measure of how many times greater the contaminant concentration at the intake is than a conservative human health toxicity threshold. The feature potency ratio was then used to assign a feature potency score, replacing the Phase 1 risk score. Sites with missing data retained their original score from Phase 1. ***Figure 3*** shows the steps involved in the refinement methodology.

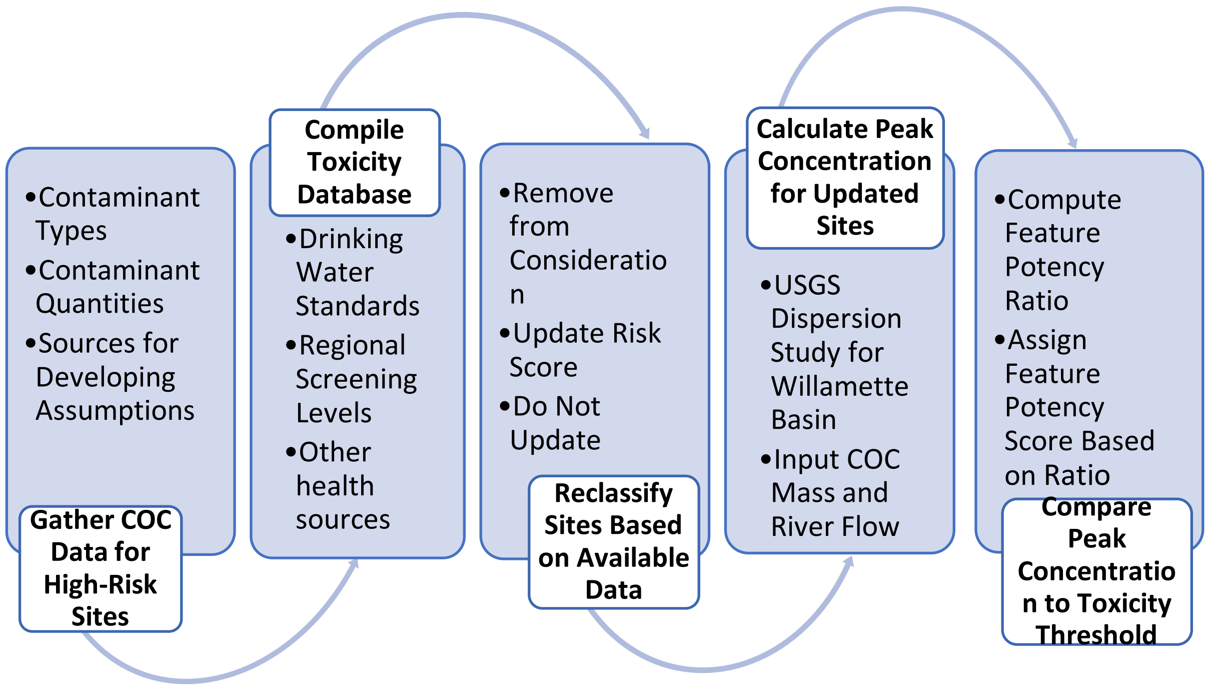

Figure 3. Flowchart of risk analysis refinement methodology.

The following variables or inputs were identified as critical for estimating peak COC concentrations at the intake facilities:

- A list of hazardous chemicals at each PCS site, information on the mechanism of release (e.g., a spill from a tanker truck at a stream crossing, a leak from an aboveground storage tank);
- The volume of contaminant that could potentially be released in an acute[3] event; and
- The threshold concentration for health effects caused by each contaminant.

[3] "Acute event" refers to chemical releases which happen at a single location and at a specific point in time (i.e., a spill) and which reach the stream network relatively rapidly. These events differ from nonpoint contaminants, which may not be traceable to a single point of origin, and from more chronic chemical exposure pathways which occur over longer periods such as slow leaks or groundwater transport.

Data describing chemical type and volume were obtained from local and regional databases which are described in detail in Section 4.

For certain PCS sites lacking specific contaminant or quantity data, assumptions were made where appropriate using conservative estimates based on research on standard operations for local sites of the same type. A complete list of assumptions, and the reasoning and sources used to make them, is included in ***Appendix A.***

The toxicity thresholds for COCs identified at the PCS sites were obtained from local and regional guidance documents (detailed in Section 5). A list of published HHSLs was compiled and used to assign the most conservative threshold value to each contaminant. After all the HHSLs were tabulated, each PCS site was classified into one of three categories:

1) Update risk score: There was enough data to calculate an updated toxicity score based on human health limits.
2) Do not update risk score: There was either not enough data to quantify or identify the COC, or these values were identified, but no HHSLs or toxicity information were found. A comprehensive list of sites which had quantity and/or HHSL data gaps is provided in ***Appendix B***.
3) Remove from consideration: Research into the site indicated that the risk was minimal due to operational or other circumstances. For example, some dry-cleaning sites that were initially classified as high risk were found to have no historical use of industrial solvents.

Sites classified as "Update risk score" (which had data for both HHSLs and COC quantity) were analyzed using a dispersion equation reported in a 1995 study (USGS, 1995) to estimate the downstream concentration at the WIF intake (Section 6). Four discharge scenarios in the Willamette River were analyzed to classify risk under varied conditions. The different scenarios were assessed to identify the river condition likely to generate the highest risk to surface water quality at the WIF intake based on COC concentration at the WIF intake and COC travel time.

Finally, each downstream COC concentration was divided by its respective HHSL to calculate a feature potency ratio, which was used to assign an updated feature toxicity score (Section 7). This feature potency score replaced the quantitative risk score originally assigned in the DEQ geodatabase.

4. REFINEMENT OF PCS CONTAMINANTS AND QUANTITIES

This section describes considerations for filling in key attributes high-risk PCS categories identified in Phase 1. Attributes include the specific COC contained at a PCS site or feature, and the quantity of COC held onsite or likely to be released to surface waters.

Generally, refining key attributes for each PCS category was achieved using local databases, publicly available permits, web-based research, and the development of appropriate assumptions. The following sections provide additional details for each PCS category.

4.1. Dry Cleaners

Four dry cleaner sites were considered in the refined risk analysis, only one of which (Site ID: 404) is still active. The 2019 source water assessment conducted by DEQ for the City of Wilsonville provided a list of dry-cleaning facilities in the region with information on their use of industrial solvents prior to 1998, and their current usage of solvents (DEQ, 2019). Three dry cleaning sites have documented use of industrial solvents (perchloroethylene (PCE), trichloroethylene (TCE) and other compounds); however, 2 of these sites (Site IDs: 404 and 258) are cross-listed as Environmental Cleanup sites (Section 4.14), and both have been classified as "No Further Action" by DEQ, indicating completed remedial action and a reduced likelihood of a release that would trigger an acute emergency response at the WIF intake. These two sites were therefore removed from further consideration in this risk refinement.

The remaining site with a record of solvent usage prior to 1998 (Site ID: 47) lacked publicly available contaminant and release quantity data, and the risk score has not been updated.

4.2. Mining Permits

24 mining sites were considered in the refined risk analysis assessment, all of which are classified as sand, gravel, and stone operations. Mining Permits are issued by the Oregon Department of Geology and Mineral Industries (DOGAMI), and their classification and activity status were retrieved from the Permit Data Spreadsheet (DOGAMI, 2021). Five closed or terminated mines (Site IDs: 24-0019, 36-0016, 36-0020, 36-0027, and 36-0018) were excluded from consideration.

Public copies of individual mining permits for Marion and Yamhill County sites have not been uploaded to the DOGAMI geographic information system (GIS) web archive, leaving data gaps in acreage and production quantities for individual sites. Mining operations are restricted from discharging waste and process water to surface waters of the state. Sites which treat stormwater onsite are required to possess a National Pollutant Discharge Elimination System (NPDES) 1200A permit, and sites which conduct subsurface disposal of process water require a Water Pollution Control Facilities (WPCF) 1000 permit. For the quantitative risk assessment, mining locations which did not have active water quality permits were listed as having a status of "No Active WQ Permit" and retained their Phase 1 risk scores.

Discharges from sand, gravel, and stone mining can expose surface waters to suspended solids and petroleum-based compounds, as primary operations include crushing and washing aggregates with heavy machinery. Depending on the specific geochemistry and land use of the mining site, heavy metals and other contaminants may also be released; however, available data was insufficient to identify and quantify these additional contaminants. Thus, sites with an active or unknown status retained their Phase 1 risk scores to account for uncertainty in overall hazard. The corresponding

"Water Quality Permit" entries for active mining sites were assigned quantitative scores following assumptions developed using guidelines from NPDES 1200A and WPCF 1000 permits described below in Section 4.5.

4.3. Confined Animal Feeding Operations

Confined, or concentrated, animal feeding operations (CAFOs) are agricultural areas where animals are kept, raised, or stabled in confined areas for more than 45 days within a 12-month period. 29 high-risk CAFOs were identified in Phase 1 of the risk assessment.

Under the Clean Water Act, CAFOs are defined as point sources of pollution and are regulated and permitted under the National Pollutant Discharge Elimination System (NPDES) program. The type of permit depends on the type of CAFO; ***Table 5*** shows the types of CAFOs identified as high-risk sites in the Phase 1 risk assessment and their permitting and cattle count attributes.

Table 5. CAFO permits upstream of the WIF intake

<table>
<tr><th>Type of CAFO</th><th>Permitting</th><th>Dairy Cattle Requirements</th><th>Cattle Requirements</th><th>Number of High-Risk CAFOs[1]</th></tr>
<tr><td>Large – General</td><td>General NPDES or WPCF Permit</td><td>Tier I: more than 700, less than 2,500
Tier II: More than 2,500</td><td>Tier I: more than 1,000, less than 3,500
Tier II: More than 3,500</td><td rowspan="2">9</td></tr>
<tr><td>Large – Individual</td><td>Individual NPDES or WPCF Permit</td><td>Tier I: more than 1,000, less than 10,000
Tier II: More than 10,000</td><td>Tier I: more than 10,000, less than 12,250
Tier II: More than 12,250</td></tr>
<tr><td>Medium</td><td>General NPDES or WPCF Permit</td><td>Less than 700
More than 200</td><td>Less than 1,000
More than 300</td><td>15</td></tr>
<tr><td>Small</td><td>General NPDES or WPCF Permit</td><td>Less than 200</td><td>Less than 300</td><td>4</td></tr>
<tr><td colspan="5">[1] One high-risk CAFO has an undefined status</td></tr>
<tr><td colspan="5">CAFO – Confined Animal Feeding Operation
NPDES – National Pollution Discharge Elimination System
WPCF – Water Pollution Control Facilities</td></tr>
</table>

The risks to surface water quality from CAFOs are many and well documented. Discharges directly from manure management facilities, or runoff or overflow events from waste management lagoons can contribute pathogens, nutrients, sediments, pharmaceuticals, heavy metals, and hormones to nearby surface waters (Burkholder et al., 2007). Excess nutrients in surface waters can contribute to the growth of harmful algal blooms, which may release toxins to surface waters. Excessive algal growth in general, and subsequent die-off, can deplete dissolved oxygen concentrations and impact aquatic life.

Available information from permits and additional research is insufficient to assign or assume discharge or release quantities for CAFO PCS sites in this risk assessment. Therefore, the quantitative risk score from Phase 1 was used in this risk assessment refinement.

4.4. Domestic Wastewater Treatment

The three domestic wastewater treatment sites considered in the refined risk analysis were quantitatively evaluated under the Water Quality Permits category, using data on facility size and concentration limits (see Section 4.5). Non-discharge hazards related to wastewater treatment storage and operations, such as biosolids application and the application of partially treated effluent to agricultural fields lacked sufficient data to develop assumptions, so these PCS sites retained their Phase 1 risk scores.

4.5. Water Quality Permits

The Water Quality permits identified as high risk to the WIF intake included NPDES permits for industrial stormwater, and WPCF permits for wastewater producing facilities. Permits were checked for active status using the DEQ web database (DEQ, n.d.).

The most common industrial permits among the risk analysis were WPCF 1400A and WPCF 1400B permits for seasonal and year-round food processors, respectively. Industry-specific waste stream guidance provided in the DEQ permit applications (DEQ, 2018) was applied to identify specific COCs. The volume of release was assumed to be the average daily effluent produced. For example, seasonal wineries produce an average of 25,000 gallons per day (gpd) of wastewater containing high levels of biological oxygen demand (BOD) and total suspended solids (TSS), among other contaminants.

Larger wastewater generators are covered under individual, industry-specific permits, which were publicly available through the DEQ permit database (DEQ, n.d.).

Septic tank waste (permitted at the Oregon Parks and Recreation Facility in Marion County) COC concentrations were assumed to be equal to average levels found in a Deschutes County, Oregon study on decentralized septic systems (Rich, 2005).

Other individual WPCF facilities were assigned discharge volumes using daily effluent values listed in their permits. COC concentrations were assigned using either contaminant discharge limits, or values listed in monitoring reports depending on data availability.

NPDES 1200A permits regulate aggregate mining operations, and place limits on TSS and oil and grease in discharges. The permitted mining operations under consideration in the risk analysis are all designated as minor facilities, generating less than one million gpd of effluent. Due to the variability in runoff volume between major storm events, five-hundred thousand gallons was the assumed discharge in the risk analysis (USEPA, 2022). Discharges from aggregate mining operations may also contain heavy metals, nitrates, sulfates, chlorides, and lignin sulfonate depending on specific mining practices (WA Department of Ecology, 2010). While these COCs were not considered in the updated risk score due to lack of data on the specific contaminants present at each mining site, WIF staff and stakeholders should be aware of additional water quality threats these facilities may pose.

See ***Appendix A*** for entry-specific assumptions made for the various permitted sites under analysis.

4.6. Boating Access Sites

Boating access sites, including boat launch ramps and slips, present a risk to surface water quality because they provide direct pathways to surface waters, which significantly shortens travel times and diminishes the potential for dispersion over overland travel pathways. Additionally, boating access sites are locations where COCs, namely petroleum products used in boats, are commonly handled.

From the Phase 1 Risk Analysis, six boating access sites were identified as high risk to the WIF intake facilities. All six sites were verified using aerial imagery (Google, 2023).

Because risk from boating access sites is related to the temporary use of the facility (as opposed to a known risk, such as an aboveground storage tank or permanent industrial facility), assumptions were made about the quantity and specific COC appropriate for this risk assessment. Gasoline was assumed as the COC for all boating access sites. Common petroleum products for motorized boats are gasoline and diesel; gasoline has a lower toxicity threshold than diesel (see Section 5), and thus was a more conservative COC. A volume of 50 gallons was assumed as the COC quantity for all boating sites as a typical recreational boat fuel tank capacity (Fortey, 2023).

4.7. Route Crossings

Similar to boating access sites, route crossings, including road and railway bridges and culverts, present a risk to surface water quality because they provide direct pathways to surface waters, which significantly shortens travel times and reduces the potential for dispersion through overland travel pathways. Additionally, the wide variety of potential COCs and potentially large release quantities make the severity of potential risks hard to determine.

From Phase 1 of the risk assessment, 52 route crossings were identified as high risk to the WIF intake facilities. Sites were verified using a combination of GIS data (NHD, 2020) and aerial imagery (Google, 2023). Three sites (Site IDs: 0M613, 0M612, and 07850A) were removed from consideration because these route crossings were not found to cross water bodies tributary to the Willamette River.

Similar to boating access sites, the risks associated with route crossings are varied and it is difficult to identify which COCs are shipped along specific routes. As such, assumptions were made about the quantity and specific COC appropriate for this risk assessment. Gasoline was assumed as the

COC for all route crossing sites. As mentioned previously, gasoline has a low toxicity threshold (see Section 5), making this assumption conservative. A volume of 11,600 gallons was assumed for all route crossing sites, a typical capacity for a large tanker truck (Harmon, 2022).

Note that rail crossings are discussed qualitatively in Section 8.2.

4.8. Effluent Outfalls

Data on contaminants for the four effluent outfalls considered in the refined risk analysis was retrieved from NPDES monitoring reports archived publicly in the EPA Enforcement and Compliance History (ECHO) portal (USEPA, 2022). COCs and concentrations released from each active location were assumed as the maximum allowable values dictated by permit limits, or maximum reported sample values. Discharge volumes were conservatively assumed to be the maximum design flows identified in the site description portion of the individual permit for each active site. Details on the site-specific assumptions used to calculate risk for effluent outfalls are included in ***Appendix A***.

4.9. Hazardous Material Generators

54 hazardous material generators were considered for the refined risk analysis. Some sites were listed and evaluated in other PCS categories, including two dry cleaners, a wastewater treatment plant, an environmental cleanup site, and several in the hazardous substance information system category.

For the remaining sites, the industry associated with each site was obtained through search engine results or the name whenever possible. COCs that were commonly associated with each site's given industry were assigned based on a table published by Benivia LLC (2023), which includes information from multiple EPA publications. Other site-specific sources (listed in the refinement analysis spreadsheet) were also used to develop assumptions about COC types. The quantities were based on DEQ's classification: DEQ classifies hazardous materials generators as Conditionally Exempt Generators (CEGs), Small Quantity Generators (SQGs), and Large Quantity Generators (LQGs). DEQ's metadata for the PCS sites defined both CEGs and SQGs as "Hazardous Material Small Quantity or Conditionally Exempt Generator", and the sites in these categories were therefore grouped together as SQGs. The assumed quantity of contaminants for each site was based on the EPA's maximum monthly generation of waste for SQGs and LQGs.

Four sites were identified as fueling stations with petroleum products being the primary COC. The quantity of petroleum was not based on their classification as SQGs, but on an assumed size of 12,000 gallons for a typical underground tank at a fueling station (GeoForward, 2022). ***Table 6*** shows a breakdown of the types of hazardous materials generators considered in the refined risk analysis.

Table 6: Hazardous material generators considered in refined risk analysis

Facility Type	Assumed Release Quantity	Regulations/Assumptions	Number of Facilities
Small Quantity Generator (SQG)	1,000 kilograms (Maximum monthly generation quantity)	May only accumulate waste on site for 180 days (3mo.)	7
		Generate no more than 100 kg of hazardous waste per month.	
		Store no more than 6000 kg on site	
Conditionally Exempt Generator (CEG)	1,000 kilograms	CEGs were assumed to have the same potential release volume as SQGs	39
		Conditionally exempt LQGs are subject to more stringent waste storage and inspection requirements than non-exempt facilities under CFR 40 Part 262	
Large Quantity Generator (LQG)	3,000 kilograms	Greater than 1 kg per month of acute hazardous waste qualifies facility as an LQG	4
		No limits exist to the amount of hazardous waste that can be kept onsite	
		May only accumulate waste on site for 90 days (3mo.)	
		Assumed maximum monthly generation of 3000 kg (twice that of SQGs)	
Petroleum Fueling Stations	12,000 gallons (Size of typical underground storage tank)	Gasoline assumed as contaminant of concern	4

4.10. Aboveground Storage Tanks

The aboveground storage tanks in the study area were found to be redundant with the Hazardous Substance Information System locations under consideration (see Section 4.11) and were removed from consideration to avoid duplicate features in the refined risk assessment.

4.11. Hazardous Substance Information System

COC information regarding PCS sites storing hazardous substances, including aboveground storage tanks (see Section 4.10) were retrieved from the Oregon Community Right to Know Hazardous Substance Manager ("CHS Manager") database, managed by the Oregon Office of the State Fire Marshal. This database provides facility usage quantity and safety datasheets (SDS) for each location. The quantity of each COC listed at a site was assumed to be the upper value of the range given for maximum daily usage. Importantly, the CHS Manager defines each COC as a solid, liquid, or gas. The units associated with the volumes of each COC are pounds for solids, gallons for liquids, and cubic feet for gases (Oregon State Fire Marshal, 2023).

Substance densities (used to convert reported volumes to mass for use in dispersion calculations [see Section 6]) were retrieved from SDS information for each COC. Where no listed density information was available, a similar chemical density was assumed.

Four sites (Site IDs: 122187, 85914, 63949, and 6471) were removed from consideration in this risk assessment due to their status listed as "inactive" in the CHS Manager database. One site (Site ID: 11070) was removed from consideration in this risk assessment because no COC's were listed in the CHS Manager database.

4.12. Other Potential Contamination Sources

11 high-risk PCS sites were identified in the initial risk analysis, which did not fit into the other categories of consideration. Most of these sites were agricultural operations and tree nursery operations, included because of potential application or storage of COCs such as fertilizer or pesticide products. The acreage of the PCS sites were estimated using the measurement tool in Google Earth, and ranged from ~2 acres to ~55 acres (Google, n.d.). Google Street View (n.d.) imagery and other publicly available visual data was used to classify the types of crops grown in the agricultural fields considered as potential contaminant sources.

Crop types included hazelnuts, vineyard grapes, and other forage-type crops. COC types and quantities were assigned based on typical annual application rates (on a mass per acre basis) for each specific crop type and were retrieved from a table adapted from a technical memorandum prepared by Herrera Consultants for a drinking water analysis in Clackamas County, Oregon (Schmidt, 2012). Sites which did not have an identifiable crop type were assigned application rates based on the "Other Crops" category listed in the table.

PCS sites which appeared inactive, or unlikely to cause acute contamination risk were removed from consideration. For example, a forest operations site in Newberg was removed due to its lack of present association with a business entity. Two impervious lots, which lacked available information on COCs, were kept in the spreadsheet for risk consideration, but did not have their toxicity scores updated.

4.13. Solid Waste Sites

DEQ's list of active permitted solid waste sites was used to check the status of the high-priority solid waste sites identified in Phase 1. Of the sites that did not appear among DEQ's active permitted solid waste sites, two were already listed under other PCS categories: composting for a CAFO and the Dundee Wastewater Treatment Plant. Two other sites were listed as "terminated" in DEQ's Drinking Water Protection Potential Contamination Sources geodatabase and were thus removed from consideration. One PCS was a landfill that has been closed and was not listed on DEQ's list of active permitted sites. This site retained its Phase 1 risk score since it still represents a potential risk, and the site is located adjacent to the Willamette River.

The Newberg Transfer Station and Recycling Center was listed in the Hazardous Substance Information System category and was therefore removed from consideration for this category. The Mid-Valley Garbage and Recycling Center was not found listed in other PCS categories, but not enough information is available to update the score. Ecology Composting may require more research as DEQ fined this site in 2016 when it was found that its leachate had contaminated stormwater runoff and consequently nearby surface waters. The risk score was not updated from Phase 1 due to a lack of data on specific contaminants.

4.14. Environmental Cleanup Sites

Data for high-risk environmental cleanup sites were retrieved from the DEQ Environmental Cleanup Site Information Database (DEQ Environmental Cleanup Program), which provided information on whether each site had confirmed release, monitoring status, and sample analysis data for certain sites.

Documentation of site assessments, remedial actions, and ongoing monitoring data were included in the spreadsheet to provide context on each site's condition. Sites marked "No Further Action" were removed from consideration from the risk analysis process.

None of the risk scores for the Environmental Cleanup Sites with confirmed release of COCs were updated due to the lack of recent public data in the database, and the lack of quantifiable acute surface water risk. For example, the Heinrich Bullet Property is under an ongoing agreement to conduct site cleanup of the high lead quantities in shallow soil present on the site, which is located less than 1000 feet from Patterson Creek. However, quantitative risk to nearby surface water systems is not clarified in public documentation and residential and industrial use of the property is only considered hazardous to occupants, therefore the original risk analysis score (based on travel time and DEQ level of hazard) was considered more appropriate. At other sites, contaminant sampling data is more than 20 years old, and may not reflect present threats to water quality downstream. These sites also retained their Phase 1 risk scores, but the highest sampled values of contaminants from historical site assessments are included in the spreadsheet as documentation.

5. DETERMINATION OF TOXICITY

5.1 Health-based Screening Levels

Health-based screening levels were compiled from various sources and assigned based on the identified COC's CAS number or surrogate CAS number. Where available, drinking water standards (maximum contaminant levels, MCLs, or MCL goals) were first used from Oregon, and then EPA. Where drinking water standards were not available, EPA regional screening levels (RSLs) were applied (US EPA, 2020). ***Appendix C*** contains the toxicity table, which includes the HSSLs available for each COC, and the Percent-Composition-Adjusted Health-Based Screening Level.

Several COCs were considered non-toxic based on their mixture composition or their tendency to volatilize or degrade. These COCs were assigned a Percent-Composition-Adjusted Health-Based Screening Level of 9,999,999 µg/L in the toxicity table to intentionally result in a negligible Feature Potency Ratio (see Section 7). PCS sites with only these COCs were designated as "Minimal Risk".

Note that both drinking water standards and RSLs are developed using chronic exposure assumptions (generally assuming consumption of 2 liters per day for 6 – 20 years). Though this risk assessment is generally developed under a framework more appropriate to acute exposure risks, acute toxicity data is less readily available and more variable than chronic exposure data. Additionally, acute exposure data is often difficult to translate into a meaningful standard (e.g., if a lethal acute reference dose is available, it is difficult to scale to an "acceptable" dose). Therefore, the toxicity values used in this analysis are conservative for acute exposure scenarios.

5.2 Assumptions

Several simplifying assumptions were made to assign toxicity limits to common contaminants. Petroleum mixtures were separated into three general petroleum classes by distillate weight and assigned a total petroleum hydrocarbon (TPH) fraction based on the likely composition of that class. The RSLs for TPH fractions are determined based on a surrogate chemical for each fraction that is determined to be representative of the toxicity for that fraction (US EPA, 2009). ***Table 7*** lists each distillate weight class, the corresponding representative petroleum mixture, TPH fraction, and surrogate chemical used for the RSL.

Substances which did not have any published HHSLs (see ***Appendix B***) were classified based on whether they were non-toxic, or whether toxicity information was not adequate to quantify risk. Non-toxic chemicals were classified as "Minimal Risk," while chemicals with data gaps were assigned a screening level of "N/A" and retained their Phase 1 risk score. For example, TSS isn't a specific chemical, is not toxic, and doesn't have health-based limits, so entries with this COC were assigned minimal risk. Dichlobenil, a pesticide, does not have published health limits, but its toxic potential is not well understood, so the PCS site retains its quantitative risk score from Phase 1.

Table 7: Surrogate chemicals for petroleum mixtures

Distillate Weight	Representative Petroleum Mixture	TPH Fraction	Surrogate Chemical
Light	Gasoline/Kerosene	TPH (Aromatic Low)	Benzene
Medium	Diesel Fuel	TPH (Aliphatic Medium)	n-Nonane
Heavy	Lubricating Oils	TPH (Aliphatic High)	Mineral Oil

6. DISPERSION CALCULATIONS

A dye tracer study (USGS, 1995) characterized the time of travel and dispersive properties of several streams within the Willamette River system. For each individual stream in the study, dye was injected upstream, concentrations were measured at multiple downstream locations, and these data points were used to develop regression equations relating the travel time of the dye plumes to the reduction in downstream concentrations. The results of all the measured streams in the study were combined to provide a composite relation for concentration dispersal within the region of study (USGS, 1995).

Equation 1:

$$C_{up} = 12100 * T_T^{-0.79}$$

Where:

C_{up} = Unit peak concentration of dye ($[(\frac{\mu g}{L})/lb] * (ft^3/s)$)
T_T = Time elapsed after dye injections (hr)

Applying ***Equation 1*** to the COCs under analysis, the peak concentration at the WIF intake downstream of each PCS location was computed assuming each contaminant was a conservative chemical (experiencing no degradation, volatilization, settling, or sorption), and that the stream-river system facilitated well-mixed (uniform) conditions in the horizontal and vertical dimensions of the water column.

The mass of each COC was calculated by multiplying the release volume by the density of the contaminant (***Equation 2***). For sites which had available SDS datasheets, densities were retrieved from these documents. Where this information was not available for a particular site, SDS sheets for a similar or identical compound were used to estimate density.

Equation 2:

$$M = \theta \cdot V$$

Where:

M = Mass of COC released (lb)
θ = Density of COC (lb/gal)
V = Volume of COC released (gal)

Following the example calculation given in the USGS (1995) study, the unit concentration equation was multiplied by the mass of the contaminant released and divided by the discharge of the stream at the upstream location.

