WATER QUALITY MONITORING REPORT
COLUMBIA COUNTY SOIL AND WATER CONSERVATION DISTRICT
WATER QUALITY MONITORING PROGRAM
2017-2022 TRENDS

PREPARED FOR

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PREFACE

The Columbia County Water Quality Monitoring program was established in 2017 by Columbia County Soil and Water Conservation District (CCSWCD). The goal of this monitoring program is to create a long-term trend monitoring network to characterize ambient water quality conditions in watersheds that are critical to Salmonids. The monitoring program consists of collecting continuous temperature data and grab samples to measure turbidity, *E. coli,* pH, dissolved oxygen, and conductivity data across 22 monitoring locations in Scappoose Bay and Lower Columbia River watersheds – Clatskanie River, Beaver Creek, McNulty Creek, Milton Creek, and North and South Scappoose Creek Watersheds. Stream channel modifications and land-use practices have reduced the quality and quantity of available native habitat. These impacts have resulted in several streams in the monitoring area being 303-(d) listed as having impaired and threatened water quality by Oregon DEQ and EPA.

In 2022, Lower Columbia Estuary Partnership (LCEP) and CCSWCD, with funding from Oregon Watershed Enhancement Board (OWEB) released a comprehensive report on trends seen in these watersheds between 2017 – 2021. A landcover analysis for these watersheds using USGS 2011 data was also included in the 2021 report. Trends observed in the Scappoose Bay sub-basins were compared to the results from an earlier monitoring program (2008-2011) conducted by the Scappoose Bay Watershed Council (SBWC) (Holmen et.al 2011). The 2017-2021 report found elevated summertime temperatures that exceeded ODEQ standards for healthy salmon habitat (18°C), which coincided with elevated *E. coli* counts in the lower reaches of most watersheds. Scappoose Bay sub-basins had seen an average increase of 1°C in temperature between 2008-2011 and 2017-2020 efforts and increased *E. coli* counts. Based on these findings, recommendations for further and focused studies were made in the previous report.

The current 2023 report builds on previous findings by reporting out on conditions observed during the 2022 and compares them to trends seen between 2017-2021. In 2021 and continuing through the 2022 field season pH and Dissolved Oxygen were added to the monitoring program, with the goal of collecting additional information about parameters that are critical to determining healthy salmon habitat conditions. Additionally, in 2022, 9 sampling locations were added across the Milton and McNulty watersheds as part of an intensive watershed study initiative, with the intent to answer questions about contributing conditions and potential sources. This report also summarizes trends observed in these parameters and compares them to results from the 2008-2011 Scappoose Bay Watershed sub-basins. In this update, LCEP has released an online dashboard that summarizes the results of the program (link). The goal of this dashboard is to make these results and data widely available to stakeholders, funders, and the general public. The Columbia Soil and Water Conservation District (CSWCD), the Lower Columbia River Watershed Council, and the Scappoose Bay Watershed Council will use the long-term trend data as a baseline watershed condition for water quality and target future monitoring data focused on restoration and mitigation effectiveness.

Acronyms and Abbreviations

ODEQ – Oregon Department of Environmental Quality

CSWCD – Columbia County Soil and Water Conservation District

DO – Dissolved Oxygen

HUC – Hydrologic Unit Code

TMDL – Total Maximum Daily Load

E. coli – *Escherichia coli* Bacteria

USGS – United States Geological Society

EPA – Environmental Protection Agency

7dMAM – 7-day Moving Average Maximum

MPN/100ml – Most Probable Number of viable cells in 100ml of sample (Bacteria Samples)

NTU – Nephelometric Turbidity Units

DO – Dissolved Oxygen

SAP – Sampling Analysis Plan

EXECUTIVE SUMMARY

Overview of Findings

The Columbia County water quality monitoring program, initiated in 2017 and expanded in 2021, has enabled the comprehensive examination of long-term trends in water quality across key watersheds, including Clatskanie River, Beaver Creek, Milton Creek, North Scappoose Creek, and South Scappoose Creek. In 2022, McNulty Creek was added to the program, and more intensive studies were carried out in the Milton Creek watershed. Through these endeavors, we have identified several water quality concerns across the region, including elevated water temperatures, high *E. coli* levels, and significant pH and DO fluctuations. This executive summary presents our findings in detail, alongside proposed recommendations to address and mitigate the identified issues.

History of Data Collection and Reporting

In 2017 the Oregon Department of Environmental Quality (ODEQ) provided grant funding to establish the Columbia County water quality monitoring program to track and characterize long-term trends in water temperature, turbidity, *E. coli* bacteria, and conductivity in Clatskanie River, Beaver Creek, Milton Creek, North Scappoose Creek, and South Scappoose Creek watersheds. A total of 13 sites were selected to provide a comprehensive overview of the County watersheds between 2017 and 2020. In 2021, pH and dissolved oxygen (DO) were added to the monitoring program. With the 2021 update, LCEP also released an online dashboard (link). The goal of this dashboard is to make these trends widely available to stakeholders, funders, and the general public. In 2022, the McNulty Creek watershed was introduced into the monitoring program, with two locations representing the north and south reaches of this watershed. Moreover, seven additional sampling locations were introduced in the Milton Creek watershed as part of an intensive watershed study to observe the influence of sub-watersheds on the mainstem Milton Creek and locate potential sources of contamination. Water quality monitoring was conducted following the methods and quality assurance protocols laid out by the ODEQ. Water quality data were summarized and compared to standard parameter ranges for ideal salmonid habitat as defined by the ODEQ, Oregon Watershed Enhancement Board (OWEB), and Environmental Protection Agency (EPA).

With this 2022 program update, LCEP continues to update an online dashboard. It is intended that the ODEQ will use these resources to assess whether the Clatskanie River, Beaver Creek, McNulty Creek, Milton Creek, and Scappoose River watersheds are meeting water quality criteria for beneficial uses. The Columbia Soil and Water Conservation District (CSWCD), the Lower Columbia River Watershed Council, and the Scappoose Bay Watershed Council will use the long-term trend data as a baseline watershed condition for water quality and target future monitoring data focused on restoration effectiveness. The following section summarizes the water quality issues observed across the watersheds. Please refer to the full report for a detailed assessment of all water quality trends.

Clatskanie River Watershed

Clatskanie and Lower Clatskanie exceeded the ODEQ temperature standard for salmon habitat (18°C). These regions, marked by more extensive pasture areas, experience higher temperatures when water levels are low and air temperatures peak. These elevated temperatures are likely a result of thermal loading, given that the lower watershed regions are more developed, predominantly used as pastures, and lack riparian shade.

The upper reaches of the watershed recorded a Max 7-day Mean Average Maximum (7dMAM) temperature surpassing the 18°C threshold for the second consecutive year in 2022. Although pH levels generally remained within the ODEQ standards in 2022, the monthly levels demonstrated high variability. Stream Dissolved Oxygen (DO) averages also showed significant fluctuations in the 2022 data, falling below the DEQ standards for ideal stream conditions (>11mg/L) between June and September.

High turbidity levels were observed across the watershed during the winter months throughout the study, corresponding with winter storm events and high flow conditions. These observations indicate the necessity for continued monitoring and targeted interventions to maintain and improve the watershed's water quality.

In terms of *E. coli* levels, the Clatskanie River watershed remained within the ODEQ 90-day geometric mean threshold in 2022. However, an isolated event at Carcus was noted, where maximum *E. coli* levels exceeded both EPA and ODEQ thresholds. In particular, Middle Clatskanie recorded elevated *E. coli* bacteria levels from June to September in 2019, and July to November in 2020, exceeding the EPA, ODEQ standards, and the five-sample geometric mean. Elevated *E. coli* levels suggest potential contamination from animal waste runoff, posing risks to human health during recreational use of these waterways.

Additional research is necessary to ascertain the precise source of the *E. coli* contamination. Possible sources could be waste from livestock or wildlife, or leakage from septic tanks into the stream. Actions to mitigate future *E. coli* exceedances could include measures such as increasing riparian buffers, restricting livestock access to the creek, enhancing manure management near streams, and updating failed septic systems throughout the watershed's targeted reach, depending on the identified source.

Beaver Creek Watershed

Two monitoring sites were established in the Beaver Creek Watershed, one each in the upper and lower regions, to assess the water quality. Over the period of 2017 to 2022, the highest 7-day Mean Average Maximum (7dMAM) temperatures were consistently recorded between July and August. Particularly in the lower watershed, stream temperatures regularly exceeded the ODEQ standard for salmon rearing habitat (18°C). We hypothesize that due to reduced water levels and increased exposure to solar radiation, the lower regions of the Beaver watershed experience heightened thermal loading.

Turbidity events above the 10 NTU threshold occurred annually in the upper reaches of Beaver Creek during the 2017-2022 study period. Despite overall monthly turbidity averages remaining below this threshold, the upper reaches demonstrated higher levels compared to the lower Beaver Creek. Although pH levels generally adhered to ODEQ standards, notable variability was observed in 2022. Similarly, stream DO averages in the watershed fell below the DEQ standards for ideal stream conditions (>11mg/L) between June and October, with considerable variability evident in the 2022 data.

Throughout the 2017-2022 study period, we observed elevated *E. coli* levels in the watershed from June to October, surpassing EPA and ODEQ standards. Even though the 90-day geometric mean values remained below the state-mandated threshold in 2022, the historical data and the maximum conditions recorded in 2022 necessitate continued monitoring and additional investigations. These are required to pinpoint the cause of elevated *E. coli* levels in the upper watersheds and to ensure that these conditions do not persist or escalate. The increased levels of turbidity and *E. coli* in the upper watershed, compared to the lower, suggest the impact of runoff and other residential uses.

Given the frequency and magnitude of *E. coli* events, it is recommended that warning signs be placed in public-accessible recreational areas along these streams. This is a vital step to safeguard public health while we continue to monitor and explore the underlying causes of these water quality issues.

Scappoose Bay Watershed

The Scappoose Bay watershed is comprised of four distinct sub-watersheds: Milton Creek, McNulty Creek, North Scappoose Creek, and South Scappoose Creek. During the period 2017-2022, two points in each creek, representing both the upper and lower regions, were sampled for temperature, turbidity, pH, DO, and *E. coli* levels. These recent observations were then compared with the datasets previously created from an intensive 2008-2011 monitoring effort. Intensive studies were also carried out on Milton Creek and McNulty Creek, the results of which are provided in later sections of this summary.

During the summer months, stream the maximum 7-day Mean Average Maximum (7dMAM) temperatures across the watersheds consistently exceeded ODEQ's standards for salmon rearing habitat (18°C) and lethal conditions (25°C), particularly in the lower regions. In contrast, the upper watersheds, which are more forested, recorded lower temperatures. Notably, Lower Milton, situated near a public park, recorded the highest temperatures. A comparison of the 2008-2011 and 2017-2022 datasets revealed an upward trend in summer temperatures across all monitoring sites.

As for pH and DO levels, Milton Creek, North Scappoose Creek, and South Scappoose Creek maintained levels within the DEQ's regulatory standards for optimal salmonid conditions (6.5 – 8.5). Variations in these readings could be attributable to agricultural runoff and sediment loading within the watersheds. Compared to the 2008-2011 data, pH and DO demonstrated greater variability, with lower levels during the summer months in the 2021-2022 period.

E. coli levels were elevated across all lower reach monitoring sites, consistently breaching EPA and ODEQ standards from June to October 2019, May to November 2020, April to December 2021, and June to October 2022. Although previous 2008-2011 data indicates an ongoing *E. coli* issue, the limited scope of sampling during that period makes it difficult to assess changes in conditions. The presence of E. coli, typically indicating animal waste runoff, can pose significant health risks for recreational waterway users. Consequently, it is recommended to install warning signs at recreational areas along these streams to alert the public due to the frequency and magnitude of *E. coli* events.

Milton Creek and McNulty Creek Watershed Intensive Monitoring Study

Our long-term Water Quality (WQ) monitoring program in Columbia County has highlighted that temperature and *E. coli* levels frequently exceed both the ODEQ Total Maximum Daily Load (TMDL) and EPA stream quality standards. These exceedances are particularly prominent in the Milton Creek watershed. In response to these findings, an intensive monitoring effort was initiated in 2022 to examine the Milton Creek watershed's sub-watersheds further and identify potential sources of water quality degradation. Seven additional monitoring stations were introduced, and the same intensive monitoring extended to the McNulty Creek watershed due to its proximity and lack of existing water quality data. This report presents the results obtained from June to December 2022.

At all monitoring sites within the Milton Creek watershed, the maximum 7-day Mean Average Maximum (7dMAM) temperatures exceeded the 18°C threshold. Moreover, the lethal habitat threshold of 25°C was surpassed at the Mid-Upper Milton, Mid-Milton, and Lower Milton Creek locations. At Dart Creek, temperatures remained above 18°C well into October.

Turbidity levels exceeded 10 NTU at Salmon Creek, Upper Milton, Cox Creek, and Milton Creek. Furthermore, dissolved oxygen (DO) levels in the Milton Creek watershed's sub-basins fell below the ODEQ threshold for ideal salmonid conditions from June to August. The minimum DO levels at Dart Creek, Milton Creek, and Salmon Creek approached the lethal condition threshold (<6mg/L).

The McNulty Creek watershed demonstrated water quality issues similar to the rest of the monitored watersheds. Summertime temperatures exceeded the 18°C threshold at both the upper and lower reaches of the watershed, with these heightened temperatures persisting longer in Lower McNulty.

E. coli levels in both Milton Creek and McNulty Creek regularly surpassed EPA (>235 MPN/100mL) and ODEQ (406 MPN/100Ml) single event thresholds during the intensive monitoring period (June – December 2022). Average *E. coli* levels in 2022 exceeded the ODEQ thresholds at Cox Creek, Dart Creek, and Salmon Creek. The 90-day geometric mean threshold of 126 MPN/100ml was exceeded at all nine locations in the Milton Creek Watershed from June to September, and at eight locations (excluding Salmon Creek) from July to November. Although *E. coli* levels at Upper McNulty remained below the 90-day geometric mean threshold, a couple of incidents exceeded the ODEQ threshold during the study period.

While further data from this study is expected, these findings indicate that water quality issues are not confined to a single sub-basin; they are spread across multiple sub-basins. Therefore, the recommended next step is to incorporate source-tracing through e-DNA sampling and analysis. This approach will enable us to identify species-level contributions to *E. coli* loads in the watershed, informing more targeted restoration and mitigation efforts.

Recommendations

To address and mitigate these issues identified in the report, we recommend the following:

- Given the scale of the *E. coli* issues observed, source-tracing studies such as e-DNA sampling and analyses, especially in Milton Creek and McNulty Creek watersheds are recommended. An evaluation of livestock access to streams and the septic tank systems should be considered to further help identify potential sources of *E. coli* throughout the County watersheds. Focusing on Scappoose Bay watershed sub-basins with an intensified water quality monitoring project could help decipher some of these sources.
- Further analyses of the long-term dataset are recommended to enable more effective evaluation of the impact of restoration measures and inform the development of future strategies to further improve water quality and support the recovery of ESA-listed species. For example, the monitoring data revealed a significant correlation between dissolved oxygen (DO) levels and *E. coli* concentrations, suggesting an issue related to Biochemical Oxygen Demand (BOD) in the streams. Continuous DO monitoring will provide a more comprehensive understanding of the spatial and temporal variations in DO levels throughout the watersheds, which can be used to pinpoint areas of concern where DO levels are consistently low and might be linked to elevated *E. coli* concentrations and other water quality issues.
- Due to the ongoing *E. coli* issues, it is also recommended that warning signs are added to recreational areas along these streams that are accessible to the public, especially in the Lower reaches of Scappoose Watershed.

- A riparian canopy cover analysis of the Scappoose Bay, Clatskanie River, and Beaver Creek watersheds is recommended in order to identify areas where canopy gaps are increasing stream solarization. Once identified, these gaps could be addressed by restoring riparian vegetation buffers to reduce thermal loading on summer water temperatures. Targeted restoration of riparian vegetation and canopy cover could also reduce turbid and bacteria-laden run-off into these streams.
- On-the-ground and aerial surveys could also be used to identify cold refugia (cold water sources and seeps), which should be protected and enhanced. These surveys could also be used to identify sources of non-point source pollution such as unstable stream banks (turbidity) and livestock use of the streams (bacteria).
- Additional shading and riparian buffers need to be introduced in the lower Scappoose Bay watershed to regulate stream temperatures and *E. coli* events across all monitoring sites.
- Continued water quality monitoring efforts are required to assess the long-term shifts in water quality conditions resulting from restoration, mitigation actions, climate change and severe weather patterns, as well as developmental pressures.

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PROJECT OVERVIEW

Introduction

The Lower Columbia River and Scappoose Bay watersheds include a variety of habitats that support multiple life stages of federally ESA-listed fall Chinook, coho, and chum salmon, as well as winter steelhead, cutthroat trout, and Pacific lamprey, though these species' numbers are dwindling due to poor water quality, limited and degraded habitat, and fish passage barriers. Estuary and tidal wetland habitats in the lower watershed provided off-channel floodplain refugia and rearing habitats serving many species of out-migrating juvenile salmon during spring freshet high flow periods. Historically, low gradient streams meandering through prairie and gravel plain topography provided instream and off-channel habitat features that included large wood jams, gravel retention, and pools, which supported coho spawning and rearing habitats. Additionally, middle and upper stream reaches with intact old-growth riparian forests and channel complexity provided quality Chinook and steelhead spawning and rearing habitat. The quality, quantity, and access to these habitats have been significantly impacted by lowland diking, ditching, development, and agriculture, as well as upper watershed timber production.

The Lower Columbia River Watershed drains nearly 300 square miles and is made up of three main fifth-field sub-watersheds, including the Clatskanie, Beaver, and Plympton subbasins. This project focuses on sampling the two largest- Clatskanie and Beaver. Stream channel modifications and land-use practices have reduced the quality and quantity of available native habitats. These include the construction of cut-off channels, dredging, diking, ditching, and draining of the lowlands to improve agriculture production.

The Scappoose Bay Watershed encompasses 132 square miles and includes Scappoose, McNulty, and Milton sub-watersheds—all were sampled during this project. These sub-basins have all been drastically altered, the lowland floodplains and Oak prairies by flood control measures, surface mining, farming, livestock production, and residential development, and the forested hills by logging. These actions not only degraded habitat but also water quality. More recently, the loss of riparian forests due to commercial timber production, agriculture, and rapid residential and commercial development continues to threaten water quality. Rising housing costs and proximity to Portland Metro have resulted in increasing population pressures and development in the southern portions of Columbia County, causing concern for increasing water quality issues in the area.

Varying degrees of water quality data have been collected over the years by several entities in the focus sub-basins. These amount to sporadic monitoring events or programs that do not provide sufficient, comprehensive data to analyze watershed trends. This monitoring program was established with the goal of creating a long-term trend monitoring network to characterize ambient water quality conditions for temperature, bacteria, and turbidity in the Clatskanie River, Beaver Creek, Milton Creek, and Scappoose River watersheds (**Error! Reference source not found.**). In 2021, the monitoring program started collecting pH and Dissolved Oxygen (DO) data at these watersheds with the goal of including additional parameters that can be used to assess salmonid habitat conditions in these watersheds. In 2022, 2 locations were introduced in the McNulty Creek Watershed as part of the long-term monitoring program. Moreover, based on the findings of this program, 7 additional monitoring locations were introduced in the Milton Creek watershed as part of an intensive monitoring effort, to study the effect of sub watersheds on the mainstem and identify potential sources of contamination and stream quality impairment. The Oregon Department of Environmental Quality (ODEQ) will use these data to assess whether the Clatskanie River, Beaver Creek, McNulty Creek, Milton Creek, and Scappoose River watersheds are meeting water quality criteria for beneficial uses. The Columbia Soil and Water Conservation District (CSWCD), the Lower Columbia River Watershed Council, and the Scappoose Bay Watershed Council will use the long-term trend data as a baseline watershed condition for water quality and complement future monitoring data focused on restoration effectiveness.

With this 2022 program update, LCEP continues to update an online dashboard that summarizes the results of the Program since 2017 (link). The goal of this dashboard is to make these trends widely available to stakeholders, funders, and the general public.

Site Selection

Monitored watersheds were selected based on areas of interest identified by the CSWCD. Specific sampling sites for continuous water temperature and grab sample parameters: pH, DO, conductivity and turbidity were selected based on three factors: HUC 12 boundary, the presence of legacy ODEQ monitoring, and TMDL limited water bodies. HUC 12 boundaries divide the river or creek into discrete monitoring reaches to better define the water body to being monitored. Sampling defined reaches of the water body can identify landscape factors influencing water temperature. *E. coli* sampling was conducted in the watersheds to highlight both areas commonly accessed by humans for recreation (near urban centers) and to evaluate the cumulative condition of the water quality within each watershed. When possible, sampling locations were also chosen based on prior ODEQ sampling sites nearby. Continuing to monitor ODEQ sampling sites augments existing monitoring data on previously TMDL limited water bodies and can inform if changes have occurred over time. Alternatively, monitoring stations located in non-TMDL limited waters were selected to monitor if conditions in the watershed were unchanged.

The 15 monitoring sites chosen through this selection process provided a comprehensive overview of the five watersheds (Figure 1Table 1, Figure 1). By monitoring the major tributary confluences, the CSWCD can observe differences and make comparisons of water quality conditions from the headwaters to the lower reaches. Over time, this will allow the CSWCD to identify problem areas and assess where further monitoring and possible restoration activities are needed throughout the watersheds. Detailed monitoring site descriptions can be found in Appendix A.

Table 1: Long-term Sampling Station Descriptions, Locations, and Parameters

Station Identification	Site Code	ODEQ LASAR #	Station Description	Latitude	Longitude	Parameter
Clatskanie Watershed						
Little Clatskanie	LC	23539	Little Clatskanie River at Apiary Road, Rocky Substrate	45.9871802	-123.0391480	Temperature, E. Coli, Turbidity, pH, DO
Upper Clatskanie	UC	n/a	Headwaters Clatskanie River at Apiary Road, Rocky Substrate	45.9882893	-123.0402836	Temperature, E. Coli, Turbidity, pH, DO
Carcus Creek	CAR	23537	Carcus Creek at mouth (Clatskanie River tributary, River Mile 11.2), Rocky Substrate	46.0390038	-123.0832678	Temperature, E. Coli, Turbidity, pH, DO
Middle Clatskanie	MC	n/a	Clatskanie River downstream of Carcus Creek- located at Swedetown Rd. Bridge crossing, Rocky Substrate	46.0482249	-123.1197820	Temperature, E. Coli, Turbidity, pH, DO
Lower Clatskanie	Low C	34152	Clatskanie River above Keystone Creek (Columbia), Mixed Substrate and Large Wood	46.0802952	-123.1632107	Temperature, E. Coli, Turbidity, pH, DO
Beaver Creek Watershed						
Upper Beaver	UB	23535	Girt Creek at Beaver Spring Road (Beaver Creek tributary River Mile 16.6), Silt Substrate	46.0631239	-122.9649379	Temperature, E. Coli, Turbidity, pH, DO
Lower Beaver	LB	23526	Beaver Creek at Beaver Falls Road (Tidewater, upstream of Stewart Creek), Rocky Substrate	46.1097865	-123.1585536	Temperature, E. Coli, Turbidity, pH, DO
McNulty Creek Watershed						
Upper McNulty	UMN	n/a	McNulty Creek off of Millard Road. Silty Substrate	45.841722	-122.856603	Temperature, E. Coli, Turbidity, pH, DO
Lower McNulty	LMN	n/a	McNulty Creek at McNulty Way, off of Gable Road. Rocky Substrate	45.846372	-122.827719	Temperature, E. Coli, Turbidity, pH, DO
Milton Creek Watershed						
Upper Milton	UM	n/a	Cox Creek South of Yankton School (Yankton), Rocky Substrate	45.8641139	-122.8879489	Temperature, E. Coli, Turbidity, pH, DO
Lower Milton	LM	n/a	Milton Creek at Boise Cascade (River Mile 0.8), Silty Substrate	45.8504302	-122.8147681	Temperature, E. Coli,

						Turbidity, pH, DO
North Scappoose Creek						
Upper North Scappoose	UNS	n/a	North Scappoose Creek below Alder Creek, Rocky Substrate	45.8227512	-122.9469585	Temperature, E. Coli, Turbidity, pH, DO
Lower North Scappoose	LNS	23566	Scappoose Creek - North Scappoose Creek at Hwy 30, Mixed Substrate	45.7711443	-122.8787030	Temperature, E. Coli, Turbidity, pH, DO
South Scappoose Creek						
Upper South Scappoose	USS	23579	Scappoose Creek - South Scappoose Creek at Bankston Road, Rocky Substrate	45.7443630	-122.9596836	Temperature, E. Coli, Turbidity, pH, DO
Lower South Scappoose	LSS	n/a	Scappoose Creek - South Scappoose Creek at Hwy 30, Silty Substrate	45.7637674	-122.8800218	Temperature, E. Coli, Turbidity, pH, DO

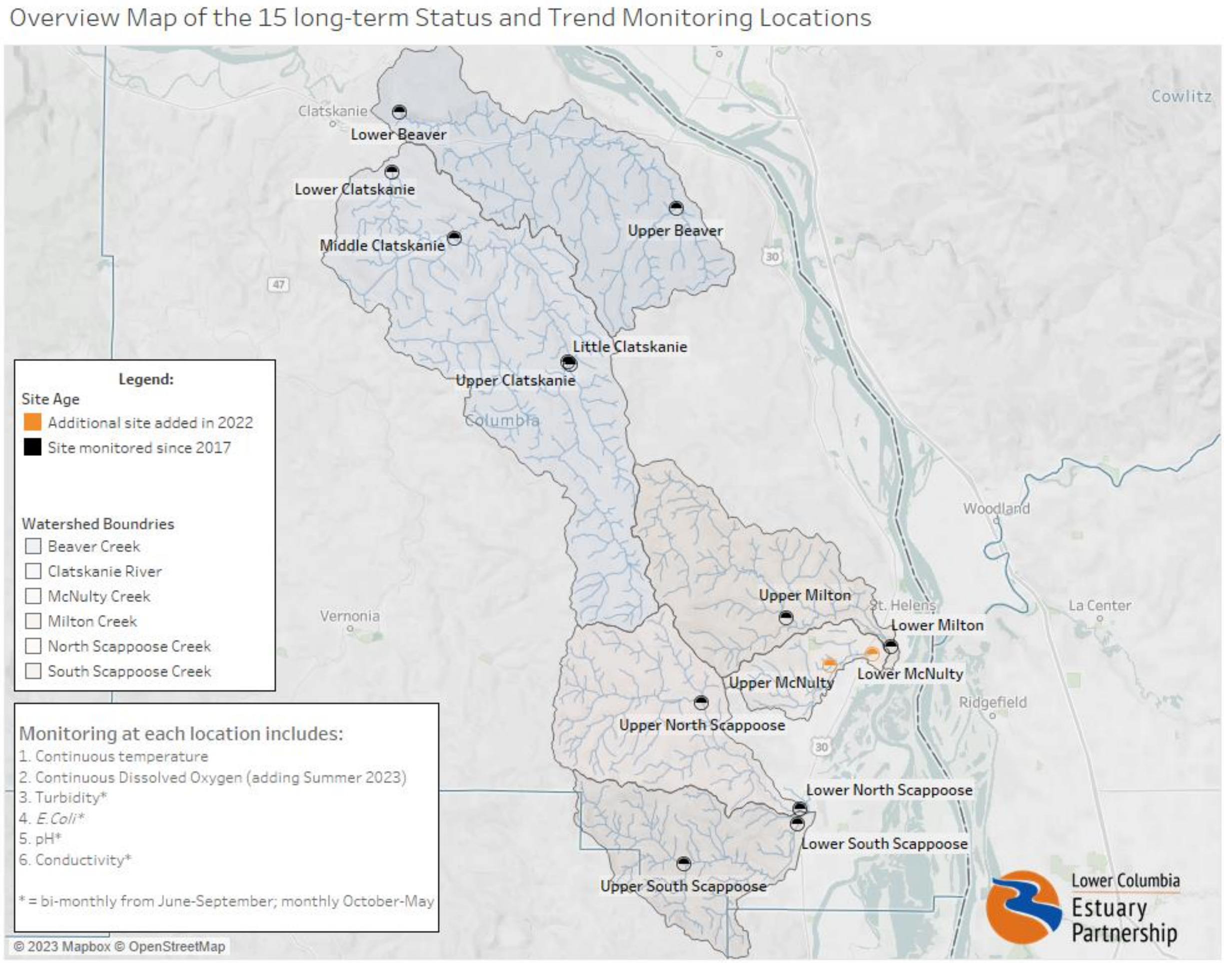


Figure 1: Map of water quality monitoring site locations within the Columbia County Watershed Boundaries

Milton Creek and McNulty Creek watersheds Intensive Monitoring Study

The results from our long-term WQ monitoring program in Columbia County indicate that temperature and *E. coli* counts regularly exceed ODEQ TMDLs and EPA standards for stream quality; however, these exceedances are more pronounced in the Milton Creek watershed. Water quality issues observed in Milton Creek Watershed include high summer temperatures (>18°C) in the upper and lower watershed between June and September. Multiple turbidity events above the 10 NTU threshold were also observed in the Upper and Lower reaches of Milton Creek during the 2017-2020 study period. In 2021, elevated *E. coli* bacteria levels were observed in the watershed between April to December, which is longer than timeframes throughout the 2017-2020 study period, exceeding the EPA and ODEQ standards including the five-sample geometric mean in 2019 and 2020. These issues warranted a closer look at the watershed, hence, in 2022, an intensive monitoring effort was undertaken to study the sub-watersheds in Milton Creek watershed and identify potential sources of water quality impairment. A total of 7 stations were introduced into the monitoring program. The intensive monitoring effort was also extended to McNulty Creek watershed, as these watersheds are adjacent and minimal information of water quality exists.

The intensive monitoring effort commenced in June 2022, and this report presents results between June and December 2022. These results are also included in the online public dashboard. The following table lists the sites included in the study, and locations are represented in Figure 2.

Overview Map of the 11 Intensive Monitoring Locations in McNulty Creek and Milton Creek Watersheds

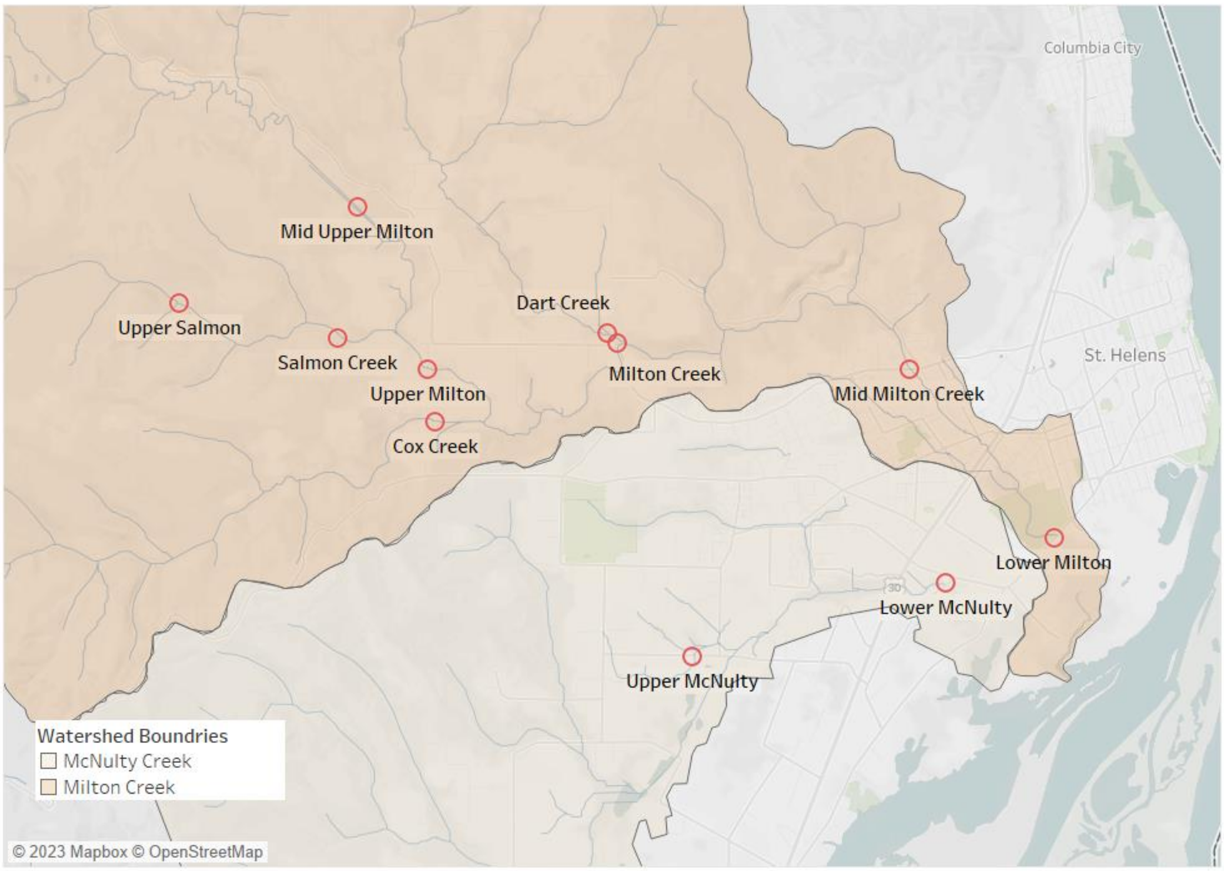


Figure 2: Map of the Intensive water quality monitoring site locations within the McNulty Creek and Milton Creek Watersheds.

Table 2: Location descriptions of sampling stations part of the intensive monitoring study.

Station Identification	Site Code	ODEQ LASAR #	Station Description	Latitude	Longitude	Parameter
McNulty Creek Watershed						
Upper McNulty	UMN	n/a	McNulty Creek off of Millard Road. Silty Substrate	45.841722	-122.856603	Temperature, E. Coli, Turbidity, pH, DO
Lower McNulty	LMN	n/a	McNulty Creek at McNulty Way, off of Gable Road. Rocky Substrate	45.846372	-122.827719	Temperature, E. Coli, Turbidity, pH, DO
Milton Creek Watershed						
Upper Salmon Creek	USAL	n/a	Salmon Creek adjacent to Brinn Road. Silty Substrate	45.871681	-122.934433	Temperature, E. Coli, Turbidity, pH, DO
Salmon Creek	SAL	n/a	Salmon Creek at Crosby Road. Rocky substrate	45.867781	-122.872375	Temperature, E. Coli, Turbidity, pH, DO
Mid-Upper Milton	Mid-UM	n/a	Milton Creek off of Pitsburg Road. Silty Substrate	45.855719	-122.860086	Temperature, E. Coli, Turbidity, pH, DO
Upper Milton	UM	n/a	Cox Creek South of Yankton School (Yankton), Rocky Substrate	45.8641139	-122.8879489	Temperature, E. Coli, Turbidity, pH, DO
Cox Creek	Cox	n/a	Cox creek on West Kapplar road, rocky substrate	45.867231	-122.877925	Temperature, E. Coli, Turbidity, pH, DO
Dart Creek	Dart	n/a	Dart Creek at the crossing of Pittsburg Road and Robinette road. Silty Substrate.	45.870647	-122.884314	Temperature, E. Coli, Turbidity, pH, DO
Milton Creek	Milton	n/a	Milton Creek on Pittsburg Road. Connected to Dart Creek through a culvert. Silty substrate	45.870647	-122.884314	Temperature, E. Coli, Turbidity, pH, DO
Middle Milton Creek	MMC	n/a	Milton Creek at the crossing of Pittsburg road and Isabella Lane. Rocky substrate	45.864283	-122.831686	Temperature, E. Coli, Turbidity, pH, DO
Lower Milton	LM	n/a	Milton Creek at Boise Cascade (River Mile 0.8), Silty Substrate	45.8504302	-122.8147681	Temperature, E. Coli, Turbidity, pH, DO

Watershed Descriptions

In order to classify land cover in the study site, the most recent available land cover data for the County was downloaded from USGS (2016) and re-categorized into forests, shrub/scrub, pastures, developed and open water (Figure 3, Figure 4, Figure 5) using ArcGIS. Areas and percent landcover were calculated for each watershed using Tableau 2023.2. This information will help aid the interpretation of water quality results and provide a complete picture of the watersheds studied in this effort.

The Clatskanie River is approximately 26 miles in length and enters the Columbia River at river mile 50. The Clatskanie watershed is approximately 47,984 acres, with 62% of landcover characterized as forests, 32% as shrub/scrub, and 4% of the landcover is characterized as developed (Figure 3**Error! Reference source not found.**, Figure 4).

Beaver Creek is approximately 19 miles in length and enters the Columbia River at the same location as the Clatskanie River at river mile 50. The Beaver Creek watershed is approximately 31,228 acres with 57.5% of landcover characterized as forests, 27.8% as shrub/scrub, and a little over 8% of the landcover is characterized as developed (Figure 3, Figure 4).

The Scappoose Bay watershed has been divided into four sub-basins: Milton Creek, McNulty Creek, North Scappoose Creek, and South Scappoose Creek. Milton Creek is approximately 20 miles in length and enters near the mouth of the Scappoose River. The Milton Creek watershed is approximately 20,680 acres, with 55% of the landcover characterized as forests, 27% as shrub/scrub, and 9% of the landcover characterized as developed (Figure 3, Figure 4, Figure 5). The McNulty Creek watershed is 7,696 acres, is 20 stream miles in length, and lies south of Milton Creek. McNulty Creek also flows into the waters of Scappoose Bay. The North Scappoose Creek and South Scappoose Creek are 12 miles in length and enter the Columbia River via Scappoose Creek at Columbia River mile 86. The North Scappoose watershed is 20,569 acres with 65% of landcover characterized as forests, 28% as shrub/scrub, and 6% of the landcover characterized as developed (Figure 3, Figure 4). The South Scappoose Creek watershed is 17,391 acres with 54% of landcover characterized as forests, 34% as shrub/scrub and 9% of the landcover characterized as developed (Figure 3, Figure 4). Due to tidal influences, Scappoose Creek is not included in this study.

Land cover of Scappoose Bay watershed (excluding McNulty Creek watershed) was previously classified in 2011 using 2001 data, the results of which are present in Appendix C. When compared to results from Figure 3, a negligible amount of change was observed.

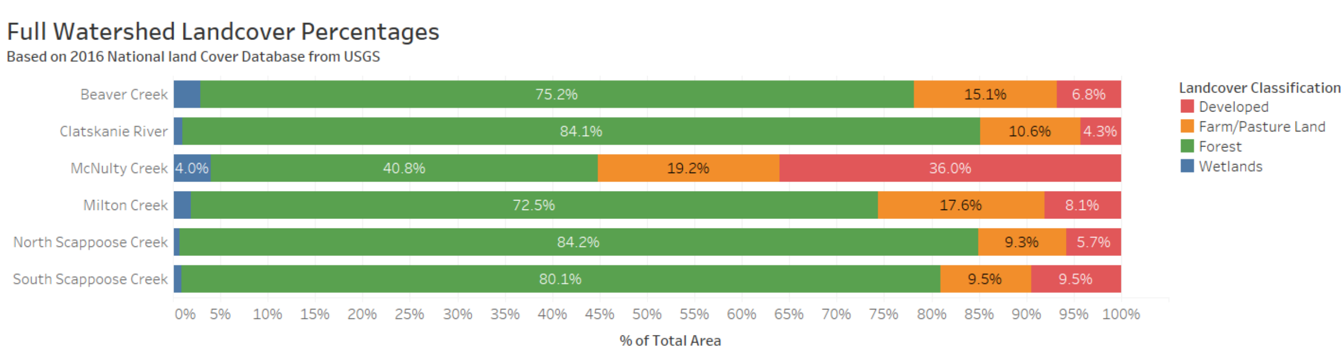


Figure 3: Percent land cover in Columbia County watersheds based on USGS 2016 Land cover data.

