Photo: Chehalis River, looking upstream toward Porter, WA (NHC, 2025)

Section 319 Nonpoint Source Assessment Report

Upper Chehalis River Basin (WRIA 23)

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EXECUTIVE SUMMARY

This document presents the Nonpoint Source (NPS) Pollution Assessment for the Upper Chehalis watershed (WRIA 23) in the State of Washington. The report was prepared to evaluate existing water quality conditions, identify the primary sources and drivers of NPS pollution, and provide the technical foundation needed to support development of a future NPS Management Program under Clean Water Act Section 319. The assessment integrates information from prior watershed studies, recent monitoring datasets, and spatial watershed analyses to characterize current conditions and identify priority areas for NPS pollution reduction and restoration within WRIA 23.

Assessment Context

The Upper Chehalis watershed forms the upstream portion of the Chehalis River Basin in southwestern Washington and includes numerous tributaries that ultimately discharge into the Chehalis River and, downstream, into Grays Harbor to the west. The basin encompasses diverse landscapes, including extensive forestlands, agricultural lands, urbanized communities, and culturally significant tribal lands. Protecting and restoring water quality within the upstream watershed is essential for maintaining aquatic ecosystem health, salmonid habitats, and beneficial uses such as recreation and fisheries within the entire basin.

This NPS Pollution Assessment Report was prepared to evaluate the nature and extent of NPS pollution within the Upper Chehalis watershed and, as noted above, establishes the technical foundation for the development of a future NPS Management Program Plan to support water quality protection efforts of the Confederated Tribes of the Chehalis Reservation in this basin.

The primary objectives of this report are to:

- Characterize surface water pollution issues across the basin, particularly in tributaries and mainstem river reaches affected by potential nonpoint sources.
- Identify likely influential sources and contributing factors such as land-use practices.
- Recommend priority areas for pollution control and generally appropriate best management practices (BMPs).

The assessment focuses primarily on the Upper Chehalis watershed (WRIA 23), while references to the Lower Chehalis watershed (WRIA 22) are included where necessary to provide broader basin context. Point source pollution is outside the scope of the Section 319 program and therefore was not evaluated in detail.

Methodology of Assessment

The assessment was developed using a combination of historical study review, evaluation of recent monitoring datasets, and synthesis of findings across the watershed.

Review of Prior Studies

An extensive review of previously completed studies and watershed planning documents was conducted. These included:

- Total Maximum Daily Load (TMDL) studies
- Watershed management and implementation plans
- Chehalis Basin Level 1 Assessment report
- Aquatic Species Restoration Plan (ASRP) documents
- Other technical studies and GIS-based watershed resources

These studies provided historical context, previously documented impairments, and information on controlling factors influencing water quality conditions.

The review of prior studies relied on the findings reported in those documents and reflects the regulatory frameworks and watershed conditions at the time they were conducted, which may have changed since then. However, the review of prior studies helped establish the historical context and legacy of water quality issues and mitigative efforts across WRIA 23.

Analysis of Current Water Quality Data

The core of the assessment consisted of analyzing recent monitoring data collected from multiple stations throughout the watershed. The primary datasets used in the evaluation were compiled from:

- Washington State Department of Ecology Freshwater Information Network (FIN)
- Water Quality Portal (WQP) datasets integrating monitoring data from USGS, EPA, and Tribal monitoring programs and local environmental monitoring efforts

The primary water quality parameters evaluated included temperature, dissolved oxygen, fecal coliform bacteria, pH, nutrients (total phosphorus and inorganic nitrogen), and total suspended solids. These datasets were used to identify exceedances of water quality criteria, evaluate spatial trends, and compare recent conditions with historical observations.

Study Synthesis and Evaluation

The final stage of the methodology integrated the results from prior studies and the recent monitoring analysis. This synthesis was used to identify areas with recurring impairments, determine likely sources of nonpoint pollution, and support the selection of appropriate BMPs for future watershed management actions.

Watershed Land-Use

Land-use plays a critical role in shaping water quality conditions throughout the Upper Chehalis watershed. The watershed contains a mixture of forested areas, agricultural lands, urban and rural residential development, and riparian corridors.

Forestland is the dominant land-cover across most subbasins, while agricultural land-uses and developed areas occur primarily in the central and lower portions of the watershed. Agricultural activities, particularly livestock grazing and manure management, have been identified as significant contributors to fecal coliform bacteria, nutrients, and sediment loading in several tributaries.

Comparison of land-cover data between 2003 and 2023 indicates a decrease in clearcut coverage and an increase in mature forest cover across both private and state forestlands; and a minor shift from agriculture and forest uses to developed uses has also occurred in some areas. Overall, basin-wide land-use changes appear limited. The basin remains predominantly forested, with agriculture and urban/rural development representing important secondary land-uses that influence water quality conditions in several tributaries and mainstem reaches.

Current NPS Control Efforts

Numerous NPS pollution control programs are currently implemented (or are ongoing) throughout the Chehalis River Basin through collaboration among federal, state, tribal, county, municipal, and non-profit partners.

Some of these efforts include:

- Agricultural nutrient management programs
- Livestock exclusion fencing and riparian restoration initiatives
- Septic system inspection, maintenance, and repair programs
- Stormwater management improvements in urban areas
- Forestry road erosion control and sediment management measures
- Monitoring programs and community outreach initiatives

These programs aim to reduce pollutant loading, improve riparian habitat conditions, and address water quality impairments identified through monitoring and TMDL studies. Despite these efforts, several water quality issues, some identified in earlier studies continue to persist, indicating that continued implementation of targeted BMPs is necessary.

Key Findings of the Assessment

The results of this assessment confirm that water quality impairments remain widespread in several tributaries and portions of the mainstem Chehalis River.

Key water quality concerns identified across the basin include:

- Increased stream temperatures exceeding water quality criteria, particularly during dry seasons
- Low dissolved oxygen levels
- Elevated fecal coliform bacteria concentrations
- Nutrient enrichment, particularly total phosphorus and inorganic nitrogen
- Elevated total suspended solids during storm events

Spatial analysis of monitoring results indicates that the “mid-basin” portion of WRIA 23 - the central portion of WRIA 23 extending roughly from upstream of the Newaukum River confluence to below the Black River confluence - exhibits the highest cumulative frequency of exceedances across temperature, dissolved oxygen, and bacterial indicators.

The most significant categories of NPS pollution identified in this assessment include:

- Thermal loading and riparian degradation
- Organic and nutrient loading
- Bacterial contamination from agricultural and rural/urban sources
- Sediment delivery from disturbed upland and riparian areas

Priority subbasins requiring focused management measures include Upper Chehalis River (#4a and #4b), Middle Chehalis River (#10 and #13), Newaukum River (#5, #6, and #7), Black River (#11), Salzer Creek (#8), and the Skookumchuck River (#9) as shown in Figure EX1.

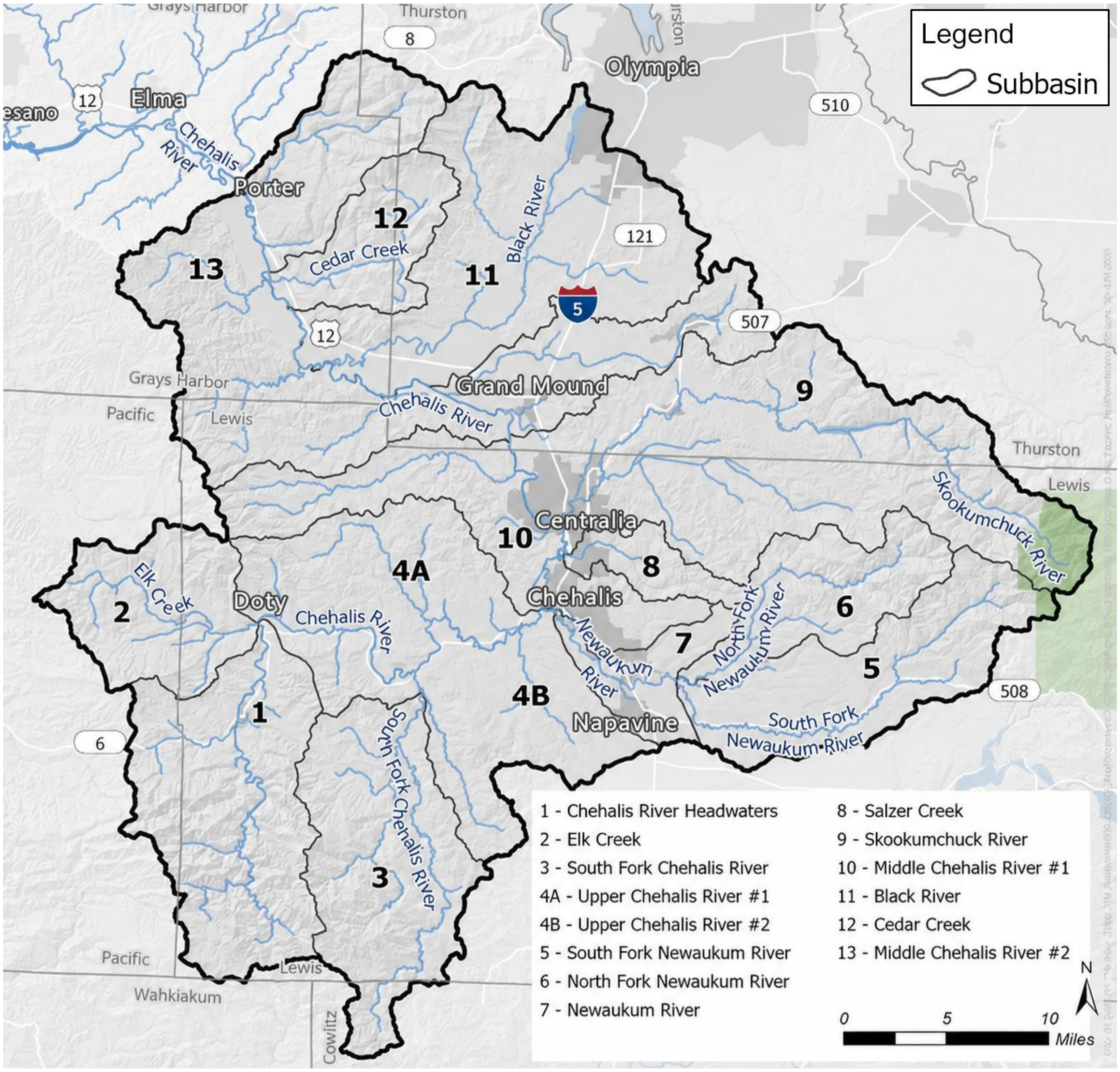

Figure EX1: Subbasins of the Upper Chehalis River Basin.

Potential Best Management Practices

Based on the assessment findings and review of prior watershed planning efforts, a range of general candidate BMPs were identified to address key NPS pollutions. These BMPs are consistent with practices implemented in similar watersheds and supported by existing management programs.

Key BMP categories include:

- Riparian and stream restoration, including livestock exclusion fencing and riparian vegetation restoration
- Nutrient, manure, and waste management practices in agricultural and rural areas
- Septic system inspection, maintenance, and upgrade programs in rural residential areas
- Erosion and sediment control measures on forest roads, agricultural lands, and construction areas
- Forestry management practices to reduce sediment delivery and protect riparian corridors
- Public education, outreach, and technical assistance programs
- Regulatory inspection, compliance, and enforcement activities related to agricultural and urban water quality protection
- Stormwater management and green infrastructure measures to reduce urban runoff
- Practices such as enhancing hyporheic exchange to improve groundwater–surface water interactions, installing constructed large woody debris and step-pool sequences to restore natural flow regimes, and implementing smart agriculture measures to improve water quality and increase water-use efficiency

These measures are intended to reduce pollutant loading, restore riparian shading and habitat conditions, and improve overall watershed resilience.

Overall Conclusions and Future Direction

This assessment provides a comprehensive evaluation of water quality conditions and NPS pollutions within the Upper Chehalis watershed. The findings confirm that several tributaries and mainstem reaches continue to experience impairments related to temperature, dissolved oxygen, bacteria, nutrients, and sediment. Among these, temperature and dissolved oxygen exceedances are the most widespread and significant water quality concerns.

The study highlights the importance of targeted implementation of BMPs and continued monitoring in priority subbasins, particularly within the mid-basin region where multiple stressors coincide. The results also reinforce conclusions from prior watershed studies that land-use practices, including agriculture, forestry, and rural development, remain key drivers of NPS pollution.

The assessment therefore establishes a scientific foundation for the development of a future NPS Management Program Plan, which will define specific management practices, geographic implementation areas, administrative structure, high-level schedules, and funding mechanisms to support long-term watershed protection and restoration.

How This Report Is Organized

This report is organized to guide the reader through the assessment process from watershed overview to conclusions and management recommendations. The following structure allows readers to understand the watershed characteristics, evaluate water quality conditions, and follow the logical progression from data analysis to management recommendations.

- Section 1 – Overview introduces the Chehalis River Basin and the purpose of the assessment.
- Section 2 – Introduction provides background on the watershed, water quality issues, and regulatory context.
- Section 3 – Methodology describes the approach used to review prior studies, analyze current monitoring data, and synthesize findings.
- Section 4 – Land-Cover and Land-Use Summary presents land-use classifications and changes across the watershed.
- Section 5 – Surface and Ground Water Summary describes the watershed's major water bodies and overall water quality conditions including findings from prior studies.
- Section 6 – Results summarizes analysis of recent monitoring data.
- Section 7 – Discussion interprets the results and identifies key pollution sources and watershed processes.
- Section 8 – Selection of BMPs identifies general candidate BMPs for reducing NPS pollution.
- Section 9 – Existing NPS Control Programs reviews implemented/ongoing watershed management programs/projects and pollution control initiatives.
- Section 10 – Conclusions summarizes the overall findings and identifies future management priorities.
- Appendices (A to E) provide detailed supporting information, including monitoring station summaries, water body and complementary descriptions, and expanded evaluations of prior studies.

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ABBREVIATIONS

Acronym / Abbreviation	Definition
7-DADMax	7-Day Average of the Daily Maximum Temperatures
ASRP	Aquatic Species Restoration Plan
BMPs	Best Management Practices
BOD	Biochemical Oxygen Demand
Br	Bridge
CO_2	Carbon Dioxide
CCWF	Centennial Clean Water Fund
CREP	Conservation Reserve Enhancement Program
DIP	Detailed Implementation Plan
DO	Dissolved Oxygen
DNR	Department of Natural Resources, Washington State
DOH	Department of Health, Washington State
E. coli	Escherichia coli
ESA	Endangered Species Act
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FC	Fecal Coliform (Bacteria)
FIN	Freshwater Information Network
FSA	Farm Service Agency
FWQI	Freshwater Quality Index
GMA	Growth Management Act
Hwy	Highway
HW6	Highway 6
HW13	Highway 13
IN	Inorganic Nitrogen
IM	Interim Milestone
IQR	Interquartile Range
Log	Logarithm

Acronym / Abbreviation	Definition
Ln	Natural Logarithm
LW	Lower Whisker
Max	Maximum
Min	Minimum
N	Nitrogen
N-Dissolved	Dissolved Nitrogen
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Unit
NEB	Net Ecological Benefit
NPS	Nonpoint Source
NF	North Fork
P	Phosphorus
P-Dissolved	Dissolved Phosphorus
pH	Potential/Power of Hydrogen
Q1	First Quartile
Q2	Median
Q3	Third Quartile
RCW	Revised Code of Washington
Rd	Road
RM	River Mile
SCC	State Conservation Commission, Washington
SF	South Fork
SRF	State Revolving Fund
SR	State Route
STC	Steering Technical Committee
St	Street
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSS	Total Suspended Solids

Acronym / Abbreviation	Definition
US	The United States
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UW	Upper Whisker
VSP	Voluntary Stewardship Program
WA	State of Washington
WDFW	Washington State Department of Fish and Wildlife
WQX	Water Quality Exchange
WQP	Water Quality Portal
WRIA	Water Resource Inventory Area
WHIP	Wildlife Habitat Incentives Program
WRP	Wetlands Reserve Program
WSDA	Washington State Department of Agriculture

SYMBOLS AND UNITS OF MEASURE

Symbol / Unit of Measure	Definition
˚C (degrees Celsius)	Metric unit for temperature, representing degrees above the freezing point of water at standard atmospheric pressure (i.e., 0 °C).
˚F (degrees Fahrenheit)	Imperial unit for temperature, where 32 °F represents the freezing point and 212 °F the boiling point of water at standard atmospheric pressure.
mg/L (milligrams per liter)	Concentration of a substance (e.g., dissolved oxygen (DO), nutrients, total suspended solids (TSS)) in milligrams per liter of water.
% saturation (for DO)	Percentage of DO concentration relative to the maximum amount water can hold at a given temperature and pressure.
cfu/100 mL (colony-forming units per 100 milliliters)	Measure of viable bacterial colonies (e.g., fecal coliform (FC), *E. coli*) present in 100 mL of water (i.e., bacterial concentration).
ln(cfu/100 mL)	Natural logarithm of bacterial concentration.
$\log_{10}$(cfu/100 mL)	Base-10 logarithm of bacterial concentration.
MPN/100 mL (most probable number per 100 milliliters)	Statistically derived estimate of bacterial density in 100 mL of water.
NTU (nephelometric turbidity units)	Unit for turbidity; indicates water clarity based on light scattering by suspended particles.
ft (feet)	Unit of length or elevation above mean sea level.
in (inch)	Imperial unit of length equal to 1/12 of a foot or 2.54 centimeters.
mi (mile)	Unit of distance equal to 5,280 feet or approximately 1.609 kilometers.
ac (acre)	Unit of area equal to 43,560 square feet.
mi^2 (square mile)	Unit of area equal to 640 acres or 2.59 km^2.
cfs (cubic feet per second)	Unit of volumetric flow rate representing one cubic foot of water passing a given point each second.

GLOSSARY

Term	Definition
7-DADMax - 7-day average of daily maximum temperatures	The arithmetic mean of seven consecutive daily maximum water temperatures. The 7-DADMax for a given day is calculated by averaging that day's daily maximum temperature with those from the three preceding and three following days.
Ambient water quality	The existing physical, chemical, and biological conditions of a surface water body, determined through direct sampling, measurement, or field observation.
BMPs - Best Management Practices	Physical, structural, or managerial practices approved by the Department of Ecology that, when implemented individually or in combination, are designed to prevent or reduce pollutant discharges to waters of the State of Washington.
BOD - Biochemical Oxygen Demand	A measure of the amount of oxygen required by microorganisms to decompose organic matter in water over a specified incubation period, usually five days at 20 °C (reported as BOD_5). BOD is an indicator of the organic pollution load and the potential for oxygen depletion in receiving waters.
DO - Dissolved Oxygen	The concentration of oxygen gas dissolved in water, typically expressed in milligrams per liter (mg/L) or as a percentage of saturation.
E. coli - Escherichia coli	A bacterium from the Enterobacteriaceae family commonly found in the intestinal tracts of warm-blooded animals. Its presence in water samples indicates fecal contamination and the possible presence of enteric pathogens.
FC - Fecal Coliform	That portion of the coliform bacterial group found in the intestinal tracts and feces of warm-blooded animals, detected through the production of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 ± 0.2 °C.
Geometric mean	The n^{th} root of the product of n sample values, or equivalently, the antilogarithm of the arithmetic mean of their logarithms. The geometric mean is especially useful when data are log-normally distributed (e.g., bacterial concentrations) or when minimizing the influence of extreme outliers in skewed datasets.
Intragravel Dissolved Oxygen	The concentration of dissolved oxygen within the pore spaces between sediment particles in a streambed. This parameter is particularly important for evaluating spawning habitat quality for salmonids, as it influences egg incubation and embryo survival.

Term	Definition
Lake	A standing water body, including reservoirs, characterized by a mean detention time greater than 15 days. Mean detention time is defined as the ratio of a reservoir's mean annual minimum total storage to the 30-day, 10-year low flow entering the reservoir.
Lower Chehalis	The State of Washington Water Resource Inventory Area (WRIA) 22, covering the Lower Chehalis Watershed within the Chehalis River Basin.
NPS - Nonpoint source	Pollution that enters surface or ground waters from diffuse, unconfined sources rather than from a discrete conveyance. Examples include runoff from agricultural fields, urban areas, forestlands, and atmospheric deposition, as well as discharges from boats or marine vessels not regulated under the National Pollutant Discharge Elimination System (NPDES).
pH	The negative logarithm (base 10) of the hydrogen ion concentration in water, used to express the degree of acidity or alkalinity of a solution.
Pollution	Any contamination or alteration of the physical, chemical, or biological properties of state waters, including changes in temperature, taste, color, turbidity, or odor, or the discharge of substances (liquid, gaseous, solid, radioactive, or other) that may render such waters harmful or injurious to public health, welfare, aquatic life, or designated beneficial uses.
Primary contact recreation	Activities involving direct and prolonged human contact with water, typically to the point of full body submergence. Examples include swimming, water skiing, and skin diving.
Salmonid spawning, rearing, and migration for naturally limited waters	A subcategory of the aquatic life use designation for waters where salmonid use (spawning, rearing, or migration) is naturally limited by inherent physical, chemical, or biological characteristics of the stream or water body.
Subbasin	Planning areas dividing up WRIA 22 and 23 based on tributary and reach (there are 14 subbasins in WRIA 23 discussed in this report)
The Chehalis Basin	The entire Chehalis River Basin including both Lower Chehalis (WRIA 22) and Upper Chehalis (WRIA 23) watersheds.
TSS - Total Suspended Solids	The total mass of particulate matter suspended in water, typically expressed in milligrams per liter (mg/L). TSS includes silt, clay, organic material, and other fine particles that can reduce water clarity, affect light penetration, and contribute to sedimentation in aquatic habitats. TSS is distinguished from suspended sediment concentration (SSC): SSC is measured as the dry weight of all sediment in a known volume of a water–sediment mixture, whereas TSS is measured from a subsample using methods originally developed for wastewater analysis (John R. Gray et al., 2000).

Term	Definition
Turbidity	An optical property that measures the scattering of light by suspended particles in water, expressed in nephelometric turbidity units (NTU). Turbidity is determined using a calibrated turbidimeter and reflects water clarity, which can affect photosynthesis, habitat quality, and drinking water treatment requirements.
Upper Chehalis	The State of Washington Water Resource Inventory Area (WRIA) 23, covering the Upper Chehalis Watershed within the Chehalis River Basin.

1 OVERVIEW OF REPORT PURPOSE

The Confederated Tribes of the Chehalis Reservation (the Chehalis Tribe), located in southwest Washington, are committed to safeguarding the rivers' health throughout the Chehalis Basin. The Tribe is seeking Environmental Protection Agency (EPA) approval and grant funding to implement a Clean Water Act Section 319 Nonpoint Source (NPS) Management Program. As an initial step, this requires the development of two key documents: an assessment report and a management program plan. This study serves as the assessment report and is intended to evaluate water quality conditions within the reservation, as well as the contributing upland watershed.

The Chehalis Basin encompasses all lands that drain into the Chehalis River, its tributaries, and Grays Harbor, where the river flows into the Pacific Ocean. The Chehalis River Basin (referred to as the "Chehalis Basin" in this document) is divided into two Water Resource Inventory Areas (WRIAs): WRIA 22 for the Lower Chehalis watershed (referred to as "Lower Chehalis" in this document) and WRIA 23 for the Upper Chehalis watershed (referred to as "Upper Chehalis" in this document) which is the contributing upland watershed (see Figure 1.1).

NPS pollution occurs when rainfall, snowmelt, or irrigation water flows over land or infiltrates the ground, picking up pollutants and transporting them into surface waters (e.g., rivers and lakes) and groundwater.

This NPS Assessment Report provides a comprehensive evaluation of water quality and sources of pollution within the Upper Chehalis (WRIA 23). The report only includes references to the lower basin (WRIA 22) conditions to provide a context for upper basin water quality impacts. The primary objectives are to establish baseline water quality conditions, inform watershed management planning, identify key nonpoint pollution sources, and propose effective mitigation strategies in the Upper Chehalis. Point source pollution is outside of the scope of the EPA 319 NPS Management Program and was excluded from this report. This document serves as foundational guidance for future management actions aimed at achieving water quality goals consistent with Clean Water Act objectives.

The Chehalis Basin represents one of the largest river basins in the State of Washington (WA), encompassing a broad range of ecological habitats and diverse land-uses. The basin includes extensive areas of forestlands as well as agricultural lands, urbanized communities, and culturally significant tribal lands. Due to its ecological diversity and cultural importance, protecting and restoring water quality in the basin is critical for both environmental and community health (Chehalis Basin Partnership, 2000, 2004).

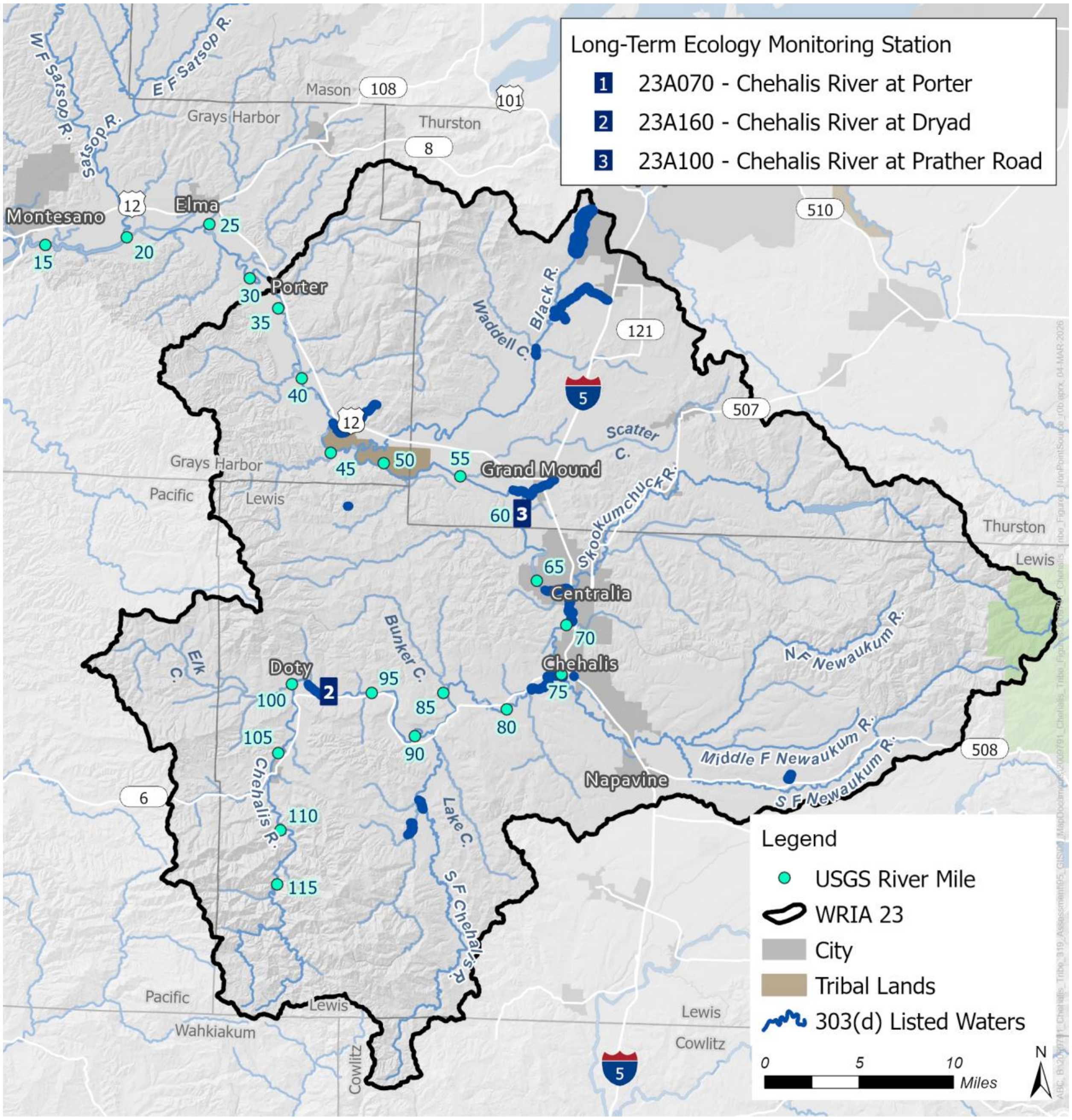

Figure 1.1 The Upper Chehalis watershed.

Addressing the complex sources of NPS pollution will require coordinated collaboration among tribal governments, local jurisdictions, state and federal agencies, landowners, and community stakeholders. As noted above, in line with this effort, the Chehalis Tribe is seeking EPA approval and grant funding to implement a Clean Water Act Section 319 NPS Management Program, requiring the development of an assessment report and a management program plan.

This study serves as the assessment report and identifies waterbodies that are unlikely to meet Tribal water quality standards without targeted pollution controls. The report also outlines existing impairments in need of restoration and highlights high-quality resources that must be protected from future degradation. It also details the types and sources of NPS pollution contributing to these concerns.

Based on the findings of this assessment, a management plan will be developed to address the identified water quality issues effectively. This report lays the foundation for targeted, strategic actions that will guide the future development of NPS management programs and implementation projects within the Upper Chehalis, in accordance with EPA requirements.

2 INTRODUCTION

The Chehalis Basin (both WRIAs 22 and 23) spans approximately 2,615 mi^2 and encompasses a wide range of landscapes, including forested uplands, agricultural valleys, and developing urban areas. WRIAs 22 and 23 cover approximately 1315 mi^2 and 1300 mi^2, respectively. The Chehalis River itself flows about 125 mi from its headwaters in the Willapa Hills to Grays Harbor. The Chehalis Basin, as the second largest watershed in WA, is a region of ecological, economic, and cultural importance.

The Chehalis Basin drainage system consists of the Chehalis River and several major river tributaries – the South Fork Chehalis, Newaukum, Skookumchuck, Black, Satsop, Wynoochee, Wishkah, and Hoquiam Rivers – and their numerous tributary creeks. In addition, the Humptulips, Grays, Johns, and Elk Rivers flow directly into Grays Harbor and are contributing to the Chehalis Basin water quality and salmon habitats. Grays Harbor is the terminus for all rivers within the Chehalis Basin. The Upper Chehalis watershed spans five counties, including Lewis, Thurston, Grays Harbor, Pacific, and Cowlitz. Annual precipitation ranges from 30 in near the City of Chehalis to 120 in near the Willapa Hills. Key communities include Tumwater at the northern edge, with Chehalis and Centralia located centrally along with other populated areas (Figure 1.1). The Chehalis Tribal Reservation lies in the northwest portion of the upper basin along the Chehalis River mainstem.

The Chehalis and Black Rivers are integral to the Chehalis Tribe's cultural practices, recreation, sustenance, and commercial fishing, which all rely on clean water. The Chehalis Basin is one of the few river basins in Washington where no salmon species are listed as threatened or endangered, and supports the state’s most diverse amphibian population with an ESA-listed amphibian – the Oregon Spotted Frog. A diverse community of aquatic species relies on streamflow throughout the Chehalis Basin. This includes three species of salmon – chinook, coho, and chum, two species of anadromous trout - steelhead and coastal cutthroat trout, and many species of native fish, amphibians, freshwater mussels, birds, and semi-aquatic mammals (e.g. beaver). Oregon Spotted Frog is currently known to occur only in the Black River subbasin.

In addition, critical habitat for ESA-listed bull trout includes portions of the lower basin, but little information exists about their presence and habitat use in the basin. Chehalis Basin aquatic species rely on healthy streamflows to support habitats critical to their full life cycle, including intact spawning areas, connected floodplains, and stable headwaters (ASRP Steering Committee, 2019; NHC, 2020).

The Chehalis Tribe, for whom the river holds profound cultural and historical importance, has resided in the basin for generations. Tribal members have long depended on the region's rivers and streams for fishing, hunting, and gathering. The Tribe continues to pursue environmental stewardship and cultural preservation while navigating development pressures and ecological degradation (Chehalis Basin Partnership, 2004).

Land within the basin is managed by a combination of Tribal, federal, state, and private entities. The Tribe has jurisdiction over environmental protection and water quality initiatives and works collaboratively with local and regional partners across broader jurisdictional areas. As development extends further into rural areas, the basin faces increasing pressures, impacting streams. Historical human activities have also reduced the hydrologic connectivity between rivers, side channels, and floodplains, resulting in negative impacts on aquatic habitats and salmon populations. These changes have altered natural river dynamics and contributed to water quality degradation throughout the basin for over a century.

Waterbodies in the Chehalis Basin were classified within TMDLs and under the legacy WA water quality classification system, which is no longer in use. Extraordinary (Class AA) waters supported salmonid spawning, drinking water supply, and primary contact recreation. Excellent (Class A) waters were designated for high-quality aquatic life use and recreation, while Class B and Class C waters reflected decreasing levels of quality and stricter treatment requirements for certain uses (Chehalis Basin Partnership, 2000). While most of the Chehalis Basin was classified as Excellent (Class A), several exceptions existed, particularly in the Upper Chehalis:

- Extraordinary (Class AA) waters include the Chehalis headwaters and upper Skookumchuck River.
- A notable deviation from Excellent (Class A) criteria occurs in the Centralia Reach (RM 65.8–75.2), where slow flows due to a naturally low gradient have prompted special temperature and DO standards.

Water quality impairments are widespread in the upper basin (WRIA 23) tributaries and in some of the mainstem reaches. Significant impairments that have been consistently documented include increased stream temperatures exceeding established criteria, low dissolved oxygen (DO), elevated fecal coliform (FC) bacteria concentrations, nutrient enrichment (particularly total phosphorus (TP) and inorganic nitrogen (IN)), and elevated levels of total suspended solids (TSS). These issues threatened aquatic ecosystems, salmonid habitats, and beneficial uses such as recreation and fisheries (Ahmed and Rountry, 2004; Ecology, 2001).

Ensuring the long-term viability of native aquatic species throughout the Chehalis Basin amid historic degradation, population growth, and climate change will require strengthening ecosystem resilience through the restoration of connected and functional habitats. The goal of this NPS Pollution Assessment Report is to assess and document the nature and extent of NPS pollution within the WRIA 23 waterways and to provide a scientific and community-based foundation for future water quality protection and restoration. The assessment is needed to evaluate current water conditions on reservation lands and in the surrounding watershed, offering insight into current water quality, identifying key issues and restoration priorities, and examining upstream influences. The findings will inform the development of a NPS management program and support collaboration with external agencies managing upland waters. To this end, the objectives of this report are:

- To characterize surface water pollution issues throughout WRIA 23 - particularly in tributaries and reaches affected by potential nonpoint sources - by identifying water bodies unlikely to meet water quality standards without targeted pollution controls, as well as high-quality waters needing protection from future pollution.
- To identify likely sources and contributing factors, such as land-use practices, to NPS pollution.
- To recommend priority areas and pollution control strategies, including preferred BMPs.

The current water quality programs, including monitoring efforts aligned with Clean Water Act Section 106, provide the basis for data collection and assessment. These programs have enabled systematic evaluation of key water quality parameters, identified water quality impairments, and implemented BMPs throughout the basin. A detailed list of existing water quality programs is provided in the "Existing NPS Control Programs" section of this assessment report.

To support transparency and public involvement, the Chehalis Tribe has included opportunities for public input during the previous assessment processes, including community meetings and document review periods. Input from tribal members, landowners, and resource managers has helped guide report development and ensure shared priorities are reflected in the findings (Chehalis Basin Partnership, 2004).

Maps and spatial analysis tools are incorporated into this report to provide clear visual context for understanding pollution sources and identifying target areas for future management efforts.

As noted, based on the assessment report's findings, a management plan should be developed later to address the identified concerns. That plan will include an overview of local water resources, the area where actions will be implemented, existing water uses, threats from NPS, and the BMPs to be applied. As required by the EPA, the plan must also describe the implementation approach, including a timeline with annual goals, relevant programs and funding sources, Tribal authority, and coordination with other ongoing efforts.

3 METHODOLOGY

In developing the NPS Assessment Report, both a review of major prior studies and an analysis of the most recent and reliable monitoring datasets were undertaken to identify water quality impairments across the basin, with specific emphasis on the Upper Chehalis, as detailed in this section.

The primary data used in the current assessment consist of observed monitoring data compiled from established databases and agency monitoring programs, including the Washington State Department of Ecology (Ecology) Freshwater Information Network (FIN), U.S. Geological Survey (USGS) monitoring stations, and local sampling efforts and environmental monitoring programs. These datasets provided the basis for all exceedance analyses, statistical summaries, and spatial evaluations conducted in the current assessment.

Previously completed hydrodynamic and water quality modeling studies (e.g., CE-QUAL-W2 development) and assessment studies (e.g., TMDLs) were not used as sources of water quality data samples in this assessment. Instead, these studies were reviewed to provide supporting context, including interpretation of physical processes, previously listed impairments, identification of controlling factors influencing observed impairments, and corroboration of spatial and seasonal patterns documented in the monitored datasets. The current assessment relied mostly on monitored data where such data were available through monitoring databases or documented sampling records. Together, these sources support a comprehensive evaluation of water quality conditions across different subbasins, from the Upper Chehalis headwaters to the lower areas.

The current assessment further evaluated the NPS pollution-related water quality impairments within the study area using the most recent water quality samples. Main conclusions from this assessment indicate a need for targeted implementation of best management practices (BMPs[1]), such as riparian vegetation restoration, agricultural runoff management, stabilization of streambanks, and improved forestry practices.

3.1 Review of Prior Studies

Surface water quality in the Chehalis Basin has been the subject of extensive monitoring and analysis over several decades, including Level 1 assessments, Total Maximum Daily Load (TMDL) studies, and implementation planning documents. In this direction, TMDLs are one of the major sources of the review of prior studies. Under the Clean Water Act, states set water quality

[1] BMPs are practical, cost-effective practices used to prevent or reduce pollution from nonpoint sources. They include both structural solutions, like fencing to keep livestock out of streams, and non-structural approaches, such as land-use regulations or buffer zone requirements. BMPs are tailored to specific land-uses and conditions, and they aim to improve water quality and inundation conditions by managing runoff and minimizing pollutant loads.

standards based on designated uses and numeric criteria approved by the EPA. If a water body fails to meet these standards despite controls, it’s listed as impaired under Section 303(d), requiring a TMDL (e.g., temperature, BOD, or FC bacteria TMDLs). The TMDL defines the pollutant limit the water can handle and allocates loads to point sources (wasteload) and nonpoint sources (load), accounting for seasonal changes and including a margin of safety to ensure standards are met. Within the TMDL framework, loading capacity is the maximum pollutant load a water body can receive without exceeding water quality standards. Load allocation refers to the portion of this capacity assigned to specific sources. The TMDL is the total sum of all load allocations.

As an initial step, this study involved a comprehensive review of prior reports and investigations concerning water quality within the Chehalis Basin. The review encompassed final and approved versions of multiple TMDL studies, Watershed Management and Implementation Plans, the Level 1 Assessment Report, the Aquatic Species Restoration Plan (ASRP), other consultant reports, and statewide GIS resources.

The outcomes of the review informed the development of Section 5 (Surface and Ground Water Summary), while detailed evaluations of the reviewed studies are provided in Appendix D (Prior Studies Detailed Evaluation). Evaluation of the recent National Land-cover Database also informed Section 4 (Land-Cover and Land-Use Summary). Sections 4 and 5 describe the watershed’s characteristics, water bodies, and key areas of concern. Specifically, Section 4 presents detailed land-use classifications for the various subbasins within the watershed, while Section 5 introduces the major water bodies and discusses overall water quality trends across the mainstem, major tributaries, and subbasins.

It should be noted that the review of previous studies relied exclusively on the findings and interpretations presented in those reports. Accordingly, the applicable water quality standards, assessment methodologies, and site conditions at specific monitoring locations or stream reaches may have changed since those studies were completed. The summarized results therefore reflect the regulatory framework and watershed conditions in place during the original study periods rather than necessarily representing current conditions. Nevertheless, synthesizing the findings of prior investigations provides an important foundation for evaluating more recent data and present-day conditions within the study area. It also helps establish the historical context and legacy of water quality issues across WRIA 23. For clarity and consistency, past tense was used in the current assessment report when referring to the findings of prior studies.

3.2 Analysis of Current Water Quality Data

This step formed the core of the current assessment report, in which recent data samples from numerous stations across the watershed were meticulously analyzed to identify impairments and to compare the findings, trends, and conditions with those reported in prior studies from the earlier stage of the assessment. The results of this step were used to develop Section 6 (Results).

3.2.1 Sources of Water Quality Data Samples

Following a review of available water quality assessment studies, we conducted a comprehensive evaluation of water quality records across the Upper Chehalis[2]. For this purpose, we compiled datasets from

- the Ecology FIN, which provides information on the condition and health of rivers and streams across WA; and
- tribal water quality data from the Water Quality Portal (WQP), which integrates data from USGS, EPA, and more than 400 state, federal, tribal, and local agencies and stores data in the Water Quality eXchange (WQX) format.

The FIN and WQP monitoring stations considered in this evaluation are listed in Appendices A and B, respectively. In Table A1 and Table B1, each station was assigned to an "associated river" along the Chehalis River, classifying the station as either on the mainstem or a specific tributary based on its geographic location and proximity to the mainstem or major tributaries, to support further analysis. The tables present the station ID, name, short name (used for ease of illustration), assigned associated river, and the latitude and longitude of each station for each dataset.

3.2.2 Water Quality Parameter Assessment

A wide range of parameters, such as temperature, DO, FC, *E. coli*, and pH, along with conductivity, turbidity, and TSS when available, were analyzed across multiple monitoring stations. Given the large number of stations and parameters, a suite of R scripts was developed to support automated data processing and analysis. These scripts:

- perform quality assurance and filtering of data based on different criteria (e.g., the number of samples, "Result_Data_Qualifier", and/or "ActivityIdentifier");
- effectively resolve inconsistencies and data gaps;
- generate statistical summaries by parameter and station over various temporal scales;
- calculate the 7-DADMax metric for temperature;
- calculate geometric means for bacterial indicators; and
- calculate all other required metrics for the water quality analysis.

To ensure the validity and robustness of the developed scripts, the results generated by the automated procedures were compared against manual calculations for multiple stations and parameters. For several parameters, script calculations were systematically compared against the

[2] Although the developed R scripts for the evaluation of water quality records were also run on station datasets in Lower Chehalis (WRIA 22), the results are not included in this report as they are outside the scope of the work.

most recent Washington State water quality standards (Table 3.1) to quantify both the number and percentage of exceedances across different reaches.

3.2.3 Plot Interpretation

To aid interpretation and presentation of the results, data were visualized using mostly boxplots as well as violin plots and temporal variation plots for individual stations.

Boxplots are presented for all stations either in the main text or in the appendices. The WQP dataset included a greater number of stations compared to the FIN dataset. To maintain brevity, boxplots for the FIN dataset are presented in the main text for DO, Temperature (7-DADMax), bacterial parameters (FC and *E. coli*), while those for pH, TSS, Turbidity, and nutrients (Orthophosphate and Nitrate + Nitrite) are included in Appendix A. For the WQP dataset with a greater number of evaluated stations, all boxplots are provided in Appendix B, and their results are discussed in the main text.

The boxplots complement the exceedance tables (summarizing exceedance rates) by illustrating the distribution of measurements at each station relative to the applicable thresholds. Each boxplot represents the following components:

- True Minimum: The smallest data point.
- True Maximum: The largest data point.
- Median (Q2): The middle value of the dataset, dividing it into two equal halves.
- First Quartile (Q1): The median of the lower half of the dataset (25^{th} percentile).
- Third Quartile (Q3): The median of the upper half of the dataset (75^{th} percentile).
- Interquartile Range (IQR): The range between Q1 and Q3 (IQR = Q3 − Q1), representing the middle 50% of the data.
- Whiskers: Lines extending from the box to the smallest (lower whisker, LW) and largest (upper whisker, UW) values within 1.5 times the IQR from Q1 and Q3, respectively.
- Outliers: Data points that fall outside the whiskers, displayed as individual markers.

  Note: As mentioned, whiskers extend to the most extreme values within 1.5 × IQR of the quartiles. Points beyond this range, if any, are considered outliers which may include the true minimum or maximum values.

For further analysis, violin plots and temporal variation plots were also evaluated at selected locations and for a limited set of parameters. A violin plot combines the features of a boxplot and a kernel density plot, providing both a statistical summary and a visualization of the probability distribution of the data across its range. The inner markers of a violin plot represent key statistics such as the quartiles and mean, while the width of the plot at each value reflects the relative frequency (or density) of observations at that level. Alternatively, temporal plots display the variation of a given parameter over the entire monitoring period at each station, allowing identification of seasonal trends, episodic events, and long-term changes in water quality conditions.

3.2.4 Spatial Assessment

To complement at-site analysis, results were integrated with GIS tools and R scripts to evaluate patterns of water quality impairment across the watershed. To identify mainstem segments where water quality criteria listed in Table 3.1 were not met, NHC analyzed both the FIN dataset (excluding continuous temperature time series) and the WQP dataset using custom-developed processing scripts.

Only monitoring stations with fifteen or more samples for a given parameter were included to ensure statistically meaningful comparisons. Each qualified station was assigned to a corresponding associated river, as summarized in Table A1 and Table B1.

For each station, the number of samples exceeding the applicable criteria was calculated. The exceedance rate values were then computed for all stations along each associated river. It should be noted that in this study, the exceedance rate for each parameter at each station was calculated using the following formula:

$$Exceedance\ Rate\ (\%) = \frac{Number\ of\ Exceedances\ from\ the\ Criterion}{Total\ Number\ of\ Samples}$$

In this formulation, all values correspond to a specific parameter measured at a specific monitoring station. The standard criterion is also listed in Table 3.1 for each parameter. Calculated exceedance rates are presented in Appendices A and B, with a discussion of these exceedances provided in Section 6.

3.3 Study Synthesis and BMP Identification

The final stage of this assessment involved integrating findings from both the review of historical studies and the analysis of current water quality datasets to form a comprehensive understanding of the Upper Chehalis NPS pollution conditions. The synthesis combined spatial, statistical, and temporal results from the FIN and WQP monitoring networks with historical insights from the TMDL and Level 1 Assessment reports to identify dominant pollutant sources, recurring problem areas, and parameters of greatest concern.

This step included a basin-wide comparison of exceedance frequencies, longitudinal patterns, and inter-parameter correlations (e.g., elevated temperature coinciding with low DO and high bacterial concentrations). These were used to evaluate the cumulative and interacting effects of land-use, hydrologic alteration, and pollutant loading across major reaches. Where possible, results from current datasets were compared with prior studies to assess progress, persistence, or worsening of impairments.

The synthesis outputs informed the identification of priority subbasins and reaches requiring targeted management attention. These locations were characterized by multiple coinciding exceedances or persistent violations of individual parameters.

All BMP recommendations were screened against land-use distribution, feasibility, and alignment with ongoing programs throughout the Chehalis Basin. The synthesis also served to refine priorities for future monitoring by identifying stations and subbasins where data gaps remain significant or where temporal coverage is insufficient to evaluate trends reliably.

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Table 3.1 Aquatic life water quality standards criteria (Ecology, 2025b).

Parameter	WAC Freshwater Water Quality Standard	Numeric Criteria
Fecal coliform bacteria (expired 2020)	173-201A-200 (2)(b)	• Extraordinary Primary Contact: geometric mean value < 50 colonies/100 mL, with < 10% exceeding 100 colonies/100 mL
E. coli	173-201A-200 (2)(b)	• geometric mean value < 100 CFU or MPN/100 mL, with < 10% exceeding 100 CFU or MPN/100 mL Sample collection dates shall be well distributed, and the averaging period shall be 30 days or less for effluent bacteria samples or 90 days or less for ambient water quality samples
Temperature[1]	173-201A-200 (1)(c)	Salmonid • Supplemental incubation temperature criteria (Sept. 15-July 1 / Oct. 1 – May 15 / Feb. 15-July 1): maximum 7-day average of the daily maximum temperature (7-DADMax) is 13°C (55.4°F) • Core Summer Salmonid Habitat criteria (June 15-Sept. 14): maximum 7-DADMax of 16°C (60.8°F) • Salmonid Spawning, Rearing, Migration criteria (May 16-June 14): maximum 7-DADMax of 17.5°C (63.5°F) Others • Supplemental temperature criteria: Maximum 7-DADMax temperatures of 9°C (48.2°F) at the initiation of spawning and at fry emergence for char • Char Spawning and Rearing: maximum 7-DADMax of 12°C (53.6°F) • Nonanadromous Interior Redband Trout: maximum 7-DADMax of 18°C (64.4°F) • Indigenous Warm Water Species: maximum 7-DADMax of 20°C (68°F)
Dissolved Oxygen[2]	173-201A-200 (1)(d)	Salmonid • Core Summer Salmonid Habitat criteria (June 15-Sept. 14): Lowest 1-Day Minimum of 10 mg/L or 95% saturation • Salmonid Spawning, Rearing, and Migration: Lowest 1-Day Minimum of 10 mg/L or 95% saturation • Salmonid Rearing and Migration Only: Lowest 1-Day Minimum of 6.5 mg/L Others • Char Spawning and Rearing: Lowest 1-Day Minimum of 10 mg/L or 95% saturation • Nonanadromous Interior Redband Trout: Lowest 1-Day Minimum of 10 mg/L or 95% saturation • Indigenous Warm Water Species: Lowest 1-Day Minimum of 6.5 mg/L

Parameter	WAC Freshwater Water Quality Standard	Numeric Criteria
Turbidity	173-201A-200 (1)(e)	Salmonid • Core Summer Salmonid Habitat criteria: Not exceed 5 NTU over background when the background is 50 NTU or less; or a 10 percent increase in turbidity when the background turbidity is more than 50 NTU • Salmonid Spawning, Rearing, Migration criteria: Same as above • Salmonid Rearing and Migration Only: Not exceed 5 NTU over background when the background is 50 NTU or less; or A 20 percent increase in turbidity when the background turbidity is more than 50 NTU Others • Char Spawning and Rearing: Not exceed 5 NTU over background when the background is 50 NTU or less; or a 10 percent increase in turbidity when the background turbidity is more than 50 NTU • Nonanadromous Interior Redband Trout: Same as above • Indigenous Warm Water Species: Not exceed 5 NTU over background when the background is 50 NTU or less; or A 20 percent increase in turbidity when the background turbidity is more than 50 NTU
pH	173-201A-200 (1)(g)	Salmonid • Core Summer Salmonid Habitat criteria: shall be within the range of 6.5 to 8.5, with a human-caused variation within the above range of less than 0.2 units • Salmonid Spawning, Rearing, and Migration: shall be within the range of 6.5 to 8.5, with a human-caused variation within the above range of less than 0.5 units • Salmonid Rearing and Migration Only: Same as above Others • Char Spawning and Rearing: shall be within the range of 6.5 to 8.5, with a human-caused variation within the above range of less than 0.2 units • Nonanadromous shall be within the range of 6.5 to 8.5, with a human-caused variation within the above range of less than 0.5 units • Indigenous Warm Water Species: Same as above

[1] Temperature (7-DADMax) not to exceed the criteria more than once every ten years on average.

[2] 1-day minimum concentration of DO not to fall below the criteria more than once every ten years on average.

4 LAND-COVER AND LAND-USE SUMMARY

The Upper Chehalis Basin supports a diverse mix of land-uses that shape water quality and habitat conditions throughout the watershed. Forestlands are the predominant land-cover, comprising roughly 67% of the basin area, followed by 12% agricultural land and only 7% low density development[1], and 1% high density development (Chehalis Basin Partnership, 2004; USGS, 2025). A pie chart depicting this land-use distribution for the Upper Chehalis Basin is provided as Figure 4.1. Most of the forestland in the Upper Chehalis Basin is in private industrial ownership at 79% and state owned and managed lands make up 20% as per the 2019 Washington State Forest Land Database (UW NRSIG, 2019) and as mapped in Figure 4.2.