Equation 3:

$$C_p = C_{up} * M/Q = 12100 * T_{intake}^{-0.79} * M/Q$$

Where:

C_p = Peak concentration at WIF of COC released from upstream PCS site
M = Mass of COC released (lb)
Q = River discharge at PCS site (cfs)
T_{intake} = Travel time from PCS site to WIF (hr)

The four discharge values considered in the analysis are shown in ***Table 8*** and represent 90th and 10th percentile flow values for the Mainstem Willamette (measured at USGS gauge 1419100 in Salem) during high and low flow months. PCS locations in the analysis were spread amongst smaller streams and Willamette mainstem reaches with varying levels of discharge and unique dispersion relationships. The composite stream dispersion equation (**Equation 1**) and Willamette Mainstem discharge values –listed as cubic feet per second (cfs) - in ***Table 8*** were utilized in the risk analysis, rather than stream-specific dispersion equations and values. This choice was influenced by data availability constraints; dispersion equations were not reported in the USGS (1995) study for all streams involved in the analysis. Since the primary objective was to estimate relative COC concentrations at the WIF, rather than obtaining precise values, the composite dispersion equation was identified as most conservative (predicting the highest concentrations) and was applied for all PCS sites.

Table 8 – Discharge values considered in Equation 10 for computing COC concentration at the WIF intake downstream.

Flow Statistic	Flow at Salem (14191000)
90th percentile January flow	85,540 cfs
90th percentile annual flow	48,200 cfs
10th percentile annual flow	7,025 cfs
10th percentile August flow	5,748 cfs

7. UPDATING RISK RANKING

7.1. Feature Potency Score

An updated Surface Water Quality Risk Ranking score was applied for each PCS site in the database which had available toxicity and quantity data (see Section 6 and Section 4, respectively). The updated scores for these entries were assigned based on a calculated feature potency ratio

(FPR), which is the ratio of the peak concentration of the contaminant at the WIF intake to the assigned toxicity threshold (i.e., the most conservative HHSL). The equation used to calculate the FPR, is shown in ***Equation 4***. Note that because the peak concentration of the COC at the WIF intake depends on the flow scenario, FPRs were calculated for each PCS site for each of the four flow scenarios analyzed.

Equation 4:

$$FPR = \frac{Peak\ Concentration\ at\ Intake\ (\frac{\mu g}{L})}{Toxicity\ Threshold\ (\frac{\mu g}{L})}$$

The FPR for each updated PCS site was assigned a normalized Feature Potency Score (***Table 9***), following the 3-point scoring criteria applied based on the DEQ qualitative risk score assigned in Phase 1. The normalized score keeps each updated entry in the analysis on the 7-point ranking system, which facilitates comparison with sites which could not be updated based on data gaps.

Table 9 – Feature Potency Score criterion based on Feature Potency Ratio

Normalized Feature Potency Score	High Risk (3)	Medium Risk (2)	Low Risk (1)
Feature Potency Ratio (FPR)	≥ 100	10 < FRP < 100	1 < FPR ≤ 10

Sites with an FPR less than 1 (indicating peak concentrations below the most conservative available HHSL) were designated "Minimal Risk" and were not assigned a feature potency score. It is important to note that these sites do not entirely lack hazard to the WIF facilities, but rather that they pose considerably lower risks than other PCS sites. Minimal risk PCS sites may still present challenges to WIF stakeholders in the event of a release, and many sites contain a mix of minimal risk and high-risk contaminants, which should be considered when assessing the overall hazard profile of each site.

Figure 3 shows the distribution of FPSs across PCS categories for the combined outcomes of all four flow scenarios. Categories with major data gaps – domestic wastewater treatment sites, CAFOs, mining permits, and environmental cleanup sites – have a high percentage of high FPSs (assigned in Phase 1). In contrast, PCS categories which were analyzed using ***Equation 3***, such as water quality permits, effluent outfalls, and hazardous material generators, have a higher percentage of features with minimal risk and low FPS score, and more variation in scores. This variation is based on the diversity of COCs identified for these PCS sites, reflecting the site-specific information added in the refinement process.

Table 10 lists the number of PCS features, by category type, assigned to each FPS score in Phase 1, and after the refined analysis. The results of the refinement analysis highlight the impact of Willamette River flow on specific risks in the region of concern. At high flows, dilution of contaminants is larger, and the 90th percentile January flow scenario (85,540 cfs) produced the lowest peak concentrations, leading to lower feature potency scores. In the10th percentile annual flow scenario of 7,025 cfs, the highest peak concentrations were calculated. The feature potency scores for the 10th percentile annual flow scenario were nearly identical to the lowest flow scenario, the 10th percentile August flow of 5,748 cfs, however the higher travel times present in the lowest flow scenario slightly reduced the predicted peak concentrations. Thus, the two flow values presented in ***Table 10*** represent the scenarios of lowest risk (85,540 cfs) and highest risk (7,025 cfs) in the refined analysis. In the low-flow condition of 7,025 cfs, significantly more PCS features were assigned a score of 2 or 3 compared with the high-flow scenario.

The results show that for PCS sites which were uniformly assigned FPSs of 2 or 3 in Phase 1, many PCS features pose minimal risk to the WIF intake based on dispersion and travel time, while others carry much higher risks. The refined FPSs can help stakeholders prioritize specific facilities which pose the greatest risk and develop an understanding of which specific hazards are of highest concern.

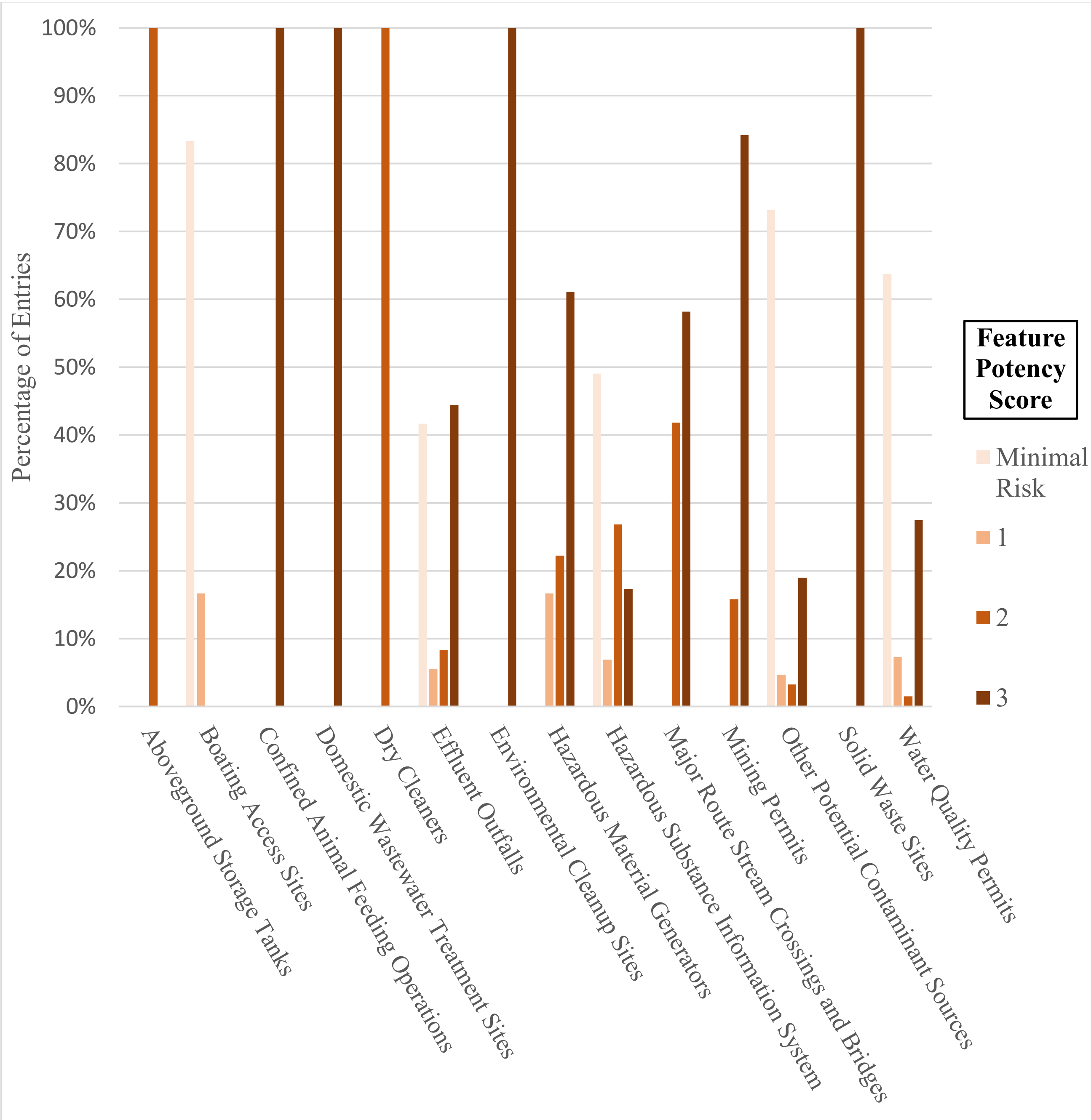

Figure 3: Feature Potency Score frequency by PCS category, using combined outcomes from all four flow scenarios in the refined risk analysis

Table 10: Counts of PCS feature FPS classified by category type for Phase 1 risk analysis and two refined risk analysis flow scenarios – 85,540 and 7,025 cfs

Potential Contaminant Source (PCS) Feature Category Type	Feature Potency Score			
	Minimal Risk	**1**	**2**	**3**
Phase 1 Risk Analysis				
Aboveground Storage Tanks			1	
Boating Access Sites				6
Confined Animal Feeding Operations				29
Domestic Wastewater Treatment Sites				3
Dry Cleaners			9	
Effluent Outfalls				21
Environmental Cleanup Sites				40
Hazardous Material Generators				54
Hazardous Substance Information System			136	148
Major Route Stream Crossings and Bridges				52
Mining Permits			6	18
Other Potential Contaminant Sources			1	71
Solid Waste Sites				9
Water Quality Permits			8	325
Total			**161**	**776**
Refined Risk Analysis - Willamette River Mainstem Flow of 85540 ft^3/s				
Aboveground Storage Tanks			1	
Boating Access Sites	6			
Confined Animal Feeding Operations				29
Domestic Wastewater Treatment Sites				3
Dry Cleaners			1	
Effluent Outfalls	8	1	1	8
Environmental Cleanup Sites				18
Hazardous Material Generators		6	11	19
Hazardous Substance Information System	140	28	70	42
Major Route Stream Crossings and Bridges			44	5
Mining Permits			3	16
Other Potential Contaminant Sources	52	3	3	12
Solid Waste Sites				5
Water Quality Permits	199	17	3	83
Total	**405**	**55**	**137**	**240**
Refined Risk Analysis - Willamette River Mainstem Flow of 7025 ft^3/s				
Aboveground Storage Tanks			1	
Boating Access Sites	4	2		
Confined Animal Feeding Operations				29
Domestic Wastewater Treatment Sites				3
Dry Cleaners			1	
Effluent Outfalls	7	1	2	8
Environmental Cleanup Sites				18
Hazardous Material Generators		6	5	25
Hazardous Substance Information System	134	12	79	55
Major Route Stream Crossings and Bridges				49
Mining Permits			3	16
Other Potential Contaminant Sources	51	3	2	14
Solid Waste Sites				5
Water Quality Permits	190	23	6	83
Total	**386**	**47**	**99**	**305**

Note: This table lists counts of Potential Contaminant Source (PCS) features. Mutiple features were documented at individual PCS sites during the risk refinement process. To facilitate comparison between Phase 1 and the refined risk analysis, Phase 1 Feature Potency Scores (FPS) were assigned uniformly to all of the site's associated PCS features.

7.2. Updated Total Risk Score

Where calculated, the feature potency score (Section 7.1) replaced the Surface Water Risk Ranking score used in Phase 1. This was added to the travel time subscore to calculate an updated total risk score for each PCS feature. Total risk scores were calculated for each flow scenario.

Figure 4 through ***Figure 7*** show the distribution of total risk scores across PCS categories under each flow scenario. The total number of PCS features identified as high risk to surface water quality across the flow scenarios analyzed are shown below in ***Table 11,*** organized by PCS site classification. The results indicate that lower Willamette River flow conditions pose greater risk to WIF intake facilities due to potential for higher contaminant concentrations in a release event. However, overall risk is not eliminated during periods of high flow because contaminant travel times decrease. Many PCS sites in the region contain a variety of hazardous features, and the refined analysis illustrates that while certain PCS features may only present significant risk during low-flow conditions, many features show a similar level risk across flow scenarios. The refined risk scores can be used to better prioritize risks to the WIF intake and provide an understanding of which specific risks are associated with which facilities.

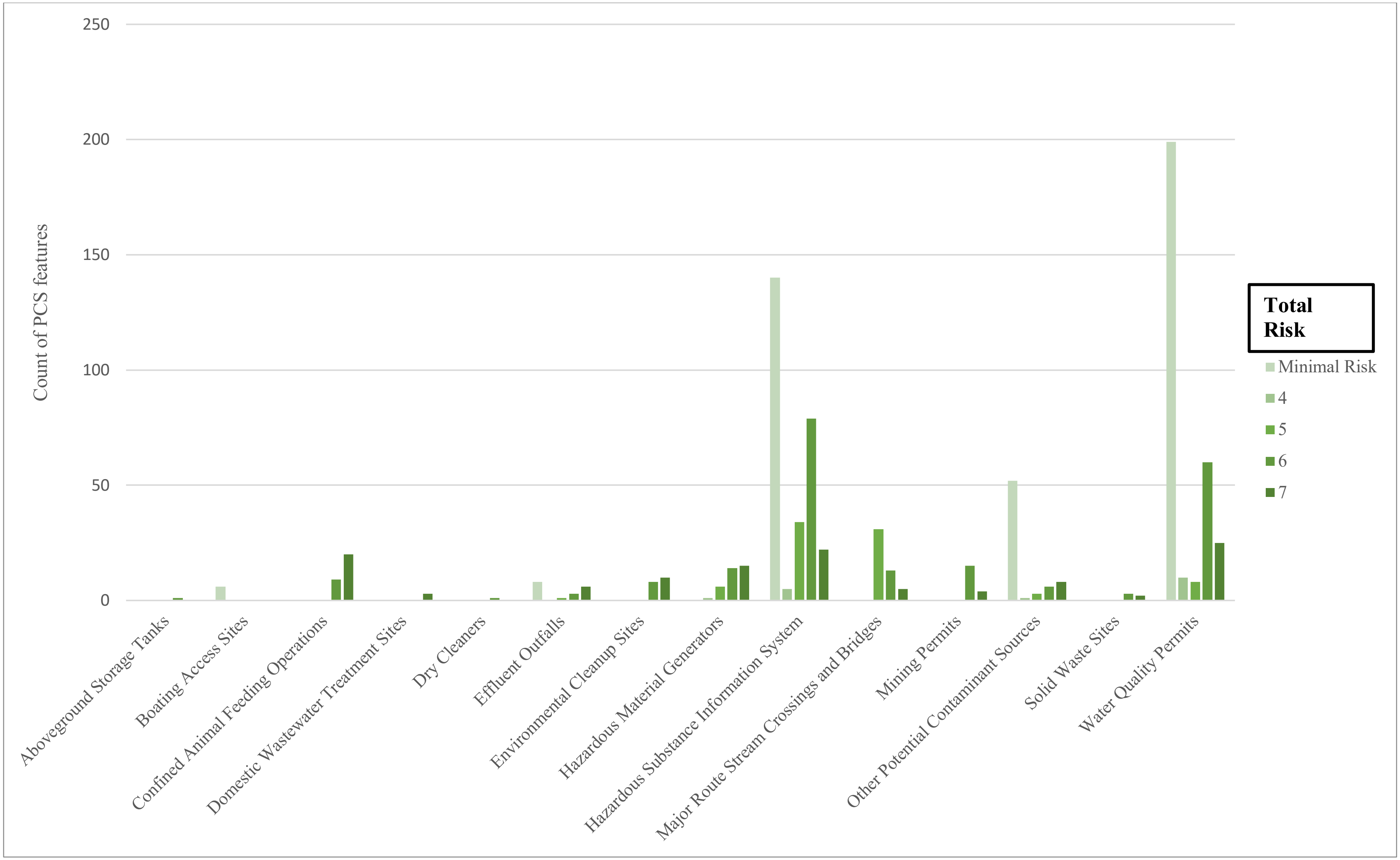

Figure 4: Histogram of total risk scores of PCS features for Willamette River discharge of 85,540 cubic feet per second

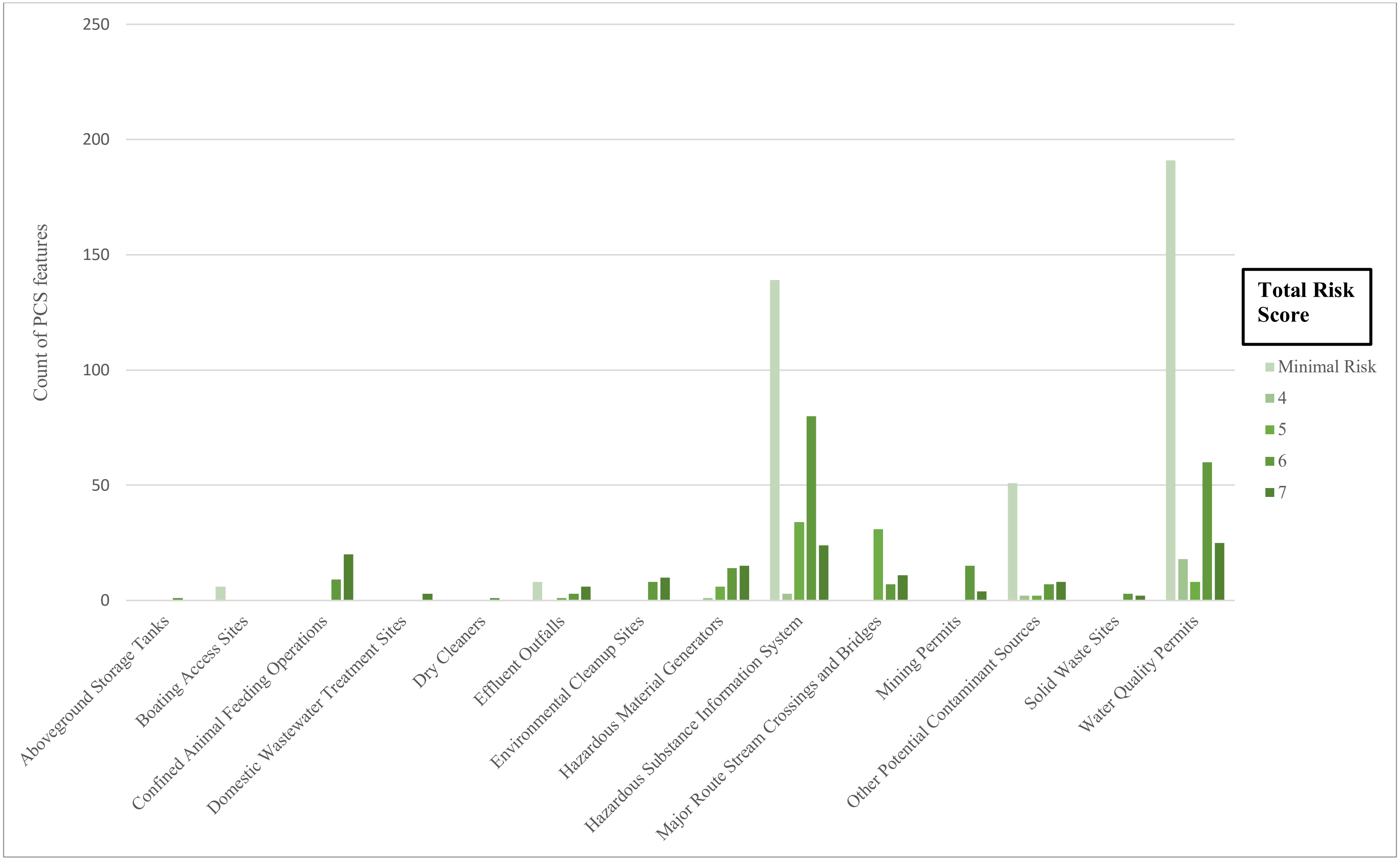

Figure 5: Histogram of total risk scores of PCS features for Willamette River discharge of 48,200 cubic feet per second

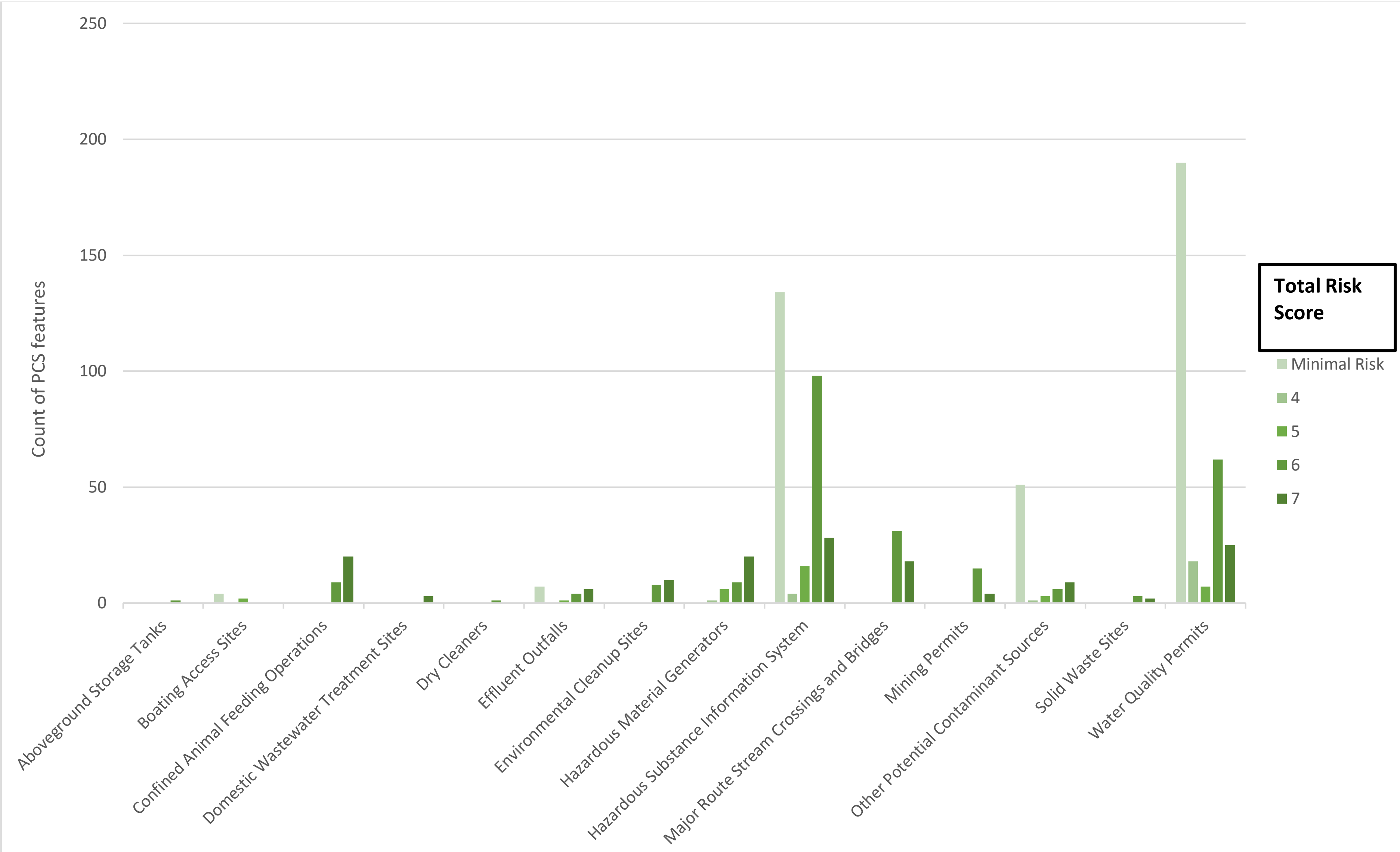

Figure 6: Histogram of total risk scores of PCS features for Willamette River discharge of 7,025 cubic feet per second

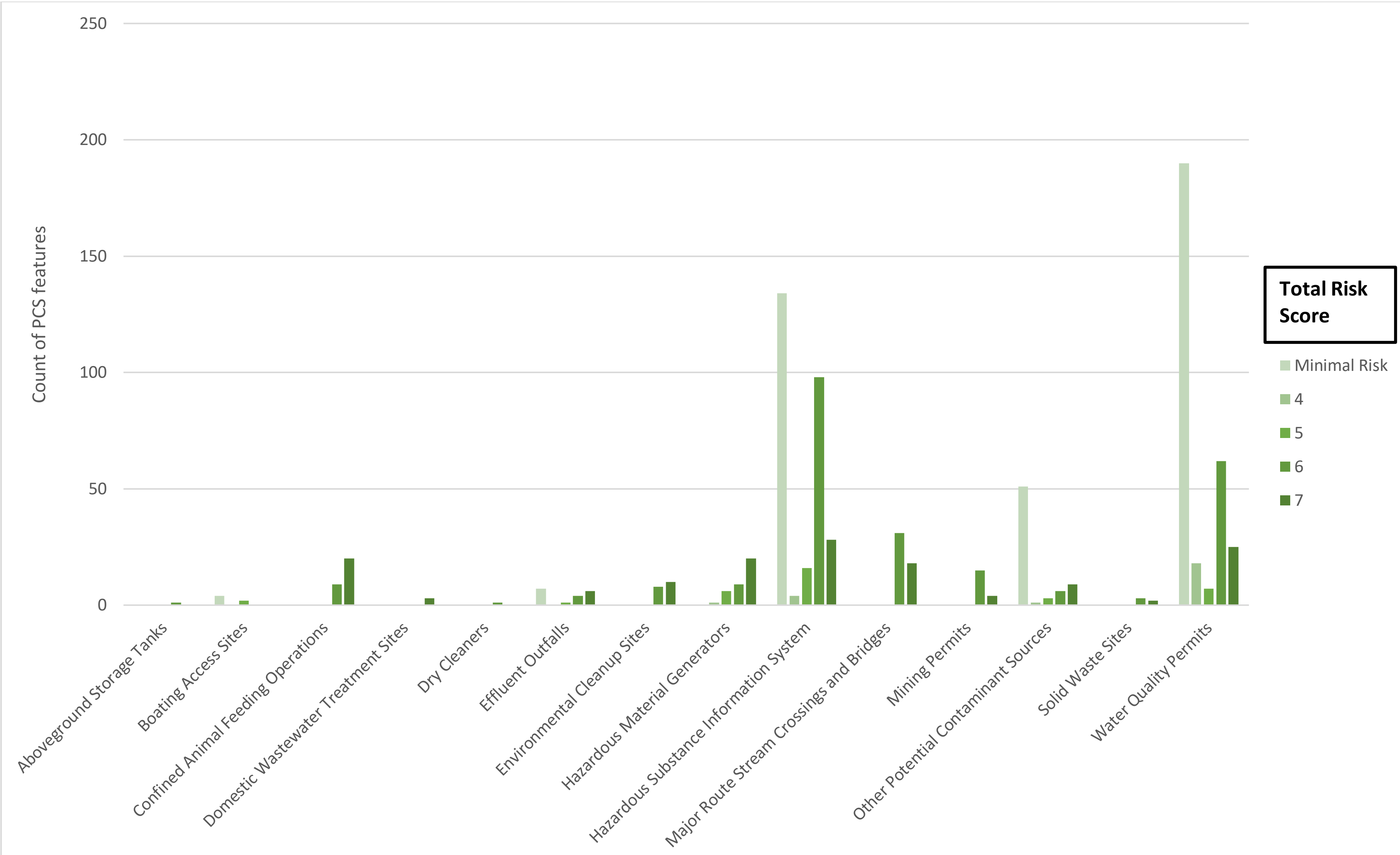

Figure 7: Histogram of total risk scores of PCS features for Willamette River discharge of 5,748 cubic feet per second

Table 11: PCS Risk Categories by PCS Type and flow scenario

Potential Contaminant Source (PCS) Feature Category Type	Mainstem Willamette River Discharge																			
	85540 ft3/s					48200 ft3/s					7025 ft3/s					5748 ft3/s				
	Total Risk Score					Total Risk Score					Total Risk Score					Total Risk Score				
	Minimal Risk	4	5	6	7	Minimal Risk	4	5	6	7	Minimal Risk	4	5	6	7	Minimal Risk	4	5	6	7
		Medium		High			Medium		High			Medium		High			Medium		High	
Aboveground Storage Tanks				1					1					1					1	
Boating Access Sites	6					6					4		2			4		2		
Confined Animal Feeding Operations				9	20				9	20				9	20				9	20
Domestic Wastewater Treatment Sites					3					3					3					3
Dry Cleaners				1					1					1					1	
Effluent Outfalls	8		1	3	6	8		1	3	6	7		1	4	6	7		1	4	6
Environmental Cleanup Sites				8	10				8	10				8	10				8	10
Hazardous Material Generators		1	6	16	13		1	6	16	13		1	6	10	19		1	6	10	19
Hazardous Substance Information System	140	5	34	79	22	139	3	34	80	24	134	4	16	98	28	134	4	16	98	28
Major Route Stream Crossings and Bridges			31	13	5			31	7	11				31	18				31	18
Mining Permits				15	4				15	4				15	4				15	4
Other Potential Contaminant Sources	52	1	3	6	8	51	2	2	7	8	51	1	3	6	9	51	1	3	6	9
Solid Waste Sites				3	2				3	2				3	2				3	2
Water Quality Permits	199	10	8	60	25	191	18	8	60	25	190	18	7	62	25	190	18	7	62	25
Total	**405**	**17**	**83**	**214**	**118**	**395**	**24**	**82**	**210**	**126**	**386**	**24**	**35**	**248**	**144**	**386**	**24**	**35**	**248**	**144**

8. ADDITIONAL POTENTIAL CONTAMINANT SOURCES

Through the risk analysis refinement process, additional potential contaminant sources surfaced that were not considered in the Phase 1 risk assessment. These PCSs will not be considered in the quantitative framework discussed above but are included here to provide a qualitative description of relative risk.