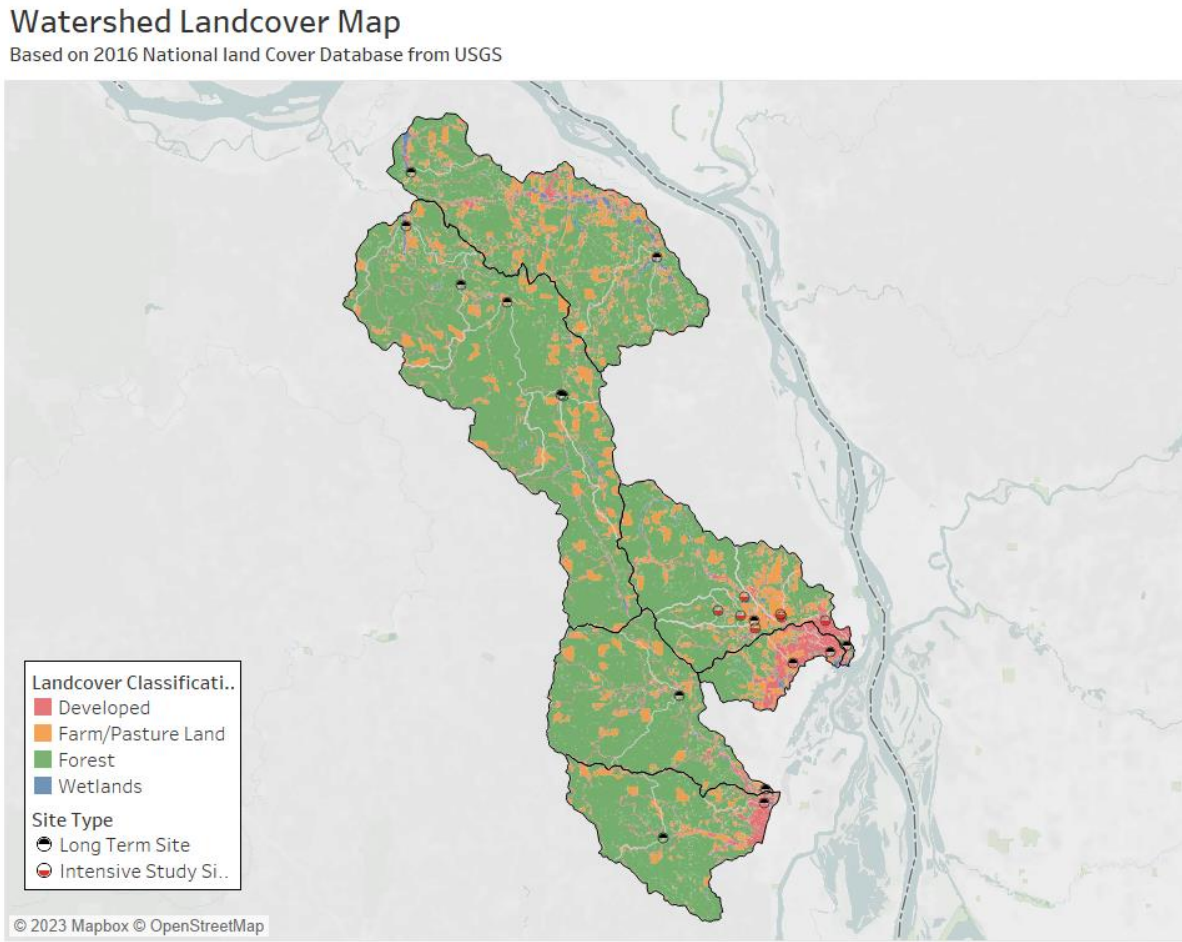


Figure 4: Columbia County Watershed Subbasin Landcover classification map with major watershed boundaries in black and minor subbasin watersheds in gray. The landcover classification is based on the 2016 National Landcover Database from USGS.

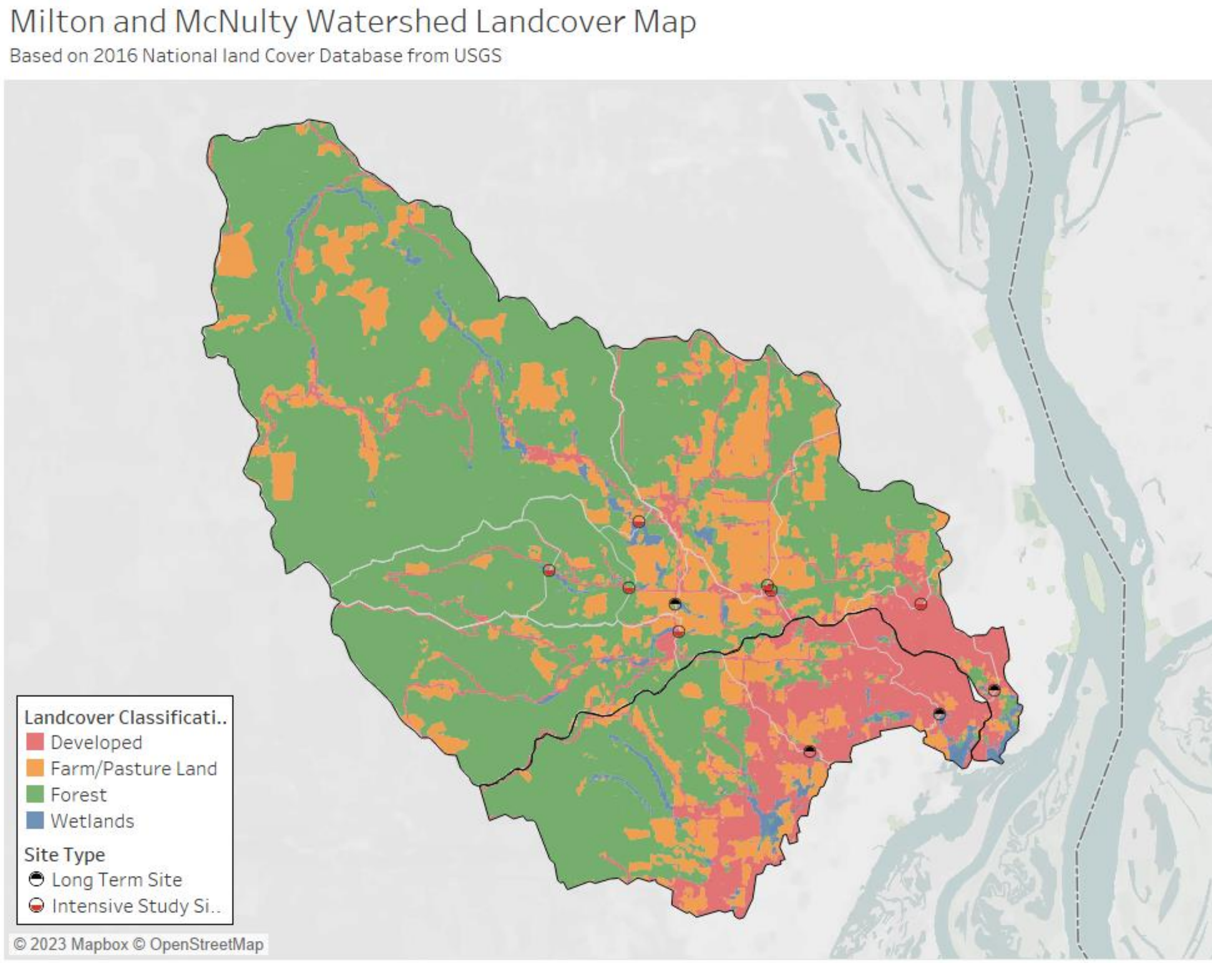


Figure 5: Columbia County Watershed Subbasin Landcover classification map of Milton Creek and McNulty Creek watersheds with minor subbasin watersheds in gray. The landcover classification is based on the 2016 National Landcover Database from USGS.

MONITORING METHODS

Water Quality Parameters

Water quality monitoring was conducted following the methods and quality assurance protocols laid out by the Oregon Department of Environmental Quality (ODEQ) for measuring water temperature, bacteria, instantaneous pH, instantaneous dissolved oxygen (DO), and turbidity (ODEQ 2003). See Table 3 for specifics on equipment used and accuracy ranges of each parameter measured. Parameters included in the program are considered limiting factors to salmon and can significantly affect the health, distribution, and survival of ESA-listed salmon (WDFW 2009, ODFW 2014). See Table 4 for a summary of the standard parameter ranges for salmonid habitat and general stream water quality.

Temperature – Stream temperatures are indicative of overall stream health because it alters the chemistry of other parameters. Moreover, all stages of ESA-Listed salmon are affected by elevated temperatures, causing stress, desmoltification, migration blockages, and death (Wasowski et. al 2013).

Turbidity – is the reduction in stream clarity due to the presence of suspended solids. It is the measure of how clear the water is, with murkier waters indicative of high levels of turbidity. Turbid waters can affect salmon health by causing gill blockages, smothering eggs, and killing benthic invertebrates. Turbid waters can be an indication of increased nutrients due to agricultural runoffs, pollutants, and pathogens (ODFW 2014, Holmen et. al 2011).

E. coli - Escherichia coli (*E. coli*) is a type of fecal coliform bacteria that comes from human and animal waste. The presence of *E. coli* in stream waters is indicative of human or animal waste and is a health threat, not only to humans but also to salmonids. The most common sources are failing septic systems and livestock (State Water Resources Control Board, 2010).

pH – Salmon have a narrow range of preferences, and values outside this range can affect salmon health to varying degrees, depending on the species. Some negative effects include changes in metabolism, damages to outer surfaces, increased ammonia toxicity, and reduction in prey resources. The pH of a stream can also lead to changes in the concentration of pollutants (Holmen et. al 2011).

Dissolved Oxygen (DO) – the concentration of oxygen present in water at a given temperature. Stream DO varies depending on respiration, photosynthesis, nutrient loading, and temperature. Different life-stages of salmon require different DO levels; however, the optimal DO level is >11mg/L. Sub-optimal DO levels can lead to reduced incubation while low DO levels can cause death (WDFW 2009, Holmen et.al 2011).

Conductivity – indicative of the ability of water to conduct electric current, which is a measure of dissolved ions. The conductivity of streams is generally <150µS/cm in the region (Holmen et al. 2011).

Data loggers were deployed at 13 long-term monitoring stations (between 2017 and 2022), and at 9 monitoring locations of the intensive monitoring effort beginning in June 2022 (**Error! Reference source not found.**, Appendix A). Continuous water temperature collected monthly, at 30-minute intervals, throughout the year. During the monitoring period, certain instances led to data gaps, which have been represented in Figure 6. Dataloggers collecting continuous temperature data in the streams were lost during some storms and high flow events. Due to a programming issue with a hoboware data shuttle used to download logged data on-site, there was a data-loss event during September and/or October of 2019. However, despite these occasions, the long-term monitoring program was able to identify trends in water quality metrics. All site location data was collected for mapping using an Ashtech Promark 220 GPS Unit. On-site, instantaneous temperature and conductivity measurements were made at monthly intervals to serve as temperature checks for continuously collected temperature data. Since 2021, pH and Dissolved Oxygen (DO) instantaneous measurements were also made at monthly intervals using a YSI Pro-plus Series Meter.

Turbidity samples were collected monthly at all monitoring stations between 2017 and 2022 and bi-monthly between June and September since 2019. One duplicate sample was collected per sampling event to ensure and check quality control. *E. coli* samples were collected in 100 mL bottles fixed with sodium thiosulfate at the temperature monitoring stations; however, the frequency of sampling varied over the reported monitoring period. In 2017, *E. coli* samples were collected monthly between July to October, while in 2018 and 2019, *E. coli* samples were collected on a biweekly basis during the summer (June – September) and then monthly from October 2019 to December 2022. Biweekly samples were also collected between June to September since 2019 to further assess if they were exceeding ODEQ thresholds for freshwater contact recreation:

a) A 90-day geometric mean of 126 *E. coli* organisms per 100 mL
b) No single sample may exceed 406 *E. coli* organisms per 100 mL.

Water Quality Data Analysis

Water quality data were summarized and compared to standard parameter ranges for ideal salmonid habitat as defined by the ODEQ, OWEB, and Environmental Protection Agency (EPA) (EPA 2001, OWEB 2001, ODEQ 2003). See Table 4 for a summary of the standard parameter ranges for salmonid habitat and general stream water quality used in this analysis.

Water temperature, turbidity, pH, DO, and *E. coli* data are reported by sampling location and watershed. The 7-day moving average maximum (7 dMAM) was calculated from the continuous water temperature data for the entire monitoring period. The number of days over 18°C and 25°C (DEQ regulatory standards for salmonid rearing habitat, Table 4) was also calculated and summarized. Turbidity, pH, DO, and *E. coli* data were summarized across years for each monitoring station. Monthly variation for listed parameters across years at each station were tabulated. All water quality data analysis was conducted using Tableau 2023.2.

Table 3: Water quality parameters measured, equipment used, and accuracy standards (ODEQ A level data quality standards) (OWEB 2001).

Water Quality Parameter	Equipment	Accuracy
***E. coli* Bacteria Counts**	Lab Analysis	(+/-) 0.5 log (MPN/100ml)
Turbidity	Hach Turbidity Meter	(+/-) 5% of standard value (NTU)
Stream Water Temperature	HOBO Data Logger and NIST Digital Thermometer	(+/-) 0.5 °C
Stream pH	YSI Pro Plus Series Meter	(+/-) 0.2 SU
Stream Dissolved Oxygen (DO)	YSI Pro Plus Series Meter	(+/-) 0.3 mg/l

Table 4: Summary of standard parameter ranges for salmonid habitat and general stream water quality (EPA 2001, OWEB 2001, ODEQ 2003, UWE 2006).

Parameters	Need	Acceptable Range	Source
***E. coli* Bacteria**	**General**	<406 MPN/100ml (DEQ) or <235 MPN/100ml (EPA)	DEQ regulatory standards (OAR 340-041), EPA recommended Criteria
Turbidity	**Salmon Habitat**	<10 NTU	University of Wisconsin Extension 2006
Temperature	**Salmon Habitat: Year-round**	18˚C 7-day moving average maximum (7dMAM)	DEQ regulatory standards for salmonid rearing habitat
Temperature	**Salmon Habitat: Healthy Adult**	7.2-15.6ºC (>25 ºC Lethal)	OWEB Water Quality Technical Manual
Temperature	**Salmon Habitat: Healthy Juvenile**	12.2-13.9ºC (>25 ºC Lethal)	OWEB Water Quality Technical Manual
pH	**General**	6.5-8.5 SU	DEQ regulatory standards for Willamette Basin
Dissolved Oxygen (DO)	**Salmon Habitat**	≥11mg/L (<6mg/L Lethal)	DEQ regulatory standards

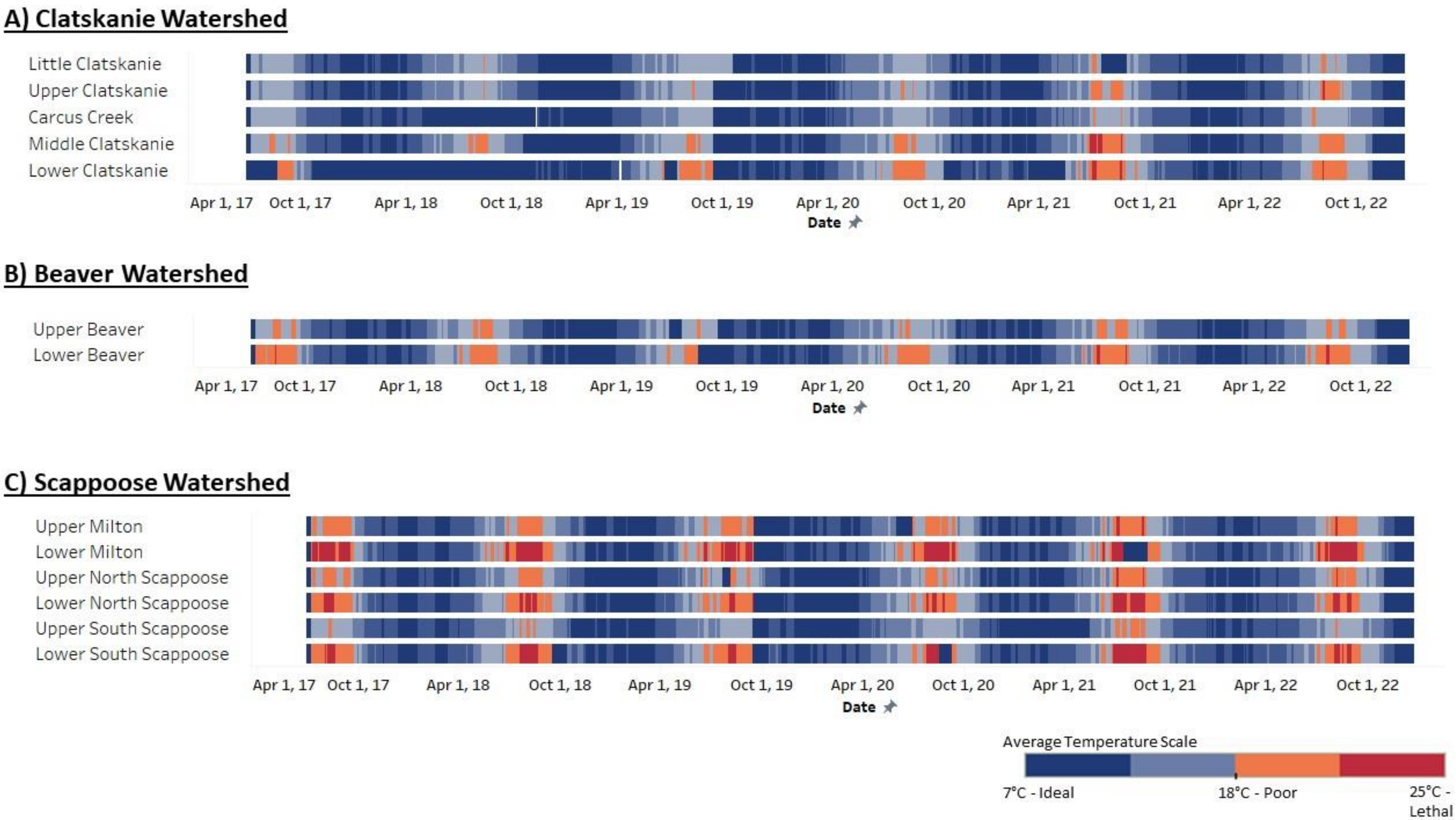
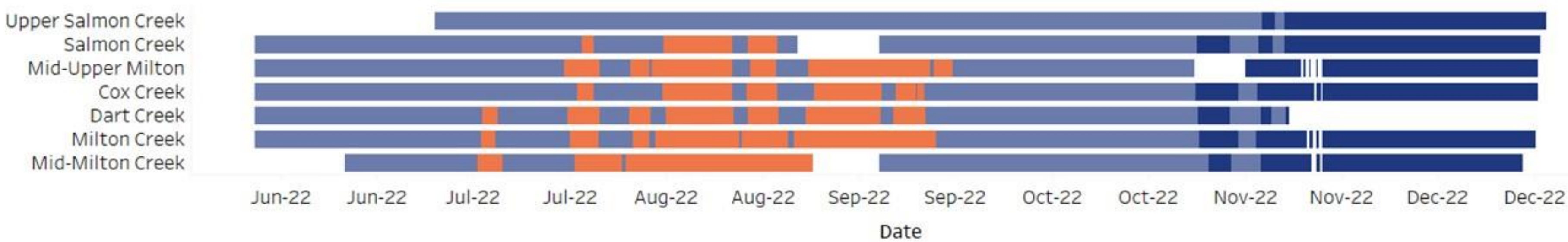


Figure 6: Data logger deployment timeline at 13 monitoring stations across three watersheds, from 2017 to 2022. The colors represent average water temperature (°C) during deployments corresponding to the temperature threshold shown in Table 4 and represented in the legend.

Milton and McNulty Intensive Monitoring Study

A) Milton Creek additional monitoring Locations



B) McNulty Creek Watershed

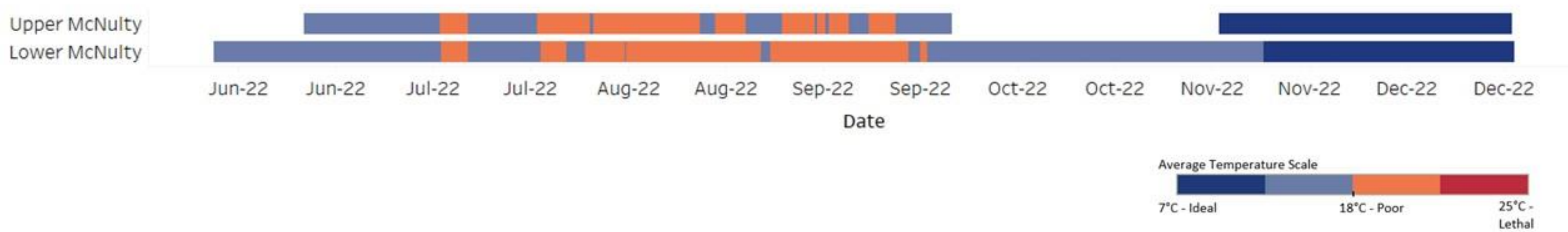


Figure 7: Data logger deployment timeline at the 9 intensive monitoring stations across three watersheds, from June to December 2022. The colors represent average water temperature (°C) during deployments corresponding to the temperature threshold shown in Table 4 and represented in the legend.

Comparative Analysis with Historic Datasets

Water quality data of the Scappoose Bay watershed collected as part of this sampling effort has been compared to baseline data collected as part of a watershed-wide monitoring program between 2008 to 2011 (OWEB, 2011). The baseline data collection effort monitored a total of 27 sites for temperature, dissolved oxygen (DO), pH, turbidity, and conductivity. Monitoring sites at Milton Creek, North Scappoose Creek, and South Scappoose Creek from both efforts were mapped and locations with close proximities were compared to identify changes in the monitored parameters (Table 5). The locations used for these comparative analyses are tabulated below. In 2022, 7dMAM Temperature, turbidity, pH, DO, and *E. coli* data from both efforts were compared and variations have been summarized in this report.

Table 5: Locations of sampling stations from the current and historic data used for the comparative analysis. Years of available data are also presented.

Sub-watershed	Site Identification	Latitude, Longitude	Monitoring Years	Historic data Monitoring Site	Latitude, Longitude	Monitoring Years
Milton Creek	Upper Milton – UM	45.8641139, -122.8879489	2017-2021	Milton Creek – MIL024	45.8933333, -122.9273500	2008-2009, 2011
				Salmon Creek – SAL148	45.8670167, -122.8925667	2008-2009, 2011
	Lower Milton – LM	45.8504302, -122.8147681	2017-2021	Milton Creek – MIL002	45.8505000, -122.8143167	2008, 2011
North Scappoose Creek	Upper North Scappoose – UNS	45.8227512, -122.9469585	2017-2021	Alder Creek – ALD077	45.8204833, -122.9468500	2008-2009, 2011
	Lower North Scappoose – LNS	45.7711443, -122.8787030	2017-2021	North Scappoose – NSC001	45.7696333, -122.8743500	2008, 2011
South Scappoose Creek	Upper South Scappoose – USS	45.7443630, -122.9596836	2017-2021	Lacey Creek – LZY028	45.7467667, -122.9694833	2008-2009, 2011
				South Scappoose – SSC041	45.7548500, -122.9772833	2008-2009, 2011
	Lower South Scappoose – LSS	45.7637674, -122.8800218	2017-2021	South Scappoose – SSCJPW	45.7567500, -122.8828500	2008, 2011

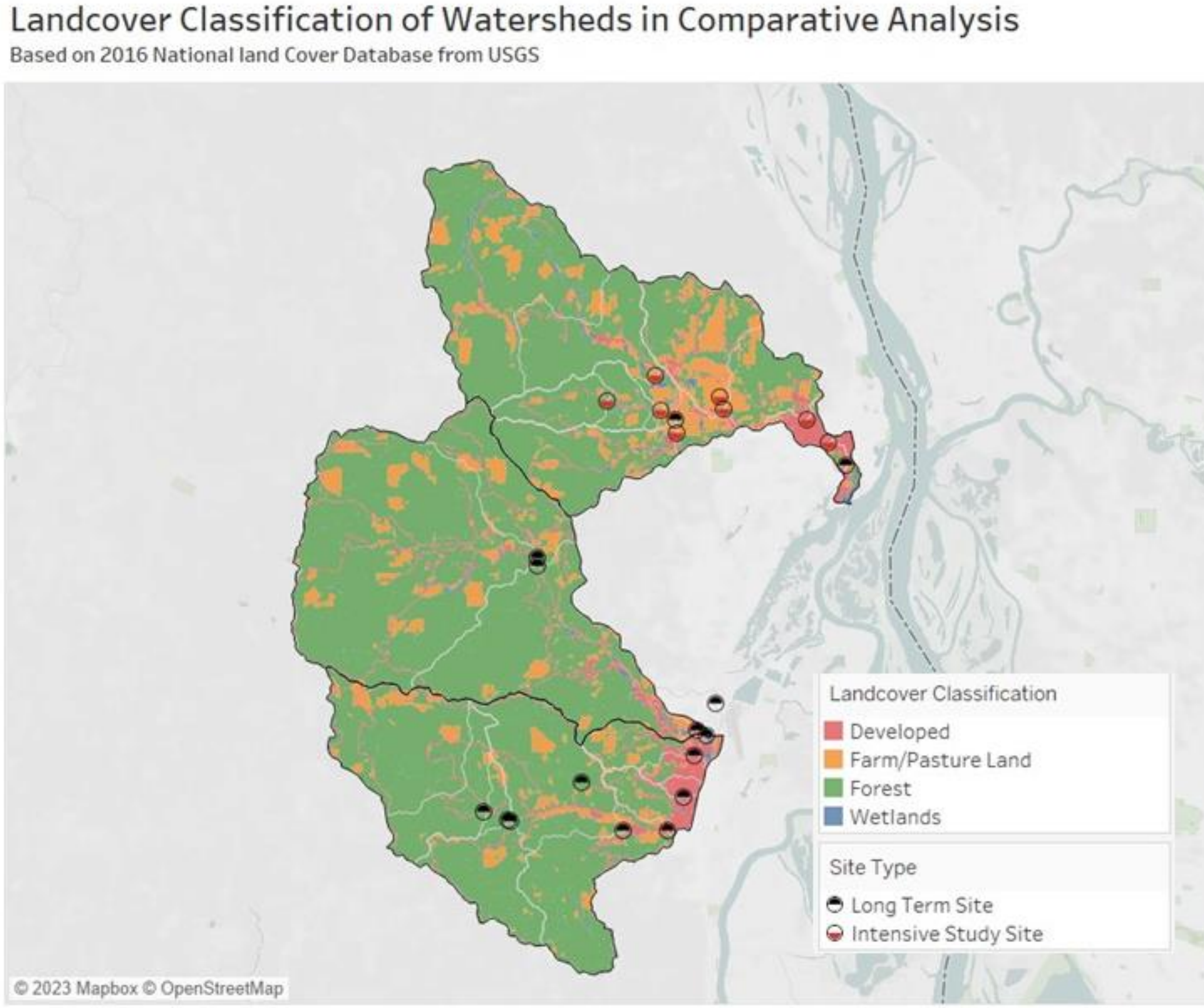


Figure 8: Landcover classification map of the monitoring locations part of the Historic Datasets used for the Comparative Analysis.

WATER QUALITY MONITORING RESULTS

Clatskanie Watershed

Study Area

Clatskanie Watershed Monitoring Locations (2017-2022)

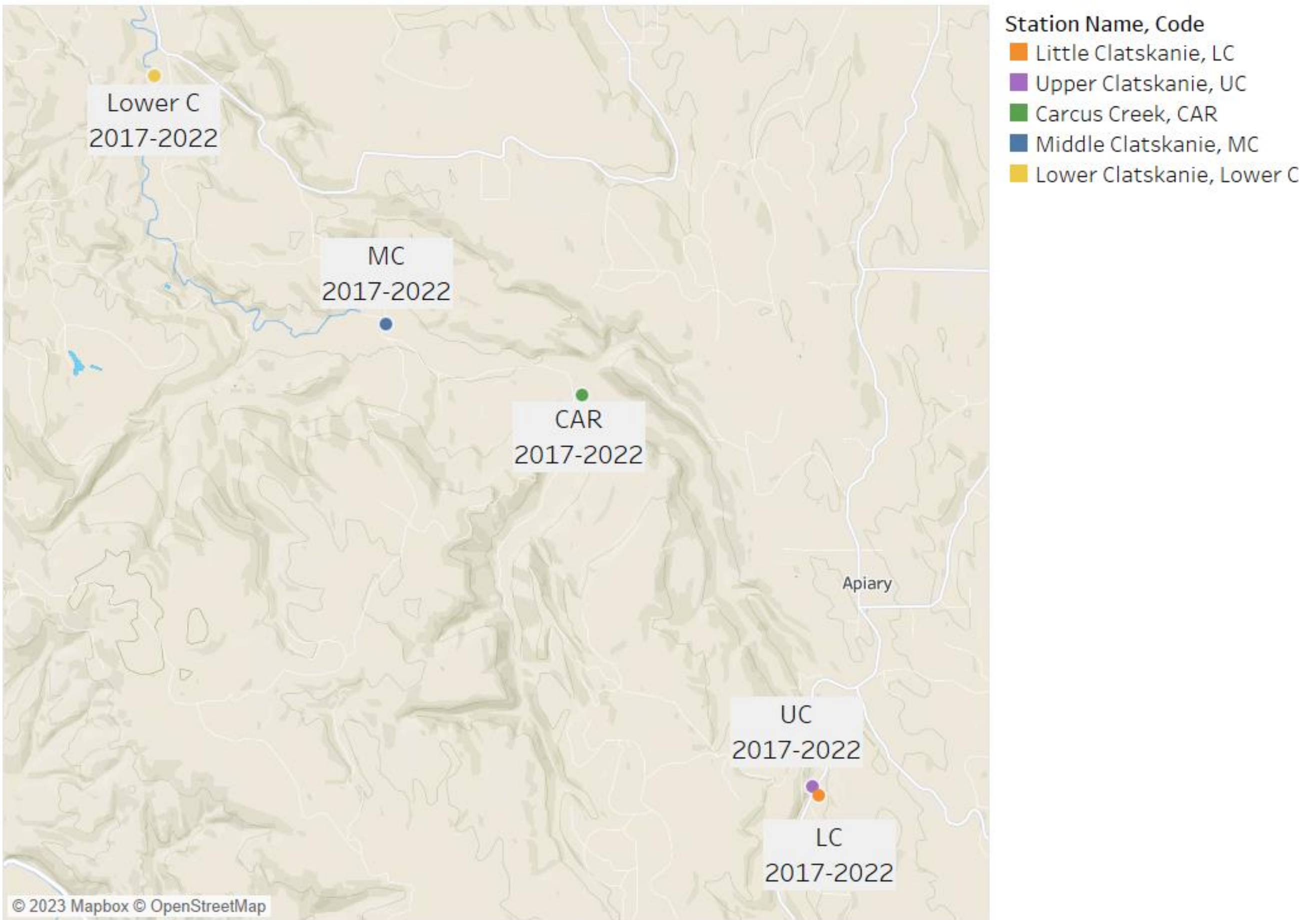


Figure 9: Focus map of Clatskanie Watershed Water Quality Monitoring Locations (2017-2022) moving from the upper watershed with Little Clatskanie (LC) to the lower watershed, nearing the confluence of Clatskanie river with the Columbia River, at Lower Clatskanie (Lower C). For a map of watershed, boundaries see Figure 1, and for specific monitoring location details, see Table 1.

Water Temperature

In 2022, 7-day moving average maximum temperatures (7dMAM) in the Clatskanie watershed ranged from 2.7 °C to 21.8 °C (Table 6), with the highest temperatures being observed in late July and early August of 2022. Between 2017-2021 these ranges were between 1.8°C – 26.8 °C, and the highest temperatures being observed in August (Figure 10). Stream temperatures tended to increase from the upper basin to the lower basin (Table 7, Figure 11). The highest seasonal 7dMAM temperatures were observed in Lower mainstem Clatskanie River.

DEQ temperature standard for salmon rearing habitat is less than 18°C. Streams with temperatures higher than 18°C are considered poor quality for salmon and temperatures above 25°C are considered lethal. In 2022, all monitoring stations exceeded the 18°C threshold between June and September (Table 7Table 6, Table 7). Previously, summertime temperatures were higher in the mainstem than in the tributaries. Little Clatskanie and Carcus Creek, which are tributaries to the mainstem, were generally below 18°C between 2017 and 2021 (Figure 11). These monitoring locations are in forested areas of the watershed (Figure 4). Summer temperatures in the Lower and Middle Clatskanie River mainstem exceeded 18° C more regularly than other sites in the watershed. These sites are in areas with pastures with runoff and reduced shading, which may contribute to increased temperatures. Temperatures in the middle and lower reaches of Clatskanie exceed 18°C for longer periods of time compared to the upper reaches of the watershed between 2017 – 2022 (Table 7).

Table 6: 7dMAM temperatures summary from 2017 to 2022 for creeks in Clatskanie River Watershed.

		Min. 7DMAM	Avg. 7DMAM	Max. 7DMAM	Number of Days over 18°	Number of Days over 25°
Carcus Creek	2017	4.9	11.9	17.6	0	0
	2018	4.3	7.3	9.7	0	0
	2019	3.0	10.1	16.8	0	0
	2020	6.1	10.7	16.7	0	0
	2021	4.5	10.9	18.4	7	0
	2022	4.4	11.2	19.5	6	0
Little Clatskanie	2017	3.3	11.4	18.0	0	0
	2018	3.4	10.5	18.2	2	0
	2019	1.8	10.8	17.2	0	0
	2020	5.5	10.6	16.9	0	0
	2021	3.5	10.1	19.9	7	0
	2022	3.4	11.0	19.3	10	0
Lower Clatskanie	2017	9.6	16.3	19.9	28	0
	2018	4.1	7.1	8.4	0	0
	2019	3.0	11.1	20.9	57	0
	2020	6.2	12.5	20.7	59	0
	2021	5.0	13.5	22.9	72	0
	2022	4.8	12.6	21.7	60	0
Middle Clatskanie	2017	4.3	12.4	19.2	15	0
	2018	4.3	12.1	19.3	29	0
	2019	2.9	13.1	19.4	21	0
	2020	6.0	11.4	19.5	30	0
	2021	4.4	12.2	26.8	64	4
	2022	4.2	12.0	20.9	45	0
Upper Clatskanie	2017	3.3	11.4	18.0	0	0
	2018	2.6	10.6	18.2	2	0
	2019	1.8	12.2	18.3	3	0
	2020	5.4	10.8	18.3	7	0
	2021	4.0	11.2	21.3	43	0
	2022	2.7	10.5	21.8	36	0

Table 7: Number of days over 18°C in the Clatskanie watershed between 2017 to 2022. Winter and spring months have been excluded from this table as stream temperature conditions are within ideal conditions at that time.

		June	July	August	September	October
Little Clatskanie	2017	0	0	0	0	0
	2018	0	0	2	0	0
	2019	0	0	0	0	0
	2020	0	0	0	0	0
	2021	3	4	0	0	0
	2022	0	2	8	0	0
Upper Clatskanie	2017	0	0	0	0	0
	2018	0	0	2	0	0
	2019	0	0	3	0	0
	2020	0	0	7	0	0
	2021	5	18	20	0	0
	2022	0	5	30	1	0
Carcus Creek	2017	0	0	0	0	0
	2018	0	0	0	0	0
	2019	0	0	0	0	0
	2020	0	0	0	0	0
	2021	1	3	3	0	0
	2022	0	6	0	0	0
Middle Clatskanie	2017	0	0	11	4	0
	2018	0	12	17	0	0
	2019	0	6	15	0	0
	2020	0	12	18	0	0
	2021	11	31	22	0	0
	2022	0	7	31	7	0
Lower Clatskanie	2017	0	0	13	15	0
	2018	0	0	0	0	0
	2019	4	18	25	10	0
	2020	3	15	31	10	0
	2021	12	31	25	4	0
	2022	0	19	31	10	0

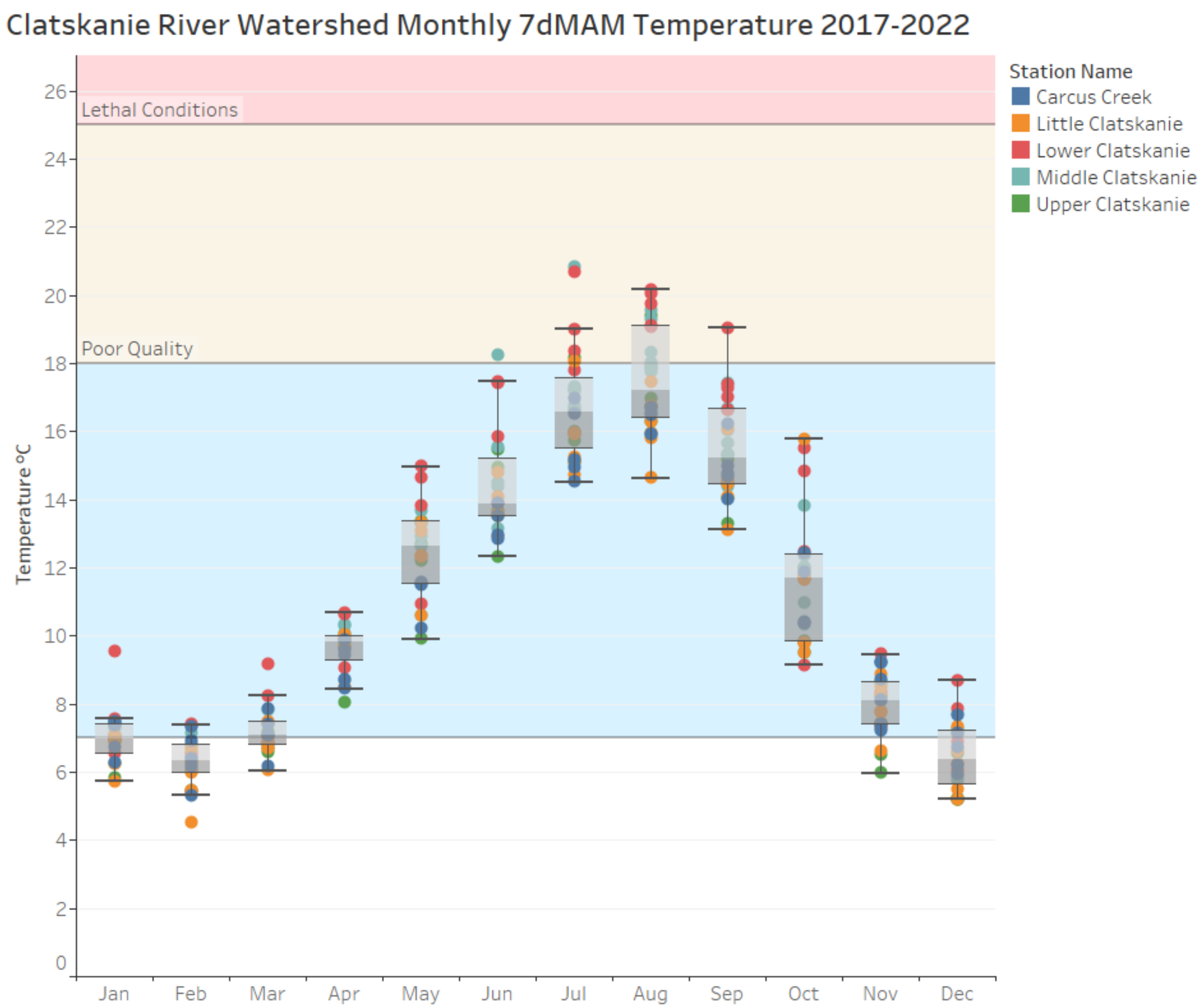


Figure 10: Monthly variation in 7dMAM temperature in the Clatskanie River watershed between 2017-2022.

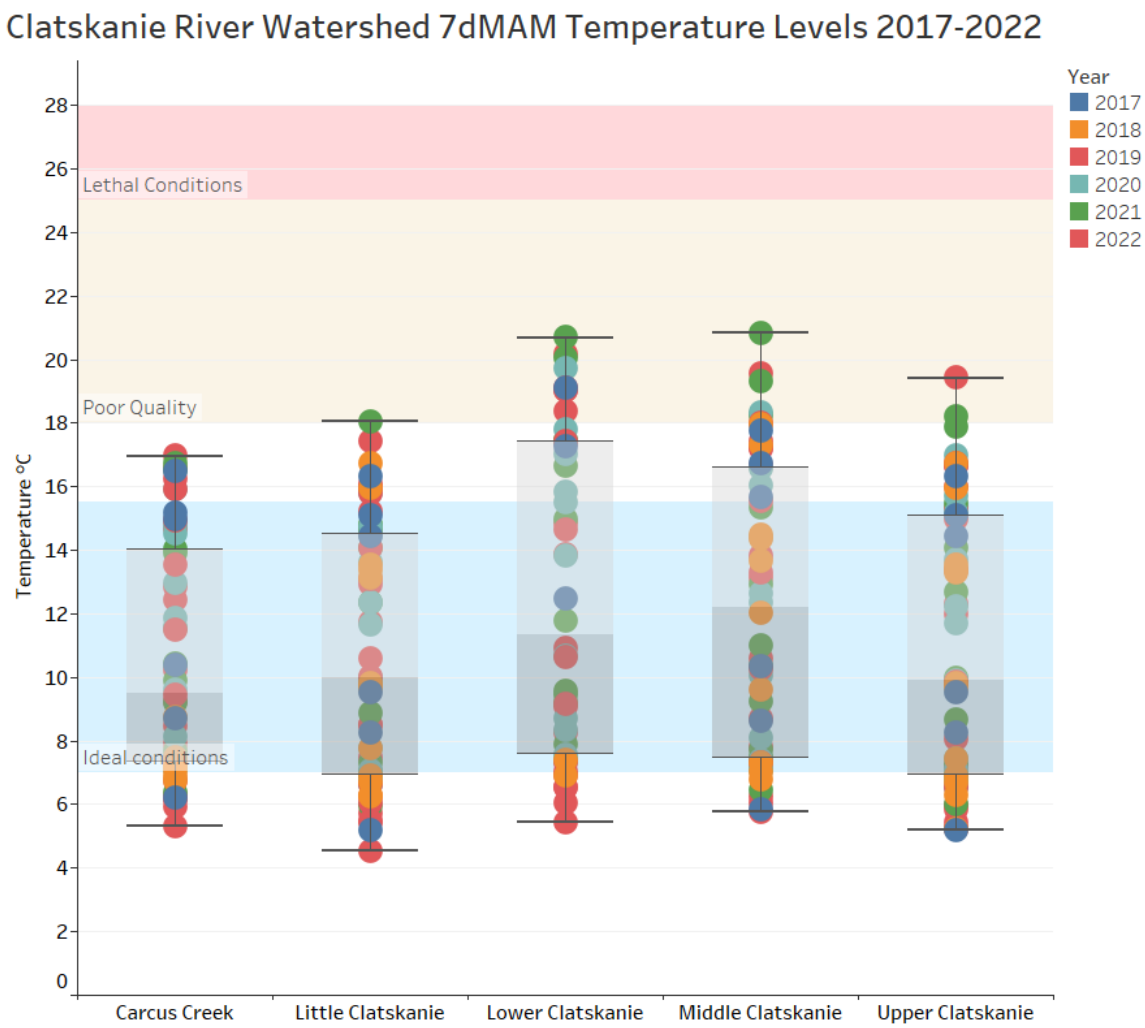


Figure 11: Annual Variation in Clatskanie Watershed 7dMAM Temperature range from 2017 to 2022, overlaid on the DEQ stream temperature standard ranges for healthy salmon habitat (Table 4). Data points represent the months monitored in a year. Ideal Conditions (7°C-15.6°C), Poor Quality (18°C-25°C) and Lethal (>25°C).