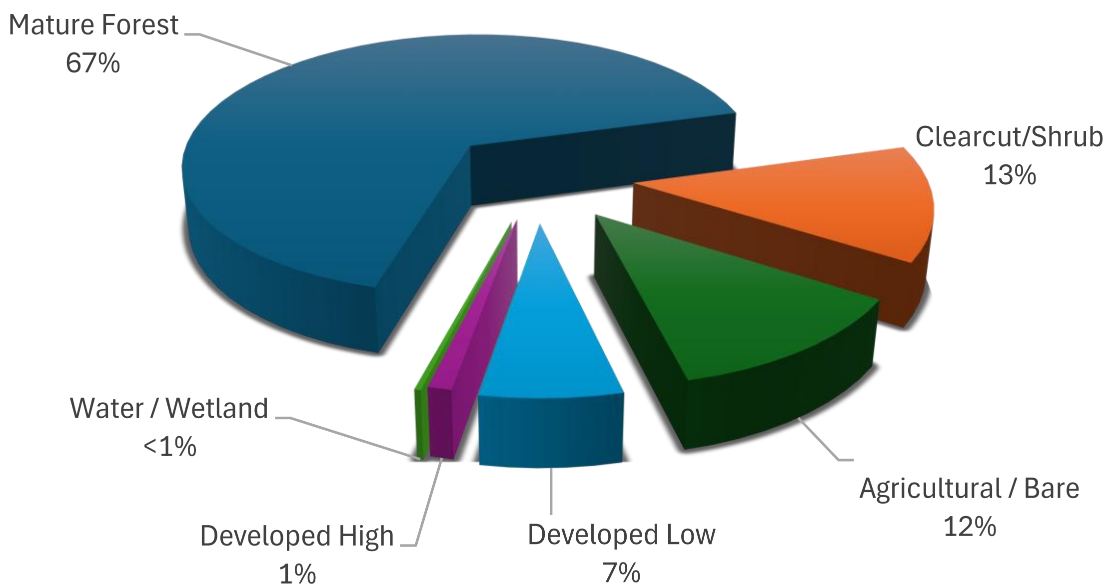
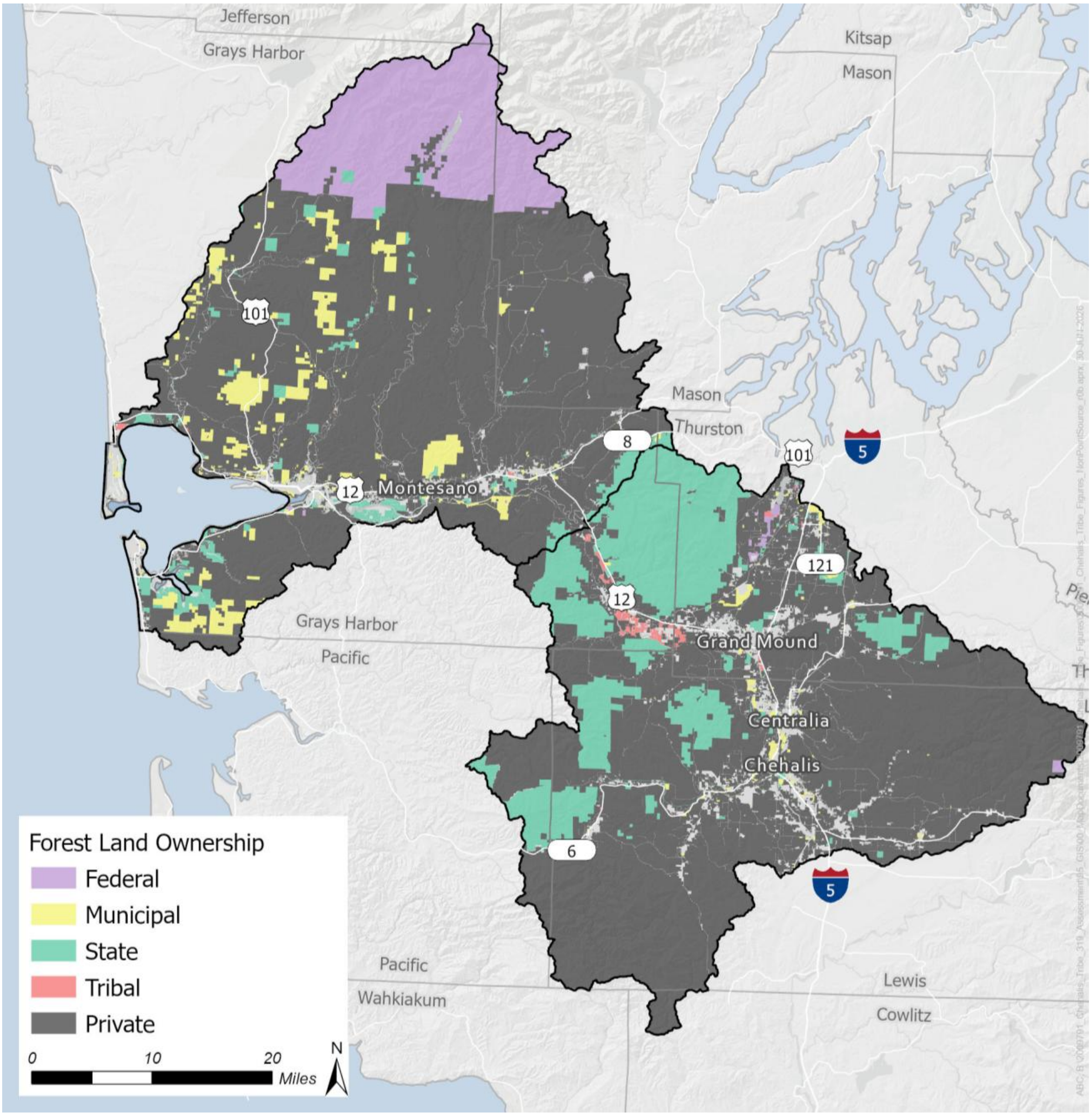


Figure 4.1 The Upper Chehalis River land-use distribution in 2023 (USGS, 2025).

[1] Low density development areas are those with less than 20% impervious surface coverage.



Note: The NRSIG database classifies parcels as forestland if their tax status is a forest use code. Non-forestlands are gaps in the dataset and appear grey on the figure.

Figure 4.2 Forest Land Ownership across the entire Chehalis River Basin (UW NRSIG, 2019).

A land-cover change analysis using remotely sensed land cover data from the USGS National Land Cover Database (NLCD) scenes from 2003 and 2023 was used to characterize land-cover changes, a surrogate for land-use change, over a 20-year analysis period. Figure 4.3 provides a visual comparison of the land-cover changes between 2003 and 2023 in map form, Table 4.1

and Table 4.2 provide a detailed summary by subbasin over the same period[1], and Figure 4.4 presents the change as a histogram by subbasin. Overall, across the Upper Chehalis study area, the Agricultural / Bare, Developed, and Water / Wetland land-uses all changed by less than ±1% on average. Most subbasins, except headwater subbasins #s 1-3 and Cedar Creek #12, experienced a small (between 0.5% and 4%) increase in developed areas with conversion to developed uses coming from a combination of mature forest, clearcut/shrub, and agriculture/bare land-covers. Based on NHC's observations, this growth is consistent with observed development in the Grand Mound, Rochester, and Centralia areas that have undergone substantial development since 2003. The headwater and Cedar Creek basins experienced negligible growth in developed land-covers based on the NLCD data.

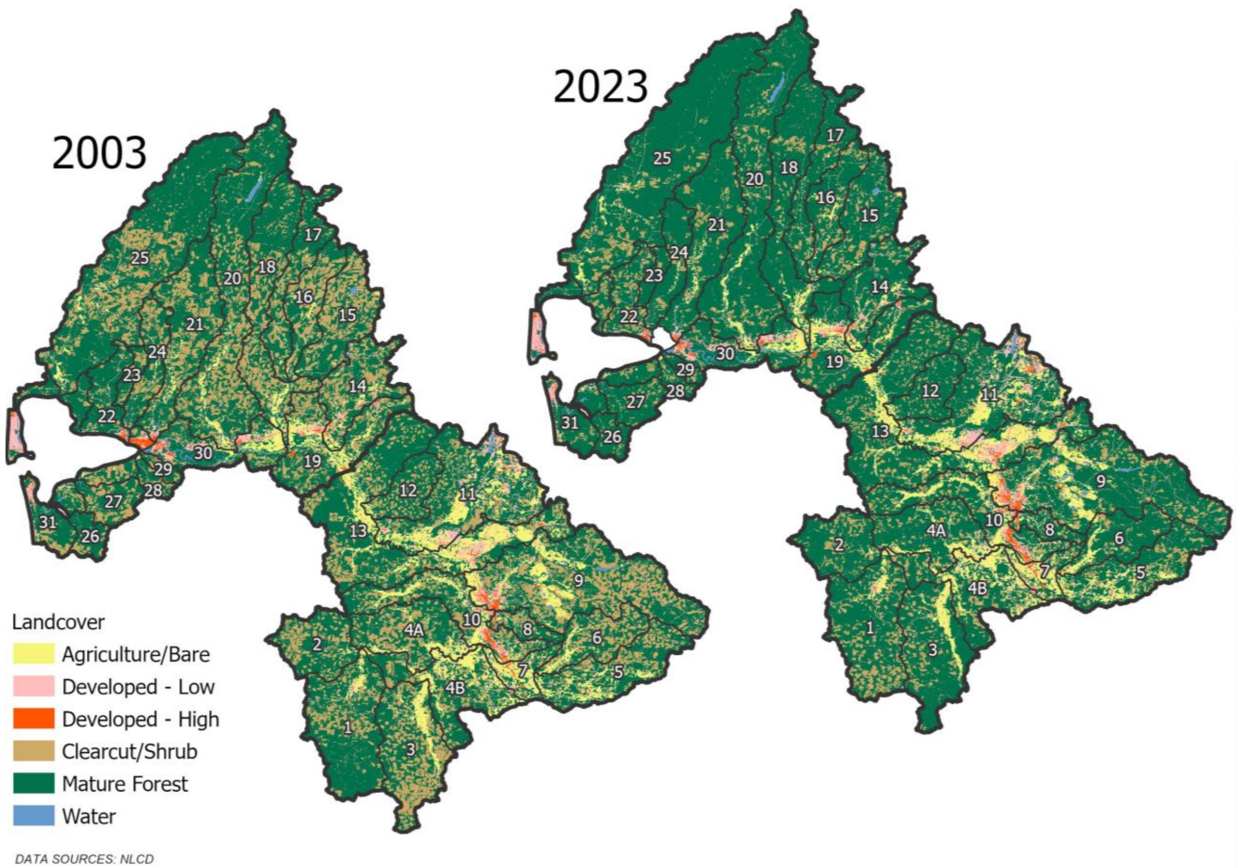


Figure 4.3 Land-cover comparison between 2003 and 2023 in the Chehalis Basin (USGS, 2025).

[1] Land-use and land-cover summary tables can also be found for the Lower Chehalis in Appendix E (Land-use and Water Bodies Description in WRIA 22: Table E1 and Table E2)

Table 4.1 Land-use summary in the Upper Chehalis in 2003 (USGS, 2025).

No.	Subbasin Name	Forest Lands		Agriculture / Bare	Developed		Water
		Mature Forest	Clearcut / Shrub		Low	High	
1	Chehalis River Headwaters	73.4%	21.1%	3.0%	2.4%	0.1%	0.0%
2	Elk Creek	66.3%	31.6%	0.8%	1.3%	0.0%	0.0%
3	South Fork Chehalis River	47.0%	42.1%	8.4%	2.5%	0.0%	0.0%
4A	Upper Chehalis River #1	57.1%	26.9%	12.4%	3.5%	0.1%	0.1%
4B	Upper Chehalis River #2	52.9%	19.1%	22.0%	5.7%	0.3%	0.0%
5	South Fork Newaukum River	56.9%	24.3%	13.7%	4.9%	0.2%	0.1%
6	North Fork Newaukum River	52.7%	36.8%	7.7%	2.8%	0.0%	0.0%
7	Newaukum River	35.9%	9.6%	38.2%	13.2%	3.0%	0.0%
8	Salzer Creek	56.6%	26.3%	7.2%	7.3%	2.6%	0.0%
9	Skookumchuck River	49.2%	31.2%	11.1%	6.0%	1.5%	1.1%
10	Middle Chehalis River #1	48.8%	23.6%	16.0%	8.3%	3.0%	0.3%
11	Black River	52.0%	14.3%	19.0%	12.6%	1.2%	1.0%
12	Cedar Creek	71.2%	24.4%	2.4%	1.8%	0.0%	0.1%
13	Middle Chehalis River #2	59.6%	19.0%	15.5%	5.1%	0.6%	0.3%
Combined Upper Chehalis		**55.7%**	**25.0%**	**12.7%**	**5.5%**	**0.9%**	**0.2%**

Table 4.2 Land-use and land-cover summary in the Upper Chehalis Basin in 2023 (USGS, 2025).

No.	Subbasin Name	Forest Lands		Agriculture / Bare	Developed		Water/ Wetland
		Mature Forest	Clearcut / Shrub		Low	High	
1	Chehalis River Headwaters	70.7%	23.7%	2.9%	2.6%	0.1%	0.0%
2	Elk Creek	80.2%	17.2%	0.8%	1.6%	0.0%	0.0%
3	South Fork Chehalis River	75.9%	12.9%	8.3%	2.8%	0.1%	0.0%
4A	Upper Chehalis River #1	69.6%	13.7%	12.1%	4.3%	0.2%	0.1%
4B	Upper Chehalis River #2	56.0%	14.5%	21.7%	7.2%	0.5%	0.1%
5	South Fork Newaukum River	64.5%	15.7%	13.6%	5.8%	0.3%	0.1%
6	North Fork Newaukum River	76.0%	12.4%	8.2%	3.3%	0.1%	0.0%
7	Newaukum River	35.3%	8.4%	36.0%	16.2%	4.0%	0.0%
8	Salzer Creek	67.4%	14.7%	6.9%	8.1%	2.8%	0.0%
9	Skookumchuck River	67.2%	12.6%	10.4%	6.6%	1.8%	1.5%
10	Middle Chehalis River #1	58.0%	13.5%	15.2%	9.2%	3.6%	0.4%
11	Black River	58.8%	5.7%	17.8%	14.9%	1.7%	1.0%
12	Cedar Creek	84.2%	11.3%	2.3%	2.0%	0.0%	0.1%
13	Middle Chehalis River #2	66.3%	11.9%	14.6%	6.0%	0.8%	0.4%
Combined Upper Chehalis		**66.4%**	**13.4%**	**12.2%**	**6.5%**	**1.1%**	**0.3%**

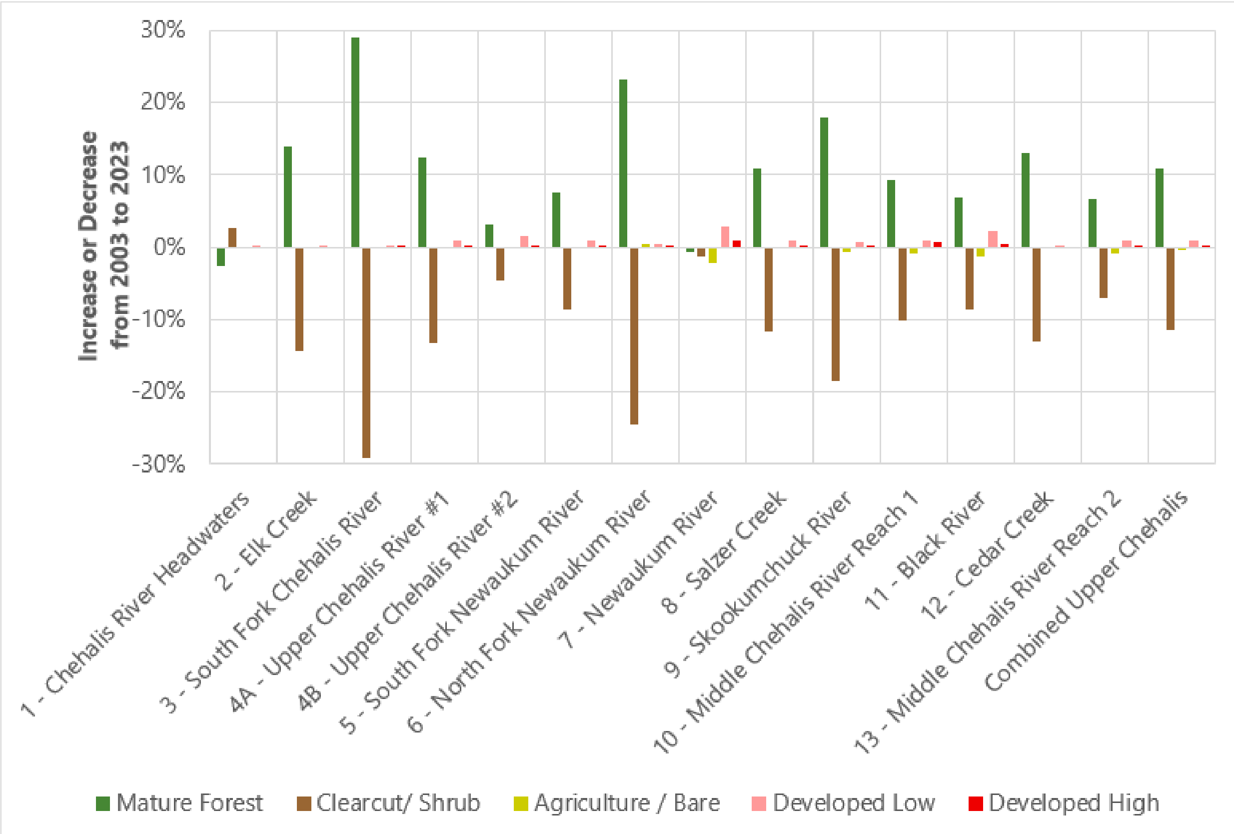


Figure 4.4 Change in land-use and land-cover composition from 2003 to 2023.

What is most notable from the land-cover change analysis is that the composition of forestland cover shifted to have less clearcut and more mature forest in nearly all subbasins, including a 10% increase across the study area, and greater than a 25% increase in some subbasins (e.g. 29% increase in South Fork Chehalis subbasin 3). Trees that are classified by the NLCD as mature forest are approximately 1-2 decades old or older, meaning that trees classified as clearcut in 2003 may have been harvested before 1990. A shift in mature forest cover between 1990 and 2023 also spans a major shift in the industrial forestry industry and timber harvesting across Washington State and the western U.S. during this time. This declining trend in timber harvest rates during this period and key events or periods in forest practices regulation and policy are illustrated in Figure 4.5 based on data from USDA (2024). These key periods or events include:

- The 1970s to 1980s high rates of harvest: Private lands maintained high, steady harvest yields exceeding 4.5 billion board feet (BBF) per year statewide.
- The 1994 Federal Northwest Forest Plan: drastically reduced federal logging by over 80% to protect the Northern Spotted Owl. As a result, more harvesting was performed on private lands, reportedly 82% of the total harvest, as per Lippke et al. in 2002. In the late 1990’s clearcuts in the Upper Chehalis would have been extremely common, which is consistent with the 2003 NLCD land cover data.

- The 1999 Forests & Fish Law: The rollout of the law permanently removed millions of harvestable acres from private inventory to form mandatory stream buffers, reducing total yield from private timberlands (UW, 2021, 2025[1]).
- 2010 to post-2020 modern era (~2.2 BBF harvested per year; USDA, 2025): Total private harvest drifted slightly downward due to increased riparian zone buffer definitions. The number and extents of clearcuts visible in the NLCD and aerial imagery decreased during this time relative to the early 2000's.

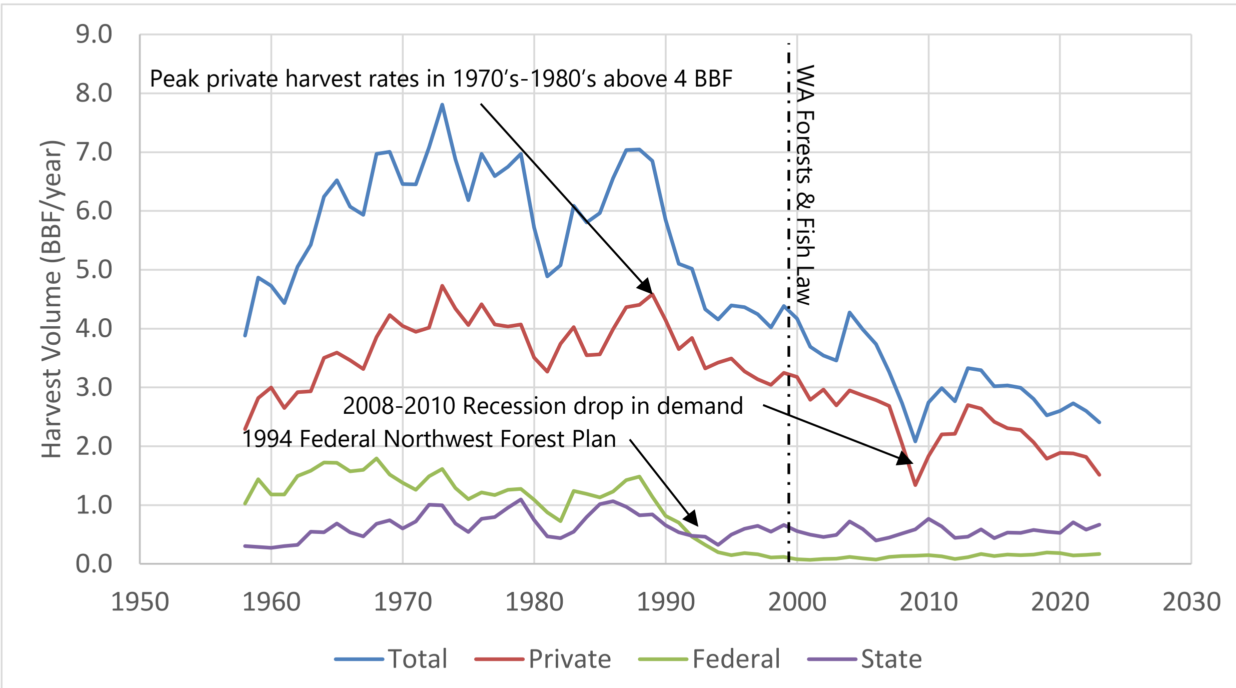


Figure 4.5 Annual Timber Harvest volumes by ownership across Washington State 1958-2023 (USDA, 2024).

Logging activities, primarily in the upland regions, can contribute sediment to waterbodies. Increased sedimentation, particularly during storm events, has been linked to elevated TSS and reduced water clarity in downstream segments of the Upper Chehalis (Chehalis Basin Partnership, 2009). Improved riparian protection and forest management are important to improving water quality in the basin.

Agricultural activities are mainly concentrated in the middle and lower reaches of WRIA 23 near major rivers, supporting dairy, livestock, crops, berries, and Christmas trees. Principal crops include hay and silage, with some vegetables and small grains. Land is also used for pasture. Elevated nutrient yields and FC counts have been documented in tributaries such as the

[1] The 2025 version of the dataset, provided by University of Washington, was also used in this assessment.

Newaukum River and Black River (Ahmed and Rountry, 2004; Chehalis Basin Partnership, 2004, 2009). Although agriculture (and bare land) cover less than 13% of the land of the entire Upper Chehalis basin, its proximity to the river corridor means its impact - through FC, BOD, and nutrient runoff - is significant (Chehalis Basin Partnership, 2009). The Newaukum River subbasin #7 provides an example of a common land-use distribution in the study area, where forestry remains the predominant land-use (~44%), but agriculture also represents a significant portion. Agricultural (~36%) and developed (~20%) uses are mainly concentrated along the river valley. The Newaukum River drains approximately 160 mi^2, extending from steep hills rising to 3,800 ft down to its confluence with the Chehalis River at about 160 ft.

Urban and residential development, though limited in area, introduces pollutants through stormwater runoff, failing septic systems, impervious surfaces, and some industrial activities. In addition to the Black River mainstem and its upstream areas, urban and residential development is primarily concentrated in the central portion of the Chehalis Basin and continues downstream, generally following the mainstem corridor of the Chehalis River. The major population centers are Chehalis and Centralia in the upper basin, with development along the I-5 corridor and around Black Lake in Thurston County. The Chehalis Indian Reservation is located near the mouth of the Black River. Although the Quinault Indian Nation's reservation was established outside the Chehalis Basin boundaries, the Nation holds treaty rights for some areas in the Lower Chehalis watershed as its Usual and Accustomed fishing area (Chehalis Basin Partnership, 2004).

Urbanized areas contribute to localized water quality concerns, adding TSS, nutrients, and bacteria. In unsewered urban zones, failing septic systems can increase FC and nitrate levels. Industrial activity is centered in Chehalis/Centralia in the Upper Chehalis. The principal industrial use of water in the Chehalis Basin is in the manufacturing of wood, pulp, and paper products (Chehalis Basin Partnership, 2004).

The basin's physical setting, ranging from steep forested headwaters to lowland floodplains, interacts with land-use to influence hydrologic processes and pollutant pathways. Water quality impairments are mainly due to human land-use and include high FC, elevated temperatures, low DO, low/high pH, excess phosphorus, and pesticide contamination. Although some issues stem from natural conditions, most are also linked to development and land disturbance. Overall, areas with little development (upland of tributaries) have better water quality.

Land-use-related pollutant yields, such as sediment from logged forests and nutrients from croplands, highlight the need for source-specific, spatially targeted management in both upland and lowland areas. Although much of the basin remains forested, development is increasingly concentrated along major rivers, where nearly half their length passes through areas dominated by non-forestry land-uses.

5 SURFACE AND GROUND WATER SUMMARY

The intent of this section is to present a summary description of the condition of surface water and ground water resources within the study area. The narrative in this section describes the segmentation of the study area, the flow conditions, and water-quality conditions based on prior studies.

5.1 Overview of Flow Conditions and Groundwater

Hydrologically, the basin experiences distinct seasonal flow regimes with peak flows occurring in winter months (December through March) and low flows in summer (July through September). Average annual discharge at the basin outlet is approximately 11,200 cfs. Figure 5.1 and Figure 5.2 present average daily discharge at the Chehalis River at Porter, WA (USGS 12031000), the most downstream monitoring station within WRIA 23, for the most recent 10-year period and for the 2025 water year, respectively. These figures clearly illustrate the variability in both the inter-annual and seasonal flow regime.

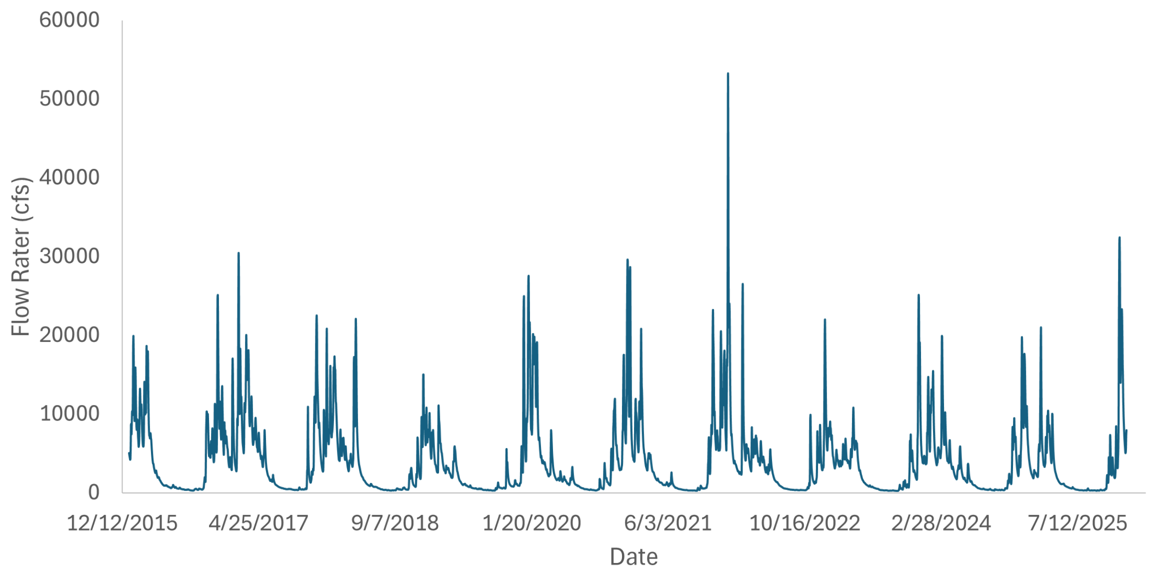


Figure 5.1 Chehalis River inter-annual variability in flow based on daily discharges at the Porter - USGS 12031000 gauge (the Upper Chehalis outlet) for the period 2015 through 2025.

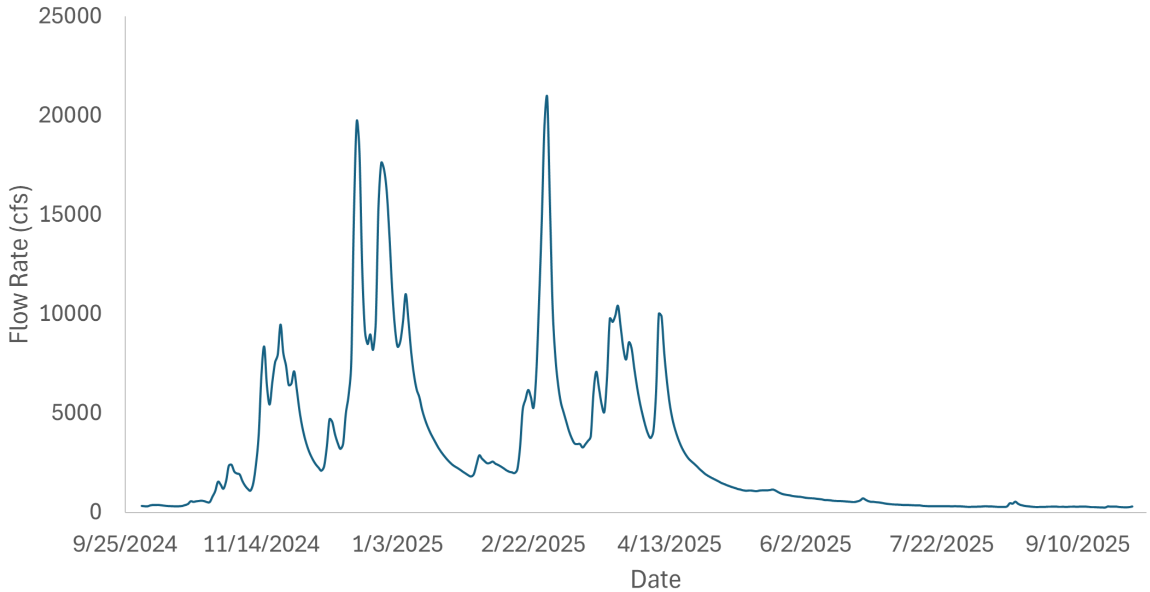


Figure 5.2 **Chehalis River seasonal variability in flow based on daily discharges at the Porter - USGS 12031000 gauge (the Upper Chehalis outlet) for water-year 2025.**

Groundwater resources, primarily contained within glacial and alluvial deposits in river valleys, provide essential baseflow support during dry periods. Groundwater quality remained less thoroughly characterized, with data gaps particularly concerning the potential impacts of groundwater withdrawals on surface water flows.

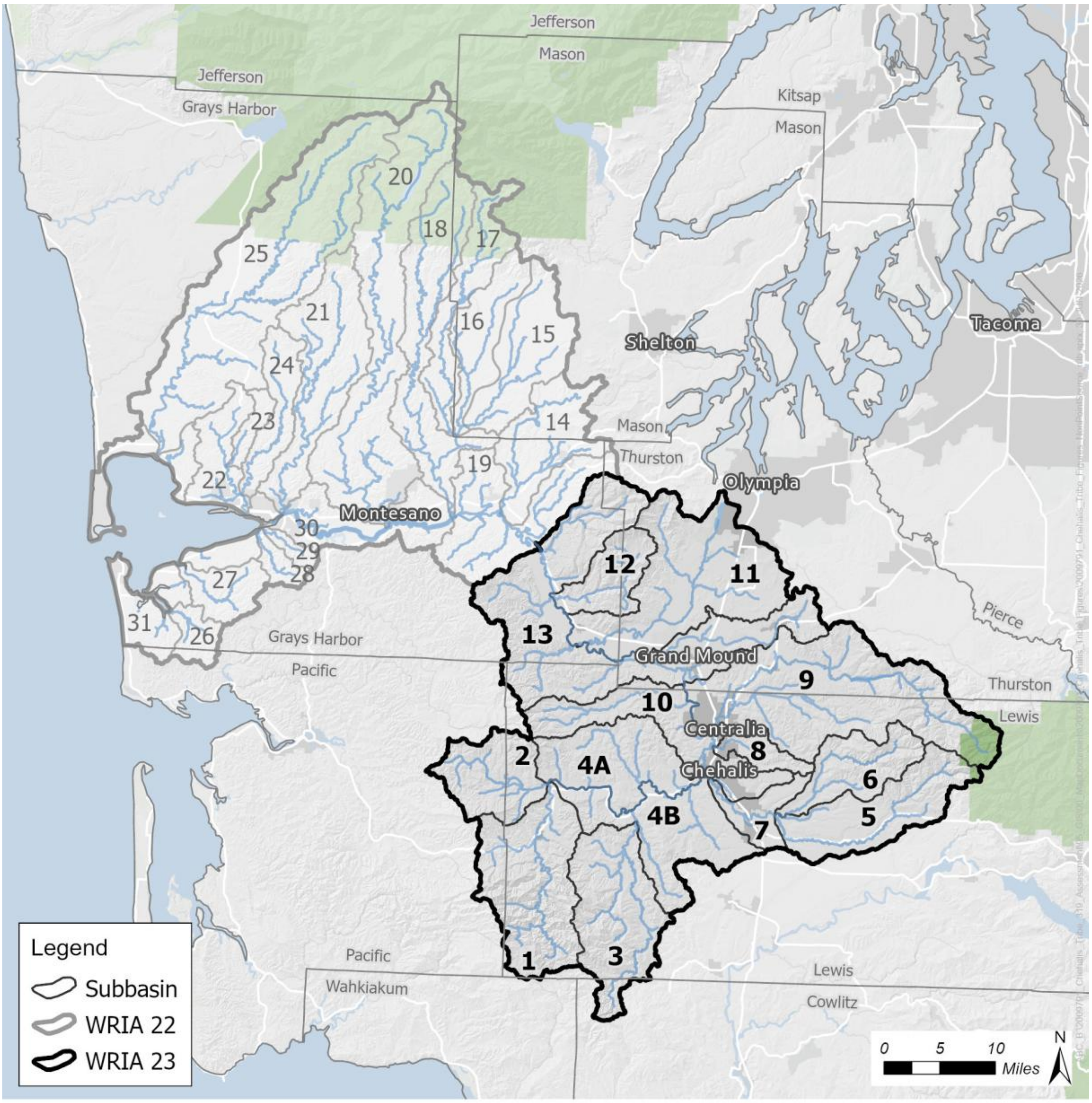
The interdependence between groundwater and surface water systems is characterized by a USGS study (Andrew S. Gendaszek, 2011) that evaluated groundwater contributions to streamflow across the basin. The investigation documented substantial groundwater inputs to the Chehalis River, including seepage-run analyses that identified significant baseflow contributions from tributary watersheds such as Scatter Creek and the Black River (Andrew S. Gendaszek, 2011).

5.2 Descriptions of Receiving Waters

This and prior studies of the Upper Chehalis Basin have divided the study area into segments of similar characteristics, these include segmentation by subbasin, by major tributary, and by mainstem reach as described in the following sub-sections.

5.2.1 By Subbasin

The Chehalis Basin is also divided into 31 subbasins to effectively capture and assess spatial variations in hydrology and water quality. Figure 5.3 presents the distribution of these subbasins across the watershed. Although the number of delineated subbasins is consistent with prior work in the area, the current study provides improvements that better capture hydrological and water-quality characteristics.



1 - Chehalis River Headwaters	8 - Salzer Creek	16 - Decker Creek	24 - East Fork Hoquiam River
2 - Elk Creek	9 - Skookumchuck River	17 - Middle Fork Satsop River	25 - Humptulips River
3 - South Fork Chehalis River	10 - Middle Chehalis River #1	18 - Satsop River	26 - Elk River
4A - Upper Chehalis River #1	11 - Black River	19 - Lower Chehalis River #1	27 - Johns River
4B - Upper Chehalis River #2	12 - Cedar Creek	20 - Wynoochee River	28 - Newskah Creek
5 - South Fork Newaukum River	13 - Middle Chehalis River #2	21 - Wishkah River	29 - Charley Creek
6 - North Fork Newaukum River	14 - Cloquallum Creek	22 - Hoquiam River	30 - Lower Chehalis River #2
7 - Newaukum River	15 - East Fork Satsop River	23 - Middle Fork Hoquiam River	31 - Grays Harbor

Figure 5.3 Subbasins across the entire Chehalis River Basin.

5.2.2 By Mainstem Reach and Major Tributary

Prior studies and planning efforts consistently identified several mainstem reaches and major tributaries as priority areas for water quality improvement in the Upper Chehalis, including the Middle Chehalis River, Black River, South Fork Chehalis River, and Newaukum River (Chehalis Basin Partnership, 2004, 2009; NHC, 2020). The current assessment builds upon these earlier findings by evaluating more recent, long-term monitoring data and quantifying spatial patterns in exceedance frequency across multiple water quality parameters. In an effort to allow for comparisons between the current work and prior studies we have attempted to use similar reach definitions where possible. Major tributaries, creeks, point sources, and USGS gauges in the Upper Chehalis are illustrated in Figure 5.4 as modified from Ahmed and Rountry (2004).

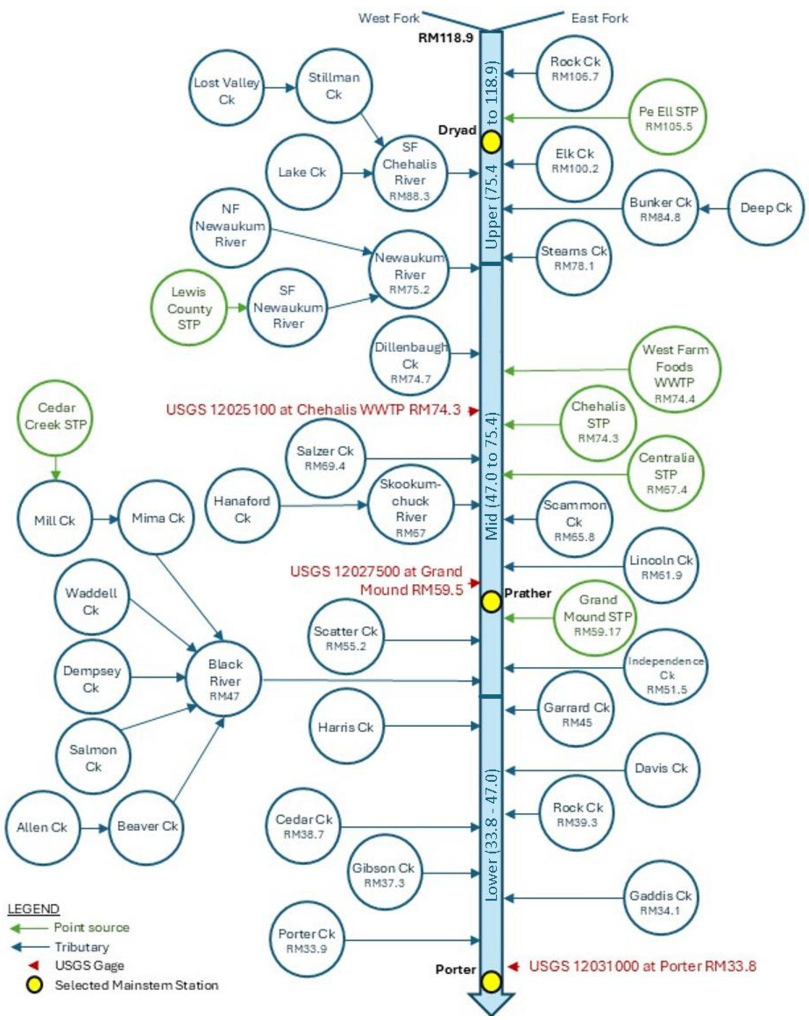


Figure 5.4 Upper Chehalis River water bodies, point sources and USGS stations (modified from Ahmed and Rountry, 2004).

One deviation in the mainstem reaches definitions shown in Figure 5.4, and used for the purposes of this assessment, relative to Ahmed and Rountry (2004), is the mid-basin. This reach has been defined as the Upper Chehalis mainstem and major tributaries from upstream of the Newaukum River confluence to below the Black River confluence, extending approximately from River Mile (RM) 75.4 to RM 47. This area includes the Newaukum River, Dillenbaugh Creek, Salzer Creek, Skookumchuck River, Scatter Creek, Black River, and adjacent mainstem reaches near Centralia and Chehalis. This mid-basin definition expands slightly beyond the Middle Mainstem segment established in earlier 303(d)-based segmentation of the Upper Chehalis River (Ahmed and Rountry, 2004) which was shorter, extending only from RM 65.8–75.4. Results from our assessment of recent Ecology FIN and Tribal WQP datasets described in Section 6 indicate that the central portion of WRIA 23, herein referred to as the “mid-basin”, exhibits the highest cumulative frequency of exceedances across temperature, DO, and bacterial indicators. The reach has been defined to reflect the spatial extent over which overlapping thermal, DO, and bacterial impairments are consistently observed in recent monitoring data. While our findings discussed in Section 6 are generally consistent with conclusions from prior studies, this refinement will support prioritization of BMP implementation in mid-basin sub-watersheds where multiple NPS stressors coincide.

The three Upper Chehalis River mainstem segments for the analysis of water quality parameters are identified in Figure 5.4 and are described as:

- **Upper Mainstem Segment (RM 75.4–106.7)**
    - This segment spans from below Rock Creek (RM 106.7) to above the Newaukum River (RM 75.4).
    - It included tributaries like Elk Creek, Bunker Creek, Lost (Valley) Creek, Lake Creek and Deep Creek.
- **Middle Mainstem Segment (RM 47.0–75.4)**
    - This segment includes both urban and agricultural zones, spanning from above Newaukum River (RM 75.4) to downstream of the Black River (RM 47.0)
    - The Newaukum and Skookumchuck Rivers along with Salzer Creek, Dillenbaugh Creek, and Berwick Creek are some of the main water bodies in this segment. It encompasses listed tributaries such as Lincoln Creek and sub-tributaries to the Black River Dempsey and Beaver Creek. It also incorporates Scatter Creek.
    - Monitoring stations at Mellen Street (RM 67.5) and Adna (RM 73.4) provide long-term data. Ecology Station 23A120 (Chehalis River at Centralia) is also located on the mainstem at Centralia in this segment.

- This reach is longer than the mid-basin segment described by Ecology in Ahmed and Rountry (2004), which extended from RM 65.8 to 75.4.

- **Lower Mainstem Segment (RM 33.8–47.0)**
  - This segment spans from downstream of the Black River to the Porter Station (RM 33.8).
  - This reach is shorter than the lower mainstem segment described by Ecology in Ahmed and Rountry (2004), which extended from RM 33.8 to 65.8.

Table 5.1 lists attributes of major tributaries of WRIA 23 that are referenced in the following sections.

Table 5.1 Description of selected major tributaries in the Upper Chehalis.

Water Body	Description
Newaukum River	The ~70-mi river (mainstem and its forks) flows around 11 mi from RM 75.2 to the confluence of the North and South forks, draining 173 mi^2.
Skookumchuck River	The ~43-mi River flows northwest into the Chehalis River at RM 67, draining 202 mi^2. Average annual flow near Centralia was 285 cfs, with land-use dominated by forestry, agriculture, and limited urban development.
Black River	The ~28-mi river drains to the Chehalis at RM 47 and includes five major tributaries Beaver, Mima, Salmon, Waddell, and Dempsey Creeks with total drainage area of ~144 mi^2.
Salzer Creek	Approximately 11 mi long Salzer Creek enters the Chehalis River at RM 69.4 between Centralia and Chehalis, draining a 17.3-square-mi watershed with a mean flow of 38 cfs. The lower third of the creek is highly urbanized, with residential and commercial development encroaching on the floodplain. Coal Creek is a tributary joining at Salzer RM 1.
Cedar Creek	Approximately 10-mi long Cedar Creek flows into the mainstem near Porter and contributes 3 to 5% of summer flow.
Lincoln Creek	Lincoln Creek and its north fork, a ~18-mi-long tributary with a mean annual flow of 123 cfs, enters the Chehalis River at RM 61.9 near Galvin.
Scatter Creek	Scatter Creek is a ~21-mi creek with an average flow of 66 cfs has its mouth at Chehalis RM 55.2.
Dillenbaugh Creek	Dillenbaugh Creek (~9 mi) flows from Chehalis RM 74.7 to headwaters. The lower Dillenbaugh (RM 0–3.4) receives urban stormwater from I-5 and Chehalis, plus runoff from an industrial park tributary (RM 3.2)

Additionally, Table C1 in Appendix C lists all streams and rivers within each subbasin of the Upper Chehalis watershed along with their corresponding stream lengths, upstream, and downstream elevations.

5.3 Water Quality Impairment Findings of Prior Studies

This section presents a summary of the status of surface water quality within the Chehalis Basin, based on past TMDL studies and watershed assessments. Emphasis is placed on key water quality parameters affected by NPS pollution, including temperature, DO, FC, TP, IN, and TSS. Within the Upper Chehalis (WRIA 23), many stream segments have been listed as impaired under Section 303(d) of the Clean Water Act due to elevated temperature, low DO, and high FC concentrations (Ecology, 2003). A brief discussion on groundwater conditions is also provided in Appendix D. Some of the applicable standards and/or water quality conditions at specific locations and stream reaches have changed since the studies were conducted.

The review of prior relevant studies is organized by major waterbody and hydrologic unit categories - mainstem river, tributaries, and subbasins - and is based on the assumed/implemented water quality standards.

The surface water quality assessment is organized to provide a concise overview of key findings, with supporting technical details provided separately. Subsection 5.3.1 presents the general status of waters based on prior studies, and Subsection 5.3.3 summarizes the primary impairments and threats previously identified across the basin. Additional detailed prior study based evaluations of mainstem conditions, major tributaries, subbasin-level patterns, and groundwater condition are provided in Appendix D.

5.3.1 General Status of Waters

Surface water quality has been extensively monitored since the 1970s, focusing on key parameters including temperature, DO, FC, pH, nutrients TP and IN, and TSS. Evaluations of previous studies showed that the Chehalis Basin's water quality was impacted by widespread NPS affecting many surface waters and potentially groundwater as well. Evaluation of long-term monitoring results by previous studies indicated impairments in temperature, DO, FC, nutrients, and sedimentation, particularly in tributaries and mainstem reaches within the Upper Chehalis (Ahmed and Rountry, 2004; Ecology, 2001, 2003; Jennings and Pickett, 2000).

Elevated summer water temperatures exceeding related standards were frequently documented, especially in wide and shallow streams, poorly shaded tributaries and slow-moving segments of the mainstem river (Ecology, 2001). These exceedances were identified to be associated with riparian canopy loss and altered hydrology, reducing critical cold-water habitat for salmonids. While past assessments showed healthy fish stocks, Bull Trout were later listed as threatened and Coho were ESA candidates (Ecology, 2001). Human activities - including deforestation, riparian degradation, altered flow regimes, and channel modifications - contributed to widespread exceedances in the area.

Intragravel DO concentrations often fell below the state's minimum standards during summer low flows, notably in the Centralia Reach (RM 65.8–75.2) where natural stratification exacerbated oxygen depletion (Jennings and Pickett, 2000). DO levels were typically lowest in summer due to high temperatures and low flows. These low DO levels posed direct threats to aquatic life and were linked to elevated BOD from nutrient enrichment and organic inputs. Some streams in the area - such as the Chehalis River from Scammon Creek (RM 65.8) to the Newaukum River (RM 75.2) - naturally fell below DO water quality standards. In these cases, natural conditions established the applicable water quality targets. Additionally, the DO TMDL (Jennings and Pickett, 2000) required Chehalis River DO levels from Rock Creek (RM 106.7) to the headwaters to exceed 9.6 mg/L while the current water-quality threshold in Ecology's Chapter 173-201A WAC is 10 mg/L.

As mentioned, Washington's previous water quality standards (Chapter 173-201A WAC) was classifying the Upper Chehalis River and most of its tributaries as Class A under the WA legacy water quality classification system, requiring a FC geometric mean of ≤100 colonies/100 mL, with no more than 10% of samples exceeding 200 colonies/100 mL (Ecology, 2025b). Protected uses included water supply, recreation, fish and wildlife habitat, and navigation within the previous revision of standards. Segments above RM 106.7, including Rock Creek and the upper Skookumchuck River and its tributaries, were designated as Class AA by the FC TMDL, with stricter standards (≤50 colonies/100 mL, and ≤10% over 100 colonies/100 mL), and currently meet these criteria.

Long-term monitoring of FC at several mainstem Chehalis River stations since the 1970s indicated that while geometric means generally meet the water quality standard (≤100 cfu/100 mL), the 90th-percentile standard (≤200 cfu/100 mL) was often exceeded between RM 50 and RM 80. Critical conditions for nonpoint FC sources typically occurred during early storm events when bacteria were flushed into streams. Seasonal analysis (1994–2003) of FC showed November–April as the most critical period, with November peaking at Porter and Prather, and September–October at Dryad (Figure D10 to Figure D12 in Appendix D). The Upper Chehalis watershed (WRIA 23) was identified as the primary source of FC bacteria affecting the Lower Chehalis watershed (WRIA 22). The Upper Chehalis Bacteria TMDL identified nonpoint sources, such as failing septic systems, livestock, farms, stormwater, and wildlife, as the main contributors of FC.

Nutrient concentrations, particularly TP, often exceeded the EPA-recommended 0.05 mg/L threshold particularly in the South Fork Chehalis and Black rivers, with seasonal peaks during wet periods. The highest TP loads and yields occurred in tributaries such as the branches and mainstem of the Newaukum River and the Chehalis branches above Dryad Station as a result of agricultural inputs and landscape disturbance from forest practices (Chehalis Basin Partnership, 2009).

IN species, including ammonia and nitrate+nitrite, were elevated in agricultural subbasins, further contributing to eutrophication risk. While Chehalis TP yields were slightly below the average Puget Sound basin values (~0.24 tons/yr-mi^2), IN yields were generally higher, indicating a distinct nutrient profile.

TSS levels vary seasonally and spatially but were notably elevated during storm events, particularly in forested basins with extensive logging roads and in agricultural areas where soil erosion was occurring (Chehalis Basin Partnership, 2009). TSS yields were notably elevated at Dryad Station. Over three decades, TP and FC loads remained stable, while TSS increased steadily during wet seasons at Dryad Station.

5.3.2 Water Quality of Subbasins based on Prior Studies

The following paragraphs provide a brief evaluation of each subbasin within the Upper Chehalis (WRIA 23) based on prior studies, including all associated waterbodies, with a focus on water quality conditions based on the prior studies (Chehalis Basin Partnership, 2000). An evaluation of WRIA 22 subbasins (Subbasins 14–31) is provided in Appendix E.

Subbasin 1 – Chehalis River Headwaters
The subbasin covers an area of 73,943 ac. Long-term monitoring at Dryad (RM 101.7) showed no significant improvement or deterioration in temperature, DO, TP, or TSS over two decades. Temperature regularly exceeded 18°C; the 1999 TMDL recommended preserving canopy cover and base flow. DO generally met standards, with occasional shortfalls. TP showed seasonal spikes; TSS yields were high, especially in wet seasons. FC levels were mostly compliant, but localized exceedances linked to Pe Ell's wastewater plant were noted. Despite 95% forest cover, elevated TSS and dry season FC suggested water quality concerns. Implementation of both the temperature and DO TMDLs was identified as a priority.

Subbasin 2 – Elk Creek
The Elk Creek subbasin covers an area of 37,434 ac. No ambient station existed, but 1991–92 TMDL monitoring showed generally good water quality. Summer temperatures peaked at 17.2°C; DO remained above 9 mg/L. TP and FC exceeded standards in some samples, with one FC count reaching 2,000 cfu/100 ml. TP and BOD sources likely lay between two sampling stations. Despite 98.4% forest cover, elevated TP and bacteria levels were identified. A new ambient station was suggested to be utilized for targeted post-implementation monitoring. TMDL recommended investigating livestock access and on-site septic systems near Murnen and Nine Creek.

Subbasin 3 – South Fork Chehalis River
The subbasin covers an area of 64,529 ac. The South Fork enters the mainstem at RM 88. Ambient monitoring (1996–97) showed compliance with DO and temperature, though 1991 TMDL detected summer temperature exceedances. A 22% increase in riparian shade and limits

on flow reductions were recommended. Nutrients were low, but TP concentrations were among the highest in the watershed. FC exceeded standards in multiple samples, with a geometric mean of 117 cfu/100 ml. Despite 89% forest cover, agricultural land (9.5%) and cattle access contributed to pollutant loads. Implementation of shading improvements and livestock management practices was suggested.

Subbasin 4 – Upper Chehalis River, including both 4A and 4B:
The subbasin covers an area of 104,222 ac. This is the 3rd largest subbasin in the Chehalis Basin. Monitoring at Claquato (RM 77.7) in 1996–97 showed temperature and DO exceedances during low-flow periods. To address this, the TMDL recommended 30% additional shading between Elk Creek and the Newaukum River, though wide channel widths were identified to possibly limit effectiveness. TP averaged 0.09 mg/L, with two exceedances above the EPA-recommended 0.05 mg/L guideline. FC exceeded standards on three of 12 dates, with a geometric mean of 61 cfu/100 mL - higher than most other stations. Bunker and Stearns Creeks, which contributed little flow, showed low summer DO, elevated nutrients, and high FC, with Bunker Creek strongly nitrogen-limited. Agricultural activity along the floodplain, though only 17% of land-use, was identified as the main contributor to these impairments. Further monitoring and control of agricultural runoff were recommended.

Subbasins 5 to 7 – South Fork, North Fork, and Newaukum River:
South Fork, North Fork, and Newaukum River subbasins cover an area of 53,349, 33,534, and 16,658 ac, respectively. These tributaries combine at the Newaukum River mouth (RM 0.1), where 1992–93 data showed no temperature exceedances, though earlier monitoring found exceedances on half the sampling dates. The TMDL recommended 35% additional shading and a 72% reduction in the width-to-depth ratio to meet temperature targets. DO generally met criteria, but reductions in carbonaceous BOD were recommended to support downstream oxygen levels. TP averaged 0.03 mg/L; ammonia-N and nitrate+nitrite-N averaged 0.02 and 0.61 mg/L, respectively. The river was identified as phosphorus-limited, and ammonia loading required substantial reductions (87% recommended). TSS levels were the highest among tributaries, contributing 16% of the total load at Porter. FC occasionally exceeded criteria, especially during the wet season. With 17% agricultural land-use, targeted runoff management was suggested to reduce nitrogen and fecal contamination.

Subbasin 8 – Salzer Creek
The subbasin covers an area of 11,516 ac. Salzer Creek reported to have a long history of water quality issues despite its small size and low flow. DO had frequently fallen below standards, with virtual anoxia observed in 1991. Major pollution sources were identified as a former food processing discharge, stormwater from the fairgrounds, potential landfill leachate, and poor agricultural practices. Temperature, conductivity, nutrients, and FC were also exceeded criteria. Though corrective actions were taken, persistent problems led to inclusion in TMDLs, recommending additional shading and maintaining background loading for oxygen-depleting substances. Continued post-remediation monitoring was suggested to assess effectiveness.

Subbasin 9 – Skookumchuck River
The subbasin covers an area of 128,006 ac. Generally good water quality was observed in this subbasin, though some summer temperatures exceeded criteria. The TMDL recommended a 20% increase in shading. DO met standards, and nutrient concentrations were moderate. TSS and FC levels were low compared to other tributaries. Hanaford Creek, a major tributary, showed temperature and oxygen issues in the 1970s but more recent monitoring found acceptable levels. Low agricultural activity likely contributed to the relatively good water quality. TMDL recommendations were suggested to be prioritized.