8.1. Kinder Morgan Petroleum Fuel Pipeline

A Kinder Morgan-owned product pipeline runs roughly adjacent to Interstate 5 approximately 114 miles from the Portland Station in Portland, Oregon south to Eugene, Oregon (Kinder Morgan, 2019). The 8-inch direct-pumping line transports gasoline and diesel fuels including conventional gas, EPA Ultra Low Sulfur Diesel (ULSD) Biodiesel, and ethanol (Kinder Morgan, 2019). The average and maximum capacity of this pipeline is unknown.

The pipeline crosses the Willamette River just west of Interstate 5 near Wilsonville (aerial and street view imagery; Google, 2023), approximately one third of a mile upstream of the WIF intake.

In the event of an accidental release from this pipeline at or near the Willamette River, a contaminant plume consisting of petroleum products would have a relatively short travel time to the WIF intake, and therefore minimal opportunity for dilution and dispersion. The pipeline has both automated and manual shut-off valves, which can limit the magnitude of a spill. This pipeline should be considered in source water protection planning efforts related to outreach, monitoring, and emergency planning.

8.2. Chemical Corridor

A desktop-level assessment of railways within the Tier 1 area showed a relatively higher density of PCS sites located on rail lines compared to other areas within the Tier 1 area. This is due in part to the railways servicing the population centers of Newberg and McMinnville, but also shows a "chemical corridor" along the railways, which may have a relatively higher density of high-risk facilities. Interstate commerce laws and reporting requirements make characterizing the types and quantities of chemicals of concern being transported more difficult, and therefore it is more difficult to assess the likelihood and risk of accidental releases along railways.

This "chemical corridor" should be considered in source water protection planning efforts related to outreach, monitoring, and emergency reporting.

9. CONCLUSION

Out of the 394 PCS sites classified as high risk (ranked 6 or 7 out of 7) to the WIF facilities, 937 PCS features were identified for further analysis. Each features represents a particular COC released from a particular site. For many of the PCS sites, numerous contaminants were present, which results in the increase in the number of overall contaminant features from the initial number of PCS sites.

Of these features, 100 were removed from consideration based on inactive status, cessation of activities, documentation of site cleanup, or determination of minimal risk based on geographic data. 115 features contained data gaps, which prevented a quantifiable risk assessment; the Phase 1 risk scores for these sites were retained.

For the 722 PCS features with available quantity and toxicity data, a peak concentration at the WIF facilities was calculated using a dispersion equation published in a USGS study on the Willamette River system. The peak concentration was compared to health-based screening limits for the contaminant to compute a feature potency ratio. This ratio was used to assign a feature potency score, which was factored into an updated overall risk score for the PCS site. This refined analysis represents a prioritization of the risks identified during Phase 1, allowing for a better prioritization for outreach efforts.

The results from this analysis are compiled in an annotated Excel Workbook for use in active management of potential contamination risks and releases. Each ranked PCS feature is identified by site name, site identification number, coordinates, and PCS type. Assumptions and sources used to assign contaminant and quantity values are listed in columns, and a more detailed explanation of assumptions is shown in a separate tab in the workbook. Peak concentrations and the associated subscores for each flow scenario rate are included in the spreadsheet, along with the toxicity database used to assign the HSSLs to each COC. This spreadsheet is intended to be searchable and filterable to identify the most pertinent risks associated with a particular event or circumstances.

The results of this analysis have implications for prioritization of outreach efforts and understanding of treatment processes. The analysis indicated that more sites were categorized as high risk under low flows (where there is minimal dilution) compared with high flows (where travel time is shorter but there is more dilution). This result was particularly notable for hazardous substance information sites and stream crossings and bridges, where a substantial number of sites were classified as high risk for low flows and lower risk under high flows. From a water treatment perspective, the risk categories considered in this memorandum can be classified in terms of contaminant classes, such as pathogens, organics, inorganics, and emerging contaminants. The contaminant classes associated with each of the PCS categories here are detailed in a separate memorandum developed by Hazen and Sawyer.

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APPENDICES

Appendix A: Contaminant and Quantity Assumptions

PCS/Site Type	Quantity Assumption/Justification	COC	Units	Quantity
Effluent Outfall/ Domestic Wastewater Treatment Sites (Site ID 101721): CENTURY MEADOWS SANITARY SYSTEM (CMSS)	TSS, BOD, E. Coli: Maximum Daily Limit Total Residual Chlorine: Highest Monthly Average Reported (2021-22 Sampling Report) Flow: Design flow of 1 MGD	TSS BOD E. Coli Total Residual Chlorine	lb/d lb/d MPN/100 mL mg/L	20 20 406 5.3
Source: NPDES Permit 101721, https://ormswd2.synergydcs.com/HPRMWebDrawer/RecordView/6071199, https://ormswd2.synergydcs.com/HPRMWebDrawer/RecordView/5724444				
Effluent Outfall (Site ID 100077): BROOKS SEWAGE TREATMENT PLANT	TSS, BOD, E. Coli: Maximum Daily Limit Total Residual Chlorine: Highest Monthly Average Reported (2021-22 Sampling Report) Flow: Design flow of 1 MGD	TSS BOD E. Coli Total Residual Chlorine	lb/d lb/d MPN/100 mL mg/L	260 260 406 0.19
Source: NPDES Permit 101397, https://ormswd2.synergydcs.com/HPRMWebDrawer/RecordView/6035303				

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PCS/Site Type	Quantity Assumption/Justification	COC	Units	Quantity
Effluent Outfall (Site ID 25567): DUNDEE SEWAGE TREATMENT PLANT	TSS, CBOD, E. Coli: Maximum Daily Limit UV treatment used instead of Chlorine Flow: Design flow of 1 MGD	TSS BOD E. Coli	lb/d lb/d MPN/100 mL	260 260 406
Source: NPDES Permit 101722, https://ormswd2.synergydcs.com/HPRMWebDrawer/RecordView/6186972, https://ormswd2.synergydcs.com/HPRMWebDrawer/RecordView/5881035, https://ormswd2.synergydcs.com/HPRMWebDrawer/RecordView/6210698				
Effluent Outfall (Site ID 102894): NEWBERG-WYNOOSKI SEWAGE TREATMENT PLANT	TSS, CBOD, E. Coli: Maximum Daily Limit (Wet Weather) Total Residual Chlorine: Average Monthly Value Flow: Wet Weather Design flow of 6.5 MGD	TSS BOD E. Coli Total Residual Chlorine	lb/d lb/d MPN/100 mL mg/L	3200 2700 406 0.1
Source: NPDES Permit 100988, https://ormswd2.synergydcs.com/HPRMWebDrawer/RecordView/5297958; City of Newberg Wastewater Treatment Plant Facilities Plan Update, https://ormswd2.synergydcs.com/HPRMWebDrawer/RecordView/5297958				

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PCS/Site Type	Quantity Assumption/Justification	COC	Units	Quantity
Water Quality Permit (Site ID 24600): DONALD SEWAGE TREATMENT PLANT	TKN, Phosphorus: Highest waste lagoon sample concentration E Coli: Maximum daily limit Total Chlorine: Highest Monthly Average of Samples Flow: Wet Weather Design flow of <1 MGD (Outfall is recycled water irrigation). Assumed 1 MG as release quantity (Lagoon overtopping/leak)	TKN	mg/L	3.78
		Phosphorus, TP	mg/L	3.62
		E.Coli	MPN/100 mL	406
		Total Chlorine	mg/L	2.38
Source: WPCF Permit 101978, https://ormswd2.synergydcs.com/HPRMWebDrawer/RecordView/5298624, https://ormswd2.synergydcs.com/HPRMWebDrawer/RecordView/5302772				

PCS/Site Type	Quantity Assumption/Justification	COC	Units	Quantity
Water Quality Permit (Site ID 34853) GRAY & COMPANY	BOD, TSS, Na, Phosphorus, TKN, Total chlorine: 1400A General Permit Table for food processing facilities – intermediate values Flow: 0.17 MGD (5 MG wastewater/month during the growing season)	BOD	mg/L	21,900
		TSS	mg/L	60000
		Na	mg/L	75
		Phosphorus, TP	mg/L	23
		TKN	mg/L	760
		Total Chlorine	mg/L	205
Source: WPCF Permit Fact Sheet 101693, https://ormswd2.synergydcs.com/HPRMWebDrawer/RecordView/5302472; COCs assumptions taken from Permit 1400A table for Food Processing Facilities, using intermediate values from the listed ranges.				
Water Quality Permit (Site ID 84076) ST PAUL SEWAGE TREATMENT PLANT	Biosolids – (Assume 40 Acres, 100 lb/acre/y of Total N, Biosolids are 4% Total N by Weight) 100000 lb/y Flow: 0.066 MGD Design dry weather flow	Biosolids	lb/yr	100000
Sources: WPCF Permit 100888, https://ormswd2.synergydcs.com/HPRMWebDrawer/RecordView/5298561; OSU PNW 508 https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/pnw508.pdf				

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PCS/Site Type	Quantity Assumption/Justification	COC	Units	Quantity
NPDES 1200A, Industrial: Sand, Gravel, Non-Metallic Mining	500,000 Gallons for minor classified facilities TSS Process Water/Mine Dewatering, Oil and Grease	TSS Oil and Grease	mg/L mg/L	100 10
Source: DEQ NPDES 1200A/B General Permit, https://www.oregon.gov/deq/FilterPermitsDocs/1200APermitF.pdf				
NPDES 1200Z, Industrial: Specific Industries; 1200C Construction Stormwater; NPDES 1700A, Vehicle/Equipment Wash Water	500,000 Gallons for minor classified facilities	Industrial Stormwater		
Source: https://enviro.epa.gov/enviro/ef_metadata_html.icis_page?p_column_name=major_minor_status_flag				

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PCS/Site Type	Quantity Assumption/Justification	COC	Units	Quantity
WPCF 1400A, Seasonal Wineries	25000 gallons/day (Previous 1400A limit - upper threshold for majority of wineries)	COD	mg/L	1000
		BOD	mg/L	2,767
		TSS	mg/L	580
		NH3 as N	mg/L	60
		NO2 as N	mg/L	0.4
		NO3 as N	mg/L	1.8
		Organic N	mg/L	17
		TKN	mg/L	64
		Total N	mg/L	78
		Na	mg/L	108
		Cl	mg/L	85
		SO4	mg/L	149

Sources: https://industry.oregonwine.org/wp-content/uploads/sites/2/Dr.-Stuart-Childs.pdf; ODEQ WPCF 1400A/B General Permit Table - intermediate values; Wine Institute. 2009. Comprehensive Guide to Sustainable Management of Winery Water and Associated Energy. Prepared by Kennedy/Jenks Consultants.

PCS/Site Type	Quantity Assumption/Justification	COC	Units	Quantity
WPCF 1400A/B, Food Processing, Fruits/Vegetables		BOD TSS Cl	mg/L mg/L mg/L	18 16.14 46.1
Source: DEQ WPCF 1400A/B General Permit Table, https://www.oregon.gov/deq/FilterPermitsDocs/1400apermit.pdf				
WPCF 1400A, Food Processing, Pickles/Salad Dressing	25,000 gallons/day (Permit values table – intermediate values – for food processing facilities)	BOD TSS Na Phosphorus, TP TKN Cl	mg/L mg/L mg/L mg/L mg/L mg/L	21,900 60000 75 23 760 205
Source: DEQ NPDES 1400A/B General Permit Table, intermediate values, https://www.oregon.gov/deq/FilterPermitsDocs/1400apermit.pdf				

PCS/Site Type	Quantity Assumption/Justification	COC	Units	Quantity
OREGON PARKS & RECREATION DEPARTMENT Septic Tank Drain field	COCs: Taken from Deschutes County Study on Septic Tank Waste Volume: Tank capacity (14250 gallons) taken from water quality permit	BOD	mg/L	261
		TSS	mg/L	94
		TN	mg/L	66
		Phosphorus, TP	mg/L	11
		Oil and Grease	mg/L	35
		Fecal Coliform	CFU/100 mL	1.50E+07
Sources: Volume from WPCF Permit 110311, https://ormswd2.synergydcs.com/HPRMWebDrawer/RecordView/5298767; Effluent Characteristics from Deschutes County Study, Table 5.1 (https://weblink.deschutes.org/Public/DocView.aspx?id=12343&dbid=0&repo=LFPUB&cr=1)				
Other Potential Contaminant Sources: Nurseries, Irrigated/Non-irrigated Agriculture	COCs and quantities assumed as full growing season application types and amounts	Pesticide and fertilizer types and volumes vary based on agricultural classification.		
Source: Schmidt, J. (2012). Drinking Water Risk Analysis Final Memoranda. Herrera Environmental Consultants. Series of technical memoranda transmitted to K.Swan of Clackamas River Water Providers in May 2012.				

PCS/Site Type	Quantity Assumption/Justification	COC	Units	Quantity
Small Quantity Generator (SQG)	May only accumulate waste on site for 180 days (3mo.)	1,000 kilograms (Maximum monthly generation)	COCs assigned based on industry category. For each site, the most toxic likely contaminant was assumed.	
	Generate no more than 100 kg of hazardous waste per month			
	Store no more than 6000 kg on site			
Conditionally Exempt Generator (CEG)	CEGs were assumed to have potential release volume as SQGs	1,000 kilograms		
	Conditionally exempt LQGs are subject to more stringent waste storage and inspection requirements than non-exempt facilities under CFR 40 Part 262			
Large Quantity Generator (LQG)	Greater than 1 kg per month of acute hazardous waste qualifies facility as an LQG	3000 kilograms		
	No limits exist to the amount of hazardous waste that can be kept onsite			
	May only accumulate waste on site for 90 days (3mo.)			
	Assumed maximum monthly generation of 3000 kg (twice that of SQGs)			
Source: USEPA. (2022). Categories of Hazardous Waste Generators. Retrieved March 22,2023 from https://www.epa.gov/hwgenerators/categories-hazardous-waste-generators				

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PCS/Site Type	Quantity Assumption/Justification	COC	Units	Quantity
Petroleum Fueling Stations	Gasoline assumed as contaminant of concern; volume based on size of typical underground storage tank	Gasoline	gallons	12000
Source: Geoforward. (2022). Underground Storage Tank Sizes and Volumes. Retrieved April 2023 from https://www.geoforward.com/underground-storage-tank-sizes-volumes/				
Major Route Stream Crossings and Bridges	Gasoline assumed as contaminant of concern; volume based on size of typical tanker tank	Gasoline	gallons	11,600
Source: Harmon, N. (2022). How Much Does A Tank Trailer Hold? Trailers of Texas. 21 June 2022. https://www.trailersoftexas.com/blog/how-much-does-a-tank-trailer-hold--25081				
Boating Access Sites	Gasoline assumed as contaminant of concern; volume based on size of typical boat fuel tank	Gasoline	gallons	50
Source: Fortey, I. (2023). Pontoon Boat Fuel Tank Location. Boat Safe. 12 February 2023.				

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Appendix B: Entries with Data Gaps

Site ID	COMMON_NM	County	City	PCS Category	Contaminant of Concern	Data Gap
42806	GEORGE FOX UNIVERSITY	YAMHILL	NEWBERG	Aboveground Storage Tanks	ULTRA SPEC 500 INTERIOR EGGSHELL BASE 1 / BENJAMIN MOORE & CO (Titanium Dioxide)	COC Quantity
1000212	MAYFIELD FARM LLC	CLACKAMAS	AURORA	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
186675	MAYFIELD FARM LLC	CLACKAMAS	AURORA	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
1000051	MAYFIELD FARM LLC	CLACKAMAS	AURORA	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
62754	WIL-VIEW FARMS	CLACKAMAS	WILSONVILLE	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
182160	E & M FARMS LLC	MARION	AURORA	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
1000135	FRAGRANT FARMS LLC	MARION	AURORA	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
63167	MILKY WAY DAIRY INC	MARION	AURORA	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
183924	ROCK RIDGE FARMS LLC	MARION	AURORA	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity

Site ID	COMMON_NM	County	City	PCS Category	Contaminant of Concern	Data Gap
63228	TWIN L FARM	MARION	GERVAIS	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
63169	MOISAN DAIRY	MARION	KEIZER	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
138629	COLEMAN RANCH INC	MARION	SAINT PAUL	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
63138	HAZENBERG DAIRY	MARION	SAINT PAUL	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
63168	MISSION LANE FARMS INC	MARION	SAINT PAUL	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
63177	OTT DAIRY	MARION	SAINT PAUL	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
174681	RICHTER RANCH INC	MARION	SAINT PAUL	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
63184	SAR BEN FARMS INC	MARION	SAINT PAUL	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
63195	VEEMAN DAIRY LLC	MARION	SAINT PAUL	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
1000164	CHAMPOEG CREEK FARM LLC	MARION	ST PAUL	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity

Site ID	COMMON_NM	County	City	PCS Category	Contaminant of Concern	Data Gap
63118	COELHO DAIRY	MARION	WOODBURN	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
138820	COLEMAN RANCH INC	MARION	WOODBURN	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
995252	New Owner	YAMHILL		Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
172732	MARCON FARMS #1 OWENS FACILITY	YAMHILL	DAYTON	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
172731	MARCON FARMS #2	YAMHILL	DAYTON	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
995253	New Owner	YAMHILL	DAYTON	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
172287	QUIMBY FARMS	YAMHILL	DAYTON	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
63738	SLEGERS INC	YAMHILL	DAYTON	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
174186	MANN FARMS LLC	YAMHILL	DUNDEE	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
994830	ILLAHEE TRAINING INC	YAMHILL	NEWBERG	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity

Site ID	COMMON_NM	County	City	PCS Category	Contaminant of Concern	Data Gap
63732	KIL-MAR ACRES	YAMHILL	NEWBERG	Confined Animal Feeding Operations	BOD, TSS, N, Ammonia, P, Bacteria/Pathogens	COC Quantity
101721	CENTURY MEADOWS SANITARY SYSTEM, INC.	MARION	N/A	Domestic Wastewater Treatment Sites	Biosolids	Toxicity; COC Quantity
101722	DUNDEE, CITY OF	N/A	Dundee	Domestic Wastewater Treatment Sites	Biosolids, Recycled Water	Toxicity; COC Quantity
100988	NEWBERG, CITY OF	YAMHILL	Newberg	Domestic Wastewater Treatment Sites	Biosolids	Toxicity; COC Quantity
47	Spring Cleaners	Yamhill	Newberg	Dry Cleaners	Solvents	COC Quantity
96010	CENTURY MEADOWS SANITARY SYSTEM (CMSS)	MARION	AURORA	Effluent Outfalls	E. Coli	COC Toxicity
100077	BROOKS SEWAGE TREATMENT PLANT	MARION	BROOKS	Effluent Outfalls	E. Coli	COC Toxicity
25567	DUNDEE STP	YAMHILL	DUNDEE	Effluent Outfalls	E. Coli	COC Toxicity
102894	NEWBERG - WYNOOSKI ROAD STP	YAMHILL	NEWBERG	Effluent Outfalls	E. Coli	COC Toxicity
4335	HEINREICH BULLET PROPERTY	MARION	N/A	Environmental Cleanup Sites	Lead - Soil	COC Quantity
859	PACIFIC CUSTOM PRODUCTS	MARION	N/A	Environmental Cleanup Sites	Chromium	COC Quantity
859	PACIFIC CUSTOM PRODUCTS	MARION	N/A	Environmental Cleanup Sites	Nickel	COC Quantity

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Site ID	COMMON_NM	County	City	PCS Category	Contaminant of Concern	Data Gap
5674	DUCK COUNTRY APARTMENTS	YAMHILL	Dundee	Environmental Cleanup Sites	Arsenic - Soil	COC Quantity
5674	DUCK COUNTRY APARTMENTS	YAMHILL	Dundee	Environmental Cleanup Sites	Lead - Soil	COC Quantity
1761	BARGELT REFINISHING	YAMHILL	N/A	Environmental Cleanup Sites	Methylene Chloride	COC Quantity
1640	OLD NEWBERG DUMP	YAMHILL	N/A	Environmental Cleanup Sites	Heavy Metals	COC Quantity
338	SMURFIT NEWSPRINT CORPORATION	YAMHILL	N/A	Environmental Cleanup Sites	Fuel Oil - Soil	COC Quantity
338	SMURFIT NEWSPRINT CORPORATION	YAMHILL	N/A	Environmental Cleanup Sites	Cadmium	COC Quantity
338	SMURFIT NEWSPRINT CORPORATION	YAMHILL	N/A	Environmental Cleanup Sites	Chromium	COC Quantity
338	SMURFIT NEWSPRINT CORPORATION	YAMHILL	N/A	Environmental Cleanup Sites	Kerosene	COC Quantity
338	SMURFIT NEWSPRINT CORPORATION	YAMHILL	N/A	Environmental Cleanup Sites	Lead	COC Quantity
2746	SOUTH RIVER ROAD SLUDGE DISPOSAL SITE	YAMHILL	N/A	Environmental Cleanup Sites	Heavy Metals	COC Quantity
626	NEWBERG LOT - HESS CREEK	YAMHILL	Newberg	Environmental Cleanup Sites	Acetone - Soil	COC Quantity
626	NEWBERG LOT - HESS CREEK	YAMHILL	Newberg	Environmental Cleanup Sites	Chromium - Soil	COC Quantity
626	NEWBERG LOT - HESS CREEK	YAMHILL	Newberg	Environmental Cleanup Sites	Copper - Soil	COC Quantity
626	NEWBERG LOT - HESS CREEK	YAMHILL	Newberg	Environmental Cleanup Sites	Lead - Soil	COC Quantity

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Site ID	COMMON_NM	County	City	PCS Category	Contaminant of Concern	Data Gap
626	NEWBERG LOT - HESS CREEK	YAMHILL	Newberg	Environmental Cleanup Sites	Methylene Chloride	COC Quantity
OR0000031815	TROJAN ENTERPRISES INC	CLACKAMAS	N/A	Hazardous Material Generators	Unknown	COC Type
ORD061495115	CHEHALEM PARK & RECREATION DIST SHOP BDG	YAMHILL	Newberg	Hazardous Material Generators	Unknown	COC Type
ORD091298760	WESTERN FARM SERVICES	MARION	N/A	Hazardous Material Generators	Unknown	COC Type
ORD987188521	T W D INC	CLACKAMAS	N/A	Hazardous Material Generators	Unknown	COC Type
ORQ000014241	ODOC Coffee Creek Correctional Facility	CLACKAMAS	N/A	Hazardous Material Generators	Unknown	COC Type
ORQ000021626	CHEHALEM PARK & RECREATION DIST SHOP BDG	YAMHILL	Newberg	Hazardous Material Generators	Unknown	COC Type
ORQ000025142	AUSTIN PROPERTY	YAMHILL	Newberg	Hazardous Material Generators	Unknown	COC Type
ORQ000025684	ELDRIEDGE ELEMENTARY SCHOOL	MARION	N/A	Hazardous Material Generators	Unknown	COC Type
ORQ000031822	SAFEWAY STORE #2623	YAMHILL	Newberg	Hazardous Material Generators	Unknown	COC Type

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Site ID	COMMON_NM	County	City	PCS Category	Contaminant of Concern	Data Gap
ORQ000037545	LOWES OF HILLSBORO OR NO 1558	Washington	Hillsboro	Hazardous Material Generators	Unknown	COC Type
ORQ000037603	BUILDING	Marion	Woodburn	Hazardous Material Generators	Unknown	COC Type
ORQ000037611	LOWES OF KEIZER OR NO 2619	Marion	Keizer	Hazardous Material Generators	Unknown	COC Type
ORR000000125	PAUL HART PROPERTY	YAMHILL	Newberg	Hazardous Material Generators	Unknown	COC Type
11070	NORTHWEST FLORICULTURE INC	MARION	AURORA	Hazardous Substance Information System	No Chemicals Listed	COC Type
7031	ACTION EQUIPMENT CO INC	YAMHILL	NEWBERG	Hazardous Substance Information System	PROPRIETARY ACRYLIC POLYMER	Toxicity
24-0036	Butteville	Marion	Aurora	Mining Permits	No active WQ permits	Activity Status
24-0030	Knife River Wheatland Concrete	Marion	Keizer	Mining Permits	NPDES 1200A: Construction Sand and Gravel (106350); WPCF 1000	COC Quantity
24-0004	Knife River Corporation - Northwest: Reed Pit	Marion	Tangent	Mining Permits	WPCF 1000: Highway and Street Construction (105664)	COC Quantity
24-0008	Palisades Ranch - Baker Rock Resources	Marion	Wilsonville	Mining Permits	NPDES 1200A: Construction Sand and Gravel (119486)	COC Quantity

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Site ID	COMMON_NM	County	City	PCS Category	Contaminant of Concern	Data Gap
36-0001	Marge Bollinger	Yamhill		Mining Permits	No active WQ permits	Activity Status
36-0019	Renne Pit - Parrot Mountain Reclamation Facility	Yamhill		Mining Permits	NPDES 1200A, Industrial: Other Crushed and Broken Stone	COC Quantity
36-0056	Renne Quarry Newberg Rock Pit - Parrot Mountain Reclamation Facility	Yamhill	Aurora	Mining Permits	NPDES 1200A, Industrial: Other Crushed and Broken Stone	COC Quantity
36-0037	Coffee Island Bar - Youngblood Mining Facility	Yamhill	Beaverton	Mining Permits	NPDES 1200A: Construction Sand and Gravel (119314)	COC Quantity
36-0061	Harney	Yamhill	Beaverton	Mining Permits	No active WQ permits	Activity Status
36-0052	Hildebrandt Property - Grand Island	Yamhill	Beaverton	Mining Permits	No active WQ permits.	Activity Status
36-0054	Youngblood Pit - Youngblood Mining Facility	Yamhill	Beaverton	Mining Permits	NPDES 1200A: Construction Sand and Gravel (119314)	COC Quantity
36-0058	Hester Property	Yamhill	Dayton	Mining Permits	No active WQ permits	Activity Status
36-0005	Timmons Quarry	Yamhill	Maple Grove	Mining Permits	WQ permit terminated: NPDES 1200A (110094)	Activity Status
36-0049	Penland Farm	Yamhill	McMinnville	Mining Permits	NPDES 1200A: Other Crushed Stone (119465)	COC Quantity
36-0009	Rex Quarry	Yamhill	McMinnville	Mining Permits	NPDES 1200A: Other Crushed Stone (123664)	COC Quantity
36-0050	Wilson Pit	Yamhill	McMinnville	Mining Permits	NPDES 1200A: Non-metallic minerals (119145)	COC Quantity
36-0025	Crabtree Pit	Yamhill	Newberg	Mining Permits	NPDES 1200A: Other Crushed Stone (111269)	COC Quantity
36-0026	Crabtree Rock Company Inc.	Yamhill	Newberg	Mining Permits	NPDES 1200A: Other Crushed Stone (111269)	COC Quantity