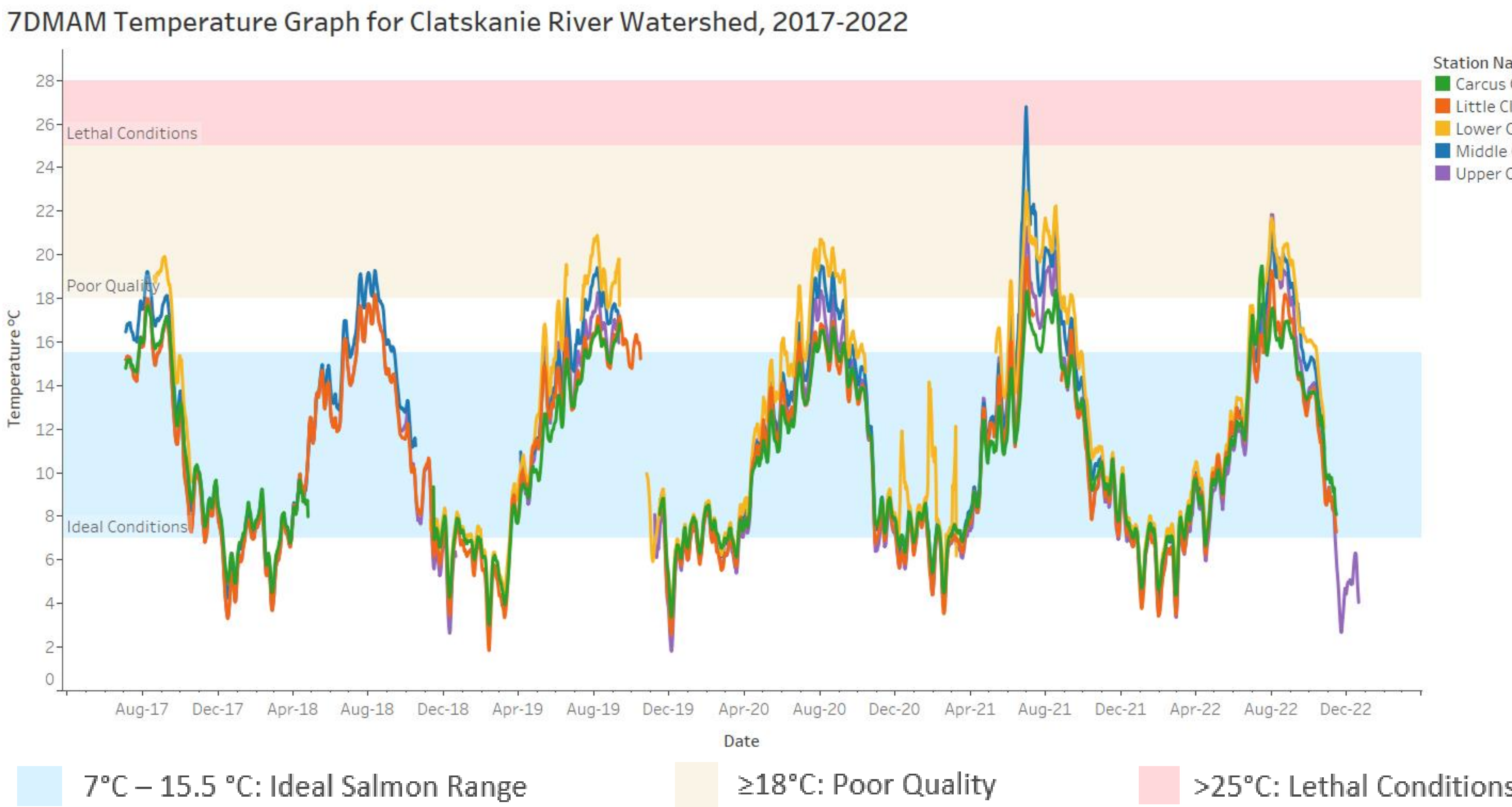


Figure 12: Clatskanie Watershed 7-day average maximum temperatures (7dMAM) from 2017-2022 overlayed on salmonid temperature threshold ranges. See Table 4 for temperature threshold details.

Water Turbidity Levels

In 2022, on average, Carcus Creek, Little Clatskanie Creek, Upper Clatskanie, Mid-Clatskanie, and Lower Clatskanie River sampling locations maintained relatively low turbidity levels, similar to previously monitored years (Table 8,

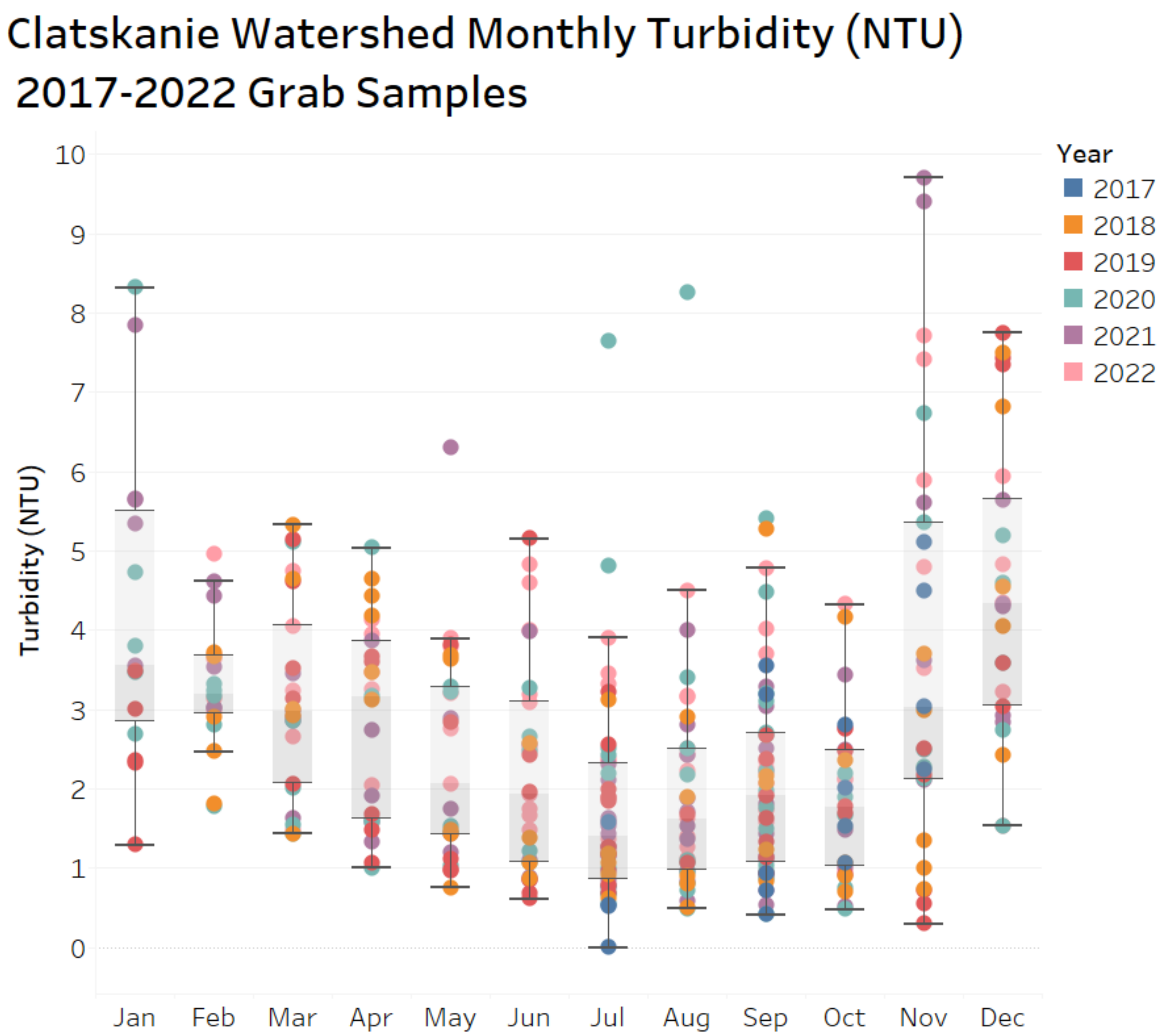


Figure *13*). Seasonally, the highest turbidity levels were recorded in the winter months (Nov., Dec., Jan.), reflecting winter storm conditions and high flow events (

Figure *13*). Elevated turbidity events were primarily observed at the headwater sampling locations Little Clatskanie, Upper Clatskanie, and Carcus Creek (

Figure *14*). All sites remained below the 10 NTU salmon habitat turbidity threshold during the study period.

Table 8: Summary Table for Clatskanie Watershed Monthly Turbidity (NTU), 2017-2022 Grab Samples. Turbidity grab sampling results for Clastkanie Watershed broken down across years and watershed sampling locations. n = number of samples collected. No samples collected went over the 10 NTU threshold.

		n	Max	Mean	+/- SD
2018	Little Clatskanie	11	6.82	3.45	1.79
	Upper Clatskanie	11	7.49	3.85	1.60
	Carcus	11	3.11	1.25	0.85
	Middle Clatskanie	11	4.55	2.03	1.20
	Lower Clatskanie	11	4.42	2.09	1.31
2019	Little Clatskanie	11	7.42	3.46	1.79
	Upper Clatskanie	11	7.35	3.34	1.59
	Carcus	11	7.75	1.68	2.06
	Middle Clatskanie	15	3.59	1.76	0.93
	Lower Clatskanie	13	3.13	1.63	0.90
2020	Little Clatskanie	16	8.32	4.11	2.30
	Upper Clatskanie	16	5.40	3.24	1.13
	Carcus	16	7.65	2.17	1.80
	Middle Clatskanie	16	3.47	1.68	0.82
	Lower Clatskanie	16	3.80	1.63	1.08
2021	Little Clatskanie	15	7.85	3.53	1.80
	Upper Clatskanie	15	5.60	3.10	1.13
	Carcus	15	5.64	1.98	1.66
	Middle Clatskanie	15	9.40	2.38	2.33
	Lower Clatskanie	15	9.70	2.51	2.38
2022	Little Clatskanie	15	7.41	3.95	1.35
	Upper Clatskanie	15	7.71	4.03	1.24
	Carcus	15	3.90	2.05	0.92
	Middle Clatskanie	15	5.88	2.71	1.11
	Lower Clatskanie	15	5.93	2.65	1.31

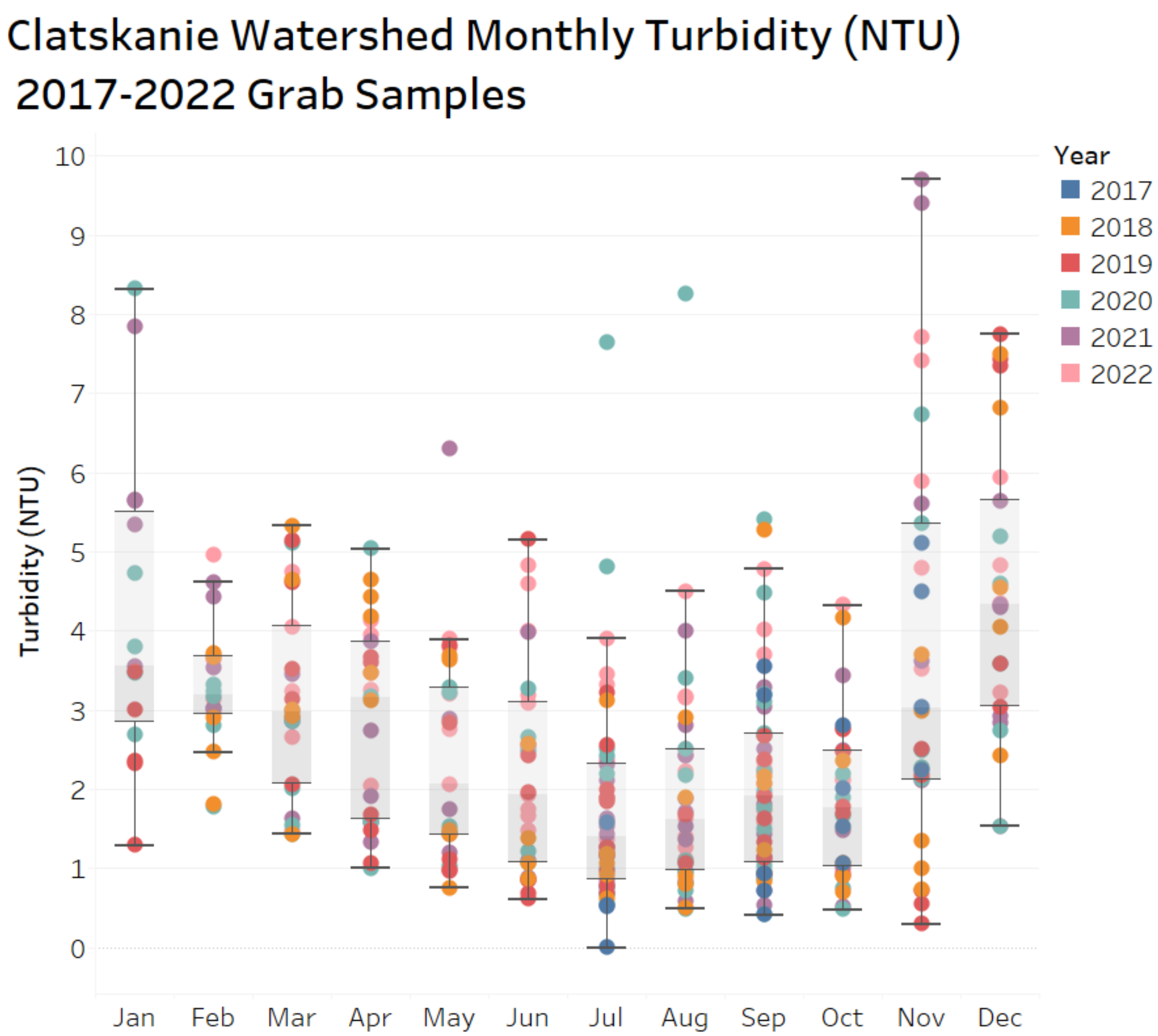


Figure 13: Turbidity (NTU) grab sampling results (boxplots) for Clatskanie watershed broken down across months sampled incorporating all watershed sampling locations. Sampling years ranging from 2017 to 2022 are highlighted within each boxplot. No samples collected went over the 10 NTU threshold. These data broken down across monitoring locations within the watershed can be seen in

Figure 14.

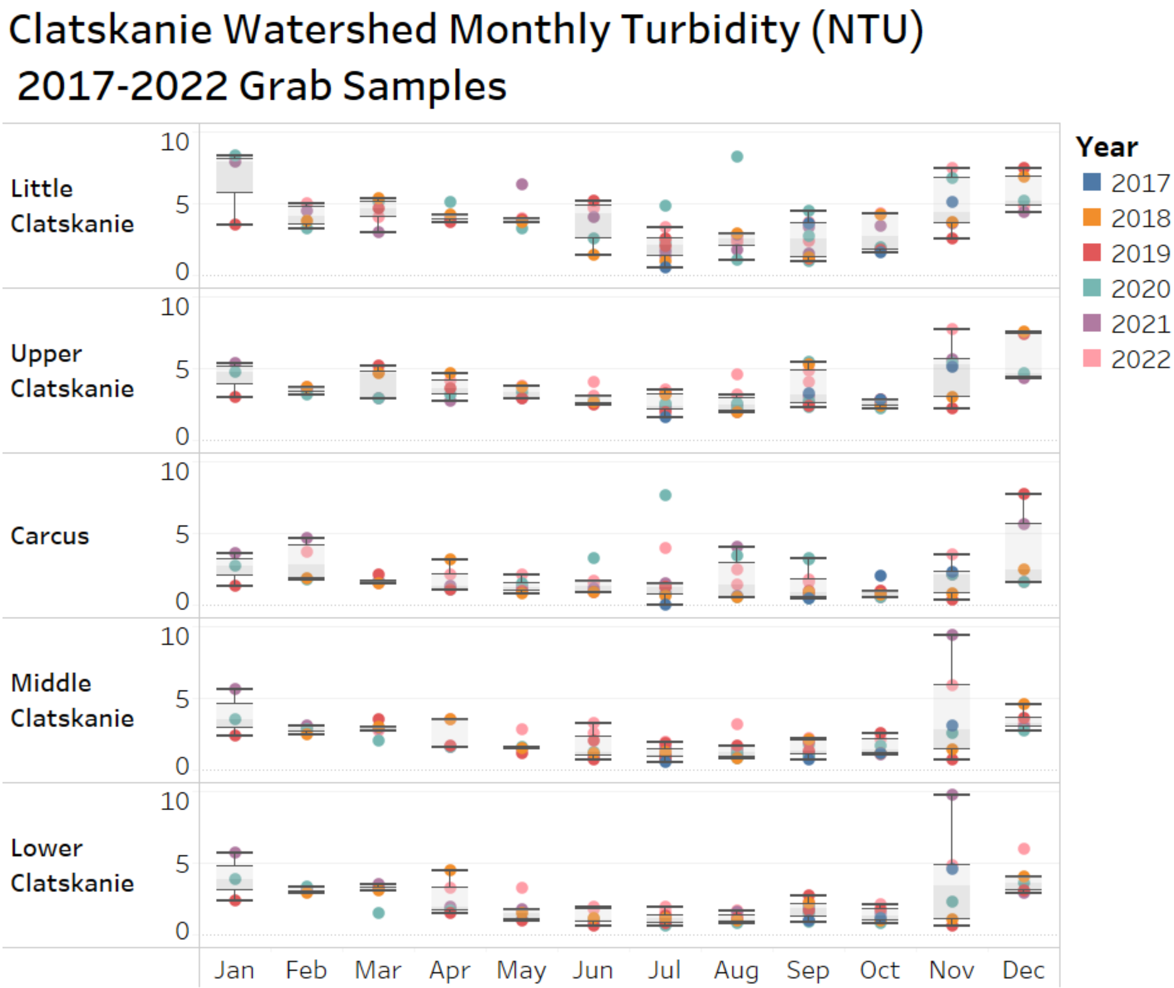


Figure 14: Turbidity (NTU) grab sampling results (boxplots) for Clatskanie Watershed broken down across sampling locations and months sampled. Sampling years ranging from 2017 to 2022 are highlighted within each boxplot. No samples collected went over the 10 NTU threshold. A summary of these data can be found in Table 8.

Water Bacteria Levels

In 2017, stream sampling of *E. coli* bacteria levels in the Clatskanie Watershed were only collected in Lower Clatskanie Creek during September and October 2017 and exhibited low *E. coli* levels (<100 MPN/100 ml) during these sampling events (Table 10, Figure 15-Figure 16). More intensive bacteria sampling has occurred since 2019, with biweekly samples collected in the summer months (ODEQ, 2020). In 2022, on average *E. coli* bacteria levels across most sampling sites remained below the EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds; however, Lower Clatskanie, Middle Clatskanie, Little Clatskanie, and Upper Clatskanie did experience elevated *E. coli* events during the 2017-2022 sampling period. These elevated sample readings primarily occurred between June-October (Figure 15-Figure 16), corresponding with summer high water temperatures (Figure 12).

The 90-day geometric mean state-mandated water quality threshold for Oregon is 126 MPN/100mL; No sampling location exceeded this threshold in 2022. Middle Clatskanie violated this threshold during the following sampling periods June-September 2019 and July-November 2020 (Table 9). Middle Clatskanie also violated the no single sample over 406 MPN/100 threshold in June of 2019 with a sample reading of 2,490 MPN/100 (Table 10). These water quality conditions merit continued monitoring and additional investigation into the cause of elevated *E. coli* levels to ensure they do not continue to decline.

Table 9: 90 Day geometric mean (5 samples or greater) of E. coli bacteria levels (MPN/100ml) across all sampling sites, those durations that are above the state-mandated threshold of 126 MPN/100 ml for the 90 day geometric mean are highlighted with red text.

		Apr Jul	May Aug	Jun Sep	Jul Oct	Aug Nov	Sep Dec
2019	Middle Clatskanie			133.3	66.7		
	Lower Clatskanie			113.7	113.7		
2020	Little Clatskanie		41.2	54.3	63.3	67.8	
	Upper Clatskanie		55.5	58.4	50.0	40.4	
	Carcus		11.2	18.2	17.7	21.3	
	Middle Clatskanie		53.7	88.9	129.7	147.7	
	Lower Clatskanie		58.6	78.4	76.5	99.1	
2021	Little Clatskanie	55.6	61.0		56.8	45.0	36.5
	Upper Clatskanie	44.9	40.3		37.2	21.8	14.8
	Carcus	8.1	13.3		22.8	14.3	12.8
	Middle Clatskanie	20.5	45.0		71.8	67.5	46.5
	Lower Clatskanie	38.2	45.3		81.9	79.6	66.9
2022	Little Clatskanie	42.8	37.7	55.1	51.0	55.9	
	Upper Clatskanie	13.3	19.4	43.5	45.5	42.6	
	Carcus	5.4	7.2	27.2	20.8	27.9	
	Middle Clatskanie	13.9	22.8	65.6	120.9	117.9	
	Lower Clatskanie	21.6	25.4	45.6	66.7	67.1	

Table 10: Summary Table of Clatskanie Watershed Monthly E. coli (2017-2022) MPN/100 ml Grab Samples. E. coli bacteria grab sampling results for Clatskanie watershed broken down across years and watershed sampling locations. Sampling locations that experienced events over the EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted in red. n = number of samples collected.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Little Clatskanie	2017												
	2018												
	2019						140	50		23	6	4	10
	2020	15	9	3	35	9	87	27	345	105	126	91	53
	2021	23	8	2		11	261	64	89	79	96	15	15
	2022		13	13		10	116	155	44	82	140	40	12
Upper Clatskanie	2017												
	2018												
	2019						144	41		59	22	2	10
	2020	3	3	3	6	14	60	54	365	150	19	58	43
	2021	5	1	3		20	54	62	30	60	16	4	5
	2022		4	5	3	11	16	60	199	144	7	14	6
Carcus	2017												
	2018												
	2019						5	18		126	10	0	0
	2020	8	2	9	1	3	16	21	29	114	15	12	15
	2021	5	2	1	2	3	5	57	30	39	11	3	28
	2022		2	8	1	1	9	138	1,120	78	3	24	1
Middle Clatskanie	2017												
	2018												
	2019						2,490	166	46	99	15	13	20
	2020	185	7	9	99	31	36	58	156	248	248	153	28
	2021	26	4	2	2	36	37	70	101	130	144	13	13
	2022		11	5	3	12	21	36	162	210	179	31	17
Lower Clatskanie	2017									44	69		
	2018												
	2019						35	271	111	132	19	15	13
	2020	13	8	14	27	76	41	82	77	190	36	127	23
	2021	20	6	6	26	19	30	82	91	79	150	58	29
	2022		17	25	19	13	36	43	59	134	47	44	21

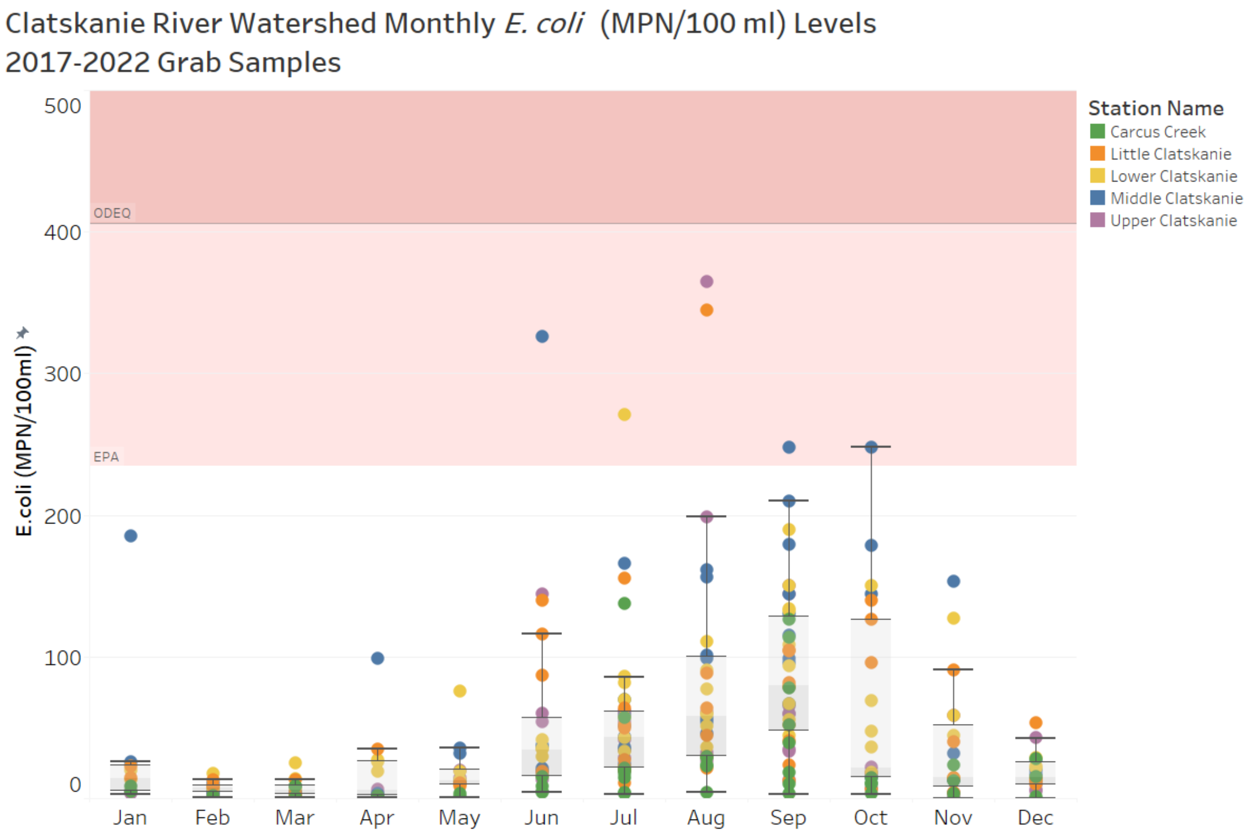


Figure 15: E. coli bacteria grab sampling results (boxplots) for Clastkanie watershed broken down across months sampled incorporating all watershed sampling locations. Sampling years ranging from 2017 to 2022 are highlighted within each boxplot. EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted on each graph. June 2019 Middle Clatskanie 2490 MPN/100 sample results are not shown.

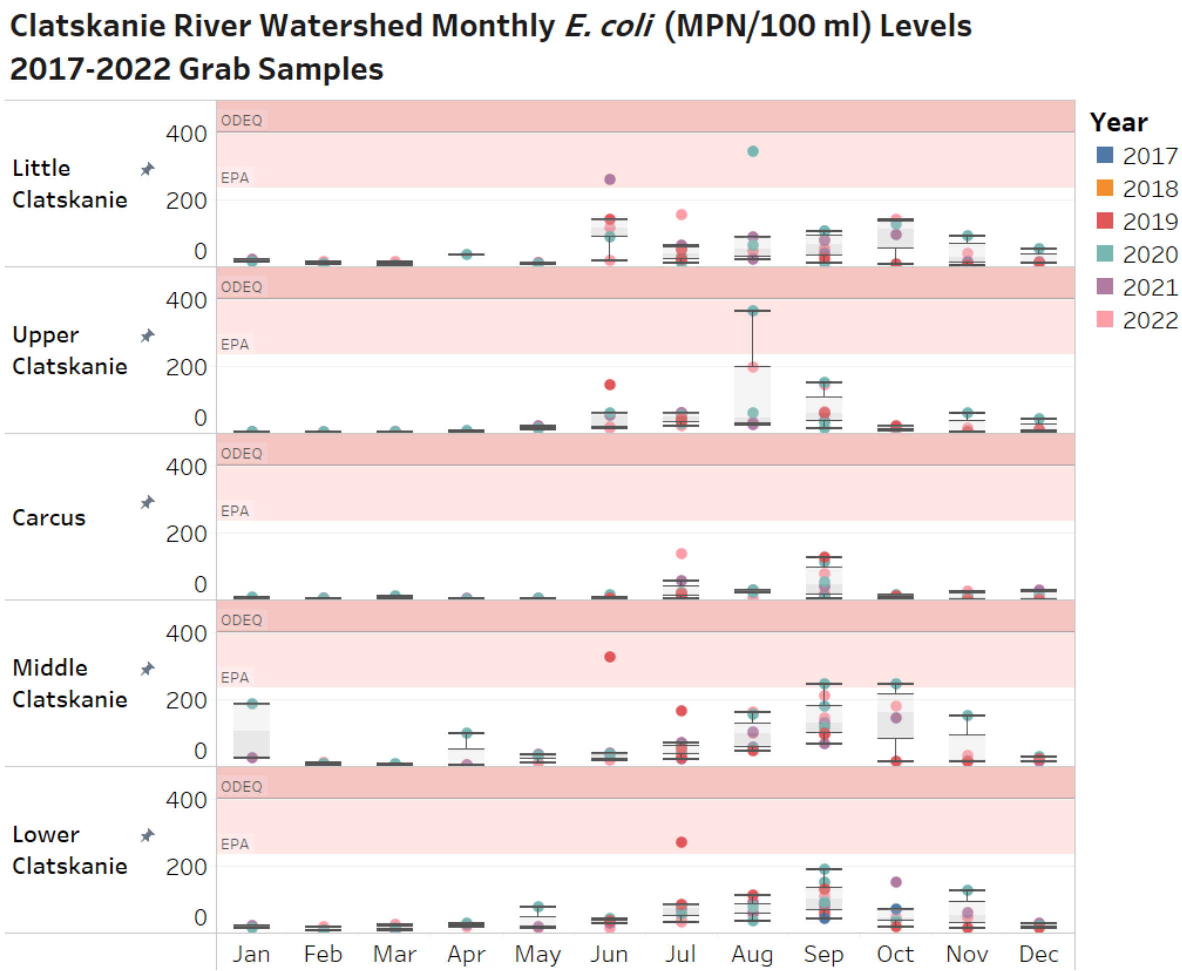


Figure 16: E. coli bacteria grab sampling results (boxplots) for Clatskanie watershed broken down across months sampled and watershed sampling location. Sampling years ranging from 2017 to 2022 are highlighted within each boxplot. EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted on each graph. June 2019 Middle Clatskanie 2490 MPN/100 sample results are not shown.

Water pH levels

Since 2021, in-situ stream pH measurements were collected using a YSI Pro-series meter, with the goal of providing additional information on stream quality. Due to probe malfunctions, measurements were not collected in March 2021 and August 2021. pH levels in the watershed ranged from 7.01 (Dec 2022, LowerC) to 7.89 (Aug 2022, UC), staying within DEQ regulatory standards for ideal stream conditions for salmonids (6.5 – 8.5) (Table 11, Figure 17) Compared to 2021, pH was lower at the monitoring sites in 2022 (

Figure *17*). However, there was a high degree of variability observed in the measurements in the monthly data (Figure 18).

Table 11: Summary Table of in-situ stream pH in Clatskanie Watershed in 2022.

		Count of P H	Min. P H	Max. P H	Std. dev. of P H
2021	Little Clatskanie	11	6.97	8.15	0.37
	Upper Clatskanie	11	7.21	8.33	0.36
	Carcus Creek	11	7.18	7.99	0.28
	Middle Clatskanie	11	7.22	8.31	0.33
	Lower Clatskanie	11	7.20	8.20	0.31
2022	Little Clatskanie	14	7.15	7.85	0.20
	Upper Clatskanie	15	7.08	7.89	0.22
	Carcus Creek	15	7.07	7.87	0.24
	Middle Clatskanie	15	7.02	7.72	0.20
	Lower Clatskanie	15	7.01	7.61	0.16

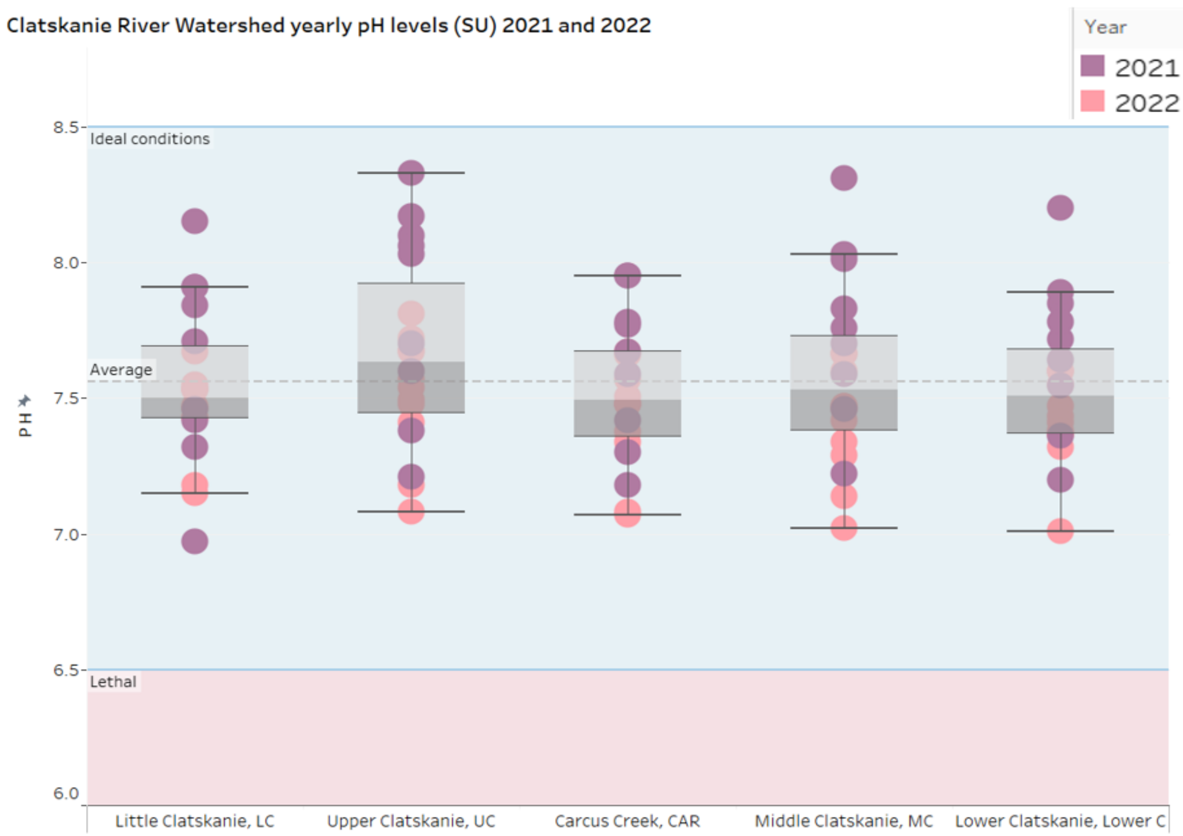


Figure 17: Yearly in-situ stream pH variation across sites in Clatskanie River watershed in 2021 and 2022. DEQ regulatory standards for lethal stream pH conditions for salmonids (<6.5) is represented as a red band. DEQ standards for ideal stream pH conditions for salmonids (6.5 – 8.5) is shown as blue band.

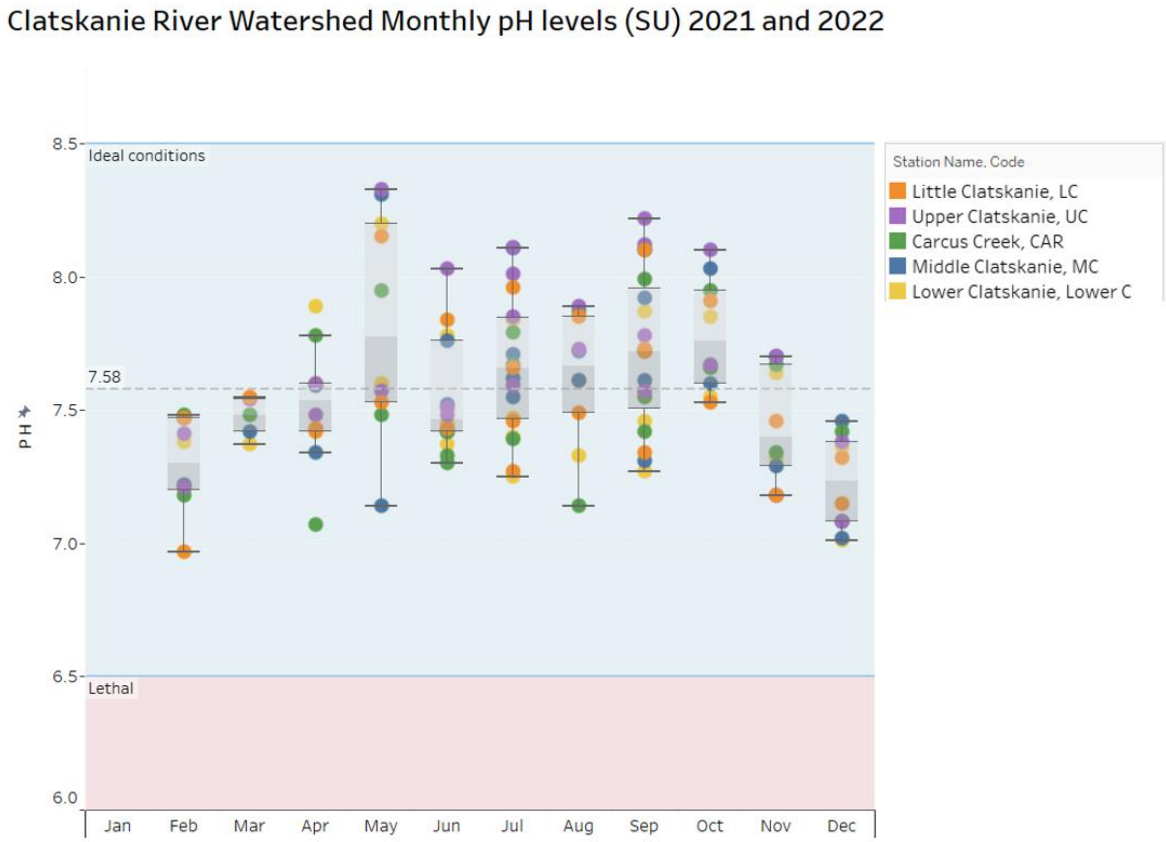


Figure 18: Clatskanie River watershed in-situ stream pH ranges across months in 2021 and 2022. DEQ regulatory standards for lethal stream pH conditions for salmonids (<6.5) is represented as a red band. DEQ standards for ideal stream pH conditions for salmonids (6.5 – 8.5) is shown as blue band.

Water Dissolved Oxygen (DO) Levels

Since 2021, in-situ stream DO measurements were collected using a YSI Pro-series meter, with the goal of providing additional information on stream quality. Measurements were made from January to August. Due to probe malfunction, measurements were not made from September to December 2022.

Stream DO averages in the watershed ranged from 5.9mg/l (August 2022, Carcus) to 14.41mg/l (February 2022, MC) falling below DEQ standards for ideal stream conditions (>11mg/l) between May and October but staying above thresholds for lethal conditions (<6mg/l, DEQ) (Table 12, Figure 19). DO levels in 2022 were similar to 2021 across various monitored reaches of the watershed. Seasonally, elevated DO levels were observed during winter and spring months reaching peak lows during summer before climbing again in the fall. DO levels in the watershed displays a high degree of variability among sites (Figure 19).

Table 12: Summary Table of in-situ Stream DO in Clatskanie Watershed in 2021 and 2022. DEQ standards for stream DO range from Lethal conditions (<6mg/L) to ideal conditions (>11mg/L).