Subbasin 10 – Chehalis River Middle Reach 1 (Mainstem Near Chehalis/Centralia)
The subbasin covers an area of 51,605 ac. This Centralia Reach exhibited chronic water quality problems, including frequent temperature and DO violations. Algal growth, slow flow, and nutrient-rich discharges, particularly from the Chehalis Water Treatment Plant and tributaries like Salzer Creek, were identified as influential contributors to eutrophic conditions. Historical studies documented long-standing stratification, oxygen depletion, and threats to aquatic life. TMDLs recommended significant shading and reduced nutrient and BOD loading. Dillenbaugh Creek, a tributary, was impacted by feedlot runoff, septic systems, and industrial discharges. Ongoing implementation of TMDLs, riparian restoration, and other BMPs were suggested to improve water quality in this highly impacted subbasin.

Subbasin 11 – Black River
The subbasin covers an area of 95,857 ac. The Black River subbasin experienced chronic water quality problems, including elevated summer temperatures, low DO, high TP, and persistent FC exceedances. These impairments were first brought to attention following a 1989 fish kill. Wet and dry season TMDLs were developed to address FC and eutrophication, with BMPs focused on reducing agricultural runoff, primarily from dairies and pasturelands. Post-implementation data showed modest improvements, especially in FC levels, but criteria for temperature and DO were still frequently exceeded. The river was phosphorus-limited in the lower reaches, with TP levels among the highest in the basin. Land-use was documented to be mostly forested, but agricultural activities were identified as remaining a significant source of pollution. Continued implementation of TMDL actions, increased riparian shading, and long-term monitoring were identified as essential for improving conditions. A USGS gage station was recommended to track pollutant yields and support future prioritization.

Subbasin 12 – Cedar Creek:
The subbasin covers an area of 26,228 ac. Water quality was high, with no temperature or DO exceedances. FC was low, with only one value above 100 cfu/100 ml, likely due to minimal livestock access. TP remained below detection limits, and TN averaged 0.27 mg/l, indicating a phosphorus-limited system. The basin was almost entirely forested, with minimal agriculture. Continued protection of this high-quality tributary was recommended, though long-term monitoring was lacking.

Subbasin 13 – Chehalis River Middle Reach 2:
This subbasin covers an area of 134,361 ac. It is the largest subbasin in the Upper Chehalis watershed. At the Porter station (RM 33.3), water quality was impacted by both natural conditions and human activities upstream. Temperature frequently exceeded criteria, leading to an adjusted standard of 21°C and a recommendation for 28% additional shade at the time. DO was usually adequate but occasionally low, prompting TMDL actions. TP concentrations approached or exceeded 0.1 mg/l; IN levels, particularly nitrate+nitrite-N, were higher than at other mainstem stations. FC levels frequently exceeded 100 cfu/100 ml. Agriculture and urban development contributed to nutrient and bacteria loading. TMDL implementation was expected to improve conditions, but success depended on collaborative efforts and shading improvements.

5.3.3 Summary of Impairments and Threats

Based on the evaluation of the results of previous relevant studies (summarized in this subsection and discussed in greater detail in Appendix D), the predominant NPS-related water quality threats across the Chehalis Basin identified by previous studies include:

- Elevated summer temperatures and low DO in slow-flowing or stratified reaches compromised salmonid habitat and spawning and aquatic life, with riparian degradation and hydrologic alterations as primary causes. For wider, slow-flowing rivers like the South Fork Chehalis, Newaukum, and Black Rivers, additional targets for reducing width-to-depth ratios were set due to limited shading effectiveness.

  Overall, temperature and DO impairments posed the greatest ecological concern (i.e., fish habitats and streamflows) to the Chehalis Basin.
- Elevated FC bacteria levels, particularly in agricultural and urban-influenced subbasins, posed risks to public health and aquatic life. Agricultural runoff, failing septic systems, and urban stormwater were identified as major contributors, causing exceedances of state water quality standards, especially during wet weather.
- Nutrient loading contributed to eutrophic conditions and oxygen depletion in sensitive areas. Excess phosphorus and nitrogen from agricultural and urban sources were identified by prior studies to promote eutrophication, contributing to BOD increases and oxygen depletion.
- Sediment loading linked to forestry practices, road construction, and disturbed riparian zones. Logging-related erosion and disturbed riparian zones were identified as influential factors to elevate TSS, affecting water clarity and spawning habitats.

Previous efforts found land-use practices responsible for the bulk of NPS pollution, these land-use practices include agriculture (livestock grazing, manure management, and crop practices), silviculture (logging and associated road construction), urban runoff (stormwater discharges, failing septic systems), and hydromodifications (stream channel alterations). Notably, agricultural practices were highlighted as significant contributors of FC bacteria, nutrients, and suspended solids, especially in the Black and Newaukum subbasins. Silvicultural activities predominantly impacted through sediment loading (Chehalis Basin Partnership, 2004, 2009).

Table 5.2 summarizes the water quality status across several major waterbodies and subbasins of interest within the Upper Chehalis, developed based on the findings and results of the previous relevant studies reviewed. See Table E5 for the equivalent water quality summary table in the Lower Chehalis.

These conclusions reflect the findings of previously completed basin assessments and technical studies. As mentioned, it is important to recognize that watershed conditions, land-use practices, hydrology, and implementation of BMP practices may have changed/impacted water quality conditions over time.

In addition, as discussed earlier in this report, applicable water quality standards and assessment methodologies have evolved. Therefore, while prior studies identified the need for targeted management actions such as riparian restoration, shading enhancement, agricultural and urban BMP implementation, and continued monitoring, the current status and regulatory context may differ from historical evaluations. Accordingly, the following section of this report evaluates water quality parameters using the most recent available data and the applicable water quality standards currently in effect.

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Table 5.2 Summary of water quality status in the Upper Chehalis based on the prior studies.

Reach / Subbasin	Water Quality Parameters Condition	Nonpoint Sources of Concern	Overall Water Quality Status
Black River	Elevated temperature; lowest DO; frequent FC exceedance; highest TP, IN; eutrophication	Dairies, pasture, agricultural runoff, riparian loss, width-to-depth ratio, sediment transport	Severely impacted
South Fork Chehalis River	Elevated summer temperature; FC exceedance; moderate-high TP	Agriculture, livestock, riparian canopy loss, width-to-depth ratio, sediment transport	Moderately impacted
Newaukum River	FC exceedance (wet seasons); nutrient enrichment; temperature exceedance; high TSS	Livestock, agriculture, runoff, width-to-depth ratio, sediment transport	Moderately impacted
Skookumchuck River	Occasional temperature exceedance; generally good otherwise with FC concerns in wet seasons	Forested, limited agriculture	Low impacted
Elk Creek	Some FC/TP exceedances, generally good otherwise	Forested, minor agriculture, livestock	Outdated data; Low impacted
Chehalis Headwaters	Regular temperature exceedance; occasional DO, TP, FC issues	Mostly forest, some WWTP, minor agriculture	Low to moderately impacted
Middle Chehalis and Centralia Reaches	Frequent temperature/DO/nutrient/FC exceedance or deficits; highest Ammonia-N; eutrophication	Urban/industrial effluent, stormwater, upstream agricultural runoff	Severely impacted
Dillenbaugh Creek	Frequent FC exceedances; high nutrients; DO deficits;	Urban and industrial runoff, feedlot/ agricultural runoff, failing septic	Severely impacted
Salzer Creek	Frequent DO deficits (anoxia); persistent FC exceedance, nutrient exceedance	Historic industry, stormwater, landfill leachate, agriculture, failing septic	Severely impacted
Cedar Creek	Meets all criteria; low FC, low nutrients	Mostly forest, minimal agriculture	Good

6 RESULTS

This section presents the results of the current data analysis. The assessment of water quality conditions incorporates data from sampling stations included in the FIN and WQP datasets to quantify and compare exceedance frequencies for key parameters such as temperature (7-DADMax), DO, FC, *E. coli*, and pH, as well as other parameters when relevant and available. It should be noted that the record period for each evaluated parameter in each station is provided in its associated table, with these tables presented in Appendix A for FIN stations and Appendix B for WQP stations. The findings are organized into the following subsections: (i) individual assessments of samples from FIN stations, (ii) individual assessments of samples from WQP stations, and (iii) a spatial assessment combining samples from both FIN and WQP stations. The main focus of the current analysis is on the Upper Chehalis. Although point sources contribute to some impairments and are addressed through other permitting programs and TMDL wasteload allocations, the current assessment focuses on NPS pollution as the dominant driver of basin-wide water quality conditions. No effort was made to distinguish relative influence of point and NPS pollution.

An evaluation of WRIA 22 subbasins (Subbasins 14–31), which are not the primary focus of this study, is provided in Appendix E.

6.1 Individual Assessment of FIN Stations

The FIN dataset provides the longest and most continuous record of water-quality monitoring in the Upper Chehalis watershed, covering stations distributed from headwaters at Pe Ell to the downstream outlet near Porter. While detailed data from all FIN stations are provided in Appendix A, Table 6.1 provides a summary of exceedance percentages for key water quality parameters across selected monitoring stations, organized in sequence from upstream to downstream. The selected stations in order of upstream to downstream include Pe Ell, Dryad, South Fork Chehalis-HW6, Newaukum-Chehalis, Centralia, Prather, Black River-HW13, and Porter. For each station and parameter, the table indicates the total number of samples analyzed (first value) and the proportion of samples exceeding the applicable water quality criteria (second value) for key parameters, including 7-DADMax_Core Summer, 7-DADMax_Spawning Period, 7-DADMax_Incubation, DO (mg/L), FC, *E. coli*, and pH.

As summarized in Table 3.1, thresholds for 7-DADMax exceedance evaluation include 13 °C (supplemental incubation, sometimes in this report referred to as “incubation” for brevity), which represents the supplemental guideline requirement, as well as 16 °C (core summer) and 17.5 °C (spawning). It should be noted that while both the core summer and spawning criteria apply to all stream segments, the 13 °C supplemental incubation criterion applies only to designated streams, with all other stream segments classified as not applicable (N/A) in relevant tables like Table 6.1.

Figure 6.1 provides a spatial perspective on how exceedance rates vary across FIN stations at the Upper Chehalis and highlights distinct patterns linked to land-use. Each pie chart in this figure summarizes the percentage of samples exceeding state water quality criteria for the corresponding parameters at that station. The background major land-use map (water, agriculture, developed, forest) provides context for interpreting spatial patterns and potential source influences.

Overall, stations located in or downstream of developed and agricultural corridors (e.g., Centralia, SF Chehalis-HW6, Newaukum-Chehalis) exhibit comparatively higher exceedance rates for multiple parameters - particularly temperature, DO, and FC - reflecting the influence of reduced riparian shading, warmer stream temperatures, channel modifications, stormwater runoff, and livestock- or septic-related issues. FC exceedances are most prominent at stations downstream of mixed land-uses and around agricultural lands (e.g., Centralia, Dryad, Newaukum-Chehalis, SF Chehalis-HW6). Temperature exceedances appear more frequent at southern and southwestern sites (e.g., SF Chehalis-HW6, Newaukum-Chehalis), consistent with wider channels, low summer flows, and limited shading.

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Table 6.1 Number of exceedances from water quality criteria in selected FIN stations.

(see Figure 6.1 for station locations)

FIN - Station	7-DADMax - Core Summer (˚C)	7-DADMax - Spawning Period (˚C)	7-DADMax - Incubation Period (˚C)	DO (mg/L)[1]	FC (cfu/100mL)	*E. coli* (cfu/100mL)	pH
Pe ELL	25 - 0.0%*	9 - 0.0%	77 – 0.0%	89 - 12.4%	46 - 4.3%	42 - 0.0%	104 - 0.0%
Dryad	145 - 2.1%	51 - 0.0%	489 – 11.9%	580 - 20.2%	547 - 28.5%	61 - 6.6%	597 - 1.5%
SF Chehalis-HW6	24 - 0.0%	9 - 0.0%	78 – 30.8%	76 - 31.6%	37 - 51.4%	No Sample	108 - 0.0%
Newaukum-Chehalis	57 - 36.8%	18 - 0.0%	210 – 21.9%	226 - 20.8%	71 – 39.5%	No Sample	242 - 0.8%
Centralia	69 - 39.1%	24 - 0.0%	N/A[2]	227 - 43.3%	202 - 47.5%	No Sample	290 - 1.0%
Prather	18 - 50.0%	8 - 0.0%	46 – 6.5%	83 - 30.1%	84 - 28.6%	No Sample	84 - 1.2%
Black River-HW13	21 - 0.0%	9 - 0.0%	N/A	85 - 80.0%	1 - 0.0%	1 - 0%	96 - 4.2%
Porter	193 - 35.2%	67 - 0.0%	480 – 7.71%	749 - 36.2%	514 - 23.5%	61 - 4.9%	836 - 0.6%

Note: [1]The first number indicates the number of evaluated samples and the second number shows the exceedance percentage; [2]N/A stands for not applicable pH exceedance rates are low throughout most stations but remain present at several sites such as Prather.

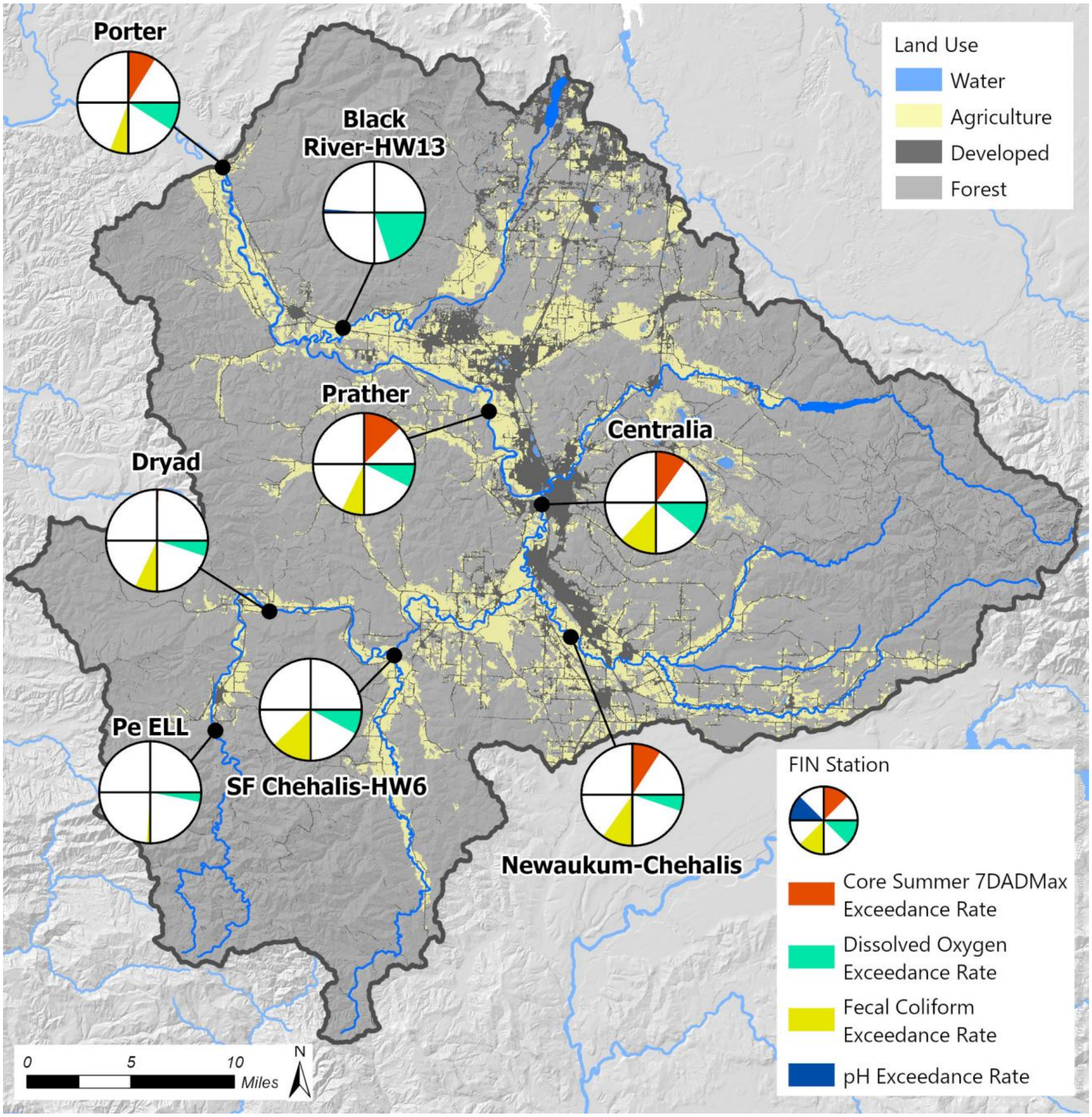


Figure 6.1 Spatial distribution of exceedance rates for four key water quality parameters at multiple FIN stations within the Upper Chehalis Basin, presented alongside land-cover data.

6.1.1 Selected Station-Specific Discussion (Upstream to Downstream on Figure 6.1)

Pe Ell (Upper Chehalis Headwaters) – Exhibits the best overall water-quality conditions. Temperatures remain below the 16 °C criterion, DO deficits are relatively better (12%), and bacterial exceedances are minor to negligible. This reach reflects predominantly forested land-cover with minimal anthropogenic and cumulative inputs.

Dryad – Marks the transition from upland to lower valley settings. Although DO falls below the standard about 20% of the time and FC exceedances rise to 29%, this station still represents moderately better quality relative to further downstream sites, considering that it has a significant number of samples evaluated. A minor temperature exceedance (~2%) is observed during core summer months when low-flow conditions prevail.

South Fork Chehalis-HW6 – Demonstrates moderate oxygen limitation (32%) and one of the highest FC exceedance rates (~51%) among all monitored tributary sites. These data may point to strong bacterial inputs from rural agricultural lands and limited dilution capacity. There are no exceedances of the previously listed 7-DADMax standards among the records at this station.

Newaukum-Chehalis – Shows a combination of thermal and bacterial stress. About 37% of core-summer samples exceed the temperature criterion, and 41% of FC samples exceed the standard. DO is low (~21% exceedances), consistent with organic loading and slow summer flows. This station reflects one of the most impaired sections of the watershed in terms of 7-DADMax, FC, and DO, due to its proximity to agricultural activities and urbanized areas.

Centralia – The poorest overall conditions in the mid-basin. DO deficiency (43%) and FC exceedance (48%) are both high, while temperature exceedance approaches 40%. The lowest daily minimum DO since 1977 was also recorded at the Centralia station, with a value of 3 mg/L. The station lies downstream of multiple urban and agricultural inputs, explaining the multi-parameter degradation. The Centralia station is located in the middle of a developed area and directly receives pollutant inputs.

Prather – Slight improvement over Centralia but still notable issues. DO below threshold for approximately 30% of days and 50% temperature exceedance during core summer period indicate sustained summer stress. Over 30% of the samples from this station also showed DO impairments, which is also located near agricultural lands and developed areas.

Black River-HW13 – Extremely low oxygen (80% below criterion) and moderate pH exceedance (~4%) show that this low-gradient reach is highly sensitive to organic matter accumulation and poor reaeration. The station is situated adjacent to agricultural lands, with one of its primary upstream tributaries originating from a fully urbanized catchment.

Porter – The most downstream FIN station in the Upper Chehalis reflects the cumulative effects of upstream inputs. DO deficiency (~36%), FC exceedances (~24%), and moderate thermal exceedances (~35%) indicate ongoing mixed nonpoint source impacts. Although this station does not exhibit the most severe parameter values, the influence of various tributaries (and also current mitigative practices) likely contributes to this outcome - some tributaries may have mitigating effects, while others with poorer (or the poorest) water quality may exert negative impacts on the mainstem. In contrast to Centralia and Prather, the Porter station is located farther from the main urbanized and agricultural core of the watershed.

6.1.2 General Patterns in FIN Dataset

Examination of temperature, DO, FC, *E. coli*, and pH data reveals some longitudinal trends and internal consistency across parameters.

Dissolved Oxygen:
Low DO remains one of the most prevalent impairments. The percentage of days below the threshold rises from about 12% at Pe Ell and 20% at Dryad to 43% at Centralia and 36% at Porter. The Black River (HW13) is the worst-performing selected station, with 80% of days below the standard, highlighting persistent oxygen depletion in downstream reaches.

Among all FIN stations (not just the selected ones), the DO exceedance was at Black River – Moon Road (~90%), while Mill Creek showed the lowest, at 0% exceedance.

Temperature (7-DADMax):
Core-summer exceedances of the 16 °C criterion increase steadily from the upper basin toward the central and lower mainstem. Headwater sites at Pe Ell and Dryad show very limited exceedance (≤ 2%), whereas Centralia, Prather, and Newaukum-Chehalis record 37–50% exceedances, confirming thermal degradation downstream. No spawning-period exceedances are observed, due to cooler winter and flow conditions.

Among all FIN stations (not just the selected ones), the worst temperature exceedances occurred at Galvin and SF Newaukum River (100%), while Pe Ell and Black River Stations had the best compliance, with no exceedances recorded across either the core summer or spawning periods.

Bacteria (FC / *E. coli*):
FC exceedance rates are highest in Centralia (~47%), South Fork Chehalis-HW6 (~51%), and Newaukum-Chehalis (~41%), confirming substantial bacterial loading from mid-basin agricultural and mixed-urban sources. In contrast, Pe Ell shows low exceedances (≤ 5%) and Dryad shows relatively lower exceedances compared to downstream (≤ 30%), reflecting reduced land-use pressure upstream. *E. coli* data are more limited (≤ 65 samples per site since 2018) but corroborate the same spatial pattern, with the highest values at Porter (~5%) and Dryad (~6%), and no exceedances at Pe Ell.

Among all FIN stations (not just the selected ones), the highest FC exceedance was at Newaukum – Mouth (~67%), while Pe Ell showed the lowest, at only 4% exceedance. The worst *E. coli* performance was observed at SF Chehalis-HW6 (14%), while Pe Ell achieved full compliance, with no exceedances.

pH:

pH excursions are infrequent (< 2%) at nearly all stations, indicating generally stable conditions. The only sites with modest departures are Black River (~4%) and Dryad (1.5%), where elevated summer pH likely coincides with reduced flow and photosynthetic activity.

Among all FIN stations (not just the selected ones), the greatest pH exceedance rate occurred at Doty (~8%, however having just 12 samples evaluated), whereas Pe Ell exhibited the most desirable pH, with no out-of-range values recorded.

6.1.3 Boxplot Evaluation of FIN Stations

A box plot offers a succinct summary of a dataset's distribution by displaying the median, quartiles, and potential outliers. It effectively communicates both central tendency and variability, while highlighting observations that deviate from the overall pattern. For a detailed discussion of box plot construction, interpretation, and evaluation, see Subsection 3.2.2, Plot Interpretation, under Section 3 (Methodology).

Dissolved Oxygen (mg/L):

Figure 6.2a presents DO boxplots across the FIN stations with a threshold line shown at 10 mg/L. Upstream headwater sites (e.g., Pe Ell and Doty) exhibit higher LW/UW values and compact distributions above 10 mg/L, indicating consistently high DO. In contrast, mid-basin and low-gradient reaches (Centralia, Prather, Newaukum–Chehalis, and Black River sites) show broader variability and frequent excursions below 10 mg/L. The lowest LW values occur at Centralia (5.4 mg/L), Black River–Moon Rd (6.3 mg/L), and Galvin station (4.9 mg/L), reflecting the most severe episodic deficits. Conversely, Mill Creek maintains an LW near 10 mg/L, with the entire box above the threshold, indicating persistently adequate DO levels. Overall, DO declines progressively from forested headwaters toward mid-basin urban/agricultural corridors, then partially recovers downstream.

For the selected stations, progressing from upstream to downstream, the following conditions are observed:

- Pe Ell: LW ≈ 8.86, UW ≈ 14.4 mg/L. Most observations lie above 10 mg/L, with a relatively tight spread centered around 11–11.5 mg/L.
- Dryad: LW ≈ 7.6 mg/L, UW ≈ 14.7 mg/L. The range is broader than at Pe Ell, with a notable fraction of measurements falling below 10 mg/L likely during summer low-flow conditions.
- South Fork Chehalis–HW6: LW ≈ 7.0 mg/L, UW ≈ 13.8 mg/L. The distribution straddles the 10 mg/L threshold, indicating occurrences of sub-criterion conditions.
- Newaukum–Chehalis: LW ≈ 7.9 mg/L, UW ≈ 14.3 mg/L. Exhibits a broad range, with a considerable portion of observations near or below 10 mg/L during warm, low-flow periods.

- Centralia: LW ≈ 5.4 mg/L, UW ≈ 13.5 mg/L. Represents the lowest lower whisker among the mainstem sites, signifying episodes of pronounced oxygen depletion.
- Prather: LW ≈ 7.8 mg/L, UW ≈ 12.8 mg/L. The interquartile range overlaps the 10 mg/L criterion, suggesting recurring shortfalls in DO.
- Black River – HW13: LW ≈ 8.85 mg/L, UW ≈ 11.9 mg/L. The distribution is centered near the 9 mg/L line, with a large proportion of values at or below the criterion, consistent with the high "percent below" reported previously.
- Porter: LW ≈ 7.2 mg/L, UW ≈ 13.5 mg/L. The spread spans the 10 mg/L threshold, with many observations near 10–11 mg/L and occasional low outliers.

Temperature - 7-DADMax (°C):

Upper-basin tributaries and Black River sites generally remain below 16 °C (core summer), with upper quartiles near or below 13 °C (supplemental incubation period), whereas mid-basin and mainstem sites (e.g., Adna, Centralia, Porter, and other Chehalis mainstem locations) exhibit upper whiskers extending to approximately 18–20 °C. These patterns indicate considerable exceedances of the core-summer criterion and noncompliance with the additional 13 °C guideline during the warmest periods. It should be noted that UW values exceeding 17.5 °C at some stations do not indicate violations of the spawning-period criterion, as these elevated temperatures were recorded during the core summer period instead of the Salmonid Spawning, Rearing, Migration period.

For the selected monitoring stations, progressing from upstream to downstream, the following temperature conditions are observed:

- **Pe Ell**: The FIN dataset reports 0% core-summer and spawning period exceedance with UW of approximately 13°C. Therefore, temperature distribution remained below the 16 °C threshold during summer months.
- **Dryad**: LW = 5.0, UW = 16.7 °C – mostly compliant, but upper quartile reaches the 16 °C limit during low flows.
- **Newaukum–Chehalis**: LW = 4.5, UW = 18.1 °C – considerable exceedances of 16 °C and occasional values above 17.5 °C; reflects warming in agricultural valley.
- **SF Newaukum River**: LW = 6.7, UW = 17.0 °C – upper tail exceeds 16 °C; susceptible to temperature stress.
- **NF Newaukum River**: LW = 5.8, UW = 17.3 °C – slightly cooler than SF Newaukum but still near criteria.
- **SF Chehalis–HW6**: LW = 6.9, UW = 15.9 °C – marginally below 16 °C, near threshold.
- **Centralia**: LW = 4.9, UW = 18.0 °C – frequent exceedances of 13 °C and 16 °C.
- **Prather**: LW = 6.6, UW ≈ 17 °C – generally meet the criteria and occasionally exceed threshold.

- **Black River–HW13**: LW = 7.9, UW = 15.7 °C – generally below 16 °C but close during warm seasons.
- **Porter**: LW = 5.0, UW = 19.2 °C – strong summer warming and the widest range, indicating cumulative thermal effects.

Bacterial Parameters:

Bacterial concentrations (Figure 6.3) exhibit strong spatial correlation with land-use and population density. The regulatory threshold of 50 cfu/100 mL ($\log_{10} 50 = 1.70$) serves as the reference for comparison for FC. Upstream stations such as Pe Ell (LW = 0, UW = 2.0) and Doty (LW = 0.7, UW = 1.7) remain almost entirely below the criterion, reflecting limited nonpoint sources impacting FC. Dryad (LW = 0.48, UW = 2.54) demonstrates moderate variability, with episodic exceedances likely tied to rainfall-driven runoff from adjacent rural and agricultural lands. The mid-basin stations South Fork Chehalis–HW6 (UW = 2.75 and a median over 1.7), Newaukum–Chehalis (UW = 2.76 and a median slightly less than 1.7), and Centralia (UW = 3.0 and a median slightly less than 1.7) display widespread violations where the median values exceed or closely approach the criterion, consistent with the previously reported highest FC exceedance rates (40–50%). These areas coincide with mixed agricultural and urban land-use, livestock operations, and stormwater inflows from developed areas.

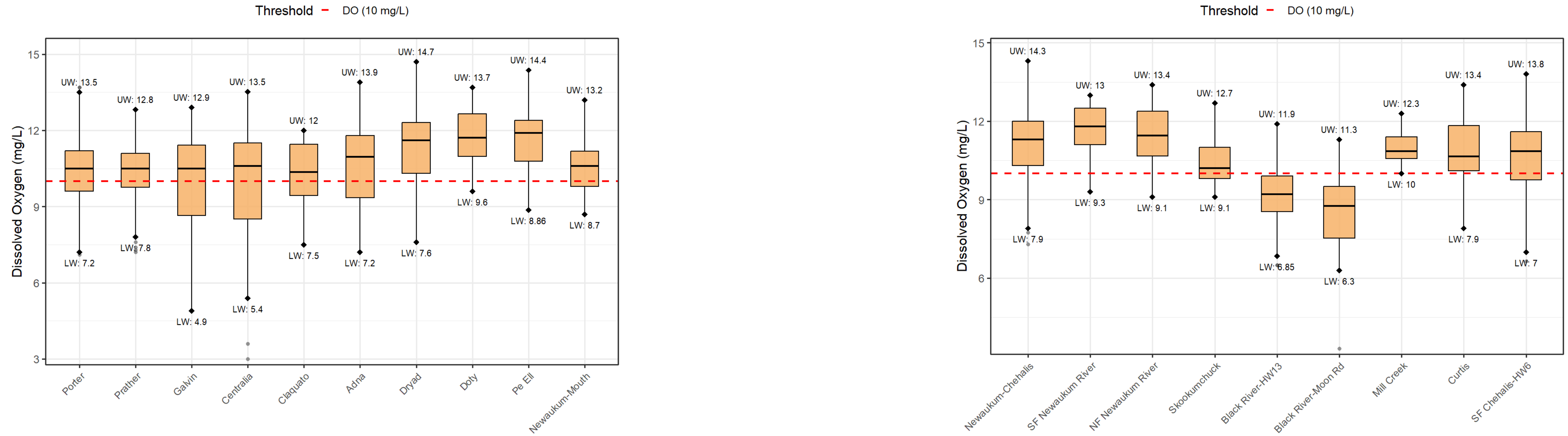
Downstream at Prather (UW = 2.57) and Porter (UW = 2.57), concentrations remain elevated but show slightly improved medians, indicating partial dilution and natural attenuation downstream. The Black River–HW13 site, with limited sampling, shows evidence of chronic contamination.

The FC boxplots thus visualize the same spatial pattern identified in exceedance analyses - minimal contamination in the uplands, a strong mid-basin maximum, and partial recovery downstream - suggesting both chronic and event-driven bacterial loading sources in the agricultural and urbanized corridors.

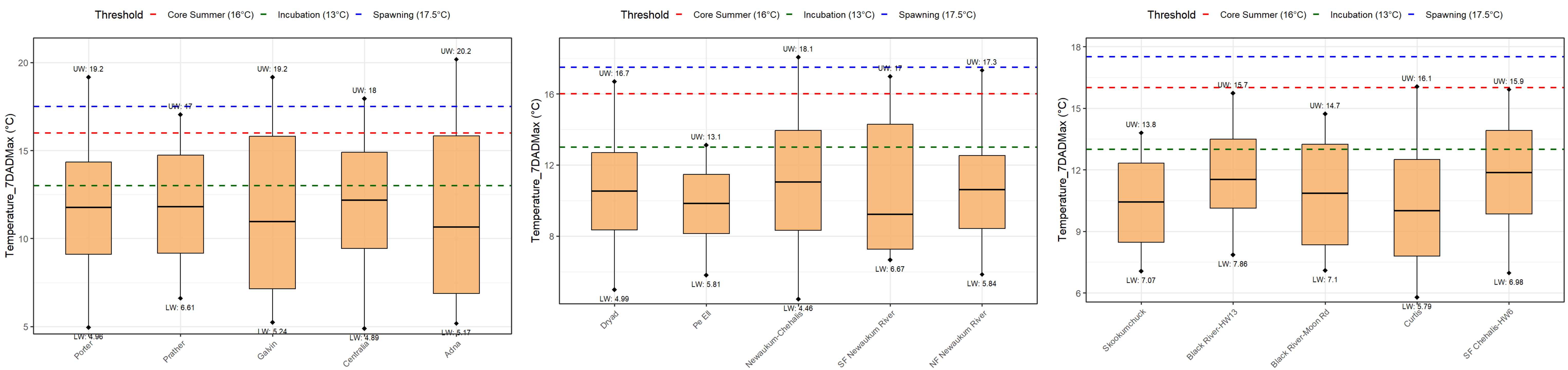
The *E. coli* dataset (Figure 6.4), though shorter with limited samples, reinforces the FC trends. The standard threshold of 100 cfu/100 mL ($\log_{10} 100 = 2.00$) delineates the same spatial progression of bacterial stress.

At Pe Ell (LW = 0, UW = 1.9), concentrations remain fully compliant. Dryad (LW = 0.30, UW = 2.15) shows modest exceedances during runoff events. The South Fork Chehalis–HW6 (LW = 0.60, UW = 2.40) station has the most consistent exceedances, indicating active fecal inputs and limited dilution. Porter (LW = 0.48, UW = 2.20) also records occasional exceedances, though median values stay slightly below Dryad and below the standard.

While the dataset is limited to fewer than 70 samples per site, the spatial consistency with FC data suggests shared bacterial sources dominated by non-point runoff and livestock access. In both datasets, bacterial concentrations peak in the same mid-basin reaches identified as having the poorest DO and temperature conditions, indicating multiple co-occurring water-quality stressors.



a. DO (mg/L)



b. 7-DADMax (˚C)

Figure 6.2 Boxplots showing the distribution of 7-DADMax Temperature and DO across sampling stations in the FIN dataset.

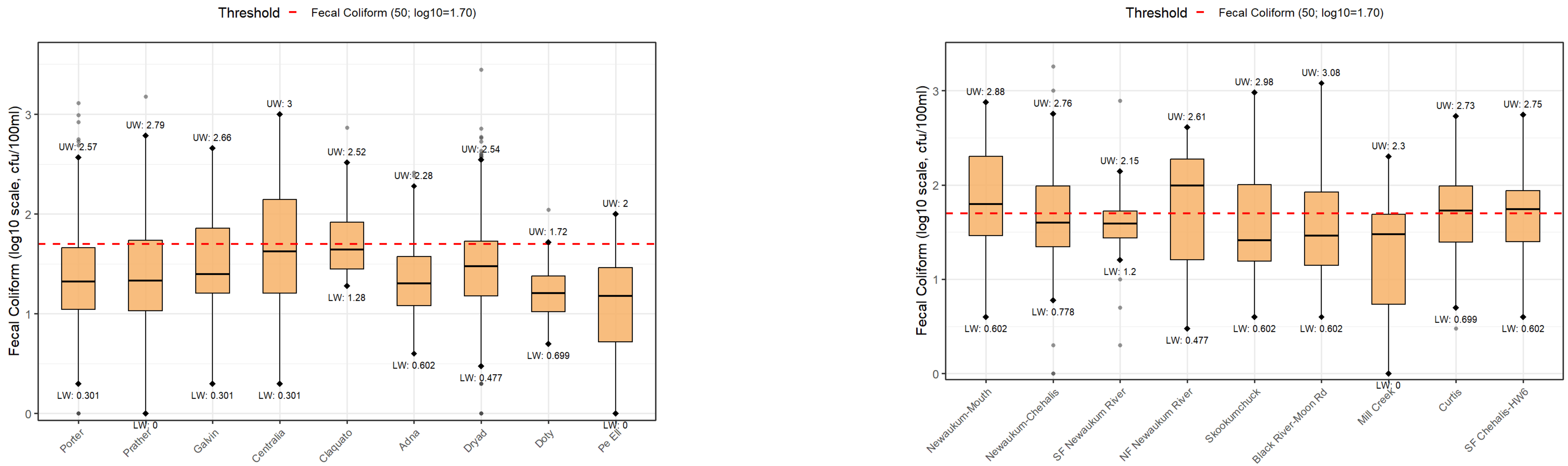


Figure 6.3 Boxplots showing the distribution of FC ($\log_{10}$ cfu/100ml) across sampling stations in the FIN dataset.

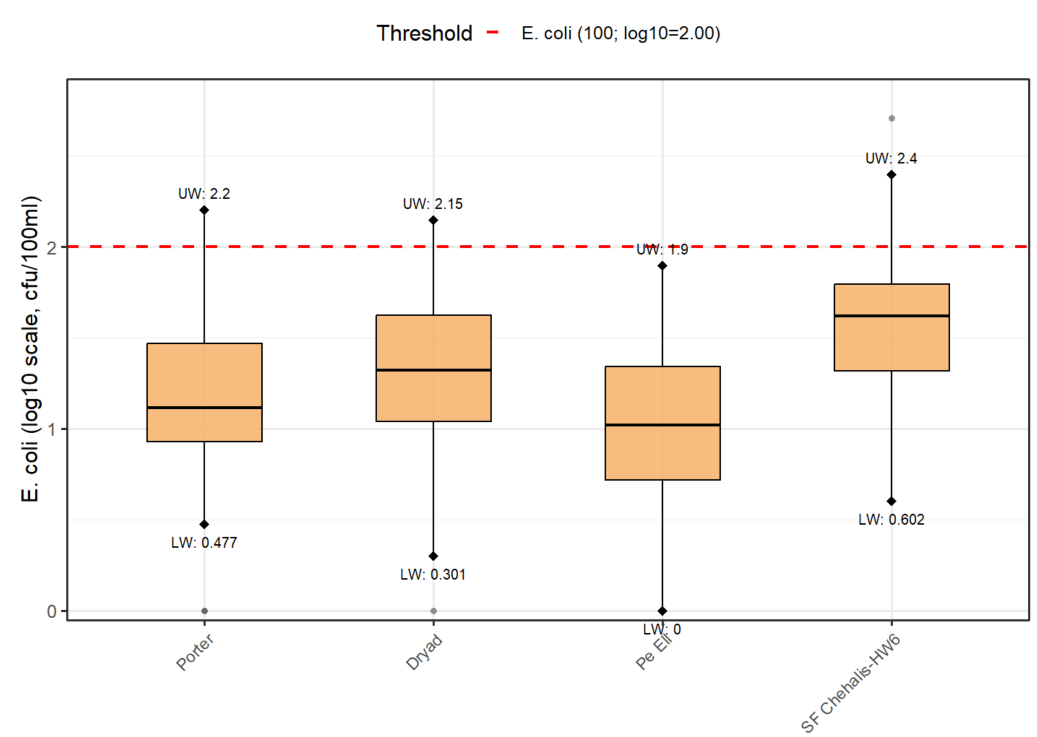


Figure 6.4 Boxplots showing the distribution of *E. coli* ($\log_{10}$ cfu/100ml) across sampling stations in the FIN dataset.

Other water quality parameters:

Other parameters presented in the Appendix A further corroborate these trends. pH values generally remain between 6.5–8.0, with limited high outliers/values at different locations. TSS and Turbidity show sporadic spikes, particularly at Dryad, Centralia, SF Chehalis-HW6, and Curtis, indicating sediment mobilization during storm events. Nutrient parameters (Orthophosphate, Dissolved P, and Nitrate + Nitrite) display higher concentrations at Galvin, Centralia, Black River-Moon Rd, and Porter, which correspond to urbanized or agricultural zones and are consistent with elevated BOD and low DO patterns. A summary of each parameter variation is provided in the following:

- pH: Nearly all within 6.5–8.0; limited high values or outliers at Porter, Galvin, Prather, Newaukum-Chehalis, and SF Newaukum River while having more notable outliers/values at Centralia, Dryad, Doty, and Black River-HW13 stations.
- TSS: Most medians < 20 mg/L; high outliers and values at Dryad (Max ~750 mg/L).
- Turbidity: Most of medians 3–6 NTU; major spikes (up to > 600 NTU) at Dryad.
- Orthophosphate (as P): Highest at Galvin (0.11 mg/L) and Centralia (0.08 mg/L) with Centralia has the highest values with outliers.
- Orthophosphate (as P-Dissolved): Very limited data; Porter (0.035 mg/L) > Dryad (0.014 mg/L).
- Nitrate + Nitrite (as N-Dissolved): Peaks at Centralia (1.3 mg/L), Curtis (1.26 mg/L), Porter (1.24 mg/L) with one large outlier.

6.2 Individual Assessment of WQP Stations

The WQP and FIN datasets together provide a more complete picture of water-quality conditions by extending temporal coverage and broadening spatial representation across both mainstem and tributary locations, with some stations overlapping along the same river corridor. To maintain continuity with the previous section, the following results focus on the selected WQP stations, listed in upstream-to-downstream order: Boistfort, Elk Rd Bridge, Ceres Hill Rd, Jackson Hwy, SR6–Chehalis, Mellen St, Ingalls–Lincoln, Prather Rd Bridge, Independence Rd, Independence–Garrard, Howanut Bridge, Sickman Ford Rd, and Porter Rd.

Station selection was based on the number of available samples for assessment, the temporal extent of sampling (i.e., start and end dates), and the spatial coverage of stations across the Upper Chehalis. Station-specific exceedance counts and percentages are presented in Table 6.2. Additionally, boxplots for the WQP dataset (Appendix B) were generated and evaluated to interpret data distributions relative to applicable thresholds. Boxplot assessments are incorporated into the subsequent evaluation of general patterns for each water quality parameter.

Figure 6.5 provides a spatial perspective on how exceedance rates vary across WQP stations within the Upper Chehalis and highlights distinct patterns linked to land-use.

Table 6.2 Number of exceedances from water quality criteria in selected WQP stations (see Figure 6.5 for station locations).

WQP - Station	7-DADMax - Core Summer (˚C)	7-DADMax - Spawning Period (˚C)	7-DADMax - Incubation Period (˚C)	DO (mg/L)	FC (cfu/100mL)	pH[3]
Boistfort	257 – 91.4%*	94 – 39.4%	893 - 28.0%	41 – 34.1%	39 – 28.2%	25 – 0.0%
Elk Rd Br	21 – 0.0%	8 – 0.0%	69 - 15.9%	75 – 28.0%	84 – 16.7%	63 – 9.5%
Ceres Hill Rd	11 – 0.0%	7 – 0.0%	44 - 40.9%	55 – 27.3%	58 – 12.1%	58 – 12.1%
Jackson Hwy	43 – 67.4%	7 – 0.0%	249 - 15.7%	290 – 39.3%	60 – 31.7%	5187 – 5.4%
SR6-Chehalis	27 – 44.4%	6 – 0.0%	N/A[2]	75 – 50.7%	80 – 21.2%	70 – 11.4%
Mellen St	29 – 44.8%	7 – 0.0%	N/A	98 – 51.0%	81 – 16.0%	92 – 7.6%
Ingalls-Lincoln	4 – 0.0%	2 – 0.0%	N/A	12 – 58.3%	14 – 0.0%	No Data
Prather Rd Br	36 – 50.0%	8 – 0.0%	71 - 11.3%	105 – 49.5%	80 – 16.2%	96 – 11.5%
Independence Rd	40 – 52.5%	7 – 0.0%	64 - 14.1%	100 – 37.0%	80 – 15%	100 – 7.0%
Independence-Garrard	19 – 0.0%	5 – 0.0%	N/A	60 – 50.0%	55 – 32.7%	50 – 28.0%
Howanut Br	20 – 5.0%	4 – 0.0%	N/A	72 – 87.5%	69 – 17.4%	74 – 17.6%
Sickman Ford Rd	300 – 93.7%	93 – 37.6%	513 - 16.8%	91 – 47.3%	80 – 25.0%	96 – 10.4%
Porter Rd	37 – 40.5%	8 – 0.0%	70 - 12.9%	105 – 40.0%	81 – 23.5%	99 – 15.2%

Notes: [1]The first number indicates the number of evaluated samples and the second number shows the exceedance percentage; [2] N/A stands for not applicable; [3] Data samples collected prior to 2016 were excluded from the pH analysis due to data quality issues

Each pie chart in this figure summarizes the percentage of samples exceeding state water quality criteria for the corresponding parameters at that station. The background major land-use map (water, agriculture, developed, forest) provides context for interpreting spatial patterns and potential source influences.

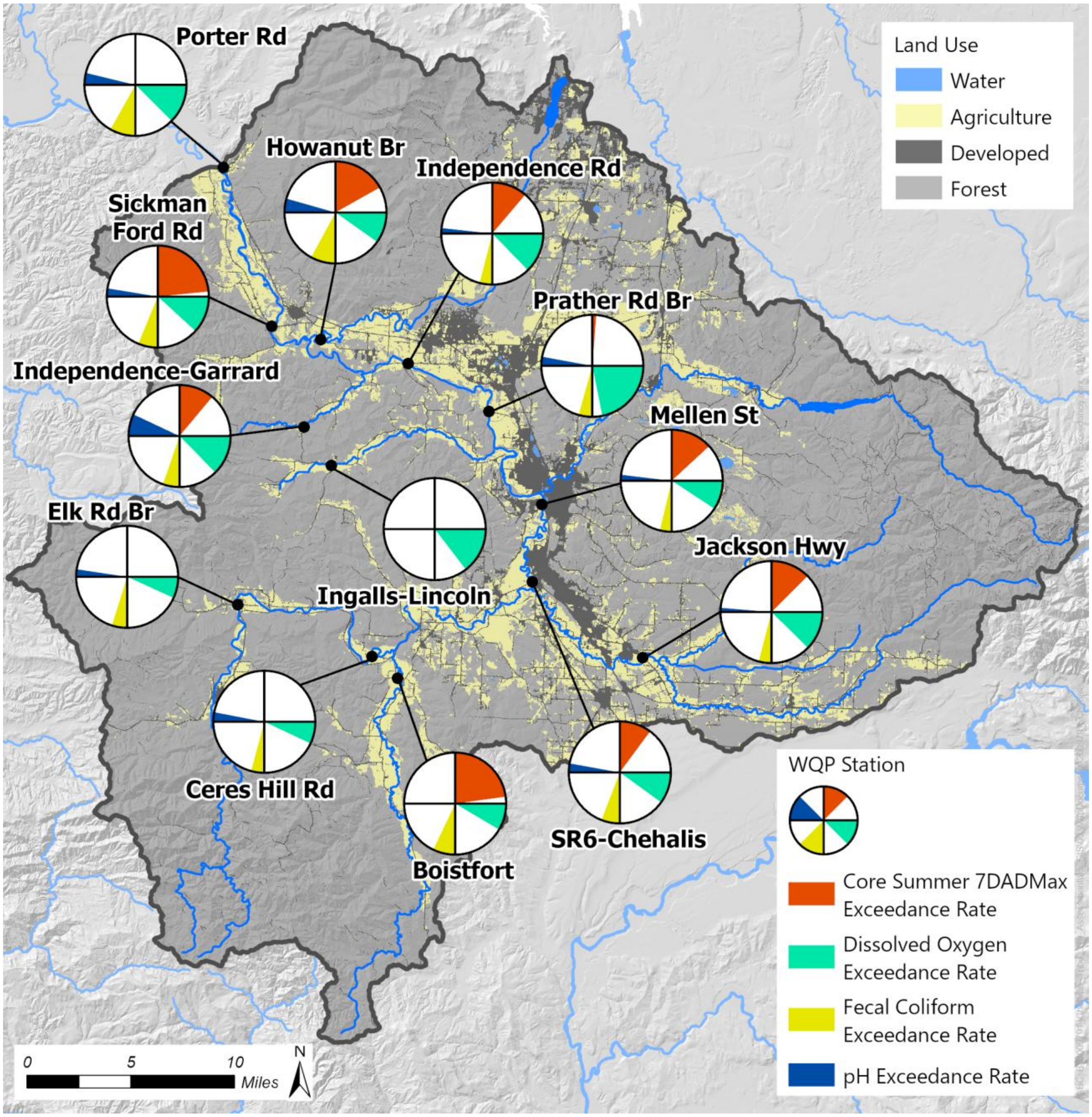


Figure 6.5 Spatial distribution of exceedance rates for four key water quality parameters at multiple WQP stations within the Upper Chehalis Basin, presented alongside land-cover data.

Several clear geographic patterns emerge. Thermal exceedances are mainly concentrated in mid-basin and southern tributary areas. These areas include Sickman Ford Rd, Boistfort, Howanut Br, Jackson Hwy, Independence Rd, and Mellen St - locations influenced by lower-gradient channels, limited shading, and/or adjacent agricultural or developed land-uses. DO exceedances are most pronounced in the central and western basin, including Prather Rd Br, Howanut Bridge, Ingalls–Lincoln, Independence–Garrard, and Mellen St, consistent with slow-moving reaches and higher organic inputs. Prather Rd station also exhibits high DO exceedances. FC exceedances remain elevated at a subset of mid-basin stations - most notably Independence–Garrard, Jackson Hwy, Porter Rd, and Sickman Ford Rd - where agricultural land-use, livestock access, and urban runoff exist. In contrast, pH exceedances are generally low across the network (although more noticeable in WQP than in FIN datasets), with somewhat higher frequencies at Ingalls–Lincoln, Independence–Garrard, and Porter Rd, where episodic low flows, high biological productivity, and/or groundwater inputs may influence water chemistry. NHC also recommends that the data quality of pH at the Ingalls–Lincoln station should also be reviewed and confirmed. The quality of the pH data appears to have improved since 2016, after which no samples were recorded at the Ingalls–Lincoln station (see further discussion in Section 6.3.5).

6.2.1 Selected Station-Specific Discussion (Upstream to Downstream)

- **Boistfort**: This station exhibits very frequent summer warming (~91% core-summer exceedance and ~39% spawning), moderate DO limitation (~34% below the threshold), and notable FC exceedance (~28%). There are wide temperature ranges often exceeding 16 °C, DO distributions crossing the 10 mg/L line, and FC values with medians near but generally below the criterion, punctuated by episodic high outliers.
- **Elk Rd Br** and **Ceres Hill Rd**: These headwater stations are characterized by relatively cool temperatures (0% core-summer exceedance), moderate DO shortfalls (~27–28% below 10 mg/L), and FC exceedances around 17–19%. Distributions cluster near compliance for both DO and FC, with seasonal dips during warm periods and spikes associated with storm events.
- **Jackson Hwy**: This site represents a clear multi-parameter stressor location, with ~67% core-summer temperature exceedance, ~39% of DO readings below the threshold, and ~32% FC exceedance. Temperature UW extend beyond 16–17.5 °C, FC medians are near the 1.70 line with frequent high events, and DO distributions straddle the 10 mg/L criterion.
- **SR6-Chehalis** and **Mellen St**: Both stations exhibit combined thermal and oxygen stress (~44–45% core-summer temperature exceedance and ~51% below-DO). FC exceedances

are ~21% at SR6 and ~16% at Mellen. The stations position their temperature and DO central tendencies close to threshold levels, with lower-tail DO events and summer temperature whiskers reaching or exceeding 16 °C. These patterns align closely with those observed at the adjacent FIN Centralia site.

- **Ingalls-Lincoln**: This station shows cool temperature conditions (0% core-summer exceedance) and 0% FC exceedance. DO exhibits substantial below-criterion incidence (~58%). Distributions show DO centered below 10 mg/L. It should be noted that this station has fewer samples and a shorter monitoring duration compared to the other selected stations.

- **Prather Rd Br**: This site experiences sustained mixed stress, with ~50% core-summer temperature exceedance, ~50% below-DO, ~16% FC exceedance, and ~11% pH out of range. Assessments show temperature upper tails reaching or exceeding 16 °C and DO distributions straddling the criterion, consistent with observations from the FIN Prather record.

- **Independence Rd**: This station exhibits ~53% core-summer temperature exceedance, ~37% below-DO, and ~15% FC exceedance. The FC evaluation indicates that the third quartile remains desirably below the 1.7 line (50 cfu/100 mL), although some spikes and outliers are observed with UW extending to approximately 158 cfu/100 mL.

- **Independence-Garrard**: This site shows 0% temperature exceedance but substantial DO limitation (~50% below the threshold) and the highest FC exceedance among the selected stations (~33%), along with elevated pH out-of-range values (~28%). Boxplots depict FC medians near or above the 1.70 line (50 cfu/100 mL) with a long upper tail, and DO centered below 10 mg/L.

- **Howanut Br**: This is the most oxygen-limited site among those evaluated (~88% below 10 mg/L), with low temperature exceedance (~5% core-summer) and moderate FC exceedance (~17%). DO distributions are centered well below the threshold, indicating a chronically low-oxygen reach in the Black River corridor, consistent with FIN station assessments.

- **Sickman Ford Rd**: One of the warmest stations, with ~94% core-summer temperature exceedance and ~38% spawning exceedance, substantial DO limitation (~47% below the criterion), and ~25% FC exceedance. There are very high summer temperature upper limits (UW around 25 °C) (which may be affected by a data-quality issue between 2022, 2023, and 2024), DO spreads crossing the threshold with frequent low values, and FC exhibiting considerable high events (3rd quartile ≈ 50 cfu/100 mL; UW ≈ 275 cfu/100 mL).