Site ID	COMMON_NM	County	City	PCS Category	Contaminant of Concern	Data Gap
36-0060	Wilsonville Concrete Products Yamhill County Site	Yamhill	Wilsonville	Mining Permits	WPCF 1000 (108480)	COC Quantity
20612	Impervious Surface	Yamhill	Newberg	Other Potential Contaminant Sources	Unknown	COC Type; COC Quantity
20614	Unknown Operations	Yamhill	Newberg	Other Potential Contaminant Sources	Unknown	COC Type; COC Quantity
104036	YAMHILL COUNTY DEPT. OF PLANNING & DEVELOPMENT	YAMHILL	N/A	Solid Waste Sites	Leachate	COC Quantity
105034		MARION	N/A	Solid Waste Sites	Unknown	COC Quantity
112011	PACIFIC COMPOSTING FACILITY	CLACKAMAS	N/A	Solid Waste Sites	Unknown	COC Type
112115	AGRI-PLAS, INC.	MARION	N/A	Solid Waste Sites	Unknown	COC Quantity
112200	ECOLOGY COMPOSTING	YAMHILL	N/A	Solid Waste Sites	Bacteria/Pathogens, TSS, BOD, Iron	COC Quantity
119987	A-DEC, INC.	YAMHILL	Newberg	Water Quality Permits	Stormwater	Toxicity
110391	BUFF AUTO CENTER	YAMHILL	Newberg	Water Quality Permits	Wastewater	Toxicity
124580	DONALD INDUSTRIAL PARK	MARION	N/A	Water Quality Permits	Stormwater	Toxicity
117630	FIRST STUDENT - NEWBERG	YAMHILL	Newberg	Water Quality Permits	Stormwater	Toxicity
112076	FMC TECHNOLOGIES INC.	YAMHILL	Newberg	Water Quality Permits	Stormwater	Toxicity

Site ID	COMMON_NM	County	City	PCS Category	Contaminant of Concern	Data Gap
124558	MARION AG	MARION	N/A	Water Quality Permits	Stormwater, Minor	Toxicity
105664	MORSE BROS.,INC.	MARION	N/A	Water Quality Permits	Wastewater	Toxicity
72615	NEWBERG OR, LLC	YAMHILL	N/A	Water Quality Permits	Stormwater	Activity Status
72615	NEWBERG OR, LLC	YAMHILL	N/A	Water Quality Permits	BOD5	Activity Status
72615	NEWBERG OR, LLC	YAMHILL	N/A	Water Quality Permits	TSS	Activity Status
115992	NEWBERG TRANSFER STATION AND RECYCLING CENTER	YAMHILL	N/A	Water Quality Permits	Stormwater	Toxicity
126023	RIVERRUN (A SUBDIVISION)	Yamhill	Newberg	Water Quality Permits	Stormwater	Toxicity
84076	ST. PAUL, CITY OF	MARION	N/A	Water Quality Permits	Biosolids	Toxicity
84076	ST. PAUL, CITY OF	MARION	N/A	Water Quality Permits	Wastewater, Domestic	Toxicity

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Appendix C: Toxicity Database

Database Notes
If an exact CAS was available, it was used. For non-petroleum mixtures, the chemical with the lowest HHSL that was >1% of the mixture was used and the chemical was noted in "Surrogate Chemical Basis" and the percent composition noted in "Percent of Product". Petroleum mixtures were separated into three general classes depending on distillate class. See "Petroleum" tab for a more detailed explanation.
Oregon Water Quality Criteria (WQC) are included for reference purposes only. These numbers are from the Oregon Toxic Standards Rule (OAR 340-041-0033) and are based on long-term consumption of water and aquatic biota (fish, shellfish). Included here as the "Oregon WQC" tab, and retrieved from a digitized PDF of the tables available at: https://secure.sos.state.or.us/oard/viewAttachment.action?ruleVrsnRsn=256054
Screening levels from various sources are compiled based on the chemical's CAS number or surrogate CAS number.
Oregon MCLs and ALs from OAS 333-061-0030. Included here as the "Oregon MCLs" tab, retrieved from digitized PDF of the rules available at: https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/DRINKINGWATER/RULES/Documents/61-0030.pdf
EPA RSLs and MCLs are from the latest RSL table, included here as the "Res Tap Water 1122" tab, retrieved from https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables for a target hazard quotient (THQ) of 1.0.
Other health-based screening values included as applicable if no other screening level is available. Units for these values may not be ug/L (for example, units for radioactive components are in pCi/L). Units are listed in the "Notes on Chemical Identity" column.
The lowest nonzero screening level from columns I through O is applied as the lowest health-based screening level.
If the screening level is based on a component of a larger mixture, the screening level is adjusted upwards based on the percentage of the mixture that is the chemical the screening level is based on.
Key
Chemical Identity Determination Columns
Health Based Screening Levels

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Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition -Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
1-Decene, homopolymer, hydrogenated	872-05-9			68037-01-4							**N/A**	No Screening Level
Automatic Transmission Fluid		Heavy		E1790670					60000		**60000**	EPA Noncancer RSL (ug/L)
ACETYLENE	74-86-2			74-86-2	NA						**99999999**	No Screening Level
Adipic Acid	124-04-9			124-04-9					40000		**40000**	EPA Noncancer RSL (ug/L)
Ammonia as N	7664-41-7			7664-41-7	NA						**99999999**	No Screening Level
Batteries, (Lead Acid)	8014-95-7			7439-92-1		15	15		15	481000	**25**	OR MCL/AL (ug/L)
Biosolids				n/a							**N/A**	No Screening Level
BOD, 5-day, 20 deg. C				n/a							**N/A**	No Screening Level
Cadmium	7440-43-9			7440-43-9		5					**5**	OR MCL/AL (ug/L)
Calcium chloride	10043-52-4			10043-52-4							**N/A**	No Screening Level
CALCIUM HYDROXIDE	1305-62-0			1305-62-0							**N/A**	No Screening Level

Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition -Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
CALCIUM SULFATE	99400-01-8			99400-01-8							**N/A**	No Screening Level
Carbon Black				1333-86-4							**N/A**	No Screening Level
CARBON DIOXIDE	124-38-9			124-38-9	NA						**99999999**	No Screening Level
Chromium	7440-47-3			18540-29-9				0.035	44		**0.035**	EPA Cancer RSL (ug/L)
Grease Lubricants		Heavy	Mineral Oil	E1790670					60000		**60000**	EPA Noncancer RSL (ug/L)
Hydraulic Oil	8012-95-1	Heavy	Mineral Oil	E1790670					60000		**60000**	EPA Noncancer RSL (ug/L)
Lubricating Oil	8012-95-1	Heavy	Mineral Oil	E1790670					60000		**60000**	EPA Noncancer RSL (ug/L)
Motor Oil		Heavy	Mineral Oil	E1790670					60000		**60000**	EPA Noncancer RSL (ug/L)
Ethanol	64-17-5			64-17-5							**N/A**	No Screening Level
Ethylene Glycol	107-21-1			107-21-1					16000		**16000**	EPA Noncancer RSL (ug/L)

Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition-Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
Oil and grease	68153-81-1	Heavy	Mineral Oil	E1790670					60000		**60000**	EPA Noncancer RSL (ug/L)
Glass oxide	65997-17-3			65997-17-3	NA						**99999999**	No Screening Level
HELIUM, COMPRESSED	7440-59-7			7440-59-7	NA						**99999999**	No Screening Level
Used Oil		Heavy	Mineral Oil	E1790670					60000		**60000**	EPA Noncancer RSL (ug/L)
Waste Oil		Heavy	Mineral Oil	E1790670					60000		**60000**	EPA Noncancer RSL (ug/L)
Iron Oxide	1332-37-2			7439-89-6		300			14000		**300**	OR MCL/AL (ug/L)
Isopropyl Alcohol	67-63-0			67-63-0					410		**410**	EPA Noncancer RSL (ug/L)
Lead	7439-92-1			7439-92-1		15	15		15		**15**	OR MCL/AL (ug/L)
Oil		Heavy	Mineral Oil	E1790670					60000		**60000**	EPA Noncancer RSL (ug/L)
Nickel	7440-02-0			7440-02-0					390		**390**	EPA Noncancer RSL (ug/L)
Nitrogen	7727-37-9			7727-37-9	NA						**99999999**	No Screening Level

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Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition-Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
Oxygen	7782-44-7			7782-44-7	NA						**99999999**	No Screening Level
PERLITE				n/a	NA						**99999999**	No Screening Level
PHOSPHORIC ACID	7664-38-2			7664-38-2							**N/A**	No Screening Level
Phosphorus	7723-14-0			7723-14-0					0.4		**0.4**	EPA Noncancer RSL (ug/L)
Portland Cement	65997-15-1			65997-15-1							**N/A**	No Screening Level
PROPANE	74-98-6			74-98-6	NA						**99999999**	No Screening Level
Propylene Glycol	57-55-6			57-55-6					400000		**400000**	EPA Noncancer RSL (ug/L)
Sand				n/a	NA						**99999999**	No Screening Level
SILICON DIOXIDE	7631-86-9			7631-86-9							**N/A**	No Screening Level
sodium hydroxide	1310-73-2			1310-73-2	NA						**99999999**	No Screening Level

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Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition-Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
sodium hypochlorite	7681-52-9			7681-52-9							**N/A**	No Screening Level
Solids, total suspended				n/a	NA						**99999999**	No Screening Level
STORM WATER INDUSTRIAL				n/a							**N/A**	No Screening Level
Titanium Dioxide	13463-67-7			13463-67-7							**N/A**	No Screening Level
Total Residual Chlorine				7782-50-5			4.0E+03 (G)		0.3		**0.3**	EPA Noncancer RSL (ug/L)
ASPHALT		Heavy		E1790670					60000		**60000**	EPA Noncancer RSL (ug/L)
Asphalt Liquid		Heavy		E1790670					60000		**60000**	EPA Noncancer RSL (ug/L)
PARAMOUNT PROCESS OIL 6001		Heavy	Mineral Oil	E1790670					60000		**60000**	EPA Noncancer RSL (ug/L)
Asphalt Emulsion Base		Heavy	Mineral Oil	E1790670					60000		**60000**	EPA Noncancer RSL (ug/L)
Drive train fluid (HIGHLY REFINED MINERAL OIL (C15-C50))		Heavy	Mineral Oil	E1790670					60000		**60000**	EPA Noncancer RSL (ug/L)

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Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition-Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
HIGHLY REFINED MINERAL OIL (C15-C50)		Heavy	Mineral Oil	E1790670					60000		**60000**	EPA Noncancer RSL (ug/L)
Gasoline		Light		E1790672					33		**33**	EPA Noncancer RSL (ug/L)
KEROSENE	8008-20-6	Light	Benzene	E1790672					33		**33**	EPA Noncancer RSL (ug/L)
AVIATION FUEL 100LL (HIGHLY BRANCHED PARAFFINIC HYDROCARBONS)		Light		E1790672					33		**33**	EPA Noncancer RSL (ug/L)
Light fuel, Lubricant		Light	Benzene	E1790672					33		**33**	EPA Noncancer RSL (ug/L)
Calcium carbonate	471-34-1			471-34-1							**N/A**	No Screening Level
Light fuel, lubricant, paints		Light	Benzene	E1790672					33		**33**	EPA Noncancer RSL (ug/L)
Light fuel, oils, solvents, detergents		Light	Benzene	E1790672					33		**33**	EPA Noncancer RSL (ug/L)
Petroleum		Light	Benzene	E1790672					33		**33**	EPA Noncancer RSL (ug/L)

Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition -Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
PETROLEUM HYDROCARBON		Light	Benzene	E1790672					33		**33**	EPA Noncancer RSL (ug/L)
PETROLEUM HYDROCARBONS	NA	Light	Benzene	E1790672					33		**33**	EPA Noncancer RSL (ug/L)
Heavy Metals				7439-92-1		15	15		15		**15**	OR MCL/AL (ug/L)
Racing Fuel		Light	Benzene	E1790672					33		**33**	EPA Noncancer RSL (ug/L)
2-methylpentane-2,4-diol	107-41-5			107-41-5							**N/A**	No Screening Level
5-CHLORO-2-METHYL-2H-ISOTHIAZOL-3-ONE	26172-55-4			26172-55-4							**N/A**	No Screening Level
Acetal Polymer (Solid)	9002-81-7			9002-81-7	NA						**99999999**	No Screening Level
Aggregate					NA						**99999999**	No Screening Level
Ammonium Nitrate	6484-52-2			6484-52-2							**N/A**	No Screening Level
AMMONIUM SULFATE	7783-20-2			7783-20-2							**N/A**	No Screening Level

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Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition-Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
AMORPHOUS SILICA	7631-86-9			7631-86-9							**N/A**	No Screening Level
ARGON	7440-37-1			7440-37-1	NA						**99999999**	No Screening Level
ARGON (gas)	7440-37-1			7440-37-1	NA						**99999999**	No Screening Level
BASE RESIN											**N/A**	No Screening Level
BLOOD MEAL					NA						**99999999**	No Screening Level
BONE MEAL					NA						**99999999**	No Screening Level
BORIC ACID	10043-35-3			10043-35-3							**N/A**	No Screening Level
Bronze C873 (solid)					NA						**99999999**	No Screening Level
CALCIUM CARBONATE	471-34-1			471-34-1							**N/A**	No Screening Level
CALCIUM CARBONATE/LIME STONE	471-34-1			471-34-1	NA						**99999999**	No Screening Level

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Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition-Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
Calcium Nitrate	13780-06-8			13780-06-8							**N/A**	No Screening Level
Calcium Oxide	1305-78-8			1305-78-8							**N/A**	No Screening Level
CALCIUM OXIDE (Portland cement)	1305-78-8			1305-78-8							**N/A**	No Screening Level
CALCIUM POLYSULFIDE	1332-68-9			1332-68-9							**N/A**	No Screening Level
Cement (Solid)	n/a			n/a	NA						**99999999**	No Screening Level
CHLORINE GAS	7782-50-5			7782-50-5			4.0E+03 (G)		0.3		**0.3**	EPA Noncancer RSL (ug/L)
Chlorine, Total Residual	7782-50-5			7782-50-5			4.0E+03 (G)		0.3		**0.3**	EPA Noncancer RSL (ug/L)
DARAVAIR 1000 SPECIALTY CONSTRUCTION PRODUCT GCP APPLIED TECHNOLOGIES				061790-51-0							**N/A**	No Screening Level
DIURON	330-54-1			330-54-1					36		**45**	EPA Noncancer RSL (ug/L)

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Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition-Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
DOLOMITE Pelletized					NA						**99999999**	No Screening Level
E. Coli											**N/A**	No Screening Level
ETHYLENEDIAMINE	107-15-3			107-15-3					1800		**1800**	EPA Noncancer RSL (ug/L)
Fatty Acid Derivatives											**N/A**	No Screening Level
FERROUS SULFATE	7720-78-7			7439-89-6		300			14000		**815.2173913**	OR MCL/AL (ug/L)
GYPSUM					NA						**99999999**	No Screening Level
GYPSUM Pelletized					NA						**99999999**	No Screening Level
HEXYLENE GLYCOL	107-41-5			107-41-5							**N/A**	No Screening Level
HYDROGEN CHLORIDE	7647-01-0			7647-01-0					42		**42**	EPA Noncancer RSL (ug/L)
IRON (Welding Wire) (Solid)					NA						**99999999**	No Screening Level

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Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition-Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
IRON HUMATE				1309-38-2							**N/A**	No Screening Level
Iron- Stainless Steel (Solid)					NA						**99999999**	No Screening Level
Iron-- Steel Alloys (Solid)					NA						**99999999**	No Screening Level
ISOOCTYL (2-ETHYLHEXYL) ESTER OF 2,4-D	1928-43-4			1928-43-4							**N/A**	No Screening Level
Diesel Fuel	68334-30-5	Medium		E1790668					100		**100**	EPA Noncancer RSL (ug/L)
LIMESTONE					NA						**99999999**	No Screening Level
LIMESTONE (Solid)					NA						**99999999**	No Screening Level
MBAE 90											**N/A**	No Screening Level
METALDEHYDE	108-62-3			108-62-3							**N/A**	No Screening Level
Modified Tall Oil Fatty Acid	61790-12-3			61790-12-3							**N/A**	No Screening Level

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Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition-Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
Nitrogen, TKN	Total Nitrate + Nitrite (as N)			Total Nitrate + Nitrite (as N)		10000					**10000**	OR MCL/AL (ug/L)
Pelletized Limestone					NA						**99999999**	No Screening Level
PHENOL	108-95-2			108-95-2					5800		**5800**	EPA Noncancer RSL (ug/L)
POLY-4,4'ISOPROPYLIDENEDIPHENYL CARBONAT	24936-68-3			24936-68-3							**N/A**	No Screening Level
POLYHEXAMETHYLENE ADIPAMIDE	32131-17-2			32131-17-2							**N/A**	No Screening Level
POLYPHENYLENE SULFIDE	9016-75-5			9016-75-5							**N/A**	No Screening Level
Potassium Chloride	7447-40-7			7447-40-7							**N/A**	No Screening Level
POTASSIUM METABISULFITE	16731-55-8			16731-55-8							**N/A**	No Screening Level
POTASSIUM SULFATE	7778-80-5			7778-80-5							**N/A**	No Screening Level

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Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition-Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
Sodium Hydroxide	1310-73-2			1310-73-2							**N/A**	No Screening Level
STYRENE	100-42-5			100-42-5		100	100		1200		**100**	OR MCL/AL (ug/L)
SULFUR	7704-34-9			7704-34-9							**N/A**	No Screening Level
TITANIUM OXIDE (solids)	12035-95-9			12035-95-9							**N/A**	No Screening Level
Triethanolamine	102-71-6			102-71-6							**N/A**	No Screening Level
TRIPHENYL PHOSPHATE	115-86-6			115-86-6							**N/A**	No Screening Level
UREA	57-13-6			57-13-6							**N/A**	No Screening Level
Waste Tires (Rubber) (Solid)					NA						**99999999**	No Screening Level
XCU											**N/A**	No Screening Level
ZINC SULFATE	7733-02-0			7440-66-6		5000			6000		**12345.67901**	OR MCL/AL (ug/L)
COD											**N/A**	No Screening Level

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Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition-Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
NO2 as N	14797-65-0 (Nitrite)			14797-65-0 (Nitrite)		1000					**1000**	OR MCL/AL (ug/L)
NO3 as N	7697-37-2 (Nitrate)			7697-37-2 (Nitrate)		10000					**10000**	OR MCL/AL (ug/L)
Organic N	Total Nitrate + Nitrite (as N)			Total Nitrate + Nitrite (as N)		10000					**10000**	OR MCL/AL (ug/L)
TKN	Total Nitrate + Nitrite (as N)			Total Nitrate + Nitrite (as N)		10000					**10000**	OR MCL/AL (ug/L)
Na	7440-23-5			7440-23-5							**N/A**	No Screening Level
SO4	14808-79-8			14808-79-8		250000					**250000**	OR MCL/AL (ug/L)
2,4-D	94-75-7			94-75-7		70	70		170		**70**	OR MCL/AL (ug/L)
Aluminum Alloy (solid)					NA						**99999999**	No Screening Level
Aluminum Alloy Ingots (solid)					NA						**99999999**	No Screening Level
Atrazine	1912-24-9			1912-24-9		3	3	0.3	54		**0.3**	EPA Cancer RSL (ug/L)
Carbaryl	63-25-2			63-25-2					1800		**1800**	EPA Noncancer RSL (ug/L)

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Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition -Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
Chlorpyrifos	2921-88-2			2921-88-2					8.4		**8.4**	EPA Noncancer RSL (ug/L)
Creosote; pentachlorophenol (PCP); arsenic; chromium; copper; PCB; PAHs; beryllium; dioxin; wood preservatives				18540-29-9				0.035	44		**0.035**	EPA Cancer RSL (ug/L)
DIATOMACEOUS EARTH, NATURAL					NA						**99999999**	No Screening Level
Diazinon	333-41-5			333-41-5					10		**10**	EPA Noncancer RSL (ug/L)
Dichlobenil	1194-65-6			1194-65-6							**N/A**	No Screening Level
Dimethenamid-P	163515-14-8			163515-14-8							**N/A**	No Screening Level
Endosulfan	115-29-7			115-29-7					100		**100**	EPA Noncancer RSL (ug/L)
Ethoprop	13194-48-4			13194-48-4							**N/A**	No Screening Level

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Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition-Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
Formaldehyde; radionuclides; photographic chemicals; solvents; mercury; ethylene oxide; chemotherapy chemicals				50-00-0				0.39	20		**0.39**	EPA Cancer RSL (ug/L)
Glyphosate	1071-83-6			1071-83-6		700	700		2000		**700**	OR MCL/AL (ug/L)
Hexazinone	51235-04-2			51235-04-2					640		**640**	EPA Noncancer RSL (ug/L)
LIGNOSULFONIC ACID	8062-15-5			8062-15-5							**N/A**	No Screening Level
Metalaxyl	57837-19-1			57837-19-1					1200		**1200**	EPA Noncancer RSL (ug/L)
Metals (such as chromium, cadmium, lead, and zinc); VOCs; chloroform; ethyl benzene; solvents; paints; inks				18540-29-9				0.035	44		**0.035**	EPA Cancer RSL (ug/L)
Metals; VOCs; dioxin; beryllium; degreasing agents; solvents; waste oils				7440-41-7		4	4		25		**4**	OR MCL/AL (ug/L)

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Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition-Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
Napropamide	15299-99-7			15299-99-7					2000		**2000**	EPA Noncancer RSL (ug/L)
NITROGEN (gas)					NA						**99999999**	No Screening Level
NITROGEN (Liquid)					NA						**99999999**	No Screening Level
NYLON 66	32131-17-2			32131-17-2	NA						**99999999**	No Screening Level
OXYGEN (Liquid)	7782-44-7			7782-44-7	NA						**99999999**	No Screening Level
PCBs, Copper				1336-36-3		0.5	0.5				**0.5**	OR MCL/AL (ug/L)
SEVERELY HYDROTREATED PETROLEUM OIL		Medium	n-Nonane	E1790668					100		**100**	EPA Noncancer RSL (ug/L)
Pharmaceuticals, mercury, silver, tin, copper				7487-94-7			2		5.7		**2**	EPA MCL (ug/L)
Plastics											**N/A**	No Screening Level
Polymers, phtalates, cadmium, solvents, resins,				7440-43-9		5					**5**	OR MCL/AL (ug/L)

Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition-Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
chemical additives, VOCs												
PVC Compounds (solid)					NA						**99999999**	No Screening Level
Salt Mix				7647-14-5							**N/A**	No Screening Level
SAND, SILICA, QUARTZ, Concrete Mix					NA						**99999999**	No Screening Level
SAND, SILICA, QUARTZ, Mortar Mix					NA						**99999999**	No Screening Level
Sediment, TSS											**N/A**	No Screening Level
SILICA, SAND CRYSTALLINE					NA						**99999999**	No Screening Level
Simazine	122-34-9			122-34-9		4	4	0.61	94		**0.61**	EPA Cancer RSL (ug/L)
SODIUM CHLORIDE (SALT)	7647-14-5			7647-14-5							**N/A**	No Screening Level
SODIUM GLUCONATE	526-95-4			526-95-4							**N/A**	No Screening Level
Triclopyr	55335-06-3			55335-06-3							**N/A**	No Screening Level

Chemical (PCS) Name	CAS #	Petroleum Category	Surrogate Chemical Basis	Surrogate CAS #	Non-Toxic/Minimal Risk Status (NA)	OR MCL/AL (ug/L)	EPA MCL (ug/L)	EPA Cancer RSL (ug/L)	EPA Noncancer RSL (ug/L)	Other Health Screening Level (see notes for units)	Percent-Composition-Adjusted Health-Based Screening Level (ug/L)	Screening Level Basis?
Trifluralin	1582-09-8			1582-09-8				2.6	40		**2.6**	EPA Cancer RSL (ug/L)
Trifuralin	1582-09-8			1582-09-8				2.6	40		**2.6**	EPA Cancer RSL (ug/L)
Waste Lead Acid Batteries (solid)				7439-92-1		15	15		15		**25**	OR MCL/AL (ug/L)

Appendix 2-D

Hazen *Technical Memorandum*

October 30, 2023

To: Jacob Krall, Geosyntec Consultants, Inc.

From: Ben Wright, PE
Andy McCaskill, PE
Hester Aw, EIT

Vulnerability Analysis Technical Memorandum

Watershed Protection, Monitoring, and Outreach Plan Task 8.2

Introduction

The information provided in this technical memorandum (Memo) is part of a larger effort to develop a Watershed Protection, Monitoring, and Outreach Plan (Source Water Protection Plan) for the Willamette Intake Facilities (WIF) Commission. This Memo presents findings of a vulnerability analysis applicable to the Willamette River Water Treatment Plant (WTP) in Wilsonville and future Willamette Water Supply System (WWSS) WTP to inform the WIF in its efforts to perform watershed protection activities with the goal of reducing potential contaminants originating in the watershed. Note that the processes are similar between the two WTPs with the exception of ultraviolet light disinfection at WWSS WTP, which is not part of the Willamette River WTP. Therefore, for this analysis, the processes at the WWSS WTP are used as the basis for the evaluation.

The WIF Partners will be investing in source water protection to monitor and advocate to maintain or enhance the quality of the water supply. This memo focuses on the water treatment processes in order to prioritize key contaminants on which the WIF's Source Water Protection Plan can focus. Source water protection is the first barrier of many in providing clean drinking water. Drinking water risks are managed through the application of multiple treatment barriers, providing a comprehensive strategy of treatment processes to remove or reduce contaminants in drinking water. This approach recognizes that no single treatment process or technology can eliminate all contaminants in drinking water. Instead, a series of treatment barriers are used to provide multiple layers of protection against potential contaminants. This approach helps to ensure that even if one barrier is less effective in treating a particular contaminant or is temporarily offline for maintenance, there are other barriers in place that continue to provide protection.

In Task 8.1, high-priority Potential Contamination Sources (PCS) were identified based on potential toxicity and time-of-travel modeling for contaminants of concern (COC) (Geosyntec, 2023). This memo for Task 8.2 builds on the prior memo by providing an assessment of the ability of the WTPs to effectively treat identified COCs. A review of the treatment processes employed at the WTPs and an assessment of the treatability of the classes of potential contaminants identified in the Willamette watershed is provided. In addition, an evaluation of potential changes in water quality that could result from extreme events (droughts, storms, forest fires, etc.) is included.

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Treatment Processes at WWSS WTP

This section provides an overview of the treatment processes designed for the WWSS WTP based on the Willamette Water Supply Program WTP_1.0 Predesign Report (Tualatin Valley Water District and City of Hillsboro, 2019). The WWSS WTP will withdraw water from the same location in the Willamette River as the City of Wilsonville's Willamette River WTP (WRWTP). As part of the design process, raw and finished water quality trends and WRWTP operational performance were reviewed and utilized in the development of WWSS WTP treatment processes. The resulting design for WWSS WTP builds off the successful treatment of the Willamette River supply by the WRWTP for more than twenty years and utilizes similar treatment processes.[1] The design parameters for WWSS WTP are based on hundreds of Willamette River water quality samples over many years to characterize treatment needs.

Figure 1 provides an overall process flow diagram of the treatment plant, and Table 1 provides a summary of the classes of constituents addressed by each major process.

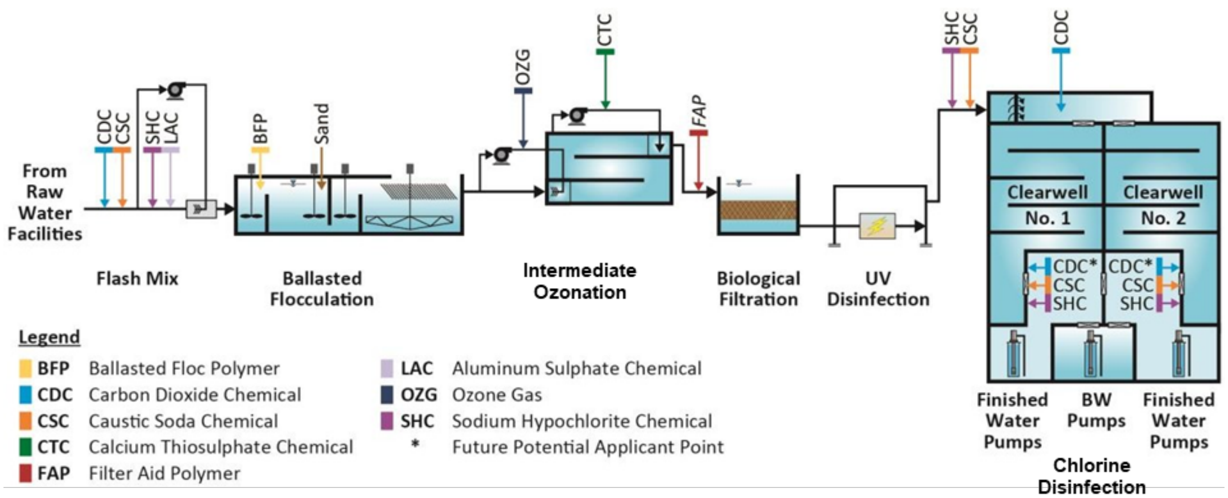

Figure 1: WWSS WTP Process Train and Chemical Application Points (Figure 3-11 in the WTP_1.0 Predesign Report)

Table 1: Treatment Barriers Provided by WWSS WTP (WWSS Commission)

Constituent	Ballasted Flocculation	Intermediate Ozonation	Biological Filtration	UV Disinfection	Chlorine Disinfection
Turbidity/Particles	X		X		
Pathogens	X[1]	X	X	X	X
Taste and Odors		X	X		
Trace Organics		X	X		
Emerging Contaminants		X	X	X	

1- Coagulation/flocculation does get some pathogen credit removal per USEPA (2010).