		Count of DO	Avg. DO	Min. DO	Max. DO	Std. dev. of DO
2021	Little Clatskanie	14	9.71	6.22	12.90	2.15
	Upper Clatskanie	14	10.38	6.70	13.07	2.16
	Carcus Creek	14	10.90	8.36	13.02	1.54
	Middle Clatskanie	14	10.91	8.56	13.03	1.48
	Lower Clatskanie	14	10.18	7.76	12.46	1.72
2022	Little Clatskanie	9	10.53	7.03	13.51	2.45
	Upper Clatskanie	10	11.19	7.64	14.00	2.20
	Carcus Creek	10	11.00	5.90	13.95	2.56
	Middle Clatskanie	10	11.26	7.40	14.41	2.28
	Lower Clatskanie	10	10.26	6.26	14.18	2.57

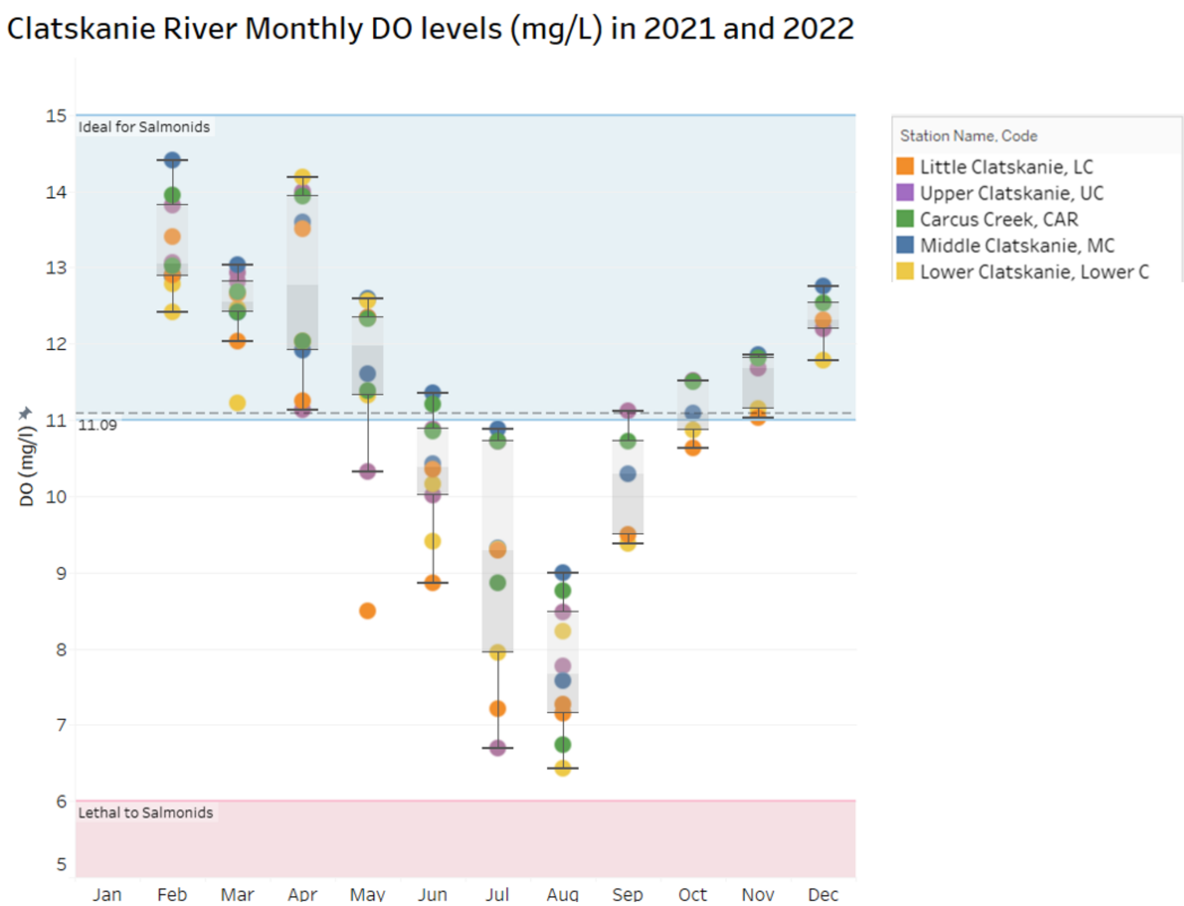


Figure 19: Monthly in-situ stream DO ranges across all monitoring locations in Clatskanie River watershed in 2021 and 2022. DEQ standards for ideal DO conditions for salmonids(>11mg/l) is depicted as a blue band in the graph. DEQ standards for Lethal conditions (<6mg/l) is depicted as red band.

Water Conductivity Levels

Stream conductivity levels were monitored starting in July 2018. Conductivity levels varied seasonally across all monitoring locations within the Clatskanie watershed (Figure 20-Figure 21). Annually, increases in water conductivity occur between April to October and declining from November to February (Figure 20). Between 2018 - 2021, Carcus Creek has exhibited the lowest overall mean conductivity levels, followed by Upper Clatskanie, Little Clatskanie, Middle Clatskanie, and Lower Clatskanie sampling locations. 2022 follows previously observed trends. (Figure 21, Table 13). These data provide baseline conductivity levels that can be used to identify new and emerging water quality issues or improvements over time. Pollution from runoff or increased turbidity levels from sediment can result in higher conductivity levels; however, there is no EPA or ODEQ threshold for conductivity in the region.

Table 13: Summary Table of Clatskanie watershed monthly conductivity (µs/cm) data for 2018-2022 grab samples. Conductivity (µs/cm) samples broken down across months sampled and watershed sampling location. n = number of samples collected.

		n	Max	Mean	+/- SD
2018	Little Clatskanie	6	85	66	20
	Upper Clatskanie	6	80	61	17
	Carcus	6	57	46	11
	Middle Clatskanie	6	73	59	15
	Lower Clatskanie	6	88	73	18
2019	Little Clatskanie	11	103	63	26
	Upper Clatskanie	11	109	63	27
	Carcus	10	71	49	18
	Middle Clatskanie	14	101	71	25
	Lower Clatskanie	12	110	80	28
2020	Little Clatskanie	17	126	70	29
	Upper Clatskanie	17	105	66	25
	Carcus	17	131	55	26
	Middle Clatskanie	17	107	72	25
	Lower Clatskanie	17	115	82	24
2021	Little Clatskanie	14	92	56	25
	Upper Clatskanie	15	88	56	23
	Carcus	15	62	44	15
	Middle Clatskanie	15	95	62	25
	Lower Clatskanie	15	105	70	27
2022	Little Clatskanie	15	85	52	25
	Upper Clatskanie	15	79	48	22
	Carcus	15	60	38	14
	Middle Clatskanie	15	81	52	22
	Lower Clatskanie	15	89	59	23

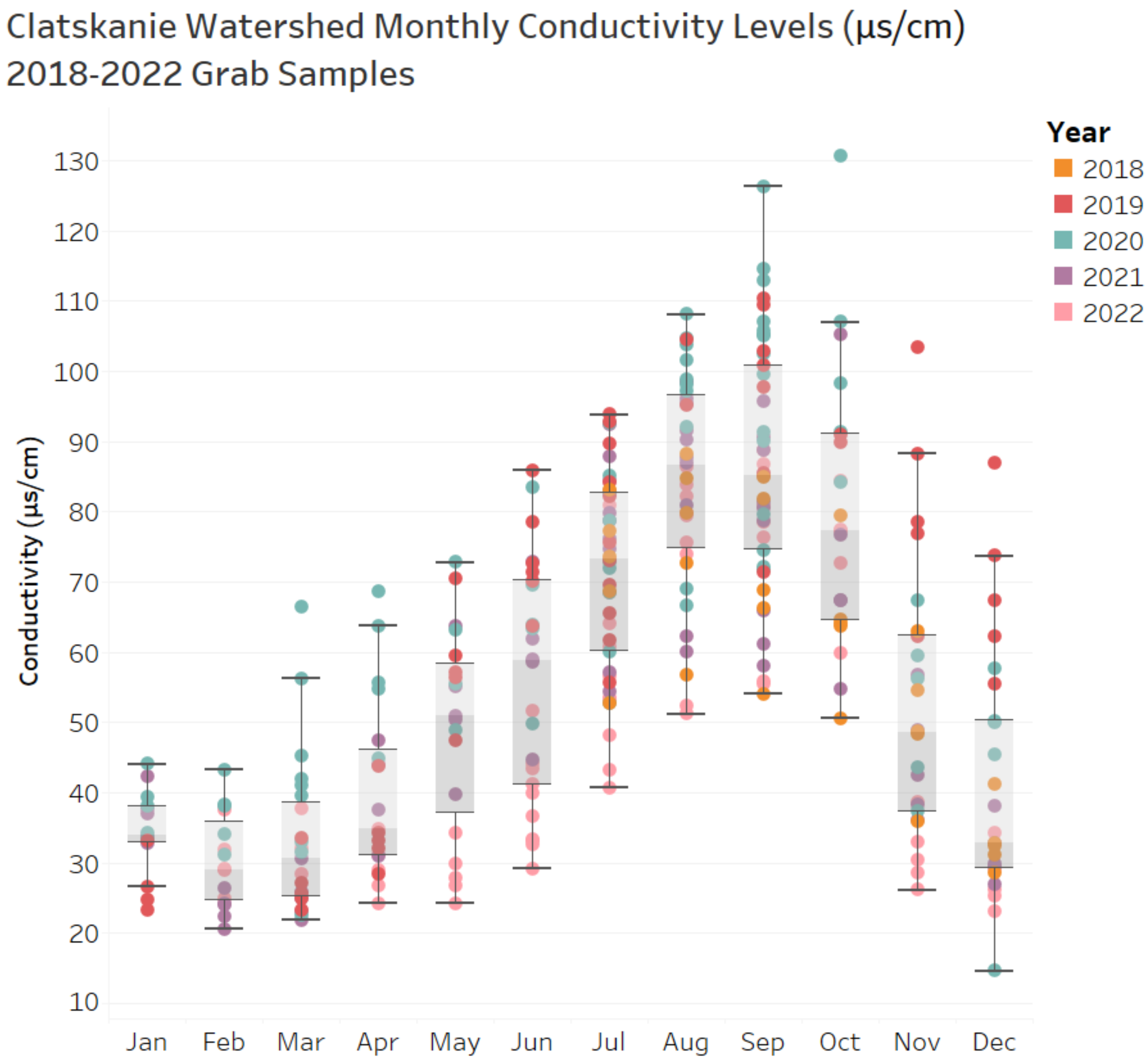


Figure 20: Conductivity levels (µs/cm) 2018-2022 Grab Samples results (boxplots) for Clatskanie watershed broken down across months sampled. Sampling years ranging from 2018 to 2022 are highlighted within each boxplot.

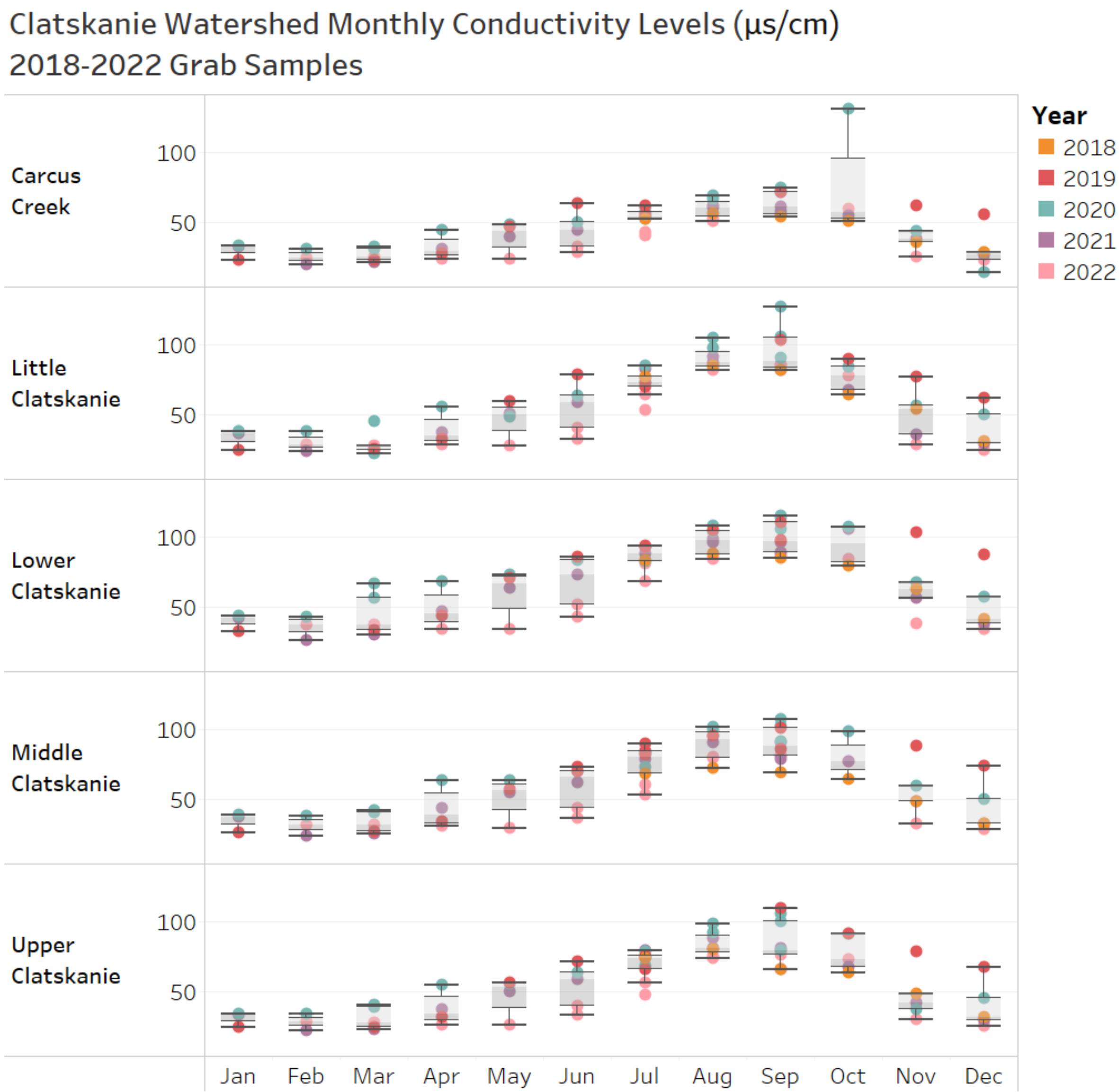


Figure 21: Conductivity levels (µs/cm) 2017-2022 Grab Samples results (boxplots) for Clatskanie watershed broken down across months sampled and watershed sampling location. Sampling years ranging from 2017 to 2022 are highlighted within each boxplot.

Water Quality Issues

Water quality issues observed in Clatskanie Watershed continue to be predominantly isolated to the lower reaches. Water quality in the upper reaches of the Clatskanie Watershed, which are predominantly forested, generally meets minimum EPA and ODEQ requirements for salmon habitat. The temperature in Middle and Lower Clatskanie exceeded the 18°C thresholds for salmon habitat during the summer across all monitoring years (2017-2022), when water levels were low, and air temperatures are high (Table 6). Max 7dMAM exceeded 18°C threshold in the upper reaches of the watershed for second year in a row in 2022. Overall elevated temperatures are likely caused by solar loading, as the lower reaches of the watershed are much more developed (pastures) and lack riparian shade (Figure 4). 2022 was a cooler year compared to 2021, with a late but significant freshet. However, 2022 had 3 heat waves, with the wave in July lasting for a greater number of days than heatwaves observed in the previous years. Low water temperatures are critical for supporting aquatic life including endangered Salmonids in the Pacific Northwest; reducing solar radiation and reducing urban and agricultural runoff can help keep water temperatures down and protect these stream habitats (USGS 2021). pH levels were lower in 2022, and generally stayed within ODEQ standards; however, a high degree of variability was observed in monthly levels. Stream DO averages in the watershed (Figure 19, Table 48) fell below DEQ standards for ideal stream conditions (>11mg/L) between June and September, however there was a high degree of variability in the 2022 data.

Clatskanie River watershed *E. coli* levels remained within the ODEQ 90-day geometric mean threshold in 2022. However, there was a single event at Carcus where max *E. coli* levels exceeded both EPA and ODEQ thresholds. Elevated *E. coli* bacteria levels were observed in Middle Clatskanie between June-September in 2019 and July-November in 2020, exceeding the EPA and ODEQ standards including the five-sample geometric mean (Table 4, Table 9). *E. coli* bacteria issues are indicative of animal waste runoff and can be very harmful to humans using these waterways for recreation (Pandey et al. 2014). Additional research is needed to determine the exact source of the elevated *E. coli*. Animal waste or septic tank leakage into the stream are possible sources to be investigated. Depending on the source, actions that could reduce future *E. coli* exceedance events include increasing riparian buffers, excluding livestock from the creek, increasing manure management near streams, and/or updating failed septic systems throughout the targeted reach of the watershed (Pandey et al. 2014). Given the frequency and scale of *E. coli* bacteria events in the lower watershed, adding warning signs to recreational areas along this reach of the stream and/or notifying nearby homeowners is recommended. No significant issues or shifts in stream water turbidity or conductivity levels were detected in Clatskanie Watershed during this study.

Beaver Creek Watershed

Study Area

Beaver Creek Monitoring Locations (2017-2022)

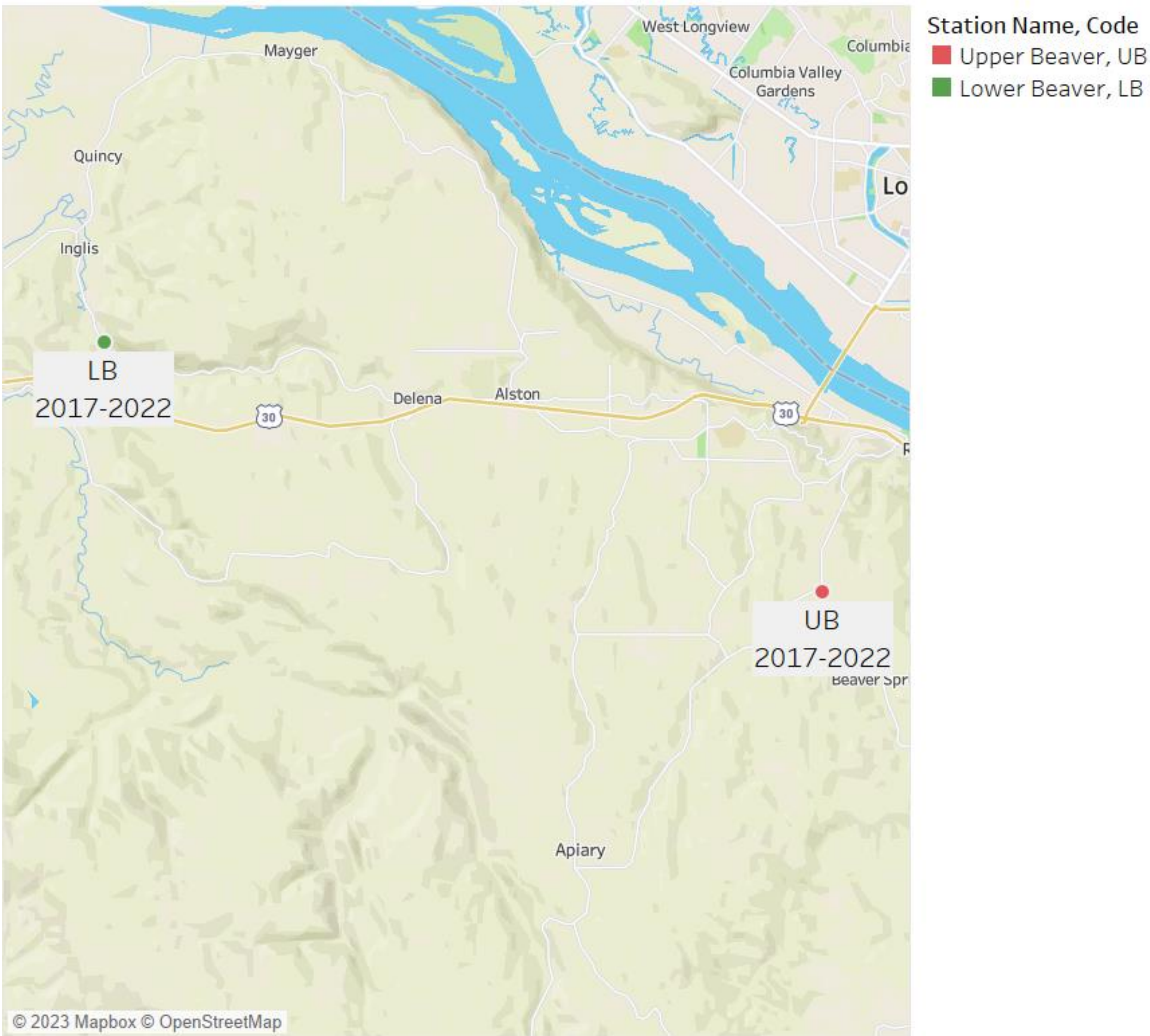


Figure 22: Focus map of Beaver Creek watershed monitoring locations; for an overview map of watershed boundaries, see Figure 1. For specific monitoring location details, see Table 1

Water Temperature

The 7dMAM in 2022 ranged from 2.38°C to 22.4°C, with highest levels observed in July and August. Previously, 7dMAM temperatures ranged from 1.8°C to 23.1°C between 2017-2021, with most elevated temperatures in August (

Table *14*). Temperatures tend to increase from the upper to lower watershed (Figure 23). Upper Beaver (Girt Creek) and Lower Beaver creeks had similar winter (January, February) and fall (November – December) temperature trends throughout the study period (Figure 24).

DEQ temperature standard for salmon rearing habitat is less than 18°C, while streams with temperatures higher than 18°C are considered poor quality for salmon. In 2022, highest 7dMAM temperatures in Upper Beaver Creek were observed in July and August, exceeding 18°C. Summer temperatures in Lower Beaver Creek continued to exceed 18°C in July and August (Figure 24, Figure 25). The number of days over 18°C in summer 2022 was similar to summer 2021 at Lower Beaver but had reduced at Upper Beaver.

Table 14: 7dMAM temperatures Summary from 2017 to 2022 for creeks in Beaver Creek Watershed. Temperatures have been color-coded according to salmonid thresholds listed in Table 4.

		Min. 7DMAM	Avg. 7DMAM	Max. 7DMAM	Number of Days over 18°	Number of Days over 25°
Upper Beaver	2017	3.9	12.4	19.7	21	0
	2018	2.9	11.2	19.3	28	0
	2019	1.9	10.1	18.2	5	0
	2020	6.1	11.4	18.6	13	0
	2021	4.2	11.6	20.5	42	0
	2022	4.2	11.7	19.7	22	0
Lower Beaver	2017	3.0	13.3	21.6	70	0
	2018	2.7	11.9	21.5	55	0
	2019	1.8	10.2	20.2	29	0
	2020	5.7	12.1	20.6	61	0
	2021	4.0	12.3	23.1	66	0
	2022	2.4	11.7	22.4	65	0

Table 15: Number of days over 18°C in the Beaver Creek watershed between 2017 to 2022. Winter and spring months have been excluded from this table as stream temperature conditions are within ideal conditions at that time.

		May	June	July	August	September	October
Upper Beaver	2017		0	0	13	8	0
	2018	0	0	11	17	0	0
	2019	0	0	0	5	0	0
	2020	0	0	5	8	0	0
	2021	0	4	18	20	0	0
	2022	0	0	3	19	0	0
Lower Beaver	2017		0	26	31	13	0
	2018	0	6	23	26	0	0
	2019	0	5	18	6	0	0
	2020	0	5	15	31	10	0
	2021	0	13	31	22	0	0
	2022	0	3	22	31	9	0

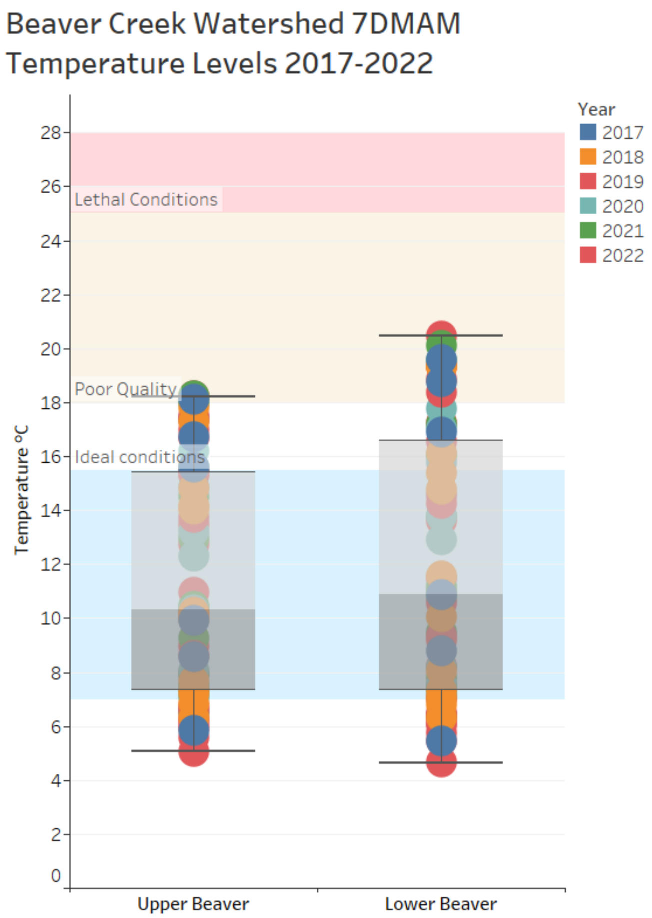


Figure 23: 7dMAM temperature variation in the Beaver Creek watershed, overlaid on the DEQ stream temperature standard ranges for healthy salmon habitat (Table 4). Data points represent the months monitored in a year. Ideal Conditions (7°C-15.6°C), Poor Quality (18°C-25°C) and Lethal (>25°C)

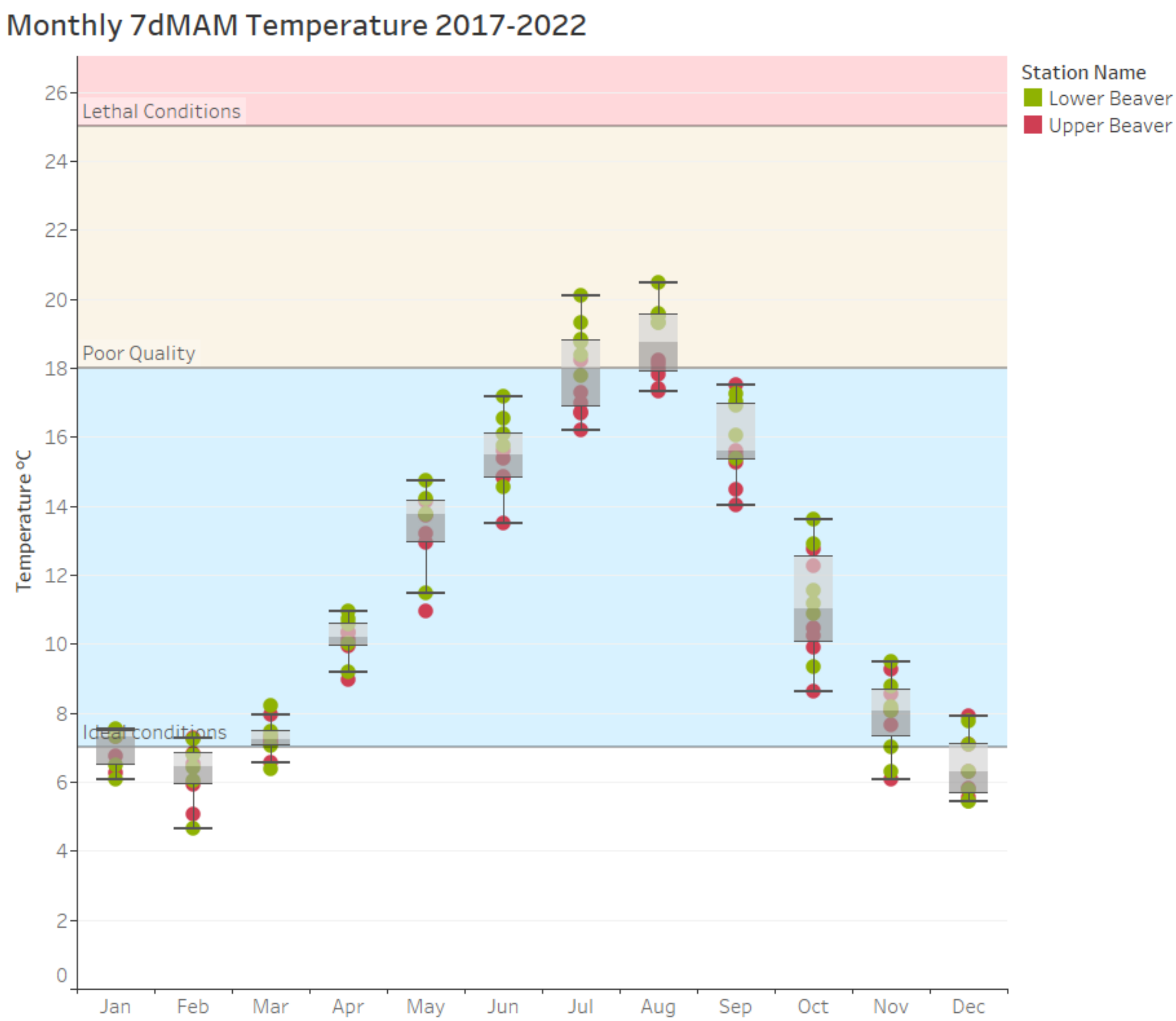


Figure 24: Monthly variation in 7dMAM temperature in the Beaver Creek watershed in between 2017 and 2022.

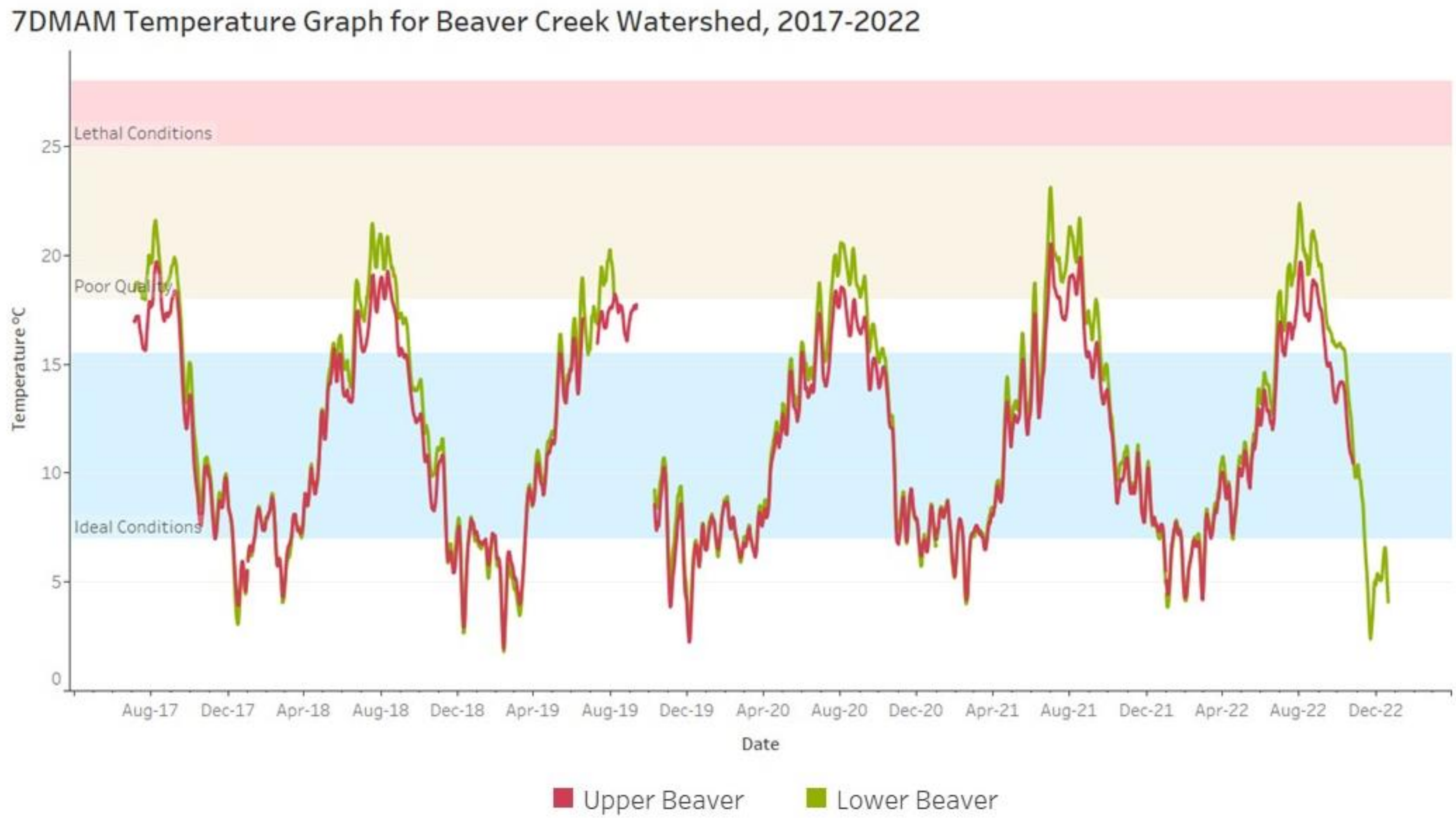


Figure 25: Beaver Creek Watershed 7-day average maximum temperatures (7dMAM) from 2017 to 2022 overlayed on salmonid temperature threshold ranges. See Table 4 for temperature threshold details.

Water Turbidity Levels

In 2022 turbidity levels in Beaver Creek watershed were similar to the levels observed between 2017 and 2021. Lower Beaver Creek experienced lower turbidity levels than Upper Beaver Creek (Girt Creek), with a mean of 4.0 NTU at Lower Beaver and 7.7 NTU at Upper Beaver Creek in 2022 (Figure 26, Table 16). Upper Beaver Creek exhibited elevated turbidity levels throughout the study period, with >10 NTU turbidity observed from July through September (Figure 26, Table 16). Land use above the Upper Beaver monitoring location is more developed with agriculture and residential than the portion of the watershed above Lower Beaver Creek, which may explain the elevated turbidity levels. Additionally, the substrate of Upper Beaver creek is primarily silty while Lower Beaver is rocky, which further highlights the potential differences in turbidity observations (Table 1). Riparian improvements in the upper basin could help reduce these harmful turbidity levels long-term.

Table 16: Summary Table for Beaver Creek Watershed Monthly Turbidity (NTU), 2017-2022 Grab Samples. Grab sample data broken down across years and watershed sampling locations. n = number of samples collected—red highlights when a sample location experienced a maximum over the 10 NTU threshold.

		n	Max	Mean	+/- SD
Upper Beaver	2017	4	10.8	7.9	2.5
	2018	11	11.2	6.5	1.8
	2019	15	12.3	7.5	2.5
	2020	16	10.5	6.8	2.2
	2021	15	18.7	8.0	3.5
	2022	15	14.7	7.7	2.6
Lower Beaver	2017	5	5.9	2.2	2.1
	2018	11	6.7	3.4	1.8
	2019	11	6.2	3.2	1.6
	2020	16	5.9	3.5	1.4
	2021	15	8.2	3.6	1.8
	2022	15	7.5	4.0	1.8

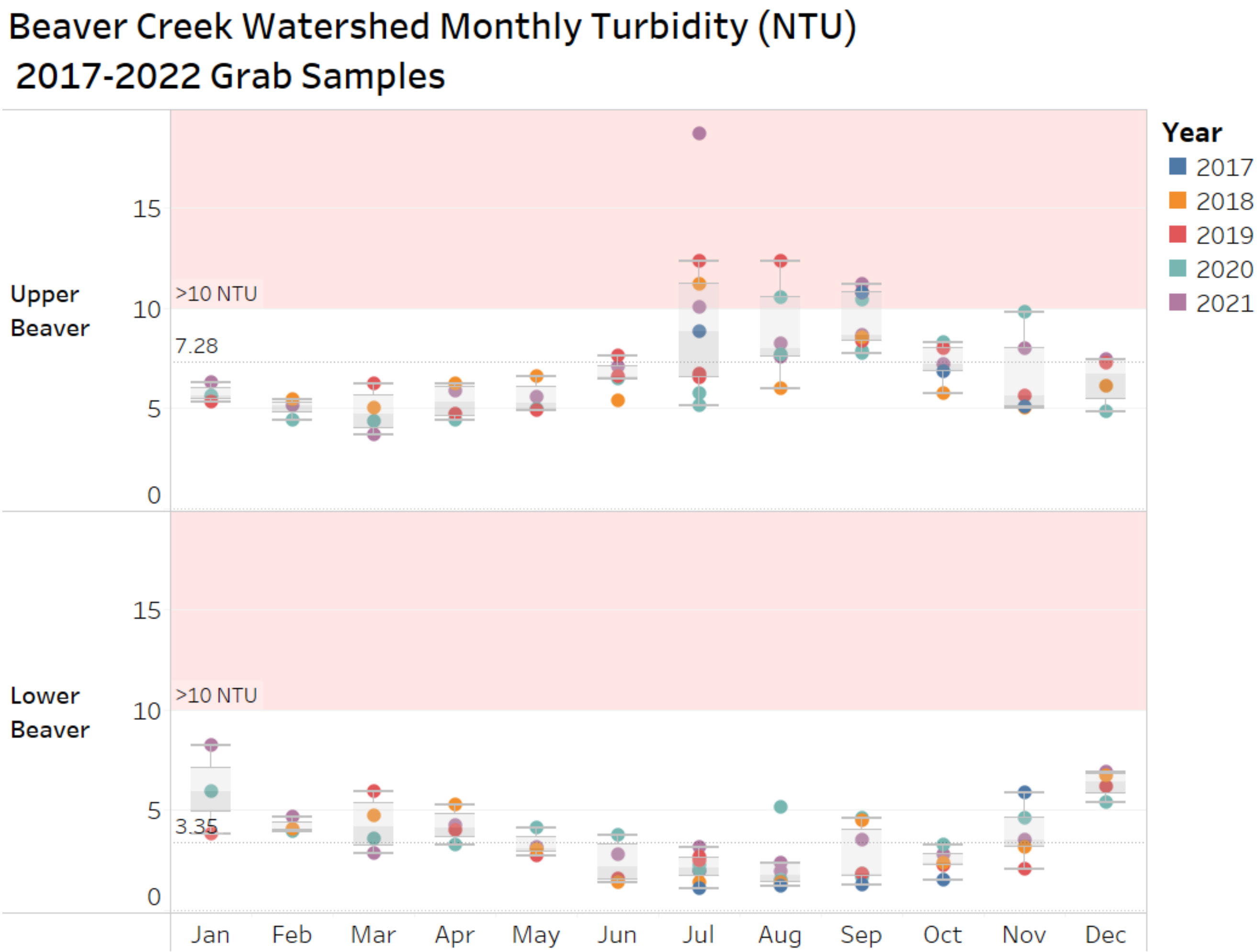


Figure 26: Turbidity (NTU) grab sampling results (boxplots) for Beaver Creek Watershed broken down across sampling locations and months sampled. Sampling years ranging from 2017 to 2022 are highlighted within each boxplot. 10 NTU threshold highlighted in pink. The overall mean for the study period is highlighted in each graph.

Water Bacteria Levels

In 2017, only Lower Beaver Creek was monitored for *E. coli* bacteria levels. During this time, elevated levels, 345 MPN/100mL , were detected in October, with July-September samples falling within a normal range (EPA <235 MPN/100mL) (Figure 27, Table 17-Table 19). In 2018, elevated *E. coli* bacteria levels were detected in Upper Beaver Creek (Girt Greek) in August, 308 MPN/100mL, and September, 727 MPN/100mL, and in Lower Beaver Creek in September, 2420 MPN/100mL (Figure 27, Table 17-Table 19). These extreme bacteria events encouraged more intensive sampling since 2019, including biweekly sampling in the summer, which allowed for the calculation of the 90-day geometric mean (Table 19). In 2022, *E. coli* levels were elevated at Lower Beaver and above EPA limits (>235 MPN/100mL) in July. By contrast, Upper Beaver stayed below the EPA and ODEQ thresholds in 2022.

The 90-day geometric mean state-mandated water quality threshold for Oregon is 126 MPN/100mL. Lower Beaver Creek experienced an elevated event in July 2022, 260 MPN/100mL, but the overall mean (Table 17) and geometric mean (Table 18) *E. coli* bacteria levels remained below the 126 MPN/100mL threshold. Levels at Upper Beaver remained below all thresholds in 2022. Throughout previous years, it was observed that Upper beaver displayed consistently elevated levels of *E. coli* during most of the year, while Lower Beaver can occasionally have levels that exceed regulatory thresholds (Table 19). Despite 90-day geometric mean values falling below the state mandated threshold in 2022, historical data and 2022 monthly maximum conditions merit the continued monitoring and additional investigation into the cause of elevated *E. coli* levels in the upper watersheds to ensure they do not continue to persist or increase.