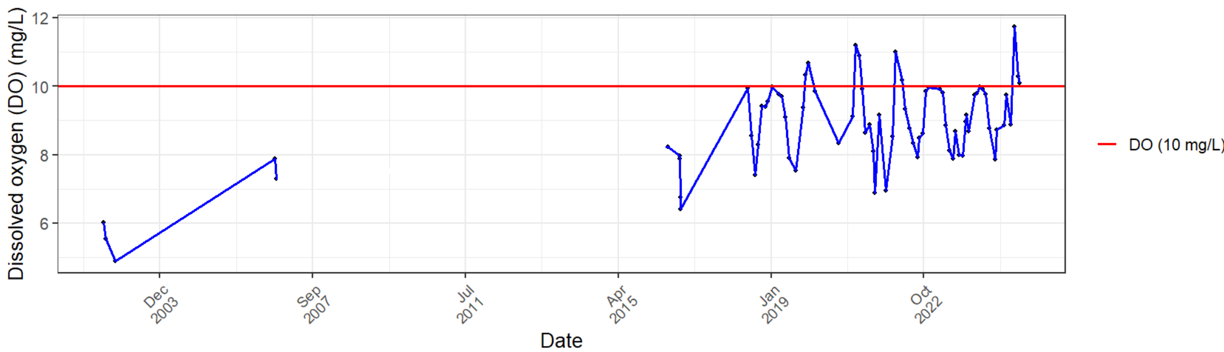
- **Porter Rd**: This downstream integrator shows ~40% core-summer temperature exceedance, ~40% below-DO, ~24% FC exceedance, and ~15% pH out-of-range. Distributions span threshold lines for all four parameters, illustrating the cumulative influence of upstream conditions. These patterns are consistent with the FIN Porter station.

6.2.2 General Patterns in WQP Dataset

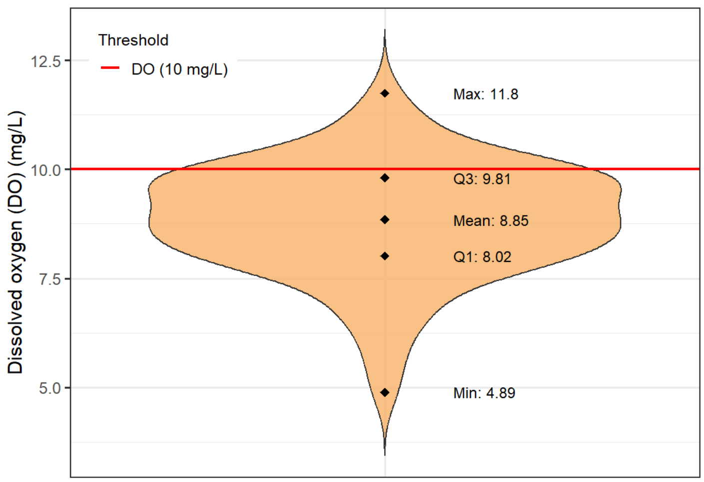
Dissolved Oxygen:
Oxygen limitation is widespread through the mid-basin corridor and in low-gradient reaches. The highest exceedance of the 10 mg/L criterion among the selected stations occurs at Howanut Br (about 87.5% of days below), consistent with persistent deficits in the Black River corridor as the station is close to and downstream of FIN Black River-HW13.

Elevated below-criterion percentages also occur at Ingalls-Lincoln (~58%), SR6-Chehalis (~51%), Mellen St (~51%), Prather Rd Br (~50%), and Independence-Garrard (~50%). Upstream headwaters perform better but still show warm-season shortfalls, for example Elk Rd Br (~28%) and Ceres Hill Rd (~27%), while the most upstream Boistfort site shows ~34%. Downstream integration at Porter Rd remains impaired (~40%), indicating cumulative effects but still better than the developed mid-basin corridor. Figure 6.6 illustrates the temporal variation of DO (Figure 6.6a) and the overall DO distribution (Figure 6.6b) at the Howanut Bridge station, which exhibits the highest frequency of DO values below the standard.

The overall distribution in the violin plot for Howanut Bridge shows a mean DO concentration of 8.85 mg/L. The position of the median and quartiles relative to the 10 mg/L threshold clearly indicates sub-criterion conditions in a substantial portion of samples. Specifically, the interquartile range (Q1 = 8.02, Q3 = 9.81 mg/L) lies entirely below the standard, meaning that more than 75% of observations do not meet the criterion, which is consistent with the 87.5% exceedance rate calculated before. The lower tail extends down to 4.9 mg/L, pointing to recurrent periods of pronounced oxygen depletion. The time-series plot reinforces this pattern: while occasional high values approach or exceed 10 mg/L - mainly during cooler or higher-flow months - many observations between 2018 and 2024 fall consistently below the threshold, confirming chronic oxygen stress.



a. DO variation over time (temporal variation plot)



b. DO Violin plot

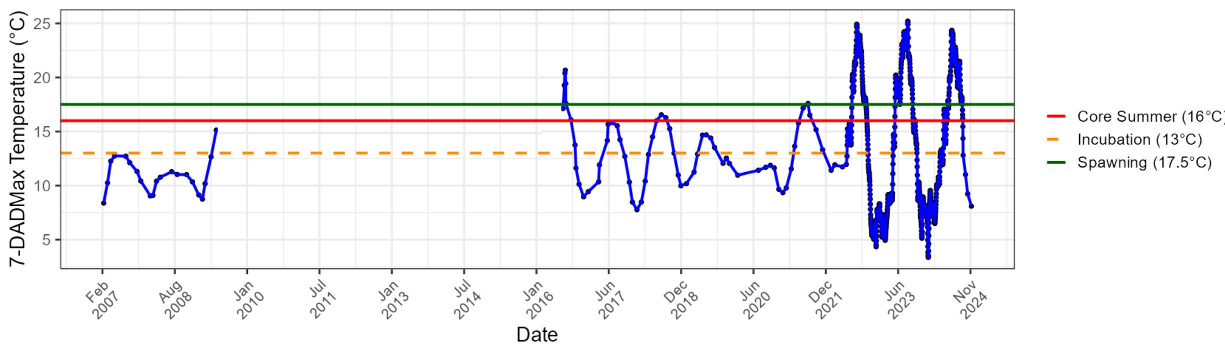
Figure 6.6 DO (mg/L) plots at Howanut Br station.

Temperature (7-DADMax):

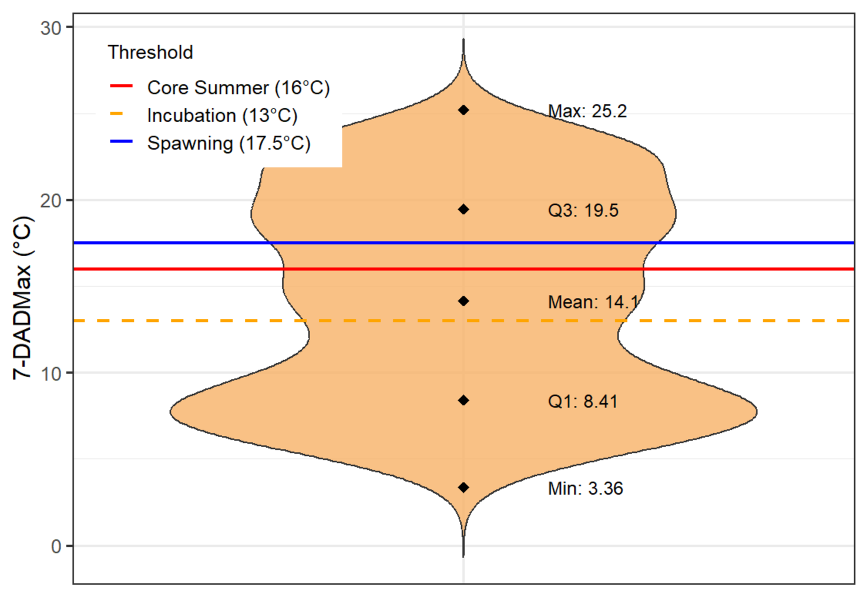
Three reference lines are available for consideration in terms of 7-DADMax: 13 °C (supplemental incubation) which is the supplemental guideline requirements, 16 °C (core summer), and 17.5 °C (spawning). Core-summer exceedances are extensive in the middle basin and on warming tributaries, while some headwater sites remain compliant. The highest core-summer exceedances among the selected stations occur at Sickman Ford Rd (~93.7%) and Boistfort (~91.4%), with Jackson Hwy (~67%), Independence Rd (~53%), and Prather Rd Br (~50%) also showing frequent warm periods. Sickman Ford Rd is located downstream of the Black River and upstream of Porter, while Boistfort is situated in the upper reach of the basin, but downstream of extensive agricultural land-use. Jackson Highway, Independence Rd, and Prather Rd stations are also located near areas of agricultural activity and developed land.

SR6-Chehalis, Mellen St, and Porter Rd each have ~40–45% core-summer exceedance. Elk Rd Br, Ceres Hill Rd, Ingalls-Lincoln, and Independence-Garrard located in the upper tributaries show 0% core-summer exceedance in the compiled record, reflecting cooler headwater and locally shaded conditions. Spawning-period exceedances are comparatively limited, but are notable at Boistfort (~39%) and Sickman Ford Rd (~38%).

Figure 6.7 illustrates the temporal variation of 7-DADMax (Figure 6.7a) and the violin plot of 7-DADMax distribution (Figure 6.7b) at the Sickman Ford Rd station, which exhibits one of the highest frequencies of 7-DADMax values exceeding the standard.



a. 7-DADMax variation over time (temporal variation plot)



b. 7-DADMax violin plot

Figure 6.7 7-DADMax (˚C) plots at Sickman Ford Rd station (WQP dataset).

The temporal variation of the 7-DADMax temperature at Sickman Ford Rd (Figure 6.7a) demonstrates a clear and persistent pattern of exceedances relative to the applicable thresholds.

Early records from 2007–2015 show moderate summer warming, with most values near or slightly below the core summer criterion (16 °C). However, after 2018, temperature values began to fluctuate notably, showing repeated warm-season exceedances. From 2019 onward, nearly every summer period recorded multiple peaks above both the core summer (16 °C) and spawning (17.5 °C) thresholds, with some events exceeding 20 °C. This consistent warm-season exceedance pattern indicates sustained thermal stress. NHC compared the observed temperature time-series for the Sickman Ford Road station to the data at the Porter Creek Road Bridge station downstream and there is no evidence of these extended periods of high water-temperature in 2022, 2023, and 2024. NHC recommends that the data quality of these data be reviewed further prior to making conclusions about the temperatures at the Sickman Ford Rd station.

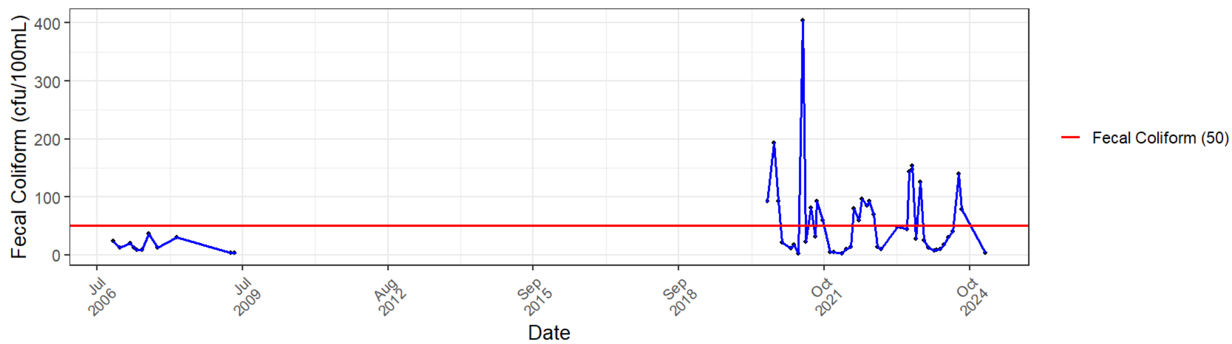
The corresponding violin plot (Figure 6.7b) further illustrates this behavior, showing a wide temperature distribution that extends substantially beyond the upper criteria. The mean value (14.1 °C) lies between the incubation and core summer thresholds, while the upper quartile (Q3 = 19.5 °C) exceeds the spawning criterion. The maximum observed temperature of 25.2 °C confirms the occurrence of acute thermal events. In contrast, the lower quartile (Q1 = 8.4 °C) and minimum value (3.4 °C) indicate that cooler conditions persist in non-summer periods. Overall, these figures collectively highlight that Sickman Ford Rd consistently experiences high and prolonged thermal stress, representing one of the most temperature-impaired sites within Upper Chehalis.

Bacteria (FC):
FC exceedance of the 50 cfu/100 mL criterion ($\log_{10} 50=1.70$) follows land-use and access patterns. Among the selected stations the highest percentages occur at Independence-Garrard (32.7%), Jackson Hwy (31.7%), and Boistfort (28.2%). Exceedances are also common at Sickman Ford Rd (25%), Porter Rd (23.5%), and SR6-Chehalis (21.2%). Lower rates occur at Elk Rd Br (16.7%), Mellen St (16%), Prather Rd Br (16.2%), and Independence Rd (15%). Ingalls-Lincoln shows 0%, indicating consistently low concentrations at that location.

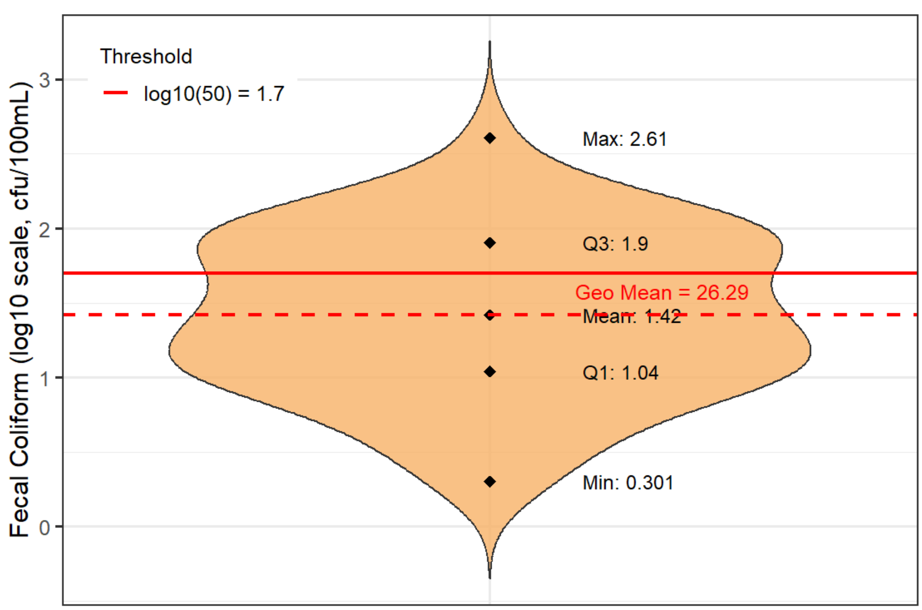
Figure 6.8a illustrates the temporal variation of FC over a nearly two-decade period, and Figure 6.8b (the violin plot) shows the distribution of observed values of FC at the Independence-Garrard station, which exhibits the highest frequency of FC values exceeding the standard.

The time-series plot (Figure 6.8a) for FC at the Independence–Garrard station shows large temporal variability with several periods exceeding the 50 cfu/100 mL standard, particularly after 2019. Earlier records from 2006 to 2012 generally remained below the threshold, but later years exhibit pronounced spikes that coincide with high-flow or runoff periods, including two extreme peaks around 2020–2021 where concentrations rose above 400 cfu/100 mL on April 26, 2021. These post-2018 increases suggest elevated nonpoint-source contributions, likely from upstream agricultural or rural residential runoff, as well as storm-driven impacts and resuspension of accumulated bacteria in the channel.

The corresponding violin plot (Figure 6.8b) summarizes the overall FC distribution and confirms this pattern of episodic but substantial exceedances. The interquartile range (Q1 = 11 cfu/100 mL, Q3 = 80 cfu/100 mL) straddles the threshold 50 cfu/100 mL (corresponding to 1.7 $\log_{10}$ cfu/100 mL), with a long upper tail extending to 405 cfu/100 mL. The geometric mean (26.29 cfu/100 mL) lies slightly below the criterion, indicating that most samples meet the standard but high-amplitude exceedances strongly influence the distribution. The overall shape of the violin, with a distinct secondary bulge above the threshold, reflects occasional extreme events that elevate bacterial loads while median conditions remain near compliance.



a. FC variation over time (temporal variation plot)



b. FC violin plot

Note: FC values on violin plot are on log10 scale and have been transformed to non-log scale values in narrative above.

Figure 6.8 FC ($\log_{10}$ cfu/100mL) plots at the Independence-Garrard station.

pH:
Following a quality review of the pH dataset, pH samples collected prior to 2016 were determined to be unreliable and were excluded from the assessment. Earlier records contained anomalously low winter values that were inconsistent with typical riverine conditions and likely reflected instrumentation or sampling limitations rather than true ambient acidity. Because these early data disproportionately influenced exceedance statistics, all summaries, exceedance rates, and figures relevant to pH presented below (and in Appendix B) are based exclusively on measurements collected from 2016 onward.

Across the Upper Chehalis monitoring network, most pH observations fall within the 6.5–8.5 criterion range. Exceedances are predominantly associated with values slightly below the lower threshold, while upper-limit exceedances are rare (see Figure 6.9 and pH plots in Appendix B). Removal of pre-2016 data results in substantially lower exceedance rates at most stations compared to the previous full-period assessment, indicating that earlier measurements introduced bias into the characterization of watershed conditions.

Among the evaluated stations, Independence–Garrard exhibits the highest exceedance rate (28.0%, 50 samples evaluated), followed by Howanut Bridge (17.6%, 74 samples) and Porter Rd (15.2%, 99 samples). Moderate exceedance rates are observed at Ceres Hill Rd (12.1%), Prather Rd Bridge (11.5%), and SR6–Chehalis (11.4%). Elk Rd Bridge (9.5%), Sickman Ford Rd (10.4%), Mellen St (7.6%), and Independence Rd (7.0%) show relatively limited departures from the standard. Jackson Hwy records the lowest exceedance rate (5.4%) despite the longest monitoring record (5,187 samples). Boistfort shows full compliance (0%). No post-2016 data are available for Ingalls–Lincoln; therefore, that station is excluded from further discussion.

As mentioned, fifty pH samples were evaluated at Independence–Garrard for monitoring years 2016 and later, of which 28.0% fall outside the 6.5–8.5 criterion range. Exceedances are primarily associated with values near or slightly below the lower threshold. Figure 6.9 presents the temporal variation in pH at this station since 2019. The record shows moderate variability, with most values clustering between approximately 6.4 and 6.9.

The distribution of 2016 and later samples is illustrated in Figure 6.10. The interquartile range (Q1 = 6.48, Q3 = 6.81) lies close to the lower criterion of 6.5, and the mean value (6.65) is slightly above the threshold. The minimum value recorded after 2016 is 6.22. The maximum value (7.58) remains well below the upper limit of 8.5. Overall, the violin plot demonstrates a relatively tight distribution centered near the lower criterion, with limited dispersion toward alkaline conditions. While exceedances occur, they are generally marginal and episodic rather than severe.

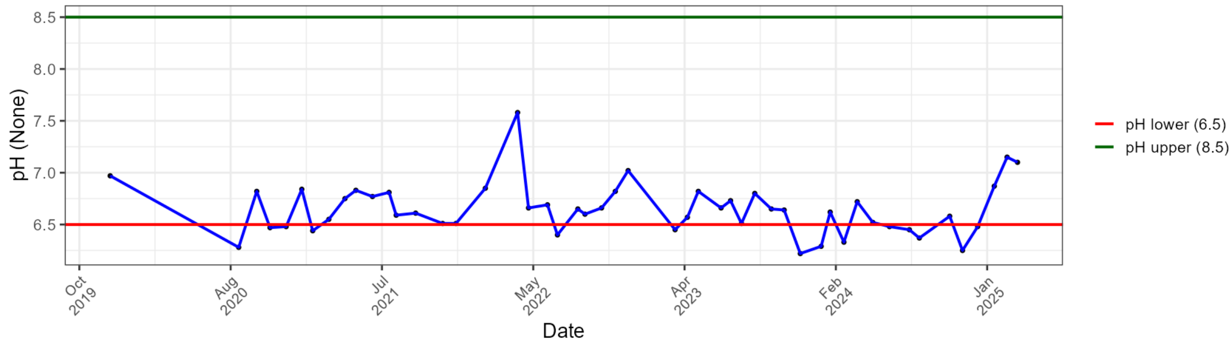


Figure 6.9 pH variations over time at the station with the highest exceedance rates at Independence–Garrard station (2019-2024).

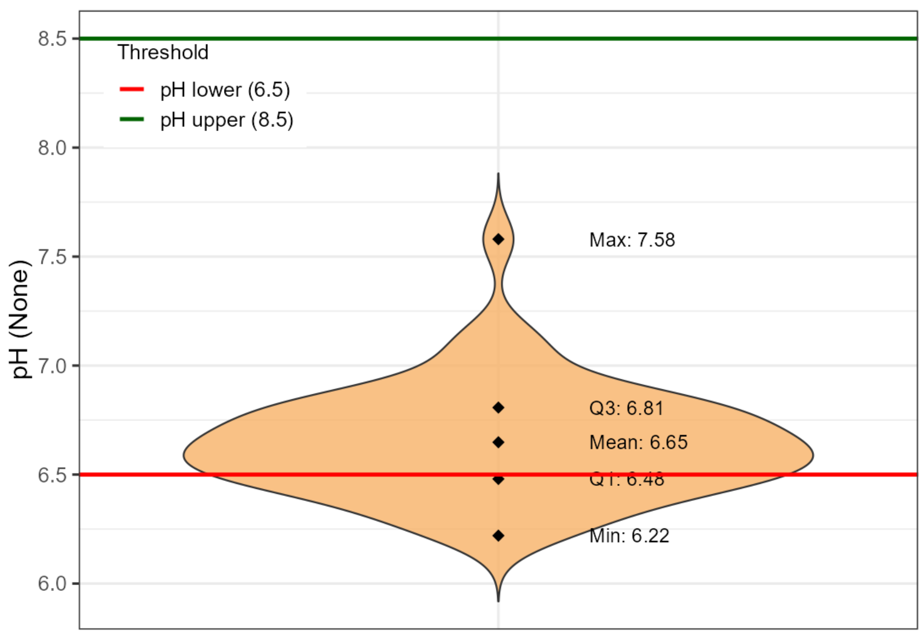


Figure 6.10 Violin plot of pH samples from 2017 to 2025 at Independence–Garrard station.

The exclusion of pre-2016 pH data considerably reduced exceedance frequencies at most stations, suggesting that poor measurement quality during that period had introduced artificial bias into the assessment. The updated analysis indicates that departures from the criterion are generally limited in magnitude and frequency.

Independent FIN monitoring data, which are considered more reliable for pH measurement, also do not indicate persistent or basin-wide acidic conditions. The FIN record supports the interpretation that current pH conditions are relatively stable and that the 2016 and later WQP data provide a more representative characterization of watershed conditions.

Although certain stations, particularly Independence–Garrard, continue to show a higher proportion of marginal low values, the absence of extreme acidity in recent years and the lack of spatially consistent impairment suggest that pH does not represent a widespread water quality concern in the Upper Chehalis watershed.

6.2.3 Boxplot Evaluation of WQP Stations

Dissolved Oxygen:

The DO boxplots corroborate percentages reported previously in the general pattern section for WQP stations. At the selected upstream headwaters (Elk Rd Br, Ceres Hill Rd) distributions are centered near or above 10 mg/L, with lower whiskers typically in the 6–8 mg/L range and upper whiskers around 14 mg/L, indicating mostly adequate conditions (relative to downstream) with warm-season dips. Through the central urban–agricultural corridor (SR6-Chehalis, Mellen St, Prather Rd Br) the boxes straddle the 10 mg/L line, lower whiskers commonly in the 3–5 mg/L range, reflecting frequent sub-criterion days during summer low flow. Ingalls-Lincoln and Independence-Garrard show broad spreads centered below 10 mg/L, consistent with their high below-threshold percentages. The Black River station Howanut Br exhibits the lowest central tendency among the selected sites, while Porter Rd shows mixed conditions with a spread across the threshold, consistent with partial dilution and cumulative upstream inputs. Where WQP and FIN are co-located or adjacent (for example Mellen St vs Centralia, Prather Rd Br vs Prather, Porter Rd vs Porter), distributions and exceedance rates align closely with the FIN patterns described earlier. For example, at the FIN Porter Station, LW and UW values were 7.2 mg/L and 13.5 mg/L, respectively, with a median of approximately 10.5 mg/L. In comparison, at the WQP Porter Rd Station, the LW and UW values were 6.58 mg/L and 12.99 mg/L, respectively, with a similar median of about 10.5 mg/L and the boxplot shape was also very similar.

Temperature (7-DADMax):

The 7-DADMax boxplots indicate that many mid-basin stations have upper whiskers above 16 °C and, at times, approaching or exceeding 17.5 °C during warm seasons, for example Jackson Hwy, SR6-Chehalis, Mellen St, Prather Rd Br, Independence Rd, and Porter Rd. The 13 °C guideline is crossed by the interquartile ranges at most of these sites in summer, confirming extended periods of thermal stress. In contrast, Elk Rd Br, Ceres Hill Rd, Ingalls-Lincoln, and Independence-Garrard have distributions with upper quartiles near or below 13 °C and upper whiskers generally below 16 °C, consistent with the 0% core-summer exceedances. Cross-checks with adjacent FIN stations again show strong agreement, for example higher summer temperatures at Mellen St near Centralia, and broad warm ranges at Porter Rd near Porter all with highly similar LWs, UWs, and boxplot shapes.

Bacteria (FC):

For the FC plots, the threshold of 50 cfu/100 mL ($\log_{10}$ = 1.70) serves as the reference line. The FC boxplots are consistent with the exceedance table (Table 6.2). Jackson Hwy and Independence-Garrard display distributions with medians near the 1.70 line and upper whiskers in the 2.3–2.6 log range, indicating frequent and sometimes pronounced events. Boistfort, SR6-Chehalis, Mellen St, Prather Rd Br, Independence Rd, and Porter Rd have medians still near but generally lower than the line with regular high tails, pointing to variable loading and source control. Elk Rd Br and Ceres Hill Rd are typically below the line, and Ingalls-Lincoln remains the best performer among the selected sites. These spatial patterns mirror those seen in the FIN network, with a mid-basin maximum in bacterial stress that coincides with areas of elevated temperature and low DO.

pH:
The pH boxplots show that most central quartiles at the selected sites sit between 7.0 and 7.8, with low outliers below 6.5 most common at Independence-Garrard, supporting their higher exceedance rates. Porter Rd, SR6-Chehalis, and Prather Rd Br also display wide IQRs with low outliers, indicating episodic insignificant excursions driven by flow variability and biological productivity. Boistfort exhibits one of the most stable ranges, remaining near-neutral with no exceedances. Overall, pH behavior is consistent with the FIN findings, namely generally stable conditions with site-specific low tails and occasional high outliers.

6.3 Spatial Assessment of Water Quality in Upper Chehalis

As mentioned under the Methodology Section, spatial analysis of exceedance patterns was performed to evaluate the severity of water quality impairments throughout the Upper Chehalis. Exceedance rates for all parameters at each monitoring station are provided in Appendices A and B for the FIN and WQP datasets, respectively. The processed FIN and WQP datasets were integrated by assigning each monitoring station to its corresponding associated river. For each associated river, exceedance rates were assessed for different water quality parameters.

6.3.1 7-DADMax Temperature Assessment

As noted, the 7-DADMax temperature parameter is a critical indicator of aquatic habitat suitability. For the 7-DADMax temperature parameter, three distinct criteria are specified in Table 3.1. The first applies to the core summer period, defined as June 15 to September 14, with a maximum allowable 7-DADMax of 16°C (60.8°F). The second applies to the Salmonid Spawning, Rearing, and Migration period, from May 16 to June 14, with a maximum allowable 7-DADMax of 17.5°C (63.5°F). These criteria reflect the different thermal tolerances and habitat needs of aquatic species during various seasonal life stages.

During the core summer period, temperature exceedances are widespread across the Upper Chehalis. The Chehalis River, South Fork Chehalis River, Black River, Skookumchuck River, and Newaukum River show the most pronounced exceedance frequencies, indicating persistent thermal stress during the warmest months. These elevated temperatures are likely associated with reduced riparian shading, low summer baseflows, and increased solar radiation. Only limited, localized segments consistently met the temperature criteria without exceedance.

During the spawning, rearing, and migration period, exceedances remain present but are generally less frequent and less severe compared to the core summer period. In particular, portions of the Chehalis River and South Fork Chehalis River exhibit relatively low exceedance rates during this time, reflecting improved thermal conditions as air temperatures decline and streamflows increase. Overall, however, temperature impairment remains a basin-wide concern, particularly during summer low-flow conditions.

6.3.2 Dissolved Oxygen (DO) Assessment

DO was evaluated using both concentration (mg/L) and percent saturation, which indicates how close the measured DO levels are to the maximum amount of oxygen water can hold under specific temperature and pressure conditions. The analysis shows that low DO is a widespread concern across nearly all major stream reaches in the Upper Chehalis watershed.

The Chehalis River, Black River, and South Fork Chehalis River consistently exhibit the highest exceedance frequencies, particularly during summer low-flow periods. Oxygen deficits coincide with elevated water temperatures, reduced reaeration potential, and increased organic and nutrient loading from tributary inflows, which promote algal growth and subsequent oxygen consumption.

In the mainstem Chehalis River, slow summer flows and nutrient enrichment intensify oxygen depletion, particularly within the Centralia Reach. Similar patterns are observed in the Black River and South Fork Chehalis River, where riparian canopy loss and increased nutrient and sediment inputs contribute to persistent oxygen stress.

Spatially, the pattern of exceedances indicates a decline in DO conditions from east to west and from upland tributaries toward the mainstem confluences, reflecting the cumulative influence of agricultural runoff, reduced shading, and sediment delivery.

Overall, DO remains the most critical freshwater quality parameter of concern in the Upper Chehalis. The exceedance analysis, when compared with the 7-DADMax temperature patterns, further emphasizes that thermal stress and low DO conditions are spatially correlated. Therefore, DO is closely correlated with elevated temperatures and nutrient enrichment that collectively degrade aquatic habitat quality.

6.3.3 Fecal Coliform (FC) Assessment

FC exceedances are particularly observed in the mainstem Chehalis River, South Fork Chehalis River, and lower reaches of the Newaukum River. Several segments exhibit high maximum exceedance frequencies, indicating chronic bacterial contamination rather than isolated events.

Land-use in areas adjacent to the Chehalis and South Fork Chehalis Rivers is influenced by agricultural operations and rural residences, where livestock access, manure management, and on-site septic systems contribute to elevated fecal loading. These reaches correspond with the same areas previously identified in the FC Bacteria TMDL (Ahmed and Rountry, 2004) as bacterial hotspots driven by agricultural and rural-residential runoff.

Localized problem areas remain evident near Centralia and Napavine, where urban stormwater and mixed Land-uses likely contribute to exceedances. However, some tributaries such as portions of the Skookumchuck and upper Newaukum River show comparatively lower exceedance frequencies.

Overall, the spatial trends highlight that FC impairment is severe in downstream and agricultural subbasins, where cumulative nonpoint sources and limited riparian buffers reduce natural attenuation capacity. These results emphasize the need for targeted implementation measures, including livestock exclusion fencing, riparian restoration, and improved wastewater management, to achieve bacterial water-quality standards across the basin.

6.3.4 *E. coli* Assessment

It should be noted that, compared to FC, the assessment of *E. coli* is relatively recent, and fewer data samples are available for this analysis. Thus, some of the evaluated associated rivers may have insufficient or even no *E. coli* data for the assessment, introducing potential uncertainty in the spatial interpretation of exceedance patterns.

In any case, the most critical areas in terms of *E. coli* exceedance rates occur primarily in the South Fork Chehalis River and the middle Chehalis mainstem near and downstream of Adna and Claquato. This is consistent with the current study's FC assessment and the FC Bacteria TMDL (Ahmed and Rountry, 2004), which identified these areas as bacterial hotspots driven by agricultural and rural-residential runoff.

Overall, *E. coli* exceedances are localized, primarily in tributaries with known agricultural and rural-residential influences. However, there is uncertainty due to insufficient samples. This emphasizes the need for continued implementation of BMPs such as riparian fencing, improved manure handling, and septic system upgrades to maintain and improve water quality across the watershed.

6.3.5 pH Assessment

pH exceedances are occasionally detected throughout the Upper Chehalis, with most monitored segments exhibiting satisfactory conditions. Elevated exceedances are most notable near the Centralia–Chehalis urban corridor.

These findings are consistent with previous basin assessments that documented nutrient enrichment and enhanced algal photosynthetic activity during summer low-flow conditions in the urban corridor. Such conditions can drive elevated pH levels due to increased primary productivity.

7 DISCUSSION

As land-use shifts from forestry and agriculture to more intensive development, it is essential to preserve remaining natural areas and implement BMPs across all land types contributing to water quality impairments. This strategy supports land conservation, raises awareness, and encourages sustainable practices that protect water quality while accommodating responsible growth. Taking action now to safeguard the basin's high-quality waters is significantly more cost-effective than attempting restoration later. Without proactive intervention, continued growth may degrade these vital resources, leaving future generations burdened with costly remediation or diminished water quality.

In the previous sections, we identified the magnitude and frequency of exceedances for various water quality parameters across multiple streams within the watershed. Streams associated with subbasins at different locations and with varying land-uses were identified and analyzed within each subbasin. This approach allows for the identification of water quality impairments along the Chehalis mainstem and its tributaries, followed by evaluation of potential NPS pollution contributors within individual subbasins.

The combined evaluation of historical studies and current monitoring data indicates that NPS pollution remains the dominant driver of water quality impairment across the Chehalis Basin, particularly within the Upper Chehalis (WRIA 23). Results consistently show that impairments are spatially structured and closely aligned with land-use, hydrologic setting, and channel morphology. Forested headwater subbasins generally maintain better water quality conditions, while agricultural, mixed rural–residential, and urbanized subbasins exhibit higher frequencies and magnitudes of exceedances across multiple parameters, particularly in mid-basin reaches.

Temperature and DO emerge as the most pervasive and interrelated impairments. Spatial and longitudinal analyses show that elevated summer temperatures and depressed DO concentrations frequently co-occur in low-gradient mainstem reaches and agriculturally influenced tributaries or areas impacted by urbanization and development, including the Centralia Reach, South Fork Chehalis, Black River, and Newaukum River. These conditions reflect the combined influence of reduced riparian shading, widened channels, low summer baseflows, and nutrient and organic loading. The spatial correlation between 7-DADMax exceedances and DO deficits confirms that thermal stress is one of the primary mechanisms driving oxygen depletion and aquatic habitat degradation in the basin.

For most streams, achieving mature late-seral riparian vegetation for long-lived, shade-tolerant tree species (e.g., 200-year-old Western Hemlock or 60-year-old Red Alder stands) is sufficient to meet temperature standards without requiring species replacement. However, three tributaries - South Fork Chehalis, Newaukum, and Black Rivers - also require stream channel restoration to address widened channels and elevated width-to-depth ratios. In addition to the three tributaries, portions of mainstem sections of the Upper Chehalis River may not fully meet current temperature criteria, indicating that both shade restoration and channel morphology improvements are needed.

Bacterial indicators further reinforce the role of land-use and hydrologic connectivity in shaping water quality outcomes. FC exceedances are widespread in mid-basin and downstream reaches, particularly along the Chehalis mainstem, South Fork Chehalis, Centralia and lower Newaukum River. These patterns are consistent with historical FC TMDL findings and are associated with agricultural activities, livestock access, on-site septic systems, and storm-driven runoff. Although *E. coli* exceedances are generally less frequent and based on shorter records, their spatial distribution is generally consistent with FC results, indicating shared NPS pathways and reinforcing the validity of the observed bacterial impairment patterns.

Nutrient-related indicators, including TP and IN species, show elevated concentrations and yields in agricultural and mixed-use subbasins, particularly the Black River, South Fork Chehalis, Newaukum River, and portions of the mainstem near Centralia. While nutrient concentrations alone do not always exceed guidance thresholds, their influence on eutrophic conditions appears to be reflected in associated increases in BOD, depressed DO, and variability in pH linked to biologically driven processes.

Sediment-related parameters display event-driven behavior, with elevated TSS and turbidity primarily occurring during storm periods. Tributaries influenced by forestry operations, unpaved roads, and disturbed riparian zones, such as portions of the Upper Chehalis tributaries (e.g., upstream of Dryad Station), contribute disproportionately to sediment loading. Although long-term trends are not always statistically significant, episodic high-sediment events degrade habitat quality, reduce light penetration, and exacerbate nutrient transport.

The subbasin-scale framework applied in this assessment provides critical insight into how localized land-use practices translate into downstream water quality effects. Subbasins dominated by forest cover generally exhibit lower exceedance rates and greater resilience, whereas agricultural and urban-influenced subbasins, particularly mid-basin ones, show multiple coincident impairments. Several subbasins with limited recent monitoring data may have underestimated impairment severity, highlighting the need for continued and targeted data collection to refine prioritization and track progress.

The alignment between historical TMDL findings and current exceedance patterns suggests that many impairments persist despite past implementation efforts, while some areas show partial improvement or localized mitigation effects. These findings emphasize the importance of integrated, subbasin-specific management strategies that address thermal loading, nutrient enrichment, bacterial contamination, and sediment delivery across the impaired areas. The methodology used in this study will help to identify priority subbasins and select appropriate BMPs, which must be tailored to dominant land-uses, impairment types, and hydrologic conditions to achieve meaningful and sustained water quality improvements across the Chehalis Basin.

8 SELECTION OF BMPs

The selection of BMPs for the Chehalis Basin is informed by the integrated findings from historical TMDLs and other relevant studies, the subbasin-scale land-use assessment, and the current analysis of water quality exceedances derived from the FIN and WQP datasets. The objective of this section is to identify BMP categories that are appropriate for addressing the dominant NPS stressors documented across the basin, with particular emphasis on the Upper Chehalis.

The discussion and results sections indicate that water quality degradation in the basin is driven by cumulative and interacting NPS pressures associated with agricultural activities, rural residential development, urban stormwater runoff, forestry practices, and riparian alteration. Accordingly, BMP selection should focus on practices that address thermal loading, nutrient enrichment, bacterial contamination, sediment delivery, associated hydrologic alterations, and support public engagement and education, while remaining consistent with existing programs and implementation frameworks throughout the Chehalis Basin.

The BMPs identified in this section are presented as general categories, rather than site-specific prescriptions, and are intended to support subsequent prioritization and implementation planning at the subbasin or reach scale. To this end, Table 8.1 lists potential BMPs based on their primary intended purpose, identified through review of relevant literature and prior studies. This table links identified stressors to appropriate BMP categories that have been recommended or implemented in prior studies and are consistent with the findings of the current assessment. The BMPs summarized in Table 8.1 reflect practices that address FC bacteria, DO, temperature, sediment, and other NPS stressors associated with agricultural, rural residential, urban, and forested land-uses within the basin.

In addition to the conventional BMPs summarized in Table 8.1, NHC conducted further investigation into emerging and innovative management approaches that may provide supplemental benefits in addressing NPS pollution in the Chehalis Basin. These approaches are not intended to replace established BMPs, but rather to enhance their effectiveness in locations where impairments are persistent or traditional measures alone may be insufficient. The applicability of the listed BMPs within the Chehalis Basin would require site-specific evaluation, feasibility assessment, and coordination with local and regulatory stakeholders.

Green Infrastructure and Stormwater Retrofit at Parcel and Community Scales:
Green infrastructure practices offer opportunities to reduce runoff volume, pollutant loading, and thermal inputs associated with urban and urbanizing areas. In portions of the basin experiencing development pressure, particularly near Centralia and Chehalis, these practices may complement traditional stormwater controls by increasing infiltration and moderating runoff temperatures.

Examples include permeable pavement, vegetated swales, bioswales, and rain gardens designed to treat stormwater at or near its source. Additional measures such as cool pavement surfaces and vegetated or green roofs may further reduce heat absorption and limit thermal loading to receiving waters through stormwater discharge pathways.

Constructed Wood Debris and Step-Pool Sequences in Degraded Reaches:
In low-gradient valleys and simplified channels, engineered in-stream structures may be used to increase hydraulic complexity and enhance physical and thermal habitat conditions. Constructed large woody debris (LWD) installations combined with step-pool sequences can promote flow mixing, increase depth and velocity heterogeneity, and improve local cooling and oxygenation.

These approaches may be particularly relevant in degraded reaches such as portions of the Porter reach and the Black River corridor, where channel simplification and limited riparian shading contribute to elevated temperatures and low DO.

Hyporheic Exchange Enhancement:
Enhancing hyporheic exchange represents a potential strategy for improving thermal buffering and DO conditions in gravel-bed rivers. Substrate enhancements or gravel augmentation may increase groundwater–surface water interaction, allowing cooler subsurface flows to moderate temperature peaks and support oxygen exchange processes. Such approaches require careful geomorphic assessment and design to ensure channel stability and sediment continuity and are most appropriate where channel conditions and sediment supply are well understood.

Smart Agriculture and Sensor-Based Nutrient and Irrigation Management:
Advances in precision agriculture provide opportunities to reduce nutrient runoff and water withdrawals through real-time monitoring and adaptive management. Sensor-based soil moisture and nutrient monitoring systems can support optimized fertilizer application and irrigation scheduling, reducing excess nitrogen and phosphorus delivery to surface waters.

These technologies may be particularly applicable in agricultural subbasins where nutrient enrichment and low-flow stress have been identified, such as mid-basin areas. Variable irrigation scheduling informed by real-time data can also support flow conservation during critical low-flow periods.

Table 8.1 List of potential BMPs based on primary purpose.

Targeted Parameter	Suggested or Implemented BMPs
FC Reduction	• Livestock exclusion fencing and riparian buffer zones • Replacement of failing septic systems • Permitting of new or expanded septic systems; oversight of operations and maintenance programs; review of land-use proposals to protect sensitive areas; and implementation of on-site sewage system (OSS) regulations by counties • Dairy waste and nutrient management plans (e.g., timing and setback controls for land application) • Waste storage facility (e.g., manure storage ponds, manure containment facilities) • Animal mortality facility • Pasture pumps installation for livestock watering to reduce direct stream access • Drainage water management and pest management • Installed catch basin filtration on city drains • Retention/treatment stormwater requirements for new developments • BMP workshops to reduce the amount of manure reaching waterways • Conduct routine inspection activity and take enforcement actions by the WA Department of Agriculture • Provide technical assistance to comply with water quality rules by the WA Department of Agriculture
DO Improvement	• Riparian restoration (planting buffers) for shading and cooling • Livestock exclusion fencing to reduce sediment and nutrient inputs • Nutrient management on agricultural lands (e.g., reduce organic loading and manure use optimization) • Wetland restoration for nutrient retention and flow moderation • Maintaining minimum flows above 500–1000 cfs before allowing discharges (seasonal discharge limits)
Temperature Reduction	• Riparian re-vegetation (native riparian trees and shrubs) and buffer establishment • Stream channel restoration/morphology stabilization (e.g., reducing width-to-depth ratios by sediment delivery, river flow and riparian vegetation) for flow re-aeration and shading improvement • Flow conservation via irrigation efficiency and groundwater protection • Bioengineering and large woody debris (LWD) placement for habitat and shading improvements
Sediment/TSS Control	• Bank stabilization and vegetated buffers to prevent sediment delivery (e.g., log deflectors, root wads, and LWDs) • Shoreline stabilization and re-vegetation • Seeding and mulching on forest roads • Erosion control practices at agricultural and construction sites

Targeted Parameter	Suggested or Implemented BMPs
General/Multi-Purpose NPS BMPs	• Educating landowners and the general public about water quality issues • Continued monitoring of BMP effectiveness • Upland wildlife habitat management (e.g., off-channel refuge alcoves creation, Spawning pads installation, LWD placement, and harvest noxious aquatic weeds) • Forest harvest management and shrub site preparation • Creating recreational trails and walkways • Grazing management • Year-round BMP implementation focused on critical months (e.g., November high-spike periods)

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9 EXISTING NPS CONTROL PROGRAMS

A variety of NPS pollution control programs and projects have been implemented or are currently operating within the Chehalis Basin to address water quality impairments associated with agriculture, forestry, urban and rural development, and riparian alteration.

9.1 Chehalis Basin Watershed Management Plan

The Chehalis Basin Watershed Management Plan (Chehalis Basin Partnership, 2004) provided an integrated program involving federal, state, tribal, and local governments for the entire Chehalis Basin (WRIAs 22 and 23) based on a shared vision, policy framework, and strategic path for sustainable water management. Developed collaboratively, it promotes voluntary, cost-effective solutions to support economic growth, water quality, and healthy fish habitats, while offering valuable new insights into the basin's water resources. The plan addresses water quantity, quality, instream flow, and habitat, offering specific recommendations in each area.

Formed in August 1998, the Chehalis Basin Partnership is a broad-based organization established to lead watershed planning. It includes representatives from four counties, two tribes, 12 cities, water utilities, state agencies, the Port of Centralia, and key interest groups such as agriculture, forestry, business, and the environment, along with citizen representatives. The Chehalis Basin Watershed Management Plan was developed under Washington's Watershed Management Act within Revised Code of Washington (RCW 90.82). RCW 90.82 requires planning for water quantity and allows three optional focus areas including water quality, habitat, and instream flows. Acting under authority of the 1998 Watershed Management Act (Chapter 90.82 RCW), with Grays Harbor County as the Lead Agency, the Partnership developed and approved the Plan on April 13, 2004, which was adopted by each of its participating counties. The initial scope of the plan included water quantity, water quality, and habitat, with instream flows added later as additional funding became available. The plan aimed to address these elements in an integrated and collaborative way across the entire basin. The plan identified a total of 56 recommended actions that were agreed upon by all parties, although the details of implementation obligations remained undecided. Among these, 30 actions addressed water quantity - focusing on hydraulic continuity, water rights, exempt wells, and water conservation; 15 actions targeted water quality; five related to habitat; and four pertained to instream flow. There were also 14 "unresolved suggested actions" in the plan (Chehalis Basin Partnership, 2004).

9.2 Detailed Implementation Plan (DIP)

As a follow-up to the Plan, the Partnership developed and approved the Detailed Implementation Plan (DIP) in June 2009, further outlining a comprehensive approach for accomplishing the 2004 Plan's goals through prioritized strategies and interim milestones (Chehalis Basin Partnership, 2009). DIP was developed through a three-step process. First, the Steering Technical Committee (STC) of the Partnership reviewed 56 suggested actions and organized them into 18 strategies (1 to 5 for immediate implementation and 6 to 18) to achieve five objectives of the plan: Planning; Public Involvement; Water Quantity; Water Quality; and Habitat. Next, the Water Quality Committee and Habitat Workgroup of the Partnership collaborated with local, state, federal, and tribal partners in workshops to refine these strategies into tasks and milestones, identifying responsible parties, resources, and timelines. Finally, the draft DIP was reviewed and adopted by the Partnership, initiating implementation. The DIP includes five strategies aligned with the Chehalis Watershed Management Plan goals to ensure adequate high-quality water for agriculture, industry, and residential use while meeting instream flow needs. Each strategy is broken into interim milestones (IMs) with detailed work plans outlining tasks, start dates, oversight responsibilities, participants, resource needs, and required approvals (Chehalis Basin Partnership, 2009).

DIP Strategy 1: Promote Flexible Water Rights Strategies

Address hydraulic continuity issues by creating more adaptable processes for water rights.

- IM 1.1: Partner with Ecology to issue and transfer water rights more flexibly.
- IM 1.2: Conduct groundwater studies to understand aquifer-stream interactions and guide water allocation decisions.

DIP Strategy 2: Secure Adequate Funding for Watershed Management

Build a sustainable financial framework to support watershed initiatives.

- IM 2.1: Develop a finance strategy work plan.
- IM 2.2: Launch education and outreach efforts to secure funding and engage stakeholders.
- IM 2.3: Establish partnerships to leverage financial resources.
- IM 2.4: Create a watershed management work plan linking projects to funding sources.

DIP Strategy 3: Develop Tools for Meeting Water Quantity Goals

Expand institutional and technical capacity to ensure sustainable water supply.

- IM 3.1: Clarify water rights and allowable uses.
- IM 3.2: Establish a Water Quantity Committee.
- IM 3.3: Resolve permit-exempt well challenges.
- IM 3.4: Develop tools including municipal toolkits, storage strategies, and incentives.
- IM 3.5: Recommend instream flow levels and implement stakeholder-driven outreach.

DIP Strategy 4: Retain Forestry and Agriculture on the Landscape

Support land-uses that provide environmental and economic benefits.

- IM 4.1: Inventory agricultural lands and assess threats and protections.
- IM 4.2a-d: Promote local forestry/agriculture through outreach, economic support, business sustainability, and innovative water rights tools.

DIP Strategy 5: Coordinate Habitat Restoration and Protection

Improve collaboration among habitat restoration groups in the basin.

- IM 5.1: Foster inter-agency and stakeholder coordination for habitat efforts.
- IM 5.2a-c**:** Develop outreach, financing, and monitoring plans to support coordinated habitat restoration, including assessment of habitat effectiveness.

Each strategy includes defined tasks, responsible oversight committees, participating agencies, resource needs, and legal requirements. Between 1998 and 2011, nearly $11.3 million was spent on projects focused on water quality, water quantity, and habitat throughout the watershed planning area (Chehalis Basin Partnership, 2009; Janel Spaulding & Lee Napier, 2011). Details of those projects can be found in the Plan's progress report (Janel Spaulding & Lee Napier, 2011).

Between 2009 and 2018, the Partnership continued to meet, providing a cooperative forum for members to engage and advise on water and habitat-related topics. However, the lack of state support for watershed plan implementation hampered progress on many of the Plan's recommendations.

9.3 Plan Addendum and Streamflow Restoration Response

In January 2018, the Washington State Legislature passed ESSB 6091, a new law addressing the 2016 Whatcom County vs. Western Washington Growth Management Hearings Board Washington Supreme Court decision, commonly referred to as the "Hirst Decision." The Partnership responded to the Streamflow Restoration law by re-engaging its full original membership, updating membership for stakeholder and citizen representatives, and developing its response through a 2020 addendum to the plan. The addendum complies with state requirements with projects and actions that are tailored to the Chehalis Basin's ecological needs and values of Partnership members. It addressed a key issue from the 2004 Plan by managing impacts from permit-exempt domestic wells. The Addendum included:

- Forecasts of future domestic groundwater use through 2040
- Assessment of potential impacts of those forecast withdrawals on streamflows
- Development of offset projects that provide a Net Ecological Benefit (NEB) to the basin

To comply with Chapter 90.94 of RCW, the Chehalis Basin Partnership divided WRIAs 22 and 23 into 19 subbasins and projected new permit-exempt wells and related consumptive use through 2040. Permit-exempt well impacts and potential offset projects were estimated within each of these 19 subbasins. Although offsets are required at the basin scale, the Partnership prioritized subbasins with the highest projected impacts - Black, Newaukum, Scatter Creek, and Skookumchuck - where water offset projects are expected to exceed consumptive use by 145% to over 2,700%. In addition to streamflow, overall ecosystem health depends on factors like riparian condition, water quality, and instream habitat diversity. The NEB assessment was guided by priorities from the Chehalis Basin Salmon Restoration and Preservation Strategy and ASRP. Habitat projects included in the Addendum are expected to restore 121 miles of stream, protect 2,180 acres of riparian and upland habitat, and reconnect over 40 miles of aquatic habitat. These are multi-purpose projects intended to improve quantity and/or quality of water and/or natural habitats. The identified projects across various subbasins aim to enhance stream restoration, protect riparian and upland areas, and improve habitat connectivity. In total, the project portfolio contains 74 separate projects, distributed over 17 of the 19 subbasins as shown in Figure 9.1 (NHC, 2020).

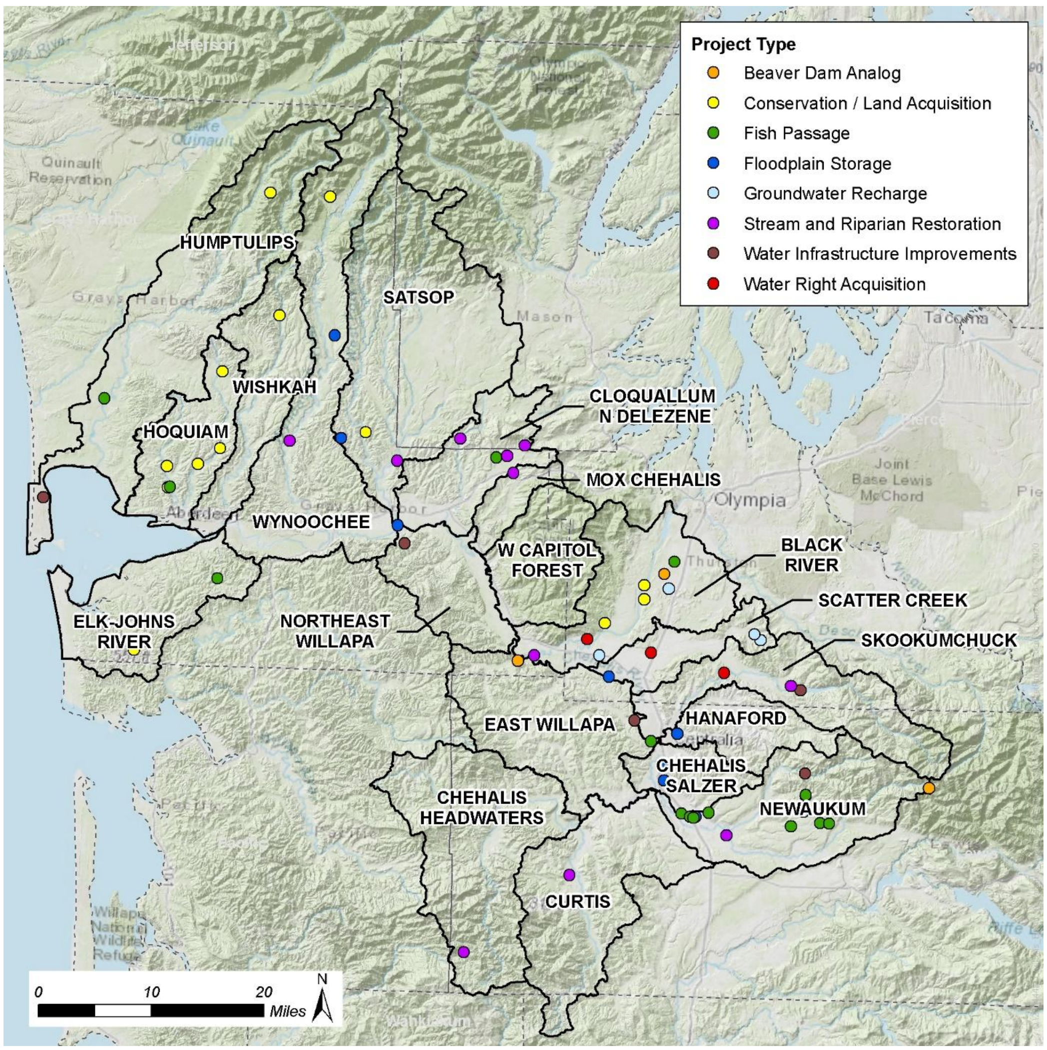

Figure 9.1 Project locations across the Chehalis Basin (NHC, 2020).