[1] https://www.ci.wilsonville.or.us/publicworks/page/water-treatment-plant

Coagulation, Flocculation, and Sedimentation

Coagulation, flocculation, and sedimentation (collectively referred to as clarification) are important physical separation processes designed to remove sediment and particles from water. The specific technology that will be employed at WWSS WTP is ballasted flocculation, which is a high-rate clarification process that is similarly employed at the WRWTP. Ballasted flocculation enables faster settling times as compared to conventional flocculation, enabling the process to treat the same amount of water with approximately one-third the total tank volume of conventional clarification processes. Figure 1 depicts a typical ballasted flocculation configuration.

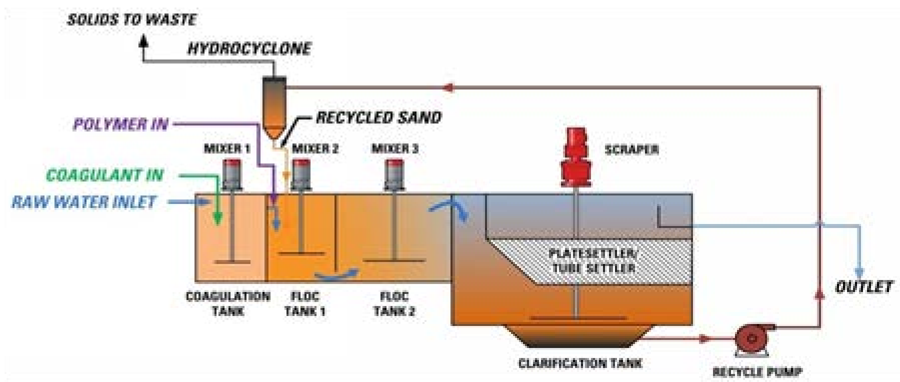

Figure 2: Ballasted Flocculation Flow Schematic (RapiSand by WesTech) (Figure 17.3-1 in the WTP_1.0 Predesign Report)

The process begins with the addition of a coagulant injected with the raw water, which mixes in the coagulation tank.[2] Water then flows into the first of two flocculation chambers, where polymer and microsand are added and mixed before flowing into the second flocculation chamber. The microsand and polymer bind to raw water solids promoting the formation of large and heavy floc[3] to be removed in the clarification tank, which includes stacks of inclined plates to enhance settling of solids.

Turbidity and particles are the primary constituents removed by coagulation, flocculation, and sedimentation. These include suspended solids, colloidal particles, and natural organic matter. In addition, the clarification process may remove some pathogens from raw water. Clarification is also effective at removing algae and cyanobacteria cells from source water, which reduces the potential for cyanotoxins or algae-derived taste and odor compounds to impact drinking water.

[2] Chemicals added during flocculation neutralize the electrical charge of particles, allowing them to join together and settle out of the water column.
[3] Flocs are an agglomeration of particles formed during clarification. Flocs are larger and denser than the naturally occurring particles, which enables rapid settling during sedimentation.

Ozone

Ozone is a powerful oxidizing agent commonly used in drinking water treatment because it reacts with target constituents including pathogens, taste and odor compounds, trace organics, and many emerging contaminants. In WWSS WTP and WRWTP, ozone is referred to as intermediate ozone, because it occurs prior to the filtration process and enhances the effectiveness of biological filtration. Ozone breaks down natural organic matter,[4] such as humic and fulvic acids, into smaller, less complex molecules that are more easily removed in the downstream biological filtration process. In addition, ozone provides valuable public health protection by inactivating pathogens (e.g., Cryptosporidium, Giardia, and viruses).[5] Further, ozone effectively oxidizes multiple types of cyanotoxins produced by cyanobacteria. Some synthetic organic chemicals are also targeted by ozone, breaking them down into smaller, less complex molecules. Ozonation is generally effective against trace chemicals, such as caffeine, some pharmaceuticals, and endocrine disruptors, while pesticides tend to be the more recalcitrant (Broséus et al., 2009). For example multiple prior studies evaluated the treatment efficacy of ozone on pesticides, and out of over 60 pesticides ozonation was effective for ten (atrazine, alachlor, chlorfenvinphos, isoproturon, diuron, parathion methyl, dimethoate, chlortoluron, metoxuron, and vinclozolin) (Meijers et al., 1995; Maldonado et al., 2006; Ormad et al., 2008; Pisarenko et al., 2012). Overall, effectiveness of treatment was dependent on ozone dose and contact time. Another benefit is ozonation helps to improve the overall taste, odor, and color of treated water.

Biologically Active Filters

Biologically active filtration (BAF) is a water treatment process that uses a combination of biological and physical processes to remove constituents from water. When ozone is used in combination with BAF, it is known as ozone biologically active filtration (O3-BAF). The biologically active filters in WWSS WTP and WRWTP are designed to use granular activated carbon (GAC) as the filter bed material. The filtration process will achieve the following treatment objectives:

- Turbidity removal;
- *Cryptosporidium*, *Giardia*, and virus removal;
- Removal of additional biodegradable organic matter; and
- Removal of taste and odor compounds and algal metabolites.

[4] Natural organic matter contributes to disinfection byproduct formation, which are regulated constituents in drinking water.

[5] The level of inactivation is calculated based on log inactivation tables provided by the USEPA.

While GAC filter media has some adsorptive removal capabilities for trace organic chemicals and a number of emerging contaminants of concern, it is not the purpose of GAC in this application. High loadings of these constituents would require frequent GAC regeneration or replacement to maintain removal efficacy.

Post-Filter Disinfection

The purpose of disinfection in drinking water treatment is to remove or inactivate harmful microorganisms such as bacteria, viruses, and parasites that can cause waterborne diseases. WWSS WTP includes two layers of disinfection following filtration as part of WWSS's multi-barrier treatment strategy:

1. Ultraviolet (UV) light disinfection located after the biologically active filters.
2. Sodium hypochlorite addition for disinfection and to provide residual chlorine in the finished water.

UV Reactors

UV light disinfection is an effective treatment process for pathogens. UV light damages the internal cell structures of pathogenic organisms, rendering them incapable of replicating and producing infection. The goal for UV disinfection design for WWSS WTP is to achieve *Cryptosporidium* and *Giardia* inactivation.

Chlorine Contact Basins

Sodium hypochlorite addition for WWSS WTP will be used for disinfection and to provide residual chlorine in the finished water. The clearwell is designed to provide sufficient contact time for disinfection, given the typical range of water quality parameters (temperature and pH), volume of water in the clearwell, and chlorine dose.[6] Sodium hypochlorite is a widely used and effective disinfectant.

Classes of Contaminants and Treatment Capabilities

This section evaluates the ability of WWSS WTP to treat contaminants occurring at the intake. The Safe Drinking Water Act authorized the U.S. Environmental Protection Agency (USEPA) to set national health-based standards for drinking water to protect against both naturally occurring and man-made contaminants that may be found in drinking water. These regulations are also enforced at the state level through Oregon Administrative Rules for Drinking Water (Chapter 333, Division 061). The National Primary Drinking Water Regulations (NPDWR) set enforceable maximum contaminant levels (MCLs) for particular contaminants and/or set treatment standards for drinking water. The regulated contaminants are classified as microorganisms, disinfectants, disinfection byproducts, inorganic chemicals, organic

[6] Per the USEPA Surface Water Treatment Rule, the contact time required for disinfection is based on the time to inactivate viruses and *Giardia* cysts.

chemicals, and radionuclides.[7] In addition to the NPDWR MCLs, the regulations include guidance on secondary contaminants that can cause aesthetic impacts, including taste, odor, and visual changes in water. Further, there are a number of emerging contaminants of concern[8] for drinking water that are not currently regulated but may be regulated in the future. While not every potential contaminant is included in the list of primary or secondary standards, the framework is useful for considering efficacy of treatment for the various classes of contaminants.

Microorganisms include bacteria, viruses, and protozoa such as *Cryptosporidium* and *Giardia.* Turbidity is a surrogate parameter for microorganisms. In this review, turbidity is addressed separately from pathogens to better align with the treatment processes.

Disinfectants are limits on concentrations of chemicals added during treatment to avoid harmful treatment byproducts in the finished water, so this class is not considered in this review.

Disinfection byproducts are the reaction byproducts of disinfectants (typically chlorine compounds) with organic matter (typically measured as Total Organic Carbon). Since these contaminants are formed after treatment, the organic material that comprise disinfection byproduct precursors are evaluated.

Inorganic chemicals include metals, nitrogen compounds, and asbestos.

Organic chemicals include pesticides, industrial chemicals and BTEX.[9]

Aesthetic contaminants include metals (iron, manganese, copper, and aluminum) [10], odor, total dissolved solids, foaming agents and other constituents that could impact the aesthetic or cosmetic quality of drinking water.

Emerging contaminants cover a wide range of previously unregulated parameters. Per- and polyfluoroalkyl substances (PFAS)[11] and cyanotoxins are addressed in this analysis and discussion.

The Risk Analysis Refinement technical memo (Geosyntec, 2023) was used to identify the contaminant classes that would likely occur for each of the potential contaminant source categories (Table 2). The descriptions of the potential pollutants and COCs identified for each of the potential source of contaminant (PSC) category (summarized below from the Risk Analysis Refinement memo) were used to populate the matrix.

[7] Wilsonville's WRWTP last sampling resulted in non-detect for all regulated radionuclides. Further there are no reported sources of radionuclides in the watershed from prior watershed evaluations, as such, these contaminants are not included in this review.

[8] An emerging contaminant is typically described as a chemical or material characterized by a perceived, potential, or real threat to human health and a lack of published health standards. A contaminant also may be emerging stemming from the discovery of a new source or a new pathway to humans.

[9] BTEX refers to the chemicals benzene, toluene, ethylbenzene, and xylene, which occur in petroleum products and other industrial chemicals.

[10] Metals at high enough concentrations in source water can contribute to discoloration and objectionable tastes in finished water.

[11] PFAS is the subject of a draft MCL but is treated as an emerging contaminant in this memo because the regulations are not finalized.

- Dry Cleaners utilize industrial solvents and are included as high-risk PSC.
- Mining Sites were identified through permits issued by the Oregon Department of Geology and Mineral Industries.
- Confined Animal Feeding Operations (CAFOs) are defined as point sources of pollution and regulated under the National Pollutant Discharge Elimination System (NPDES) program.
- Water Quality Permits includes facilities permitted by the NPDES program (other than CAFOs) for discharges from industrial facilities, stormwater outfalls, and wastewater treatment plants.
- Boating Access Sites are boat launch ramps and slips present in the watershed.
- Route Crossings include road and railway bridges and culverts, which present a risk to surface water quality because they provide direct pathways to surface waters.
- Hazardous Material Generators are based on facilities regulated under the Resource Conservation and Recovery Act.
- Aboveground Storage Tanks (AST) and Hazardous Substance Information System (HSIS) are sites storing hazardous substances. These locations were identified from the Oregon Community Right to Know Hazardous Substance Manager database, managed by the Oregon Office of the State Fire Marshal.
- Other Potential Contamination Sources consisted of high-risk PCS that did not fit into the other categories. These sites consisted of agricultural operations with the potential for application or storage of fertilizer or pesticide products.
- Solid Waste Sites are from the Oregon Department of Environmental Quality's (DEQ) list of active permitted solid waste disposal locations.
- Environmental Cleanup Sites consist of hazardous environmental cleanup sites from the DEQ Environmental Cleanup Site Information Database (DEQ Environmental Cleanup Program).

Table 2: Matrix of Contaminant Classes by Potential Source of Contamination (Summarized from the Task 8.1 Risk Refinement Memo (Geosyntec, 2023))

	Pathogens	Turbidity	Disinfection Byproduct Precursors	Synthetic Organics	Inorganics	Aesthetic Contaminants	Emerging Contaminants
Dry Cleaners				X			
Mining Permits		X		X	X	X	
Confined Animal Feeding Operations	X	X	X	X		X	X
Water Quality Permits	X	X	X	X	X	X	X
Boating Access Sites				X			

Route Crossings				X			
Hazardous Material Generators				X	X		
AST/ HSIS				X	X		
Other Potential Contamination Sources			X	X			
Solid Waste Sites	X	X	X	X	X	X	X
Environmental Cleanup Sites				X	X		

Pathogens

Pathogens are microorganisms that can cause illness or disease when present in drinking water, typically originating from human or animal waste. Types of pathogens include bacteria, viruses, protozoa, and parasites. Sources of pathogens identified in the Willamette River watershed include confined animal feeding operations, NPDES-permitted discharges, and solid waste sites. Each of these types of facilities is permitted and managed to limit the discharge of pollutants. However, instances, such as maintenance problems, extreme rainfall, or flooding can result in increased loading of pathogens to the river from natural and human-caused sources due to sewer overflows, untreated discharges, animal waste, or increased runoff.

WWSS WTP and WRWTP include robust barriers to pathogens. Each of the three primary treatment processes (clarification, filtration, and disinfection) are effective at pathogen removal. Further, WWSS WTP utilizes multiple disinfectants (ozone, UV light, and free chlorine) that provide robust inactivation of a range of pathogenic organisms. Pathogen removal and inactivation is measured as log reduction for regulatory compliance. The total log reduction credits for the WWSS WTP exceed the minimum regulatory requirements for compliance with the Surface Water Treatment Rule and Long-Term 2 Enhanced Surface Water Treatment Rule (Table 3).

Table 3: Summary of WWSS WTP Log Reduction Credits (Excerpted from Table 3-5 in the WTP_1.0 Predesign Report)

Target Organism	OHA Primary Disinfection Requirements for Conventional Filtration Plants	OHA Regulatory Compliance Disinfection Credits for WWSS WTP	Log Reduction Credits for Public Health Protection at WWSS WTP
Giardia	3.0	6.0	7.0
Virus	4.0	6.0	20.0
Crypto	2.0	6.0	6.0

The WWSS WTP has multiple options to optimize treatment if a source water event results in an excessive load of pathogens. Options include:

- Increase coagulant dose for enhanced particle removal during clarification.
- Increase filter aid polymer for enhanced removal through filtration.
- Increase ozone, UV (WWSS WTP), or chlorine doses for additional disinfection.

Another option for operators to maintain the production of safe drinking water would be to temporarily reduce production rates. This would slow the flow rate through the system, increasing residence time through each process, maximizing treatment effectiveness. Microbiological sampling at the Wilsonville WRWTP resulted in no detection of pathogen indicators for the last five years (Wilsonville, 2023), demonstrating the effectiveness of the disinfection processes (ozone and free chlorine).

Turbidity

Turbidity is a measure of the cloudiness of water, typically caused by suspended particles, colloidal particles, and dissolved colored material (e.g., tannins). Turbidity is a regulatory surrogate for pathogens and is a key regulated parameter for drinking water. Further, sediment, cloudiness, or color in water is undesirable from an aesthetic standpoint and can result in the perception of unsafe water, leading to public concern and complaints to water providers. The WTP_1.0 Predesign Report (2019) presented data that indicates source water turbidity is typically less than 10 Nephelometric Turbidity Units (NTU)[12] but can occasionally exceed 100 NTU following rain events. For reference, the turbidity removal goal for the plant is less than 0.1 NTU 95% of the time in the finished water. Turbidity originates from erosion during rainfall events as well as discharges from a variety of facilities present in the watershed (e.g., mining operations, confined animal feeding operations, NPDES-permitted outfalls, and solid waste sites).

Clarification is the primary process for removing turbidity from raw water. Filtration also removes turbidity, but water entering the filters should have low turbidity (less than approximately 2.0 NTU), because high turbidity loads can clog filters leading to frequent backwashing. The flocculation and sedimentation process for WWSS WTP and WRWTP are designed to effectively remove turbidity over 100 NTU. Turbidity at the upper end of the range may require increased coagulant doses to optimize flocculation and sedimentation and reduced filter run times. Another consideration, particularly during extended periods of high turbidity, is the solids handling process. WWSS WTP is designed with a multi-step process to store, thicken, and dewater solids collected during clarification and filtration. If the solids handling rate is exceeded due to high turbidity loads, the water production rate would be reduced to maintain operations. Production rates can also be reduced to allow more residence time for flocculation and sedimentation during sustained heavy turbidity loads.

Water quality reporting for the Wilsonville WRWTP indicate that treated water had a turbidity of less than 0.1 NTU 100% of the time for the last five years (Wilsonville, 2023), indicating successful management of turbidity across a wide range of conditions.

[12] NTU is one of the standard units for turbidity, which is a unit for measuring light scatter through a water sample.

Disinfection Byproduct Precursors

Disinfection byproducts (DBPs) are chemicals that are formed when disinfectants (such as chlorine) react with naturally occurring organic matter (precursors) in water. Precursors can come from both natural and anthropogenic sources in the watershed. Sources include:

- Humic and fulvic acids are organic compounds formed from the decomposition of plant and animal material in soil and water.
- Algae and cyanobacteria produce organic compounds that can act as DBP precursors.
- Soil and sediment can be a source of organic compounds due to erosion.
- Wastewater effluent typically contains high levels of organic compounds.
- Industrial effluent can also be a source of organic compounds for water sources, which can include chemical manufacturing, food processing, and paper mills.

DBPs are formed when organic material comes into contact with disinfectants, primarily free chlorine.[13] Processes employed at WWSS WTP and WRWTP are designed to effectively remove DBP precursors to limit the formation of DBPs. Ozone breaks down organic matter into smaller compounds that can be consumed by microorganisms present on the BAF filter media, thus reducing the available precursor materials available to form DBPs.

In the event of higher-than-normal DBP precursor loads, there are process options that can minimize the potential for DBP formation.

- Increase coagulant dose and lower pH to enhance natural organic matter removal during clarification.
- Increase ozone dose to break down higher than normal loadings of organic matter.
- Reduce production rates.

Water quality reporting for the Wilsonville WRWTP indicate that DBPs are consistently well below regulatory levels (Wilsonville, 2023), which is indicative of the effectiveness of treatment processes for DBPs.

Synthetic Organic Contaminants (SOCs)

Synthetic organic contaminants (SOCs) are a broad class of man-made compounds. While there are 53 SOCs listed in the NPDWR, there are millions of types of organic chemicals in use. These include petroleum products, pesticides, pharmaceuticals, and industrial chemicals (KnowYourH2O, 2021). Because the category is so broad, there are many potential sources of SOCs that could impact the

[13] Ozone can also result in DBP formation (Manasfi & Boudenne, 2021). However, bromate is the only regulated DBP formed from ozonation, which requires high levels of bromide in the source water. This was indicated as a low risk based on data presented in the WTP_1.0 Predesign Report (2019).

Willamette River. Treatment of these materials is complicated because there is a wide range of chemical properties and no single treatment process that is effective for all chemicals. Because these chemicals often occur very intermittently in source waters, they rarely warrant investment in costly dedicated treatment technologies. SOCs are not common in the Willamette River. Prior analyses for the WRWTP of 30 SOCs and 50 volatile organic chemicals[14] resulted in no detections (Tualatin Valley Water District and City of Hillsboro, 2019). Further, the ozone and BAF treatment processes employed at WWSS WTP and WRWTP are effective at treating trace levels of organic chemicals. Petroleum products, particularly refined fuels, are the most common organic chemicals throughout the watershed by both number of potential locations and total volume. The WIF Commission has already developed relationships with Kinder Morgan, who operates the refined petroleum pipeline upstream of the intake and have conducted a tabletop emergency response exercise for spill response.

Inorganics

Inorganics are compounds that do not contain carbon. The USEPA regulates inorganics under the NPDWR, which includes nitrate/nitrite, asbestos, cyanide and 12 metals (antimony, arsenic, barium, beryllium, cadmium, chromium, copper, fluoride, lead, mercury, selenium, thallium). As there are few potential sources of inorganic contaminants in the watershed, inorganics are a relatively low risk in the Willamette River. Water quality sampling for the Wilsonville WRWTP have resulted in non-detect for most inorganic parameters or levels well below regulatory levels (nitrate and barium)[15] (Wilsonville, 2023). Nitrate/nitrite tend not to be major concerns in surface waters because the compounds are bioavailable and tend to attenuate naturally. The source of asbestos is erosion of natural deposits, none of which have been identified in the watershed. Metals in surface water systems tend to become part of the sediment mass through precipitation with carbonates, sulfides, phosphates, etc. or adsorption to clay or organic matter (USEPA, 2023). Cyanide is discharged from metal and plastic fabrication factories, which have not been identified in the watershed. As such, inorganic contaminants are unlikely to pose a major risk to WWSS WTP, consistent with the experience at the WRWTP.

Aesthetic Contaminants

The USEPA provides guidance concentrations for 15 parameters that can cause objectionable water quality.[16] These are primarily inorganic materials that result in taste and color in water (e.g., iron, manganese, sulfate, and total dissolved solids). These inorganic contaminants require specialized treatment if they occur in high enough concentrations in source water. Based on the information provided in the WTP_1.0 Predesign Report (2019), additional treatment is not warranted due to their low concentrations.

Taste and odor issues can also result from organic material and algal activity in the source water. These taste and odor issues are often associated with MIB (2-Methylisoborneol) and geosmin. These are

[14] Volatile organic chemicals are a subset of SOCs.

[15] Most regulated inorganic parameters were not detected in the Willamette River source water. Nitrate and barium were the typical inorganics detected and were well below regulatory levels.

[16] https://www.epa.gov/sdwa/secondary-drinking-water-standards-guidance-nuisance-chemicals

naturally occurring compounds that are produced by certain types of algae and bacteria and are characterized by strong earthy and musty odors. While MIB and geosmin are not considered harmful to humans, they can make drinking water unpalatable and unpleasant to taste and smell. While prior water quality analyses have not identified these substances in the Willamette River, a benefit of the O3-BAF process at WWSS WTP and WRWTP is its effectiveness at treating taste- and odor-causing substances by oxidizing and removing the constituents.

Emerging Contaminants of Concern

The USEPA continues to evaluate new and emerging contaminants that may pose a threat to human health through drinking water. Prior to initiating a rulemaking procedure to establish a new MCL for an emerging contaminant, the USEPA may begin by establishing a health advisory or including contaminants on the Unregulated Contaminant Monitoring Rule (UCMR) list. Health advisories are guidance documents that bring attention to particular contaminants without creating new drinking water standards. Including contaminants on the UCMR list enables regulators to establish the presence of contaminants in drinking water supplies across the country for future rulemaking.

While emerging contaminants are not required to be removed from drinking water, public alarm over emerging contaminants should be considered. It is beneficial to be prepared to respond to stakeholder concerns to emerging contaminants. A robust source water protection program that provides a procedure for evaluating emerging contaminants when they arise is a utility best management practice. Incorporating new contaminants into a source water monitoring plan and identifying PSC in the watershed can help a utility focus management efforts and articulate to the public that there is a response plan in place to address emerging contaminants. From a treatment perspective, it is generally more challenging to upgrade WTPs to address emerging threats, as compared to prevention and management in the drinking water source.

The following sections describe the treatability review of two recent emerging contaminants: PFAS and cyanotoxins.

Per- and Polyfluoroalkyl Substances (PFAS)

PFAS are a group of man-made chemicals that are found in a wide range of consumer products, including non-stick cookware, waterproof clothing, and food packaging. They are persistent in the environment and have been linked to a range of health issues, including cancer, thyroid disease, and developmental problems.

In May 2016, the USEPA established Health Advisory Levels for PFOA (perfluoroactanoic acid) and PFOS (perfluorooctanesulfonic acid). On March 14, 2023, EPA announced a proposed NPDWR for six PFAS compounds. The pre-publication release of the proposed rule included several supporting documents detailing the regulation of six PFAS chemicals (Table 3). If promulgated as published, this rule will require utilities to limit the presence of PFAS in drinking water. The 60-day public comment period ended on May 30, 2023, and the final rule is expected by the end of 2023 with a three-year implementation schedule. To better understand the occurrence of PFAS, the WRWTP will begin sampling in 2024 for 29 PFAS chemicals under the Unregulated Contaminant Monitoring Rule 5 (UCMR5) at distribution system entry points. This UCMR5 monitoring includes the six PFAS chemicals targeted in the proposed regulation. To date, both the prior WRWTP UCMR3 sampling, which included six PFAS compounds, and Oregon DEQ statewide screening have detected no PFAS compounds in the Willamette River. Further, neither sampling program found PFAS in surface water sources in Oregon.

Table 4: Regulated PFAS Compounds

Common Name	Full Compound Name
PFOA	Perfluoroactanoic acid
PFOS	Perfluorooctanesulfonic acid
GenX (also referred to as HFPO-DA)	Hexafluoropropylene Oxide Dimer acid
PFBS	Perfluorobutanesulfonic acid
PFNA	Perfluorononanoic acid
PFHxS	Perfluorohexanesulfonic acid

While not anticipated to be needed for treating Willamette River water, the following PFAS treatment summary is provided for reference. Several treatment technologies are known to be effective for the removal of PFAS compounds from drinking water including granular activated carbon (GAC), [17] Ion Exchange (IX), and high-pressure membranes (nanofiltration and reverse osmosis). Advanced oxidation processes have demonstrated some success for removing select PFAS compounds, but the performance is inconsistent and/or requires specialized catalysts. Several emerging treatment technologies are currently in development and include novel absorbents such as cyclodextrin polymers and surface modified organoclays, that may be available at scale in the future.[18] It should be noted the disposal of spent media and residuals from these processes will likely be expensive due to the concentrated levels of PFAS present.

Cyanotoxins

Cyanotoxins are toxins produced by cyanobacteria that can cause liver damage, respiratory problems, and other health issues. Cyanobacteria and their associated cyanotoxins have been found in source waters of drinking water utilities across the country. While not subject to regulatory control (i.e., maximum contaminant levels) in the US, the USEPA has published Health Advisories for total microcystins and Cylindrospermopsin. The Willamette River does not have a history of cyanotoxins on the mainstem Willamette River upstream of the intake.[19] While cyanotoxins are not anticipated for the Willamette River source of supply, WWSS WTP and WRWTP provide effective treatment against potential cyanotoxins.

[17] Note that the GAC used for the BAF should not be relied upon for sustained PFAS treatment. A dedicated GAC contactor would be required to enable swapping out GAC media once saturated without disturbing the BAF process.

[18] While commercial products for these technologies do not currently exist, they would likely be deployed as media in a contact vessel.

[19] The cyanotoxin detection in Salem, OR in May 2018 was at the Detroit Lake Reservoir and not in the mainstem Willamette River. The preliminary cyanotoxin detection by Wilsonville in June 2018 was determined to be a false positive based on subsequent verification sample testing. There have been cyanotoxin detections in the Willamette River in the Portland area downstream of Ross Island Lagoon, downstream of the intake and below Willamette Falls. However, regular source water sampling for cyanotoxins is still required at the intake per OAR 333-061-0510 Cyanotoxin Monitoring and Public Notification at Public Drinking Water Systems.

As stated in the Predesign Report (2019) "WWSS WTP will include both intermediate ozone and chlorine. Ozone is highly effective for destroying extracellular microcystin and cylindrospermosin within seconds of contact time. Chlorine is effective for oxidizing saxitoxin. The combination of ozone and chlorine provide an effective multi-barrier approach to prevent cyanotoxins from reaching the finished water supply."

Water Quality Challenges from Extreme Events

Extreme weather events can significantly impact source water quality which, in turn, can stress treatment plant processes and potentially impact finished water quality. As part of the design of WWSS WTP, anticipated extreme events were considered as part of the Resiliency, Reliability, Redundancy, and Recovery Plan. By considering the range of potential water quality changes from extreme events, decisions regarding treatment plant resiliency and operational enhancements can be made. Typical extreme events include heavy rainfall, flooding, snowmelt, drought, extreme temperatures, and wildfires; these conditions are defined below based on the Water Research Foundation report, *Water Quality Impacts of Extreme Weather-Related Events* (Stanford et al., 2014). The similar designs of the WWSS WTP and WRWTP are sufficiently robust that source water quality changes from extreme events would effectively be managed by the plants. A worst-case scenario following an extreme event that exceeded historical conditions may result in a temporary production slowdown in order to facilitate proper treatment during periods of very poor water quality due to extreme events but would not prevent the production of safe drinking water.