Table 17: Summary table of Beaver Creek watershed E. coli (2017-2022) MPN/100 ml grab samples. Grab sample data broken down across years and watershed sampling locations. Sampling locations that experienced events over the EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted in red. n = number of samples collected; for monthly max data, see Table 19.

		n	Max	Mean	+/- SD
Upper Beaver	2017	0			
	2018	4	727	325	282
	2019	11	816	290	246
	2020	16	435	139	119
	2021	15	579	136	144
	2022	15	166	78	46
Lower Beaver	2017	4	345	132	143
	2018	4	2,420	639	1,188
	2019	7	152	44	50
	2020	16	649	116	156
	2021	15	132	72	37
	2022	15	260	66	65

Table 18: 90 Day geometric mean (5 samples or greater) of E. coli bacteria levels (MPN/100ml) across all sampling sites, those durations that are above the state-mandated threshold of 126 MPN/100 ml for the 90 days geometric mean are highlighted with red text.

		Apr Jul	May Aug	Jun Sep	Jul Oct	Aug Nov	Sep Dec
Upper Beaver	2019			291.1	214.8		
	2020		172.6	193.7	224.4	174.2	
	2021	110.4	129.0		181.5	151.8	127.3
	2022	35.7	57.9	62.2	70.0	60.1	
Lower Beaver	2020		66.4	78.8	90.4	71.4	
	2021	68.7	86.8		93.8	58.3	54.9
	2022	35.7	57.9	62.2	70.0	60.1	

Table 19: Beaver Creek watershed monthly max E. coli (MPN/100mL) grab samples. Grab sampling results for broken down across years and watershed sampling locations. Sampling locations that experienced events over the EPA (235 MPN/100mL) and ODEQ (406 MPN/100mL) thresholds for E. coli bacteria levels are highlighted in red. n = number of samples collected.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Beaver	2017												
	2018						166	98	308	727			
	2019						816	387	308	240	248	15	51
	2020	11	4	16	45	153	69	206	276	435	185	55	15
	2021	42	11	8	41	91	204	196	248	579	118	40	62
	2022		8	27	11	50	114	166	108	126	75	130	33
Lower Beaver	2017							82	58	42	345		
	2018						56	37	41	2,420			
	2019						30	152		49	24	4	31
	2020	62	24	649	74	50	26	81	299	146	70	32	74
	2021	82	29	31	34	51	66	127	108	132	75	8	96
	2022		14	27	23	32	82	260	115	115	17	104	32

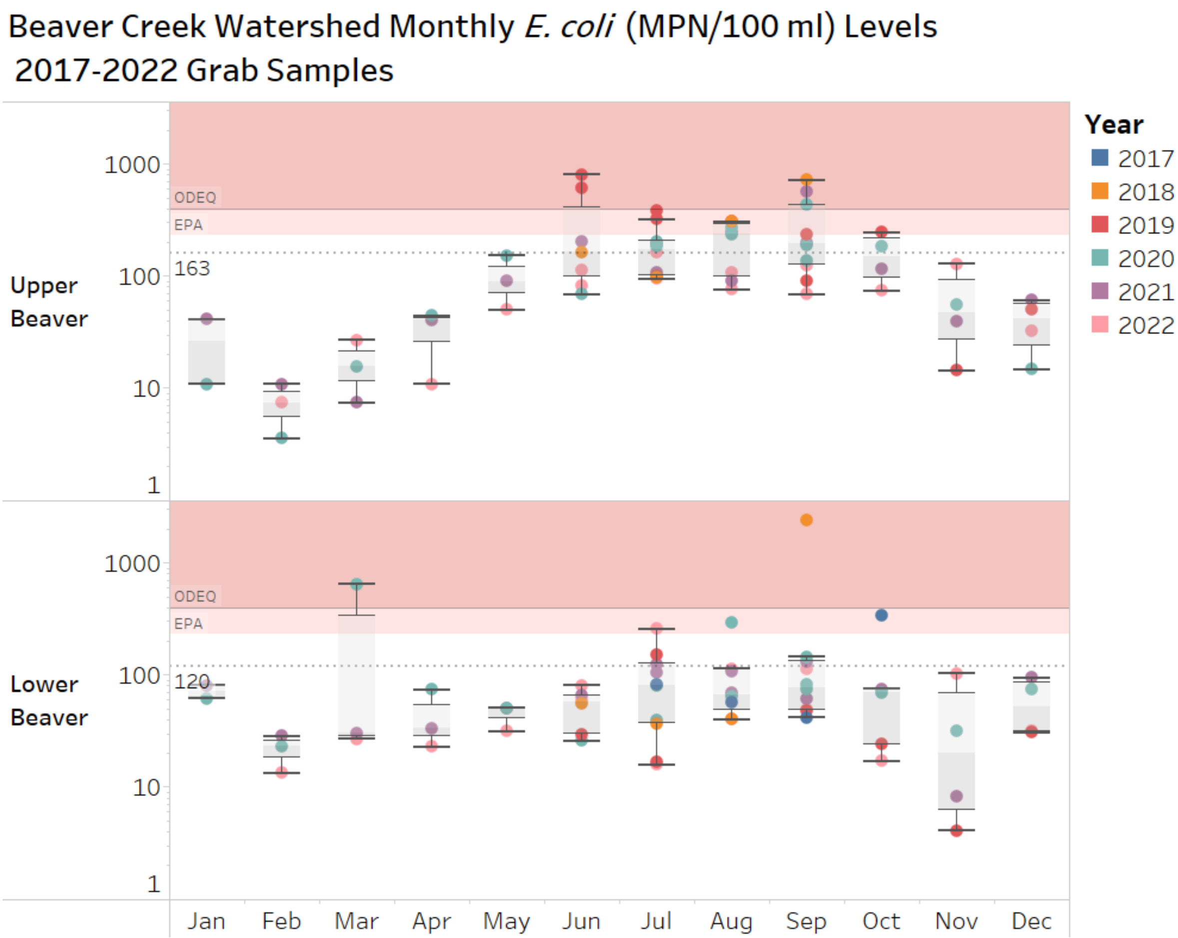


Figure 27. E. coli bacteria grab sampling results (boxplots) for Beaver Creek Watershed broken down across months sampled and watershed sampling locations. Sampling year ranging from 2017 to 2022 are highlighted within each boxplot. EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted on each graph. The overall mean for the study period highlighted in each graph. Logarithmic scale used on the y-axis.

Water pH Levels

Since 2021, in-situ stream pH measurements were collected using a YSI Pro-series meter, with the goal of providing additional information on stream quality. pH levels in the watershed ranged from 6.76 (May 2022, UB) to 7.68 (August 2022, UB) (Table 20). Lower watershed had higher pH values, while staying within DEQ regulatory standards for ideal stream conditions for salmonids (6.5 – 8.5) (

Figure *28*, Figure 29). Compared to 2021, pH was lower at the monitoring sites in 2022 (Table 20,

Figure *28*). However, there was a high degree of variability observed in the measurements in the monthly data. (Figure 29).

Table 20: Summary Table of in-situ stream pH in Beaver Creek Watershed in 2021 and 2022.

		Count of P H	Min. P H	Max. P H	Std. dev. of P H
2021	Upper Beaver	11	6.74	7.43	0.20
	Lower Beaver	11	7.17	8.20	0.33
2022	Upper Beaver	15	6.76	7.68	0.28
	Lower Beaver	15	6.90	7.65	0.24

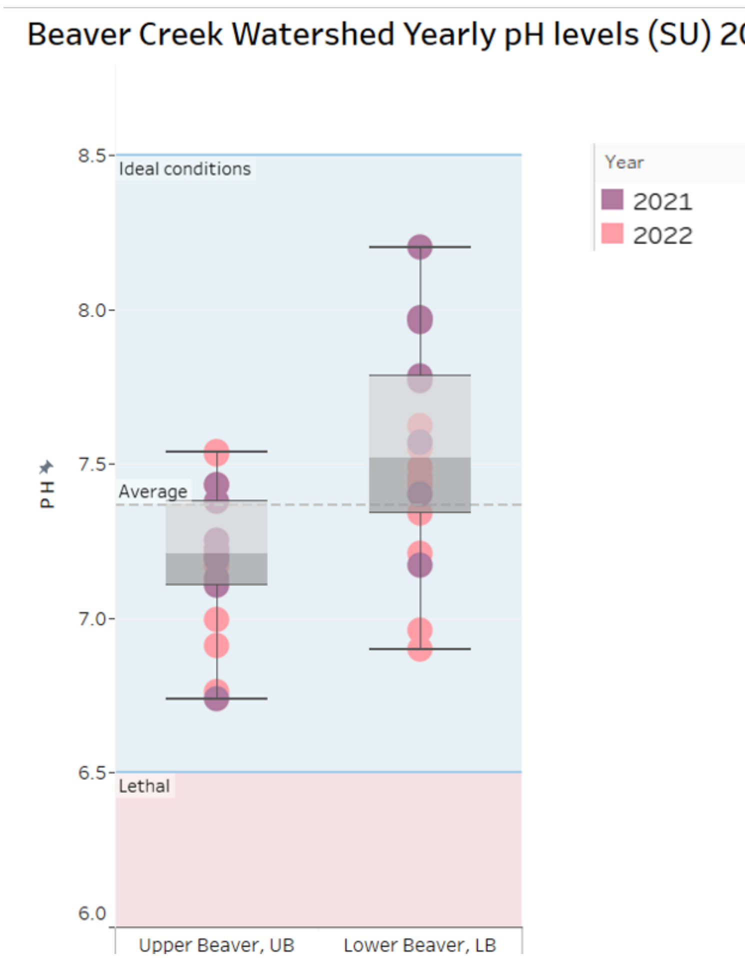


Figure 28: Yearly in-situ stream pH variation across sites in Beaver Creek watershed in 2021 and 2022. DEQ regulatory standards for lethal stream pH conditions for salmonids (<6.5) is represented as a red band. DEQ standards for ideal stream pH conditions for salmonids (6.5 – 8.5) is shown as the blue band.

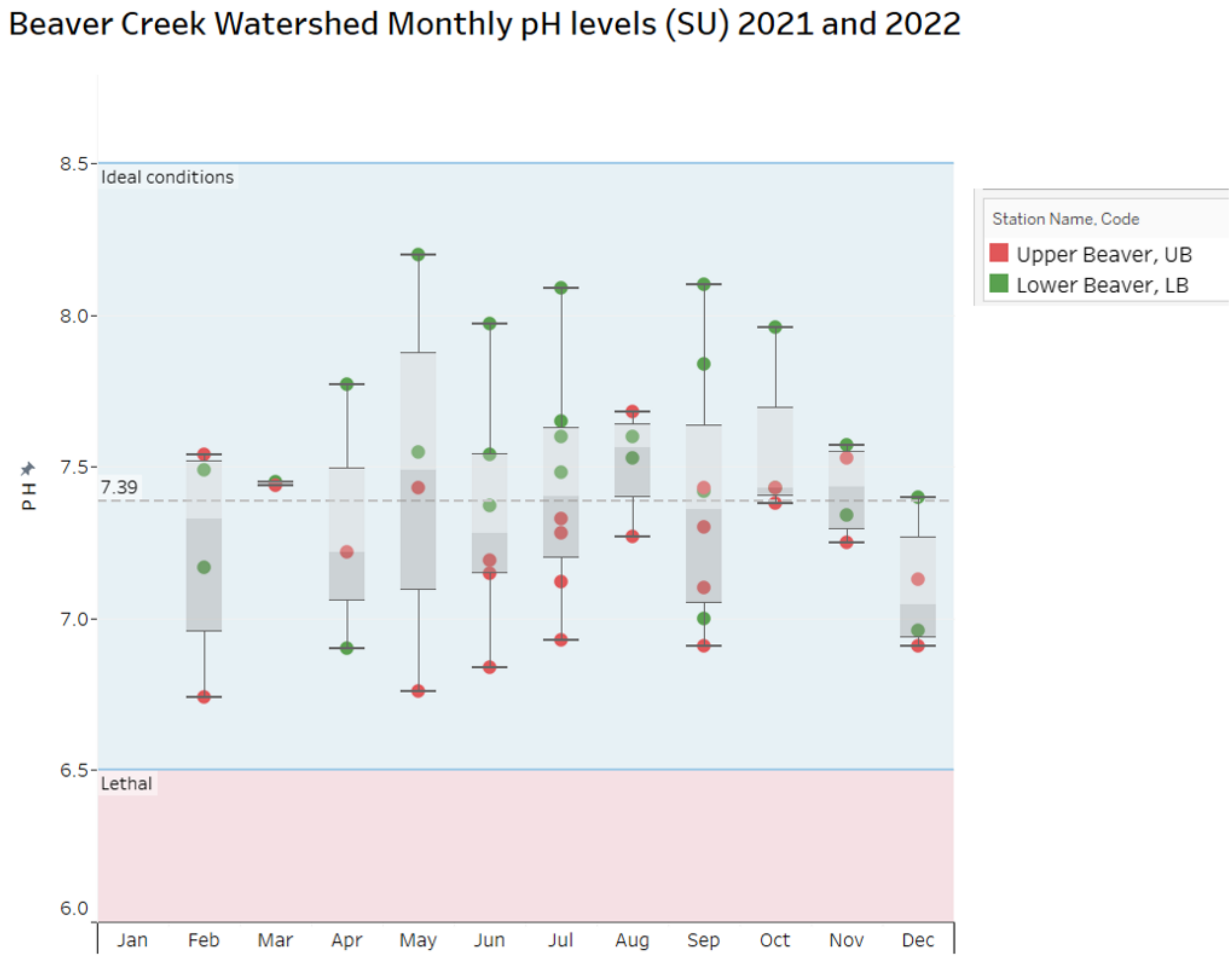


Figure 29: Beaver Creek watershed in-situ stream pH ranges across months in 2022. DEQ regulatory standards for lethal stream pH conditions for salmonids (<6.5) is represented as a red band. DEQ standards for ideal stream pH conditions for salmonids (6.5 – 8.5) is shown as the blue band.

Water Dissolved Oxygen (DO) Levels

In 2022, stream DO averages in the watershed ranged from 5.04mg/L (July 2022, UB) to 15.46mg/L (February 2022, LB), falling below DEQ standards for ideal stream conditions (>11mg/L) between May and November (Table 21). DO levels in Upper Beaver also fell below the DEQ lethal limit of <6mg/L in August 2022 (5.92mg/L). DO levels tended to increase from upper to lower reaches of the watershed. DO levels in the watershed displays a high degree of variability in 2022.

Table 21: Summary Table of in-situ Stream DO in Beaver Creek watershed in 2021 and 2022. DEQ standards for stream DO range from Lethal conditons (<6mg/l) to ideal conditions (>11ppm).

		Count of DO	Avg. DO	Min. DO	Max. DO	Std. dev. of DO
2021	Upper Beaver	13	8.68	5.06	12.67	2.87
	Lower Beaver	14	10.46	7.08	12.93	1.73
2022	Upper Beaver	10	9.86	5.04	13.84	3.18
	Lower Beaver	10	11.22	6.82	15.46	2.73

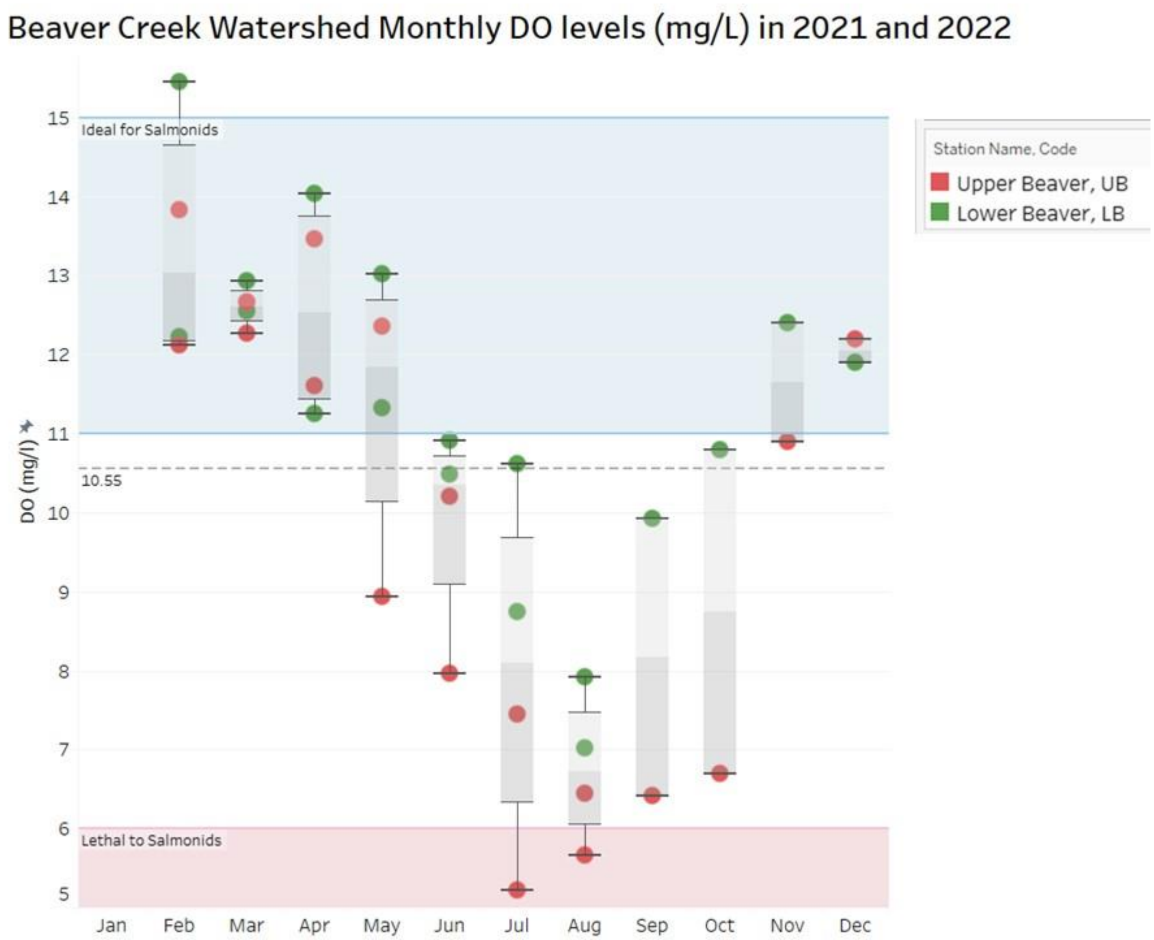


Figure 30: Monthly in-situ stream DO ranges across all monitoring locations in Beaver Creek watershed. DEQ standards for ideal DO conditions for salmonids(>11mg/l) is depicted as a blue band in the graph. DEQ standards for Lethal conditions (<6mg/l) is depicted as the red band.

Water Conductivity Levels

Conductivity levels varied seasonally across both monitoring locations within the Beaver Creek watershed (Figure 31, Table 22). At both locations, annual increases in water conductivity were observed between May to October and declined from November to March (Figure 31, Table 22). Between 2018-2022, Upper Beaver Creek (Girt Creek) exhibited lower overall mean conductivity levels ranging from 60-73 µs/cm compared to 66-87 µs/cm observed at the Lower Beaver monitoring location (Figure 31, Table 22). These data provide baseline conductivity levels that can be used to identify new and emerging water quality issues or improvements over time. Pollution from runoff or increased turbidity levels from sediment can result in higher conductivity levels; however, there is no EPA or ODEQ threshold for conductivity in the region.

Table 22: Summary Table of Beaver Creek watershed monthly conductivity (µs/cm) data for 2018-2022 grab samples. Conductivity (µs/cm) samples broken down across months sampled and watershed sampling location. n = number of samples collected.

		n	Max	Mean	+/- SD
Upper Beaver	2018	5	85	60	19
	2019	15	100	67	26
	2020	17	103	73	19
	2021	15	90	61	20
	2022	15	77	52	18
Lower Beaver	2018	6	109	82	27
	2019	10	129	80	33
	2020	17	137	87	30
	2021	15	115	76	30
	2022	15	106	66	29

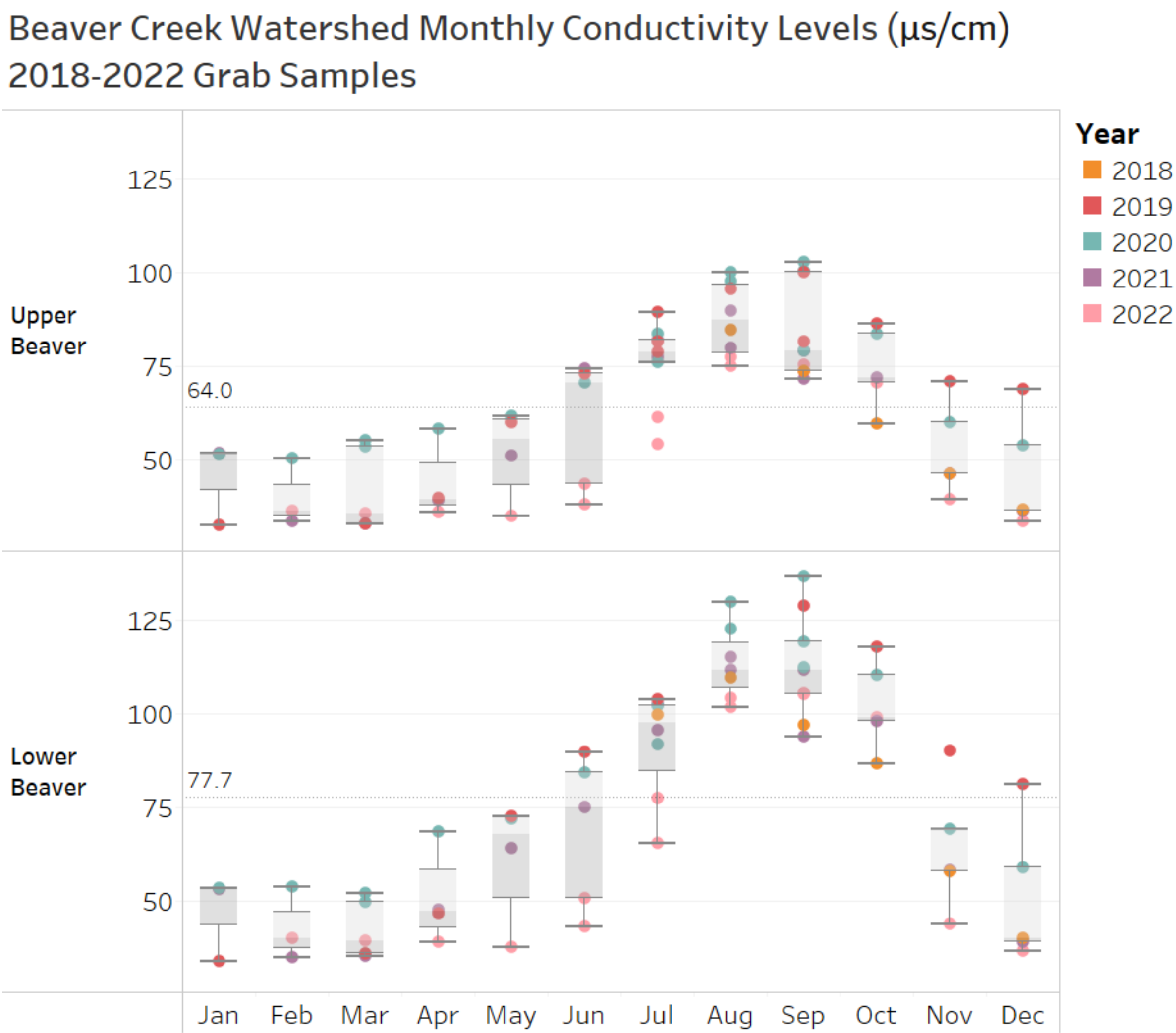


Figure 31: Conductivity levels (µs/cm) 2018-2022 Grab Samples results (boxplots) for Beaver Creek watershed broken down across months sampled and watershed sampling location. Sampling years ranging from 2018 to 2022 are highlighted within each boxplot. The overall mean for the study period is highlighted in each graph.

Water Quality Issues

Water quality issues observed in Beaver Watershed include high summer temperatures (>18°C) between July and August (Table 14, Figure 23). Overall elevated temperatures are likely caused by solar loading as the water moved through the watershed. Beaver Creek has extensive residential and agricultural development in the upper watershed, which increases the amount and duration of solar loading experienced by the water moving through the watershed (Figure 4). Low water temperatures are critical for supporting aquatic life, including endangered Salmonids in the Pacific Northwest; reducing solar radiation and reducing urban and agricultural runoff can help keep water temperatures down and protect these stream habitats (USGS 2021). Turbidity events above the 10 NTU threshold were also observed in the Upper reaches of Beaver Creek every year during the 2017-2022 study period. Overall monthly averages of turbidity remained below the 10 NTU threshold; however, the upper reaches were elevated compared to Lower Beaver Creek (Table 16). Similar to recommendations for temperature improvements, increasing riparian cover and reducing runoff can reduce erosion events and sediment loading in stream environments. pH levels generally stayed within ODEQ standards; however, a high degree of variability was observed in 2022 (Figure 29). Stream DO averages in the watershed fell below DEQ standards for ideal stream conditions (>11mg/L) between June and October with a high degree of variability in the 2022 data (Figure 30).

Additionally, elevated *E. coli* bacteria levels were observed in the watershed between June-October throughout the 2017-2022 study period, exceeding the EPA and ODEQ standards (Table 4, Table 17, Table 19). Despite 90-day geometric mean values falling below the state mandated threshold in 2022, historical data and 2022 monthly maximum conditions merit the continued monitoring and additional investigation into the cause of elevated *E. coli* levels in the upper watersheds to ensure they do not continue to persist or increase. *E. coli* bacteria issues are indicative of animal waste runoff and can be very harmful to humans using these waterways for recreation (Pandey et al. 2014). Additional research is needed to determine whether these longer periods of elevated levels are a sustained trend and exact sources of the elevated *E. coli*. Animal waste or septic tank leakage into the stream are possible sources to be investigated. Depending on the source, actions that could reduce future *E. coli* exceedance events include increasing riparian buffers, excluding livestock from the creek, increasing manure management near streams, and/or updating failed septic systems throughout the targeted reach of the watershed (Pandey et al. 2014). Given the frequency and scale of *E. coli* bacteria events adding warning signs to recreational areas along the stream in the Upper watershed is recommended. No significant issues or shifts in stream water conductivity levels were detected in Beaver Creek Watershed during this study.

Scappoose Bay Watershed

The Scappoose Bay watershed is a large watershed which has been divided into 4 smaller sub-watersheds in this study – Milton Creek, McNulty Creek, North Scappoose Creek and South Scappoose Creek. These watersheds (excluding McNulty Creek) were part of an earlier water quality study undertaken by the Scappoose Bay Watershed Council between 2008-2011 (Holmen et al., 2011). Results from the current effort have been compared to the data from the past effort for temperature, turbidity, *E. coli*, dissolved oxygen (DO), and pH.

Milton Creek

The subsequent section is dedicated to presenting the findings derived from the long-term monitoring locations – Upper Milton and Lower Milton. Sites included as part of the intensive effort have been analyzed and discussed in the next few sections.

Study Area

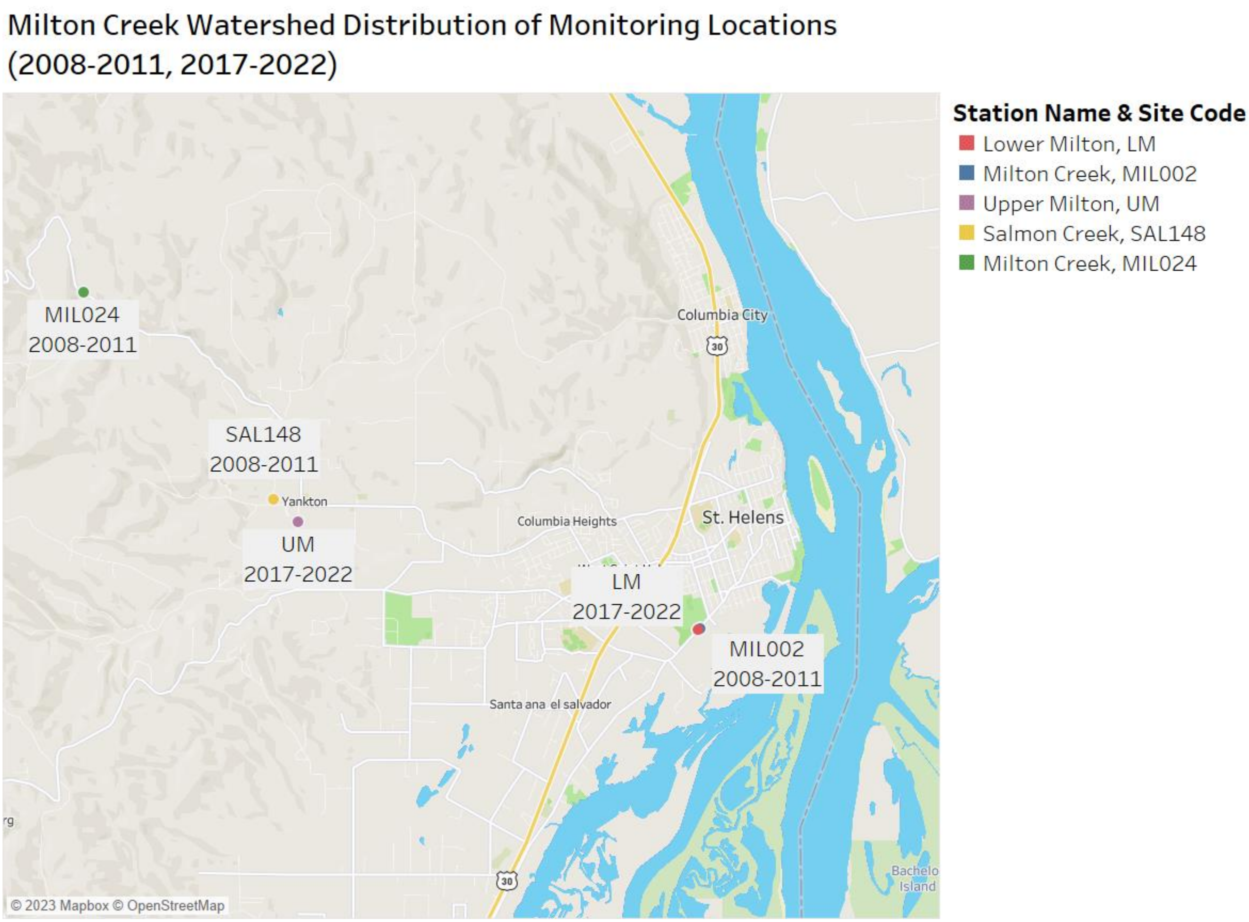


Figure 32: Overview map of Milton Creek watershed monitoring locations; for a map of watershed boundaries, see Figure 1. For specific monitoring location details, see Table 1. Upper watershed monitoring starts at MIL024 and then moves through the watershed with MIL002 being closest to the outlet of Milton Creek into Scappoose Creek and the Columbia River.

Upper Milton Creek Distribution of Monitoring Locations
(2008-2011, 2017-2022)

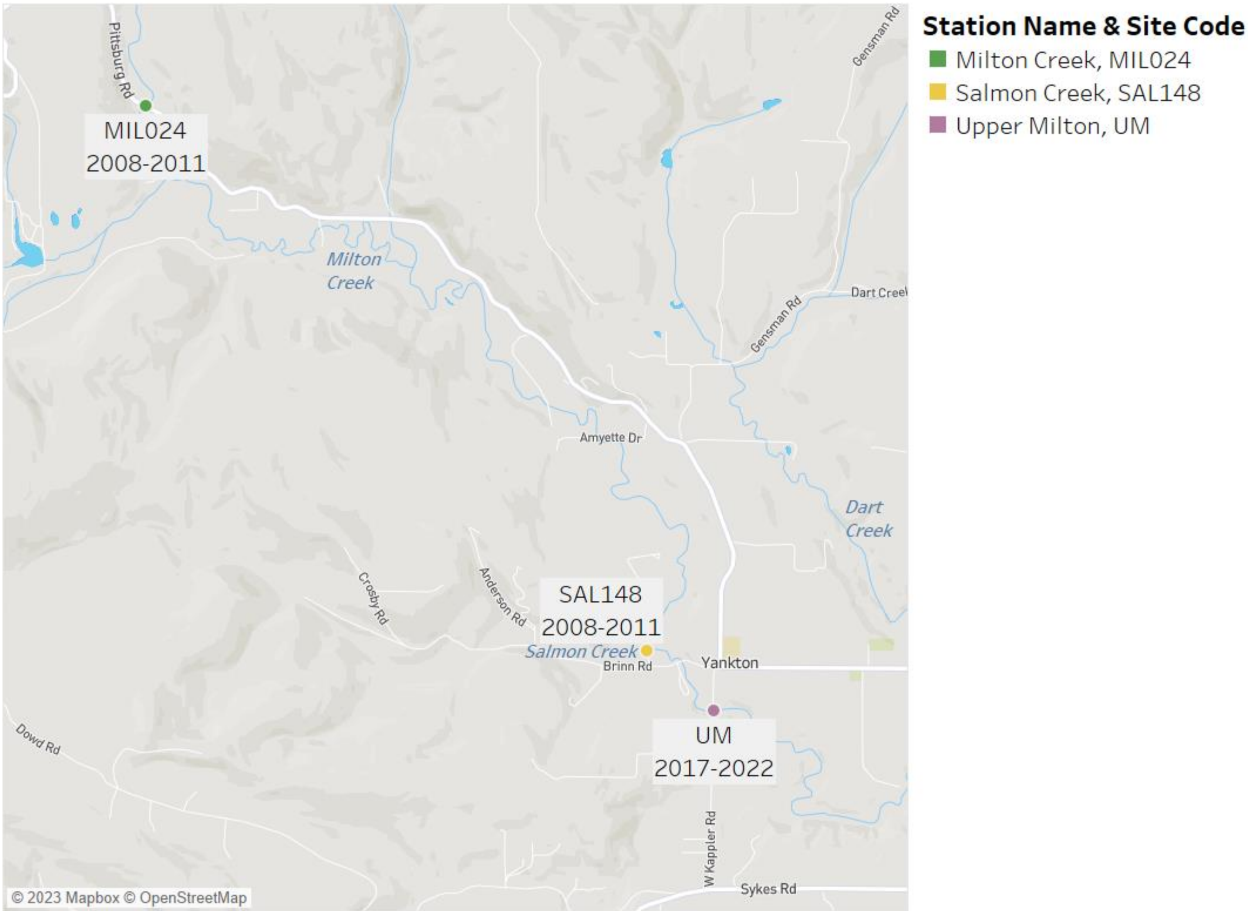


Figure 33: Focus map of Upper Milton Creek watershed monitoring locations; for a map of watershed boundaries, see Figure 1, and for a general overview map, see Figure 32. For specific monitoring location details, see Table 1.

Figure 34: Focus map of Lower Milton Creek watershed monitoring locations; for a map of watershed boundaries, see Figure 1, and for a general overview map, see Figure 32. For specific monitoring location details, see Table 1.

Water Temperature

The 7dMAM in 2022 ranged from 3.9°C to 26.4°C in the Milton watershed (Table 23). The highest seasonal temperature in the Milton Creek sub-watershed was observed in July 2022 (Figure 36). In comparison, between 2017 and 2021, 7dMAM temperature in the Milton watershed ranged from 2.1°C to 27.9°C (Table 23), with highest seasonal temperatures being observed in August. Temperatures tend to increase from upper to lower watershed. (Figure 35). Upper Milton and Lower Milton creeks have similar winter temperature trends (December, January-February), after which around late-March or early-April, 7dMAM temperature of Lower Milton Creek starts increasing faster than Upper Milton (Figure 36).

DEQ temperature standard for salmon rearing habitat is less than 18°C, and streams with temperatures higher than 18°C are considered poor quality for salmon. In 2022, the temperature at Upper Milton exceeded 18°C mostly during July and August, similar to trends observed in 2017 and 2018; however, during 2019 and 2020, temperatures exceeded 18°C from June to September. Lower Milton Creek temperatures for 2022 followed previously observed trends of exceeding the 18°C threshold from June to September. This coincides with land use data for the two monitoring stations. Lower Milton is situated in a more developed area and thus is more exposed to solar radiation and human use during the summer.

When the number of days was compared across the watershed, temperatures in the lower watershed remain above 18°C for extended periods during the summer. The greatest number of days over 18°C was observed at Lower Milton in 2019. 7dMAM temperatures at Lower Milton exceeded ODEQ threshold for lethal conditions (25°C) for six days in 2022 (Table 23).

Table 23: 7dMAM temperatures Summary from 2017 to 2022 in Milton Creek Watershed. Temperatures have been color-coded according to salmonid thresholds listed in Table 4.

		Min. 7DMAM	Avg. 7DMAM	Max. 7DMAM	Number of Days over 18°	Number of Days over 25°
Lower Milton	2017	3.2	15.1	25.4	77	4
	2018	2.8	13.5	25.6	103	9
	2019	2.5	13.0	24.1	102	0
	2020	4.9	13.6	24.4	92	0
	2021	4.3	12.9	27.9	63	8
	2022	4.1	13.9	26.4	89	6
Upper Milton	2017	3.1	13.1	21.4	61	0
	2018	2.3	11.7	21.2	50	0
	2019	2.1	11.3	20.4	56	0
	2020	4.7	11.6	20.3	49	0
	2021	4.7	12.4	23.1	65	0
	2022	3.9	12.2	22.1	53	0

Table 24: Number of days over 18°C in the Milton Creek watershed between 2017 to 2022. Winter and spring months have been excluded from this table as stream temperature conditions are within ideal conditions at that time.

		May	June	July	August	September
Upper Milton	2017		0	16	31	14
	2018	0	4	20	26	0
	2019	0	6	16	23	11
	2020	0	4	14	25	6
	2021	0	11	31	23	0
	2022	0	0	14	31	8
Lower Milton	2017		0	28	31	18
	2018	11	16	31	31	14
	2019	7	22	31	31	11
	2020	2	14	31	31	14
	2021	5	23	12	6	17
	2022	0	6	31	31	21

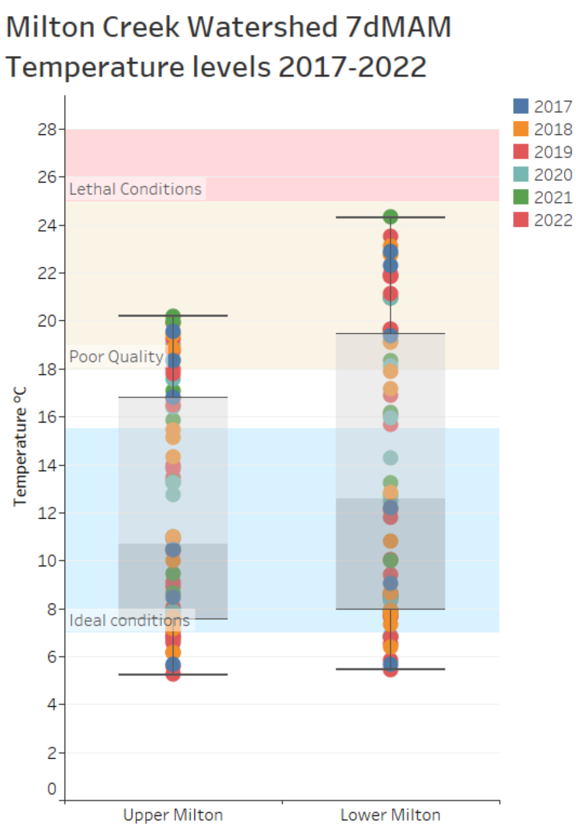


Figure 35: 7dMAM temperature variation in the Milton Creek sub-watershed, overlaid on the DEQ stream temperature standard ranges for healthy salmon habitat (Table 4). Data points represent the months monitored in a year. Data points represent the months monitored in a year. Ideal Conditions (7°C-15.6°C), Poor Quality (18°C-25°C) and Lethal Conditions (>25°C)

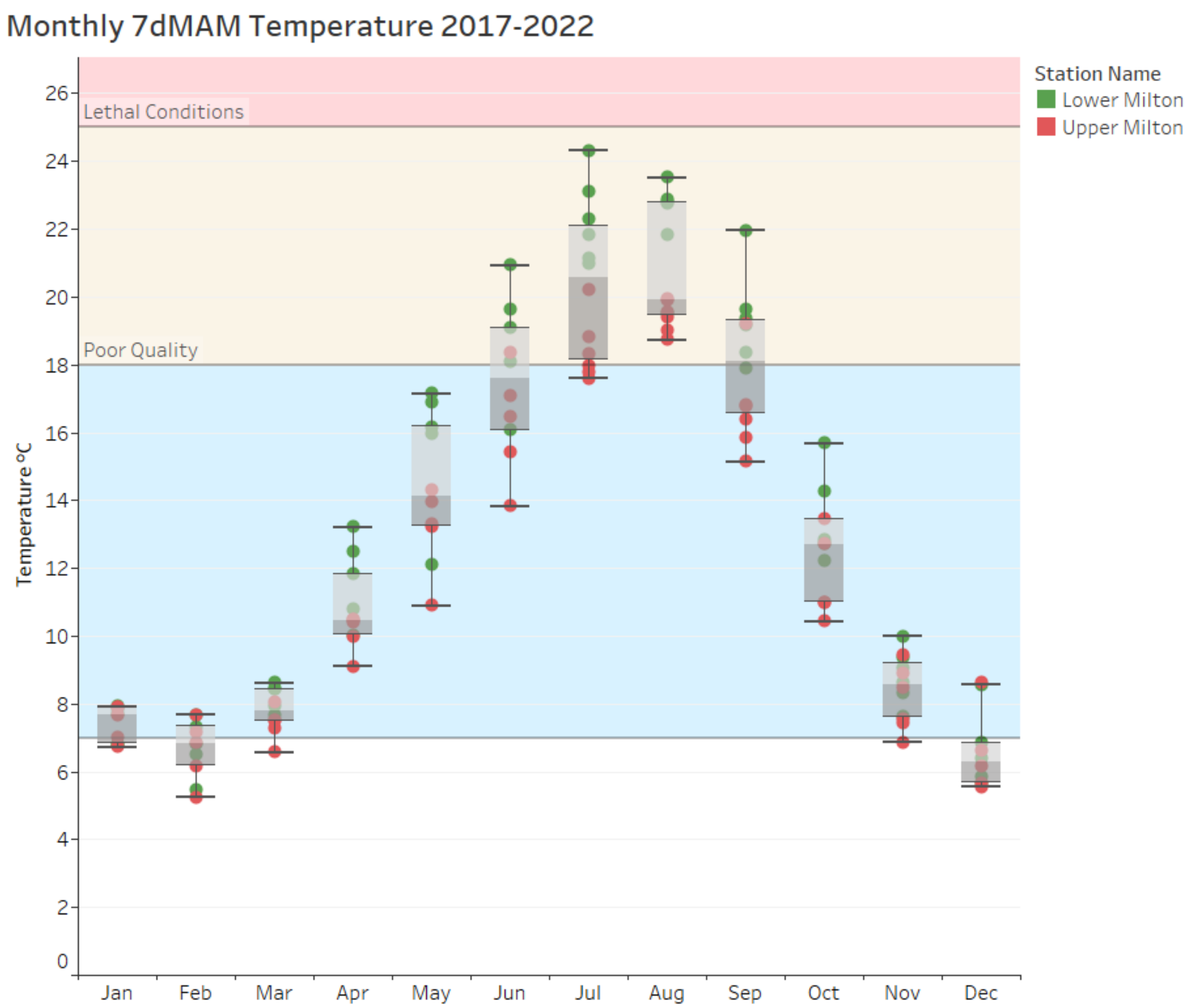


Figure 36: Monthly variation in 7dMAM temperature in the Milton Creek watershed between between 2017 and 2022.