9.4 Voluntary Stewardship Program (VSP)

Another important initiative related to NPS pollution control is Washington State's Voluntary Stewardship Program (VSP), which has been adopted by counties within WRIA 23 (WA Conservation Commission, 2025).

9.4.1 Program Framework and Legislative Intent

VSP is a voluntary, non-regulatory pathway under the Growth Management Act (GMA) designed to protect critical areas on agricultural lands while maintaining long-term agricultural viability. Established in 2011 (RCW 36.70A.700–760), the VSP provides counties with an alternative to implementing traditional critical areas regulations for agricultural activities. To meet GMA requirements in areas where agriculture occurs, counties must choose between two approaches: enforce regulatory protections on agricultural landowners or opt into the VSP framework, which relies on voluntary, site-specific stewardship actions. Under the VSP model, participating landowners proactively implement stewardship practices that both sustain working lands and protect ecological functions. In doing so, landowners may reduce the likelihood of future regulatory requirements while contributing to measurable environmental outcomes.

VSP is built around locally driven planning and measurable outcomes. To participate, a county must opt in and be accepted by the Washington State Conservation Commission (SCC) as defined in RCW 89.08.030, establish a stakeholder watershed work group, and develop a countywide watershed work plan. The work plan sets goals and benchmarks for protecting and enhancing critical areas in areas where agricultural activities are conducted, and is supported by monitoring and adaptive management to evaluate progress and adjust implementation over time. VSP is administered by the SCC with support from the Statewide Advisory Committee (representing county, agricultural, environmental, and tribal interests) and a Technical Panel comprised of leadership from the Washington State Department of Fish and Wildlife (WDFW), Washington State Department of Agriculture (WSDA), Ecology, and SCC.

The legislative intent of VSP emphasizes protecting and improving critical area functions while strengthening the long-term viability of agriculture and reducing the conversion of farmland to other uses. The program prioritizes voluntary, incentive-based stewardship, leverages existing local, state, and federal resources, and promotes cooperation among counties, tribes, environmental organizations, and the agricultural community. It also seeks to improve compliance with laws related to water quality and fish habitat. Importantly, VSP does not expand regulatory authority over agricultural activities, does not require legally existing agricultural operations to cease, and does not replace participation in conservation districts or other state and federal conservation programs.

For agricultural landowners in VSP counties, participation is voluntary and flexible. Landowners may choose whether to prepare a stewardship plan; when developed, the plan is intended to protect critical areas while maintaining economic viability. VSP is results-oriented, emphasizing measurable stewardship outcomes rather than prescriptive regulation. Participation may provide benefits such as improved understanding of on-farm critical areas, enhanced operational efficiency, reduced exposure to violations or future regulatory action, and access to cost-share funding for eligible practices, such as fencing or pasture improvements. Program success ultimately depends on sustained landowner participation and collaboration through county work groups.

VSP funding supports both program administration and on-the-ground implementation through operating and capital funds. Operating funds are non-competitive and distributed equally to participating counties with approved work plans through biennial contracts. These funds may be used for program administration, outreach, technical assistance, training, travel, monitoring, and work group–approved cost-share projects or district-implemented projects.

Capital funds support cost-share projects and district-implemented projects through a combination of initial allocations and competitive awards. Eligible capital projects must be approved by the county work group; located within participating watersheds; aligned with work plan goals and benchmarks; include BMPs with a design life greater than one year; and be documented through the five-year reporting cycle. Capital awards are administered through the Washington State Conservation Commission's CPDS, evaluated through a competitive scoring process, and must meet applicable technical standards and state requirements, including completion of cultural resource review prior to ground disturbance.

9.4.2 Lewis County Voluntary Stewardship Work Plan

The Lewis County Voluntary Stewardship Work Plan (Lewis County VSP Work Group, 2018) provides a practical example of how VSP is implemented at the county level within WRIA 23, as Lewis County encompasses most of the watershed. It is organized around measurable goals, action strategies, and benchmarks consistent with VSP's statutory requirements. Five goals focus on protecting and enhancing wetlands, critical aquifer recharge areas, fish and wildlife habitat conservation areas, frequently flooded areas, and geologically hazardous areas. An additional seven complementary goals address the sustainability and economic viability of agriculture. Progress is evaluated against the July 22, 2011 watershed-scale baseline, with the primary objective of maintaining existing critical area functions while promoting voluntary enhancement through incentive-based stewardship practices.

For each critical area, the Work Plan establishes management objectives, identifies representative stewardship practices - many aligned with United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) conservation standards - and sets quantifiable benchmarks. Protection benchmarks are designed to ensure no net loss of critical area functions at the watershed scale, using indicators such as changes in vegetative cover, impervious surface area, and water quality parameters. Enhancement benchmarks call for measurable improvements beyond baseline conditions. Progress is tracked through biennial High Resolution Change Detection, review of stewardship implementation activities, and analysis of available water quality and regulatory data. Together, this framework links voluntary, on-the-ground actions to measurable environmental outcomes.

Implementation is overseen by the Lewis County VSP Work Group, supported by the Lewis Conservation District as the technical service provider and Lewis County as fiscal agent. The Work Group establishes priorities, guides outreach and participation, reviews monitoring results, and applies adaptive management when necessary to ensure continued progress toward benchmarks. Particular attention is given to engaging both commercial and small-scale agricultural operators through Individual Stewardship Plans and targeted technical assistance. Through coordinated planning, monitoring, and biennial reporting, the Lewis County Work Plan demonstrates how VSP serves as a watershed-scale alternative to regulation, aligning environmental protection with agricultural viability.

9.4.3 Summary of Specific NPS Pollution Control Practices

Overall, a wide range of management practices, initiatives, and programs has been implemented in the area to control NPS pollutions. Table 8.1 previously presented a list of potential BMPs and was developed primarily based on BMPs that have been previously implemented or recommended in the study area. As noted, TMDLs define the pollutant limits that waterbodies can accommodate from both point and nonpoint sources. Table 9.1 provides a more detailed summary of major NPS pollution control programs and/or projects that have been implemented or are ongoing as part of the TMDL implementation plans (Ecology, 2001, 2011), as well as other NPS improvement practices and initiatives.

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Table 9.1 Implemented/Ongoing NPS control activities.

Pollution Source	Responsible Agency	Activities	Funding
Animal & Livestock Waste	NRCS	Implementation of Comprehensive Nutrient Management Plans and livestock conservation measures, including manure storage and transfer systems, animal mortality facilities, roof runoff controls, livestock exclusion fencing, nutrient management on cropland, prescribed grazing, and off-stream watering infrastructure	Environmental Quality Incentives Program (EQIP), Farm Bill Programs
Agrichemicals	NRCS	Development and implementation of cropland conservation plans addressing pesticide and nutrient transport through drainage water management and integrated pest management practices	EQIP, Farm Bill Programs
Soil Erosion	NRCS	Forestry conservation planning to reduce sediment delivery, including forest road improvements, seeding and mulching, critical area planting, and streambank and shoreline stabilization	EQIP, Farm Bill Programs
Forestry Practices	NRCS	Forestry and wetland conservation planning addressing forest health, riparian habitat protection, forest stand improvement, harvest management, slash treatment, habitat restoration, and stream habitat enhancement	EQIP, Wetlands Reserve Program (WRP), Farm Bill Programs
Wetland Enhancement & Restoration	NRCS	Agricultural wetland restoration and enhancement including fencing, wetland restoration, wildlife habitat management, early successional habitat development, and restoration of rare or declining habitats	WRP, Wildlife Habitat Incentives Program (WHIP), Farm Bill Programs
Animal & Livestock Waste	Conservation Districts and NRCS	Farm planning, riparian fencing and planting, livestock exclusion measures, and landowner outreach including manure management workshops and demonstrations	Centennial Clean Water Fund (CCWF), Conservation Reserve Enhancement Program (CREP),

Pollution Source	Responsible Agency	Activities	Funding
			State Conservation Funds
Animal & Livestock Waste	WSDA	Routine dairy inspections, compliance assistance, and enforcement under the Dairy Nutrient Management Act, including corrective actions where required	WSDA Operating Funds
Mixed Nonpoint Sources	Volunteer and Non-Profit Organizations	Water quality monitoring, riparian restoration, landowner education, conservation easements, reforestation, litter control, floodplain restoration, and invasive species management	CCWF, Section 319 Grants, Private Foundations
Mixed Nonpoint Sources	Support Industries	Evaluation of emerging technologies to reduce manure transport and delivery to surface waters	CCWF
Agricultural & Mixed NPS	Ecology	Technical assistance and enforcement for agricultural nonpoint sources, ambient water quality monitoring, and long-term BMP effectiveness evaluation	Ecology, EPA, United States Fish and Wildlife Service (USFWS)
Agricultural & Mixed NPS	Counties Conservation Districts	Voluntary, locally led program that protects critical areas on agricultural lands through incentive-based stewardship rather than regulation, while maintaining long-term farm viability. Counties develop watershed work plans with measurable goals, monitoring, and adaptive management to achieve environmental outcomes	State Operating Funds and State Capital Cost-Share Funds (administered by SCC)
Septic Systems	Grays Harbor County Health Department	County-wide on-site sewage system operation and maintenance, septic surveys, system evaluations, repairs, and investigation of septage handling near waterways	CCWF State Loan Program, County Funds
Septic Systems	Lewis County Health Department	Identification and follow-up of high-risk septic systems, monitoring, public education, and coordination with conservation programs	County Budget, CCWF, Section 319 Grants

Pollution Source	Responsible Agency	Activities	Funding
Septic Systems	Thurston County Health Department	Permitting and regulation of on-site systems, mandatory inspections, complaint response, operator assistance, workshops, and loan and grant programs for repairs	Department of Health (DOH) Grants, State Revolving Fund (SRF) Loans, Ecology Grants
Septic Systems	Chehalis Tribe and Washington Department of Health	Survey and assessment of on-site septic systems on the reservation	Tribal Funds, DOH Assistance
Stormwater	Cities of Chehalis and Centralia	Adoption of stormwater manuals, BMP implementation, infrastructure maintenance, and pilot stormwater projects	SRF Loans, CCWF, Stormwater Grants
Stormwater	City of Cosmopolis	Stormwater monitoring, sewer conversions from septic systems, catch-basin filtration installation, and retention/treatment requirements for new development	CCWF
Stormwater	City of Westport	Coordination with county health agencies to reconstruct failing septic systems contributing to stormwater impacts	CCWF
Tribal & Education Programs	Chehalis Tribe and Grays Harbor College	Water quality monitoring, restoration and stewardship projects, GIS development, community outreach, riparian land acquisition, and enforcement of riparian buffers	Tribal Budget, State Water Quality Grants
Riparian Degradation / Temperature	USDA FSA, Conservation Districts	Implementation of CREP, including retirement of riparian agricultural lands and planting of native riparian vegetation to meet temperature shade targets	CREP
Riparian Degradation / Temperature	Chehalis River Council	Voluntary riparian planting and outreach through the Shade the Chehalis program, providing guidance and materials to streamside landowners to improve riparian shade	State and Local Grants

Pollution Source	Responsible Agency	Activities	Funding
Forestry Practices / Temperature	Washington DNR	Implementation of Forest Practices rules and watershed analysis requirements, including riparian management prescriptions to improve shade, channel stability, and sediment control	Forest Practices Program
Agriculture / Temperature	Local Conservation Districts	Development and implementation of farm conservation plans incorporating riparian fencing, native vegetation planting, and maintenance activities to improve riparian function and reduce thermal loading	State Conservation Funds, Federal Cost-Share Programs
Mixed Nonpoint Sources / Temperature	Confederated Tribes of the Chehalis Reservation	Riparian protection and restoration projects including fencing installation, riparian planting, and wetland restoration to support temperature and habitat objectives	Tribal Funds, State and Federal Grants
Mixed Nonpoint Sources / Temperature	Chehalis Basin Fisheries Restoration Program	Funding and implementation of riparian restoration, fencing, habitat improvement projects, and long-term monitoring to evaluate temperature-related restoration effectiveness	Federal Interagency Funding
Monitoring and Evaluation	Ecology	Ambient stream temperature monitoring, riparian shade tracking, and evaluation of BMP implementation effectiveness to support Temperature TMDL compliance	Ecology Program Funds, EPA Support

10 CONCLUSIONS

This NPS Assessment of the Upper Chehalis (WRIA 23) integrates findings from prior TMDL studies, watershed planning documents, and an evaluation of current EIM and tribal monitoring data from FIN and WQP to characterize water quality conditions and NPS stressors across the basin. The assessment provides a basin-wide and subbasin-scale understanding of impairments, identifies priority NPS pollution categories, and informs the selection and prioritization of BMPs consistent with historical and ongoing implementation efforts.

10.1 Water Quality Condition

Results from both historical studies and current datasets demonstrate that NPS pollution remains the dominant contributor to water quality impairments throughout the Upper Chehalis basin. Impairments are spatially structured and associated with land-use, hydrologic setting, and channel morphology. Forested headwater subbasins generally exhibit better water quality conditions, while agricultural, rural residential, and urban-influenced subbasins - particularly in mid-basin reaches - experience more frequent and severe exceedances.

Temperature and DO are the most pervasive and interrelated impairments identified in this assessment. Elevated summer temperatures and depressed DO concentrations frequently co-occur in low-gradient mainstem reaches and agriculturally influenced tributaries, including portions of the mid-basin reach near Centralia (RM 65.8–75.2), South Fork Chehalis, Black River, and Newaukum River. These conditions are consistent with historical temperature and DO TMDLs and reflect cumulative effects of reduced riparian shading, widened channels, low summer baseflows, and organic and nutrient loading.

Bacterial indicators, particularly FC, show widespread exceedances in mid-basin (RM 75.4-47.0) and downstream reaches of the Chehalis mainstem and major tributaries. These patterns align closely with findings from the Upper Basin Bacteria TMDL and subsequent implementation reports, and are associated with agricultural activities, livestock access to streams, failing or poorly maintained on-site sewage systems, and storm-driven runoff from rural and urban areas. Although *E. coli* records are more limited, their spatial distribution is generally consistent with FC results.

Nutrient-related indicators, including TP and IN species, are elevated in agricultural and mixed-use subbasins such as South Fork Chehalis, Newaukum River, and portions of the Chehalis mainstem near Centralia. While nutrient concentrations do not always exceed available guideline thresholds, their influence may be reflected in associated DO deficits, BOD, and pH variability linked to biologically driven processes.

Sediment-related impairments, reflected in turbidity and TSS, are primarily event-driven and associated with storm periods. Tributaries influenced by forestry operations, unpaved roads, and disturbed riparian areas contribute disproportionately to sediment loading. Episodic high-sediment events degrade habitat quality, increase nutrient transport, and exacerbate other water quality stressors. The regions upstream of Dryad Station have been the most impacted by sediment loads in the Upper Chehalis.

Based on the combined findings of this assessment, the most detrimental NPS pollution categories throughout the Chehalis Basin are, in priority order:

1. Thermal loading and riparian degradation, driving elevated temperatures and DO impairment;
2. Organic and nutrient loading, contributing to low DO and eutrophic conditions;
3. Bacterial contamination, primarily FC, associated with agricultural, rural residential, and stormwater sources;
4. Sediment delivery, particularly during storm events from disturbed upland and riparian areas.

These categories represent the primary focus for future Section 319-supported activities.

10.2 Current Efforts and Future Direction

A wide range of NPS control programs and BMPs have been implemented across the basin through coordinated efforts by federal, state, tribal, county, municipal, and non-profit partners. Key initiatives include implementation of agricultural nutrient management plans, livestock exclusion fencing, riparian restoration through Conservation Reserve Enhancement Program (CREP) and other programs, septic system inspection and repair programs, stormwater management improvements, forestry road and erosion control measures, and monitoring and outreach activities.

Despite these efforts, many impairments identified in earlier TMDLs persist, indicating that continued and expanded implementation of targeted BMPs remains necessary, particularly in mid-basin (RM 75.4-47.0) and low-gradient tributary reaches (e.g. the Black River).

Related subbasin planning efforts also support the development of effective NPS management strategies in the subbasin. For example, NHC recently completed a “Local Strategy Plan” for the Scatter Creek watershed for the Chehalis Basin Partnership (NHC, 2025) under the Chehalis Basin Strategy ASRP. The strategy plan, developed as an implementation action under the 2020 Streamflow Restoration Plan, identifies strategies to restore aquatic habitat, improve streamflow conditions, and protect groundwater resources in a watershed experiencing increasing development pressure. Recommended actions include riparian restoration, invasive species management, flow augmentation, floodplain reconnection, groundwater conservation, and aquifer protection measures that also support the reduction and prevention of NPS pollution (NHC, 2025). Findings from this and similar watershed-level planning efforts provide useful guidance for protecting water quality and sustaining streamflows in priority areas of the Chehalis Basin.

Future NPS management efforts in the Chehalis Basin should prioritize subbasin-specific strategies that address the dominant stressors identified in this assessment. Emphasis should be placed on riparian protection and restoration, nutrient and manure management, bacterial source control, sediment reduction, and flow conservation during critical low-flow periods. Continued monitoring is essential to refine prioritization, evaluate BMP effectiveness, and track long-term trends.

The assessment framework and results presented in this report provide a defensible basis for identifying priority subbasins considering water quality impairments and associated land-use and selecting BMPs that are consistent with existing plans and regulatory requirements. The analysis emphasized areas where water quality degradation is linked to NPS drivers such as intensive agricultural activity, reduced riparian shading, livestock access, and runoff from urbanized areas.

NHC recommends that the 319 management plan prioritize the following subbasins from previous Figure 5.3:

- Upper Chehalis River (Subbasins #4a and 4b)
- Middle Chehalis River #1 and #2 (Subbasins #10 and #13)
- Newaukum River mainstem and forks (Subbasins 5, 6, and 7)
- Salzer Creek (Subbasin 8)
- Skookumchuck River (Subbasin 9)
- Black River (Subbasin 11)

Building on these findings, candidate BMPs were identified based on several factors including parameters of concern, severity of violation of water quality standards, documented effectiveness in prior studies, application in similar basins and/or with similar dominant land-uses. Principal categories of BMPs considered include:

- Riparian and stream restoration and livestock exclusion fencing, to reduce thermal loading, sediment input, direct bacterial contamination and BOD loading;
- Nutrient, waste, and manure management practices
- Septic system maintenance and upgrade programs, particularly in rural residential zones;
- Regulatory, inspection, and enforcement activities on urban and agricultural lands,
- Public education and technical assistance;
- Forest harvest and upland wildlife management;
- Erosion and sediment control measures on forest roads and agricultural lands; and
- Stormwater management plans and retrofits to treat urban and agricultural runoff.

Emerging and innovative approaches, such as those outlined in Section 8, when evaluated and implemented in coordination with local stakeholders, may further enhance the effectiveness of established BMPs in areas with persistent impairments.

As noted, the findings of this NPS Assessment provide the technical foundation for development of a subsequent NPS Management Program Plan to address the identified water quality concerns throughout the Upper Chehalis. Building on the results of this assessment, the management program plan will define the appropriate management practices and the geographic areas where management practices will be implemented. The plan will specify the BMPs to be applied to address priority impairments at subbasin levels. The management plan will outline the proposed implementation approach, including a four-year schedule with measurable annual milestones, identification of relevant programs and funding sources, identification of local and private experts to assist plan implementation, Tribal authority and responsibilities, and coordination with ongoing federal, state, tribal, and local watershed management efforts.

11 REFERENCES/SOURCES OF INFORMATION

Andrew S. Gendaszek. (2011). *Hydrogeologic Framework and Groundwater/Surface-Water Interactions of the Chehalis River Basin, Southwestern Washington* (Scientific Investigations Nos. 2011–5160). U.S. Army Corps of Engineers, Washington State Department of Ecology, and the Chehalis Basin Partnership.

Ahmed and Rountry. (2004). *Upper Chehalis River Fecal Coliform Bacteria Total Maximum Daily Load* (Nos. 04-10–041). Washington State Department of Ecology.

ASRP Steering Committee. (2019). *Chehalis Basin Strategy: Aquatic Species Restoration Plan—Phase I* (Nos. 19-06–009).

Butkus, S. R. (1999). *Upper Chehalis River Basin Temperature: Total maximum daily load* (No. OL5788286W).

Chehalis Basin Partnership. (2000). *Chehalis Basin Level 1 Assessment*.

Chehalis Basin Partnership. (2004). *Chehalis Basin Watershed Management Plan*.

Chehalis Basin Partnership. (2009). *Detailed Implementation Plan—Volume 1*.

Coots, R. (1994). *Black River Wet Season Nonpoint Source Total Maximum Daily Load Study* (Nos. 94–104). Washington State Department of Ecology.

Ecology. (2001). *Upper Chehalis River Basin Temperature Total Maximum Daily Load* (Nos. 99–52). Washington State Department of Ecology.

Ecology. (2002). *A Water Quality Index for Ecology's Stream Monitoring Program* (Nos. 02-03–052). http://www.ecy.wa.gov/biblio/0203052.html

Ecology. (2003). *Supplement to the Chehalis Basin Level 1 Assessment: Documentation of Existing Water Quality Conditions, Monitoring Activities and TMDLs* (No. 2140067).

Ecology. (2011). *Reporting Watershed Improvement—Reducing fecal coliform bacteria levels in the Chehalis River watershed, Washington* (SP-12 Option 2a).

Ecology. (2025a). Freshwater Quality Index. *Freshwater Information Network*. https://apps.ecology.wa.gov/continuousflowandwq/

Ecology. (2025b). *Water Quality Standards for Surface Waters of the State of Washington Chapter 173-201A WAC* (06-10–91). https://apps.ecology.wa.gov/publications/SummaryPages/0610091.html

Embry, S. S., & Inkpen, E. L. (1998). *Water-quality assessment of the Puget Sound Basin, Washington, Nutrient Transport in Rivers, 1980-1993* (Nos. 97–4270). U.S. GEOLOGICAL SURVEY.

Janel Spaulding & Lee Napier. (2011). *Chehalis Basin Partnership: A Look at the Implementation Progress of the Chehalis Basin Watershed Management Plan and Detailed Implementation Plan*.

John R. Gray, G. Douglas Glysson, Lisa M. Turcios, & Gregory E. Schwarz. (2000). *Comparability of Suspended-Sediment Concentration and Total Suspended Solids Data* (Water-Resources Investigations Nos. 00–4191). USGS. https://water.usgs.gov/osw/pubs/WRIR00-4191.pdf

Jennings and Pickett. (2000). *Revised Upper Chehalis River Basin Dissolved Oxygen Total Maximum Daily Load* (Nos. 00-10–018). Washington State Department of Ecology.

Lewis County VSP Work Group. (2018). *Lewis County Voluntary Stewardship Work Plan* [Work Plan].

Lippke et al. (2002). *An Assessment of Forest Policy Changes in Western Washington.* Journal of Sustainable Forestry Vol 14(2).

Mueller, D. K., & Helsel, D. R. (1996). Nutrients in the Nation's waters Too much of a good thing? *U.S. Geological Survey, Circular*. https://doi.org/10.3133/cir1136

NHC. (2020). *Addendum to the Chehalis Watershed Management Plan*.

NHC. (2025). *Scatter Creek Local Strategy Plan—A Subbasin Implementation Plan for the Chehalis Basin Aquatic Species Restoration Program* (No. 2009024). The Chehalis Basin Partnership.

Pickett, P. J. (1994). *Upper Chehalis River Dry Season Total Maximum Daily Load Study* [94-126]. Washington Department of Ecology.

UW NRSIG. (2019). 2019 Forest Land Database Summarizer. University of Washington. School of Environmental and Forest Sciences. Natural Resource Spatial Informatics Group. https://nrsig.org/projects/small-forest-landowner-regulatory-impacts.

Downloaded June 2026.

USDA (2024). *Production, prices, employment, and trade in Northwest forest industries: 1958-2023.* U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Online only. "https://research.fs.usda.gov/pnw/products/dataandtools/production-prices-employment-and-trade-northwest-forest-industries-1958"

USDA (2025). *Washington's Forest Products Industry and Timber Harvest, 2020*. USDA Pacific Northwest Research Station. General Technical Report PNW-GTR-1032. April 2025

USGS. (2025). *U.S. Geological Survey, 2025, Annual National Land-cover Database (NLCD) Collection 1.0 Reference Data Product: U.S. Geological Survey data release* [Dataset]. https://doi.org/10.5066/P13EDMAF

UW (2021). *Washington's Small Forest Landowners in 2020. Status, trends and recommendations after 20 years of Forests & Fish*. University of Washington College of the Environment. January 11, 2021.

WA Conservation Commission. (2025). *Voluntary Stewardship Program (VSP)* [Program Funding Guidelines].

Wampler, P. L., Knudsen, E. E., Hudson, M., & Young, T. A. (1993). *Chehalis River Basin Fishery Resources: Salmon and Steelhead Stream Habitat Degradations*. U.S. Fish and Wildlife Service.

APPENDIX A

FIN Stations Summary Tables and Boxplots

Table A1 List of the Chehalis Basin stations in the FIN database.

Upper Chehalis					
Station ID	Station Name	Short Name	Associated River	Latitude	Longitude
23A070	Chehalis River at Porter	Porter	Chehalis River	46.93918	-123.31399
23A100	Chehalis River at Prather Rd	Prather	Chehalis River	46.77537	-123.03519
23A110	Chehalis River at Galvin	Galvin	Chehalis River	46.73611	-123.01888
23A120	Chehalis River at Centralia	Centralia	Chehalis River	46.71179	-122.97851
23A130	Chehalis River at Claquato	Claquato	Chehalis River	46.64205	-123.01583
23A140	Chehalis River at Adna	Adna	Chehalis River	46.62777	-123.05972
23A160	Chehalis River at Dryad	Dryad	Chehalis River	46.6311	-123.25099
23A170	Chehalis River Near Doty	Doty	Chehalis River	46.634628	-123.28412
23A190	Chehalis River above Pe Ell	Pe Ell	Chehalis River	46.5464	-123.3012
23B050	Newaukum at Mouth	Newaukum-Mouth	Newaukum River	46.65055	-122.97972
23B070	Newaukum River near Chehalis	Newaukum-Chehalis	Newaukum River	46.61980	-122.94493
23B090	South Fork Newaukum River and Forest	SF Newaukum River	South Fork Newaukum River	46.60333	-122.85361
23C070	North Fork Newaukum River at Forest	NF Newaukum River	North Fork Newaukum River	46.608405	-122.85176
23D055	Skookumchuck River near Centralia	Skookumchuck	Skookumchuck River	46.73055	-122.95361
23E060	Black River at Hwy 13	Black River-HW13	Black River	46.83034	-123.186102
23E070	Black River at Moon Road Bridge	Black River-Moon Rd	Black River	46.83919	-123.13805
23F070	Mill Creek Near Bordeaux	Mill Creek	Mima Creek	46.89627	-123.09561
23G070	South Fork Chehalis River at Curtis	Curtis	South Fork Chehalis River	46.57433	-123.12039
23K060	South Fork Chehalis at Hwy 6	SF Chehalis-HW6	South Fork Chehalis River	46.60322	-123.1233
Lower Chehalis					
Station ID	Station Name		Associated River	Latitude	Longitude
22A070	Humptulips River near Humptulips	Humptulips	Humptulips River	47.22981	-123.96184

22B070	Wf Hoquiam River near Hoquiam	Hoquiam	Hoquiam River	47.05666	-123.92638
22C050	Chehalis River near Montesano	Montesano	Chehalis River	46.9625	-123.60333
22F090	Wynoochee River near Montesano	Wynoochee	Wynoochee River	47.07888	-123.69916
22G070	Satsop River near Satsop	Satsop	Satsop River	47.00194	-123.49361
22T070	Mox-Chehalis Creek at US 12HWY 13	Mox-Chehalis	Chehalis River	46.95639	-123.32711

Table A2 Summary of DO (mg/L) exceedances across different FIN stations in the Upper Chehalis.

Station	Start Date	End Date	No. of Days	Days Below Threshold	Percent Below Threshold	Lowest Daily Min. (mg/L)
Porter	1960-10-06	2025-01-28	749	271	36.2	7.1
Prather	1994-10-26	2005-09-19	83	25	30.1	7.2
Galvin	1971-10-04	1977-09-29	72	33	45.8	4.9
Centralia	1977-10-04	2025-01-28	277	120	43.3	3
Claquato	1996-10-30	1997-09-28	12	5	41.7	7.5
Adna	1971-10-04	1977-09-29	72	22	30.6	7.2
Dryad	1959-07-07	2025-01-28	580	117	20.2	7.6
Doty	2008-10-21	2009-09-22	12	2	16.7	9.6
Pe Ell	2016-10-19	2025-01-28	89	11	12.4	8.86
Newaukum-Mouth	1992-10-26	1993-09-27	12	5	41.7	8.7
Newaukum-Chehalis	1960-07-18	2025-01-29	226	47	20.8	7.3
SF Newaukum River	1974-10-15	1975-09-15	24	1	4.2	9.3
NF Newaukum River	1974-10-15	1975-09-15	24	3	12.5	9.1
Skookumchuck	1992-10-26	1997-08-27	23	8	34.8	9.1
Black River-HW13	2008-08-28	2025-01-28	85	68	80.0	6.5
Black River-Moon Rd	1990-07-30	1997-09-30	62	56	90.3	3.3
Mill Creek	1992-10-26	1993-09-27	12	0	0.0	10
Curtis	1996-10-30	2009-09-22	24	5	20.8	7.9
SF Chehalis-HW6	2016-10-19	2025-01-28	76	24	31.6	6.64

Table A3 Summary of 7-DADMax (˚C) exceedances across different FIN stations in the Upper Chehalis.

Station	Start Date	End Date	No of 7-DADMax Samples – Core Summer	Percent Exceeding Threshold - Core Summer (%)	No of 7-DADMax Samples – Spawning Period	Percent Exceeding Threshold – Spawning Period (%)	No of 7-DADMax Samples – Incubation Period	Percent Exceeding Threshold – Incubation Period (%)
Porter	1960-10-06	2025-01-28	193	35.2	67	0.0	480	7.7
Prather	1994-10-26	2005-09-19	18	50.0	8	0.0	46	6.5
Galvin	1971-10-04	1977-09-29	16	100.0	5	0.0	43	7.0
Centralia	1977-10-04	2025-01-28	69	39.1	24	0.0	N/A	N/A
Claquato	1996-10-30	1997-09-28	1	0.0	1	0.0	4	0
Adna	1971-10-04	1977-09-29	16	93.8	5	0.0	43	4.7
Dryad	1959-07-07	2025-01-28	145	2.1	52	0.0	489	11.9
Doty	2008-10-21	2009-09-22	1	0.0	1	0.0	6	33.3
Pe Ell	2016-02-08	2025-01-28	25	0.0	9	0.0	77	0.0
Newaukum-Mouth	1992-10-26	1993-09-27	1	0.0	1	0.0	N/A	N/A
Newaukum-Chehalis	1960-07-18	2025-01-29	57	36.8	18	0.0	210	21.9
SF Newaukum River	1974-10-15	1975-09-15	4	100.0	2	0.0	15	20.0
NF Newaukum River	1974-10-15	2025-01-29	18	27.8	6	0.0	60	10.0
Skookumchuck	1992-10-26	1997-09-30	4	0.0	2	0.0	16	12.5
Black River-HW13	2008-08-28	2025-01-28	21	0.0	9	0.0	N/A	N/A
Black River-Moon Rd	1990-07-30	1997-09-30	13	0.0	5	0.0	25	24.0
Mill Creek	1992-10-26	1993-09-27	1	0.0	1	0.0	N/A	N/A
Curtis	1996-10-30	2009-09-22	4	25.0	2	0.0	16	12.5
SF Chehalis-HW6	2015-08-19	2025-01-28	24	0.0	9	0.0	78	30.8

Table A4 Summary of FC (cfu/100mL) exceedances across different FIN stations in the Upper Chehalis.

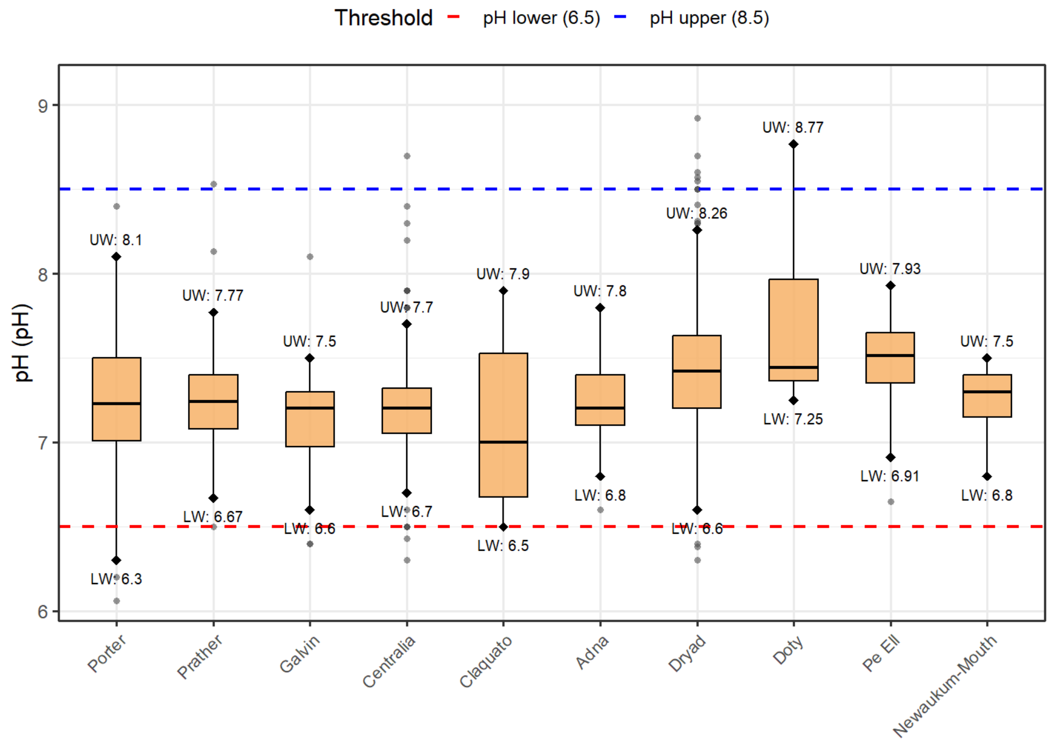
Station	Start Date	End Date	No of Samples (months)	Percent Exceedances Criteria (%)
Porter	1970-12-21	2025-01-28	514	23.5
Prather	1994-10-26	2005-09-19	84	28.6
Galvin	1974-10-15	1977-09-29	24	33.3
Centralia	1977-10-04	2017-09-20	202	47.5
Claquato	1996-10-30	1997-09-28	12	50.0
Adna	1974-10-15	1977-09-29	24	16.7
Dryad	1977-10-04	2025-01-28	547	28.5
Doty	2008-10-21	2009-09-22	12	16.7
Pe Ell	2018-10-24	2023-09-20	46	4.3
Newaukum-Mouth	1992-10-26	1993-09-27	12	66.7
Newaukum-Chehalis	1974-10-15	2018-09-11	71	39.5
SF Newaukum River	1974-10-15	1975-09-15	12	50.0
NF Newaukum River	1974-10-15	1975-09-15	12	58.3
Skookumchuck	1992-10-26	1997-08-27	23	34.8
Black River-HW13	2021-08-18	2021-08-18	1	0.0
Black River-Moon Rd	1990-07-30	1997-09-30	61	34.4
Mill Creek	1992-10-26	1993-09-27	12	25.0
Curtis	1996-10-30	2009-09-22	24	54.2
SF Chehalis-HW6	2019-10-21	2023-09-20	37	51.4

Table A5 Summary of E. coli (cfu/100mL) exceedances across different FIN stations in the Upper Chehalis.

Station	Start Date	End Date	No of Samples (months)	Percent Exceedances Criteria (%)
Porter	2018-10-24	2025-01-28	61	4.9
Dryad	2018-10-24	2025-01-28	61	6.6
Pe Ell	2018-10-24	2023-09-20	42	0.0
Black River-HW13	2021-08-18	2021-08-18	1	0.0
SF Chehalis-HW6	2019-10-21	2023-09-20	35	14.29

Table A6 Summary of pH exceedances across different FIN stations in the Upper Chehalis.

Station	Start Date	End Date	Total No of Samples	No of Samples Out of Range	Percent of Samples Out of Range (%)
Porter	1959-07-10	2025-01-28	836	5	0.6
Prather	1994-10-26	2005-09-19	84	1	1.2
Galvin	1971-10-04	1977-09-29	72	2	2.8
Centralia	1977-10-04	2025-01-28	290	3	1.0
Claquato	1996-10-30	1997-09-28	12	0	0.0
Adna	1971-10-04	1977-09-29	72	0	0.0
Dryad	1959-07-07	2025-01-28	597	9	1.5
Doty	2008-10-21	2009-09-22	12	1	8.3
Pe Ell	2016-02-08	2025-01-28	104	0	0.0
Newaukum-Mouth	1992-10-26	1993-09-27	12	0	0.0
Newaukum-Chehalis	1960-07-18	2025-01-29	242	2	0.8
SF Newaukum River	1974-10-15	1975-09-15	24	1	4.2
NF Newaukum River	1974-10-15	1975-09-15	24	0	0.0
Skookumchuck	1992-10-26	1997-09-30	24	0	0.0
Black River-HW13	2016-01-27	2025-01-28	96	4	4.2
Black River-Moon Rd	1990-07-30	1997-09-30	63	0	0.0
Mill Creek	1992-10-26	1993-09-27	12	0	0.0
Curtis	1996-10-30	2009-09-22	24	0	0.0
SF Chehalis-HW6	2015-08-19	2025-01-28	108	0	0.0



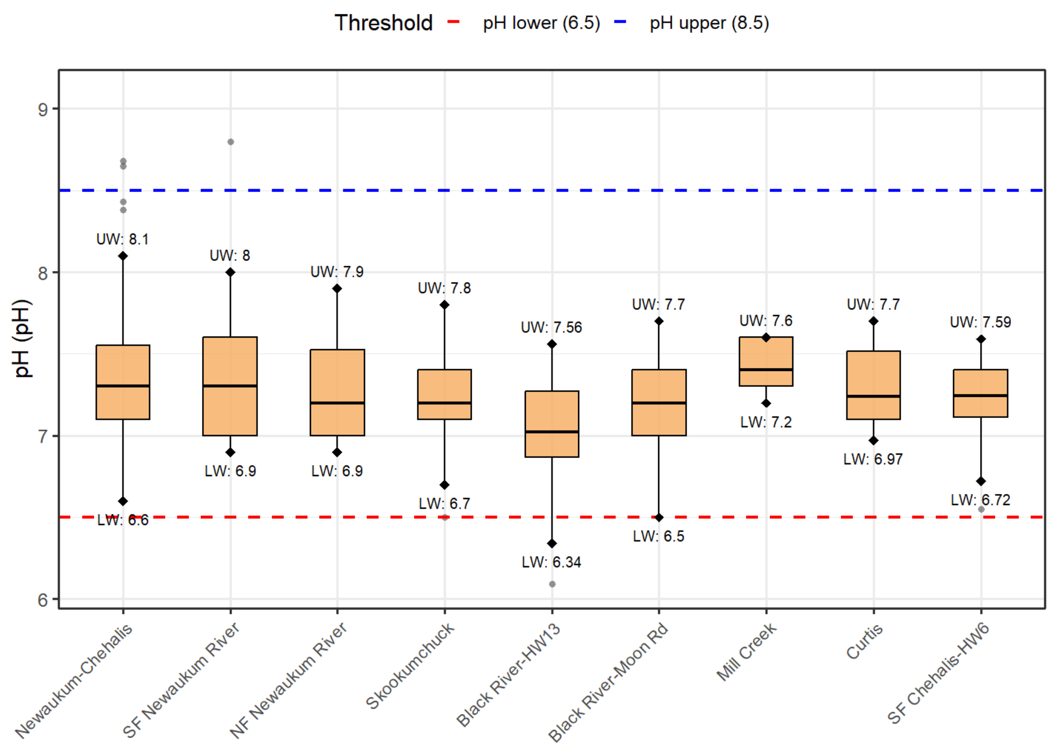


Figure A1 Boxplots showing the distribution of pH across Upper Chehalis sampling stations in the FIN dataset.

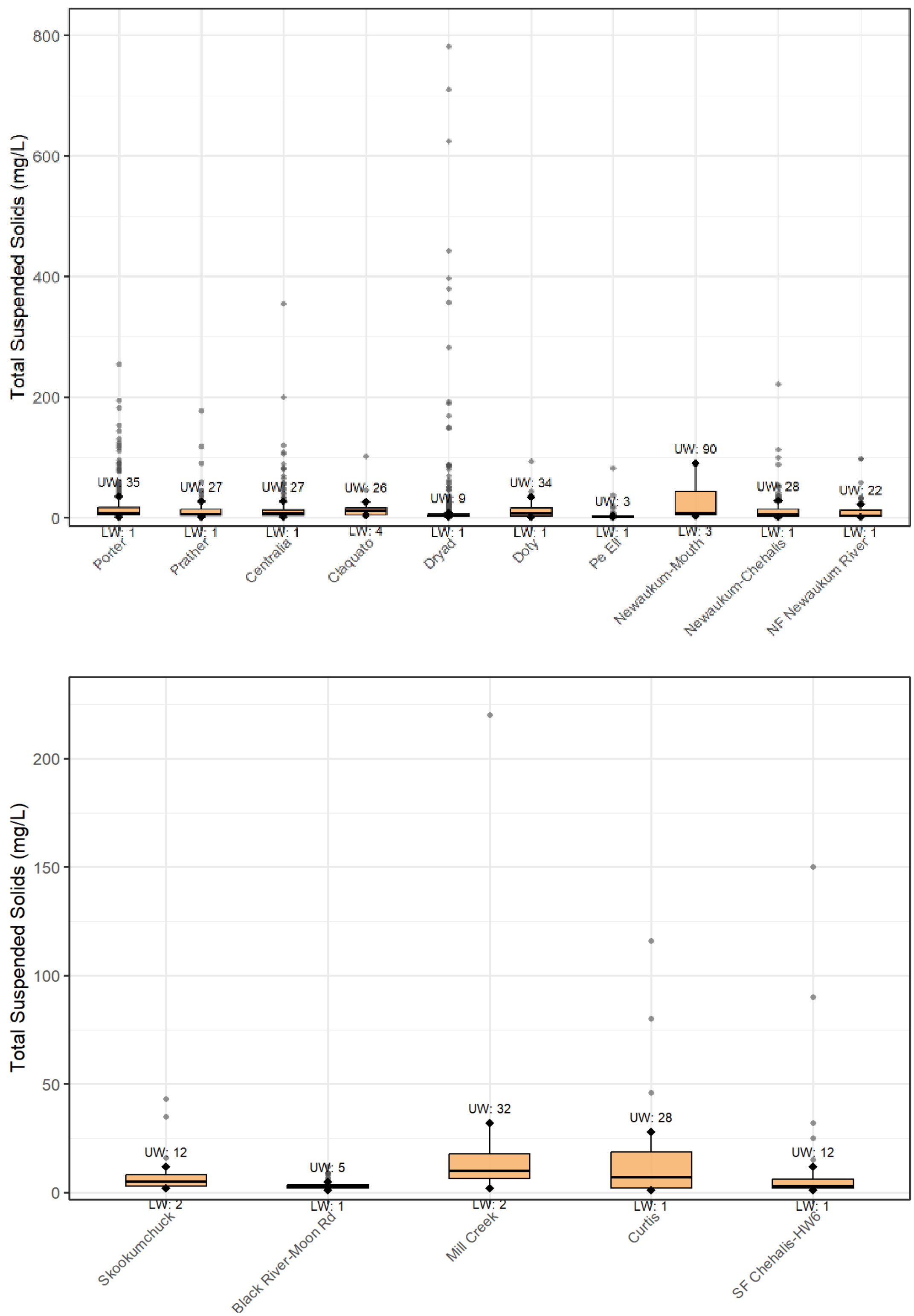


Figure A2 Boxplots showing the distribution of TSS (mg/L) across Upper Chehalis sampling stations in the FIN dataset.

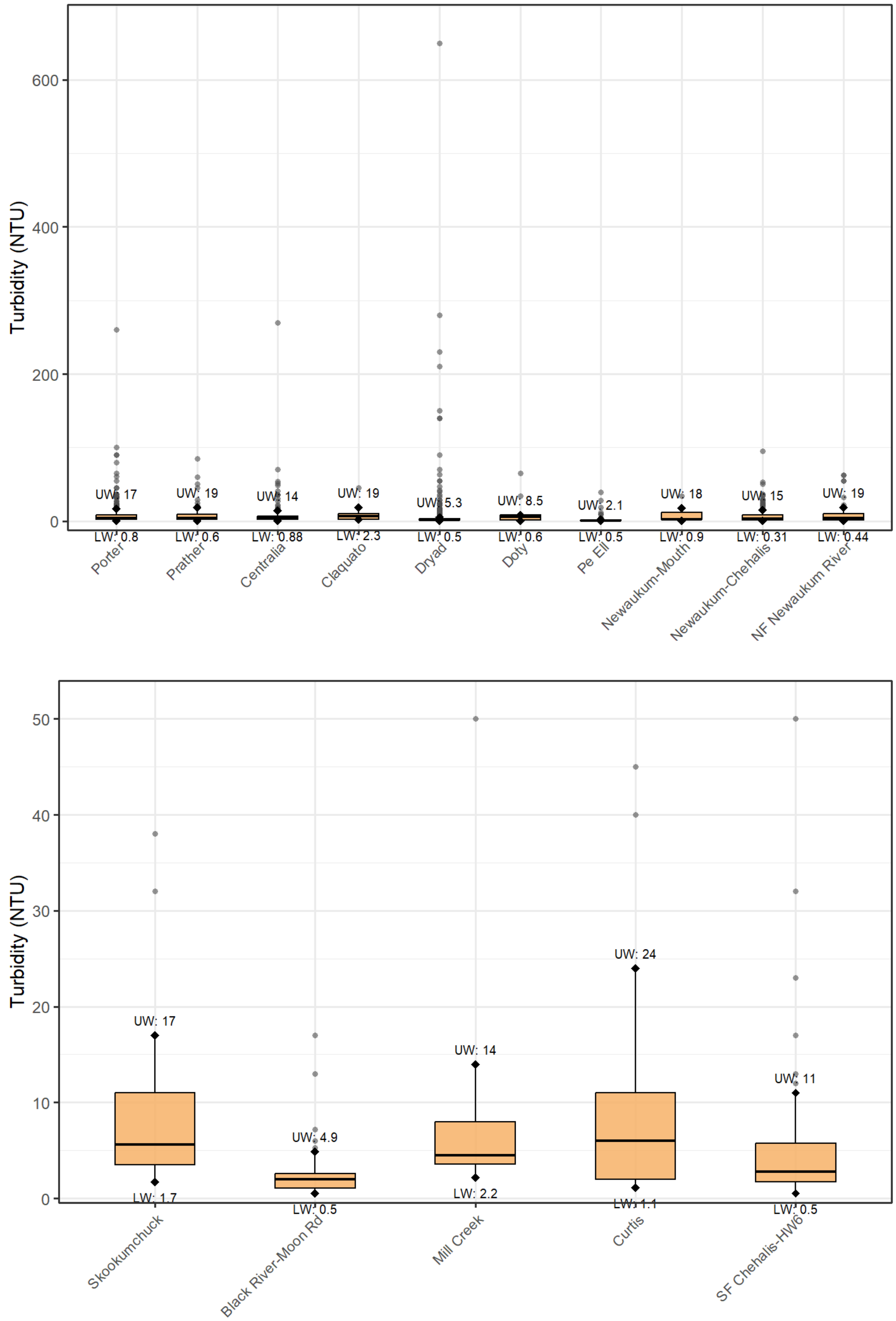


Figure A3 Boxplots showing the distribution of Turbidity (NTU) across Upper Chehalis sampling stations in the FIN dataset.

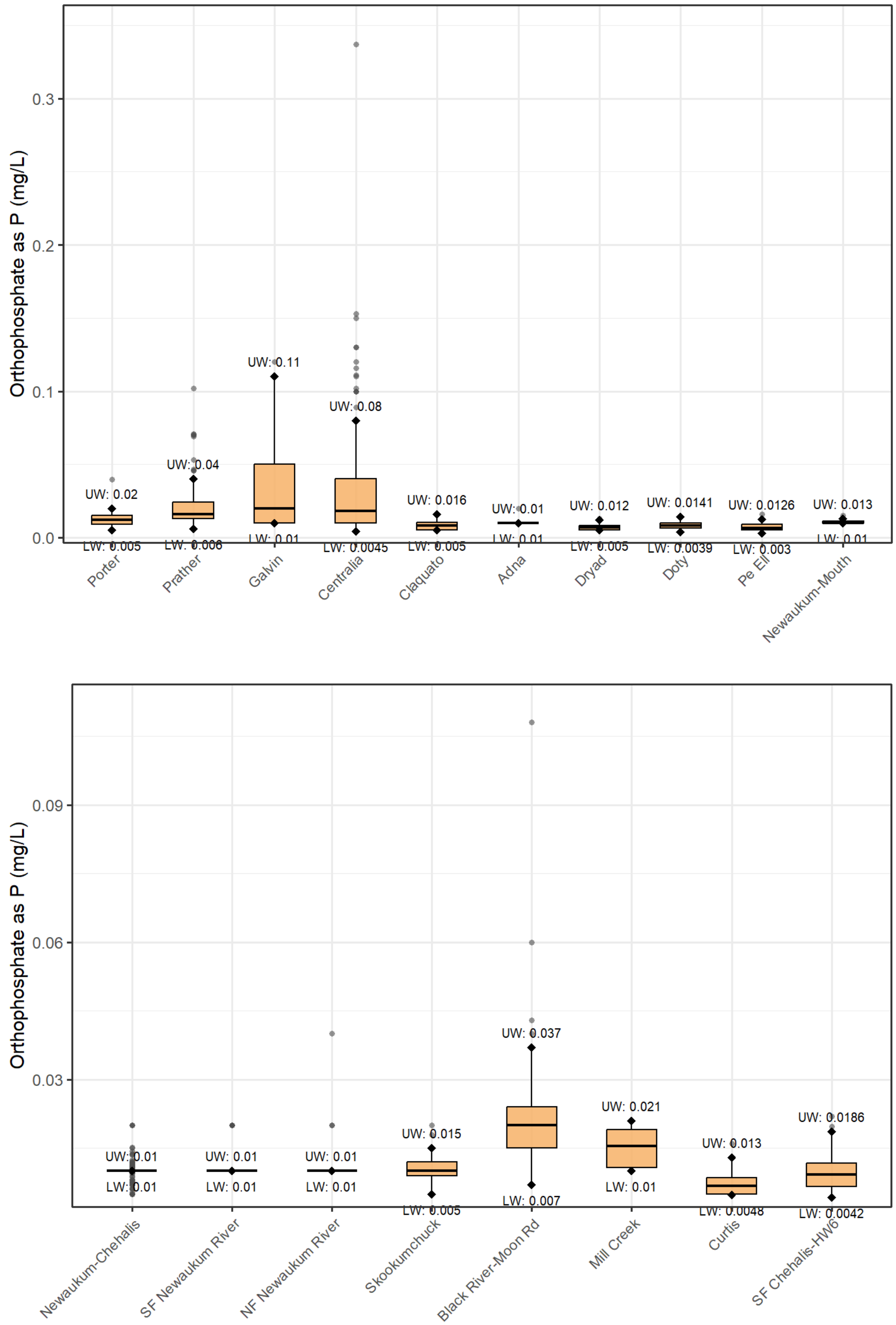


Figure A4 Boxplots showing the distribution of Orthophosphate as P (mg/L) across the FIN stations in Upper Chehalis.

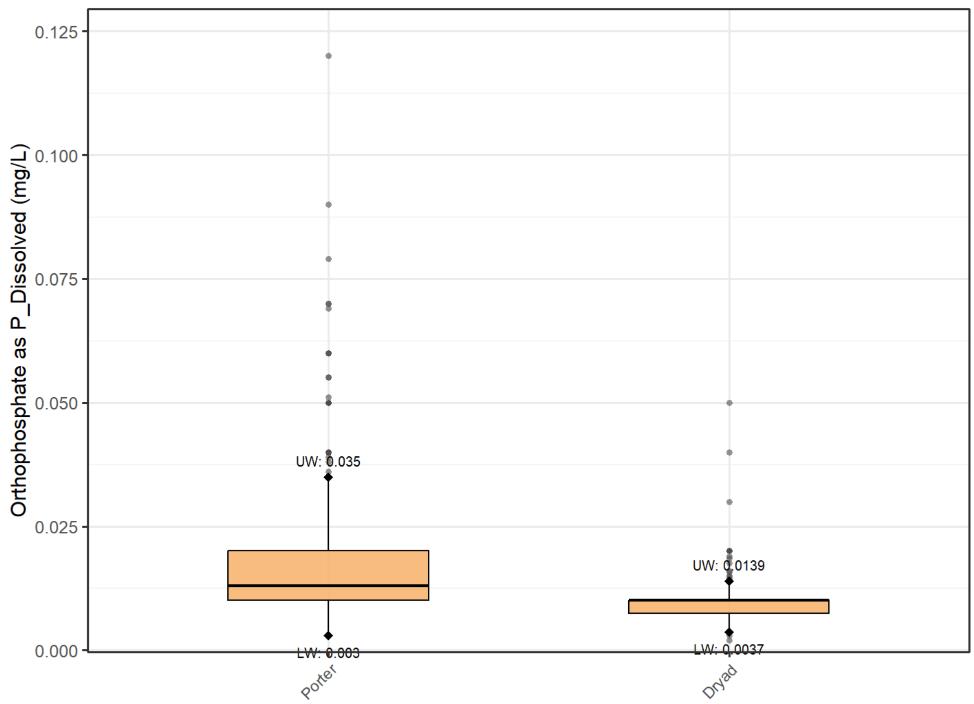


Figure A5 Boxplots showing the distribution of Orthophosphate as P-Dissolved (mg/L) across the FIN stations in Upper Chehalis.