Heavy rainfall, flooding, and snowmelt: These events can result in water quality challenges through the mobilization and disturbance of contaminants in the watershed from surface erosion, stormwater discharges, and sewer overflows. These events typically result in increases in raw water turbidity and pathogen loads. Floods can also damage upstream infrastructure that may result in the transport of chemicals into source water supplies.

Drought: During droughts the lack of runoff can result in the accumulation of potential contaminants on the land surface that get mobilized once normal rainfall returns to the basin. Agricultural areas are the typical concern because of fertilizers, pesticides, and animal wastes applied to the land, which can contribute to DBP precursors, pathogens, and chemicals. While this could result in short-term water quality changes, they can be readily managed by the proposed plant design and are not a concern.

Extreme temperatures: High temperatures can result in multiple issues in the source water. [20] The rate of formation of DBPs is dependent on temperature. High temperature extremes can increase the speed at which DBPs are formed within the treatment plant and throughout the distribution system. Other heat-associated challenges include increased risk of algae blooms, taste and odor challenges, and pathogens in the source water.

[20] Higher air temperatures due to climate change can result in higher water temperatures that influence water quality.

Wildfires: Typical water quality changes after wildfire are associated with color, turbidity, algae, cyanobacteria, MIB, geosmin, nitrogen, and phosphorus. Runoff from burn scars can result in volatile organic carbon, such as benzene, being mobilized into drinking water sources (OHA, 2022).

Future Potential Effects of Climate Change

This section presents summaries of a few recent studies on future climate trends in the region that may affect water quality in the Willamette Basin. This section builds from evaluations conducted as part of phase 1 of the project (Geosyntec Consultants, 2022). Climate change is a threat multiplier that is expected to result in an increase of challenging conditions in the Willamette River in the future. While the specific changes in the Willamette Basin are uncertain, there are consistent trends across multiple studies (warmer temperatures, less snowfall, more extreme precipitation, higher wildfire risk) that are expected to impact water quality in the Willamette River.

Historical Trends and Future Projections of Climate and Streamflow in the Willamette Valley and Rogue River Basins

The Oregon Climate Change Research Institute (OCCRI) conducted a report for the U.S. Army Corp of Engineers Portland District summarizing potential future changes in temperature, precipitation, snowpack, and streamflow in the Willamette and Rogue River Basins using global climate model simulations. Future projections of these parameters are based on 20 global circulation models (GCMs) with a high degree of confidence. The OCCRI found that the annual average increase in minimum temperature would range between 0.8 to 5.3 degrees Fahrenheit, and 1.1 to 5.5 degrees Fahrenheit increase in maximum temperature. Snowfall is expected to generally decrease across the region. Mountainous areas that typically have high snowfall (e.g., North Santiam) were projected to see reductions from 27% to 67%, while areas that typically see limited snowfall (e.g., the Willamette Valley between Salem and Portland) were projected to receive no snow in most years. In terms of streamflow, the Willamette Basin was projected to experience increased flows in the winter, decreased flows in the summer, and an overall increase in annual peak flows (OCCRI 2015). Trends in drought events and increased temperatures are expected to increase the severity and frequency of wildfires in Oregon.

Fifth Oregon Climate Assessment

The Oregon Legislative Assembly charges OCCRI with biennial assessment of the state of climate change science, including biological, physical, and social science, as it relates to Oregon and the likely effects of climate change on the state. The summary of the fifth assessment indicates the following potential changes for the state (Dalton and Fleishman, eds., 2021).

- Annual average air temperatures have increased by about 2.2°F since 1895. Temperatures are projected to increase on average by 5°F by the 2050s and 8.2°F by the 2080s relative to a 1970 to 1999 historical baseline.
- Precipitation is projected to increase during winter and decrease during summer. The number and intensity of heavy precipitation events, particularly in winter, is projected to increase. As

temperatures warm, the proportion of precipitation falling as snow is projected to decrease, especially at lower to intermediate elevations in the Cascade Range.

- The frequency and magnitude of days that are warmer than 90°F is increasing across Oregon. The frequency, duration, and intensity of extreme heat events is expected to increase throughout the state during the twenty-first century.
- Over the past 20 years, the incidence, extent, and severity of drought in the Northwest increased. As summers in Oregon continue to become warmer and drier, and mountain snowpack decreases, the frequency of droughts is likely to increase.
- Wildfire dynamics are affected by climate change and other factors (land management, human activity, and expansion of non-native invasive grasses). From 1984 through 2018, annual area burned in Oregon increased considerably. Over the next 50 to 100 years, area burned, and fire frequency are projected to continue to increase due to warmer and drier summer conditions.
- Flood magnitudes in Oregon are likely to increase due to increases in heavy precipitation and reduced snowfall.

A Comparative Assessment of Projected Meteorological and Hydrological Droughts

Portland State University faculty members released a publication to analyze drought in the Willamette River Basin to compare future trends in meteorological (i.e., rainfall) and hydrological (i.e., streamflow) drought conditions (Ahmadalipour et al., 2017). Researchers analyzed future drought trends in duration, frequency, and intensity over the Willamette River Basin using ten general circulation models, two downscaling techniques (MACA and BCSD), and two future greenhouse gas scenarios (RCP 4.5 and RCP 8.5) for the period 2010 to 2099. While there is variation of potential future conditions given the uncertainties in modeling future climate variables decades in the future, there are general trends that indicate some increases in annual precipitation on the order of 0% to 10% for the basin, which would have the potential to decrease meteorologic drought. In contrast, warming temperatures (up to 3-5°C) would reduce snowpack and increase evapotranspiration in the basin, which will tend to increase hydrologic drought by reducing summer snowmelt contributions to streamflow. However, the reservoirs in the Willamette Basin can mitigate the impact on streamflow on the mainstem Willamette. Tullos et al. (2020) found that the ability to meet summer flow targets was unlikely to be impacted by climate change.

Temperature and Water-Quality Diversity and the Effects of Surface-Water Connection in Off-Channel Features of the Willamette River, Oregon, 2015-16

This study was conducted in response to the high temperature extreme weather event causing unusually warm and low streamflows in 2015. During the heat event, water temperatures did not meet the State of Oregon's maximum water-temperature standard of 18°C. Continuous water quality monitoring showed that the measured dissolved oxygen (DO) concentration regularly dropped below the State of Oregon cold-water criterion of 6.5 milligrams per liter (Smith et al., 2020).

Summary

The review of potential sources of contamination in the Willamette River watershed in conjunction with the proposed treatment processes for WWSS WTP indicate it and the WRWTP will be resilient to a wide range of contaminants and conditions. The majority of the potential contaminants identified in the watershed characterization (Geosyntec, 2023) would be effectively treated at the plants. The robust treatment trains will provide high quality drinking water and be able to readily meet or perform better than current regulatory requirements. The proposed and current multiple barrier designs for the facilities are proven, robust treatment approaches for a broad range of water quality challenges and concerns.

Based on this vulnerability review, the following recommendations were developed to for the source water monitoring and protection program. These recommendations will provide additional data and guidance to the WIF to support treatment operations at the plants as well as other source water protection activities.

- Although PFAS are not yet regulated in drinking water, the USEPA has indicated that the currently proposed PFAS NPDWR will be finalized in the very near future. The Agency PFAS Roadmap also strongly suggested that future regulatory actions will include more PFAS compounds. It is highly recommended that the WIF conduct baseline water quality sampling for the 29 UCMR5 PFAS and monitor the Agency activities in this arena. A proactive stance will be more favorably accepted by customers and will provide the downstream utilities with time to identify and implement appropriate treatment as needed. Recommended water quality screening for PFAS would be a combination of grab samples and passive sampling. Passive samplers are PFAS-selective media that are placed in the water source for four to six weeks that allow for the identification of intermittent PFAS discharges in the raw water. If PFAS is found at concentrations that require treatment, it is recommended a treatment evaluation be conducted to assess the best option for each downstream WTP. Additionally, it is recommended that the WIF Commissions continue to track evolving regulatory requirements and analytical methods applicable to PFAS compounds as part of its source water protection program
- As with many drinking water supplies, the risk of contamination from organic chemicals, particularly petroleum products, are the primary vulnerabilities for the plants. The best approach for managing potential spill events is to continue a strong outreach program as part of a comprehensive source water protection program. Through outreach, the public can be made aware of how their actions can impact the quality of their drinking water supply and the WIF can coordinate with facilities that have the highest risk to the intake due to large volumes of chemicals, close proximity, or high risk of spills. By developing and maintaining contacts and relationships with upstream facilities and owners, the WIF can encourage direct communication in the event of a discharge that could affect the intake, allowing for advance notice to turn off the intake, thereby reducing the amount of contaminants conveyed to the downstream treatment facilities.
- With respect to monitoring cyanotoxins, it is recommended that the USEPA *Method 546: Determination of Total Microcystins and Nodularins in Drinking Water and Ambient Water by Adda Enzyme-Linked Immunosorbent Assay (ELISA)* only be used as a screening tool for

microcystins and nodularin in raw water. The ELISA method is both quicker and less expensive than other methods, but it can lead to false positives (Aranda-Rodriguez, et al., 2015) in finished water. It is recommended that *Method 544: Determination Of Microcystins And Nodularin In Drinking Water By Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)* be used for finished water samples and to confirm positive results from the ELISA method for raw samples.

- Monitor the activities of state and federal regulatory agencies to understand future regulations and impacts of new, emerging constituents of concern.
- Install a minimum of one water quality sensor at the intake for petroleum to support early warning of contamination. A secondary sensor upstream of the intake should be evaluated as well.
- Establish relationships with local industries to facilitate communication in the event of spills or releases that could impact the WIF intake. Create call trees and contact lists that can be used in case of such events. Update at least annually.
- Create a public information program that educates the public regarding disposal of materials, protection of stormwater outfalls, and reporting unusual events, such as dumping and illegal discharges.

Overall, the data and information collected and evaluated for this report demonstrate that the processes employed at Wilsonville's WRWTP and under construction for the WWSS WTP are appropriate and robust, ensuring high quality drinking water to customers in the region.

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Appendix 2-E

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VIA ELECTRONIC MAIL

Christina Walter
Tualatin Valley Water District

Task 7 Memorandum: Monitoring Technology and Case Studies

Dear Christina,

Consistent with the scope of work for development of a Watershed Protection, Monitoring, and Outreach Plan, as amended August 2022, Hazen and Sawyer has prepared, with Geosyntec input, a revised technical memorandum for Task 7, Monitoring Technology and Case Studies. This document has been revised based on comments from TVWD and partners. If you have any questions, please don't hesitate to contact us.

Sincerely,

Jacob Krall, Ph.D., P.E. (OR, CA)
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Hazen *Technical Memorandum*

April 14, 2023

To: Jacob Krall, Geosyntec Consultants, Inc.

From: Ben Wright, PE
Andy McCaskill, PE
Hester Aw

Monitoring Technology and Case Studies Technical Memorandum

Watershed Protection, Monitoring, and Outreach Plan Task 7

Introduction

The information provided in this technical memorandum (Memo) is part of a larger effort to develop a Watershed Protection, Monitoring, and Outreach Plan (Source Water Protection Plan) for the Willamette Intake Facilities (WIF) Commission. This Memo presents findings from the evaluation of source water quality monitoring technology and source water management case studies.

Job no

Contents

Source Water Quality Monitoring Technology

Source water quality monitoring is an important component of regular water system operations. Source water monitoring can support treatment optimization by alerting operators to changes in quality as well as supporting long-term trend analysis of the water supply. Further, monitoring can be used as an early warning system, particularly for acute water quality challenges, by detecting contaminants of concern during spill events. This section reviews the parameters that are available for monitoring source waters using continuous online sensor technology to support source water characterization and treatment operations. Recommendations of sensor technology for the WIF are provided in the Recommendations and Next Steps section. Source water monitoring is separate from, but would augment, sampling required during treatment operations as required by Oregon Administrative Rules (OAR 333-061-0036) Sampling and Analytical Requirements.[1]

Parameters

Source water quality monitoring technology typically consists of continuous monitoring equipment that does not rely on the manual collection of water samples. This enables the collection of reliable and frequent readings of water quality but is limited to certain parameters that can be detected using automated sensors. In addition to sensor technology, continuous probes require data transmission and storage to make the data accessible. The following sections describe the sensors that are typically considered for source water monitoring programs.

[1] https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/DRINKINGWATER/RULES/Documents/61-0036.pdf

pH – pH is a measure of the acid or alkaline condition of a water sample. pH is critical to many aspects of water chemistry and plays an important role in water treatment processes including coagulation, disinfection, chemical precipitation, cyanotoxin oxidation, and corrosion control. Electrodes that measure pH based on the electrical potential as a measurement signal are commonly used with online sensors.

Temperature – Temperature is a basic property of water that is important from a water treatment perspective for determining the effectiveness of disinfection, coagulation, and other processes. Online monitoring of temperature is accomplished with a thermistor sensor, where the resistance of the thermistor changes as water temperature changes. The measured resistance is then converted to temperature measurements. Temperature sensors are a common parameter monitored using online sensors.

Turbidity – Turbidity is a measure of water clarity, and turbidity sensors measure the level of light scatter in a water sample. Turbidity is a regulated parameter for drinking water due to its association with disease-causing microorganisms, such as viruses, parasites, and some bacteria. Source water turbidity sensors are useful for monitoring changes in turbidity that could require changes to chemical dosages, filter run times, and solids handling. Online turbidimeters that measure continuous flow across the probe are commonly used at drinking water intake facilities.

Conductivity – Electrical conductivity is typically used as a surrogate measure for total dissolved solids concentration and/or salinity. In fresh water supplies conductivity provides an indicator of spikes in salinity that could be due to industrial discharges/spills. Online conductivity probes are commonly used for source water monitoring.

Dissolved Oxygen – Dissolved oxygen (DO) is the concentration of oxygen in water, which is important for sustaining aquatic growth and reproduction in a water body. Spikes in concentration of dissolved or suspended organic matter can lead to reduced DO levels, which can be indicative of increased municipal, agricultural, or industrial discharges or spills. In contrast, diurnal variations in DO that include unusually high DO levels can indicate increased algal activity and can serve as an early warning for harmful algal blooms. Low DO levels caused by excessive organic wastes or die-off of algae blooms can result in anoxic conditions that could result in fish kills. Therefore, DO is an important parameter for tracking the overall health of the watershed. Sensors that measure the pressure of oxygen dissolved in a water sample are the most commonly used tool for DO measurements and are commonly used to monitor source waters.

ORP – Oxidation Reduction Potential (ORP) is a measure of the potential flow of electrons between oxidizers and reducers, which determines the oxidizing/reducing potential of a water sample (i.e., the reactivity of the water). ORP is measured as the net voltage potential in millivolts (mV). Oxidizers have a positive ORP value, while reducers have a negative ORP value. ORP can sometimes be useful as an indicator of possible contamination that impacts the reactivity of water, which could be spills of industrial chemicals (certain acids, sulfite compounds, peroxides, halogens, etc.) or highly concentrated organic waste. Because of the reactive nature of these pollutants, attenuation is relatively quick compared to other pollutants. Further, ORP can be used as an indicator of iron and manganese flux from sediment or similar impacts from low-oxygen conditions in reservoirs. Due to its dependence upon the concentrations of multiple chemical substances, it can be a challenge to identify the cause or significance of ORP measurements. As such, ORP is a less common parameter for source water monitoring.

Algae and Cyanobacteria – Algae and cyanobacteria blooms in water supplies can cause operational problems at treatment plants (e.g., low filter runtimes) and may be a source of cyanotoxins. Direct measurement of algae, cyanobacteria, or cyanotoxins with a sensor is not currently possible. The most typical parameters used as surrogates for algae and cyanobacteria are colored dissolved organic matter (CDOM), fluorescent dissolved organic matter (fDOM), phycocyanin and chlorophyll a, which may be used both together and individually.

CDOM and fDOM are classes of dissolved organic matter that absorb ultraviolet (UV) light in water. Phycocyanin (blue-green) and chlorophyll-a (green) are pigments found in cyanobacteria and algae species. Phycocyanin and chlorophyll-a are measured with fluorescence technology.[2] CDOM and fDOM are a general indicator of organic matter in the water column, while phycocyanin and chlorophyll-a are more focused on cyanobacteria and algae in the water column. These parameters are typically measured in systems that experience periodic algal blooms. The usefulness of these surrogates can vary between waterbodies due to the variability of physical and chemical characteristics of different algal species and their byproducts from decay. Given that these are surrogate parameters, they are often included as part of a monitoring approach to trigger more detailed analysis using microscopy[3] or sampling for cyanotoxins.

Nitrate – Nitrate is a highly water-soluble ion that is present in agricultural runoff, septic systems, and municipal wastewater. Its concentration in drinking water is regulated under the National Primary Drinking Water Standards, and it can contribute to surface water impairments and algal blooms. The source of nitrates is typically agricultural runoff (e.g., fertilizers and animal wastes), leaking septic systems, and sewage discharges. Nitrate can be more of an issue in groundwater than in surface water because natural processes typically attenuate nitrate in surface waters. There are a variety of sensor technologies available to measure nitrates that can be employed if monitoring data indicate it could be an issue.

Total Organic Carbon – Total Organic Carbon (TOC) is the amount of organic matter (typically naturally occurring) from decaying plants and organisms, soil erosion, and biological wastes. High levels of TOC are not a direct health concern, but elevated levels can indicate potential for aesthetic issues (taste and odor) or disinfection byproduct (DBPs) formation[4] in finished water. TOC can also serve as an early warning for increased discharges or spills of organic wastes at high concentrations, similar to DO. The two most common methods of measurement are "wet chemistry" and optical methods, defined below.

- Wet chemistry method – These sensors filter and combust samples from a constant water feed to measure the quantity of carbon dioxide gas and calculate TOC. These types of systems are

[2] Fluorescence occurs in certain molecules that absorb light of one wavelength and release light of a longer (lower energy) wavelength.
[3] Microscopy technologies, such as the FlowCam, are used to directly identify, count, and measure phytoplankton for source water monitoring.
[4] While there is a general correlation between concentration of TOC and DBP formation, because natural organic matter (NOM) is a complex mixture of organic compounds that vary greatly in terms of physical and chemical characteristics, the specific makeup of NOM molecules can influence both the concentration and type of DBP formed during disinfection.

complex and require a higher level of operations and maintenance (O&M) than other continuous monitoring technologies but provide direct measurement of TOC.

- Optical methods – These technologies use either ultraviolet (UV) light absorbance or fluorescence at different wavelengths to estimate TOC. UV absorbance at 254 nanometers (nm) is a common surrogate for TOC. However, more advanced probes are available that measure light across a broad spectrum of wavelengths, which provides more data points to calibrate for TOC concentrations. These broad-spectrum probes can also provide surrogate measurements for other parameters such as dissolved organic carbon, nitrate, and particulates.

Hydrocarbons – Hydrocarbons include oil, diesel fuel, gasoline, and other petroleum products. Hydrocarbon monitoring in source water is important to detect petroleum spills or leaks in the watershed that reach the intake facilities. Hydrocarbon sensors typically use UV fluorescence technology, which reacts to the polycyclic aromatic hydrocarbons (PAHs) in petroleum products. Hydrocarbon sensors are not as common as other water quality metrics and are typically used in areas of river-centric petroleum shipping, petrochemical manufacturing, and high-density transportation or industrial areas.

Deployment Considerations

This section lists key considerations when planning for sensor deployment.

Location – Siting monitoring equipment at the intake facility is a common practice. This location gives an accurate characterization of the water entering the intake. However, this location provides limited early warning. Siting equipment at upstream locations provides more reaction time for operators but introduces additional challenges. For example, permission is needed to install sensor equipment on private property. Public property can be a good option but increases the potential for theft and vandalism. As the site moves away from the intake, there is the concern whether the data is representative of what will be at the intake due to river flow patterns. This is a particular challenge with hydrocarbon sensors. Depending on the location of a spill and the hydrodynamics of the river, it is not uncommon for petroleum plumes to affect one side of a river and not the other due to limited lateral mixing. Buoys or docks in the river are often used at remote locations to place sensors closer to the main flow channels and away from the shore.

Utilities – Monitoring sensors require electricity and telecommunications utilities for effective operation. Hardwired utilities provide the most reliability but are only feasible where these services are present. In remote locations, electricity can be provided by batteries and telecommunications for data transmittal can be provided by cellular technology.

Security – Vandalism and theft is an issue for any field-deployed technology. As with utilities, the most secure option is to install equipment in a secured area or building on utility property. For sensors deployed at off-site locations, theft and vandalism can be minimized by installing the sensors in inconspicuous locations and properly securing the equipment.

Operations and Maintenance Considerations

Water quality sensors require regular maintenance and calibration to ensure accurate, reliable data collection. The steps below provide an overview of O&M needed to keep monitoring equipment working properly. Depending on the equipment, maintenance schedules can range from monthly to every six months.

- Cleaning: It is important to keep the equipment clean to prevent any biofouling, dirt or debris from interfering with the sensor measurements.
- Calibration: Calibrating sensors using a standard solution or by comparing the instrument's readings to those of a calibrated reference instrument ensures that they are providing accurate measurements.
- Replacing the batteries: The instrument probe (also referred to as a sonde) may have batteries that need to be checked and replaced on a regular basis to ensure that the sonde has a sufficient power supply.
- Checking cables and connectors: The cable and connectors should be checked for any damage or wear and tear that could affect the sensor performance.
- Sensor replacement: Manufacturers recommend replacement of water quality sensors periodically (e.g. every 2-4 years). Refer to specific product user manual for Recommended Replacement Time.

Planning Level Costs

Hazen compiled planning level costs with multiple manufacturers of continuous sensor equipment including Hach, YSI, Eureka and In-Situ. Costs range widely based on the specific sensor and selected options. The sensors can be purchased individually or as part of a multi-parameter sonde, which can be equipped with up to seven probes, depending on the manufacturer. Multi-parameter sondes are typically preferred in off-site locations due to efficient, compact design.

A multi-parameter sonde with typical water quality parameters would range from $5,000 to $20,0000. These would include parameters such as temperature, conductivity, DO, pH, ORP, turbidity, and algae indicators. The higher costs are based on more parameters and the specific mix of parameters. When purchased as individual sensors, these parameters can cost in the range of $800 to $5,000 each. Nitrate sensor costs vary more widely and can range as high as $15,000 for an individual sensor. Hydrocarbon sensors would not typically be available for a multi-parameter sonde, but a standalone sensor would cost in the range of $25,000 to $50,000. A UV254 probe for monitoring TOC would cost in the range of $20,000 to $30,000. A broad spectrum optical or wet chemistry system for measuring TOC would be in the range $50,000+ range.

In addition to the capital and O&M costs, another cost consideration is accessing and managing the data. Continuous monitoring creates substantial data over time. Options for managing the data include connecting with SCADA, developing a custom database, or purchasing a subscription service. Many sensor manufacturers offer subscription services to enable consolidation and viewing of data on any device. These services may include tools or dashboards to visualize data, analyze trends, and issue alerts. Some of these data management solutions include Claros (Hach), HydroVu (In-Situ), and HydroSphere (YSI). Further, staff costs associated with reviewing, analyzing, and reporting on the data on a regular basis should be considered.

As described in the next section (Source Water Quality Case Studies), utilities often collaborate with the US Geological Survey (USGS) to share costs of monitoring stations to provide mutual benefit. USGS's monitoring and data quality is of the highest standards,[5] providing both extensive real-time and historical data from chemical, physical, and biological sample collection and analyses. Further, USGS's historical analyses and data are publicly available over the internet, which is not the case with commercial subscription services. Cost-sharing agreements are negotiated with the USGS individually, and available funds can depend on federal appropriations and monitoring priorities. Based on discussions with utilities currently working with the USGS, annual costs per monitoring station can be in the range of $30,000 to $40,000 or more, depending on the specifics of the agreement.

Source Water Quality Case Studies

The following case studies are presented to provide examples of source water protection programs, and provide summaries of the water quality challenges, watershed protection strategies, monitoring programs, and outreach plans. These summaries were compiled from a mix of published reports and conversations with watershed managers.

Overall, these case studies demonstrate that other utilities with river supplies have similar challenges from land development, agricultural pollution, industrial spills, and climate change. Further, while the details of each utility's source water protection program vary, there are commonalities that include water quality monitoring, pollution source identification, public outreach, regional collaboration and preserving high quality watershed lands. These case studies demonstrate that the potential source water quality issues in the WIF watershed are not unique and there are successful strategies available for managing risks in order to maintain the quality of the water supply.

Clackamas River Water Providers

The Clackamas River Water Providers (CRWP) is a coalition of the municipal water providers that get their drinking water from the Clackamas River. The Clackamas River flows 82.7 miles from its headwaters to its confluence with the Willamette River near Gladstone and Oregon City, which is downstream from the WIF Commission intake. The watershed drains more than 940 square miles with more than half of its length flowing through forested lands (Figure 1). However, the lower reaches of the river flow through agricultural and densely populated areas. Land ownership in the watershed includes federal land administered by the US Forest Service (USFS) and Bureau of Land Management (BLM),

[5] USGS maintains comprehensive internal and external procedures for ensuring the quality, objectivity, utility, and integrity of data, analyses, and scientific conclusions. These include quality assurance and quality control, error checking, repairing data issues, and documenting data quality.

state land, and private land (CRWP, 2021). While the CRWP water supply watershed is substantially smaller than the WIF supply watershed, it has similar characteristics and challenges expected for the mainstem Willamette River.

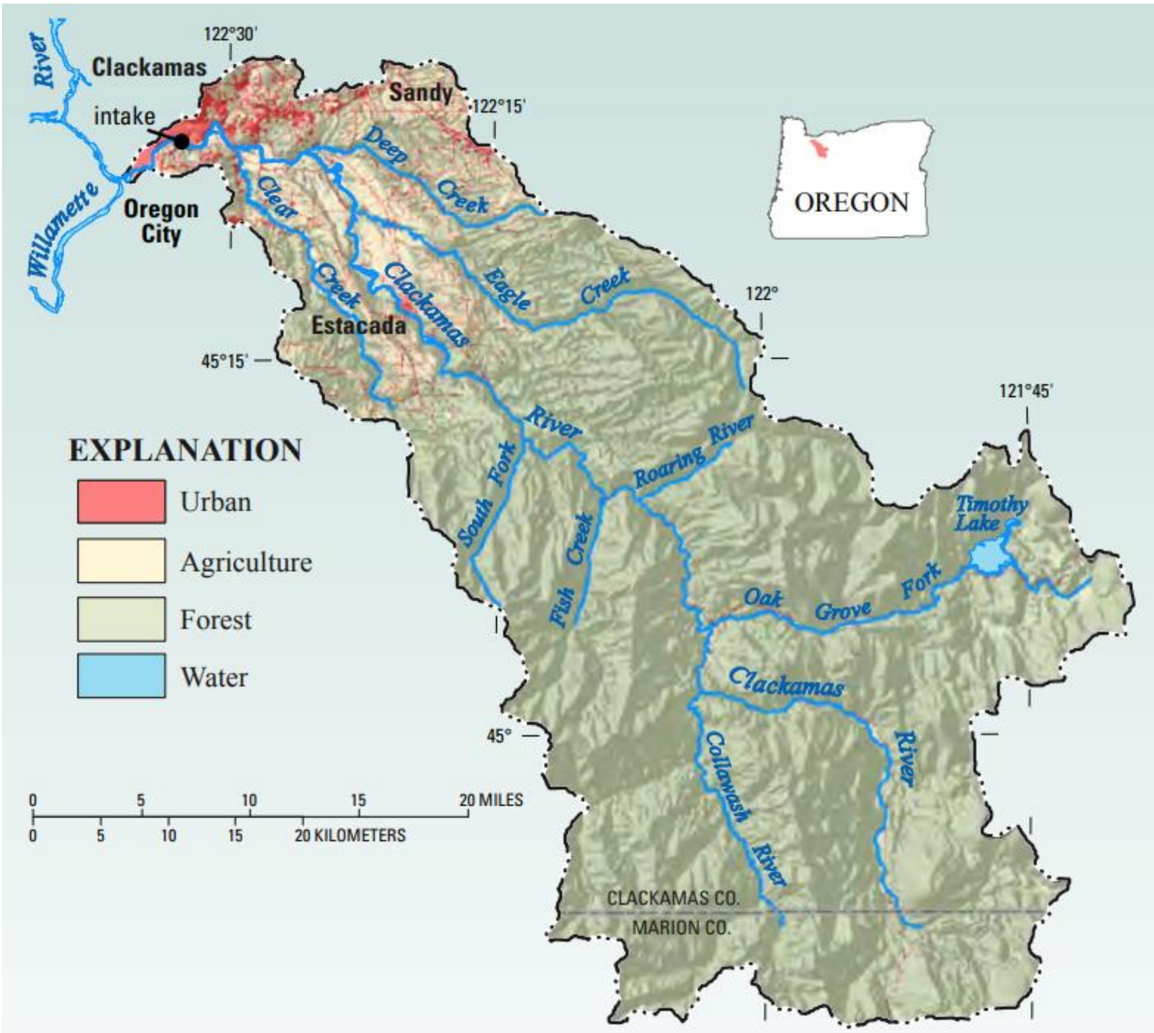

Figure 1: Map of the Clackamas River Watershed Land Use[6]

In 2019, the Oregon Health Authority and the Oregon Department of Environmental Quality updated the Source Water Assessments for the Clackamas River Public Water Systems. The updated Source Water Assessment identified over 3,000 potential sources of pollution within the 8-hour time-of-travel upstream of the lower Clackamas River intakes and 135 potential sources of pollution within 8-hour time-of-travel upstream of the Estacada intake (the most upstream intake). Many of these potential sources of pollution pose a moderate to high risk to the drinking water supply. Potential contaminant sources identified in the assessment fell into four broad categories: Agricultural/Forest, Commercial/Industrial,

[6] https://pubs.usgs.gov/fs/2009/3030/

Residential/Municipal, and Miscellaneous (which includes the remaining land uses within the watershed).[7]

In 2010 CRWP adopted its Drinking Water Protection Plan (DWPP) to actively pursue and implement source water protection programs and public education and outreach efforts. The plan was updated in 2021 to refine the strategies for source water protection. The purpose of the plan is to address the various threats to water quality and prevent the degradation of the Clackamas River as a drinking water source. The overall concept of source protection is to have the ability to measure the balance between watershed health and human use over time and implement actions that maintain a healthy balance for production of exceptional water quality. The Water Providers have three primary goals for the source water protection program for the Clackamas River (CRWP, 2021):

1. Identify, prevent, minimize, and mitigate activities that have known or potentially harmful impacts on drinking water quality so that the Clackamas River can be preserved as a high-quality drinking water source that meets human future needs and minimizes drinking water treatment costs.