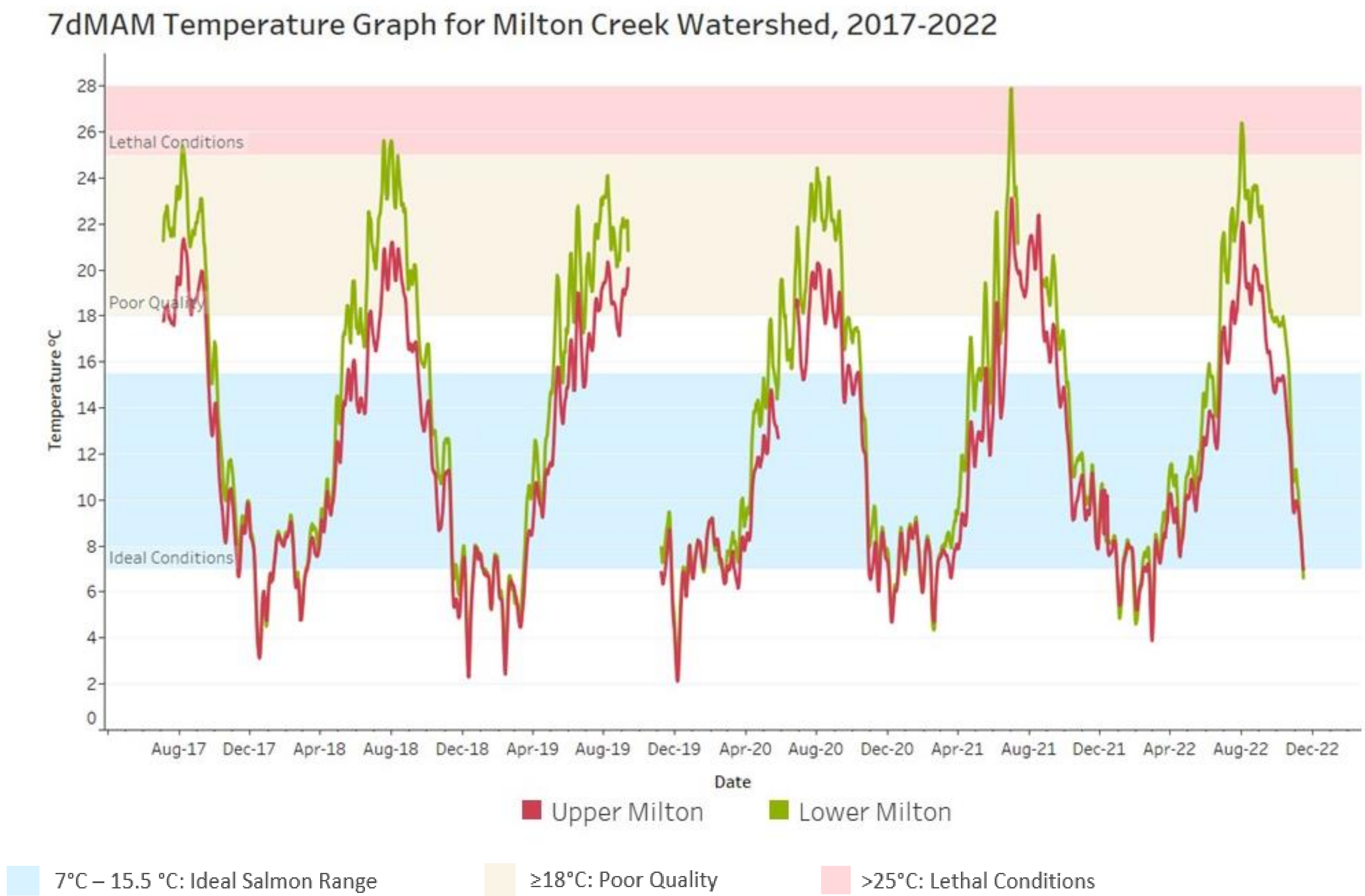


Figure 37: Milton Creek Watershed 7-day average maximum temperatures (7dMAM) from 2017 to 2022, overlayed on salmonid temperature threshold ranges. See Table 4 for temperature threshold details.

When May to October temperature 7dMAM temperature data was compared to the overlapping timeframe from 2008-2011, an average increase of 1.0°C was observed in the watershed. However, it should be noted that the complete temperature profile is unavailable for the 2008 – 2011 dataset, and 2010 data was missing from this dataset, so we cannot definitively say whether this increase is consistent (Figure 38).

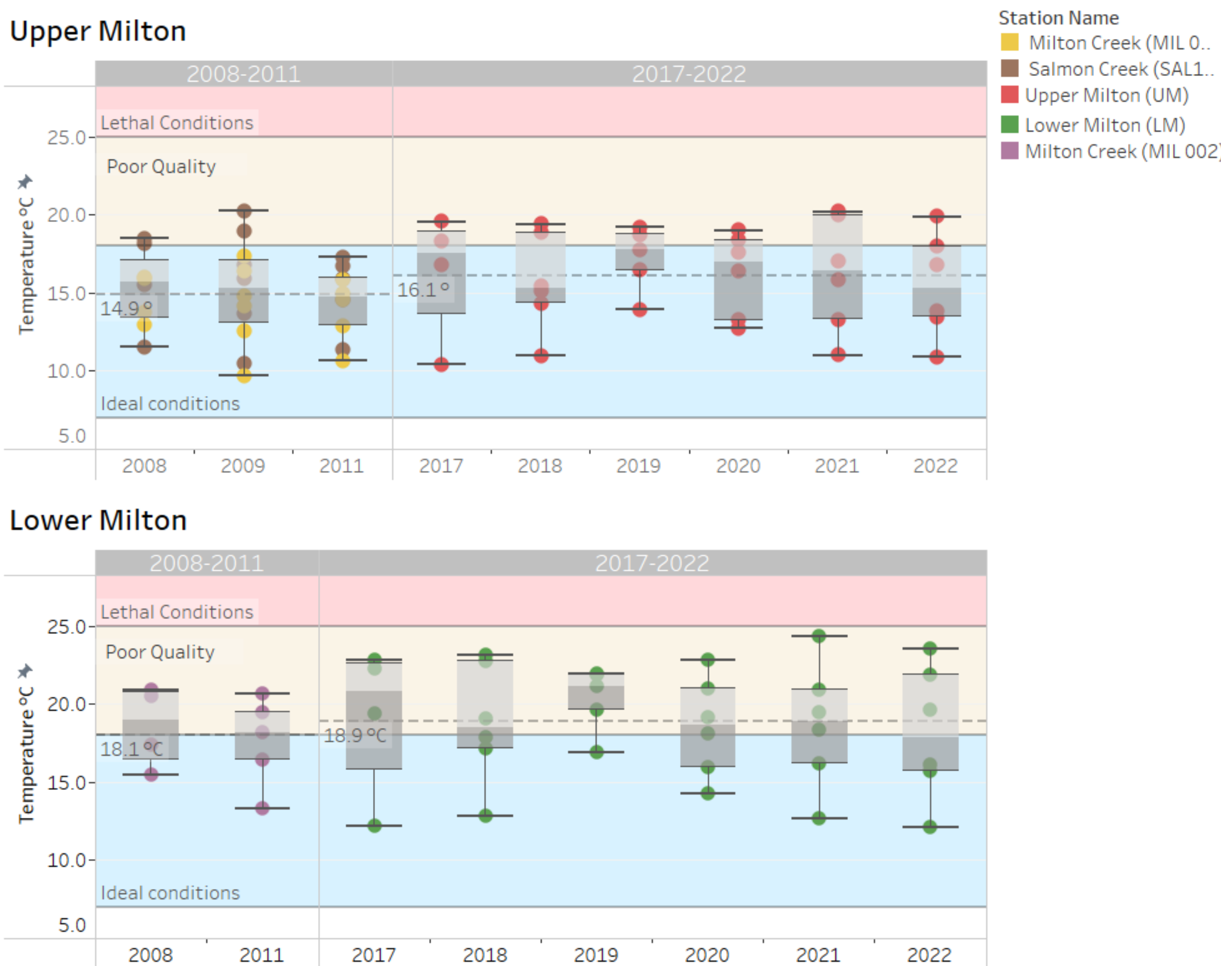


Figure 38: Monthly 7dMAM temperature comparisons between 2017-2022 data and 2008-2011 data for Milton Creek Watershed. Upper Milton and Lower Milton have data available from June 2017 to December 2022. Milton Creek (MIL002) has data available for May to October of 2008 and 2011. Milton Creek (MIL024) and Salmon Creek (SAL148) have data available for May to October of 2008, 2009, and 2011.

Water Turbidity Levels

Lower Milton Creek consistently experienced lower turbidity levels than Upper Milton Creek, with mean levels ranging from 3.7-6.2 NTUs at Lower Milton and 6.0-8.5 at Upper Milton Creek across the 2017-2022 study period (Figure 39, Table 25). In 2022, Upper and Lower Milton creeks exhibited elevated turbidity levels (>10 NTU turbidity events) during January, August, September, and November. Previously, turbidity events >10 NTU were observed between July and January (Figure 39, Table 25). When comparing the 2018-2022 data to the 2008-2011 data, no significant shift in turbidity was observed (

Figure *40*). Riparian improvements in the basin could help reduce these harmful turbidity levels long-term.

Table 25: Summary Table for Milton Creek Watershed Monthly Turbidity (NTU), 2017-2022 Grab Samples. Grab sample data broken down across years and watershed sampling locations. n = number of samples collected—red highlights when a sample location experienced a maximum over the 10 NTU threshold.

		n	Max	Mean	+/- SD
Upper Milton	2017	4	11.5	7.9	3.1
	2018	11	9.8	6.5	1.7
	2019	14	11.5	6.3	2.6
	2020	16	9.5	6.0	1.5
	2021	15	14.5	6.4	3.3
	2022	15	15.2	8.5	3.4
Lower Milton	2017	5	7.6	3.7	2.2
	2018	11	8.7	5.1	1.5
	2019	15	13.5	5.9	3.8
	2020	16	12.5	5.5	2.8
	2021	15	16.4	6.2	3.9
	2022	16	15.7	6.2	3.3

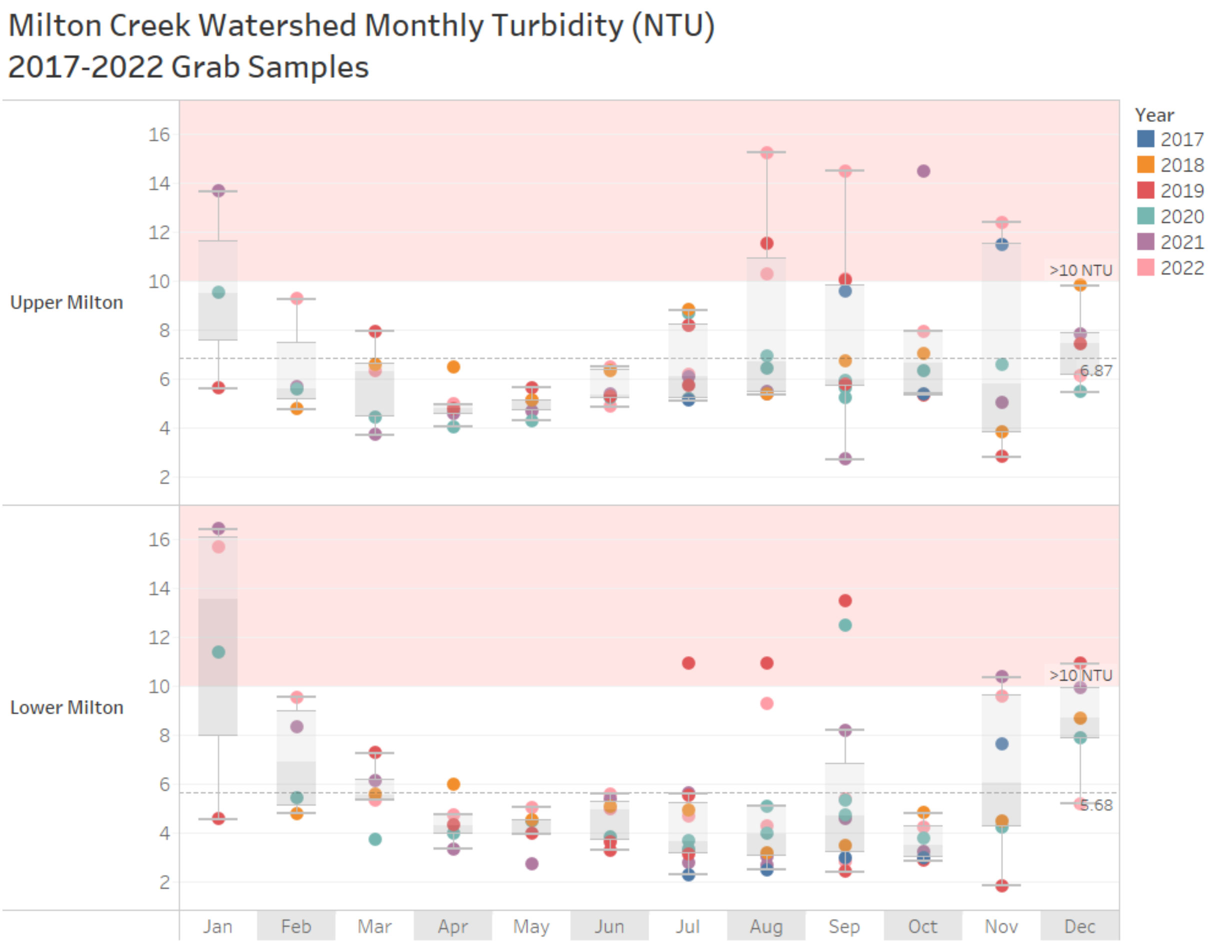


Figure 39. Turbidity (NTU) grab sampling results (boxplots) for Milton Creek Watershed broken down across sampling locations and months sampled. Sampling years ranging from 2017 to 2022 are highlighted within each boxplot. 10 NTU threshold highlighted in pink. The overall mean for the study period highlighted in each graph.

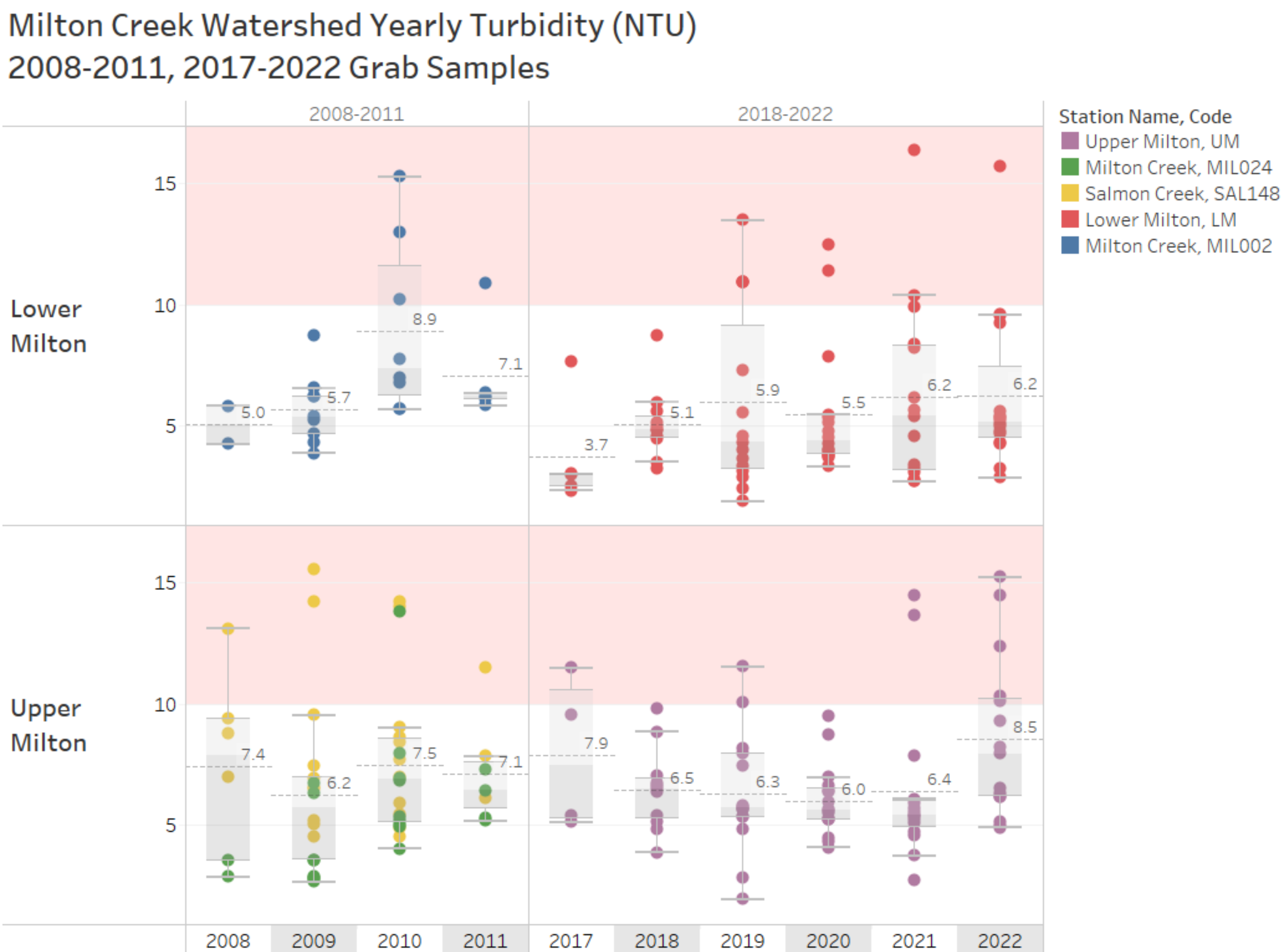


Figure 40: Turbidity (NTU) grab sampling results (boxplots) for Milton Creek Watershed broken down across years sampled. Sampling locations are highlighted within each boxplot. 10 NTU threshold highlighted in pink. Overall mean for each year highlighted.

Water Bacteria Levels

In 2017, only Lower Milton Creek was monitored for *E. coli* bacteria levels; during this time, elevated levels exceeding the EPA health standard of 235 MPN/100 ml were detected in July, September, and October (

Figure *41*, Table 26-Table 28). In 2018, elevated *E. coli* bacteria levels were only detected in Lower Milton Creek in July, 291 MPN/100 ml, and August, 322 MPN/100 ml (Table 26). These bacteria events encouraged more intensive sampling since 2019, including bi-monthly sampling in the summer which allowed for the calculation of the 90-day geometric mean (Table 27). In 2022, *E. coli* levels at Upper and Lower Milton exceeded the EPA health standard (235 MPN/100) or ODEQ threshold (>406 MPN/100mL), between July-October (Table 28: Milton Creek watershed monthly max E. coli (MPN/100 ml) grab samples. Grab sampling results for broken down across years and watershed sampling locations. Sampling locations that experienced events over the EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted in red.,

Figure *41*).

The 90-day geometric mean state-mandated water quality threshold for Oregon is 126 MPN/100. In 2022, elevated levels at Upper Milton were observed between May-November with geometric means ranging from 140-168 MPN/100mL. When compared to previous years, Upper Milton Creek exhibited elevated *E. coli* bacteria levels in 2021 from May-August and July-December with geometric means ranging from 131-220 MPN/100mL and May-September 2020 with geometric means ranging from 127-189 MPN/100mL (Table 27). In comparison, Lower Milton Creek exhibited elevated *E. coli* levels in 2022 between May-November with geometric means ranging from 166-267 MPN/100mL. In previous years, Lower Milton also experienced elevated *E. coli* bacteria levels in 2021 from April-August and July-December with a geometric means ranging from 132-240 MPN/100mL and in 2020 from May-November ranging from 204-244 MPN/100mL (Table 27).

When comparing the 2017-2022 data to the 2008-2011 data, it is clear that Upper and Lower Milton have historically experienced elevated *E. coli* bacteria events (

Figure *42*). The frequency of these events appears to be increasing in Lower Milton creek when comparing overall monthly maximum values between 2017-2022 to 2008-2011 (

Figure *42*). These water quality conditions merit continued monitoring and additional investigation into the cause of elevated *E. coli* levels to ensure they do not continue to persist or increase.

Table 26: Summary table of Milton Creek watershed E. coli (2017-2022) MPN/100 ml grab samples. Grab sample data broken down across years and watershed sampling locations. Sampling locations that experienced events over the EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted in red. n = number of samples collected, for monthly max data, see Table 25.

		n	Max	Mean	+/- SD
Lower Milton	2017	4	1,046	430	429
	2018	3	322	227	139
	2019	11	980	259	263
	2020	16	461	187	124
	2021	15	1,120	209	268
	2022	16	649	186	186
Upper Milton	2017	0			
	2018	3	90	63	27
	2019	10	411	173	141
	2020	16	326	117	93
	2021	15	1,300	191	316
	2022	15	365	132	101

Table 27: Milton Creek watershed 90 Day geometric mean (5 samples or greater) of E. coli bacteria levels (MPN/100ml) across all sampling sites, those durations that are above the state-mandated threshold of 126 MPN/100 ml for the 90 day geometric mean are highlighted with red text.

		Apr Jul	May Aug	Jun Sep	Jul Oct	Aug Nov	Sep Dec
Upper Milton	2019			185.8	162.2		
	2020		189.8	127.5	99.5	89.4	
	2021	110.9	131.8		220.8	181.7	157.5
	2022	111.6	140.5	168.2	161.7	142.8	
Lower Milton	2019			226.5	194.1		
	2020		222.0	221.6	244.4	204.4	
	2021	132.4	132.9		196.5	183.3	240.2
	2022	110.7	166.4	216.1	267.4	227.6	

Table 28: Milton Creek watershed monthly max E. coli (MPN/100 ml) grab samples. Grab sampling results for broken down across years and watershed sampling locations. Sampling locations that experienced events over the EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted in red.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Milton	2017												
	2018						62	90	36				
	2019						121	411	219	365	72	24	78
	2020	120	5	13	26	228	214	326	119	192	38	205	36
	2021	18	40	42	70	96	141	135	186	1,300	115	25	83
	2022		30	10	63	30	179	308	150	365	119	93	41
Lower Milton	2017							248	61	1,046	365		
	2018						67	291	322				
	2019						488	185	138	980	166	86	219
	2020	28	25	59	156	167	219	387	205	461	365	111	147
	2021	308	29	24	52	162	179	248	133	1,120	178	91	148
	2022	55	40	48	49	58	115	517	387	649	328	104	34

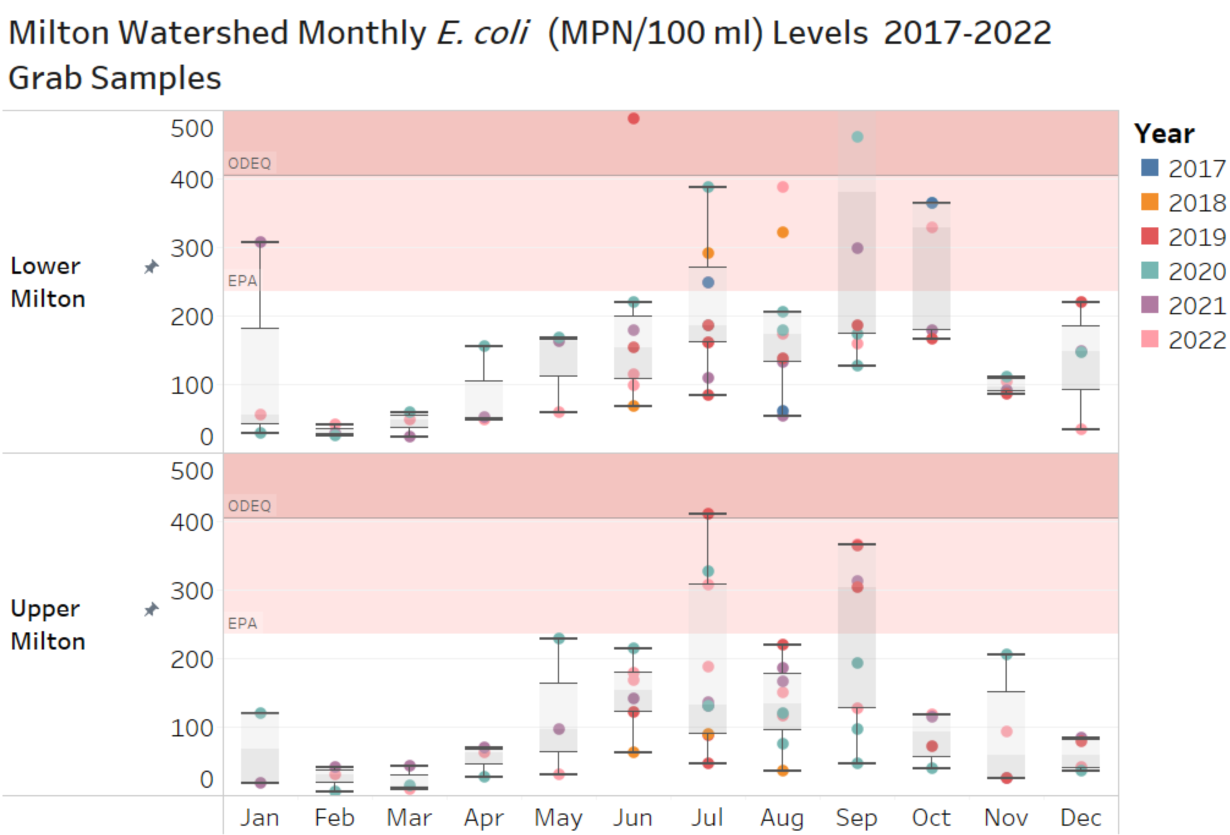


Figure 41. E. coli bacteria grab sampling results (boxplots) for Milton Creek Watershed broken down across months sampled and watershed sampling locations. Sampling years ranging from 2017 to 2022 are highlighted within each boxplot. EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted on each graph. The overall mean for the study period highlighted in each graph.

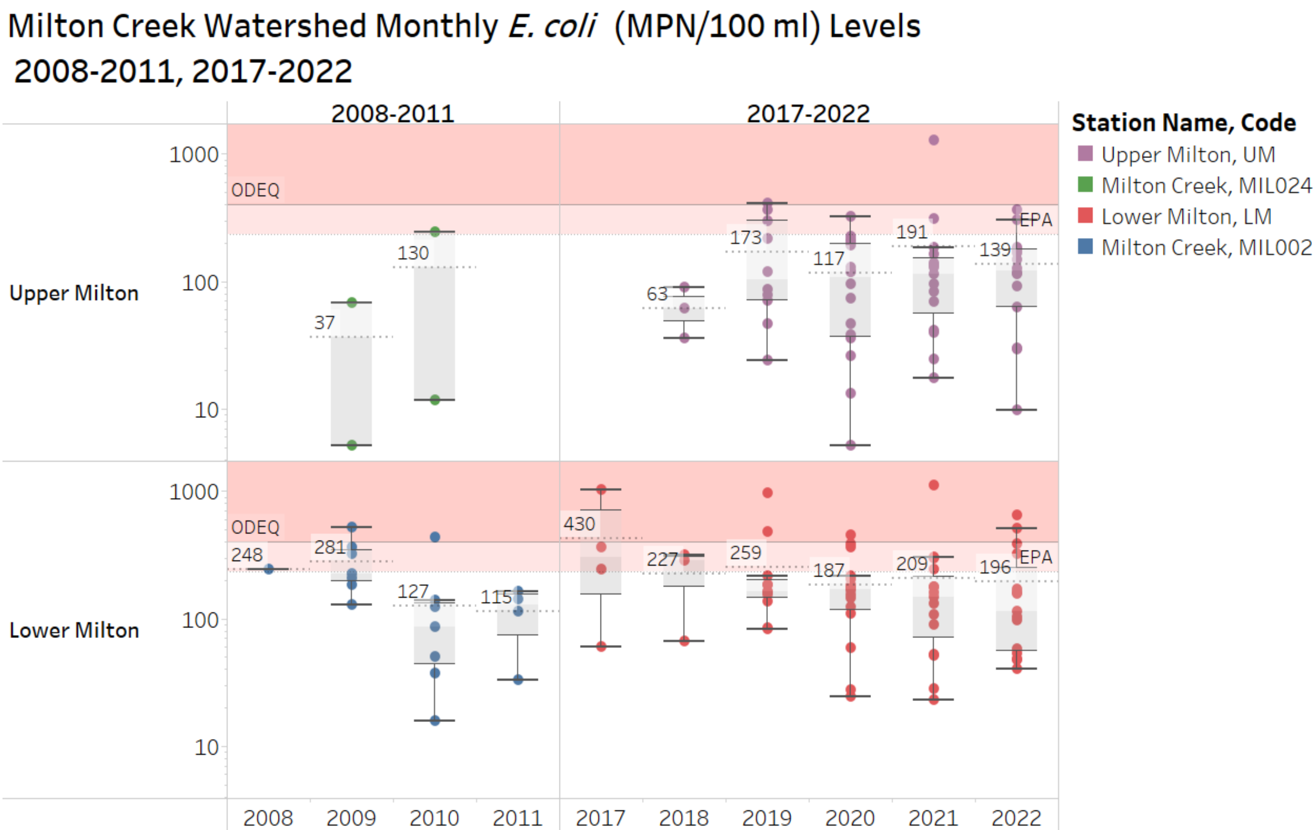


Figure 42: E. coli bacteria grab sampling results (boxplots) for Milton Creek Watershed broken down across years sampled and watershed sampling locations. Sampling location highlighted within each boxplot. EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted on each graph. The overall mean for the study period highlighted in each graph. Logarithmic scale used on the y-axis.

Water pH Levels

Since 2021, in-situ stream pH measurements were collected using a YSI Pro-series meter, with the goal of providing additional information on stream quality. Measurements were made between January-December.

pH levels in the watershed ranged from 6.8 (May 2022, UM) to 8.3 (July 2022, LM), staying within DEQ regulatory standards for ideal stream conditions for salmonids (6.5 – 8.5) (Table 29,

Figure *43*). pH ranges tended to increase from upper to lower reaches of the Milton Creek watershed. Compared to 2008-2011 data, pH values were highly variable in 2021-2022 (

Figure *43*).

Table 29: Summary Table of in-situ stream pH in Milton Creek Watershed in 2022.

		Count of P H	Min. P H	Max. P H	Std. dev. of P H
2021	Upper Milton	11	6.80	7.69	0.31
	Lower Milton	11	7.30	8.30	0.33
2022	Upper Milton	15	6.86	7.82	0.35
	Lower Milton	15	6.99	8.30	0.32

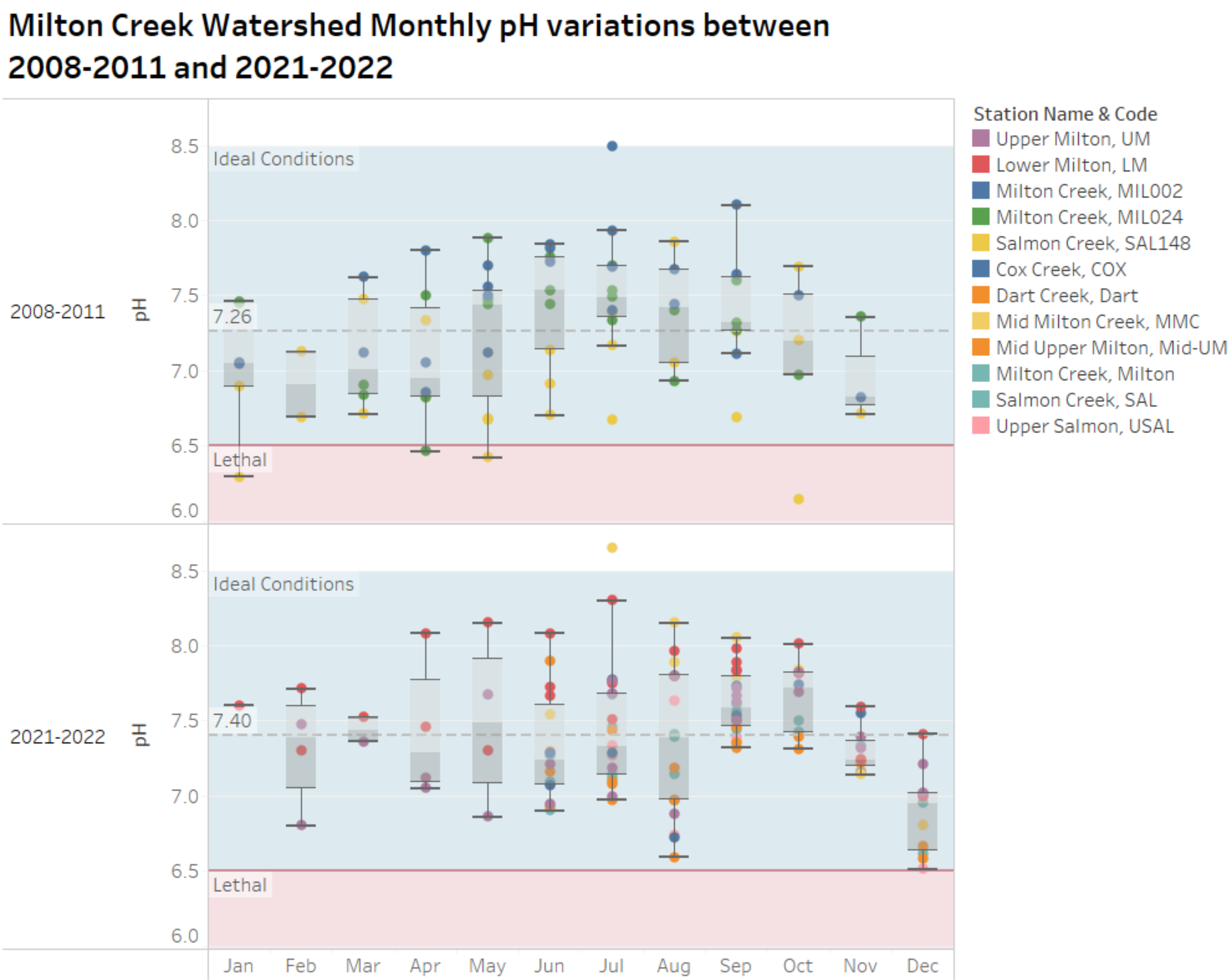


Figure 43: Milton Creek watershed in-situ stream pH ranges compared across months between 2008-2011 data and 2022 data. DEQ regulatory standards for lethal stream pH conditions for salmonids (<6.5) is represented as a red band. DEQ standards for ideal stream pH conditions for salmonids (6.5 – 8.5) is shown as the blue band.

Water Dissolved Oxygen (DO) Levels

Since 2021, in-situ stream DO measurements were collected using a YSI Pro-series meter, with the goal of providing additional information on stream quality. Measurements were made from January to August. These measurements were compared to 2008-2011 DO data.

Stream DO measurements in the watershed ranged from 5.53mg/L (August 2022, UM) to 15.26mg/L (February 2022, LM) (Table 30,

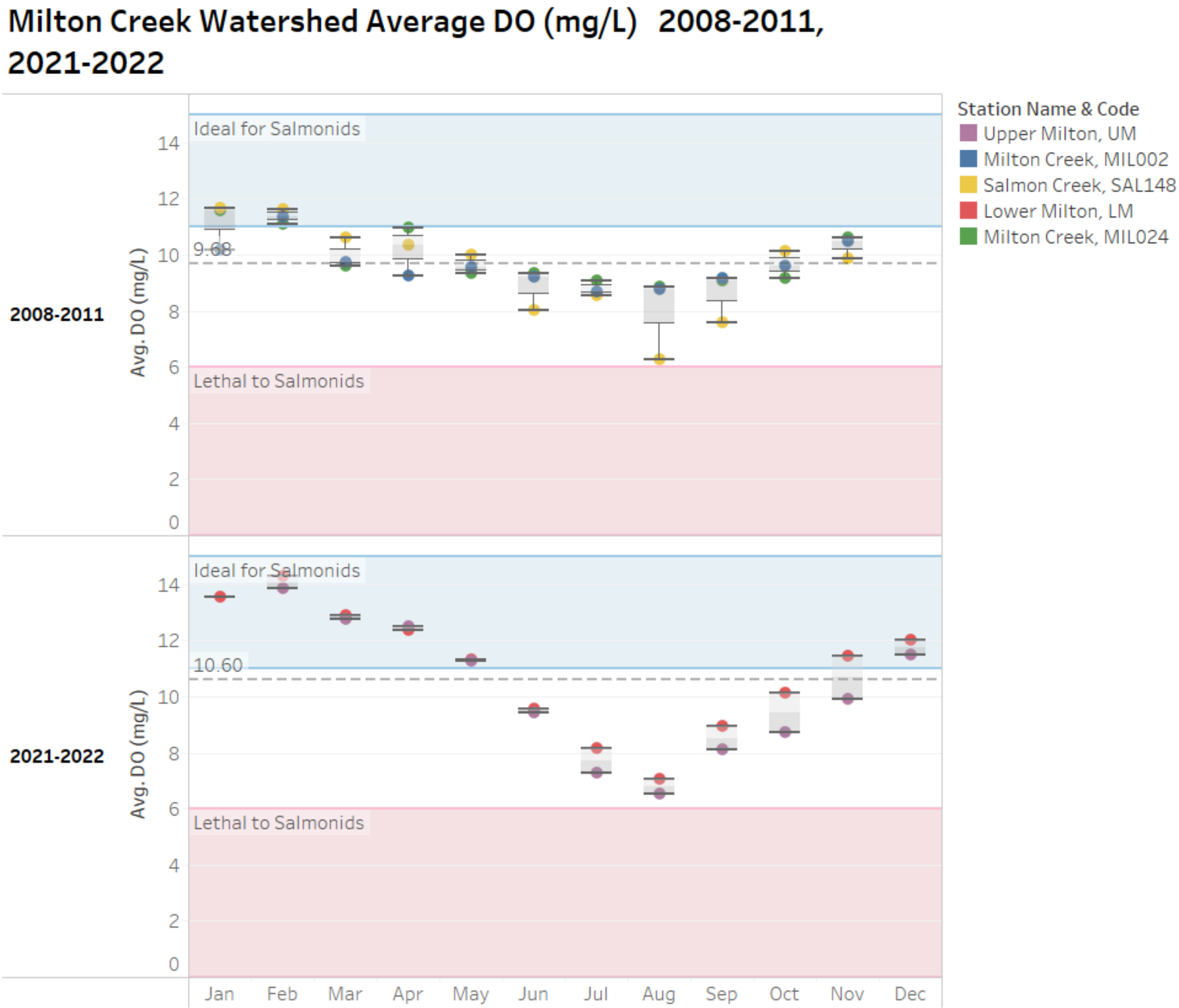


Figure *44*). falling below DEQ standards for ideal stream conditions (>11mg/L) between June and August. DO levels tended to increase from upper to lower reaches of the watershed. Seasonally, elevated DO levels were observed during winter and spring months reaching peak lows during summer before climbing again in the fall. When compared to 2008-2011 data, DO levels were more variable and summertime levels were lower in 2021-2022 in the watershed (

Figure *44*).