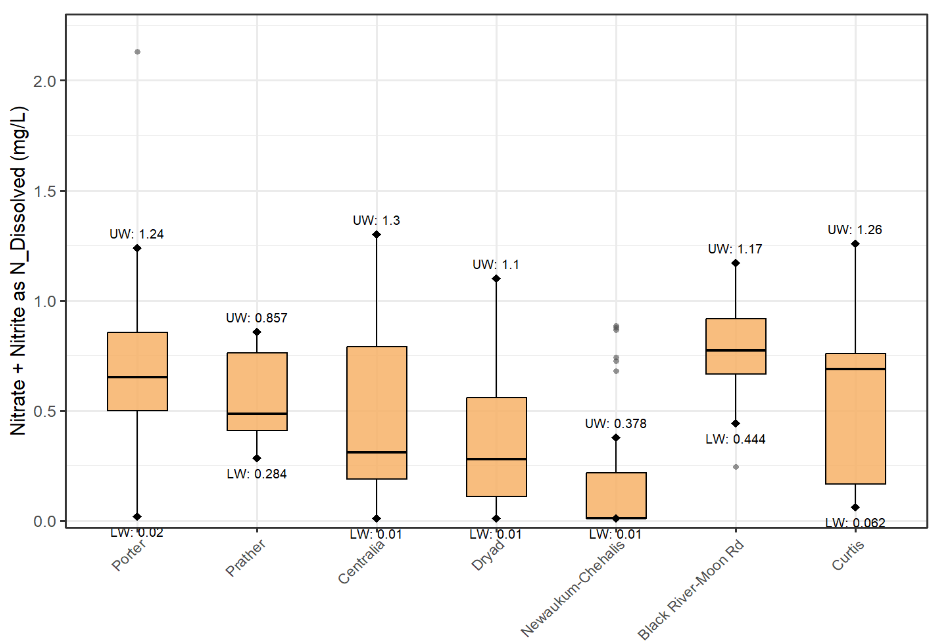


Figure A6 Boxplots showing the distribution of Nitrate-Nitrite as N-Dissolved (mg/L) across Upper Chehalis sampling stations in the FIN dataset.

APPENDIX B

WQP Stations Summary Tables and Boxplots

Table B1 List of the Chehalis Basin stations in the WQP database.

Station ID	Station Name	Short Name	Associated River	Latitude	Longitude
22000400101	Boat Launch @ Burrows Road	Burrows Rd-BL	Humptulips River	47.049315	-124.044559
22000400601	Boat Launch @ Newsom Road	Newsom Rd-BL	Humptulips River	47.090211	-124.061963
22000402301	Boat Launch @ Humptulips Hatchery	Humptulips Hatchery-BL	Humptulips River	47.231587	-123.974272
22000403601	Forest Road 22-West Fork Humptulips	WF Humptulips-FR22	West Fork Humptulips River	47.297466	-123.837483
22008001501	Forest Road 22-East Fork Humptulips	EF Humptulips-FR22	East Fork Humptulips River	47.330452	-123.726336
22013700001	East Hoquiam Road Bridge	E Hoquiam Rd	Hoquiam River	46.97938	-123.884373
22013700901	Dekay Road Bridge	Dekay Rd	West Fork Hoquiam River	47.057119	-123.927769
22013801701	Youmans Road Bridge	Youmans Rd	East Fork Hoquiam River	47.153447	-123.840415
22019001301	HWT 107 Bridge	HWY107	Chehalis River	46.962186	-123.603669
22019002001	Keys Road Bridge	Keys Rd	Chehalis River	46.978402	-123.478776
22019002301	Wakefield Road Bridge	Wakefield Rd	Chehalis River	46.981876	-123.412489
22019100001	HWY 12 Bridge @ Wishkah River	Wishkah-HWY12	Wishkah River	46.976089	-123.811623
22019101601	Hoquiam-Wishkah Road Bridge	Hoquiam-Wishkah Rd	Wishkah River	47.109498	-123.789316
22026000101	Devonshire Road Bridge	Devonshire Rd	Wynoochee River	46.970851	-123.625074
22026000501	Geissler Road Bridge	Geissler Rd	Wynoochee River	47.009107	-123.651256
22026001301	Wynoochee - Wishkah Road Bridge	Wynoochee-Wishkah	Wynoochee River	47.079272	-123.700246
22026004701	Forest Road 22 Bridge Near Wynoochee Lake	Wynoochee Lake-FR22	Wynoochee River	47.376374	-123.627525
22036000201	Monte Elma Road Bridge	Monte Elma Rd	Satsop River	47.001185	-123.495219
22036001201	Schafer Park Bridge	Schafer Park	East Fork Satsop River	47.098191	-123.466579
22036400001	Middle Satsop Road Bridge @ West Fork Satsop	WF Satsop-Satsop Rd	West Fork Satsop River	47.043636	-123.524476
22036401701	Cougar Smith Rd - Satsop	Satsop-Cougar Rd	West Fork Satsop River	47.17957	-123.55981

Station ID	Station Name	Short Name	Associated River	Latitude	Longitude
22041400001	Middle Satsop Road Bridge @ Middle Fork Satsop	MF Satsop- Satsop Rd	Middle Fork Satsop River	47.085686	-123.489635
22041401301	Kelly Road Bridge	Kelly Rd	Middle Fork Satsop River	47.224105	-123.513035
22050101001	Cloquallum Road Bridge @ Mi 8	Cloquallum Rd	Cloquallum Creek	47.108432	-123.346895
22050300101	Heise Road	Heise Rd	Wildcat Creek	47.029469	-123.344882
22052100001	Delezenne Creek Road	Delezene Rd	Delezene Creek	46.968906	-123.38056
22127000001	Boat Launch @ Johns River	Johns R-BL	Johns River	46.899963	-123.996304
22132400001	Plum Street Bridge	Plum St	Dempsey Creek	46.879208	-124.018288
23019003301	Porter Creek Road Bridge	Porter Rd	Chehalis River	46.939194	-123.313539
23019004301	Gillie Fishing Spot	Gillie	Chehalis River	46.83694	-123.24963
23019004401	Sickman Ford Road Bridge	Sickman Ford Rd	Chehalis River	46.829822	-123.258713
23019004501	Mouth Of Garrard Creek	Garrard-Mouth	Chehalis River	46.818583	-123.253617
23019004701	Mouth Of Black River	Black R-Mouth	Chehalis River	46.821337	-123.218875
23019004901	Sand Bars	Sand Bars	Chehalis River	46.8083	-123.19722
23019005201	Bull Hole	Bull Hole	Chehalis River	46.805464	-123.150045
23019005202	Independence Tribal Property	Independence Tribal	Chehalis River	46.804807	-123.151229
23019005301	P.M. Smith Independence Rd, Chehalis R.	PM Smith Rd	Chehalis River	46.80624	-123.13942
23019005401	Independence Road Bridge	Independence Rd	Chehalis River	46.806892	-123.118916
23019006001	Prather Rd Bridge	Prather Rd Br	Chehalis River	46.775297	-123.035291
23019006401	Galvin Road Bridge	Galvin Rd Br	Chehalis River	46.735856	-123.020418
23019006601	Boat Launch @ Borst Park	Borst Park-BL	Chehalis River	46.719162	-122.985532
23019006701	Mouth Of Skookumchuck River	Skookumchuck-Mouth	Chehalis River	46.719443	-122.980008
23019006702	Mellen Street Bridge	Mellen St	Chehalis River	46.71179	-122.978748
23019007401	SR6 @ Chehalis	SR6-Chehalis	Chehalis River	46.657701	-122.985446
23019007501	Alexander Park	Alexander Park	Chehalis River	46.651355	-122.981687
23019007701	HWY 603 Bridge	HWY603	Chehalis River	46.641662	-123.017383

Station ID	Station Name	Short Name	Associated River	Latitude	Longitude
23019008101	SR6 @ Adna	SR6-Adna	Chehalis River	46.627406	-123.060677
23019009001	Ceres Hill Road Bridge	Ceres Hill Rd	Chehalis River	46.601766	-123.145252
23019009401	Mays Bridge, Near Rainbow Falls, Chehalis	Mays	Chehalis River	46.63408	-123.18941
23019009701	Rainbow Falls State Park	Rainbow Falls	Chehalis River	46.630721	-123.231767
23019010001	Elk Creek Road Bridge In Doty	Elk Rd Br	Chehalis River	46.634706	-123.282851
23019010301	Pe Ell Tribal Property	Pe Ell Tribal	Chehalis River	46.60261	-123.278531
23019010601	SR6 @ Pe Ell	SR6-Pe Ell	Chehalis River	46.569622	-123.303843
23019010801	Panesko Bridge	Panesko	Chehalis River	46.539728	-123.294616
23019011901	East Fork Chehalis River	EF Chehalis	East Fork Chehalis River	46.45081	-123.29172
23019012601	Upper East Fork	Upper EF Chehalis	East Fork Chehalis River	46.39246	-123.29615
23050100101	HWY 12 Bridge @ Cloquallum Creek	Cloquallum-HWY12	Cloquallum Creek	47.003995	-123.386873
23054300001	HWY 12 Bridge @ Porter Creek	Porter-HWY12	Porter Creek	46.937677	-123.310551
23054300401	Porter Creek Camp Ground	Porter-Campground	Porter Creek	46.977395	-123.257624
23056500001	HWY 12 Bridge @ Gibson Creek	Gibson-HWY12	Gibson Creek	46.902836	-123.291102
23057000001	Elma Gate Road Bridge	Elma Gate	Cedar Creek	46.878035	-123.277471
23057000201	Capital Forest Road	Capital Forest	Cedar Creek	46.876286	-123.243827
23060400001	Norton Road	Williams-Norton	Williams Creek	46.86644	-123.311334
23062700001	Matson Rd-Garrard Creek	Garrard-Matson	Garrard Creek	46.81174	-123.25323
23062700101	Jenkins 2	Jenkins 2	South Fork Garrard Creek	46.788051	-123.310507
23062700501	Brooklyn Road Bridge @ Garrard Creek	Garrard-Brooklyn	Garrard Creek	46.806057	-123.309471
23064900001	Percy's Landing	Percy's	Black River	46.81996	-123.21426
23064900101	Howanut Road Bridge	Howanut Br	Black River	46.821627	-123.208403
23064900201	Boat Launch @ Tribal Fish Hatchery	Tribal Hatchery BL	Black River	46.82011	-123.1993
23064900401	Jenkins 1	Jenkins 1	Black River	46.832374	-123.176673
23064900701	Moon Road Bridge	Moon Rd Br	Black River	46.839157	-123.139419
23064900901	Steel Trestle	Trestle	Black River	46.836181	-123.124758

Station ID	Station Name	Short Name	Associated River	Latitude	Longitude
23064901901	123rd Ave Bridge	123rd Ave	Black River	46.90908	-123.02013
23064902001	110th Ave Bridge	110th Ave	Black River	46.873087	-123.02393
23066700001	Littlerock Road Bridge Near 133rd Avenue	Littlerock Rd	Beaver Creek	46.897679	-123.019772
23066700401	Hwy 121 Bridge @ Reeder Road	Reeder Rd	Beaver Creek	46.896169	-122.947171
23067700101	Waddell Creek Road Sw Bridge	Waddell	Waddell Creek	46.913975	-123.051371
23069600101	Hyppa Rd - Independence Creek	Independence-Hyppa	Independence Creek	46.78761	-123.17796
23069600401	Garrard Creek Rd. @ Independence Creek	Independence-Garrard	Independence Creek	46.760184	-123.222544
23071600101	James Road Bridge	James Rd	Scatter Creek	46.807067	-123.072296
23071600301	Sargent Road	Sargent	Scatter Creek	46.829066	-123.048633
23071600601	Case Road Bridge	Case Rd	Scatter Creek	46.83087	-122.993085
23071600701	Leitner Road Sw	Leitner Rd	Scatter Creek	46.830679	-122.978126
23071601401	Old Hwy 99 Bridge @ Tenino	Tenino	Scatter Creek	46.850289	-122.865609
23072900101	Prairie Creek	Prairie	Prairie Creek	46.7915	-123.02232
23073300101	Lincoln Creek Road Bridge @ Mi 1	Lincoln-Mi 1	Lincoln Creek	46.741467	-123.045748
23073300401	Teague Rd Bridge	Teague Rd	Lincoln Creek	46.760194	-123.098161
23073300901	Buck Rd	Buck Rd	Lincoln Creek	46.735327	-123.18902
23073300902	Ingalls Road Bridge @ Lincoln Creek	Ingalls-Lincoln	Lincoln Creek	46.734079	-123.193333
23074900201	Lepisto	Lepisto	North Fork Lincoln Creek	46.736099	-123.25155
23076100001	Borst Park Near Mouth	Borst Park-Mouth	Skookumchuck River	46.720337	-122.978419
23076100101	Harrison Ave Bridge	Harrison Ave	Skookumchuck River	46.722437	-122.969283
23076100401	Big Hanaford Road @ Schaefer Park	Hanaford-Schaefer	Skookumchuck River	46.753504	-122.940482
23076101001	Tono Road Se Bridge	Tono Rd	Skookumchuck River	46.79621	-122.865897
23076101801	Skookumchuck Road Bridge Near Johnson Creek Road	Skookumchuck-Johnson	Skookumchuck River	46.796196	-122.760918

Station ID	Station Name	Short Name	Associated River	Latitude	Longitude
23076102001	Skookumchuck Hatchery	Skookumchuck Hatchery	Skookumchuck River	46.78894	-122.723013
23076500901	Big Hanaford Road @ End of Pavement	Hanaford-Paved	Hanaford Creek	46.745598	-122.776504
23077300001	Teitzel Road Bridge	Teitzel Rd	Hanaford Creek	46.75881	-122.900911
23087000201	China 0	China	China Creek	46.727721	-122.931692
23087100001	North Airport Road Bridge	N Airport	Salzer Creek	46.691726	-122.971071
23087100201	Centralia Alpha Road Bridge Near Heidger Lane	Alpha Rd	Salzer Creek	46.699322	-122.929259
23087200201	Coal Creek Road Bridge	Coal Cr	Coal Creek	46.665585	-122.937364
23088200101	Shorey Road Bridge	Shorey Rd	Newaukum River	46.650043	-122.980903
23088200901	Jackson Hwy Bridge, Newaukum	Jackson Hwy	Newaukum River	46.60697	-122.87145
23088201201	Middle Fork Road Bridge	MF Rd Br	South Fork Newaukum River	46.590554	-122.841424
23088201401	Guerrier Rd- S.F. Newaukum	Guerrier Rd	South Fork Newaukum River	46.575484	-122.824489
23088202301	Jorgenson Road Bridge	Jorgenson Rd	South Fork Newaukum River	46.575668	-122.684297
23088700201	Tauscher Road Bridge @ North Fork Newaukum	Tauscher Rd-NF	North Fork Newaukum River	46.611506	-122.820661
23088800001	Tauscher Road Bridge @ Middle Fork Newaukum	Tauscher Rd-MF	Middle Fork Newaukum River	46.602392	-122.819126
23093400001	Twin Oaks Road Bridge	Twin Oaks	Stearns Creek	46.633142	-123.017263
23093400301	Pleasant Valley Road Bridge	Pleasant Valley	Stearns Creek	46.596391	-123.003104
23095500001	Bunker Creek Road Bridge @ Bunker Creek	Bunker Rd	Deep Creek	46.648259	-123.117525
23095500701	Ingalls Road Bridge @ Bunker Creek	Ingalls-Bunker	Bunker Creek	46.707894	-123.203289
23095700001	Bunker Creek Road Bridge @ Deep Creek	Deep Cr	Deep Creek	46.648274	-123.118426
23097700001	South Fork Bridge, Chehalis R.	SF Chehalis Br	South Fork Chehalis River	46.60324	-123.12326
23097700101	Boistfort Road Bridge Near Curtis	Boistfort	South Fork Chehalis River	46.587559	-123.11901
23097700501	Lost Valley Road Bridge	Lost Valley	South Fork Chehalis River	46.546688	-123.133116

Station ID	Station Name	Short Name	Associated River	Latitude	Longitude
23100100201	Mc Donald Road	McDonald	Stillman Creek	46.527796	-123.146457
23117000001	Crim Creek	Crim	Crim Creek	46.540708	-123.301319
23118200001	Rogers Creek	Rogers	Chehalis River	46.502007	-123.28747
23118500001	Alder Creek Lower Bridge	Alder-Lower Br	Chehalis River	46.482948	-123.29761
23119200001	West Fork Chehalis	WF Chehalis	Chehalis River	46.45116	-123.29241
23119200601	Upper West Fork Chehalis	UWF Chehalis	West Fork Chehalis River	46.40179	-123.31501
3328	Mouth Of Independence Creek	Independence-Mouth	Independence Creek	46.79811	-123.166078
7505	Black River at HWY 12	Black R-HWY12	Black River	46.829953	-123.185805
7537	Sludge Site on Lincoln Creek	Lincoln-Sludge	Lincoln Creek	46.74532	-123.159681
7538	1977 Bridge on Lincoln Creek	Lincoln-1977	Lincoln Creek	46.739386	-123.166659
7539	Buck Rd. Bridge on Lincoln Creek	Lincoln-Buck	Lincoln Creek	46.735216	-123.189068
7546	East of Bower on Garrard Creek	Bower E	South Fork Garrard Creek	46.773295	-123.307965
7547	South of Bower on Garrard Creek	Garrard-Bower	South Fork Garrard Creek	46.764481	-123.304498
7548	Swecker on Black River	Black R-Swecker	Black River	46.830922	-123.11774
7549	Black River Slough	Black R-Slough	Black River	46.859274	-123.039886
7550	Canoe Club on Black River	Canoe Club	Black River	46.858765	-123.039187
7553	China Creek Near Centralia Sewer Plant	China-Sewer Plant	Chehalis River	46.713746	-122.977636
7554	Butcher Shop on Chehalis River	Butcher Shop	Chehalis River	46.701126	-122.973628
7555	Mouth Of Salzer Creek	Salzer-Mouth	Chehalis River	46.692991	-122.976027
7557	Near Slough on Chehalis River	Chehalis-Slough	Chehalis River	46.691844	-122.98295
7558	Slough Near Airport on Chehalis River	Chehalis-Airport	Chehalis River	46.689153	-122.983701
7559	Chehalis Sewer Plant on Chehalis River	Chehalis-Sewer Plant	Chehalis River	46.661451	-122.984085
7560	Darigold Discharge Chehalis River	Darigold	Chehalis River	46.661761	-122.984844

Station ID	Station Name	Short Name	Associated River	Latitude	Longitude
7561	Mouth Of Dillenbaugh Creek	Dillenbaugh-Mouth	Chehalis River	46.660465	-122.983985
7576	Garrard Creek Road Bridge on Garrard Creek	Garrard Rd Br	Garrard Creek	46.80451	-123.299706
9911	Salzer	Salzer Cr-Salzer	Salzer Creek	46.691659	-122.97111
9915	Prather	Prather-Ch	Chehalis River	46.775297	-123.035291
23087000001	West Plum Street Bridge	W Plum Br		46.7150239	-122.96883
3283	Tidal Gate @ Winters Creek	Tidal Gate		46.89113	-124.10175
23064902701	Black Lake-Belmore Road Bridge	Black Lake		47.009853	-122.965048
ABF052 (Well)	The Oaks	Oaks_Well	-	46.835333	-123.230123
BAL399 (Well)	Bean Field	Bean Field_Well	-	46.814438	-123.145024
3384	Discovery Avenue SE	Discovery Ave		46.951079	-124.131842
BAL394 (Well)	Community Center	Community Center_Well	-	46.810285	-123.163257
AGK620 (Well)	South Well	South Well	-	46.812579	-123.157949
APF933 (Well)	Pink House	Pink House	-	46.819494	-123.194883
BIQ691 (Well)	Water Tower	Water Tower_Well	-	46.812898	-123.173401
BAL629 (Well)	Wellness Center	Wellness Center_Well	-	46.814546	-123.170733

Table B2 Summary of DO (mg/L) exceedances across different WQP stations in the Upper Chehalis.

Station	Start Date	End Date	No. of Days	Days Below Threshold	Percent Below Threshold	Lowest Daily Min. (mg/L)
110th Ave	2002-07-25	2009-06-24	25	24	96	2.5
Hanaford-Paved	2006-11-08	2009-06-08	12	6	50	3.4
Hanaford-Schaefer	2006-11-08	2009-06-08	16	12	75	1.2
Borst Park-BL	2006-12-06	2009-06-01	15	9	60	2.1
Tribal Hatchery BL	2017-07-06	2021-10-06	930	753	81	4.7
Boistfort	2006-10-23	2025-03-25	41	14	34.1	0.0
Garrard-Brooklyn	2006-11-15	2009-06-08	11	6	54.5	4.1
Buck Rd	2002-07-25	2002-11-06	3	3	100	5.9
Bull Hole	2006-11-01	2009-05-05	13	8	61.5	1.6
Bunker Rd	2006-10-23	2009-06-10	15	9	60	3.0
Deep Cr	2006-10-23	2009-06-10	15	9	60	3.9
Black R-HWY12	2006-10-16	2006-11-02	2	2	100	7.3
Borst Park-Mouth	2019-10-30	2021-01-25	3	0	0	11.7
Capital Forest	2008-03-25	2009-06-09	4	3	75	5.2
Case Rd	2006-11-14	2007-11-30	9	7	77.8	5.5
Alpha Rd	2006-11-06	2009-06-11	18	10	55.6	1.7
Ceres Hill Rd	2018-06-19	2025-03-25	55	15	27.3	0.0
China	2002-07-25	2002-11-06	3	3	100	4.1
Coal Cr	2006-11-06	2009-06-11	16	9	56.2	2.2
Elk Rd Br	2006-10-24	2025-03-25	75	21	28	0.0
Elma Gate	2006-11-07	2009-06-09	14	5	35.7	5.1
Galvin Rd Br	2002-07-25	2009-05-27	18	12	66.7	3.7

Station	Start Date	End Date	No. of Days	Days Below Threshold	Percent Below Threshold	Lowest Daily Min. (mg/L)
Guerrier Rd	2018-06-21	2025-03-27	57	16	28.1	8.2
Independence-Garrard	2006-11-15	2025-03-14	60	30	50	0.0
Harrison Ave	2016-10-24	2025-03-14	57	21	36.8	0.0
Howanut Br	2002-07-25	2025-03-11	72	63	87.5	4.9
Gibson-HWY12	2006-11-07	2009-06-09	15	7	46.7	1.6
Porter-HWY12	2006-11-07	2009-06-09	15	4	26.7	2.2
Reeder Rd	2006-11-14	2009-05-28	15	12	80	2.6
HWY603	2006-10-23	2009-06-10	15	8	53.3	3.2
Independence-Hyppa	2019-01-31	2025-03-14	53	26	49.1	0.0
Independence Rd	2006-11-01	2025-03-14	100	37	37	3.5
Ingalls-Bunker	2006-11-15	2009-05-27	13	8	61.5	3.0
Ingalls-Lincoln	2006-11-15	2009-05-27	12	7	58.3	4.5
Independence Tribal	2006-11-01	2009-06-08	12	7	58.3	3.0
Jackson Hwy	2016-10-03	2025-03-27	290	114	39.3	-0.1
James Rd	2006-11-14	2009-06-02	15	11	73.3	1.2
Jorgenson Rd	2006-11-05	2009-06-11	13	6	46.2	2.4
Leitner Rd	2008-02-05	2009-06-02	7	4	57.1	2.0
Lepisto	2002-07-25	2006-10-17	4	3	75	6.1
Lincoln-Mi 1	2006-10-17	2009-05-27	19	13	68.4	1.1
Littlerock Rd	2006-11-14	2009-06-24	13	6	46.2	2.8
Lost Valley	2006-10-23	2009-06-01	18	11	61.1	3.6
Garrard-Matson	2019-01-30	2025-03-11	58	28	48.3	0.0
Mays	2016-10-10	2025-03-25	59	16	27.1	0.0

Station	Start Date	End Date	No. of Days	Days Below Threshold	Percent Below Threshold	Lowest Daily Min. (mg/L)
McDonald	2008-04-02	2009-06-01	5	5	100	4.6
Mellen St	2006-10-18	2025-03-14	98	50	51	2.7
MF Rd Br	2006-11-05	2009-06-11	13	8	61.5	4.3
Moon Rd Br	2002-07-25	2025-03-11	72	61	84.7	0.0
Black R-Mouth	2006-11-01	2009-05-05	12	9	75	3.1
Garrard-Mouth	2006-11-01	2009-04-30	11	7	63.6	1.9
Skookumchuck-Mouth	2006-10-18	2009-06-03	6	3	50	4.4
N Airport	2002-07-25	2009-05-06	23	19	82.6	2.4
Williams-Norton	2008-05-27	2009-06-08	4	4	100	4.6
Tenino	2006-11-14	2009-05-28	13	7	53.8	2.7
PM Smith Rd	2016-07-14	2018-07-19	336	99	29.5	6.8
Panesko	2016-10-10	2019-12-16	642	325	50.6	-0.2
Pleasant Valley	2006-11-06	2025-03-25	71	35	49.3	0.0
Porter-Campground	2006-11-07	2009-06-12	14	5	35.7	4.9
Porter Rd	2006-11-07	2025-03-11	105	42	40	3.3
Prather Rd Br	2002-07-25	2025-03-14	105	52	49.5	3.2
Rainbow Falls	2006-10-23	2009-06-01	15	10	66.7	1.3
Sargent	2008-01-22	2009-06-02	6	3	50	1.1
SHOREY ROAD BRIDGE	2006-10-24	2025-03-27	74	25	33.8	0.0
Sickman Ford Rd	2006-11-01	2025-03-11	91	43	47.3	3.0
Skookumchuck Hatchery	2006-12-27	2009-05-28	11	3	27.3	6.5
Skookumchuck-Johnson	2006-12-27	2009-05-28	9	3	33.3	6.4
SR6-Adna	2006-11-03	2019-11-19	29	13	44.8	1.3

Station	Start Date	End Date	No. of Days	Days Below Threshold	Percent Below Threshold	Lowest Daily Min. (mg/L)
SR6-Chehalis	2006-10-18	2025-03-27	75	38	50.7	0.0
SR6-Pe Ell	2006-10-24	2009-06-01	14	6	42.9	5.0
Trestle	2002-07-25	2006-11-02	5	5	100	4.8
Tauscher Rd-MF	2006-11-05	2009-06-11	13	8	61.5	2.2
Tauscher Rd-NF	2006-11-05	2025-03-27	71	25	35.2	2.6
Teague Rd	2002-07-25	2006-10-17	4	4	100	4.0
Teitzel Rd	2006-12-20	2008-05-28	11	5	45.5	3.8
Tono Rd	2006-11-08	2009-05-28	11	3	27.3	5.4
Twin Oaks	2006-10-23	2025-03-25	80	48	60	0.0
Waddell	2006-11-08	2009-06-24	12	5	41.7	5.7
WF Chehalis	2017-12-11	2017-12-11	1	0	0	12.5
W Plum Br	2006-11-15	2009-06-03	17	10	58.8	1.8

Table B3 Summary of 7-DADMax (˚C) exceedances across different WQP stations in the Upper Chehalis.

Station	Start Date	End Date	No. of 7-DADMax Samples – Core Summer	Percent Exceeding Threshold - Core Summer (%)	No. of 7-DADMax Samples – Spawning Period	Percent Exceeding Threshold – Spawning Period (%)	No. of 7-DADMax Samples – Incubation Period	Percent Exceeding Threshold – Incubation Period (%)
110th Ave	2002-07-25	2009-06-24	4	0	0	-	23	0
123rd Ave	2023-09-16	2024-07-15	28	71.4	30	0	N/A	N/A
Alexander Park	2017-08-14	2024-03-10	154	100	60	48.3	N/A	N/A
Hanaford-Paved	2006-11-08	2009-06-08	5	0	2	0	9	0
Hanaford-Schaefer	2006-11-08	2009-06-08	5	0	2	0	20	5
Borst Park-BL	2006-12-06	2009-06-01	5	0	1	0	17	5.9
Tribal Hatchery BL	2017-07-06	2021-10-06	310	98.1	60	0	N/A	N/A
Boistfort	2006-10-23	2025-03-25	257	91.4	94	39.4	893	28
Garrard-Brooklyn	2006-11-15	2009-06-08	4	0	1	0	N/A	N/A
Buck Rd	2002-07-25	2002-11-06	0	-	0	-	N/A	N/A
Bull Hole	2006-11-01	2009-05-05	4	0	1	0	16	12.5
Bunker Rd	2006-10-23	2009-06-10	5	0	0	-	8	0
Deep Cr	2006-10-23	2009-06-10	4	0	0	-	8	0
Black R-HWY12	2006-10-16	2006-11-02	0	-	0	-	N/A	N/A
Borst Park-Mouth	2017-08-17	2021-01-25	116	96.6	30	0	328	34.5
Capital Forest	2008-02-26	2009-06-09	2	0	0	-	3	0
Case Rd	2006-11-14	2007-11-30	0	-	0	-	N/A	N/A
Alpha Rd	2006-11-06	2009-06-11	5	0	0	-	N/A	N/A
Ceres Hill Rd	2018-06-19	2025-03-25	11	0	7	0	44	40.9
China	2002-07-25	2002-11-06	0	-	0	-	N/A	N/A

Station	Start Date	End Date	No. of 7-DADMax Samples – Core Summer	Percent Exceeding Threshold - Core Summer (%)	No. of 7-DADMax Samples – Spawning Period	Percent Exceeding Threshold – Spawning Period (%)	No. of 7-DADMax Samples – Incubation Period	Percent Exceeding Threshold – Incubation Period (%)
Coal Cr	2006-11-06	2009-06-11	5	0	0	-	N/A	N/A
Crim	2017-08-17	2020-02-18	210	78.6	60	0	N/A	N/A
Elk Rd Br	2006-10-24	2025-03-25	21	0	8	0	69	15.9
Elma Gate	2006-11-07	2009-06-09	6	0	1	0	N/A	N/A
Galvin Rd Br	2002-07-25	2009-05-27	5	0	1	0	17	0
Gillie	2016-08-03	2018-06-01	87	100	13	84.6	N/A	N/A
Guerrier Rd	2018-06-21	2025-03-27	14	0	5	0	44	6.8
Independence-Garrard	2006-11-15	2025-03-14	19	0	5	0	N/A	N/A
Harrison Ave	2016-10-12	2025-03-14	17	0	4	0	42	23.8
Howanut Br	2002-07-25	2025-03-11	20	5	4	0	N/A	N/A
Gibson-HWY12	2006-11-07	2009-06-09	5	0	1	0	N/A	N/A
Porter-HWY12	2006-11-07	2009-06-09	6	0	1	0	N/A	N/A
Reeder Rd	2006-11-14	2009-05-28	5	0	0	-	N/A	N/A
HWY603	2006-10-23	2009-06-10	5	0	0	-	19	5.3
Independence-Hyppa	2019-01-31	2025-03-14	18	0	3	0	N/A	N/A
Independence Rd	2006-11-01	2025-03-14	40	52.5	7	0	64	14.1
Ingalls-Bunker	2006-11-15	2009-05-27	5	0	2	0	N/A	N/A
Ingalls-Lincoln	2006-11-15	2009-05-27	4	0	2	0	N/A	N/A
Independence Tribal	2006-11-01	2021-08-05	101	96	2	0	12	0

Station	Start Date	End Date	No. of 7-DADMax Samples – Core Summer	Percent Exceeding Threshold - Core Summer (%)	No. of 7-DADMax Samples – Spawning Period	Percent Exceeding Threshold – Spawning Period (%)	No. of 7-DADMax Samples – Incubation Period	Percent Exceeding Threshold – Incubation Period (%)
Jackson Hwy	2016-10-03	2025-03-27	43	67.4	7	0	249	15.7
James Rd	2006-11-14	2009-06-02	5	0	1	0	N/A	N/A
Jorgenson Rd	2006-11-05	2009-06-11	5	0	0	-	17	0
Leitner Rd	2008-01-28	2009-06-02	1	0	0	-	N/A	N/A
Lepisto	2002-07-25	2006-10-17	0	-	0	-	N/A	N/A
Lincoln-Mi 1	2006-10-17	2009-05-27	4	0	2	0	N/A	N/A
Littlerock Rd	2006-11-14	2009-06-24	4	0	0	-	N/A	N/A
Lost Valley	2006-10-23	2009-06-01	7	0	0	-	19	5.3
Garrard-Matson	2019-01-30	2025-03-11	38	34.2	18	0	N/A	N/A
Mays	2016-10-10	2025-03-25	13	0	7	0	45	26.7
McDonald	2008-01-23	2009-06-01	3	0	0	-	7	0
Mellen St	2006-10-18	2025-03-14	29	44.8	7	0	N/A	N/A
MF Rd Br	2006-11-05	2009-06-11	5	0	0	-	17	0
Moon Rd Br	2002-07-25	2025-03-11	20	10	4	0	23	39.1
Black R-Mouth	2006-11-01	2009-05-05	4	0	1	0	16	18.8
Garrard-Mouth	2006-11-01	2009-04-30	3	0	0	-	13	0
Skookumchuck-Mouth	2006-10-18	2009-06-03	5	0	1	0	3	66.7
N Airport	2002-07-25	2009-06-03	3	0	1	0	N/A	N/A
Williams-Norton	2008-01-30	2009-06-08	2	0	1	0	3	0
Tenino	2006-11-14	2009-05-28	1	0	0	-	N/A	N/A
PM Smith Rd	2016-07-14	2018-07-19	183	100	52	51.9	453	7.5

Station	Start Date	End Date	No. of 7-DADMax Samples – Core Summer	Percent Exceeding Threshold - Core Summer (%)	No. of 7-DADMax Samples – Spawning Period	Percent Exceeding Threshold – Spawning Period (%)	No. of 7-DADMax Samples – Incubation Period	Percent Exceeding Threshold – Incubation Period (%)
Panesko	2016-10-10	2019-12-16	224	96	33	0	444	19.8
Pleasant Valley	2006-11-06	2025-03-25	21	0	6	0	N/A	N/A
Porter-Campground	2006-11-07	2009-06-12	6	0	1	0	10	0
Porter Rd	2006-11-07	2025-03-11	37	40.5	8	0	70	12.9
Prather Rd Br	2002-07-25	2025-03-14	36	50	8	0	71	11.3
Pe Ell Tribal	2017-08-14	2017-08-14	328	98.8	90	41.1	N/A	N/A
Percy's	2023-09-16	2024-05-28	0	-	10	0	N/A	N/A
Rainbow Falls	2006-10-23	2009-06-01	6	0	0	-	14	7.1
Rogers	2017-08-14	2019-07-16	150	12.7	60	0	N/A	N/A
Sargent	2008-01-22	2009-06-02	2	0	0	-	N/A	N/A
SHOREY ROAD BRIDGE	2006-10-24	2025-03-27	22	18.2	5	0	72	25
Sickman Ford Rd	2006-11-01	2025-03-11	300	93.7	93	37.6	513	16.8
Skookumchuck Hatchery	2006-12-27	2009-05-28	5	0	0	-	15	0
Skookumchuck-Johnson	2006-12-27	2009-05-28	5	0	0	-	8	0
SF Chehalis Br	2017-08-14	2018-06-19	18	100	30	33.3	N/A	N/A
SR6-Adna	2006-11-03	2019-11-19	7	0	3	0	23	4.3
SR6-Chehalis	2006-10-18	2025-03-27	27	44.4	6	0	N/A	N/A
SR6-Pe Ell	2006-10-24	2009-06-01	7	0	0	-	17	0
Trestle	2002-07-25	2006-11-02	0	-	0	-	N/A	N/A

Station	Start Date	End Date	No. of 7-DADMax Samples – Core Summer	Percent Exceeding Threshold - Core Summer (%)	No. of 7-DADMax Samples – Spawning Period	Percent Exceeding Threshold – Spawning Period (%)	No. of 7-DADMax Samples – Incubation Period	Percent Exceeding Threshold – Incubation Period (%)
Sand Bars	2021-08-05	2024-07-11	246	97.6	90	40	N/A	N/A
Tauscher Rd-MF	2006-11-05	2009-06-11	5	0	0	-	N/A	N/A
Tauscher Rd-NF	2006-11-05	2025-03-27	22	0	7	0	N/A	N/A
Teague Rd	2002-07-25	2006-10-17	0	-	0	-	N/A	N/A
Teitzel Rd	2006-12-20	2009-06-08	5	0	2	0	N/A	N/A
Tono Rd	2006-11-08	2009-05-28	5	0	0	-	15	0
Twin Oaks	2006-10-23	2025-03-25	22	0	6	0	N/A	N/A
Upper EF Chehalis	2018-07-17	2023-09-08	508	0	150	0	N/A	N/A
UWF Chehalis	2018-07-17	2020-09-10	174	6.9	60	0	N/A	N/A
Waddell	2006-11-08	2009-06-24	4	0	0	-	8	0
W Plum Br	2006-11-15	2009-06-03	4	0	1	0	N/A	N/A
WF Chehalis	2017-08-14	2019-10-09	213	68.5	60	3.3	274	26.3

Table B4 Summary of FC (cfu/100mL) exceedances across different WQP stations in the Upper Chehalis.

Station	Start Date	End Date	No. of Samples (months)	Percent Exceedances Criteria (%)
110th Ave	2002-07-25	2009-06-24	22	9.1
123rd Ave	2002-07-25	2006-11-02	4	25
Hanaford-Paved	2006-11-08	2007-10-24	12	0
Hanaford-Schaefer	2006-11-08	2009-06-08	15	6.7
Borst Park-BL	2006-12-06	2009-06-01	13	0
Boistfort	2006-10-23	2025-03-25	39	28.2
Garrard-Brooklyn	2006-11-15	2009-06-08	18	11.1
Buck Rd	2002-07-25	2002-11-06	3	33.3
Bull Hole	2006-11-01	2009-06-08	17	5.9
Bunker Rd	2006-10-23	2009-05-13	13	7.7
Deep Cr	2006-10-23	2009-06-10	19	5.3
Case Rd	2006-11-14	2007-11-30	7	0
Alpha Rd	2006-11-06	2009-06-11	16	6.2
Ceres Hill Rd	2017-07-19	2025-03-25	62	19.4
Coal Cr	2006-11-06	2009-06-11	9	11.1
Elk Rd Br	2006-10-24	2025-03-25	84	16.7
Elma Gate	2006-11-07	2009-06-09	11	9.1
Galvin Rd Br	2002-07-25	2008-03-04	15	0
Guerrier Rd	2017-04-25	2025-03-27	61	42.6
Independence-Garrard	2006-11-15	2025-02-20	55	32.7
Harrison Ave	2017-03-30	2025-02-25	67	22.4
Howanut Br	2002-07-25	2025-02-25	69	17.4

Station	Start Date	End Date	No. of Samples (months)	Percent Exceedances Criteria (%)
Gibson-HWY12	2006-11-07	2009-06-09	11	9.1
Porter-HWY12	2006-11-07	2008-04-22	13	7.7
Reeder Rd	2006-11-14	2009-05-28	11	9.1
HWY603	2006-11-03	2009-06-10	15	6.7
Independence-Hyppa	2019-03-28	2025-02-20	52	42.3
Independence Rd	2006-11-01	2025-02-20	80	15
Ingalls-Bunker	2006-11-15	2009-05-27	13	0
Ingalls-Lincoln	2006-11-15	2009-05-27	14	0
Jackson Hwy	2017-03-29	2025-03-27	60	31.7
James Rd	2006-11-14	2009-06-02	11	9.1
Jenkins 1	2002-08-13	2006-11-02	2	0
Jorgenson Rd	2006-11-05	2009-06-11	15	6.7
Leitner Rd	2008-01-28	2009-06-02	5	0
Lepisto	2002-07-25	2006-10-17	4	75
Lincoln-Mi 1	2006-10-17	2009-05-27	19	10.5
Littlerock Rd	2006-11-14	2009-06-24	15	0
Lost Valley	2006-10-23	2009-05-04	13	7.7
Garrard-Matson	2019-03-28	2025-02-12	51	62.7
Mays	2017-01-10	2025-03-25	66	19.7
Mellen St	2006-10-18	2025-02-25	81	16
MF Rd Br	2006-11-05	2009-05-18	13	15.4
Moon Rd Br	2002-07-25	2025-02-25	72	13.9
Black R-Mouth	2006-11-01	2009-05-05	17	0

Station	Start Date	End Date	No. of Samples (months)	Percent Exceedances Criteria (%)
Garrard-Mouth	2006-11-01	2009-04-30	15	6.7
Skookumchuck-Mouth	2006-10-18	2017-04-20	5	20
N Airport	2002-07-25	2009-06-03	19	21.1
Williams-Norton	2009-04-24	2009-06-08	2	0
Tenino	2006-11-14	2009-05-28	13	7.7
PM Smith Rd	2018-07-12	2018-08-02	2	0
Panesko	2017-01-10	2019-11-19	28	7.1
Pleasant Valley	2006-11-06	2025-03-25	83	51.8
Porter-Campground	2006-11-07	2008-03-25	8	0
Porter Rd	2007-01-10	2025-02-12	81	23.5
Prather Rd Br	2002-07-25	2025-02-25	80	16.2
Rainbow Falls	2006-10-23	2009-04-06	11	9.1
SHOREY ROAD BRIDGE	2006-10-24	2025-03-27	82	35.4
Sickman Ford Rd	2006-11-01	2025-02-12	80	25
Skookumchuck Hatchery	2006-12-27	2009-05-28	11	0
Skookumchuck-Johnson	2006-11-16	2009-05-28	10	0
SF Chehalis Br	2017-01-12	2021-09-29	38	57.9
SR6-Adna	2006-11-03	2019-11-19	29	17.2
SR6-Chehalis	2006-10-18	2025-03-27	80	21.2
SR6-Pe Ell	2006-10-24	2009-06-01	15	0
Trestle	2002-07-25	2006-11-02	3	0
Tauscher Rd-MF	2006-11-05	2009-06-11	16	12.5
Tauscher Rd-NF	2006-11-05	2025-03-27	76	46.1

Station	Start Date	End Date	No. of Samples (months)	Percent Exceedances Criteria (%)
Teague Rd	2002-07-25	2006-10-17	4	25
Teitzel Rd	2006-12-20	2009-06-08	18	0
Tono Rd	2006-11-08	2009-05-28	16	12.5
Twin Oaks	2006-11-05	2025-02-27	84	63.1
Waddell	2006-11-08	2009-06-24	13	0
W Plum Br	2006-11-15	2009-06-03	16	18.8

Table B5 Summary of pH exceedances after 2015 across different WQP stations in the Upper Chehalis.

Station	Start Date	End Date	Total No. of Samples	No. of Samples Out of Range	Percent of Samples Out of Range (%)
Boistfort	2016-10-10	2025-03-25	25	0	0
Borst Park-Mouth	2019-10-30	2021-01-25	5	0	0
Ceres Hill Rd	2018-06-19	2025-03-25	58	7	12.1
Elk Rd Br	2016-10-10	2025-03-25	63	6	9.5
Garrard-Matson	2019-01-30	2025-03-11	62	9	14.5
Gillie	2016-08-03	2016-08-03	2	0	0
Guerrier Rd	2018-06-21	2025-03-27	60	7	11.7
Harrison Ave	2016-10-12	2025-03-14	61	5	8.2
Howanut Br	2016-06-30	2025-03-11	74	13	17.6
Independence Rd	2016-06-29	2025-03-14	100	7	7
Independence-Garrard	2019-12-18	2025-03-14	50	14	28
Independence-Hyppa	2019-01-31	2025-03-14	57	14	24.6
Jackson Hwy	2016-10-03	2025-03-27	5187	280	5.4
Mays	2016-10-10	2025-03-25	62	6	9.7
Mellen St	2016-06-30	2025-03-14	92	7	7.6
Moon Rd Br	2016-10-12	2025-03-11	73	17	23.3
Panesko	2016-10-10	2019-12-16	10183	303	3
Pleasant Valley	2018-06-21	2025-03-25	59	9	15.3
PM Smith Rd	2016-07-14	2018-07-19	1303	49	3.8
Porter Rd	2016-06-30	2025-03-11	99	15	15.2
Prather Rd Br	2016-06-29	2025-03-14	96	11	11.5
SHOREY ROAD BRIDGE	2016-10-11	2025-03-27	66	7	10.6

Station	Start Date	End Date	Total No. of Samples	No. of Samples Out of Range	Percent of Samples Out of Range (%)
Sickman Ford Rd	2016-07-19	2025-03-11	96	10	10.4
SR6-Adna	2018-10-16	2019-11-19	12	5	41.7
SR6-Chehalis	2016-06-29	2025-03-27	70	8	11.4
Tauscher Rd-NF	2018-06-21	2025-03-27	60	4	6.7
Tribal Hatchery BL	2017-07-06	2021-10-06	8742	1248	14.3
Twin Oaks	2018-06-21	2025-03-25	61	17	27.9
WF Chehalis	2017-12-11	2017-12-11	2	0	0

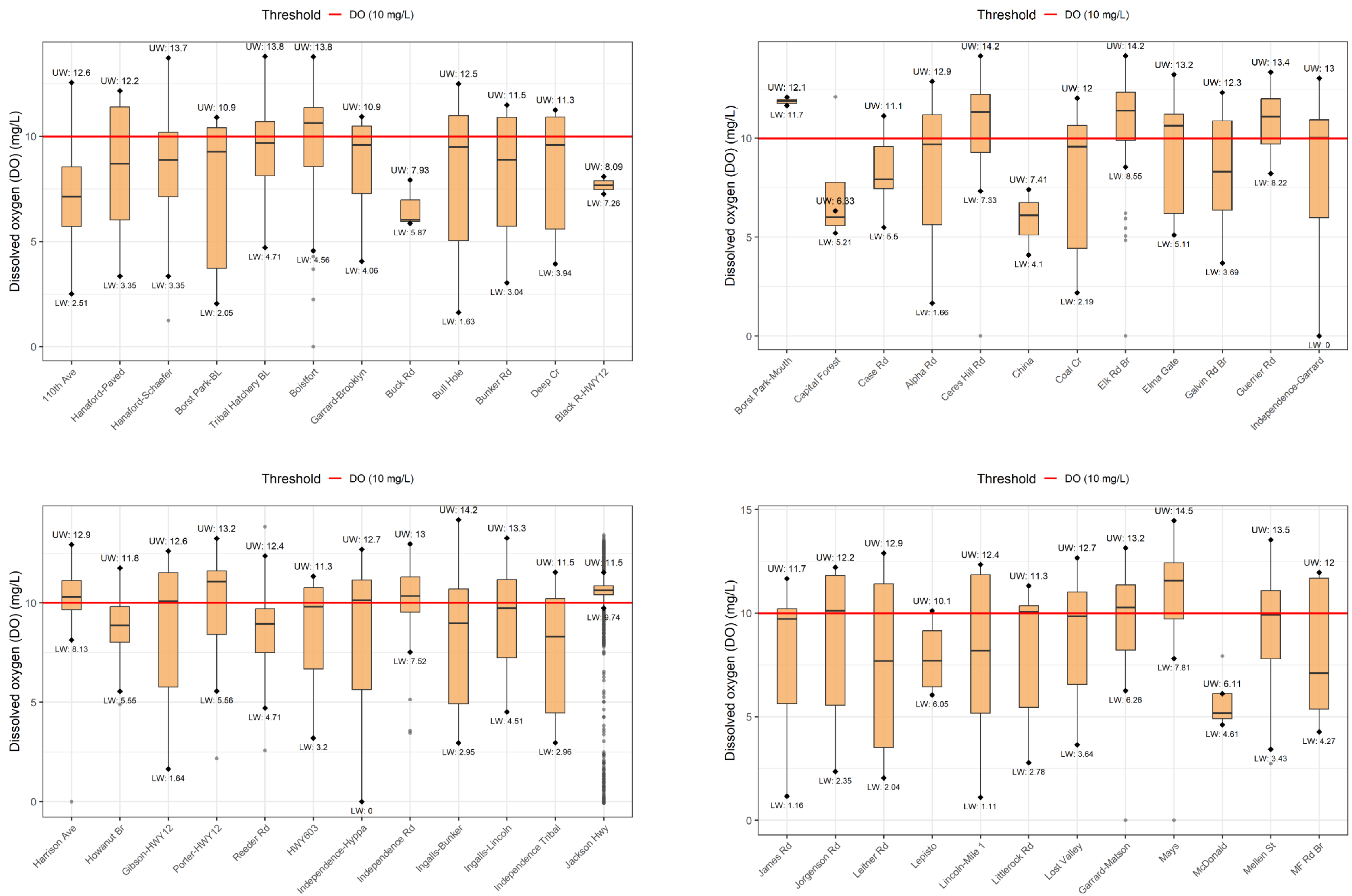


Figure B1 Boxplots showing the distribution of DO (mg/L) across sampling stations in the Upper Chehalis WQP dataset.

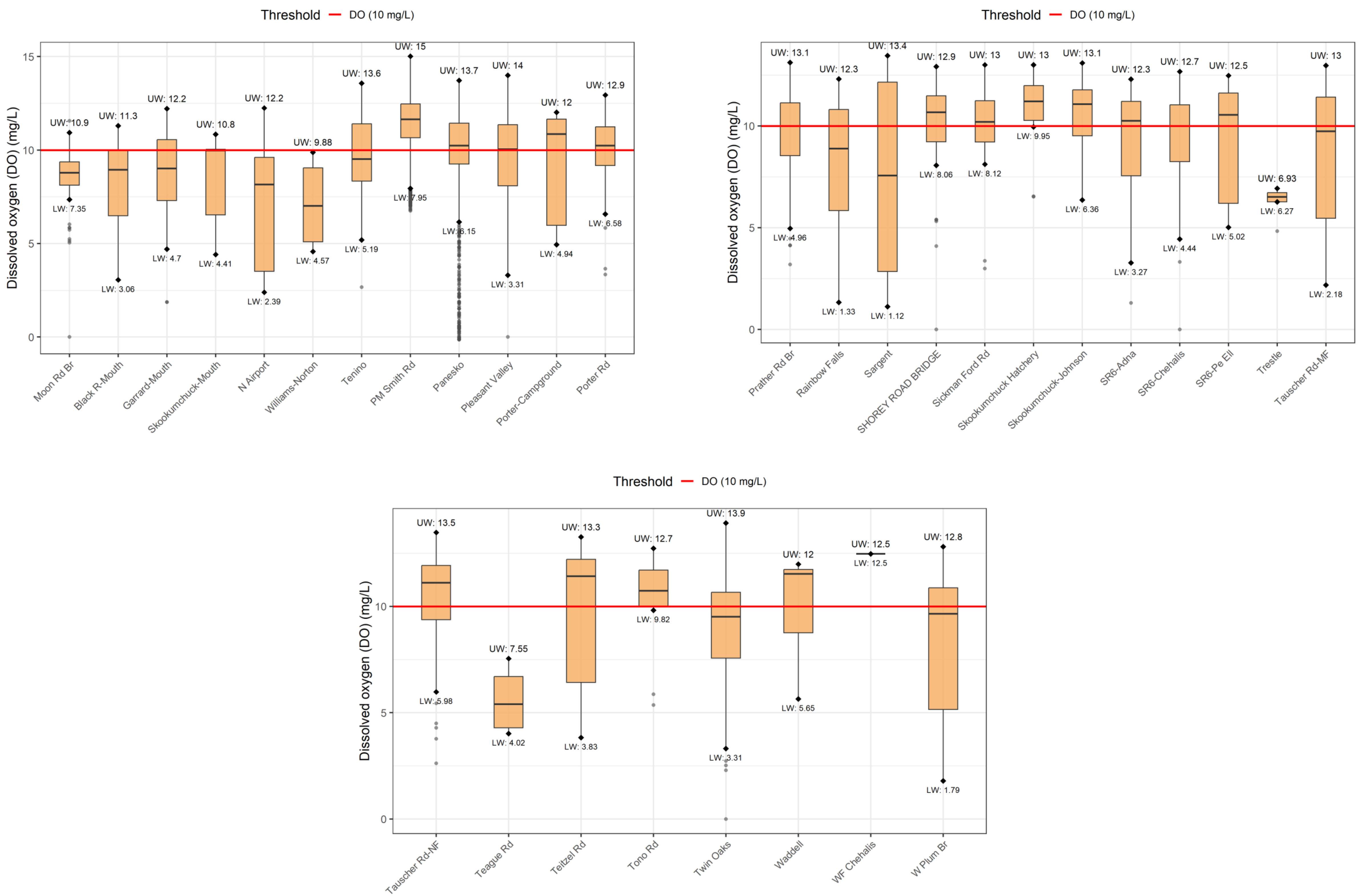


Figure B1 Boxplots showing the distribution of DO (mg/L) across sampling stations in the Upper Chehalis WQP dataset - Continue.