2. Identify climate mitigation and adaptation strategies that will help ensure a more resilient watershed and drinking water source.

3. Promote public awareness and stewardship of healthy watershed ecology in collaboration with other stakeholders.

The overall strategy includes nine elements listed below from the CRWP Drinking Water Protection Plan 2021 Update report. The first element outlines continuing work that must be completed by the CRWP to better understand the watershed and to help prioritize mitigation strategies, and the remaining elements outline a variety of mitigation strategies designed to protect drinking water. Each of these elements describes an overarching strategy to inventory, evaluate and track the risks to source water. To identify areas where mitigation can be implemented through technical and financial assistance and where the CRWP can be an advocate for drinking water through education and outreach to regulators, stakeholders, CRWP water customers and citizens who live in the watershed.

Basin Analysis: Studies, GIS, Modeling and Water Quality Monitoring – This strategy entails working with USGS, Portland State University (PSU) and other partners to monitor, conduct studies and develop models to improve CRWP's understanding of water quality in the river. The long-term goal is for CRWP to have the data and tools to determine if water quality is improving over time and if mitigation strategies are successful.

Climate Change/Water Supply – CRWP has been working with regional partners to better understand what climate change means in terms of changes in temperature, rain and snow, impacts on water quality and quantity, and wildfire risk, as well as communicating changes to stakeholders. The overall goal is to

[7] In addition to the potential sources of pollution identified in the watershed, there are Total Maximum Daily Loads established for water temperature and bacteria due to water quality impairments. However, based on conversations with CRWP staff, these TMDLs have had limited effect on the risks targeted by CRWP.

prepare and position CRWP members to be able to adapt to changing water conditions in the watershed and to support basin-wide climate change planning efforts.

Education and Research Assistance – Leverage partnerships with universities and agencies to explore cooperative efforts to fund and promote research in the Clackamas River watershed. The long-term goal is to provide an educational opportunity for university students to develop research projects on real world problems, while helping to answer questions and watershed issues which support the source water protection efforts in the Clackamas watershed.

Point Source Evaluation and Mitigation – This strategy includes inventorying, tracking, evaluating, and monitoring point source permits to understand potential threats and work with regulatory agencies, facilities, and permittees to reduce the potential threat to drinking water. Examples of permits to be tracked include National Pollution Discharge Elimination System (NPDES), Underground Injection Control, Confined Animal Feeding Operations, above- and below-ground storage tanks, Portland General Electric (PGE) dam permits and licenses, and air contaminant discharge permits.

Nonpoint Source Evaluation and Mitigation – Work with regulatory agencies, landowners, and business groups and other basin stakeholders to implement best management practices and mitigation strategies to reduce the impacts of stormwater runoff on the Clackamas River. The strategy also includes developing technical and financial assistance programs to support these efforts. The long-term goal is to engage watershed landowners, basin stakeholders and regulators in supporting actions that reduce the impacts of stormwater runoff and to be partners in solutions that improve downstream water quality.

Disaster Preparedness and Response – This strategy includes continuing to develop and promote relationships with federal, state, and local agencies to develop an emergency response system that would identify potential threats to drinking water as well as response strategies. Areas of focus include CRWP member preparedness, hazardous material spills, forest fire preparedness, dam breaches, and other natural disasters. The long-term goal is to ensure first responders and basin stakeholders understand how their drinking water systems work and, be active partners in protecting them and mitigating risks, while helping position water providers to be able to respond to any potential threats or critical emergencies.

Public Outreach and Information Sharing – Promote community awareness of the watershed as a drinking water source by developing educational materials and outreach programs that bridge the gap between public perception of the watershed and the technical information about the factors affecting it. Community engagement areas include youth education programs, community events, presentations to neighborhood associations or other groups, providing information via e-newsletter, website, and social media, summer conservation campaign and holding watershed tours. The long-term goal is to have CRWP member citizens, watershed residents and stakeholders be active participants in helping CRWP conserve and protect the drinking water source.

Watershed Land Use Tracking and Management – Take advantage of opportunities to provide public comment and input on land use activities and zoning changes to advocate for drinking water protection with the goal of ensuring that growth and development within the watershed is not detrimental to the water quality of the Clackamas River.

Land Acquisition – CRWP will work with organizations such as Metro, Clackamas County, the Clackamas Soil and Water Conservation District, and the Nature Conservancy to identify and acquire critical pieces of land through direct purchase or conservation easements in order to protect the watershed as a high-quality source of drinking water.

To achieve these strategies, CRWP has estimated costs for each of the nine strategies over a five-year horizon (Table 1). In addition to the program costs, CRWP has two staff members (a Water Resource Manager and a Public Outreach and Education Coordinator) dedicated to implementing these strategies.

Table 1: CRWP Drinking Water Protection Plan Subprogram Budget Estimate

Source Protection Subprogram	Total Estimated Costs FY 2022-2027
Basin Analysis: Studies, GIS, Modeling, & Comprehensive Monitoring	$900,000
Education and Research Assistance	$36,000
Point Source Evaluation and Mitigation	$8,000
Nonpoint Source Evaluation and Mitigation	$270,000
Disaster Preparedness	$210,000
Public Outreach and Information Sharing	$600,000
Land Use Tracking and Management	$0
Land Acquisition	$0
PGE Stored Water Fee	$48,000
TOTAL ESTIMATED COSTS	**$2,072,000**

CRWP Source Water Monitoring

The CRWP have a joint funding agreement with USGS for the operation and maintenance of three water quality monitoring stations at Carter Bridge, River Mill, and Oregon City on the Clackamas River. These monitoring stations continuously log pH, conductivity, DO, turbidity, and temperature. The River Mill and Oregon City sites also record chlorophyll and streamflow. In addition to the USGS contract, the CRWP also provides funding for replacement probes and cables, and for the utility fees for the real-time data signal associated with the USGS monitoring sites.

In addition to continuous monitoring, CRWP has been working with PGE since 2006 to monitor for harmful algal blooms in the Clackamas River. Through these efforts, PGE conducts weekly monitoring for blooms at North Fork Reservoir from May to October each year. If a harmful algae bloom[8] is identified by PGE, samples are taken and tested for toxins.

[8] The term “harmful algal bloom” is used to describe excessive algae or cyanobacteria in a waterbody.

Eugene Water & Electric Board (McKenzie River)

The Eugene Water & Electric Board (EWEB) is a publicly owned water and electric utility that receives their water from the McKenzie River.[9] EWEB's Strategic Planning Technical Report for the Drinking Water Source Protection Program, published in December of 2017, states that the McKenzie River subbasin covers 1,338 square miles in the Upper Willamette Basin ten miles downstream from the confluence of the Middle Fork and Coast Fork Willamette Rivers with headwaters originating in the High Cascades region (Figure 2). The EWEB water supply watershed is substantially smaller than the WIF supply watershed, but has similar characteristics and challenges expected for the mainstem Willamette River.

EWEB's 2017 technical report outlines potential threats to the McKenzie watershed from agriculture, forestry, development, and climate change sectors through multiple pollution source assessments completed from 2000 to 2014. Agricultural threats include contamination by pesticides, bacteria, nutrients, and organic compounds typically found in the Camp Creek basin, which is 20 miles upstream of EWEB's intake. Further, development impacts, such as urban runoff, spills, septic systems, highways, dams, and industry/point sources, are significant sources of water pollution within the lower part of the McKenzie watershed.

[9] EWEB is in the process of planning an intake and treatment plant on the Willamette River as an alternate source of supply.

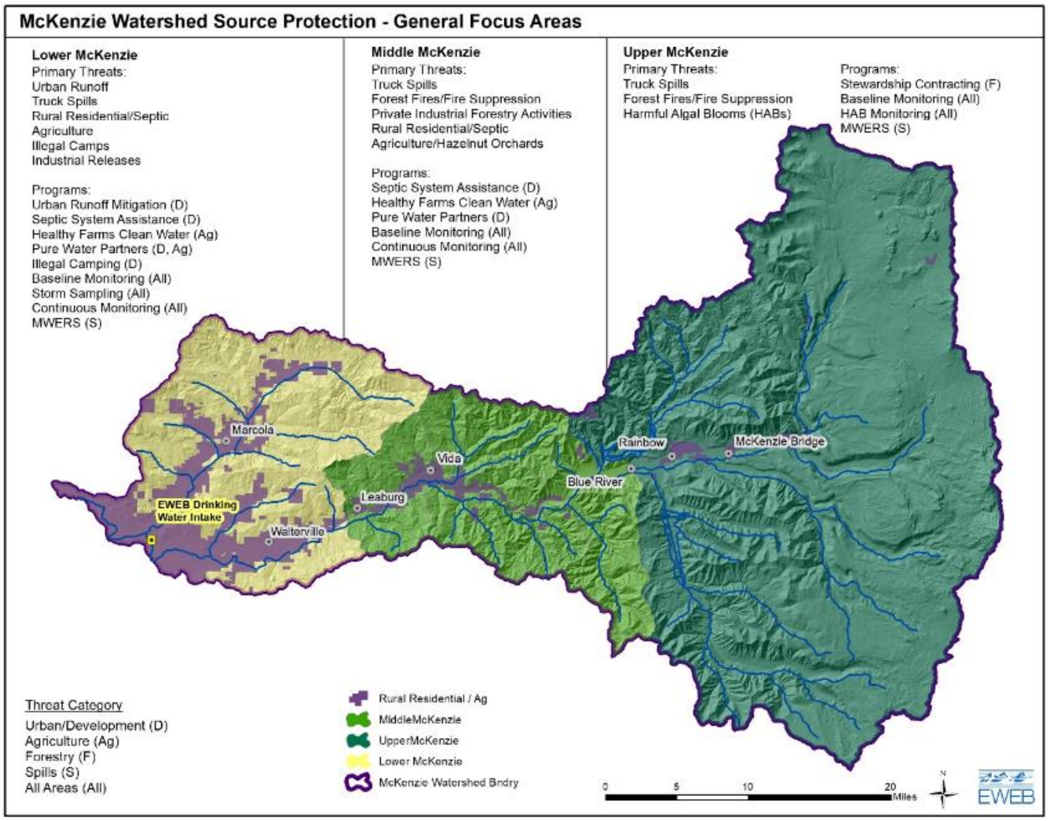

Figure 2: Map of the McKenzie watershed (EWEB, 2020).

EWEB initiated their Drinking Water Source Protection (DWSP) 10-Year Strategic Plan in 2017 for the years 2018-2028. The purpose of the plan is to balance watershed health with human use over time by accomplishing three primary objectives as described in the report (EWEB, 2017a).

1. Plan and implement actions that maintain source water quality in a way that balances risks with benefits in partnership with others.

2. Prioritize source protection efforts that provide the greatest benefit to water treatment and electricity generation in the McKenzie watershed.

3. Promote public awareness and stewardship of a healthy watershed through targeted actions and programs.

The main elements of EWEB's Drinking Water Source Protection (DWSP) Plan are listed below. EWEB's source water protection plan focuses heavily on outreach and public involvement in order to protect the McKenzie watershed, bringing in collaborative measures with first responders, farmers, forest service, landowners, and other program partners. The strategies share the same goal of protecting water quality for long-lasting improvements (EWEB, 2017a). Further EWEB's DWSP Plan elements are focused on sections of the watershed based on types of risks.

Water Quality and Watershed Health Monitoring (Entire Watershed) – Water quality monitoring efforts including episodic and seasonal constituent monitoring, harmful algal bloom monitoring, continuous monitoring at the lower and middle watershed, and data management/analysis to inform the utility about watershed health and environmental impacts.

McKenzie Watershed Emergency Response System (MWERS) (Entire Watershed) – Geographic Information System (GIS)-based web application developed in close partnership with first responders to plan spill response strategies, equipment needs, critical resources, personnel, travel times, coordination, and communication. MWERS provides fast and effective hazardous material spill response protocols to prevent the spread of contaminants in the McKenzie watershed. First responders and other collaborative members are annually trained to navigate and utilize the GIS application.

Urban Runoff Mitigation (Lower Watershed Focus) – Project program that works on mitigating runoff upstream of the Hayden Bridge intake and the Keizer Slough of the McKenzie watershed. The actions to accomplish this include constructing wetlands that would treat and buffer urban runoff.

Pure Water Partners (PWP) (Middle and Lower Watershed Focus) – PWP manages the McKenzie Watershed Conservation Fund, which receives funding from EWEB, Metropolitan Wastewater Management Commission, USFS Willamette National Forest, Oregon Watershed Enhancement Board, foundations, business sponsors, and various grants. EWEB's source water protection plan includes investments into PWP to protect riparian and floodplain forests. The protection of riparian and floodplain forests is incentivized to landowners who agree to maintain healthy riparian habitats on their property long-term (15-20 years). Participating landowners in agreement with EWEB are provided with a management plan outline, visited by partner agencies to conduct riparian health assessments, and assisted with funding for potential repairs or restoration to their riparian habitats.

Septic System Assistance (Middle and Lower Watershed Focus) – EWEB provides a 50% cost-share assistance to homeowners for the inspection, pump-out, and completion of minor repairs within their septic system to reduce water quality impacts. Major repairs and replacement of failing systems can be assisted with zero-interest loans from EWEB.

Healthy Farms Clean Water (Middle and Lower Watershed Focus) – Collaborative effort between EWEB and McKenzie farmers to reduce chemical usage and increase natural pollution treatment systems such as riparian buffers. The program focuses on reducing chemical use and chemical storage on farmland through cost-share and technical assistance from program partners. McKenzie farmers are qualified for zero-interest loans on projects that benefit water quality with Federal Natural Resources Conservation Service (NRCS) funds.

Healthy Forests Clean Water (Middle and Upper Watershed Focus) – This program consists of two main components: (1) EWEB collaboration with the USFS and related watershed partners to use timber harvesting funds on restoration projects on the Willamette National Forest and private lands with PWP; (2) Management of EWEB's Leaburg Forest through increasing beneficial habitats and protecting water quality, while collecting funds through maintenance work of the area. These partnerships and collaborations encourage healthy forests, reduce wildlife risks, protect aquatic life and habitat, and generate revenue for future restoration projects.

Figure 3 presents the breakdown of its 5-year outlook for DWSP expenditures from its 10-year strategic plan (2018 to 2028). In addition to anticipated costs, DWSP programs are supported by external funding sources, regional partners, and some revenue sources (e.g., targeted logging on EWEB land). Table 2 provides a summary of funding for DWSP programs from EWEB's 2020 state of the watershed report. Additionally, Table 3 provides a list of grants and other external funding that currently supports EWEB's watershed protection efforts.

Strategic Area	5-Year Spending
PWP	$1,470,000
WQ Monitoring	$1,100,000
Urban Runoff	$920,000
MWERS	$330,000
Other Programs	$740,000
Capital Projects	$1,130,000
Total	$5,690,000

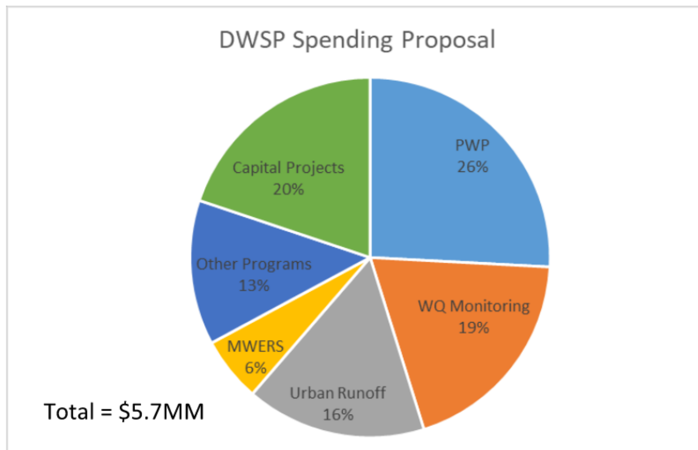

Figure 3: EWEB 5-Year Outlook for DWSP Expenditures (EWEB, 2017a).

Table 2: Summary of Funding by Source Protection Program in 2020 (EWEB, 2021).

Source Protection Program	EWEB Funds	Outside Funds	Total Funding
Water Quality	$268,000	$146,000	$414,000
MWERS	$37,000	$5,000	$42,000
Urban Runoff Impacts	$11,000	$6,000	$17,000
Illegal Camping	$2,400	$2,000	$4,400
PWP	$240,000	$188,000	$428,000
Septic System Assistance	$19,000	$19,000	$38,000
Healthy Farms	$14,000	$25,000	$39,000
Healthy Forests	$63,000	$27,000	$90,000
Totals	**$654,400**	**$418,000**	**$1,072,400**

Table 3: Summary of External Funding Supporting DWSP Programs 2020 (EWEB, 2021).

Grant (EWEB DWSP Program Supported)	Grant Amount	% EWEB Match	Granting Organization	Grantee or Fiscal Manager
Healthy Watershed Grant (PWP)	$143,000	43%	U.S. Endowment for Forestry and Communities (with contributions from NRCS, USEPA)	EWEB
Developmental Focused Investment Program (PWP)	$136,000	20%	Oregon Watershed Enhancement Board	Cascade Pacific Resource Conservation and Development (CPRCD)
Programmatic Support Funding (PWP)	$30,000	65%	Metropolitan Wastewater Mgmt Commission (MWMC)	CPRCD
Riparian Restoration Funding (PWP)	$30,000	0%	USFS (Retained Receipts)	CPRCD
GIS Support (OWERS)	$500	80%	Springfield Utility Board (SUB)	EWEB
Pesticide Reduction Program (Healthy Farms Clean Water)	$25,000	0%	Portland State University – Governor's Oregon Solutions Program	EWEB
Pesticide Reduction Program	$25,000	0%	Meyer Memorial Trust (MMT)	CPRCD
Community Capacity and Land Stewardship (Healthy Forests Clean Water)	$10,000	50%	National Forest Foundation	CPRCD
Support Water Quality Monitoring and Streamflow Gages (Water Quality Monitoring)	$154,880 (47.3 %)	$172,680 (52.7 %)	USGS	USGS
Support Water Quality Monitoring (Water Quality Monitoring)	$2,000	NA	SUB	EWEB
Develop Urban Green Infrastructure (Urban Runoff)	$200,000	20%	US EPA	CPRCD
Develop Urban Green Infrastructure (Urban Runoff)	$30,000	50%	Oregon Health Authority (OHA)	EWEB and SUB
LiDAR Flight of McKenzie Watershed and HFF Impact Area DWSP Program	$148,000	50%	USGS	OR Dept of Geology and Mineral Industries

Recent Source Water Quality Challenges

The 2020 State of the McKenzie Watershed Report noted recent source water quality challenges such as fires and spills.

The Holiday Farm Fire was a wildfire that started at the Holiday Farm RV Resort in Blue River, OR on September 7, 2020, and spread rapidly throughout the surrounding areas. The fire caused major damage in the McKenzie watershed across more than 200,000 acres and left the affected area with destroyed habitats. Water quality monitoring was negatively impacted during that time due to ash fall and inaccessibility to monitoring locations. The results of the fire are anticipated to negatively impact water quality for years to come.

Reported spills in the McKenzie watershed during 2020 are presented can in Table 4. The October spill left an oily sheen that traveled for miles downstream. EWEB was able to use absorbent booms at Leaburg Dam to prevent further contamination.

Table 4: Reported spills in the McKenzie watershed from the 2020 State of the McKenzie Watershed Report

Date	Responsible Party	Material Released	Quantity (gallons)	Details	Response
1/16/20	Private	Diesel	25-100 gal	Semi-truck crash	Land only, boom/pads
1/29/20	Private	Vehicle fluids	Minor	Jeep in river, above Hendricks Bridge	Jeep removed from river on 3/17/20
2/10/20	Private	Vehicle fluids	Minor	Vehicle crash, Deerhorn	Absorbents
7/1/20	ODFW	Diesel	Minor	Fish truck stuck at ramp	Absorbents
10/15/20	Private	Vehicle fluids	Unknown	Dump truck crash	Absorbent boom/pads

To mitigate impacts of contamination EWEB works with Mason Bruce and Girard consultants for the Oregon Watershed Emergency Response System (OWERS) to facilitate timely spill notifications and hazardous spills monitoring.

EWEB Source Water Monitoring

Long-term continuous monitoring is used to assess water quality trends such as seasonal variability, hydrologic variability, climate change impacts, and land use impacts. EWEB staff currently have a number of active continuous monitoring locations in the McKenzie watershed. In addition, EWEB has a joint funding agreement with the USGS to operate several streamflow monitoring stations and one water quality station. These stations are operated on a cost share basis with the USGS.

EWEB conducts continuous water quality sampling at five sites: all five sites include turbidity, temperature and conductivity, and three sites include pH, fDOM, total algae, and DO.[10] In addition to continuous sampling EWEB employs a YSI EXO2 multiparameter water quality sonde for random sampling at 16 sites to measure turbidity, temperature, conductivity, pH, DO, chlorophyll, and fDOM. Further, quarterly sampling of metals, nutrients (i.e., nitrogen and phosphorus), bacteria, TOC, microorganisms, organics, and general water quality parameters (e.g., pH, temperature, turbidity, total suspended solids, biological demand) are also conducted at locations in the watershed.

[10] One site is contracted out to USGS.

Philadelphia Water Department (Delaware River)

The Delaware River is a source of drinking water for nearly 15 million people and is a major water supply for the City of Philadelphia.[11] The City's Delaware River intake is located in the lower section of the river in the tidal freshwater zone. The watershed above Philadelphia's intake is approximately 8,000 square miles and includes a mix of land uses: urban, suburban, forest, and agricultural. While this watershed is located in a different geographic area than the WIF, it is comparable in size to the Willamette, and the utility has a well-established source water protection program for a developed watershed and a sophisticated early warning system for alerting the utility to spills.

The Delaware River Valley in the vicinity of Philadelphia is one of the oldest settled areas of the US, dating back to the colonial era. Development and industry around the river led to substantial pollution. Modern environmental regulations and wastewater treatment have resulted in substantial improvement in water quality, improving it as a source of drinking water and restoring recreation opportunities. However, there remain challenges related to point source discharges from municipal and industrial wastewater treatment plants, urban stormwater runoff, and spills from cars, trains, shipping vessels, pipelines, and industrial accidents. Continued growth and development in the region reduces forest cover and converts land to uses that can become sources of pollution. Further, the Delaware River is a freshwater tidal resource, which experiences periods of high salinity during drought conditions that are expected to worsen with climate change.

The Delaware River Basin Commission

The Delaware River Basin Commission (DRBC) was formed through an agreement between the states of Delaware, New Jersey, Pennsylvania, and New York along with the federal government. The DRBC is a regulatory body with authority to oversee a unified approach to managing the Delaware River system without regard to political boundaries. The DRBC's regulations are designed to address both water quality and water flows in the river.

The Philadelphia Water Department (PWD) conducted an extensive source water assessment for the approximately 8,000 square mile watershed to identify water quality trends, potential sources of contamination, restoration options, and formulate recommendations (Figure 4). Following the assessment, PWD drafted the Delaware Source Water Protection Plan (2007) to document the strategy to counter current and future water supply concerns of the drinking water utilities that share the Delaware River as a resource. PWD takes a cooperative approach to source water protection by enlisting utility staff, citizens, regulators, environmental organizations, educational institutions, state government, and local governments.

[11] Philadelphia also has a water supply intake on the Schuylkill River, but this case study focuses on the Delaware River.

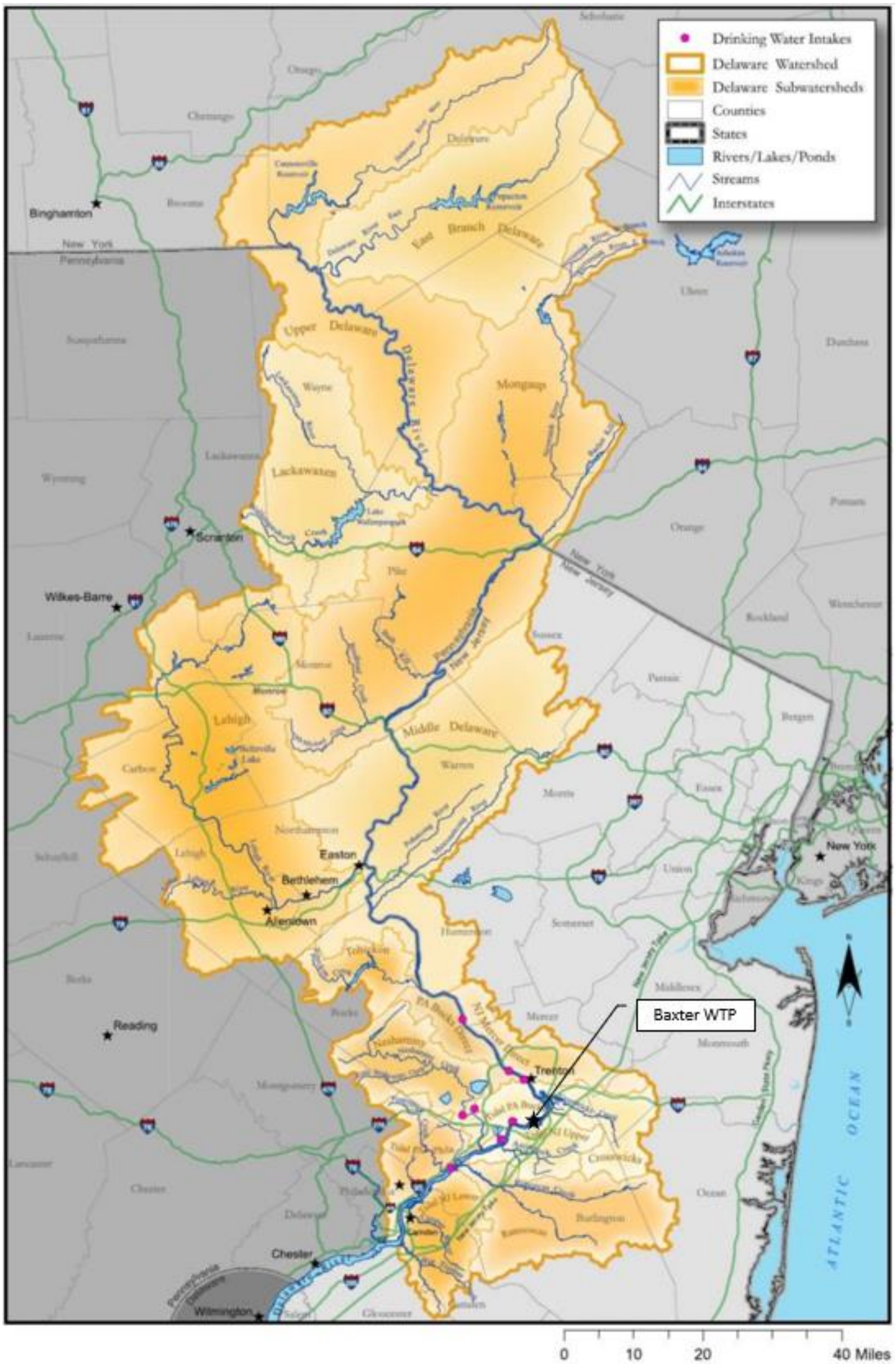

Figure 4: Map of the Delaware watershed (PWD, 2007).