Table 30: Summary Table of in-situ stream DO in Milton Creek Watershed in 2022.

		Count of DO	Avg. DO	Min. DO	Max. DO	Std. dev. of DO
2021	Upper Milton	13	9.31	6.10	12.63	2.18
	Lower Milton	14	9.84	6.25	13.35	2.26
2022	Upper Milton	10	10.31	5.53	15.06	3.17
	Lower Milton	10	10.53	6.47	15.26	2.76

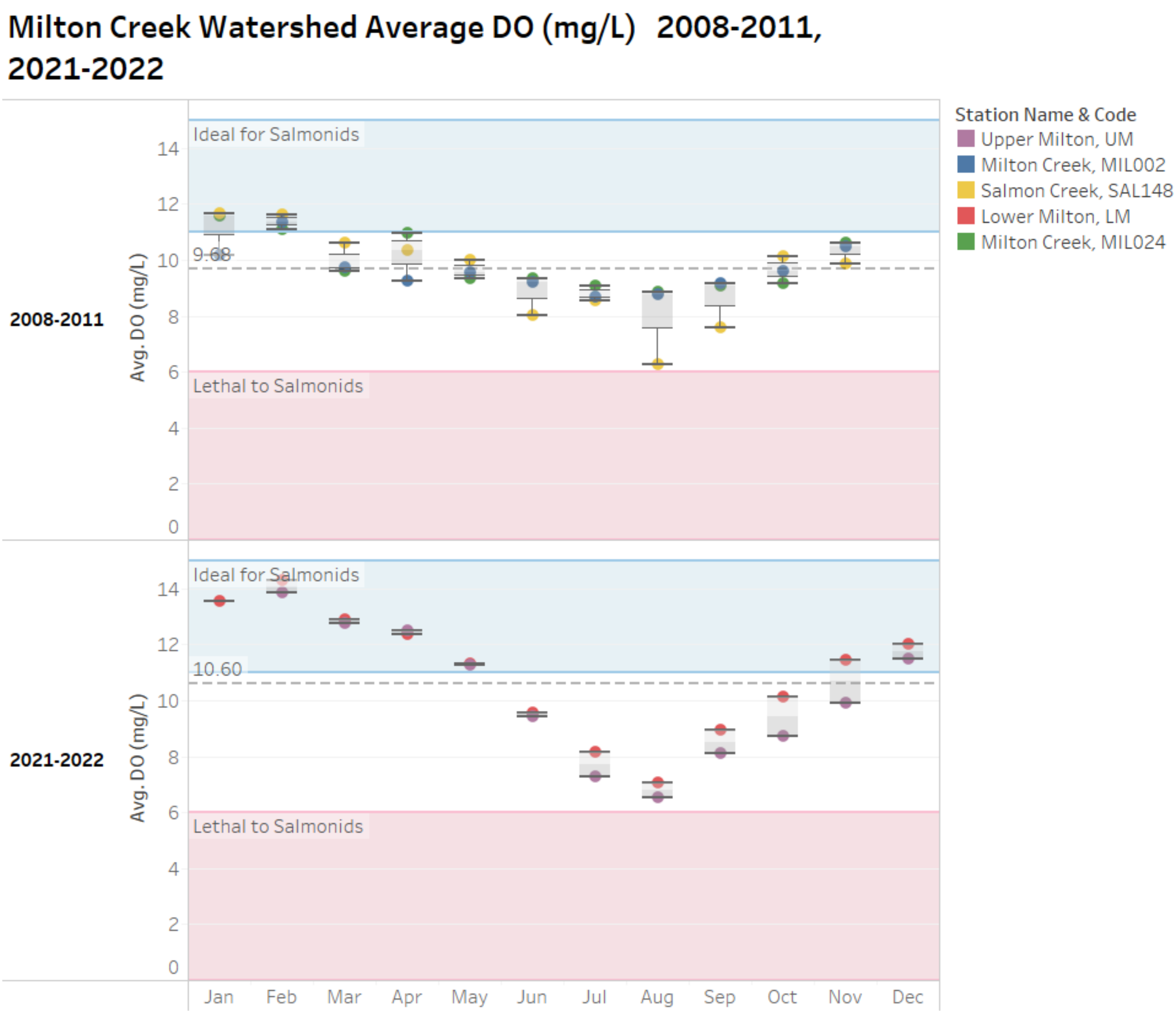


Figure 44: Monthly in-situ stream DO ranges across all monitoring locations in Milton Creek watershed between 2008-2011 (top panel) and 2021-2022 (bottom panel). DEQ standards for ideal DO conditions for salmonids

(>11mg/l) is depicted as a blue band in the graph. DEQ standards for Lethal conditions (<6mg/l) is depicted as a red band.

Water Conductivity Levels

Conductivity levels varied seasonally across both monitoring locations within the Milton Creek watershed (Figure 45, Pollution from runoff or increased turbidity levels from erosion can result in higher conductivity levels; however, there is no EPA or ODEQ threshold for conductivity in the region.

Table 31). At both locations, annual increases in water conductivity were observed between April to September and declined from October to February (Figure 45, Pollution from runoff or increased turbidity levels from erosion can result in higher conductivity levels; however, there is no EPA or ODEQ threshold for conductivity in the region.

Table 31). Between 2018-2022, Upper Milton exhibited lower overall mean conductivity levels (60.7 µs/cm) compared to Lower Milton (69.1 µs/cm) (Figure 45, Pollution from runoff or increased turbidity levels from erosion can result in higher conductivity levels; however, there is no EPA or ODEQ threshold for conductivity in the region.

Table 31). These data provide baseline conductivity levels that can be used to identify new and emerging water quality issues or improvements over time. When comparing the 2018-2022 data to the 2008-2011 data, no significant shift in conductivity was observed (Figure 46). Pollution from runoff or increased turbidity levels from erosion can result in higher conductivity levels; however, there is no EPA or ODEQ threshold for conductivity in the region.

Table 31: Summary Table of Milton Creek watershed monthly conductivity (µs/cm) data for 2018-2022 grab samples. Conductivity (µs/cm) samples broken down across months sampled and watershed sampling location. n = number of samples collected.

		n	Max	Mean	+/- SD
Upper Milton	2018	6	79	59	16
	2019	14	89	64	21
	2020	17	98	71	20
	2021	15	89	57	21
	2022	15	77	51	19
Lower Milton	2018	6	108	75	27
	2019	15	97	70	21
	2020	17	131	78	26
	2021	15	121	70	30
	2022	16	104	56	25

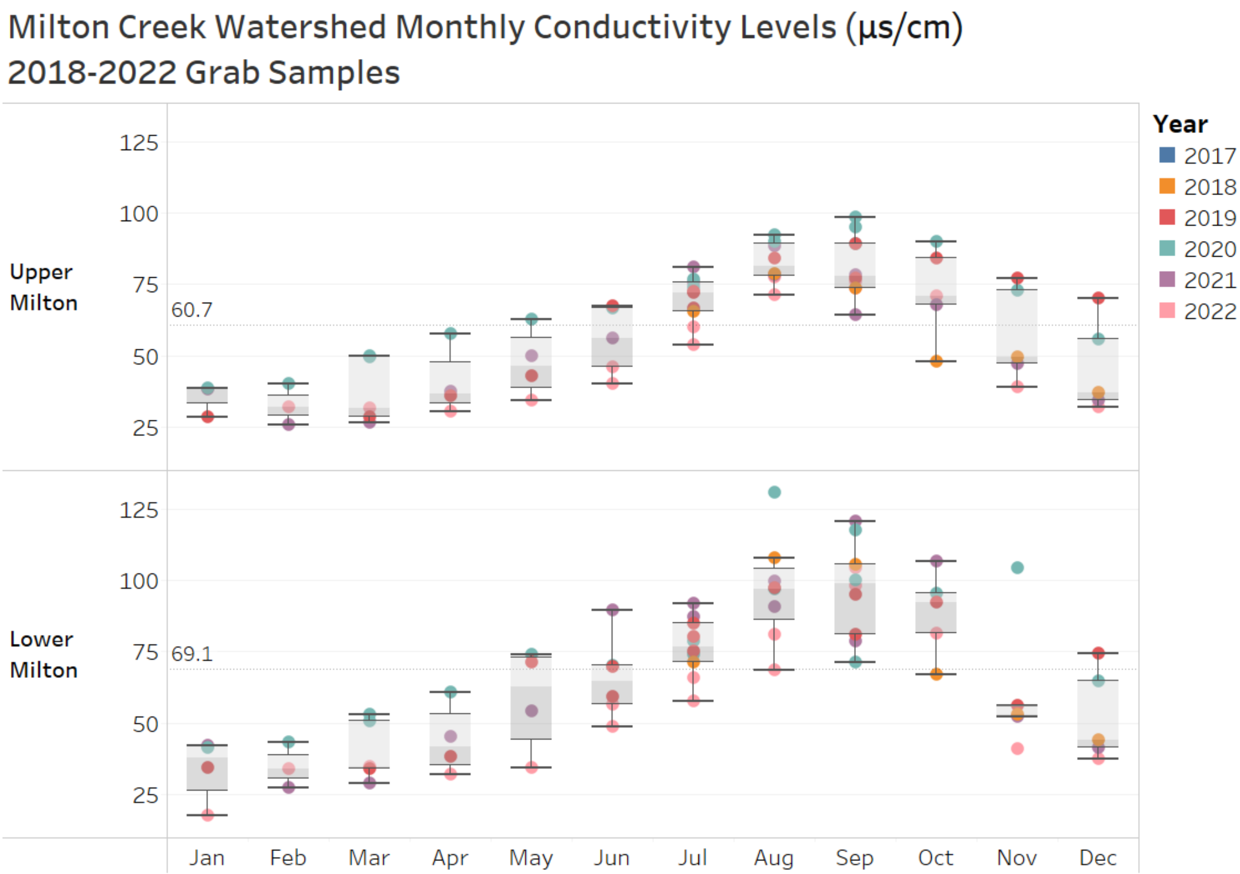


Figure 45: Conductivity levels (µs/cm) 2018-2022 Grab Samples results (boxplots) for Milton Creek watershed broken down across months sampled and watershed sampling location. Sampling years ranging from 2018 to 2022 are highlighted within each boxplot. The overall mean for the study period is highlighted in each graph.

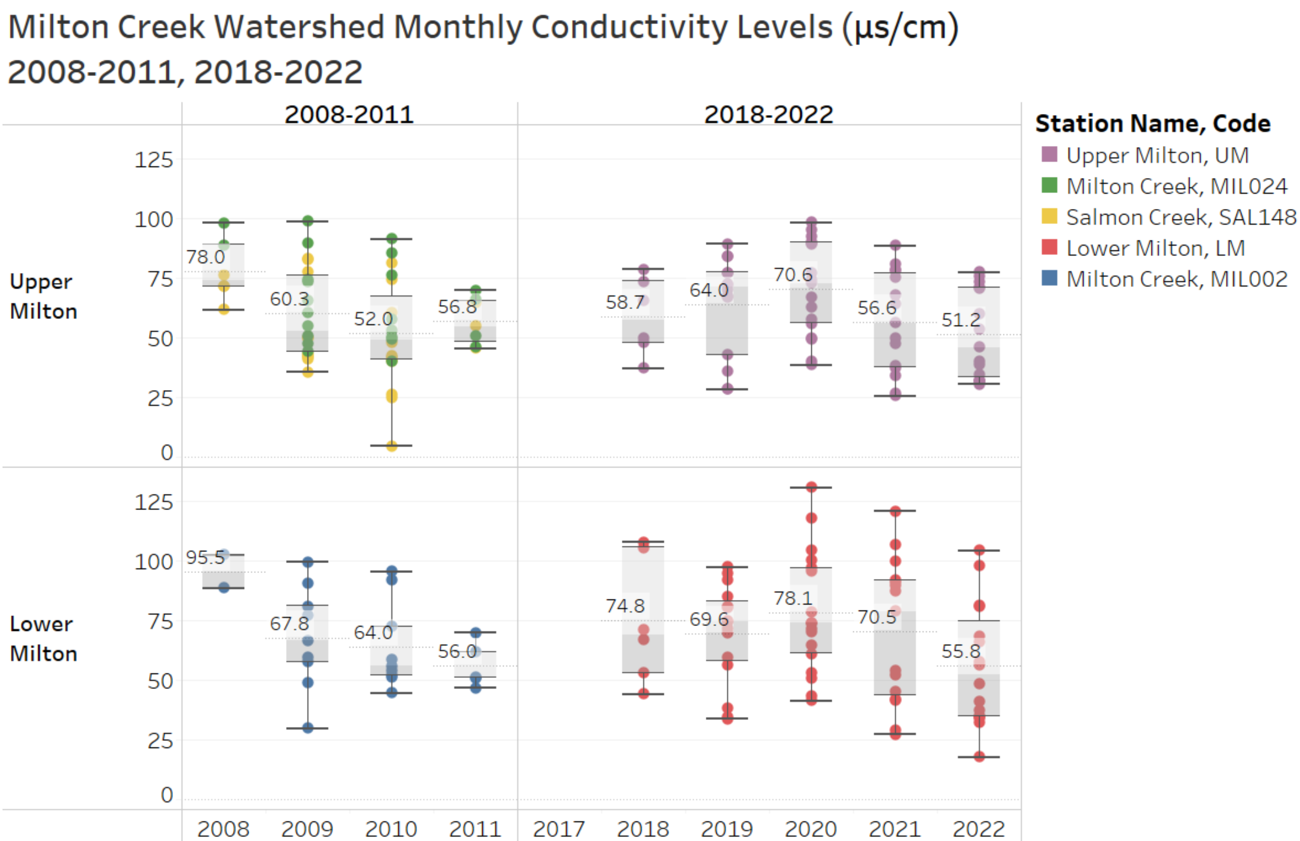


Figure 46: Conductivity levels (µs/cm) 2008-2022 Grab Samples results (boxplots) for Milton Creek watershed broken down across years, with monitoring location highlighted within each boxplot. Sampling years ranging from 2008-2011 and 2018- 2022. Overall mean for each year annotated.

Water Quality Issues

Water quality issues observed in 2022 in the Milton Creek Watershed are similar to those observed in the previous years. Consistently high summer temperatures (>18°C and >25°C) are observed in the upper and lower watershed between June and September (Figure 36). Overall elevated temperatures are likely caused by solar loading, especially within the lower reaches of the watershed, which are much more heavily developed and lack riparian shade (Figure 4). Both Upper and Lower portions of Milton Creek have experienced a potential increase in water temperatures since the previous 2008-2011 study indicating that further action is required to prevent continued temperature issues in the basin (Figure 38). Low water temperatures are critical for supporting aquatic life including endangered Salmonids in the Pacific Northwest; reducing solar radiation and reducing urban and agricultural runoff can help keep water temperatures down and protect these stream habitats (USGS 2021). Multiple turbidity events above the 10 NTU threshold were also observed in the Upper and Lower reaches of Milton Creek during the 2017-2022 study period (Figure 39, Table 25). Similar to recommendations for temperature improvements, increasing riparian cover and reducing runoff can aid in reducing sediment loading in stream environments which can help with turbidity issues in the watershed. pH and DO levels generally stayed within ODEQ standards; however, a high degree of variability was observed in 2022 (Figure 43,

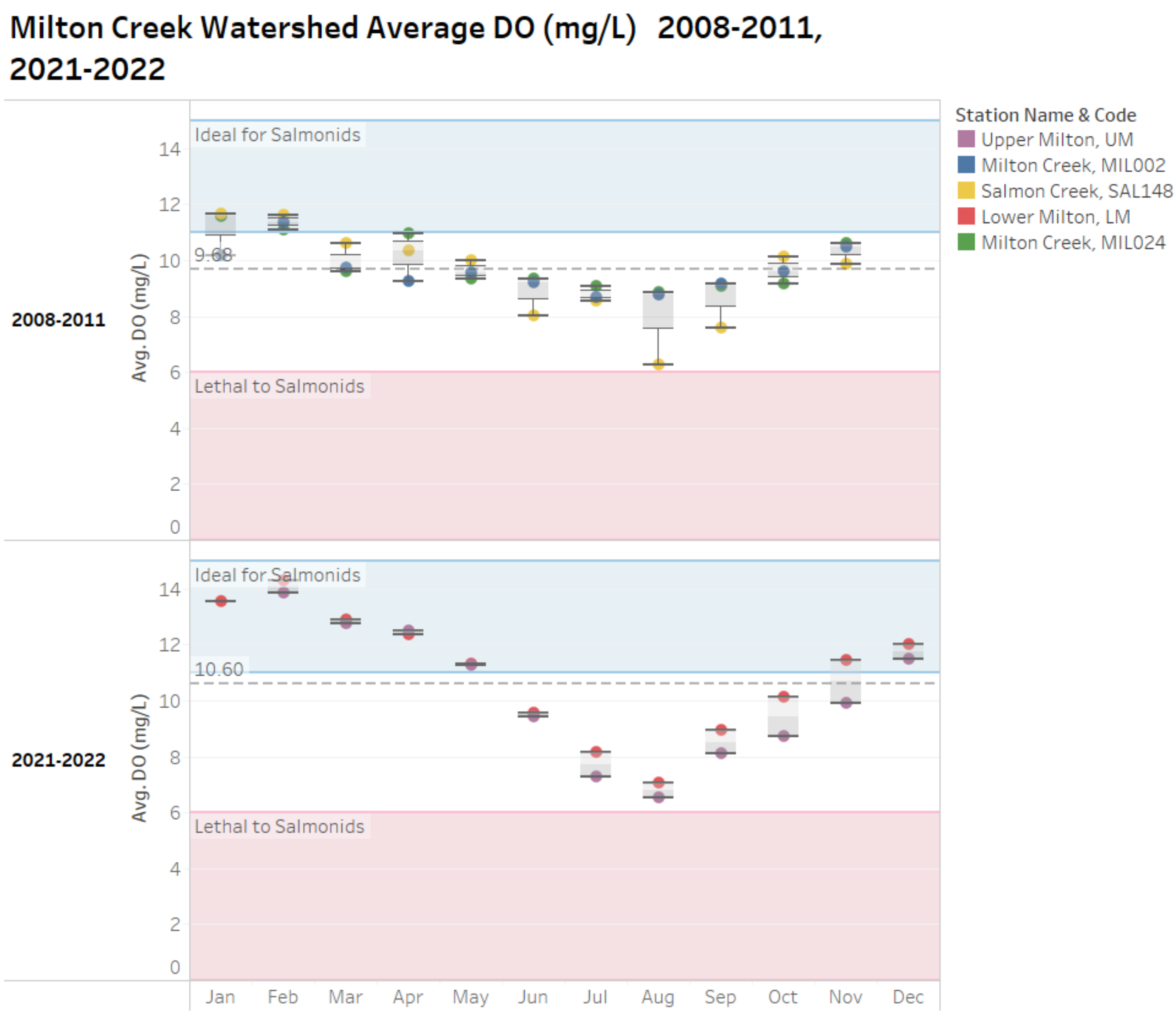


Figure *44*). No significant issues or shifts in stream water conductivity levels were detected in Milton Creek Watershed during this study.

In 2022, elevated *E. coli* bacteria levels were observed in the watershed between July-October, exceeding the EPA and ODEQ standards, including the five sample geometric mean in 2019, 2020, and 2021 (Table 4, Table 27). *E. coli* bacteria issues are indicative of animal waste runoff and can be very harmful to humans using these waterways for recreation (Pandey et al. 2014). Additional research is needed to determine the exact source of the elevated *E. coli*. Animal waste or septic tank leakage into the stream are possible sources to be investigated. Depending on the source, actions that could reduce future *E. coli* exceedance events include increasing riparian buffers, excluding livestock from the creek, increasing manure management near streams, and/or updating failed septic systems throughout the targeted reach of the watershed (Pandey et al. 2014). Given the frequency and scale of *E. coli* bacteria events adding warning signs to recreational areas along the stream is recommended due to persisting issues observed in Milton Creek watershed, an intensive monitoring effort was launched in June 2022. The watershed was divided into contributing sub-basins and monitoring locations were established in these sub-basins to identify potential sources of contamination. This report provides results of this effort between June and December 2022 in the subsequent sections.

North Scappoose Creek

Study Area

North and South Scappoose Creek Watersheds
Distribution of Monitoring Locations (2008-2011, 2017-2022)

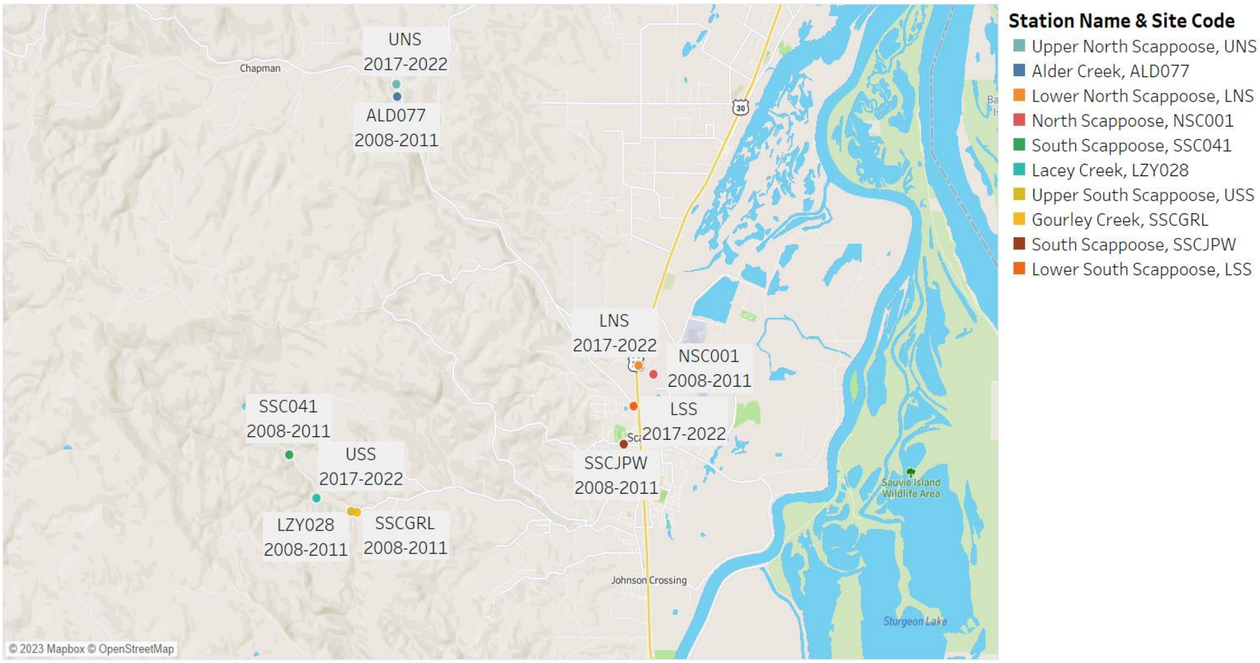


Figure 47: Overview map of North and South Scappoose Creek monitoring locations, for watershed boundaries, see Figure 1. For specific monitoring location details, see Table 1.

Upper North Scappoose Creek Distribution of Monitoring Locations (2008-2011, 2017-2022)

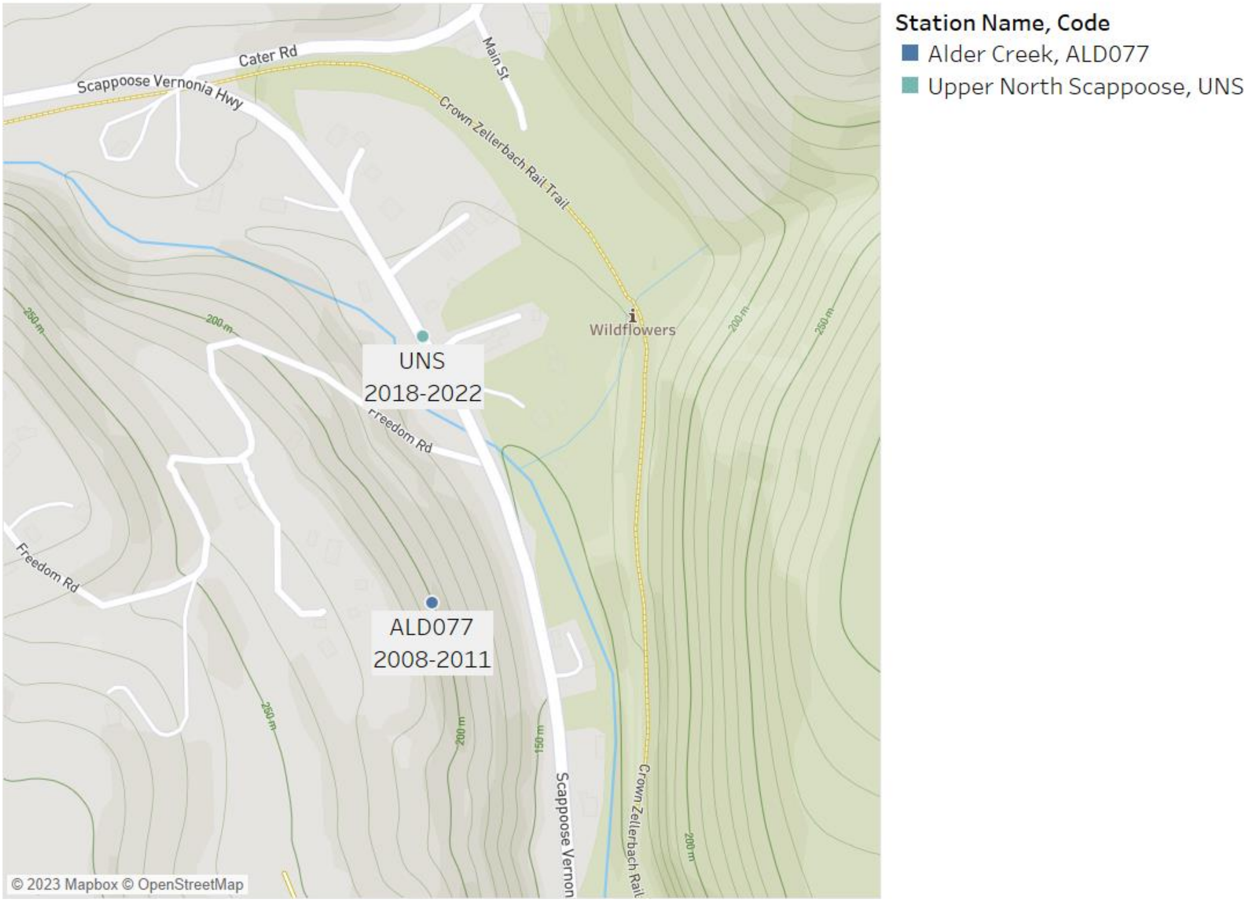


Figure 48: Focus map of Upper North Scappoose Creek monitoring locations; for an overview map, see Figure 1 & Figure 47. For specific monitoring location details, see Table 1.

Lower North Scappoose Creeks Distribution of Monitoring Locations (2008-2011, 2017-2022)

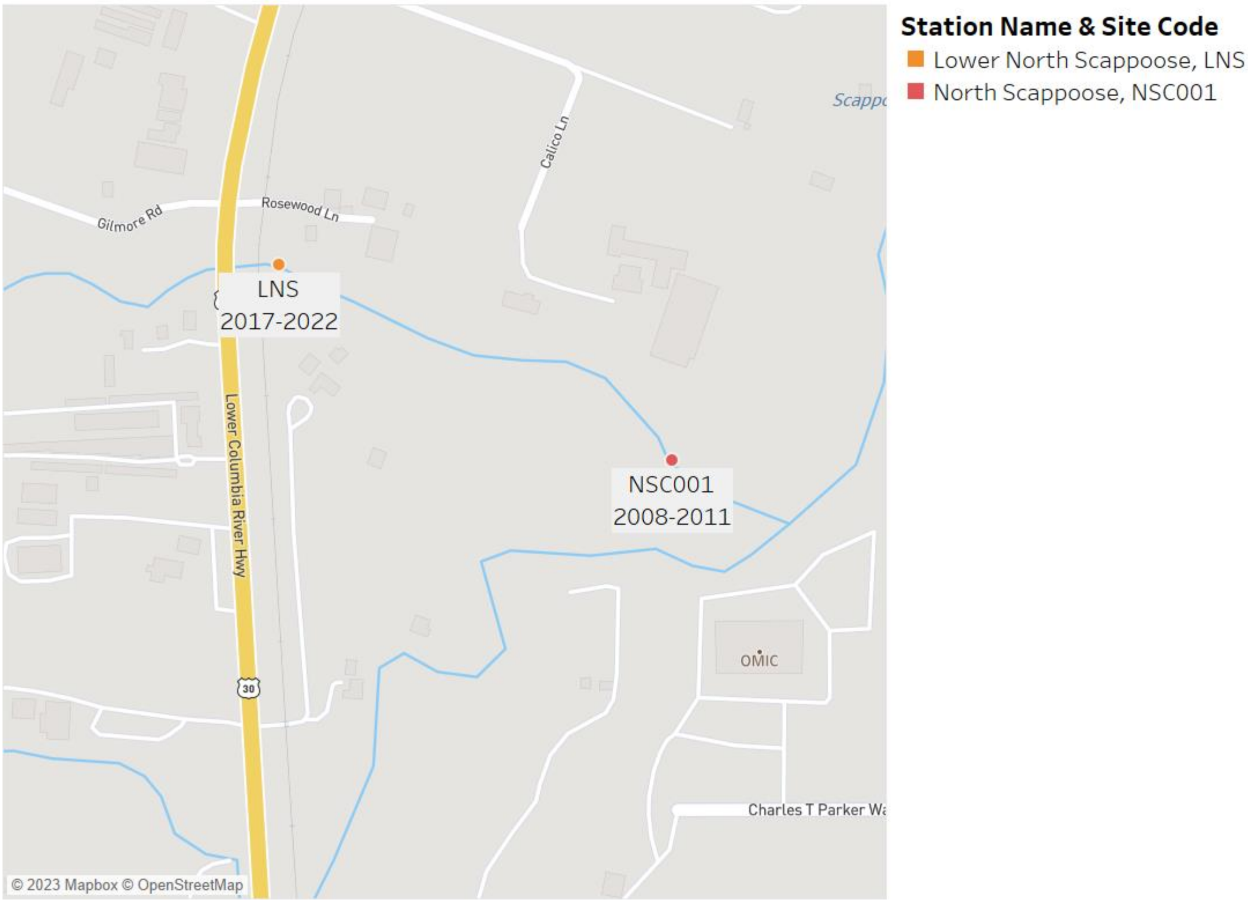


Figure 49: Focus map of Lower North and South Scappoose Creek monitoring locations; for an overview map, see Figure 1 & Figure 47. For specific monitoring location details, see Table 1.

Water Temperature

In 2022, 7dMAM ranged from 3.5°C – 24.3°C, with highest seasonal temperatures being observed in August 2022. In comparison, between 2017 and 2021 7dMAM temperature ranged from 1.9°C to 25.7°C in the North Scappoose Creek Watershed, with the highest seasonal temperatures being observed in August (Table 32). Temperatures tended to increase from upper to lower reaches (

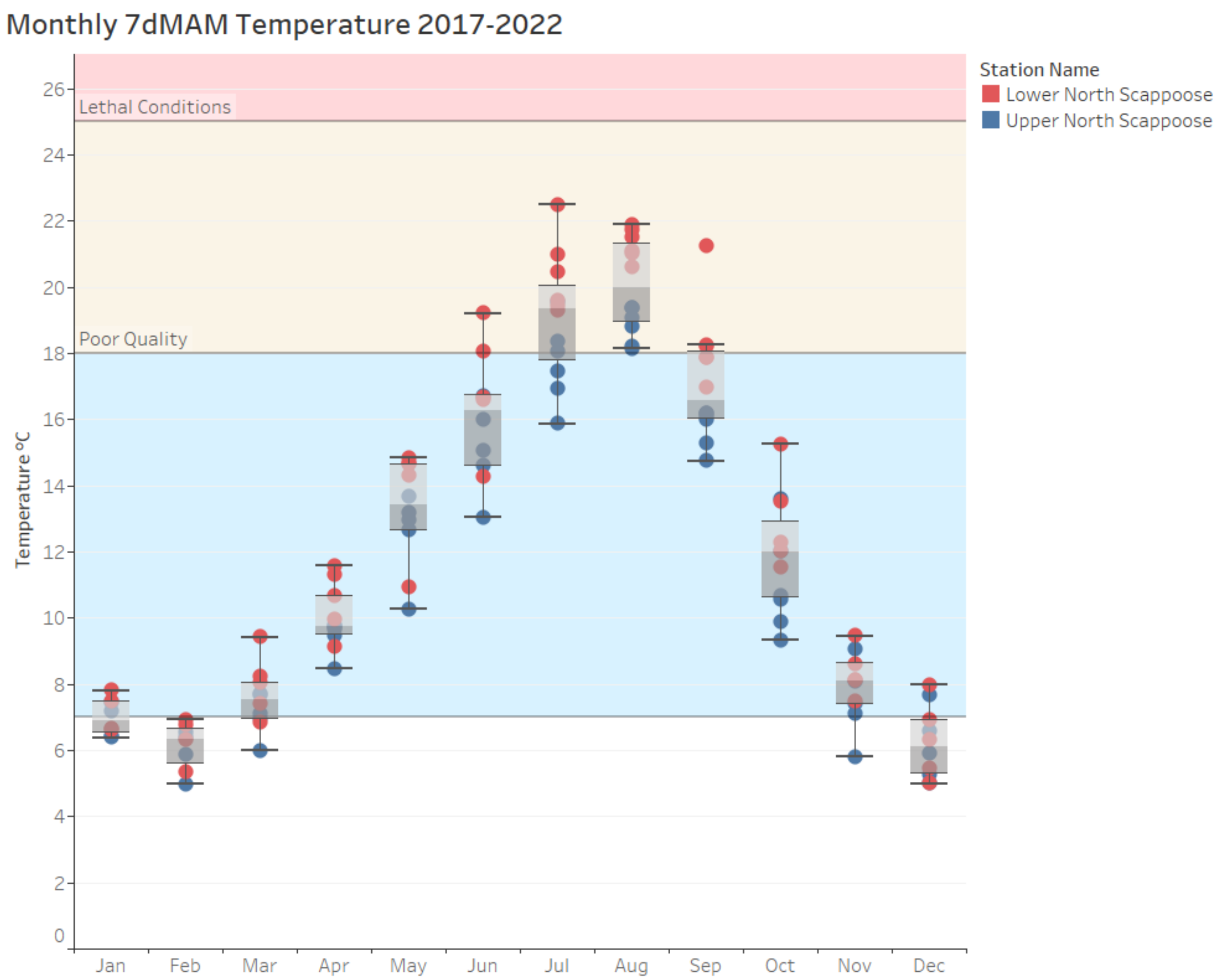


Figure *51*). Upper and Lower North Scappoose creeks followed similar temperature trends during the winter months of 2018-2022 (January – February).

DEQ temperature standard for salmon rearing habitat is less than 18°C and streams with temperatures higher than 18°C are considered poor quality for salmon. Temperatures in the Upper North Scappoose Creek exceeded 18°C in August 2022 while Lower North Scappoose Creek maintained temperatures above 18°C during between July – September in 2022, with the average 7dMAM for September 2022 exceeding the 18°C threshold (18.2°C) (Figure 52).

When the number of days was compared across the watershed, Lower North Scappoose had a greater number of days above 18°C as compared to Upper North Scappoose during the monitoring period (Table 33). The lower temperatures at Upper North Scappoose are indicative of the presence of forests and vegetation providing adequate shading and lesser runoffs. Lower North Scappoose is located in a medium intensity developed area of the watershed. The creek passes through developed areas and temperatures at the Lower North Scappoose monitoring station are heightened, seemingly due to solar exposure, runoffs, etc.

Table 32: 7dMAM temperatures Summary from 2017 to 2022 for creeks in North Scappoose Creek Watershed. Temperatures have been color-coded according to salmonid thresholds listed in Table 4.

		Min. 7DMAM	Avg. 7DMAM	Max. 7DMAM	Number of Days over 18°	Number of Days over 25°
Upper North Scappoose	2017	3.0	12.6	20.3	44	0
	2018	2.2	11.2	21.0	44	0
	2019	1.9	10.4	19.6	22	0
	2020	5.2	12.5	19.5	33	0
	2021	4.5	11.9	22.4	63	0
	2022	3.5	11.8	21.6	46	0
Lower North Scappoose	2017	3.2	14.2	23.3	76	0
	2018	3.0	12.5	23.5	83	0
	2019	2.7	12.3	22.6	82	0
	2020	5.4	14.1	22.7	70	0
	2021	4.6	13.3	25.7	97	2
	2022	3.9	13.0	24.3	69	0

Table 33: Number of days over 18°C in the North Scappoose Creek Watershed between 2017 to 2022. Winter and spring months have been excluded from this table as stream temperature conditions are within ideal conditions at that time.

		May	June	July	August	September	October
Upper North Scappoose	2017		0	14	18	12	0
	2018	0	1	18	25	0	0
	2019	0	5	0	12	5	0
	2020	0	0	13	17	3	0
	2021	0	10	31	22	0	0
	2022	0	0	10	30	6	0
Lower North Scappoose	2017		0	28	31	17	0
	2018	0	10	31	30	12	0
	2019	0	15	25	31	11	0
	2020	0	7	20	31	12	0
	2021	0	18	31	31	17	0
	2022	0	3	23	31	12	0

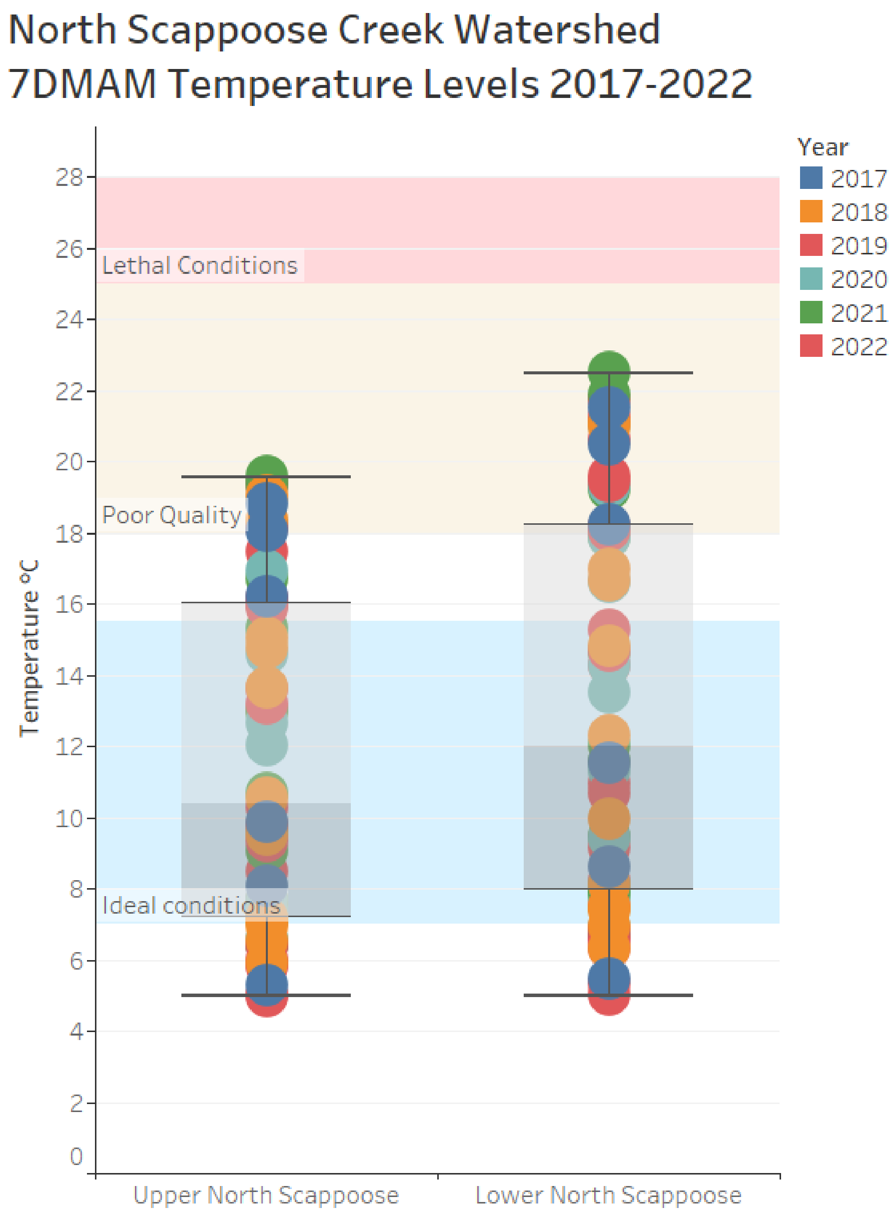


Figure 50: 7dMAM temperature variation in the North Scappoose Creek Watershed, overlaid on the DEQ stream temperature standard ranges for healthy salmon habitat (Table 4). Data points represent the monthly average conditions observed in a year. Ideal Conditions (7˚C-15.6˚C), Poor Quality (18˚C-25˚C) and Lethal Conditions (>25˚C).