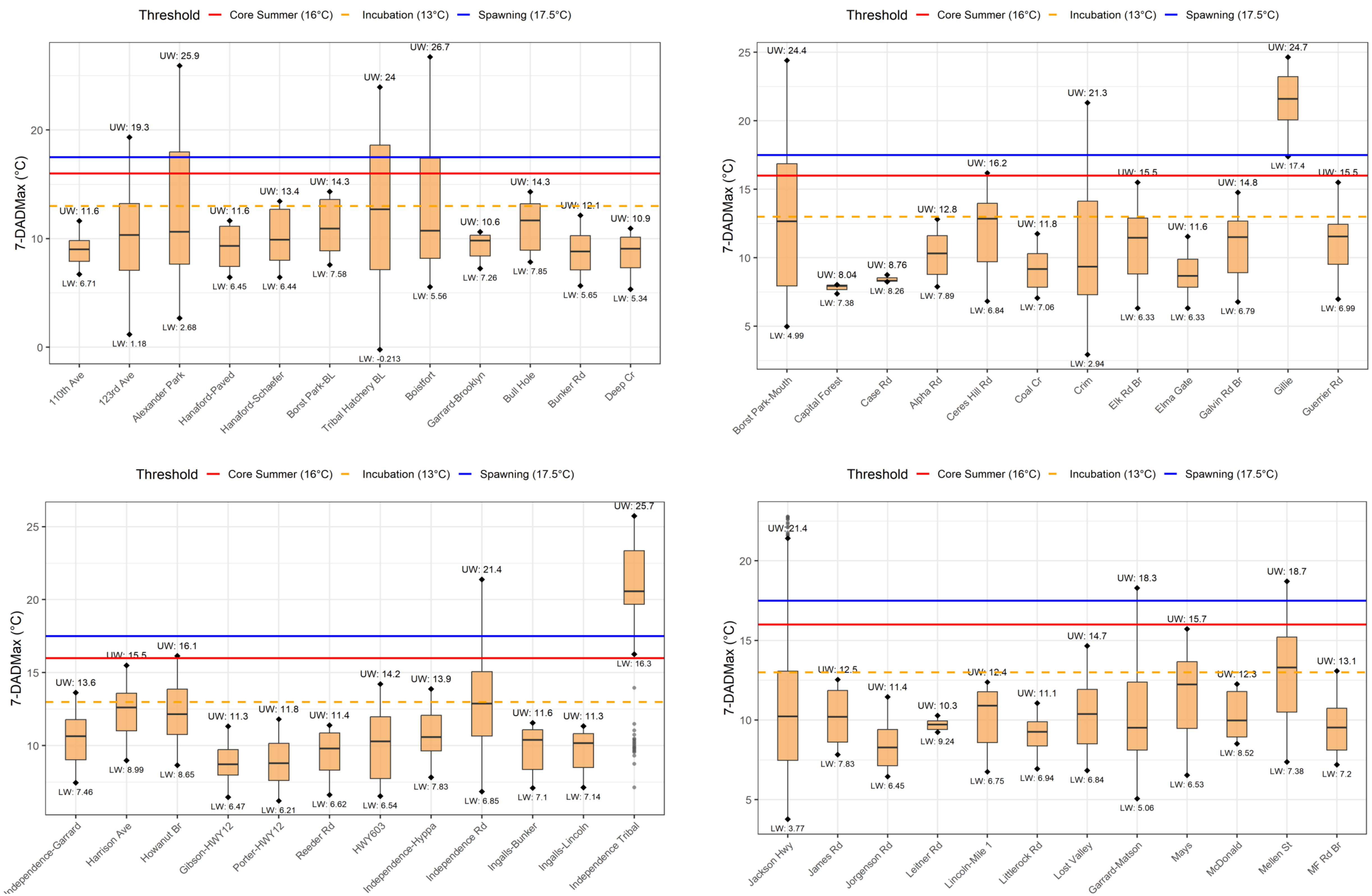


Figure B2 Boxplots showing the distribution of 7-DADMax (˚C) across sampling stations in the Upper Chehalis WQP dataset.

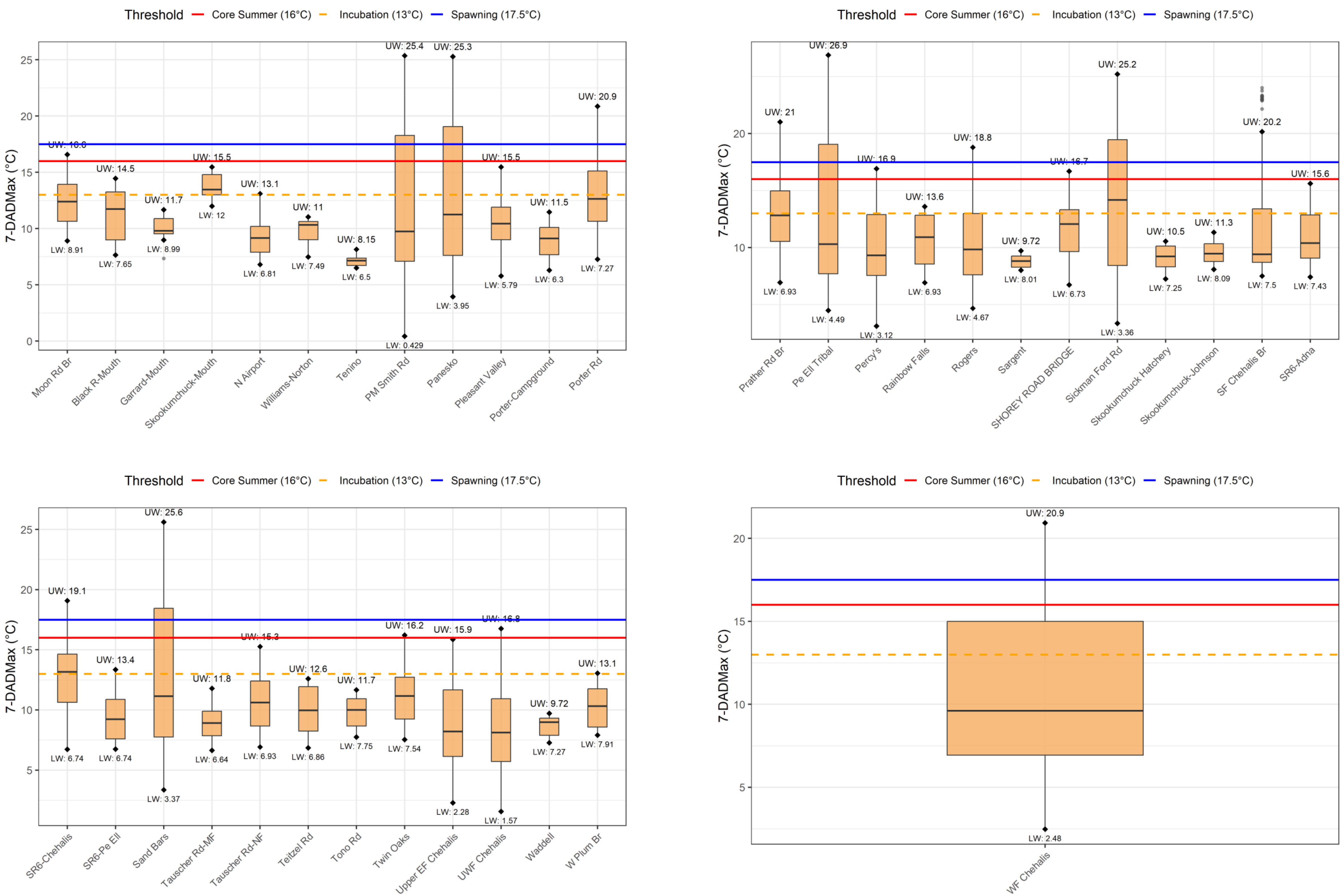


Figure B2 Boxplots showing the distribution of 7-DADMax (˚C) across sampling stations in the Upper Chehalis WQP dataset - Continue.

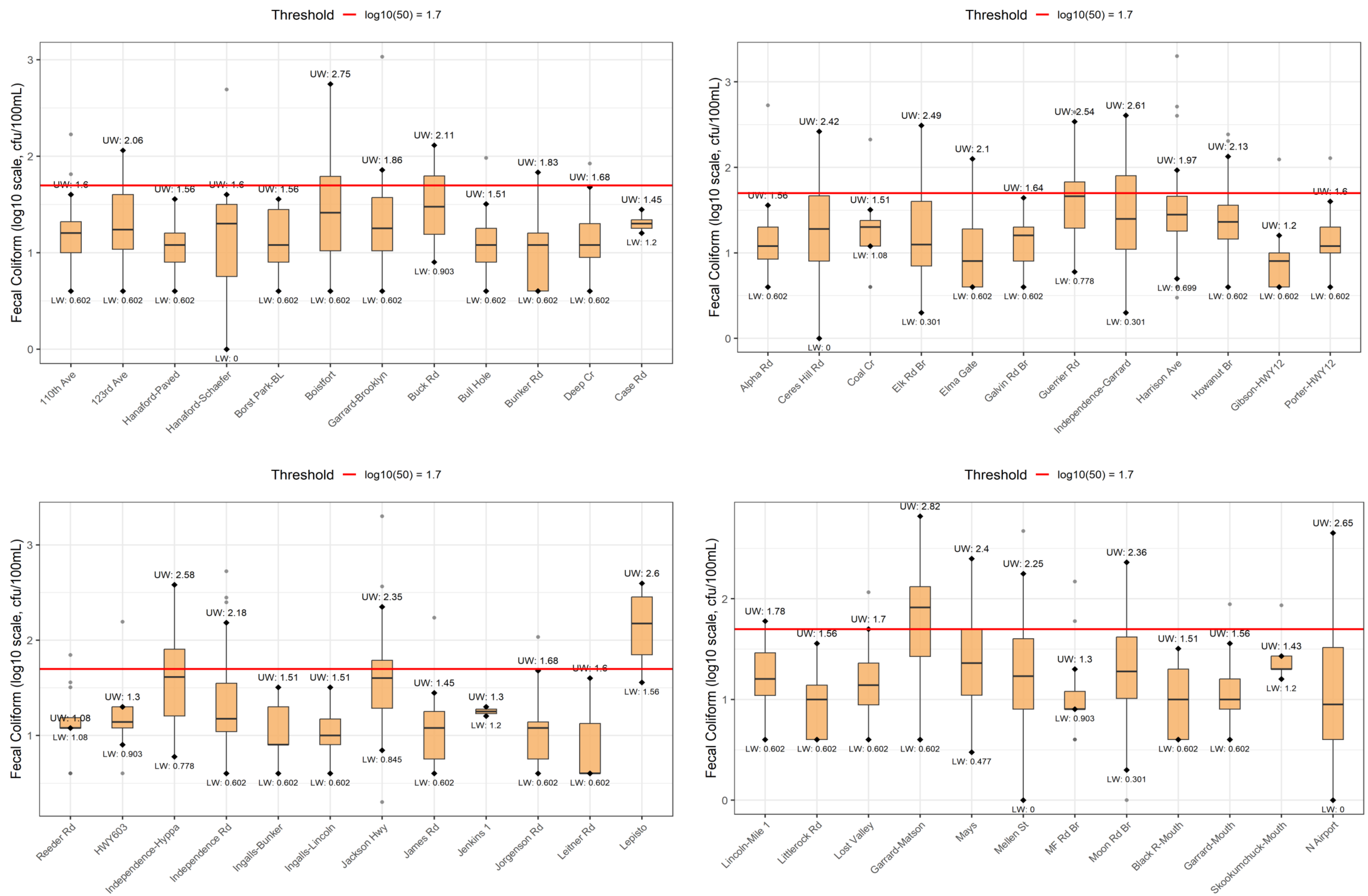
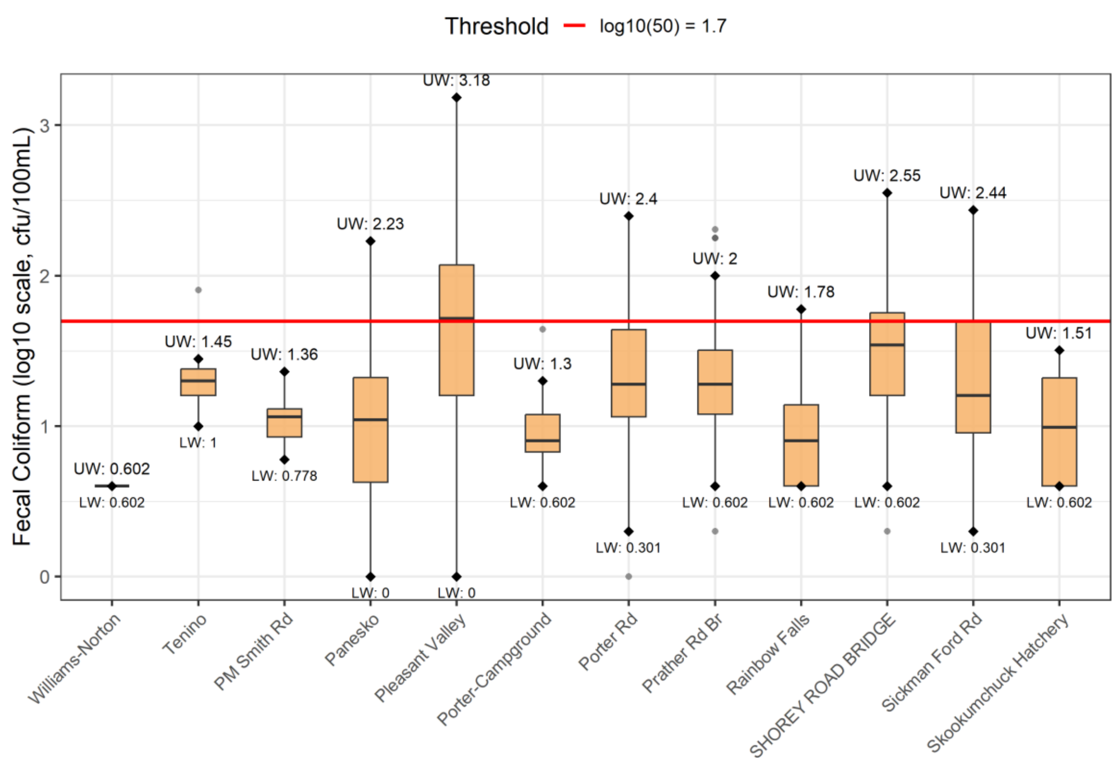
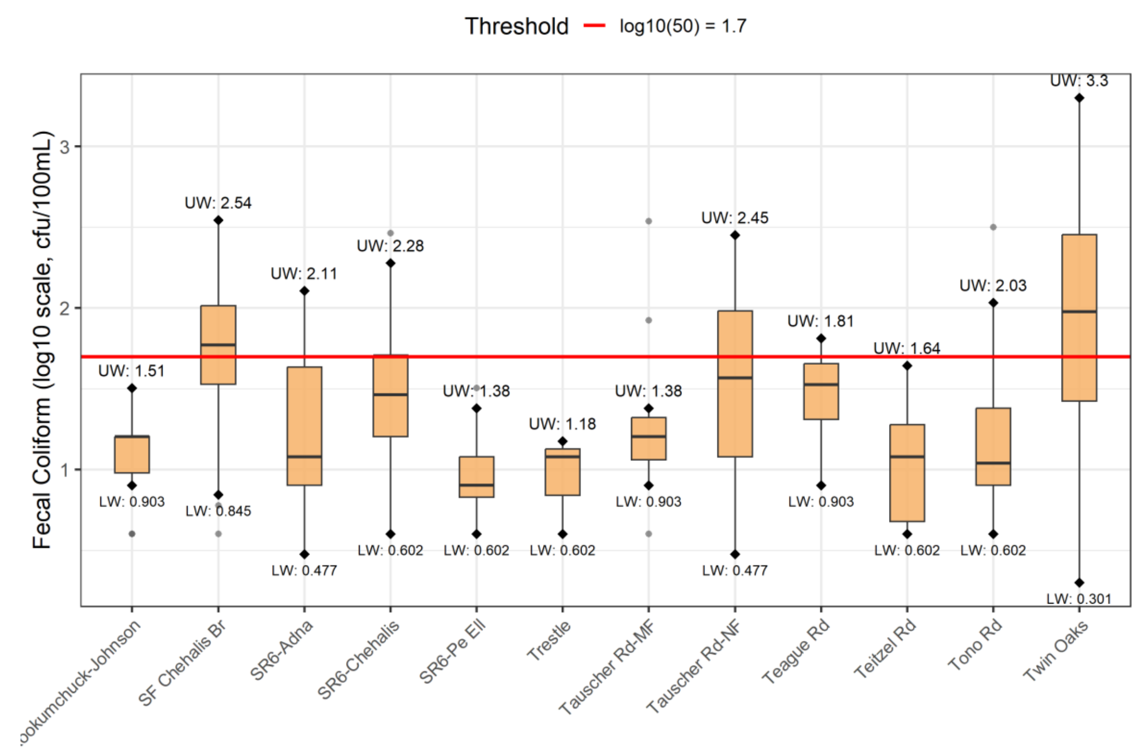


Figure B3 Boxplots showing the distribution of FC ($\log_{10}$ cfu/100mL) across Upper Chehalis WQP sampling stations.





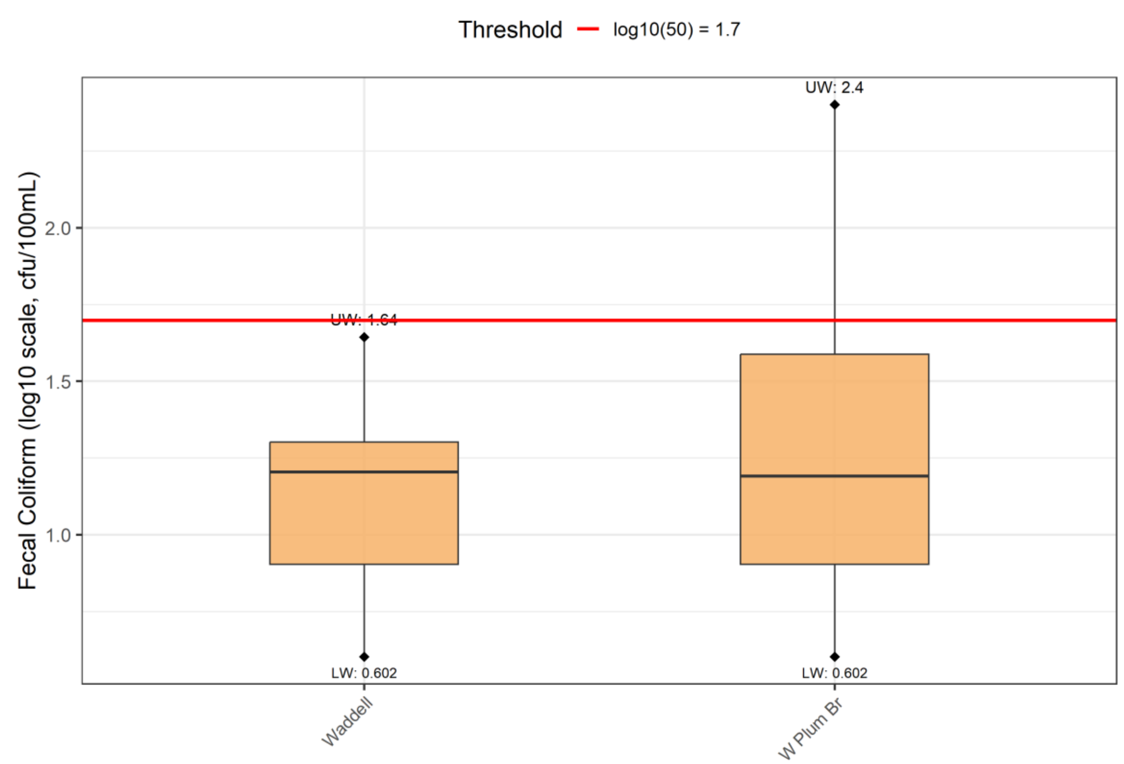


Figure B3 Boxplots showing the distribution of FC (log_{10} cfu/100mL) across Upper Chehalis WQP sampling stations - Continue.

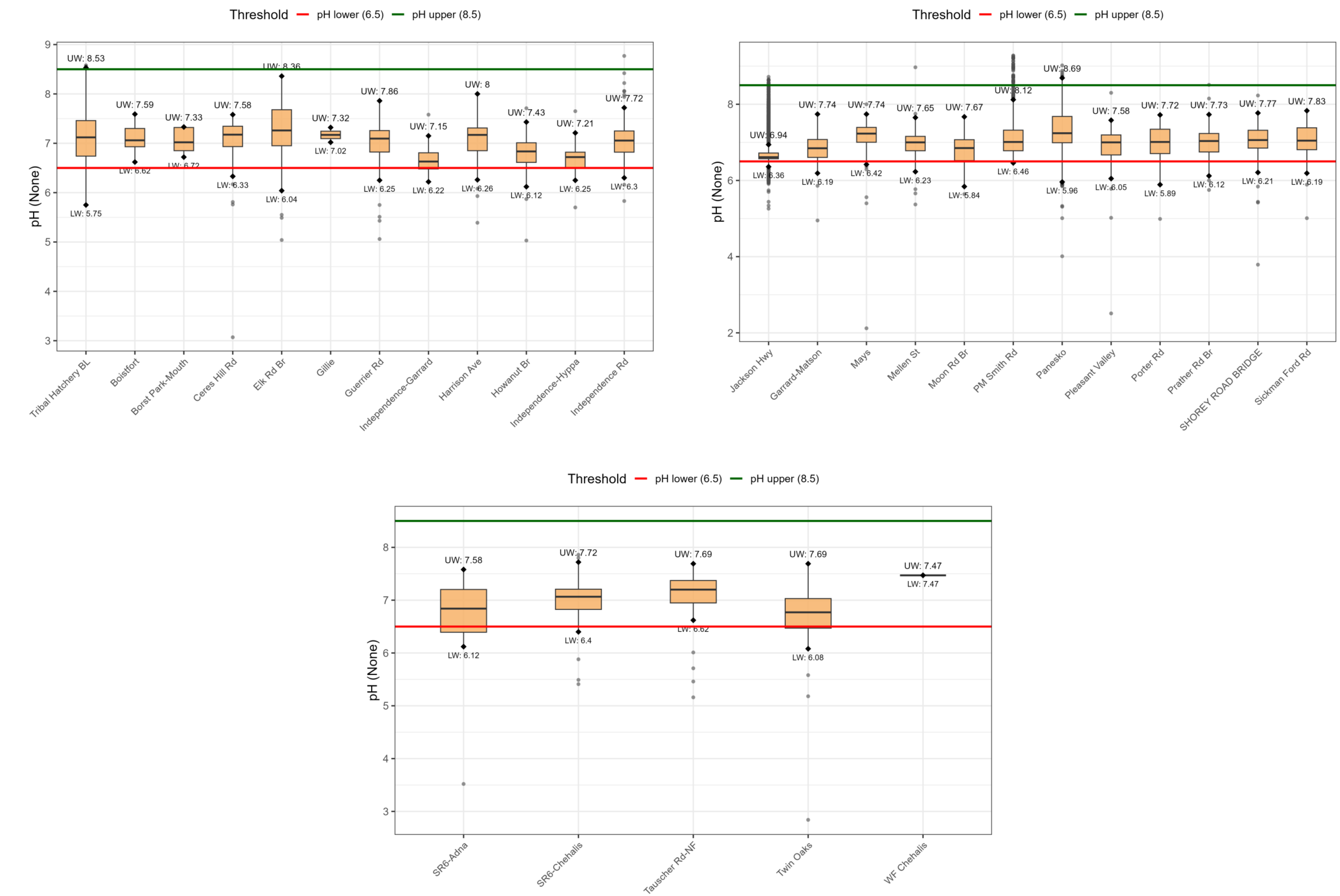


Figure B4 Boxplots showing the distribution of pH (since 2016) across Upper Chehalis sampling stations in WQP dataset.

APPENDIX C

Description of Water Bodies in Upper Chehalis

Table C1 List of Upper Chehalis streams and tributaries.

Subbasin	Stream/Tributary	Length (Miles)	Upstream Elevation (ft)	Downstream Elevation (ft)
Black River	Allen Creek	3.05	193.79	175.79
Black River	Beaver Creek	10.49	245.81	122.60
Black River	Black River	28.26	161.30	85.76
Black River	Blooms Ditch	8.52	229.85	131.82
Black River	Davis Creek	5.98	362.82	69.37
Black River	Dempsey Creek	3.05	156.63	132.90
Black River	Harris Creek	3.64	729.12	69.57
Black River	Independence Creek	8.62	423.80	105.75
Black River	Mill Creek	2.29	649.03	258.75
Black River	Mima Creek	7.40	966.89	107.06
Black River	Noski Creek	2.10	1,351.96	406.89
Black River	Roundtree Creek	1.98	924.00	96.61
Black River	Salmon Creek	7.55	198.84	131.73
Black River	Stony Creek	3.03	1,120.37	180.09
Black River	Waddell Creek	10.87	1,291.61	131.42
Cedar Creek	Camp Seven Creek	1.45	1,072.27	697.10
Cedar Creek	Cedar Creek	7.71	384.17	56.14
Cedar Creek	Chehalis River	87.40	846.30	40.01
Cedar Creek	Fall Creek	1.81	1,265.34	596.78
Cedar Creek	Lost Valley Creek	2.56	1,068.11	452.41
Cedar Creek	Monroe Creek	2.89	1,527.73	549.37
Cedar Creek	North Creek	3.15	1,664.56	274.73
Cedar Creek	Phantom Creek	1.24	1,179.02	697.10
Cedar Creek	Shelton Creek	5.07	1,651.16	92.64
Cedar Creek	Sherman Creek	5.62	778.69	384.17
Chehalis River Headwaters	Alder Creek	1.67	1,695.29	665.20
Chehalis River Headwaters	Big Creek	3.23	1,877.99	541.95
Chehalis River Headwaters	Big Roger Creek	3.08	2,086.24	718.87
Chehalis River Headwaters	Browns Creek	1.01	1,098.80	529.95
Chehalis River Headwaters	Cannonball Creek	1.32	640.85	341.78
Chehalis River Headwaters	Cinnabar Creek	3.18	2,216.97	921.83
Chehalis River Headwaters	Crim Creek	8.84	2,336.22	442.12
Chehalis River Headwaters	East Fork Chehalis River	8.47	1,591.79	846.30
Chehalis River Headwaters	Fronia Creek	1.05	635.73	390.26
Chehalis River Headwaters	George Creek	2.91	1,759.54	1,075.03
Chehalis River Headwaters	Hull Creek	1.02	889.68	476.21
Chehalis River Headwaters	Jones Creek	5.13	540.97	325.28
Chehalis River Headwaters	Katula Creek	2.27	484.17	352.20
Chehalis River Headwaters	Kowalski Creek	1.92	592.82	416.21
Chehalis River Headwaters	Lester Creek	5.01	1,796.33	514.60

Subbasin	Stream/Tributary	Length (Miles)	Upstream Elevation (ft)	Downstream Elevation (ft)
Chehalis River Headwaters	Little Roger Creek	2.02	1,834.84	718.87
Chehalis River Headwaters	Mack Creek	1.42	1,780.15	769.19
Chehalis River Headwaters	Mahaffey Creek	1.24	865.45	410.66
Chehalis River Headwaters	McCormick Creek	4.37	1,303.05	453.73
Chehalis River Headwaters	Robinson Creek	1.40	773.66	317.66
Chehalis River Headwaters	Rock Creek	8.00	1,724.00	360.18
Chehalis River Headwaters	Roger Creek	1.02	718.87	576.32
Chehalis River Headwaters	Sage Creek	1.83	1,752.45	1,025.89
Chehalis River Headwaters	Salmon Creek	1.93	1,010.22	675.31
Chehalis River Headwaters	Sand Creek	2.70	665.86	464.93
Chehalis River Headwaters	Shields Creek	1.87	609.13	331.61
Chehalis River Headwaters	Smith Creek	1.13	1,507.16	611.94
Chehalis River Headwaters	Stowe Creek	5.59	1,131.03	355.00
Chehalis River Headwaters	Thrash Creek	4.32	2,124.16	706.37
Chehalis River Headwaters	Water Mill Creek	2.55	701.27	378.67
Chehalis River Headwaters	West Fork Chehalis River	8.70	1,932.61	846.30
Elk Creek	Brush Creek	1.64	656.83	508.37
Elk Creek	Deer Creek	4.55	1,857.49	324.01
Elk Creek	Eight Creek	7.27	1,754.90	376.66
Elk Creek	Elk Creek	16.42	687.00	290.08
Elk Creek	Fourth Creek	2.48	570.65	475.36
Elk Creek	Little Elk Creek	4.31	712.92	487.19
Elk Creek	Nine Creek	5.02	1,319.87	352.35
Elk Creek	Seven Creek	3.58	1,551.82	372.37
Elk Creek	Smith Creek	4.51	1,775.71	436.14
Elk Creek	Swem Creek	5.05	1,667.53	455.03
Lower Chehalis River #1	Chehalis River	0.19	43.49	39.28
Middle Chehalis River #1	Coal Creek	4.02	505.38	174.56
Middle Chehalis River #1	Coal Creek	2.79	296.30	158.90
Middle Chehalis River #1	Dillenbaugh Creek	9.16	532.88	161.18
Middle Chehalis River #1	Eagle Creek	3.25	333.34	145.08
Middle Chehalis River #1	Lincoln Creek	11.73	217.22	138.65
Middle Chehalis River #1	North Fork Lincoln Creek	6.22	1,947.96	217.22
Middle Chehalis River #1	Scammon Creek	5.69	412.51	152.08
Middle Chehalis River #1	South Branch Scammon Creek	1.46	413.29	198.62
Middle Chehalis River #1	South Fork Lincoln Creek	6.50	1,996.69	217.22
Middle Chehalis River #1	Sponenbergh Creek	2.38	300.72	157.77
Middle Chehalis River #1	Wildcat Creek	3.24	1,389.25	284.13
Middle Chehalis River #2	Bloomquist Creek	2.56	427.68	138.26
Middle Chehalis River #2	Bozy Creek	4.70	1,419.26	476.54

Subbasin	Stream/Tributary	Length (Miles)	Upstream Elevation (ft)	Downstream Elevation (ft)
Middle Chehalis River #2	Gaddis Creek	4.26	584.40	45.90
Middle Chehalis River #2	Garrard Creek	10.97	1,402.91	73.49
Middle Chehalis River #2	Gibson Creek	5.47	1,210.85	50.94
Middle Chehalis River #2	Hell Creek	3.81	1,827.50	470.01
Middle Chehalis River #2	Iron Creek	2.27	1,559.06	545.56
Middle Chehalis River #2	Jamaica Day Creek	2.03	706.58	50.31
Middle Chehalis River #2	Kellogg Creek	2.23	513.13	160.07
Middle Chehalis River #2	North Fork Porter Creek	7.68	1,509.62	335.52
Middle Chehalis River #2	Porter Creek	5.59	335.52	38.58
Middle Chehalis River #2	Prairie Creek	5.32	299.33	131.87
Middle Chehalis River #2	Rock Creek	11.49	975.71	55.82
Middle Chehalis River #2	Scatter Creek	21.18	439.16	113.28
Middle Chehalis River #2	South Fork Garrard Creek	6.79	1,615.33	105.98
Middle Chehalis River #2	South Fork Porter Creek	5.69	1,885.80	335.52
Middle Chehalis River #2	Swan Creek	3.61	1,716.77	620.00
Middle Chehalis River #2	Thurston Creek	2.78	1,597.80	307.30
Middle Chehalis River #2	West Fork Porter Creek	7.24	1,678.88	199.08
Middle Chehalis River #2	Williams Creek	6.02	379.34	78.32
Newaukum River	Berwick Creek	7.21	580.55	195.89
Newaukum River	Lost Creek	2.60	611.97	512.71
Newaukum River	Middle Fork Newaukum River	10.60	1,267.59	284.70
Newaukum River	Newaukum River	11.33	266.61	163.31
Newaukum River	North Fork Newaukum River	20.43	1,920.18	266.61
Newaukum River	South Fork Newaukum River	27.62	2,978.97	266.61
North Fork Newaukum River	Bear Creek	1.08	748.76	401.01
North Fork Newaukum River	Lucas Creek	7.20	1,233.74	346.93
North Fork Newaukum River	Mitchell Creek	4.81	1,734.88	456.65
Salzer Creek	Salzer Creek	11.32	493.71	157.36
Skookumchuck River	Baumgard Creek	2.01	1,337.63	517.15
Skookumchuck River	Bigwater Creek	2.28	2,958.29	1,407.07
Skookumchuck River	Bloody Run	3.20	1,168.89	337.77
Skookumchuck River	China Creek	2.53	296.70	188.78
Skookumchuck River	Coal Creek	2.46	472.49	303.70
Skookumchuck River	Coffee Creek	4.35	374.91	204.40
Skookumchuck River	Deer Creek	1.13	2,863.16	1,940.06
Skookumchuck River	Drop Creek	1.76	2,454.92	1,299.29
Skookumchuck River	Dry Creek	2.93	145.55	142.41
Skookumchuck River	Eleven Creek	3.49	2,441.85	864.64
Skookumchuck River	Fall Creek	3.22	1,961.92	484.23
Skookumchuck River	Hanaford Creek	16.87	1,847.01	188.37

Subbasin	Stream/Tributary	Length (Miles)	Upstream Elevation (ft)	Downstream Elevation (ft)
Skookumchuck River	Hospital Creek	2.41	1,843.03	748.58
Skookumchuck River	Houser Creek	1.47	2,253.20	1,047.19
Skookumchuck River	Johnson Creek	4.85	382.70	302.24
Skookumchuck River	Laramie Creek	1.98	1,026.37	612.53
Skookumchuck River	North Hanaford Creek	7.23	551.86	197.28
Skookumchuck River	Packwood Creek	5.47	447.97	207.24
Skookumchuck River	Pheeny Creek	2.60	2,215.85	890.47
Skookumchuck River	Range Creek	2.20	2,918.39	1,354.26
Skookumchuck River	Run Creek	1.28	983.53	581.61
Skookumchuck River	Salmon Creek	3.88	962.48	296.87
Skookumchuck River	Skookumchuck River	42.31	2,912.17	156.31
Skookumchuck River	Snyder Creek	5.40	574.80	215.01
Skookumchuck River	South Hanaford Creek	9.04	390.89	200.45
Skookumchuck River	Thompson Creek	8.46	1,947.39	300.88
Skookumchuck River	Three Deer Creek	2.18	2,293.09	940.97
Skookumchuck River	Three Forks Creek	1.27	2,733.76	1,648.60
Skookumchuck River	Twelve Creek	1.90	1,477.11	1,006.46
South Fork Chehalis River	Beaver Creek	2.27	431.18	236.97
South Fork Chehalis River	Black Creek	3.75	507.35	366.57
South Fork Chehalis River	Bull Pen Creek	1.62	453.26	324.37
South Fork Chehalis River	Cedar Creek	2.71	529.66	348.86
South Fork Chehalis River	Foster Creek	1.24	1,156.64	316.52
South Fork Chehalis River	Halfway Creek	6.35	621.18	300.99
South Fork Chehalis River	Hanlan Creek	4.66	1,564.59	657.73
South Fork Chehalis River	Keller Creek	2.88	1,228.75	419.04
South Fork Chehalis River	Laughlin Creek	1.58	512.59	383.63
South Fork Chehalis River	Lentz Creek	2.19	488.65	320.69
South Fork Chehalis River	Little Mill Creek	2.73	1,777.05	388.04
South Fork Chehalis River	Lost Creek	4.94	620.27	252.72
South Fork Chehalis River	Neiman Creek	1.88	438.67	303.77
South Fork Chehalis River	Newland Creek	1.54	1,134.39	335.56
South Fork Chehalis River	Root House Creek	1.57	1,178.18	322.03
South Fork Chehalis River	Sep Creek	1.81	884.55	344.34
South Fork Chehalis River	Slide Creek	1.67	905.15	334.78
South Fork Chehalis River	Slide Creek	3.47	1,540.41	370.44
South Fork Chehalis River	Stillman Creek	15.47	2,055.31	244.01
South Fork Chehalis River	Trout Creek	1.74	1,265.99	493.74
South Fork Chehalis River	Water Creek	1.44	1,396.95	326.66
South Fork Chehalis River	West Fork Stillman Creek	3.92	1,954.06	642.14
South Fork Newaukum River	Beaver Creek	4.35	2,153.12	790.02
South Fork Newaukum River	Bernier Creek	3.57	1,666.34	801.78

Subbasin	Stream/Tributary	Length (Miles)	Upstream Elevation (ft)	Downstream Elevation (ft)
South Fork Newaukum River	Frase Creek	2.14	1,373.28	728.23
South Fork Newaukum River	Kearney Creek	5.51	1,493.56	656.60
Upper Chehalis River	Absher Creek	1.88	942.21	282.53
Upper Chehalis River	Barney Creek	2.23	648.02	283.12
Upper Chehalis River	Bunker Creek	13.26	842.06	192.99
Upper Chehalis River	Byron Creek	1.35	410.56	300.59
Upper Chehalis River	Capps Creek	2.18	1,183.90	302.33
Upper Chehalis River	Carson Creek	0.91	392.08	269.10
Upper Chehalis River	Deep Creek	2.08	628.00	326.30
Upper Chehalis River	Deep Creek	6.54	426.20	197.82
Upper Chehalis River	Dell Creek	2.84	409.49	248.47
Upper Chehalis River	Dunn Creek	5.35	1,815.74	280.19
Upper Chehalis River	Garret Creek	2.31	550.15	241.98
Upper Chehalis River	Hope Creek	4.77	517.15	258.78
Upper Chehalis River	Lake Creek	10.71	545.05	216.19
Upper Chehalis River	Marcuson Creek	3.69	588.94	268.81
Upper Chehalis River	Mill Creek	5.87	441.49	173.11
Upper Chehalis River	Moquet Creek	1.39	360.96	274.99
Upper Chehalis River	Nicholson Creek	1.62	555.33	243.68
Upper Chehalis River	Prairie Creek	2.99	456.16	244.35
Upper Chehalis River	Rudolph Creek	1.18	438.47	266.49
Upper Chehalis River	Shaw Creek	1.54	358.97	278.62
Upper Chehalis River	South Fork Chehalis River	30.55	1,311.99	206.59
Upper Chehalis River	Stearns Creek	10.40	446.65	165.45
Upper Chehalis River	Tapp Creek	2.09	537.28	240.15
Upper Chehalis River	Van Ornum Creek	2.20	483.27	184.05
Upper Chehalis River	West Fork Stearns Creek	3.47	655.42	193.96
Upper Chehalis River	Wisner Creek	0.94	479.62	261.68

APPENDIX D

Prior Studies Detailed Evaluation

This appendix presents a complementary summary of prior study findings, organized according to water quality variation along the Chehalis River mainstem, major tributaries, and subbasin-level conditions within the study area. A summary of these findings was already included in Section 5.3 of the main text.

Water Quality Parameters Variation over Chehalis River Mainstem

Historical data from three mainstem stations, Dryad, Porter, and Montesano, were used by prior studies to compare water quality parameters across wet and dry seasons, along the river's course. To summarize those studies, each water quality parameter is discussed in the following individually, with TP, IN, and TSS data from the most recent decade in the time of the studies used to estimate loading and yield[6] at four mainstem and two tributary stations.

- **Temperature –** Under the Clean Water Act, heat was regulated as a pollutant, and in the Upper Chehalis, temperature standard exceedances were caused primarily by solar radiation reaching surface waters (Ecology, 2001). Reduced riparian shade was the primary cause of elevated temperatures due to increased solar exposure. Average dry season temperatures generally approached but do not exceed the 18°C criterion for Class A; however, localized exceedances were documented, notably in the Centralia Reach (RM 65.8–75.2) where summer thermal stratification limited mixing and raised temperature to 19–20°C (Ecology, 2001). No significant long-term temperature trends were detected over the 30 years. However, temperature monitoring data from the Upper Chehalis, collected by Ecology's Ambient Monitoring Program at ten stations between October 1991 and September 1998, revealed clear seasonal patterns in water temperature. Figure D1 shows that average dry season (August through October) temperatures approached the water quality criterion set by the State of Washington to protect salmon, while remaining relatively consistent by river mile. Over three decades, no statistically significant temperature changes were observed. Although average temperatures did not exceed criteria, several tributaries recorded frequent exceedances above 18°C during low flows and summers. These elevated temperatures were linked to riparian canopy loss (Wampler et al., 1993) and were highest in the Centralia Reach, where summer stratification limited mixing. These exceedances prompted the Upper Chehalis temperature TMDL (Butkus, 1999).

[6] Pollutant yields represent loads adjusted for the contributing land area, allowing better comparisons across watersheds.

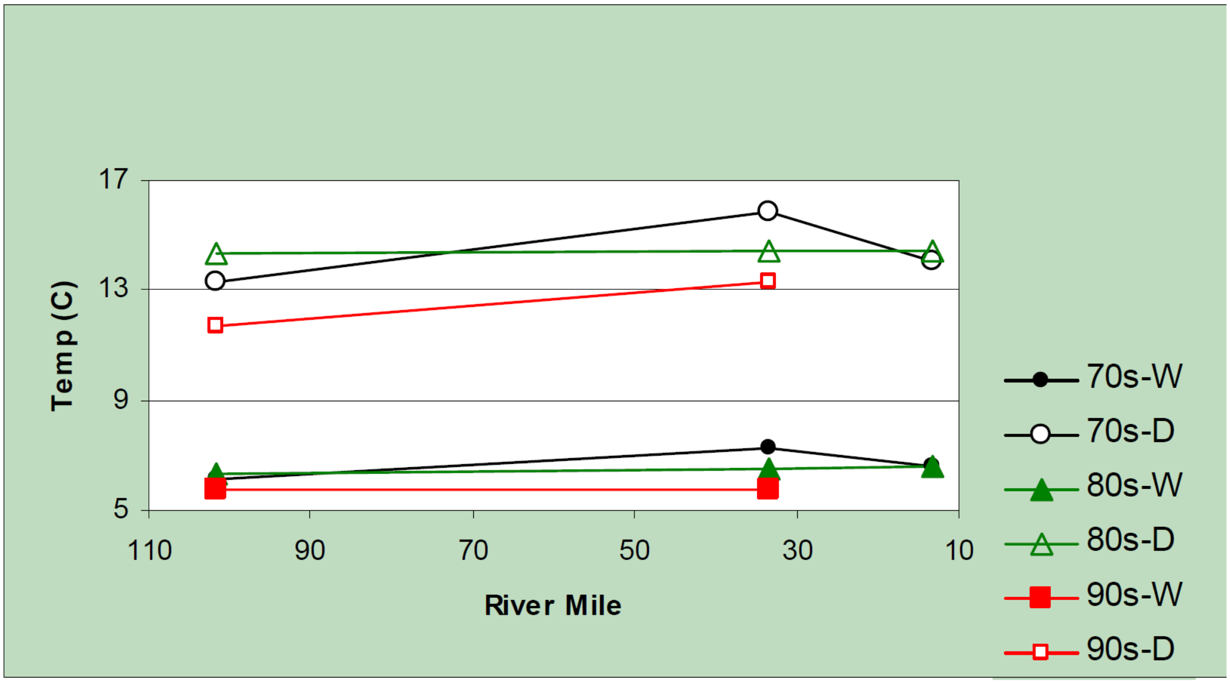


Figure D1 3-Year Mean temperatures along Chehalis River; W: wet period - November 1 through March 31; D: dry period - August 1 and October 31 (Chehalis Basin Partnership, 2000).

- **Dissolved Oxygen -** DO is essential for aquatic life and overall water quality. Low DO levels, which are often caused by pollutant discharge, nutrient runoff, or organic matter decay, can stress or kill fish and other organisms. Figure D2 shows that DO concentrations were lower during the dry season but mostly remained above the 8.0 mg/L Class A criterion (previously used WA standard). However, some locations, particularly in the Centralia Reach, fell below the criterion because of stratification and oxygen depletion with depth. Only Dryad and Montesano consistently met the standard. While no significant differences were observed across decades, dry season exceedances led to a TMDL recommending reductions in BOD, ammonia-N, and TP (Pickett, 1994). DO concentrations were seasonally depressed during summer low flows. Otherwise, during non-dry seasons, DO levels were typically above the 8.0 mg/L standard. The Centralia Reach regularly experienced substandard DO levels, occasionally falling below 5.0 mg/L, triggering site-specific criteria and TMDL recommendations for oxygen-demanding pollutant reductions due to stratification and elevated BOD (Jennings and Pickett, 2000).

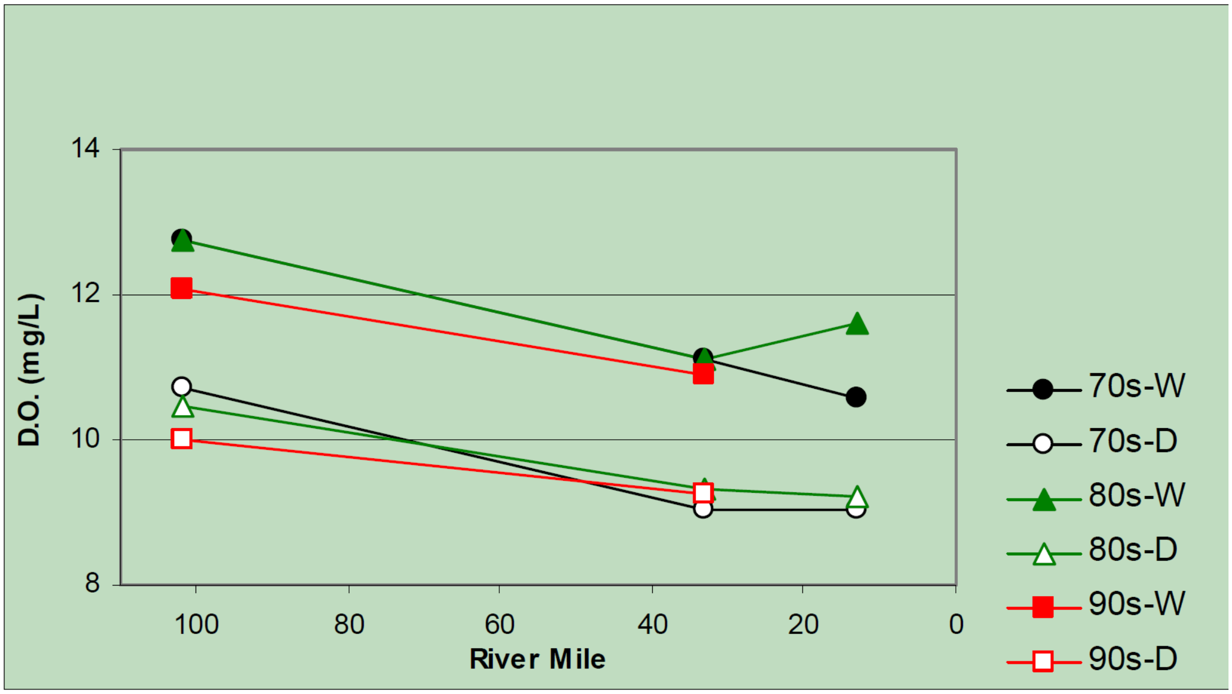


Figure D2 3-Year mean DO along Chehalis River; W: wet period - November 1 through March 31; D: dry period - August 1 and October 31 (Chehalis Basin Partnership, 2000).

- **Total Phosphorus -** TP and also IN (inorganic nitrogen, see below) are key nutrients that, in excess, can fuel harmful algal blooms and excessive aquatic plant growth. This leads to oxygen depletion, disrupting aquatic ecosystems and harming fish and wildlife. TP concentrations (Table D1) peaked between RM 77.7 and RM 67.5 in the Centralia Reach, exceeding the EPA's 0.05 mg/L guideline. TP loads were generally higher in the wet season due to increased flow and particulate sorption of Phosphorus, but trends by river mile or decade were not statistically significant (Figure D3). TP loads from the 1990s were further assessed using USGS flows at four mainstem stations, including Prather Road, and showed downstream increases (Figure D4). TP yields were highest at Montesano (Table D2) and comparable to other Puget Sound basins (Embry and Inkpen, 1998).
  In the Chehalis Basin, TP yields were relatively consistent along the mainstem, with the highest yield at Montesano. TP levels also peaked between RM 67.5 and RM 77.7 in the Centralia Reach, with several measurements above 0.1 mg/L during high flows, exceeding the 0.05 mg/L guideline and indicating potential phosphorus-driven eutrophication.

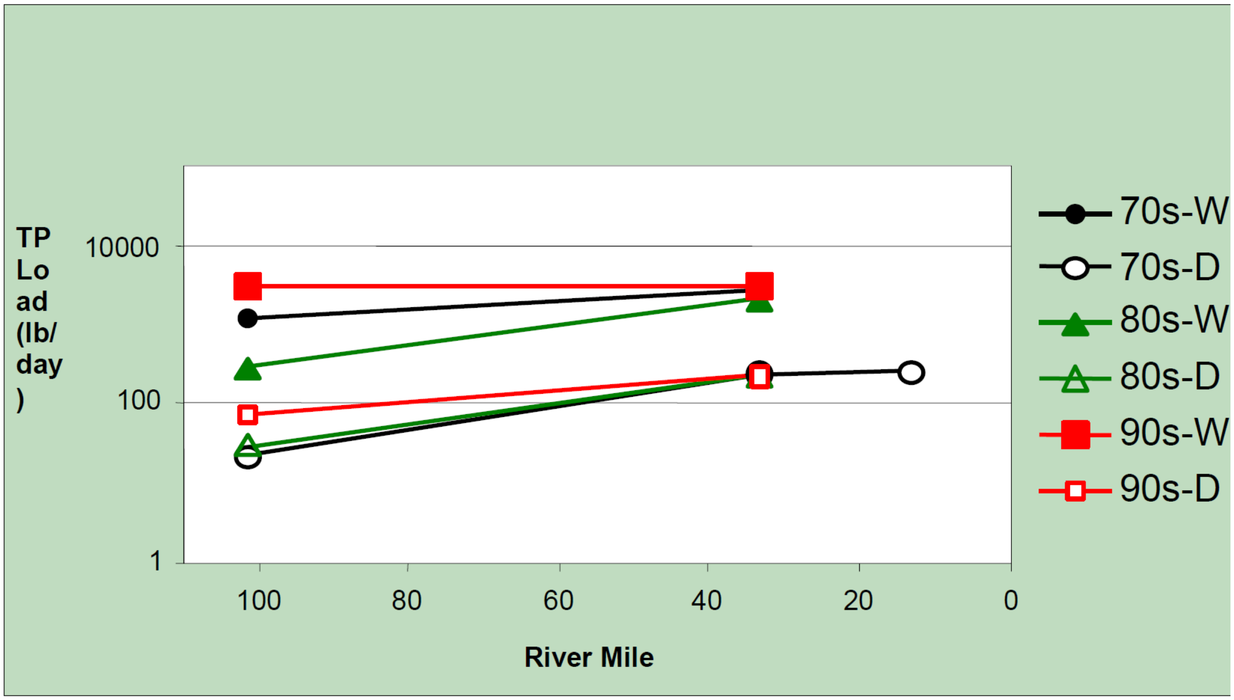


Figure D3 3-Year mean TP loads along Chehalis River; W: wet period - November 1 through March 31; D: dry period - August 1 and October 31 (Chehalis Basin Partnership, 2000).

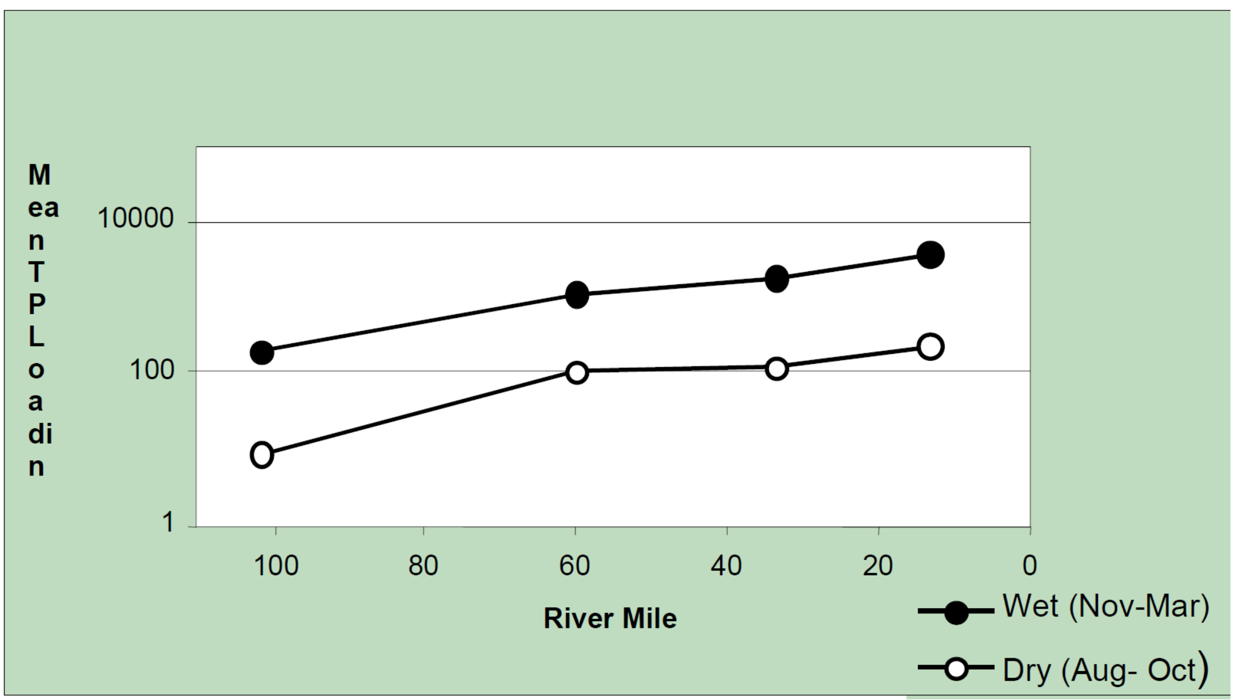


Figure D4 Chehalis River mean TP loading in 90s (Chehalis Basin Partnership, 2000).

- **Inorganic Nitrogen-** IN concentrations increased downstream but generally remained below the national background thresholds of 0.1 mg/L ammonia-N and 0.7 mg/L nitrate+nitrite-N (Ahmed and Rountry, 2004; Chehalis Basin Partnership, 2009; Jennings and Pickett, 2000). IN yields increased downstream (Table D2) along the mainstem. Ammonia-N was highest at Centralia Reach. Nitrate+nitrite-N peaked at Porter but remained below the 0.7 mg/L background threshold (Ecology, 2003). Ammonia-N was highest at Centralia Reach, exceeding the USGS reported background level of 0.1 mg/L (Mueller & Helsel, 1996).