The source water protection strategies are guided by four primary goals:

1. Ensure the Delaware River Baxter WTP, in northeast Philadelphia, is adequately protected under regional water policy from climate change effects on the tidal salt line[12] and streamflow.

2. Prevent the Baxter WTP from losing Bin 1 status (the highest quality source water bin) under the Long Term 2 Enhanced Surface Water Treatment Rule, which is based on *Cryptosporidium, E. coli*, and turbidity levels in the source water.

3. Become a regional leader and facilitator of efforts to offset the effects of land cover change on the water quality and quantity of the Delaware River.

4. Raise the profile of the Delaware River as a drinking water supply that needs to be maintained and protected in the eyes of the public, government, and regulatory communities.

To achieve these goals the plan highlights key initiatives to focus source water protection efforts.

Enhance the DRBC Special Protection Waters Resolution – PWD supports the enhancement of the Special Protection Waters Resolution (SPW). The SPW is designed to prevent degradation in streams and rivers where existing water quality is better than the established water quality standards by requiring there be no measurable change in existing water quality of SPW except towards natural conditions.

Delaware River Salinity Reduction Initiative – Due to increasing trends in sodium in the river and the health concerns associated with sodium for customers on a salt-restricted diet, While salts can have other impacts to overall watershed health, including corrosion of metals leading to elevated metal contamination in drinking water, as well as higher nutrient and metal concentrations in waterbodies, the PWD program is driven by the USEPA Health Advisory for sodium. PWD would like to reverse the rising trend in sodium concentrations. The first step toward this goal is for the PWD to research specific contributions of sodium from watershed sources, such as road salt applications, wastewater treatment plants, sodium hypochlorite disinfection, and water softening chemicals, to establish loadings and prioritize salt-reduction activities.

Forest Protection and Conservation Development Initiative – The aim of this initiative is to preserve forested lands and open spaces. Support ongoing forest protection initiatives by providing information to counties, municipalities, land trusts, the Smart Growth Alliance, and other environmental conservation groups. Explore with the Pennsylvania Department of Conservation and Natural Resources (DCNR) about purchasing, or otherwise conserving, forested lands for source water protection. Identify funding options for purchasing land or easements in the name of source water protection.

Delaware Valley Climate Change Initiative – The PWD will partner with the Partnership for the Delaware Estuary (PDE) to explore climate change issues relating to the tidal salt line and water quality of the Delaware River, for example an updated model of tidal salt line movement based on current climate change predictions for sea level rise and altered freshwater flow.

[12] Philadelphia's water supply is in the tidal portion of the river. The salt line is the boundary between fresh and salt water that moves based on flow conditions and tides.

Early Warning System Expansion – In order to further protect the water supply of the Delaware River, the PWD will expand the Delaware Valley Early Warning System (EWS). The EWS will be expanded to strengthen its response mechanism in the event of terrorist attacks or catastrophes, the notification system will be expanded to include industrial intakes and dischargers, and standalone time of travel models will be developed to help utilities update emergency response plans.

Regional Disinfection Byproduct Precursor Investigation – Research disinfection byproduct precursors/indicators (bromide, TOC, DOC, and UV254) and work to reduce their prevalence in the Delaware River. With a vast network of data and knowledge of watershed sources, source water protection projects can be designed to reduce disinfection byproduct precursors.

To achieve PWD's source water protection objectives, there are approximately 3.5 full-time equivalent staff dedicated to source water protection activities. Further the budget for support services from technical engineering firms and non-profits (e.g., the Partnership for the Delaware Estuary) is approximately $2.0 million annually. Support services include source water planning, climate planning, EWS management and development, regional partnerships, modeling, and watershed monitoring/analysis.

PWD Source Water Monitoring (Delaware Valley Early Warning System)

The Delaware Valley EWS provides alerts to water systems about discharges into rivers and streams, or changes in surface source water quality and flow, in the Schuylkill and lower Delaware River watersheds. EWS focuses on those discharges that might affect drinking water quality. Technological components of the system include a notification system, secure database portal, user-friendly website, comprehensive water quality and flow monitoring network, and spill modeling. PWD uses the EWS to be better informed about upstream water quality and spill events. Water quality and flow data from the EWS monitoring network, consist of approximately 90 on-line monitoring stations at USGS sites and drinking water treatment plant intakes throughout the coverage area. The core parameters collected as part of PWD's network includes conductivity, turbidity, pH, temperature, and dissolved oxygen. Data from the system can be viewed by subscribers through the EWS website's Real-Time and Historic Data Query functions. The notification system allows reporting of spills or other events along with the ability to track and map pollution discharge events with predictive modeling that can estimate downstream arrival times of pollution discharges at water system intakes using real time water data and tidal conditions.

Washington, D.C., Metropolitan Area (Potomac River)

The Potomac River, a tributary of the Chesapeake Bay, is the primary source of supply for five water utilities that serve the Washington, D.C., Metropolitan Area (WMA).

- Washington Aqueduct, a Division of the U.S. Army Corps of Engineers (USACE) in the District of Columbia
- Washington Suburban Sewer Commission (WSSC) in Maryland
- Fairfax Water in Virginia

- City of Rockville in Maryland
- Loudoun Water in Virginia

These five utilities provide water for 4.6 million residents of Virginia, Maryland and the District of Columbia.[13] The utilities withdraw water upstream of a series of falls near Washington DC that are the transition to the tidal portion of the Potomac River. The upstream watershed is approximately 11,000 square miles in area. Land use transitions from rural in the mountainous headwaters through extensive agricultural areas in the valleys and to suburban/urban areas in vicinity of the intakes (Figure 5). While this watershed is located in a different geographic area than the WIF, it is similar in size to the Willamette and the strategies employed for a large watershed can be informative to the WIF.

Historically, water quality challenges have consisted of nutrient pollution, algal blooms, turbidity, pesticides, industrial spills, sewerage discharges, etc. In 2010, the USEPA established a total maximum daily load (TMDL) for the Chesapeake Bay for phosphorous, nitrogen and sediment. Since that time, there has been substantial investment in the region in a variety of pollution management strategies to meet the TMDL requirements. Some of the efforts include wastewater treatment plant upgrades, reductions in septic systems, agricultural best management practices, riparian buffer requirements, stream restoration, and reductions in impervious surface. These efforts were not intended as source water protection measures but have resulted in direct benefits to the regions' drinking water utilities.

[13] https://www.potomacriver.org/wp-content/uploads/2017/08/ICP17-3_Schultz.pdf

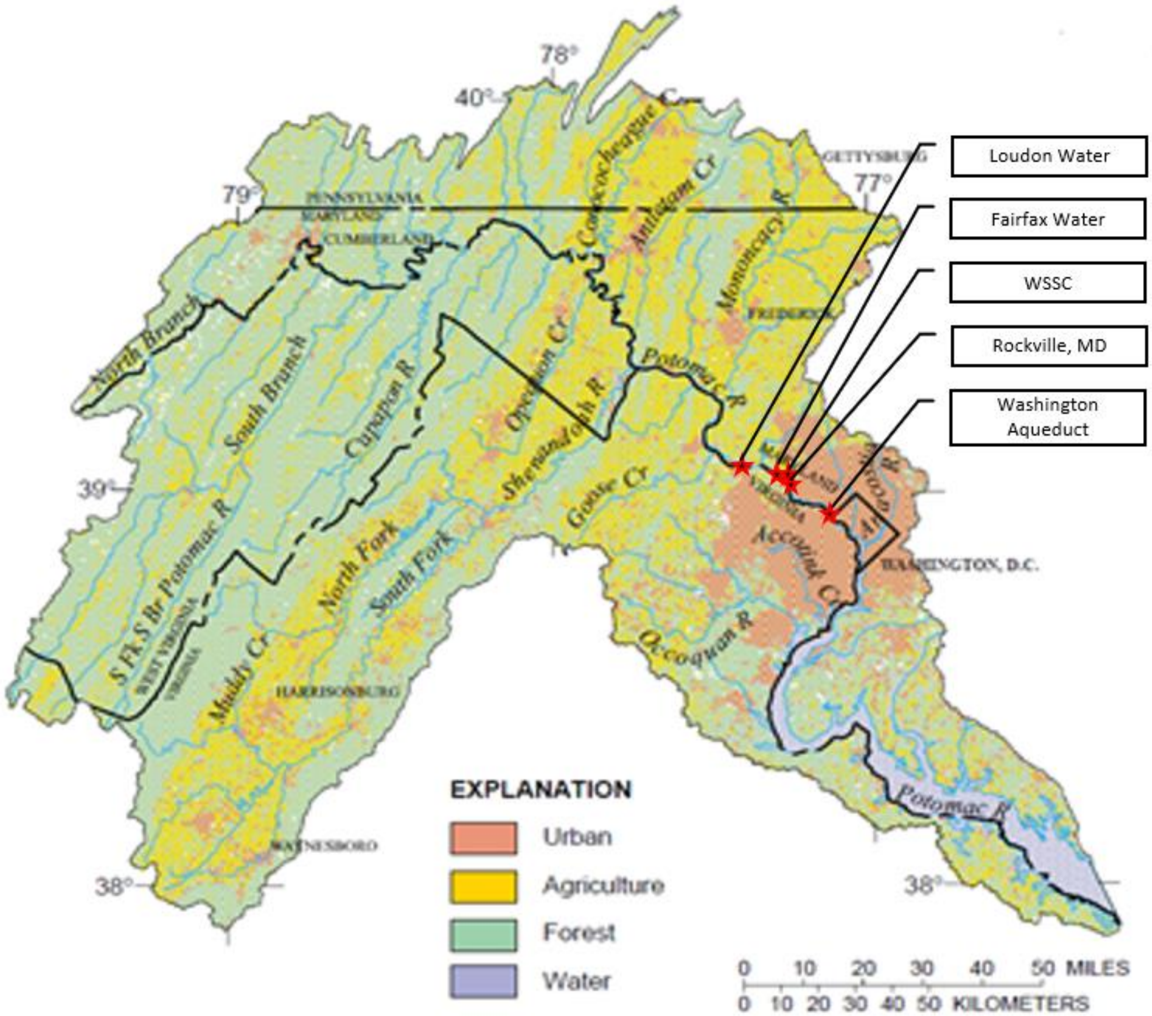

Figure 5: Map of the Potomac River watershed and tributaries with different land use (adapted from USGS Circular 1166).

While the Chesapeake Bay TMDL prompted regulations of nutrients and sediment that helped reduce pollutant loads, source water protection efforts are still needed given the development pressures from a growing population in the watershed. Industrial spills remain one of the largest concerns in the watershed. Further, a number of emerging contaminants have been a growing concern, which includes conductivity, pharmaceuticals and personal care products and Per- and Polyfluoroalkyl Substances (PFAS).

Many of the WMA utilities do not have published source water protection plans, but the utilities work both individually and collaboratively on efforts to monitor Potomac River pollution and manage risks. Further, the Interstate Commission on the Potomac River Basin (ICPRB)[14] serves as a coordinating organization to support water resources management and source water protection efforts.

[14] https://www.potomacriver.org/

Authorized by an Act of Congress in 1940, the ICPRB is an advisory, non-regulatory interstate compact agency of the Potomac basin states of Maryland, Pennsylvania, Virginia, West Virginia, and the District of Columbia. ICPRB was formed in response to extreme pollution levels that required a regional, cooperative response by all the jurisdictions. The primary focus areas for the ICPRB are water quality, drinking water resources, aquatic life, and education/communication. The ICPRB provides water resources analyses, mapping tools, spill modeling, and educational materials to support management of the Potomac River.

The ICPRB leads the Drinking Water Source Protection Partnership (DWSPP),[15] which is a voluntary association of 25 water utilities and government agencies focused on protecting sources of drinking water in the Potomac River basin. The DWSPP meets regularly to share information on source protection efforts across its members and coordinate actions across six workgroups (Potomac River Basin DWSPP, 2020).

Early Warning and Emergency Response Workgroup – This workgroup helps members prepare for spills and helps them keep abreast of regional efforts to safeguard the Potomac River from accidental or intentional releases of contaminants. Specific activities conducted by the workgroup include:

- Ensure that emergency communications systems and protocols reflecting the specific needs of the water supply community are in place, understood, and regularly practiced.
- Establish a relationship with significant potential contaminant sources identified through the various source water assessments and other means, to facilitate a mutual understanding of hazardous material procedures and risks to water supply.
- Establish a relationship with local, state, and Federal emergency response agencies to foster a mutual understanding of drinking water vulnerabilities.
- Coordinate annual emergency spill response exercise using ICPRB's spill travel time model and the Regional Incident Communication and Coordination System.
- Lead the Potomac River basin hazardous liquids pipeline safety review and tabletop exercises with Colonial Pipeline.

Outreach Workgroup – The workgroup collaborates with partner utilities to promote and educate outside stakeholders on their activities and projects and develops tools for effective communication of source water protection values.

Contaminants of Emerging Concern Workgroup – The workgroup tracks and reports on findings of research related to emerging and newly identified threats posed to the Potomac River drinking water supply. Over the years, the focus of the workgroup has covered PFAS, microplastics, pharmaceuticals and personal care products, cyanotoxins, and endocrine disruptors, among other emerging water quality issues in the region. The workgroup also advocates for related national-level studies with the goal of providing sound science on how these emerging challenges should be addressed.

[15] https://www.potomacdwspp.org/

Urban and Industrial Issues Workgroup – The workgroup promotes environmental stewardship in the Potomac River basin by its urban and industrial stakeholders to protect sources of drinking water. The goal of the workgroup is to enhance communication of drinking water needs and related Clean Water Act and Safe Drinking Water Act water quality programs to urban and industrial stakeholders with point and non-point source discharges. The workgroup's activities include ongoing efforts to review state stormwater standards, national and state water quality standards, NPDES permits and renewals, and road salts and winter-weather impacts.

Water Quality Workgroup – The workgroup addresses regional water quality needs by maintaining a list of water quality resources and by helping other workgroups with analysis and mapping. Through these efforts the workgroup facilitates the water quality data needs related to ongoing DWSPP projects, tracks issues related to source water protection and water quality and supports the identification of possible sources of contaminants in the watershed.

Agricultural Issues Workgroup – The workgroup coordinates with soil conservation districts and state NRCS offices to advocate for good stewardship practices and collaboration with farmers. Further the workgroup coordinates with NRCS on Farm Bill funding initiatives in the basin.

The DWSPP is a voluntary organization, so it does not conduct water quality monitoring data collection. Each individual member monitors source water conditions at their respective intake and shares the data with partner utilities, as necessary. Typical online monitoring data collected by utilities in the Potomac Basin include conductivity, turbidity, temperature, DO, pH, total organic carbon, polyaromatic hydrocarbons (i.e., petroleum sensor), and oxidation reduction potential.

The utilities included in the case study that withdraw from the Potomac River are structured such that source water protection is integrated into other functions the utilities. Therefore, it is a challenge to accurately identify funding and staff levels for source water protection efforts. For one utility, Fairfax Water, it is estimated that approximately three staff members in their Planning Department are mostly dedicated to source water protection activities, and the utility has budgeted approximately $1.2 million for watershed management activities.

Another coordinating organization in the WMA is the Metropolitan Washington Council of Governments (MWCOG). The MWCOG is an independent, nonprofit association, with a membership of elected officials from the local, state and the federal government in the region. The goal of the MWCOG is to support planning initiatives to address challenges and support the future of the region across multiple areas: housing, environment, equity, transportation, public safety, and health. The MWCOG participates with the DWSPP and collaborates with the WMA drinking water utilities on source water protection initiatives. For example, the MWCOG contracted with WaterSuite to develop a data system tool to house and update regional source water assessment data for the Potomac River in Maryland, Virginia, Pennsylvania, and West Virginia. The goals of the project were to update the source water assessments completed in the early 2000's, develop an online tool to facilitate regular data updates so that assessments and information remain relevant to conditions on the ground, support a common information sharing, and assist development of source water protection priorities.

Water Quality Comparison

The purpose of this section is to compare the case studies mentioned previously and determine similarities, differences, key variables, and water quality trends at different geographic locations in the U.S.

The Oregon DEQ ranks the water quality of rivers throughout the state using the Oregon Water Quality Index (OWQI)[16]. Variables included in the OWQI are temperature, DO, biochemical oxygen demand (BOD), pH, total solids, ammonia, nitrate, total phosphorous, and bacteria. Water quality for each parameter is converted into sub-index values using parameter specific equations that account for variability within the data. These values are then aggregated using a formula that allows the most impaired parameter to impart the greatest influence on the water quality index and ensures that small individual changes are detectable in the aggregated index value. This formulation of the index makes it sensitive to poor water quality conditions for a single parameter. The 2021 OWQI characterizes the Willamette River at Wheatland Ferry, about 10 miles downstream from Salem, OR, as excellent (89.6 out of 100) and just downstream of Wilsonville at Canby Ferry as good (87.7 out of 100) (Figure 6). Oregon DEQ has not developed a long-term trend at either station.[17]

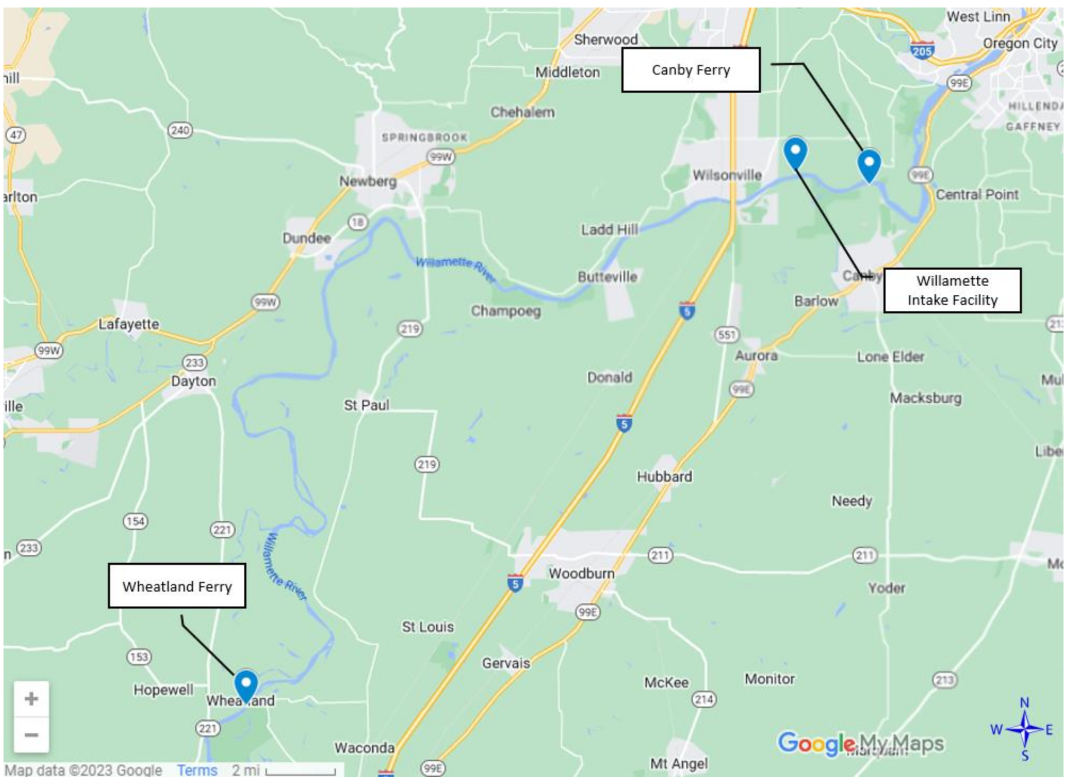

Figure 6: Wheatland and Canby Ferry locations.

[16] https://www.oregon.gov/deq/wq/Pages/WQI.aspx
[17] Oregon DEQ has been collecting water quality samples at these locations since 2002.

Water quality data was downloaded from the USEPA Water Quality Portal (WQP)[18] for upstream of the WIF intake at Wilsonville and for the case study sources. The WQP is a cooperative service that integrates publicly available water-quality data from over 400 state, federal, tribal, and local agencies. Water quality data collected for comparison was limited to the last approximately 20 years. Further, multiple stations were selected in the general vicinity of the intake to broadly characterize water quality in the source of supply. For the Willamette, seven stations between Wheatland Ferry and Wilsonville were selected to compile data.

The database for each source included hundreds of water quality parameters including physical conditions, nutrients, metals, bacteria, radionuclides, and chemicals (e.g., pesticides, hydrocarbons, PCBs, endocrine disrupters, PFAS). The results in the database were obtained from grab samples, and the sampling frequency ranges widely with more common parameters (e.g., alkalinity, pH, DO) having up to a hundred or more sample results, while many of the chemical parameters only have a small number of samples recorded (e.g., 1 to 5).

Table 5 provides a summary of minimum, maximum, and average values from the collected data for key water quality parameters.[19] The sources are within similar ranges for most of the parameters. Some of the differences are that the Willamette River is higher than the Clackamas and McKenzie Rivers for fecal coliform, but lower than the more developed Potomac and Delaware Rivers. The range in organic carbon and turbidity is lower for the Willamette River than the Clackamas and McKenzie Rivers, and measured values are lower overall than the Potomac and Delaware Rivers. Consistent with the OWQI, the data review indicates the section of the Willamette River in the vicinity of the WIF is a high-quality water source for providing drinking water.

With respect to chemical constituents, the available data indicates that each source of supply has had hundreds of individual chemicals detected. Across the data, it is difficult to discern a pattern. Each source has some chemicals that are present in larger concentrations based on local watershed factors including discharges, land uses, types of industry, atmospheric deposition, and legacy contamination. The main takeaway is that no water supply has completely avoided impacts from anthropogenic pollutants. While there is limited value in a side-by-side comparison of the chemical pollutants across the different watersheds, the data for the Willamette River will be useful for evaluating potential sources of contamination for the source water program for the WIF. The subsequent Task 8 will undergo a refined risk analysis to better understand potential contamination sources (PCS) followed by an assessment of potential preventative or mitigative measures moving forward for the WIF.

[18] https://www.waterqualitydata.us/

[19] Note that these data provide a snapshot of the data across these watersheds for comparison and are not comprehensive to describe all potential conditions.

Table 5: Summary USEPA Water Quality Portal of Select Water Quality Parameters in the Vicinity of the WIF and Case Study Intakes+

	Willamette River (WIF)			Clackamas River			McKenzie River			Delaware River			Potomac River		
	min	max	avg	min	max	avg	min	max	avg	min	max	avg	min	max	avg
Alkalinity, total (mg/l)	18.0	34.0	25.3	12.0	34.0	23.8	15.0	32.0	23.7	12.0	95.0	41.4	9.0	200.2	73.4
Chlorophyll a (ug/L)	0.5	9.6	1.8	0.8	8.4	1.9	0.2	3.6	1.0	0.0	111.0	12.7	0.2	49.8	3.9
Dissolved oxygen (DO) (mg/L)	6.6	16.7	10.3	8.2	14.7	11.2	9.0	14.1	11.3	0.2	79.0*	8.3	0.4	56.3*	10.5
Fecal Coliform (cfu/100ml)	14.0	460.0	87.3	4.0	32.0	20.7	0.0	24.0	6.8	5.0	4,400.0	191.2	25.0	2,000.0	468.6
Nitrate + Nitrite (mg/l)	0.1	1.3	0.3	0.0	0.6	0.1	0.0	0.3	0.0	0.0	0.8	0.4	1.0	1.8	1.5
Organic carbon (mg/L)	0.0	4.8	1.6	0.0	44.0	1.3	0.0	18.0	0.8	0.2	14.0	3.4	0.1	40.9	2.7
Orthophosphate (mg/L)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	10.0	0.1	0.0	0.5	0.0
pH	6.4	9.5	7.5	6.5	8.0	7.6	7.0	8.6	7.6	4.8	9.4	7.2	5.1	9.7	7.6
Turbidity (NTU)	1.0	34.0	6.5	1.0	69.0	6.9	0.0	45.0	2.6	0.9	861.0	12.3	0.0	1,185.0	19.6

+ It should be noted that the available data provides a snapshot of source water quality based on data in the WQP. Locally collected data is not typically reported to USEPA.

* Some values for DO in the WQP database may have been entered as percent saturation and listed as mg/L.

Recommendations for WIF and Next Steps

In making recommendations for monitoring equipment, the goal is to focus on parameters that will provide the most value for operations. The WWSS Raw Water Facilities building design includes space for monitoring equipment, feed lines, and a raw water quality panel for source water monitoring at the intake. At this stage of the source water planning process our recommendation would be either a set of standalone probes or a multi-parameter sonde at the intake to measure temperature, conductivity, DO, pH, and turbidity. The Willamette River water quality data nor the watershed risk assessment to-date supports the need for ORP or nitrate sensors.

Algae and cyanobacteria indicators are not as critical given the effectiveness of the treatment processes employed at the WIF.[20] However, they may be useful for tracking conditions to provide additional information to plant operators in responding to harmful algal blooms. Further, because the Newberg Pool of the Willamette River upstream of the intake is a popular recreational area, it may be worth considering how monitoring for harmful algal blooms could be a collaborative effort between WIF and state and local governments to develop a robust monitoring program to support both drinking water and recreation.

The Willamette Water Supply System (WWSS) WTP will have an online TOC sensor as part of its operational monitoring needs. The data from this sensor can also be used to support source water monitoring related to changes in TOC over time for the water supply.

From the source water risk assessment to-date, there does not appear to be the risk factors (e.g., large marina, petrochemical manufacturing, barge transport, etc.) to warrant deployment of a hydrocarbon sensor. However, there is a Kinder Morgan refined fuels pipeline that crosses the Willamette River approximately a half mile upstream of the WIF. While a hydrocarbon sensor can provide additional confidence in advanced notification in the event of a pipeline leak, developing a direct line of communication with the pipeline operator is often a more reliable strategy for notification.[21] We will have additional discussion with WIF staff to develop appropriate recommendations for addressing risks from this important PCS under Task 8.

With respect to sensor deployment at an upstream location, because the Willamette River watershed is so large, it is neither useful nor practical to characterize the entire watershed. Smaller and further upstream sources of pollution will have limited influence on the overall water quality of the river given the effects of dilution and natural attenuation of pollutants.[22] A goal, therefore, would be to identify location(s) that could have a disproportionate effect on water quality for the WIF. These locations could be clusters of development, major dischargers, or important tributaries.

[20] The treatment train consists of ballasted flocculation, ozone and biologically active filtration, which are robust processes for managing algae and cyanotoxins.
[21] Refined fuels pipelines are required to be actively monitored to identify pressure anomalies that could be indicative of a leak. State law requires reporting leaks to the Oregon Emergency Response System.
[22] Natural attenuation of pollutants occurs through biological action, photodegradation, oxidation, adhesion, settlement and other processes that convert or remove pollutants from the water column.

For example, one candidate location for remote monitoring is in the vicinity of Newberg, OR. At this location there are two wastewater treatment plants (WWTPs) (Newberg and Dundee[23]), urban stormwater discharges from the two towns, and is just downstream of the Yamhill River confluence. The Yamhill River may be a concern because it is rated as poor by the OWQI and has a significant watershed area (approximately 840 square miles). While these sources are 15 to 20 miles upstream of the WIF, they are on the same side of the river and the Newberg Pool is relatively free of obstructions, which increases the potential for pollutants to reach the WIF with limited mixing and natural attenuation.[24] There is an existing USGS gauge at Newberg that collects flow and water temperature data. However, it appears to be upstream of the Newberg WWTP discharge.

A next step for monitoring would be to review water quality data from the Wilsonville WTP and discuss with operators at that plant their experience with water quality conditions to help inform whether remote monitoring would be beneficial. Additional next steps would be to incorporate the information for the monitoring review and case studies into the risk assessment (Task 8) and overall WIF Source Water Protection Plan (Task 9).

[23] The average daily discharge across the two plants is approximately 3 mgd.
[24] These sources are all within the tier 1 previously determined from the risk assessment.

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