Table D1 Ambient water quality parameters (average and maximum or minimum) – 1990s data (Chehalis Basin Partnership, 2000).

River Mile	Location (Subbasin #)	Temp (°C)		DO (mg/l)		TP (mg/l)		NH_3 (mg/l)		NO_{2+3} (mg/l)		TSS (mg/l)		FC^2 (cfu/100 ml)	
		ave	max	ave	min	ave	max	ave	max	ave	max	ave	max	ave	max
Mainstem															
101.7	Dryad (1)	10.3	24.5	11.1	8.0	0.03	0.36	0.01	0.08	0.30	0.96	26	782	33	2,800
77.7	Claquato[1] (4)	10.2	20.1	10.2	7.5	0.09	0.41	0.02	0.04	0.46	0.87	20	102	61	730
67.5	Centralia (10)	12.1	21.3	9.7	5.4	0.08	0.38	0.06	0.58	0.48	1.1	16	109	47	1,000
59.9	Prather Rd. (10)	11.2	22.1	10.0	7.2	0.06	0.14	0.03	0.12	0.59	0.86	15	118	37	1,500
33.3	Porter (13)	11.4	22.1	10.1	7.1	0.05	0.19	0.02	0.08	0.68	2.13	13	95	29	1,300
13.15	Montesano (30)	12.2	20.5	10.0	8.4	0.04	0.17	0.03	0.04	0.46	0.74	14	131	43	790

[1] Sampled only in 1970's
[2] Fecal coliform average is geometric mean

Table D2 TP loading and yield and IN yield along Chehalis mainstem – 1990s data (Chehalis Basin Partnership, 2000).

River Mile / Season	Location	TP Loading (lb/day) Wet	TP Loading (lb/day) Dry	TP Yield ($tons/yr\text{-}mi^2$) Wet	TP Yield ($tons/yr\text{-}mi^2$) Dry	TP Yield ($tons/yr\text{-}mi^2$) Ave. Annual*	IN Yield ($tons/yr\text{-}mi^2$) Ave. Annual*
Mainstem							
101.7	Dryad	197	8.7	0.31	0.01	0.14	1.4
59.9	Prather Rd.	1,099	105	0.23	0.02	0.12	1.5
33.3	Porter	1,851	126	0.26	0.02	0.13	1.9
13.15	Montesano	3,779	231	0.39	0.02	0.18	2.2

Average annual yield calculations based on all data available for 1990's

- **Total Suspended Solids –** TSS consists of fine particles suspended in water that can increase turbidity, harm aquatic habitats, carry attached pollutants, and alter water temperature conditions. TSS concentrations and yields were highest upstream of Dryad Station during wet seasons, linked to forestry runoff and unstable riparian zones. Porter had the lowest (Table D1). Wet season TSS loads exceeded dry season loads, as expected due to wet season soil saturation, erosion, and sediment runoff (Figure D5). No statistically significant trends were observed over three decades, but episodic high sediment events degrade water clarity and habitat quality (Chehalis Basin Partnership, 2000). Based on annual and seasonal yields, TSS yield was highest above Dryad particularly in case of wet season yield (Table D3), while other stations showed similar annual yields. Dryad is the most upstream ambient station and recorded higher TSS yields during frequent and intense precipitation events over steeper headwater slopes.

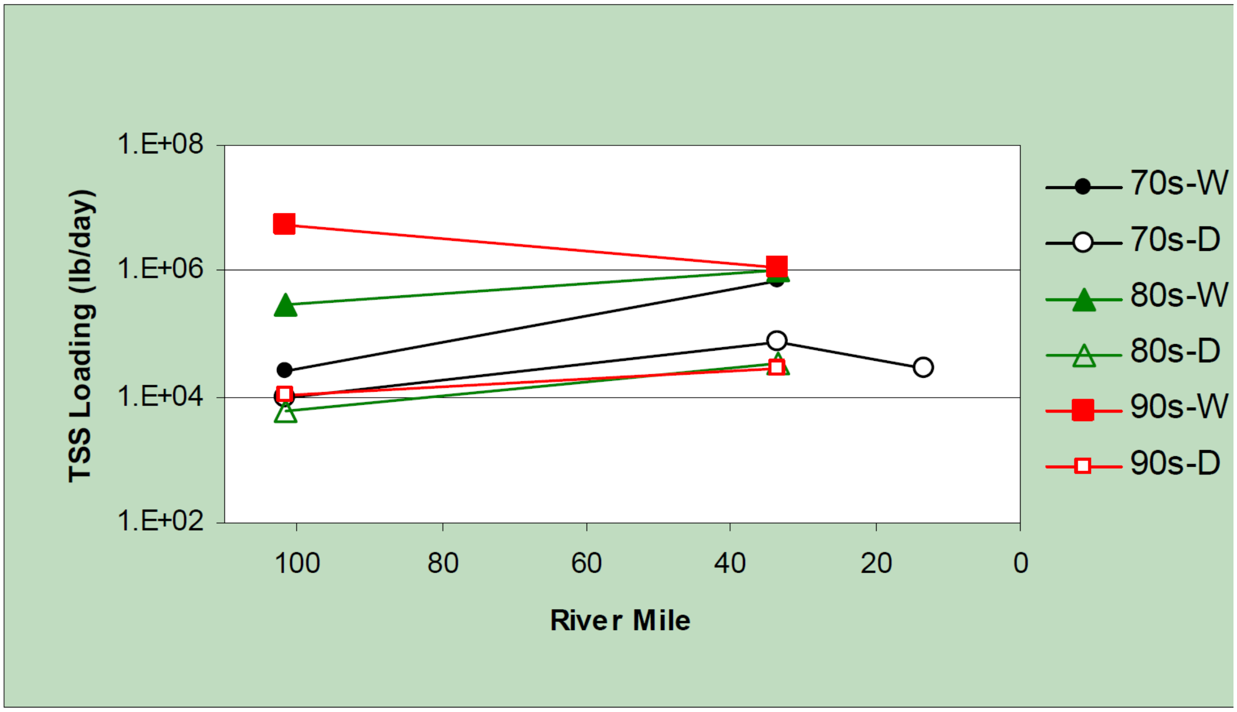


Figure D5 3-Year mean TSS loads along Chehalis River; W: wet period - November 1 through March 31; D: dry period - August 1 and October 31 (Chehalis Basin Partnership, 2000).

Table D3 TSS yield along Chehalis mainstem – 1990s data (Chehalis Basin Partnership, 2000).

River Mile	Location	TSS Yield (tons/yr-mi^2)		TSS Yield (tons/yr-mi^2)
Season		Wet	Dry	Ave. Ann.*
Mainstem				
101.7	Dryad	343	2.3	143
59.9	Prather Rd.	90	1.1	42
33.3	Porter	107	1.3	49
13.15	Montesano	93	30	48

* Average annual yield calculations based on all data available for 1990's

- **Fecal Coliform** - FC bacteria, including *E. coli*, indicate fecal contamination from humans, livestock, wildlife, and pets. They enter waterways through discharge, runoff, agriculture, and failing septic systems. Though not harmful themselves, their presence signals potential pathogens and health risks. Their survival depends on temperature, pH, nutrients, ammonia, UV exposure, and microbial predation.
  While geometric mean concentrations met the 100 cfu/100 mL criterion, maximum values at all stations exceeded the 200 cfu/100 mL threshold, particularly at Dryad and Prather Road (Table D1). FC loadings, influenced by higher wet season flows, showed no significant spatial or temporal trends in mainstem rivers (Figure D6). Wet weather events caused spikes in FC concentrations with maxima exceeding 500 cfu/100 mL at monitoring locations such as Dryad and Prather (Ahmed and Rountry, 2004). Geometric mean concentrations of FC generally were near 100 cfu/100 mL which complied with standards (i.e., 200 cfu/100 mL), indicating episodic bacterial pollution. For example, monitoring at Ecology Station 23A120 over the mainstem showed historical 90th-percentile exceedances, peaking at 763 cfu/100 mL, requiring 74% target reduction.

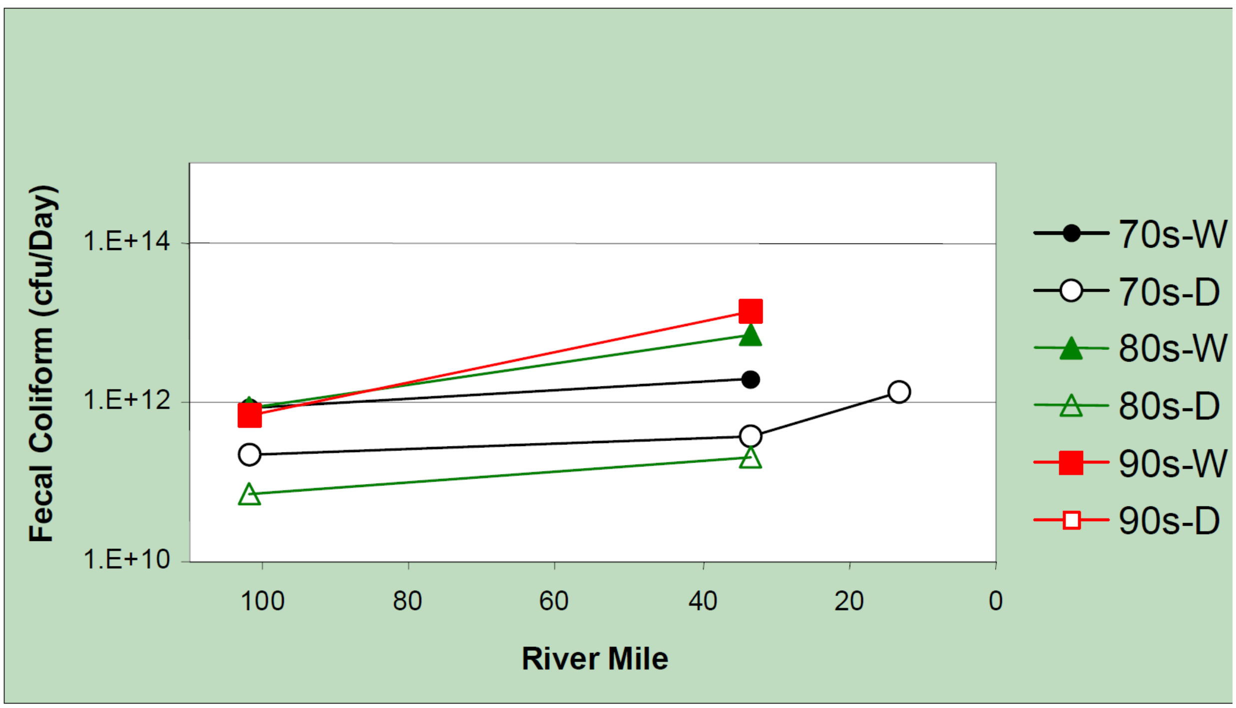


Figure D6 3-Year geometric mean FC loads along Chehalis River; W: wet period - November 1 through March 31; D: dry period - August 1 and October 31 (Chehalis Basin Partnership, 2000).

Figure D7 to Figure D9 also illustrate the Freshwater Quality Index (FWQI) scores calculated by Ecology at three mainstem stations along the upper Chehalis River, from upstream to downstream (Ecology, 2025a): Dryad (RM 101.7), Prather (RM 59.9), and Porter (RM 33.8). Both monthly and yearly FWQI scores are shown for each station. FWQI is a composite, unitless metric used to summarize overall stream water quality, with values ranging from 1 to 100 and higher scores indicating better conditions. The index integrates measurements of several parameters, such as temperature, pH, DO, fecal indicator bacteria, nutrients, and suspended sediment, by evaluating each relative to applicable state criteria or expected background conditions for the region and aggregating them into a single score for each monitoring site (Ecology, 2002).

Moving downstream from the Dryad monitoring station to mid-basin Prather Rd. station, the frequency of poor water quality conditions increased as pollutants accumulated and were transported through the river system. Phosphorus, nitrogen, TSS, and turbidity were especially critical, with the worst conditions observed at the most downstream station on the Upper Chehalis River (Porter station). However, phosphorus and nitrogen index scores were generally improved over time at this station, most likely due to mitigation measures and TMDLs. Additionally, oxygen, pH, and temperature generally showed improvement across all stations. Moderate FC index scores were also noted at the sampling sites. Seasonal variation was also evident, with April and May consistently displaying the best monthly overall water quality scores. April and May were the period during which groundwater discharge to the river was likely highest.

Yearly overall scores

Water Year	Score	Flow Adjusted Score	Data Status
2025	74		Final
2019	44		Final
2018	47	57	Final
2017	59		Final
2016	53	69	Final
2015	53	59	Final
2014	63		Final
2013	65	64	Final
2012	72	54	Final
2011	52	67	Final
2010	69	69	Final
2009	65	67	Final
2008	51	56	Final
2007	74	76	Final
2006	68	66	Final
2005	70	69	Final
2004	61	62	Final
2003	59	44	Final
2002	36	60	Final
2001	66	65	Final
2000	66	78	Final
1999	56	56	Final
1998	46	56	Final
1997	54	61	Final

lavender - good pale yellow - moderate red - poor
blank - not sampled or calculated
higher scores -> better water quality
maximum possible score: 100

Yearly parameter scores

Water Year	Fecal Coliform Bacteria	Oxygen	pH	Suspended Solids	Temperature	Total Persulf Nitrogen	Total Phosphorus	Turbidity	Data Status
2025		99	98		98	55			Final
2019	77	91	98	56	87	41		62	Final
2018	71	92	98	56	88	58		65	Final
2017	84	93	98	62	90	46		71	Final
2016	83	89	98	56	85	47		60	Final
2015	85	85	99	70	85	54		75	Final
2014	87	89	97	81	87	70		85	Final
2013	76	92	98	83	89	82	73	83	Final
2012	84	91	99	77	90	74	75	81	Final
2011	71	93	97	53	91	67	46	55	Final
2010	82	98	98	68	96	67	64	67	Final
2009	82	95	95	66	84	72	59	62	Final
2008	80	89	97	41	89	72	44	48	Final
2007	78	97	95	77	87	69	83	79	Final
2006	82	93	97	83	85	67	78	86	Final
2005	88	96	92	77	84	52	82	84	Final
2004	86	94	91	67	83	52	76	81	Final
2003	85	94	95	82	84	45	59	85	Final
2002	69	94	96	61	83	34	41	72	Final
2001	72	91	99	81	89	50	62	83	Final
2000	74	95	96	67	89	78	45	72	Final
1999	81	89	98	37	94	58	24	42	Final
1998	79	91	95	72	86	56	49	70	Final
1997	78	91	97	72	92	41	47	76	Final

lavender - good pale yellow - moderate red - poor
blank - not sampled or calculated
higher scores -> better water quality
maximum possible score: 100

a. Yearly freshwater quality indices

Figure D7 Freshwater quality indices in Dryad Station (Ecology, 2025a).

Monthly overall scores

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Data Status
2025	87	69		87									Final
2019	95	57	48	80	86	91	95	88	75	70	71	26	Final
2018	96	30	86	72	87	90	81	84	84	83	59	51	Final
2017	37	71	78	79	72	82	90	87	80	80	69	80	Final
2016	88	24	67	77	84	86	87	91	70	75	73	88	Final
2015	57	88	72	84	97	63	87	92	50	51	65	78	Final
2014	85	91	85	83	98	88	94	92	72	58	70	60	Final
2013	89	98	96	97	98	98	96	91	54	73	80	68	Final
2012	14	93	96	95	97	77	94	92	93	77	63	84	Final
2011	62	71	100	95	94	94	94	94	88	72	83	71	Final
2010	87	66	93	76	98	96	95	90	85	76	82	76	Final
2009	96	98	52	94	84	62	91	89	74	74	69	78	Final
2008	76	81	97	83	93	82	96	80	69	43	57	78	Final
2007	81	97	99	99	100	96	96	95	84	67	79	85	Final
2006	89	98	96	96	97	99	99	84	85	52	79	72	Final
2005	82	52	97	96	99	89	96	89	71	68	72	83	Final
2004	98	92	54	87	97	92	95	84	74	66	65	96	Final
2003	13	47	86	93	96	84	95	87	61	63	75	76	Final
2002	69	89	95	91	98	98	95	80	48	69	66	81	Final
2001	75	88	53	92	96	84	85	88	62	76	68	69	Final
2000	91	95	43	91	96	97	95	93	70	90	85	93	Final
1999	26	72	81	97	58	86	92	94	86	72	66	95	Final
1998	95	50	78	76	95	94	92	94	67	44	77	84	Final
1997	88	38	92	85	83	87	89	93	82	67	77	45	Final

lavender - good pale yellow - moderate red - poor
blank - not sampled or calculated
higher scores -> better water quality
maximum possible score: 100

a. Monthly freshwater quality indices

Figure D7 (Continued) Freshwater quality indices in Dryad Station (Ecology, 2025a).

Yearly overall scores

Water Year	Score	Flow Adjusted Score	Data Status
2005	48	31	Final
2004	32	61	Final
2003	52	70	Final
2002	52		Final
1997	43		Final

lavender - good pale yellow - moderate red - poor
blank - not sampled or calculated
higher scores -> better water quality
maximum possible score: 100

Yearly parameter scores

Water Year	Fecal Coliform Bacteria	Oxygen	pH	Suspended Solids	Temperature	Total Persulf Nitrogen	Total Phosphorus	Turbidity	Data Status
2006		94	95		92				Final
2005	81	93	95	63	88	34	42	67	Final
2004	75	93	96	48	85	39	29	51	Final
2003	83	97	94	75	86	38	34	80	Final
2002	85	96	97	73	86	35	34	76	Final
1997	69	93	94	66	91	21	31	63	Final

lavender - good pale yellow - moderate red - poor
blank - not sampled or calculated
higher scores -> better water quality
maximum possible score: 100

a. Yearly freshwater quality indices

Figure D8 Freshwater quality indices in Prather Station (Ecology, 2025a).

Monthly overall scores

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Data Status
2006	44	93	76										Final
2005	1	79	54	75	81	56	87	85	66	50	50	64	Final
2004	66	48	81	88	93	90	82	87	51	58	43	69	Final
2003	61	60	62	78	85	74	80	94	69	56	53	60	Final
2002	61	60	62	59	72	81	68	91	47	58	51	64	Final
1997	63	5	65	72	59	66	82	88	60	63	43	54	Final

lavender - good pale yellow - moderate red - poor
blank - not sampled or calculated
higher scores -> better water quality
maximum possible score: 100

b. Monthly freshwater quality indices

Figure D8 (Continued) Freshwater quality indices in Prather Station (Ecology, 2025a).

Yearly overall scores

Water Year	Score	Flow Adjusted Score	Data Status
2025	63		Final
2019	39	73	Final
2018	53	55	Final
2017	45		Final
2016	40	57	Final
2015	50	52	Final
2014	59		Final
2013	62	51	Final
2012	54	45	Final
2011	41	55	Final
2010	45	54	Final
2009	57	60	Final
2008	59	64	Final
2007	61	57	Final
2006	58	51	Final
2005	47	46	Final
2004	37	54	Final
2003	52	53	Final
2002	49	50	Final
2001	53	56	Final
2000	50	57	Final
1999	51	50	Final
1998	45	47	Final
1997	47	47	Final

lavender - good pale yellow - moderate red - poor
blank - not sampled or calculated
higher scores -> better water quality
maximum possible score: 100

Yearly parameter scores

Water Year	Fecal Coliform Bacteria	Oxygen	pH	Suspended Solids	Temperature	Total Persulf Nitrogen	Total Phosphorus	Turbidity	Data Status
2025	83	98	97		95			72	Final
2019	75	94	97	47	84	50		56	Final
2018	77	96	96	62	86	54		72	Final
2017	76	95	95	52	88	37		61	Final
2016	80	95	95	57	83	42		60	Final
2015	88	96	95	65	82	46		72	Final
2014	90	96	96	71	84	55		78	Final
2013	89	96	97	74	88	59	60	81	Final
2012	81	96	97	66	87	58	61	72	Final
2011	68	97	96	49	90	42	44	50	Final
2010	84	95	97	53	94	43	33	49	Final
2009	84	93	97	60	89	45	47	64	Final
2008	87	97	97	69	89	39	54	64	Final
2007	93	95	96	69	89	36	55	77	Final
2006	91	94	96	67	84	39	55	75	Final
2005	77	93	97	57	88	23	59	62	Final
2004	81	93	96	44	84	33	51	55	Final
2003	85	94	99	61	87	24	47	67	Final
2002	80	94	96	56	90	24	44	67	Final
2001	83	94	98	72	91	36	47	76	Final
2000	80	93	98	65	94	34	42	71	Final
1999	83	93	97	67	94	15	43	73	Final
1998	77	91	98	66	91	28	45	69	Final
1997	74	92	95	61	92	17	38	67	Final

lavender - good pale yellow - moderate red - poor
blank - not sampled or calculated
higher scores -> better water quality
maximum possible score: 100

a. Yearly freshwater quality indices

Figure D9 Freshwater quality indices in Porter Station (Ecology, 2025a).

Monthly overall scores

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Data Status
2025	67	62		77									Final
2019	68	35	33	81	81	86	86	91	73	61	66	49	Final
2018	71	46	81	97	79	83	66	83	74	74	60	52	Final
2017	22	59	65	90	64	75	85	57	58	64	57	69	Final
2016	67	21	48	60	73	77	68	81	65	51	66	79	Final
2015	45	80	65	79	68	47	77	87	66	62	58	81	Final
2014	56	81	79	77	99	76	82	85	61	71	60	65	Final
2013	34	87	80	80	83	90	85	84	62	75	65	59	Final
2012	3	80	85	82	87	73	73	84	72	65	62	81	Final
2011	62	31	77	87	76	73	71	62	78	57	73	75	Final
2010	78	55	56	71	89	87	82	92	50	74	79	54	Final
2009	69	91	49	69	74	60	76	75	75	65	77	72	Final
2008	69	58	85	76	75	75	84	90	64	78	64	78	Final
2007	50	85	92	90	87	84	91	95	74	63	73	64	Final
2006	29	93	71	77	75	82	83	81	65	59	81	72	Final
2005	12	88	70	76	90	49	81	85	73	63	77	79	Final
2004	68	68	84	81	93	92	86	92	67	69	44	55	Final
2003	56	53	61	41	76	62	76	83	69	53	61	70	Final
2002	48	57	82	57	74	78	46	86	48	62	65	60	Final
2001	61	52	41	87	81	78	81	80	70	67	55	59	Final
2000	69	61	77	76	74	83	82	83	73	56	56	64	Final
1999	57	49	69	55	58	65	79	82	50	59	47	60	Final
1998	50	54	56	56	44	71	85	78	56	41	88	77	Final
1997	55	42	56	80	64	57	74	75	47	48	48	48	Final

lavender - good pale yellow - moderate red - poor
blank - not sampled or calculated
higher scores -> better water quality
maximum possible score: 100

b. Monthly freshwater quality indices

Figure D9 (Continued) Freshwater quality indices in Porter Station (Ecology, 2025a).

Major Tributaries Conditions

Ambient monitoring data were available for several major tributaries in WRIA 23, including the South Fork Chehalis, Newaukum, Skookumchuck, and Black rivers. Key water quality parameters are summarized in Table D4.

- **Temperature -** Among all tributaries, the South Fork Chehalis had the lowest average temperature, while the Black River had the highest. Maximum temperatures in the Black River exceeded the water quality criterion. Dry season temperature exceedances in WRIA 23 tributaries also contributed to the Upper Chehalis Temperature TMDL (Butkus, 1999), which recommended increased riparian shading and prohibited further base flow reductions.

- **Dissolved Oxygen -** The Black River recorded the lowest average and minimum DO levels (Table D4). Widespread DO deficiencies were noted in WRIA 23 tributaries due to elevated BOD and nutrient inputs (Pickett, 1994). The Upper Chehalis TMDL identified areas, such as the Centralia Reach, with no remaining assimilative capacity for oxygen-depleting pollutants.
- **Total Phosphorus -** Average TP concentrations were highest in the South Fork Chehalis and Black rivers, with the Black River also showing the highest maximum value. TP loading and yield were evaluated for the Newaukum River [and Humptulips River in the Lower Chehalis] (Table D5). The Newaukum yield was similar to that of the Nisqually River.
- **Inorganic Nitrogen -** Ammonia-N was highest in the Black River, while the Hoquiam and Satsop had the lowest levels. Nitrate+nitrite-N concentrations were highest in the Newaukum River. In the South Fork Chehalis, Newaukum, and Skookumchuck rivers, average nitrate+nitrite-N concentrations approached the national background level of 0.7 mg/L (Mueller & Helsel, 1996), with maximum values exceeding it. IN yields were also highest in the Newaukum, surpassing those of Puget Sound rivers reported by Embry and Inkpen (Embry & Inkpen, 1998) (Table D6).
- **Total Suspended Solids -** Average TSS concentrations were highest in the Newaukum River.
- **Fecal Coliform -** The South Fork Chehalis had a geometric mean above the 100 cfu/100 mL criterion (Table D4), and maximum levels exceeded the 200 cfu/100 mL standard in all but the Satsop and Hoquiam rivers. The Black River recorded the highest maximum level at 1,200 cfu/100 mL. Implementation of TMDLs in the Black River (Coots, 1994) and Upper Chehalis (Pickett, 1994) were implemented to reduce FC exceedances in WRIA 23 tributaries.

Table D4 WDOE ambient monitoring water quality program (average and maximum or minimum) - 1990s data (except as noted) (Chehalis Basin Partnership, 2000).

River Mile	Location (Subbasin #)	Temp (°C)		DO (mg/l)		TP (mg/l)		NH_3 (mg/l)		NO_{2+3} (mg/l)		TSS (mg/l)		FC[2] (cfu/100 ml)	
		ave	max	ave	min	ave	max	ave	max	ave	max	ave	max	ave	max
Tributaries															
3.0	S. Fork Chehalis (3)	9.5	17.5	10.5	8.0	0.05	0.08	0.02	0.05	0.56	0.77	14	80	117	540
0.1	Newaukum (5-7)	10.8	17.2	10.6	8.7	0.03	0.05	0.02	0.03	0.61	1.60	27	90	78	760
2.3	Skookumchuck (9)	10.6	16.9	10.3	9.1	0.04	0.14	0.02	0.07	0.54	1.48	8	43	41	960
7.1	Black (11)	11.2	19.7	8.5	3.3	0.05	0.17	0.03	0.16	-	-	3	12	39	1,200
2.7	Satsop (15-18)	10.0	17.9	11.2	9.6	0.02	0.11	0.01	0.05	0.23	0.60	17	170	15	110
13.6	Wynoochee[1] (20)	10.9	21	11.3	9.0	0.03	0.09	0.07	0.24	-	-	-	-	13	70
12.3	Wishkah[1] (21)	10.4	18.5	11.0	9.4	0.02	0.11	0.04	0.09	-	-	-	-	10	110
9.3	Hoquiam (22-24)	9.7	15	11.1	9.7	0.01	0.02	0.01	0.07	0.13	0.43	2	4	10	51
23.6	Humptulips (25)	9.9	21	11.2	9.0	0.02	0.29	<0.01	0.04	0.11	0.34	17	344	8	290

1 Sampled only in 1970's
2 Fecal coliform is calculated as a geometric mean value.

Table D5 TP loading and yield and IN yield in Chehalis Tributaries – 1990s data (Chehalis Basin Partnership, 2000).

River Mile	Location	TP Loading (lb/day)		TP Yield (tons/yr-mi^2)		TP Yield (tons/yr-mi^2)	IN Yield (tons/yr-mi^2)
Season		Wet	Dry	Wet	Dry	Ave. Ann. **	Ave. Ann**
0.1	Newaukum	125	5.7	0.15	<0.01	0.08	2.03
23.6	Humptulips	292	20	0.41	0.03	0.20	1.15

** Average annual yield calculations based on all data available for 1990's

Table D6 Pollutant yields for Chehalis Basin mainstem and tributary stations (Embry & Inkpen, 1998).

River Mile	Location	TP Yield (tons/yr-mi^2)			TSS Yield (tons/yr-mi^2)			IN Yield (tons/yr-mi^2)[1]
Season		Wet	Dry	Average	Wet	Dry	Average	Average
101.7	Dryad	0.31	0.01	0.14	343	2.3	143	1.43
59.9	Prather Rd.	0.23	0.02	0.12	90	1.1	42	1.59
33.3	Porter	0.26	0.02	0.13	107	1.3	49	1.92
13.15	Montesano	0.39	0.02	0.18	93	30	48	2.22
0.1	Newaukum	0.15	<0.01	0.08	155	11.3	7.8	2.03
23.6	Humptulips	0.41	0.03	0.2	396	6.1	186	1.15

1 IN=inorganic nitrogen. This information is provided to allow comparisons to other basins in the Puget Sound

The Black River was characterized by elevated summer temperatures frequently exceeding 18°C, low DO with minimum values below 7.0 mg/L, and persistent FC levels exceeding state standards. The river experienced high TP and IN loads (Ammonia-N was highest in the Black River), primarily from dairy operations and pasture runoff and impaired riparian zones, resulting in documented fish kills and chronic impairment (Ahmed and Rountry, 2004; Chehalis Basin Partnership, 2009). The Black River also recorded the highest maximum FC level at 1,200 cfu/100 mL (Chehalis Basin Partnership, 2000).

Some tributaries in WRIA 23 such as the South Fork Chehalis, Newaukum, and Skookumchuck exhibited variable water quality, with temperature exceedances linked to riparian canopy loss or FC exceedances linked to agricultural land-uses. Average TP concentrations were the second highest in the South Fork Chehalis (after Black River). As noted earlier, Nitrate+nitrite-N concentrations were highest in the Newaukum River. In the South Fork Chehalis, Newaukum, and Skookumchuck rivers, average Nitrate+nitrite-N levels were close to the national background level, with some maximum values exceeding this threshold. Additionally, IN yields were greatest in the Newaukum River. WRIA 23 tributaries also showed significant DO deficiencies. The Upper Chehalis Temperature TMDL recommended increased shading and flow protection to mitigate these issues (Ecology, 2001).

Subbasin-Level Conditions

Water quality condition in each subbasin of WRIA 23 was previously outlined in Section 5 of the main text briefly. Although the Upper Basin has the majority of documented water quality problems, likely due to higher human activity, limited monitoring in the Lower Basin may underestimate issues there.

Review of the results of prior studies across the delineated subbasins highlighted variability in water quality conditions based on geography, land-use, and hydrology:

- Forested subbasins like Chehalis River Headwaters and Cedar Creek exhibited generally good water quality, with temperature rarely exceeding criteria, DO levels consistently above 8.0 mg/L, and low FC counts.
- Agricultural subbasins such as Newaukum and Black Rivers elevated FC concentrations (sometimes > 200 cfu/100 mL), increased nutrient concentrations (average TP up to 0.09 mg/L), and sporadic DO depressions related to organic loading associated with livestock and crop management (Ahmed and Rountry, 2004; Chehalis Basin Partnership, 2009). Elevated FC concentrations in the Newaukum and Black Rivers were strongly correlated with adjacent agricultural activities, including livestock access and manure management (Ahmed and Rountry, 2004).
- Only the Chehalis headwaters met temperature targets; all other reaches needed 12–42% more riparian shade. The South Fork Chehalis, Newaukum, and Black Rivers were three tributaries with the most critical temperature issues, necessitating targeted channel restoration strategies.
- Urban and industrial influences were notable in subbasins surrounding Centralia and Chehalis, where wastewater treatment plant effluent and stormwater runoff contributed nutrients, bacteria, and oxygen-demanding substances. These inputs, combined with very low flow velocities and lake-like hydraulic conditions in the Centralia Reach,

historically resulted in eutrophic to meso-eutrophic conditions, episodic bacterial contamination, and low DO episodes in downstream reaches (Chehalis Basin Partnership, 2009).

- Subbasins such as Salzer Creek showed chronic impairment from multiple sources, including historic wastewater and industrial discharges, stormwater, landfill leachate, and agricultural runoff, causing persistent DO depletion and fecal contamination despite ongoing remediation. Thus, the condition associated with the historic pollution sources and hydrologic alterations (Ahmed and Rountry, 2004; Chehalis Basin Partnership, 2009).

Groundwater Quality

Groundwater cooling may play an important role in moderating surface-water temperatures; however, its influence is more difficult to quantify than surface heat-exchange processes due to comparatively limited groundwater monitoring data. In addition, historic land-use changes may have reduced groundwater recharge and diminished associated cooling effects in some areas. For medium-sized streams, air temperature, humidity, and solar radiation are generally the dominant drivers of predicted maximum daily temperatures.

In this context, the 2011 USGS study by Gendaszek provided important hydrogeologic framework information for WRIA 23 (Andrew S. Gendaszek, 2011). The study delineated major hydrogeologic units, inventoried wells, and evaluated groundwater contributions to streamflow across the Chehalis River basin. Mapping indicated that extensive alluvial and glaciofluvial aquifers underlie portions of the Chehalis River valley and associated tributaries, particularly in the central and western basin.

The study showed groundwater flow in the basin generally follows surficial topography, moving from upland recharge areas toward the alluvial lowlands of the Chehalis River. Hydraulic gradients were steeper in tributary valleys such as the Newaukum River valley (approximately 23 ft/mi), decreased across the central Chehalis River valley (approximately 6 ft/mi), and became tidally influenced near the river’s outlet to Grays Harbor.

Seepage investigations conducted during summer low-flow conditions documented an overall net gain of approximately 57 ± 24 cubic feet per second over a 32.8-mile reach (about 1.7 cfs per mile) along the central Chehalis River. Reach-scale measurements showed alternating gains and losses ranging from roughly –48 to +31 cfs per mile, with variability becoming more pronounced downstream of Grand Mound. Although many individual reach-scale gains and losses were within measurement uncertainty, the cumulative results indicated that groundwater discharge contributed to sustaining baseflows during dry-season conditions.

The hydrogeologic framework identified multiple aquifer units, including Vashon-age advance outwash and alluvial deposits, that are hydraulically connected to surface waters, as well as confining units that influence vertical and lateral groundwater movement. These findings supported the interpretation that groundwater–surface water exchange was spatially variable and was particularly relevant in low-gradient valley segments and in subbasins such as Scatter Creek and the Black River.

For purposes of the Upper Chehalis NPS Assessment, these findings indicate that:

- Groundwater contributions represented a considerable component of summer baseflow to Chehalis River in portions of WRIA 23, particularly in the Scatter Creek and Black River subbasins.
- Groundwater–surface water interactions likely influenced seasonal flow persistence and might contribute to thermal moderation in downstream groundwater-influenced reaches.
- Protection of recharge areas and maintenance of aquifer connectivity were relevant considerations for long-term watershed management.

While the USGS study improved understanding of the basin's hydrogeologic framework and confirmed groundwater inputs in certain areas, it did not provide comprehensive groundwater quality characterization. Therefore, targeted groundwater monitoring remains important for evaluating potential contaminant pathways from septic systems, agricultural lands, and other nonpoint sources in groundwater-influenced subbasins.

Management strategies such as riparian restoration and careful regulation of groundwater withdrawals may help maintain groundwater recharge and stream–aquifer connectivity, although these effects were not directly quantified in the prior study.

The final graphs in this appendix illustrate the seasonal variation of FC based on prior studies. Figure D10 to Figure D12 show the seasonal analysis (1994–2003) of FC from November to April as the most critical period at three different locations.

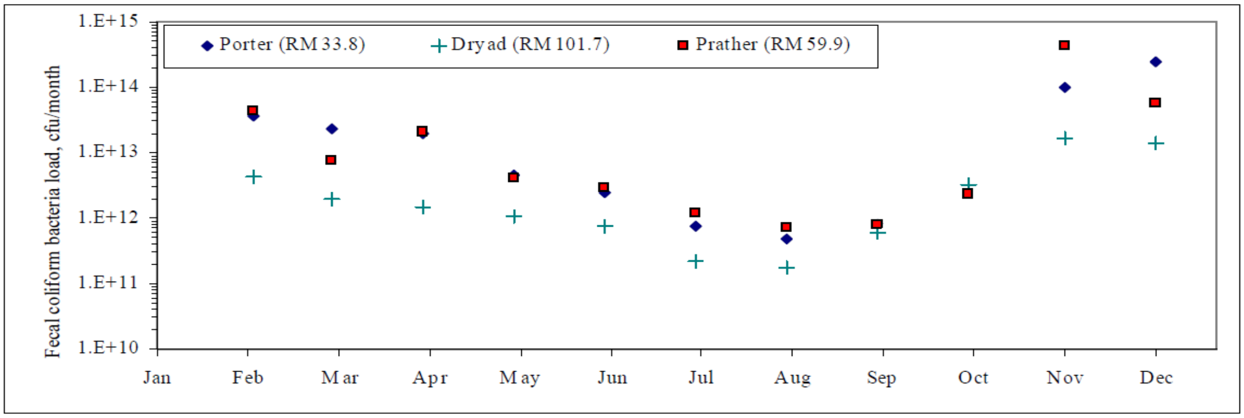


Figure D10 Seasonal variation in FC loads (90th percentile) at three locations in the Upper Chehalis River, 1994-2003 (Ahmed and Rountry, 2004).

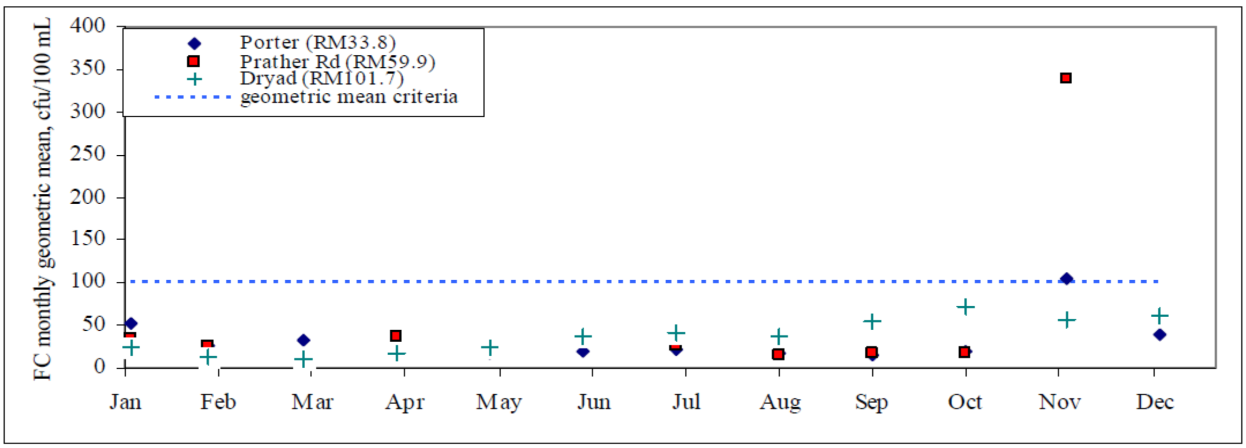


Figure D11 Long-term monthly geometric mean FC concentrations at three locations in the Upper Chehalis River, 1994-2003 (Ahmed and Rountry, 2004).

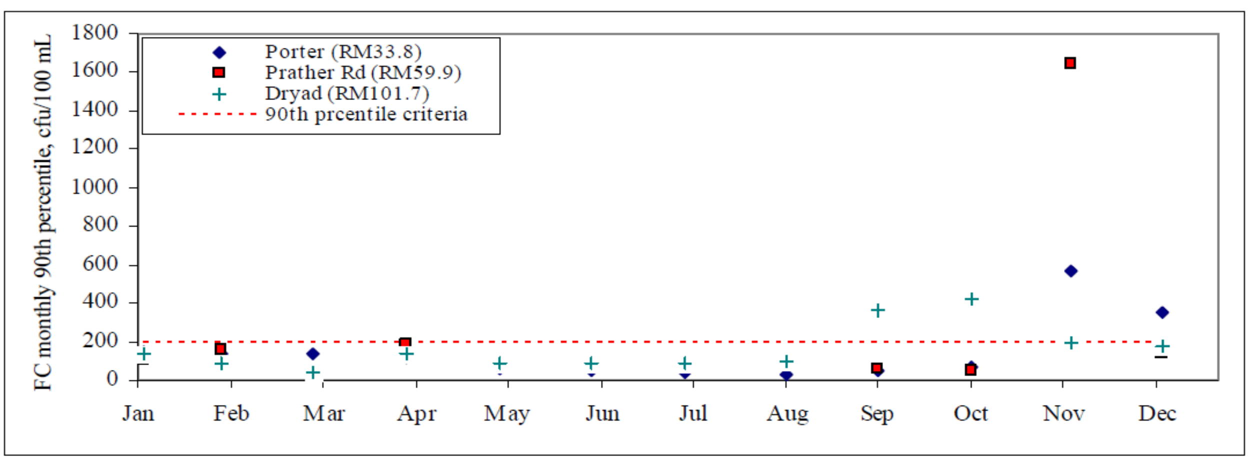


Figure D12 Long-term monthly 90th-percentile FC concentrations at three locations in the Upper Chehalis River, 1994-2003 (Ahmed and Rountry, 2004).

APPENDIX E

Lower Chehalis (WRIA 22) – Supplemental Information

Land-use and Water Bodies Description in WRIA 22

Table E1 Land-use and land-cover summary in the Lower Chehalis in 2003 (USGS, 2025).

No.	Subbasin Name	Forest		Agriculture / Bare	Developed		Water
		Mature	Clearcut/ Shrub		Low	High	
14	Cloquallum Creek	53.0%	32.6%	6.9%	6.4%	0.9%	0.2%
15	East Fork Satsop River	54.3%	41.8%	0.7%	2.5%	0.1%	0.7%
16	Decker Creek	53.3%	39.1%	3.9%	3.6%	0.0%	0.0%
17	Middle Fork Satsop River	69.2%	27.2%	1.5%	2.0%	0.0%	0.0%
18	Satsop River	61.5%	32.3%	4.1%	1.8%	0.0%	0.3%
19	Lower Chehalis River Reach 1	51.7%	26.5%	13.5%	6.0%	1.7%	0.6%
20	Wynoochee River	66.4%	26.7%	3.3%	2.2%	0.1%	1.2%
21	Wishkah River	63.9%	30.8%	2.2%	2.5%	0.4%	0.2%
22	Hoquiam River	79.6%	10.7%	0.7%	5.5%	2.4%	1.2%
23	Middle Fork Hoquiam River	69.1%	30.5%	0.0%	0.2%	0.0%	0.1%
24	East Fork Hoquiam River	62.4%	33.6%	1.2%	2.1%	0.2%	0.5%
25	Humptulips River	73.8%	22.6%	1.6%	1.5%	0.0%	0.4%
26	Elk River	80.5%	19.0%	0.0%	0.4%	0.0%	0.1%
27	Johns River	64.7%	33.7%	0.1%	1.0%	0.0%	0.6%
28	Newskah Creek	57.4%	37.3%	2.4%	2.3%	0.1%	0.5%
29	Charley Creek	69.5%	25.8%	0.8%	1.6%	0.6%	1.6%
30	Lower Chehalis River Reach 2	51.8%	13.0%	12.7%	13.9%	3.2%	5.5%
31	Grays Harbor	58.6%	18.0%	2.7%	13.6%	4.1%	2.9%

Table E2 Land-use and land-cover summary in the Lower Chehalis in 2023 (USGS, 2025).

No.	Subbasin Name	Forest		Agriculture / Bare	Developed		Water
		Mature	Clearcut/ Shrub		Low	High	
14	Cloquallum Creek	76.6%	8.4%	6.3%	7.4%	1.0%	0.2%
15	East Fork Satsop River	80.6%	14.9%	0.7%	3.0%	0.1%	0.7%
16	Decker Creek	76.3%	15.4%	4.1%	4.1%	0.0%	0.0%
17	Middle Fork Satsop River	86.4%	9.8%	1.5%	2.2%	0.0%	0.0%
18	Satsop River	86.2%	7.4%	4.0%	2.0%	0.1%	0.3%
19	Lower Chehalis River Reach 1	68.7%	9.0%	12.9%	6.9%	1.8%	0.7%
20	Wynoochee River	84.4%	8.7%	3.0%	2.6%	0.1%	1.3%
21	Wishkah River	84.4%	10.0%	2.1%	2.8%	0.4%	0.3%
22	Hoquiam River	64.8%	25.3%	0.4%	5.9%	2.4%	1.2%
23	Middle Fork Hoquiam River	88.5%	11.2%	0.0%	0.2%	0.0%	0.1%
24	East Fork Hoquiam River	85.8%	10.0%	1.2%	2.4%	0.1%	0.5%
25	Humptulips River	88.5%	7.9%	1.5%	1.6%	0.0%	0.4%
26	Elk River	89.1%	10.3%	0.0%	0.4%	0.0%	0.1%
27	Johns River	85.2%	12.8%	0.1%	1.2%	0.0%	0.6%
28	Newskah Creek	80.9%	13.3%	2.5%	2.7%	0.1%	0.6%
29	Charley Creek	70.0%	25.0%	0.5%	2.0%	0.7%	1.7%
30	Lower Chehalis River Reach 2	57.9%	6.3%	11.8%	14.7%	3.6%	5.6%
31	Grays Harbor	69.7%	8.8%	2.1%	13.6%	2.4%	3.4%

Table E3 Description of major tributaries in the Lower Chehalis referenced in this report.

Water Body	Description
Humptulips River	The river has two main tributaries - the East Fork (20 mi) and West Fork (30 mi) - joining to form a 20-mi main river. Its 276-square-mi basin has an average flow of 1,344 cfs, with recorded extremes from 82 to 37,500 cfs.
Wynoochee River	The river is a 60-mi tributary of the Chehalis with a drainage basin area of approximately 218 mi^2

Identified Water Quality Trends in WRIA 22

Ambient monitoring data are available in the Hoquiam and Humptulips rivers (WRIA 22). For the Wynoochee and Wishkah rivers, data were limited to the 1970s

Temperature - Maximum temperatures in the Black, Humptulips, Wynoochee, and Wishkah rivers exceeded the water quality criterion.

Total Phosphorus - TP loading and yield were evaluated for the Newaukum and Humptulips rivers (Table D5 in Appendix D). The Humptulips in the Lower Chehalis had more than twice the wet season TP load and the highest annual TP yield, comparable to the Green River (Embry & Inkpen, 1998).

Total Suspended Solids - Average TSS concentrations were highest in the Newaukum, Satsop, and Humptulips rivers, and lowest in the Hoquiam. The Humptulips recorded the highest maximum TSS value of any tributary. Seasonal and annual TSS yields (Table) were also highest in the Humptulips, making it the largest sediment contributor among tributaries evaluated.

Table E4 TSS yield – 1990s data (Chehalis Basin Partnership, 2000).

River Mile	Location	TSS Yield ($tons/yr-mi^2$)		TSS Yield ($tons/yr-mi^2$)
Season		Wet	Dry	Ave. Ann.*
0.1	Newaukum	155	11.3	7.8
23.6	Humptulips	396	6.1	186

* Average annual yield calculations based on all data available for 1990's

Fecal Coliform - While older data indicated no FC issues in the Wishkah and Wynoochee, no recent data are available.

Subbasin Water Quality Assessment in WRIA 22

Subbasin 14 – Cloquallum Creek:
The subbasin is located in WRIA 22 (Lower Chehalis) and covers an area of 44,165 ac. Cloquallum Creek, entering near Elma, has limited and outdated data. Historical monitoring indicated compliance with temperature and DO standards, though pH excursions and occasional high TP, ammonia, and FC levels occurred, especially during storms. Wildcat Creek, a tributary impacted by past discharges, has seen improvements following Wastewater Treatment Plant upgrades and a 1993 TMDL. The watershed is mostly forested, with minor agriculture and urban activity. Reestablishing monitoring was recommended to assess current water quality and guide future actions.

Subbasins 15 to 18 – Satsop River and Tributaries:
While these subbasins are all located in WRIA 22 (Lower Chehalis), East Fork Satsop River, Decker Creek, Middle Fork Satsop River, and Satsop River cover an area of 47,610, 32,079, 37,965, and 73,239 ac, respectively. The Satsop River system, including the East Fork, Middle Fork, Decker Creek, and the mainstem, shows generally good water quality. Temperature and DO met criteria, while TP and IN were the lowest among mainstem tributaries. However, wet season TSS levels were extremely high, likely due to forest practices. FC levels were low, but a 29% reduction in NPS loads was recommended in the Grays Harbor TMDL. Continued monitoring and targeting sediment sources was suggested to maintain and improve water quality.

Subbasin 19 – Lower Chehalis River Reach 1:
The subbasin is located in WRIA 22 (Lower Chehalis) and covers an area of 58,861 ac. This reach, from Porter to Satsop, lacks long-term monitoring. Water quality conditions are discussed under Subbasin 30 for the 2nd reach of the Lower Chehalis River.

Subbasin 20 – Wynoochee River:
The subbasin is located in WRIA 22 (Lower Chehalis) and covers an area of 125,436 ac. Forestlands dominate land-use, with minor agricultural presence. Historical data (1970s) indicated generally good water quality, with few temperature excursions and low nutrient and FC levels. However, no recent data were available, and monitoring was suggested to be re-established to assess current conditions.

Subbasin 21 – Wishkah River:
The subbasin is located in WRIA 22 (Lower Chehalis) and covers an area of 65,856 ac. Limited and outdated data showed low nutrient and FC levels, with few exceedances. However, the Grays Harbor TMDL identified this river as a significant bacteria source, recommending a 62% load reduction. Re-establishing monitoring and verifying current bacteria sources were identified as essential.

Subbasins 22 to 24 – Hoquiam River and Forks:
While these subbasins are all located in WRIA 22 (Lower Chehalis), Hoquiam River, Middle Fork Hoquiam River, and East Fork Hoquiam River cover an area of 25,206, 7,819, and 25,908 ac, respectively. Data from the Hoquiam River (western parts) indicated very low nutrient and FC levels, with all monitored parameters meeting Class A criteria. However, the Grays Harbor TMDL called for substantial FC reductions, particularly near the mouth. While historical data showed high water quality, further monitoring and re-evaluation of bacteria sources were suggested to support TMDL goals.

Subbasin 25 – Humptulips River:
The subbasin is located in WRIA 22 (Lower Chehalis) and covers an area of 157,772 ac. This is the largest subbasin in the Chehalis Basin. The Humptulips River showed generally good water quality, with few exceedances of temperature and DO standards. However, it has the highest TSS and TP yields among Chehalis tributaries, likely due to logging and sediment runoff. Although FC levels at the monitoring station were low, the river is a major contributor to Grays Harbor bacterial loading, prompting a 67% TMDL load reduction. Continued monitoring, BMP implementation, and source identification were suggested.

Subbasins 26 to 29 – Elks River, Johns River, Newskah Creek, Charley Creek:
While these subbasins are all located in WRIA 22 (Lower Chehalis), Elks River, Johns River, Newskah Creek, and Charley Creek cover an area of 11,670, 19,350, 7,676, and 5,039 ac, respectively. No water quality data were available for these subbasins at the time the referenced studies were conducted.

Subbasin 30 – Lower Chehalis River Reach 2:
The subbasin is located in WRIA 22 (Lower Chehalis) and covers an area of 39,111 ac. The Montesano station reflects cumulative impacts from upstream. Temperature and FC frequently exceeded standards, while TP and IN yields were the highest among mainstem stations. TSS levels were also elevated. Urban land-use is relatively high near the station, but upstream activities, including agriculture, logging, and septic systems, likely contribute. Renewed monitoring and source reduction were recommended to improve water quality.

Subbasin 31 – Grays Harbor:
The subbasin is located in WRIA 22 (Lower Chehalis) and covers an area of 57,070 ac. It is included in the evaluation of the area mostly for water right and water use assessment purposes. Conditions within the estuary vary depending on location, tidal and wind-driven mixing, and the degree of density stratification. The harbor is generally divided into an inner harbor and an outer harbor, each exhibiting distinct hydrodynamic and water-quality characteristics. The Chehalis River has been the primary source of FC loading to the estuary.

Results Summary of Water Quality Assessment in WRIA 22

- In addition to the Black River in WRIA 23, the maximum temperatures in the Humptulips, Wynoochee, and Wishkah rivers in WRIA 22 exceeded the water quality criterion.
- The Humptulips River, heavily influenced by forestry activities, contributes the highest TSS and TP yields of all tributaries. Among tributaries, the Humptulips River showed the highest TP yield but remained within the typical range observed elsewhere. Despite generally good FC levels, sediment and nutrient loading posed threats to water quality (Chehalis Basin Partnership, 2009). It also recorded the highest maximum TSS value of any tributary. High TSS levels in the Humptulips River aligned with extensive logging operations and associated sediment runoff (Chehalis Basin Partnership, 2000, 2009).
- Data from the Wynoochee and Wishkah rivers were identified as outdated (1970s) during the prior studies reviewed, and monitoring reestablishment was suggested to determine current water quality status (Chehalis Basin Partnership, 2000).
- Several subbasins lack recent or sufficient data for comprehensive evaluation (e.g., Wynoochee, Wishkah, Elks, Johns Rivers), highlighting the need for enhanced monitoring and assessment.

Table E5 Summary of water quality status in the Lower Chehalis based on the prior studies.

Reach / Subbasin	Water Quality Parameters Condition	Nonpoint Sources of Concern	Overall Water Quality Status
Humptulips River	Highest TSS and TP yields; some temperature exceedances	Forestry/logging sediment, agricultural runoff	Moderately impacted
Wynoochee River	Historic data: generally good quality; no recent data	Forested, minor agriculture	Data gap; presumed good
Wishkah River	Limited data; listed as bacteria source needing reduction	Agriculture, septic, rural runoff	Data gap; needs assessment
Satsop River & Forks	Generally, meets temperature and FC criteria; wet season TSS spikes	Forestry/logging, sediment	Low impacted
Cloquallum Creek	Meets standards historically; some high parameters (nutrients, FC, pH) during storms	Mixed forest/agriculture, minor urban	Outdated data, Low impacted
Montesano (Mainstem Lower Chehalis)	Frequent temperature and FC exceedances; highest TP/IN yields	Urban/ agricultural upstream, septic, logging	Moderately impacted