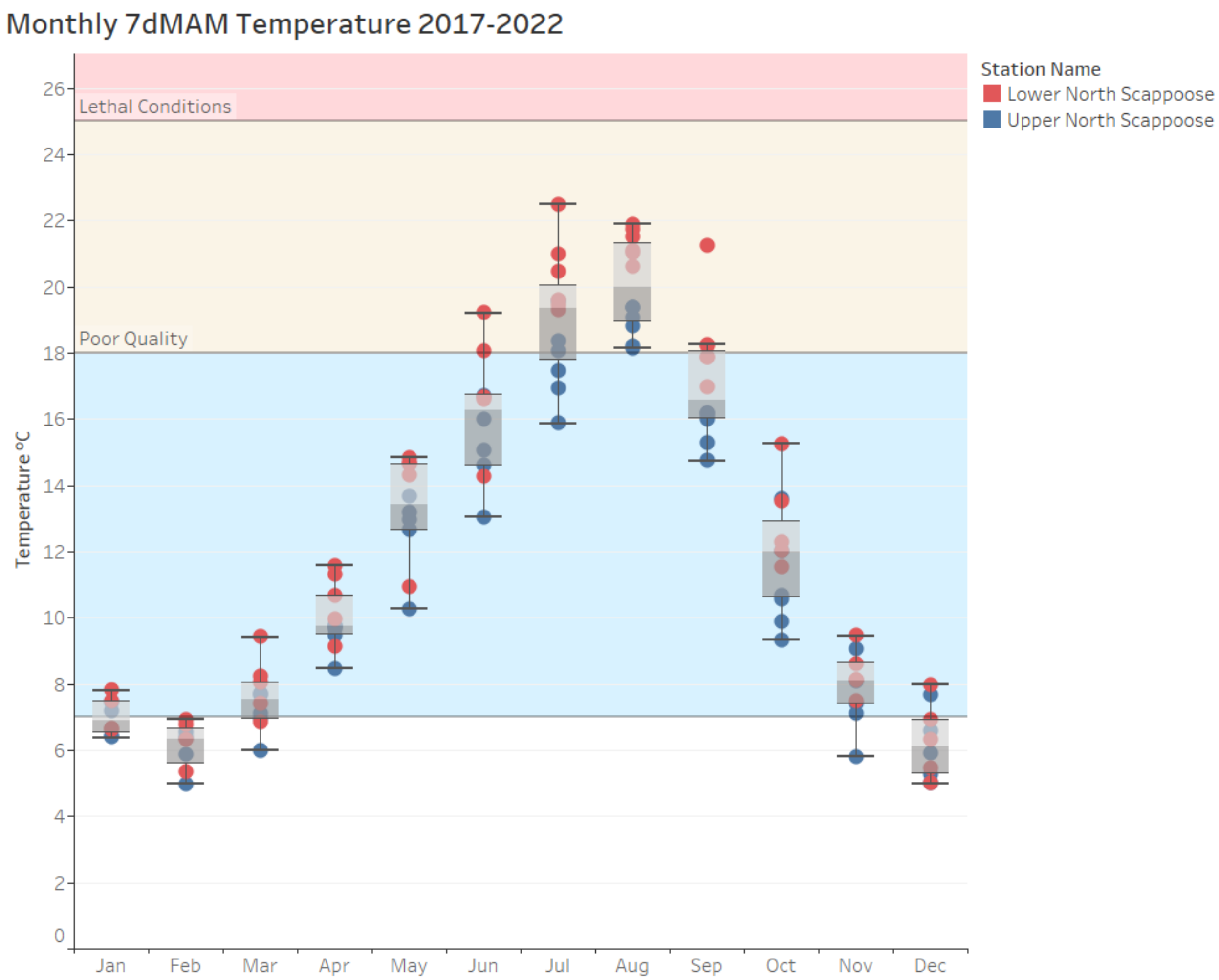


Figure 51: Monthly variation in 7dMAM temperature in the North Scappoose Creek Watershed between 2017 – 2022.

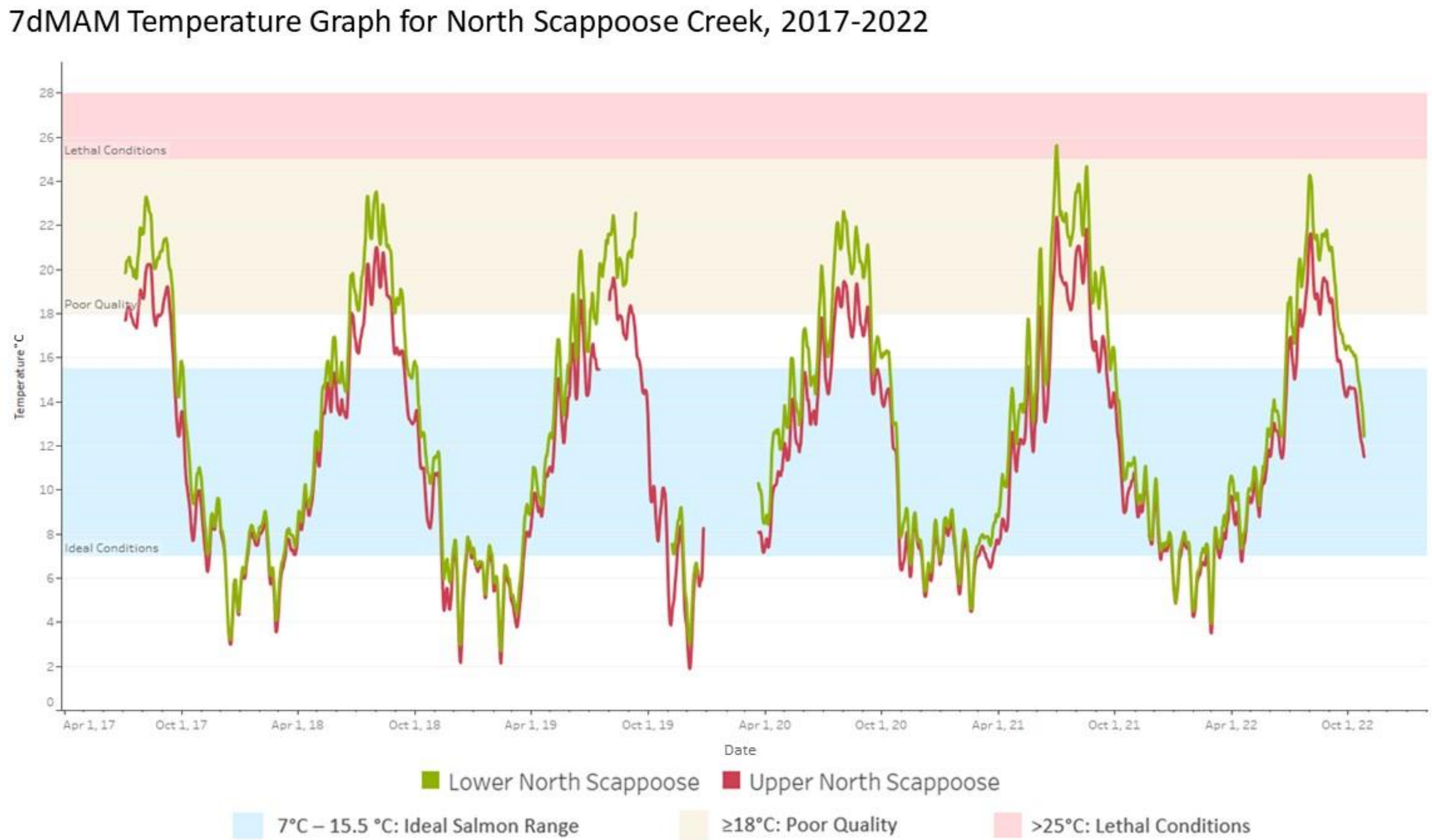


Figure 52: 7-day average maximum temperatures (7dMAM) for Lower North Scappoose and Upper North Scappoose creeks from June 2017 to December 2022 overlayed on salmonid temperature threshold ranges. See Table 4 for temperature threshold details.

When May to October temperature 7dMAM temperature data were compared to the overlapping timeframe from 2008-2011, increased temperature trends were observed; however, the average increase is more significant in the lower watershed. There was an average increase of 0.5°C in the upper watershed, whereas during the same time, the average increase in the lower watershed was 0.9°C. However, it should be noted that the complete temperature profile is unavailable for the 2008 – 2011 dataset, and 2010 data was missing from this dataset, so we cannot definitively say whether this increase is consistent (

Figure *53*).

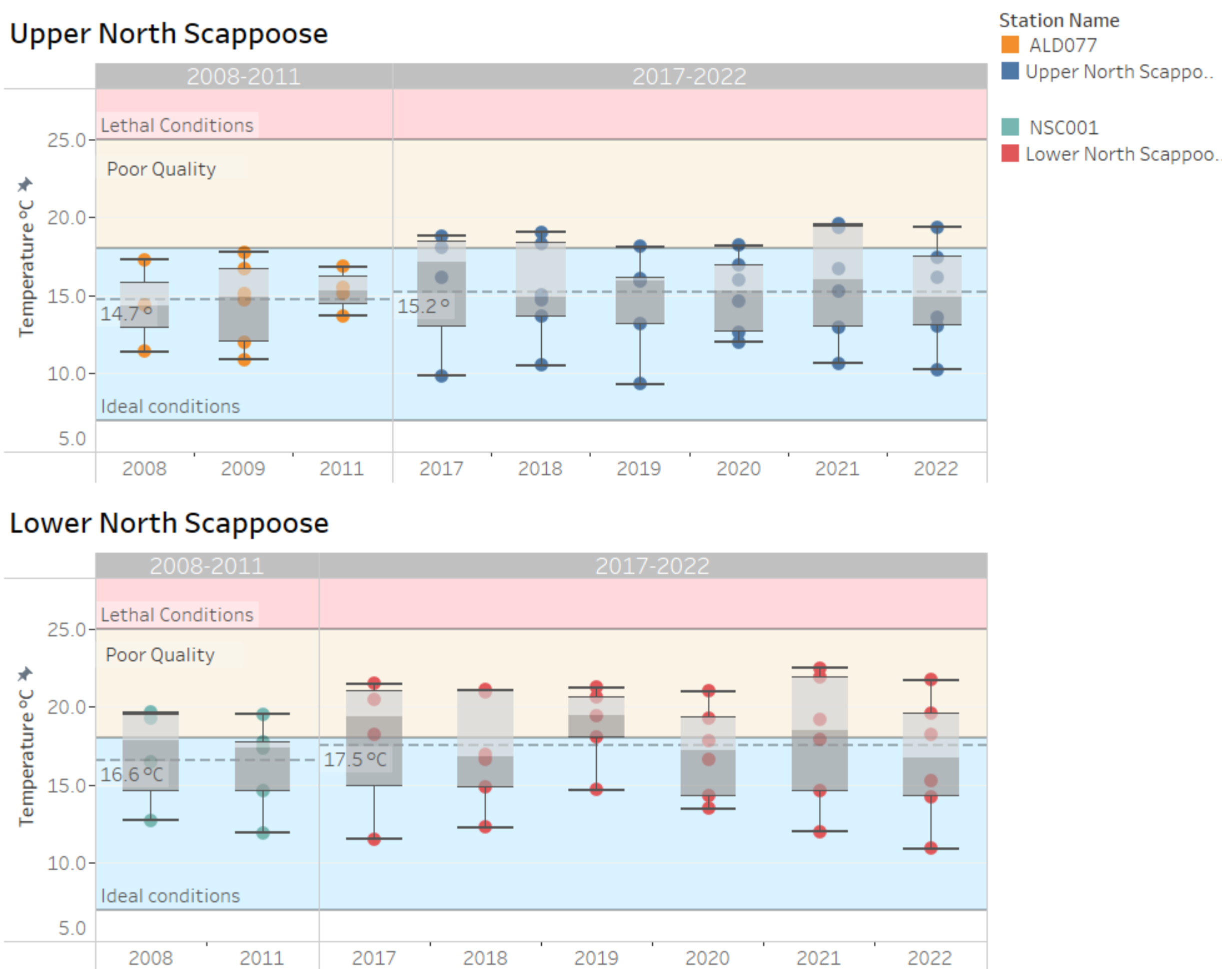


Figure 53: Monthly 7dMAM temperature comparisons between 2017-2022 data and 2008-2011 data for North Scappoose Creek Watershed. Upper North Scappoose and Lower North Scappoose have data available from June 2017 to October 2022. Alder Creek has data available from May to October of 2008, 2009, and 2011. North Scappoose (NSC001) has data available for May to October of 2008 and 2011.

Water Turbidity Levels

Over the six-year monitoring period, on average, Upper and Lower North Scappoose Creek sampling locations maintained relatively low (< 4.5 NTU) turbidity levels (Table 34, Figure 54). Seasonally, the highest turbidity levels were recorded in the winter months (Nov, Dec, Jan, Feb), reflecting winter storm conditions and high flow events (Figure 54). In 2022, during a high flow event, one occurrence above the 10 NTU salmon habitat turbidity threshold was recorded at Lower North Scappoose (14.5 NTU). Previously, one occurrence above the 10 NTU salmon habitat turbidity threshold was recorded in Lower North Scappoose Creek during the 2017-2020 study period (Table 34, Figure 54). When comparing the 2017-2022 data to the 2008-2011 data, no significant shift in turbidity was observed between Upper and Lower North Scappoose Creek (

Figure *55*).

Table 34: Summary Table for North Scappoose Creek Watershed Monthly Turbidity (NTU), 2017-2022 Grab Samples. Grab sample data broken down across years and watershed sampling locations. n = number of samples collected—red highlights when a sample location experienced a maximum over the 10 NTU threshold.

		n	Max	Mean	+/- SD
Upper North Scappoose	2017	4	4.9	2.7	1.5
	2018	11	5.3	2.9	1.2
	2019	14	7.0	2.9	1.9
	2020	16	8.9	3.4	1.8
	2021	15	18.8	3.8	4.3
	2022	15	6.3	3.9	1.1
Lower North Scappoose	2017	5	5.2	2.0	1.8
	2018	11	5.0	2.9	1.3
	2019	15	7.2	3.2	2.0
	2020	16	10.1	3.0	2.1
	2021	15	16.5	3.6	3.7
	2022	16	14.5	4.5	2.9

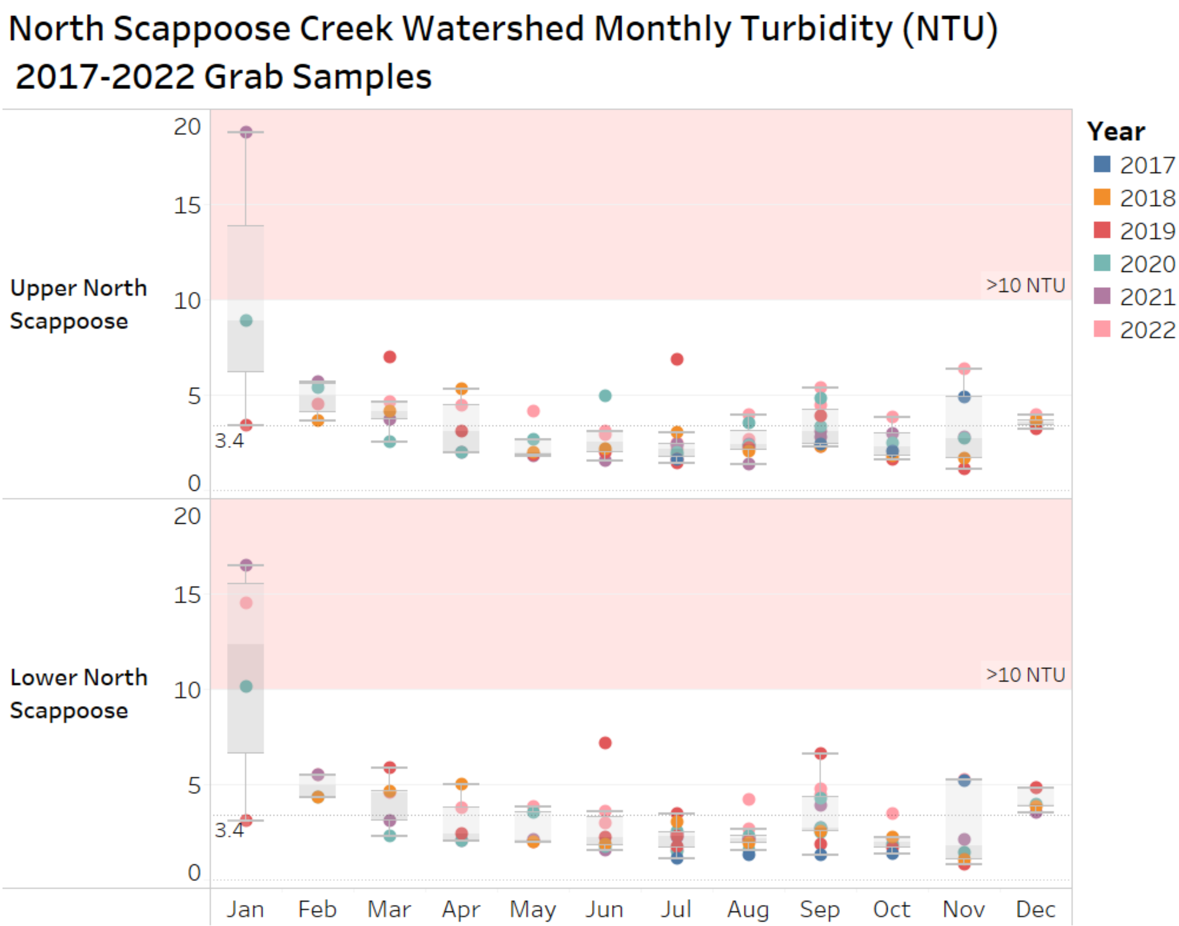


Figure 54. Turbidity (NTU) grab sampling results (boxplots) for North Scappoose Creek Watershed broken down across sampling locations and months sampled. Sampling years ranging from 2017 to 2022 are highlighted within each boxplot. 10 NTU threshold highlighted in pink. The overall mean for the study period is highlighted in each graph.

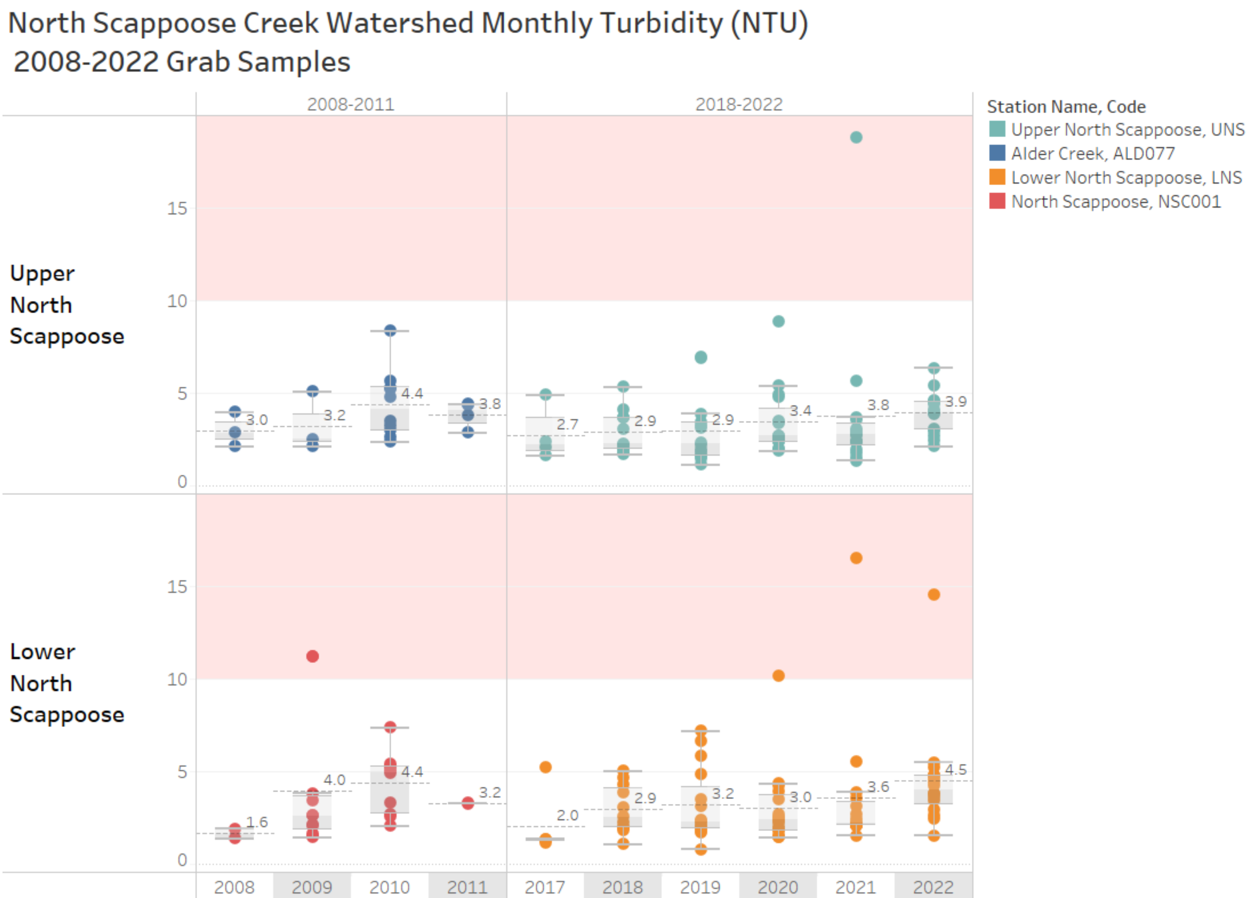


Figure 55: Turbidity (NTU) grab sampling results (boxplots) for North Scappoose Creek Watershed broken down across years sampled. Sampling locations are highlighted within each boxplot. 10 NTU threshold highlighted in pink. Overall mean for each year highlighted.

Water Bacteria Levels

In 2017, only Lower North Scappoose Creek was monitored for *E. coli* bacteria levels; during this time, elevated levels exceeding the EPA health standard <235 MPN/100mL were detected in September. In 2018, sampling only took place between June-August, and no elevated samples were collected (Table 37). More intensive sampling was conducted since 2019, including bi-monthly sampling in the summer which allowed for the calculation of the 90-day geometric mean (Table 36).

The 90-day geometric mean state-mandated water quality threshold for Oregon is 126 MPN/100mL (Table 36). In 2022, the 90-day geometric mean at Upper North Scappoose Creek stayed within ODEQ threshold. Previously, elevated geometric mean levels in the upper watershed were observed between May-August and April-August in 2020 and 2021 respectively.

In comparison, Lower North Scappoose Creek experienced elevated *E. coli* bacteria levels in 2022 from June to November, with 90-day geometric mean values ranging from 159.5-208.4 MPN/100mL within that period. Previously, elevated levels that exceeded the ODEQ threshold for 90-day geometric mean were observed from June-September in 2019; May-November in 2020; May-August 2021 and July-November 2021. Seasonally, both Upper and Lower North Scappoose monitoring locations tend to have elevated bacteria levels starting in spring and going through the fall, coinciding with generally warmer stream temperatures (

Figure *51*, Table 37).

When comparing the 2017-2022 data to the 2008-2011 data, it is clear that both Upper and Lower North Scappoose have historically experienced elevated *E. coli* bacteria events (

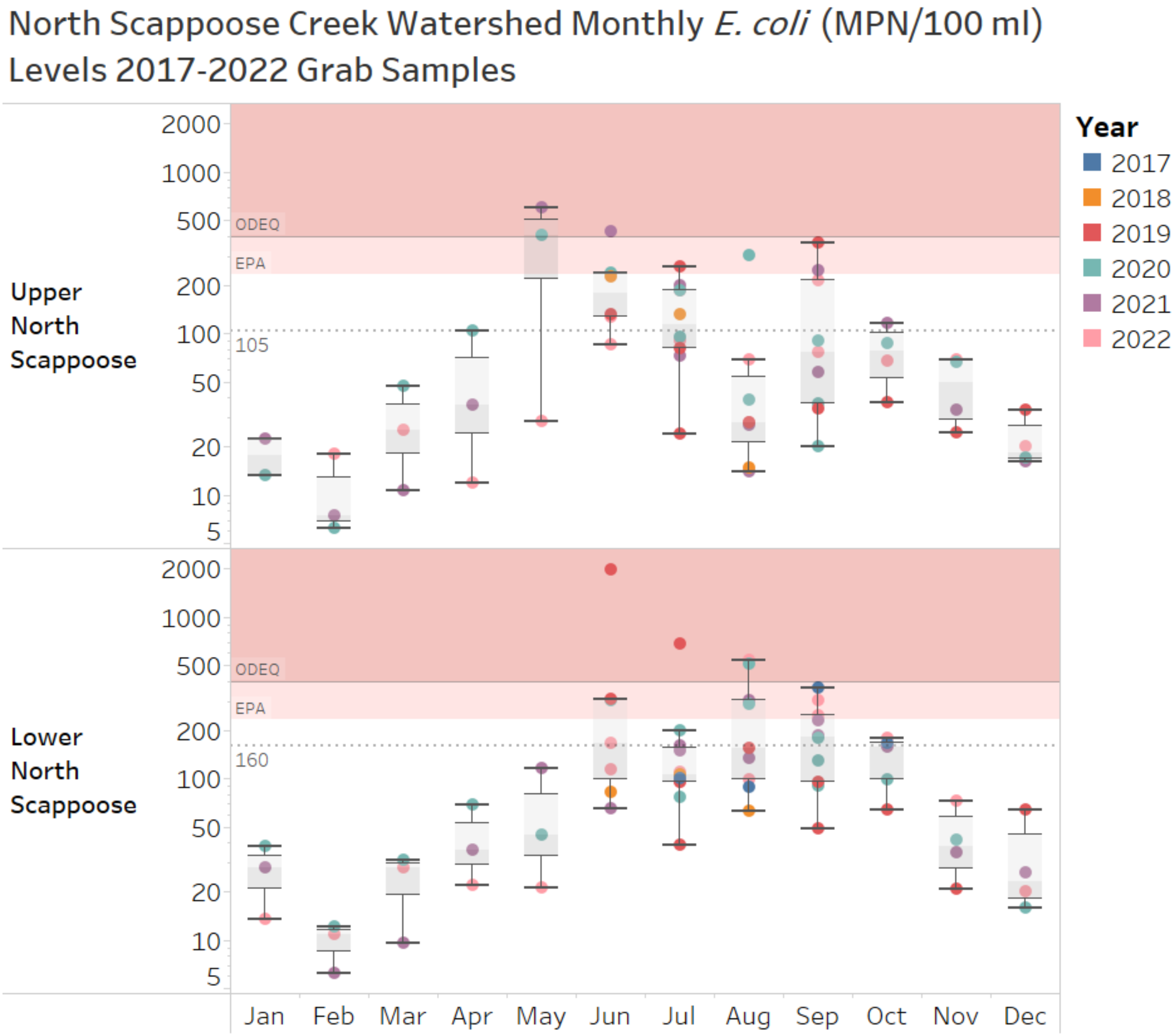


Figure *56*). The frequency of these events, however, appears to be increasing, especially in Lower North Scappoose creek (

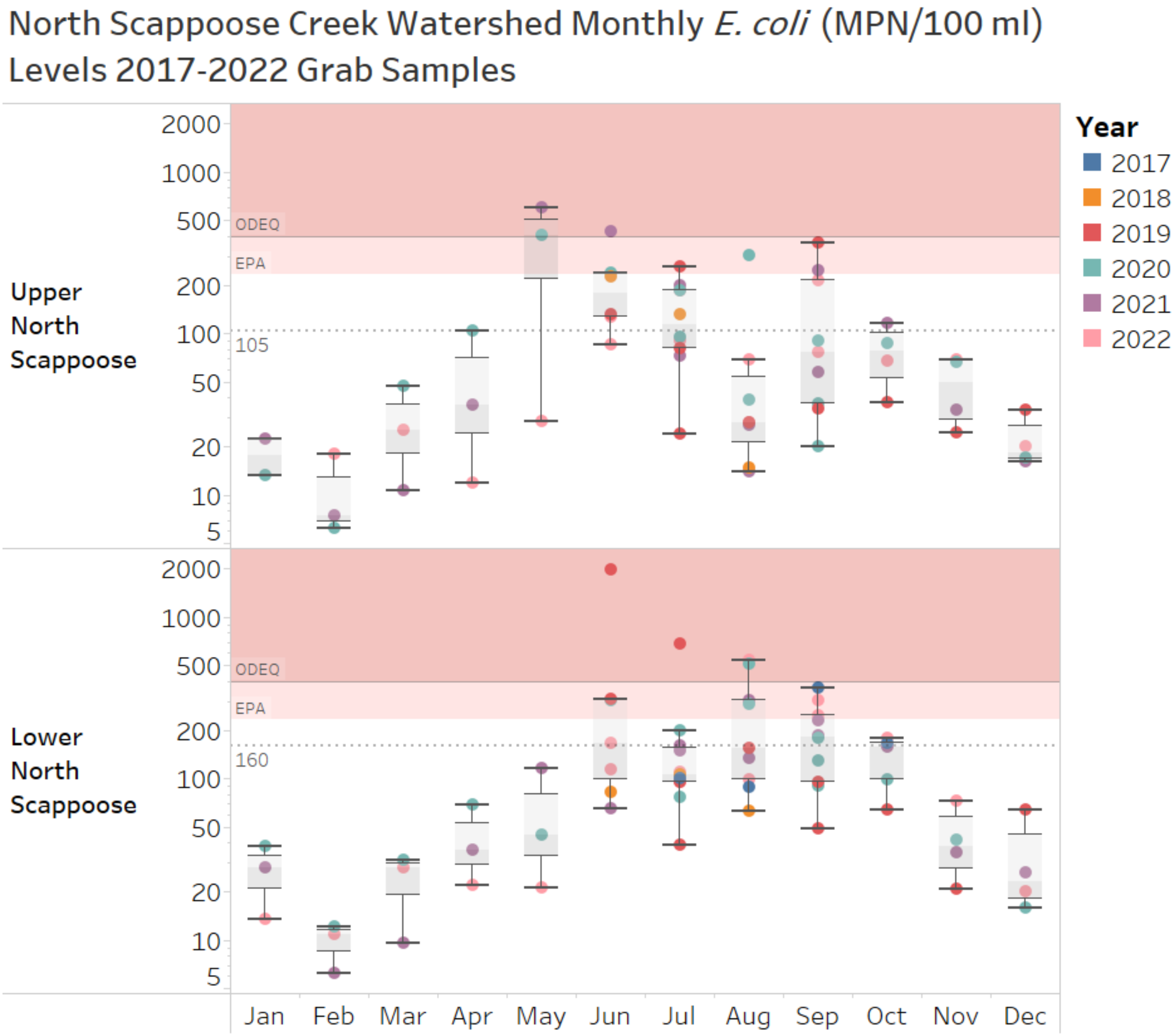


Figure *56*). These water quality conditions merit continued monitoring and additional investigation into the cause of elevated *E. coli* levels to ensure they do not continue to persist or continue to decline.

Table 35: Summary table of North Scappoose Creek watershed E. coli (2017-2022) MPN/100 ml grab samples. Grab sample data broken down across years and watershed sampling locations. Sampling locations that experienced events over the EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted n red. n = number of samples collected, for monthly max data, see Table 37.

		n	Max	Mean	+/- SD
Upper North Scappoose	2017	0			
	2018	3	226	125	106
	2019	10	365	103	119
	2020	16	411	111	117
	2021	15	613	127	179
	2022	15	214	75	61
Lower North Scappoose	2017	4	365	181	127
	2018	3	107	84	22
	2019	11	1,990	325	585
	2020	16	517	134	137
	2021	15	308	110	90
	2022	16	548	129	142

Table 36: North Scappoose Creek watershed 90 Day geometric mean (5 samples or greater) of E. coli bacteria levels (MPN/100ml) across all sampling sites, those durations that are above the state-mandated threshold of 126 MPN/100 ml for the 90 day geometric mean are highlighted with red text.

		Apr Jul	May Aug	Jun Sep	Jul Oct	Aug Nov	Sep Dec
Upper North Scappoose	2019			75.6	68.5		
	2020		221.9	87.7	68.4	50.1	
	2021	209.6	140.5		71.4	53.0	62.4
	2022	50.9	88.1	83.0	86.3	73.1	
Lower North Scappoose	2019			199.5	103.4		
	2020		178.7	187.7	181.0	128.8	
	2021	92.3	141.5		182.6	146.4	90.9
	2022	61.4	84.8	159.5	208.4	194.4	

Table 37: North Scappoose Creek watershed monthly max E. coli (MPN/100 ml) grab samples. Grab sampling results for broken down across years and watershed sampling locations. Sampling locations that experienced events over the EPA (235 MPN/100mL) and ODEQ (406 MPN/100mL) thresholds for E. coli bacteria levels are highlighted in red.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper North Scappoose	2017												
	2018						226	133	15				
	2019						133	261	29	365	38	25	34
	2020	13	6	47	105	411	238	186	308	91	88	67	17
	2021	22	8	11	36	613	435	199	27	249	116	34	16
	2022		18	25	12	29	127	186	70	214	68	69	20
Lower North Scappoose	2017							101	90	365	166		
	2018						83	107	63				
	2019						1,990	687	156	96	65	21	65
	2020	39	12	32	70	45	308	201	517	179	99	42	16
	2021	28	6	10	36	116	66	161	308	231	158	35	26
	2022	14	11	29	22	21	167	111	548	308	179	73	20

North Scappoose Creek Watershed Monthly *E. coli* (MPN/100 ml) Levels 2017-2022 Grab Samples

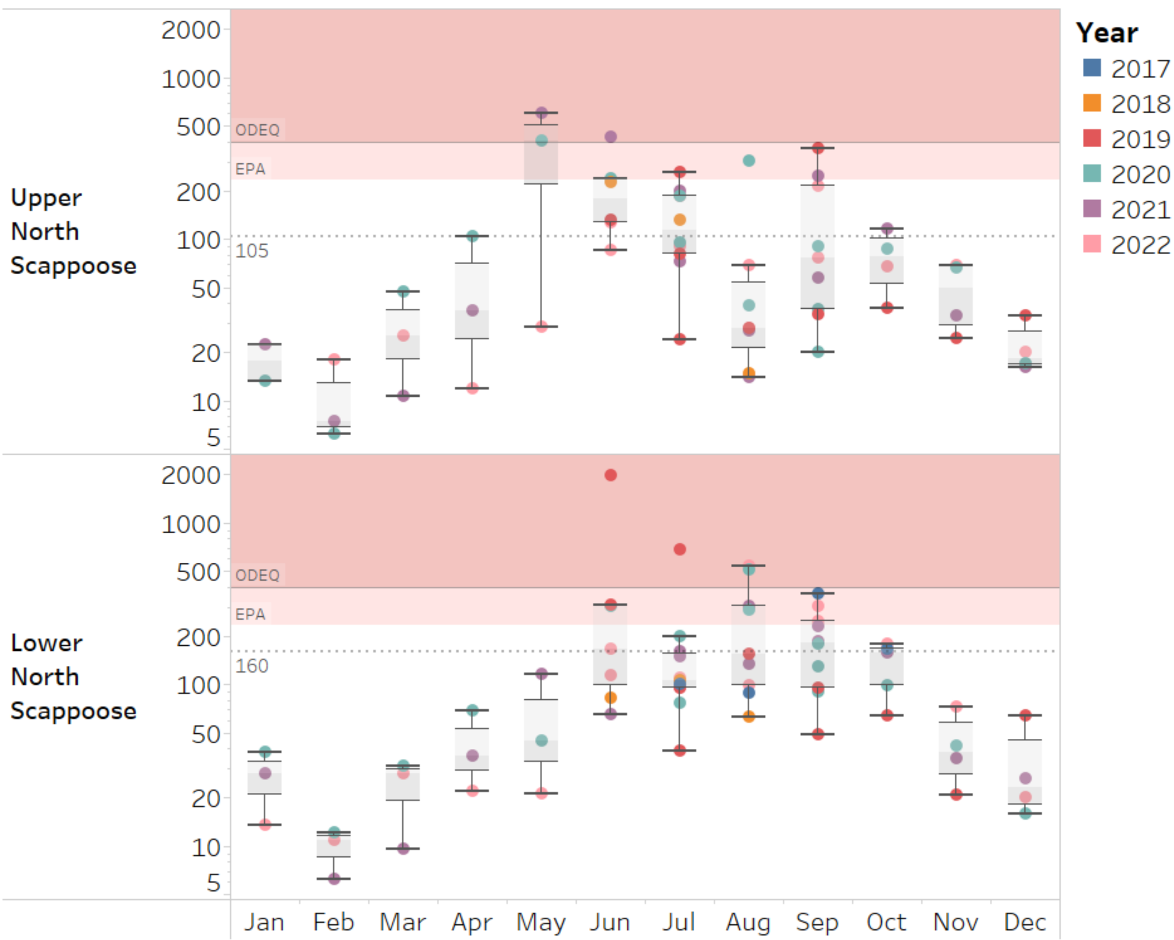


Figure 56: E. coli bacteria grab sampling results (boxplots) for North Scappoose Creek Watershed broken down across months sampled and watershed sampling locations. Sampling year ranging from 2017 to 2021 are highlighted within each boxplot. EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels

are highlighted on each graph. The overall mean for the study period highlighted in each graph. Logarithmic scale used on the y-axis.

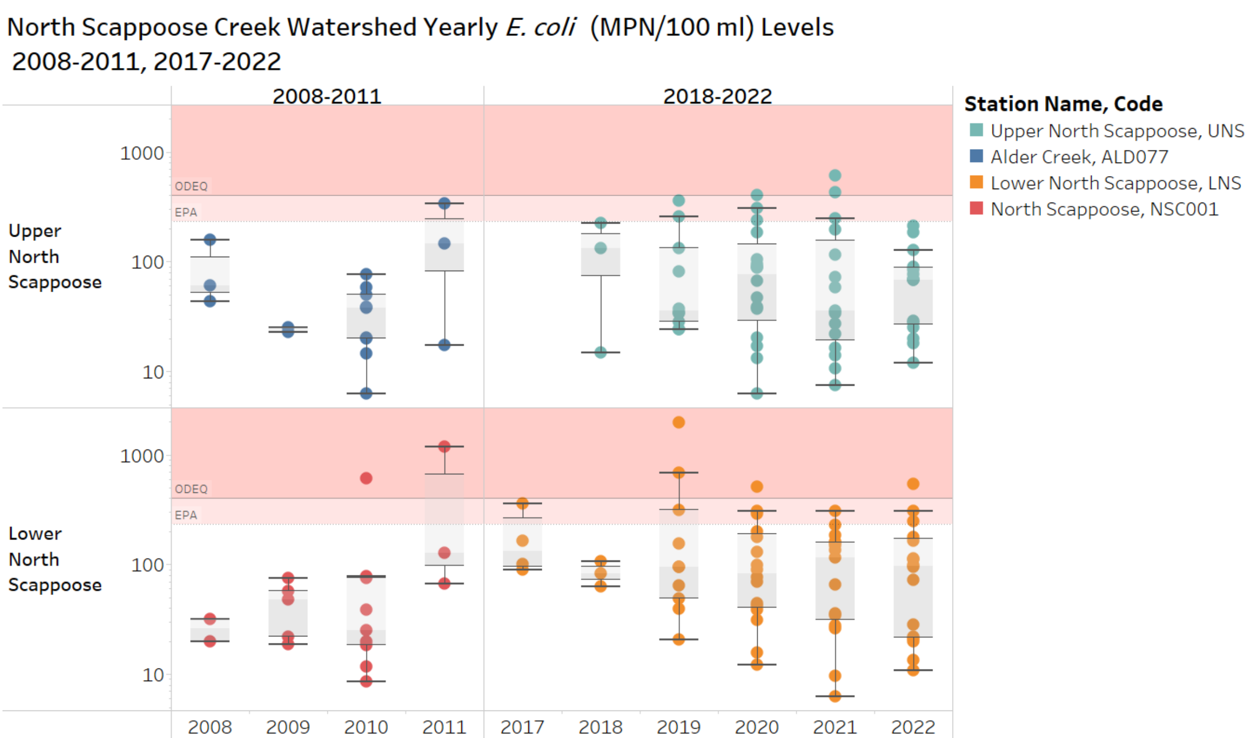


Figure 57: E. coli bacteria grab sampling results (boxplots) for North Scappoose Creek Watershed broken down across years sampled and watershed sampling locations. Sampling location highlighted within each boxplot. EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted on each graph. The overall mean for the study period highlighted in each graph. Logarithmic scale used on the y-axis.

Water pH Levels

Since 2021, in-situ stream pH measurements were collected using a YSI Pro-series meter, with the goal of providing additional information on stream quality. pH levels in the watershed ranged from 7.0 (December 2022, LNS) to 7.76 (November 2022, LNS), staying within DEQ regulatory standards for ideal stream conditions for salmonids (6.5 – 8.5) (Table 38, Figure 58). Compared to 2008-2011 data, pH values were highly variable in 2021-2022 (Figure 58).

Table 38: Summary Table of in-situ stream pH in North Scappoose Creek Watershed in 2022.

		Count of P H	Min. P H	Max. P H	Std. dev. of P H
2021	Upper North Scappoose	10.00	7.15	8.12	0.32
	Lower North Scappoose	10.00	7.06	7.80	0.28
2022	Upper North Scappoose	15.00	7.04	7.73	0.20
	Lower North Scappoose	15.00	7.00	7.76	0.20

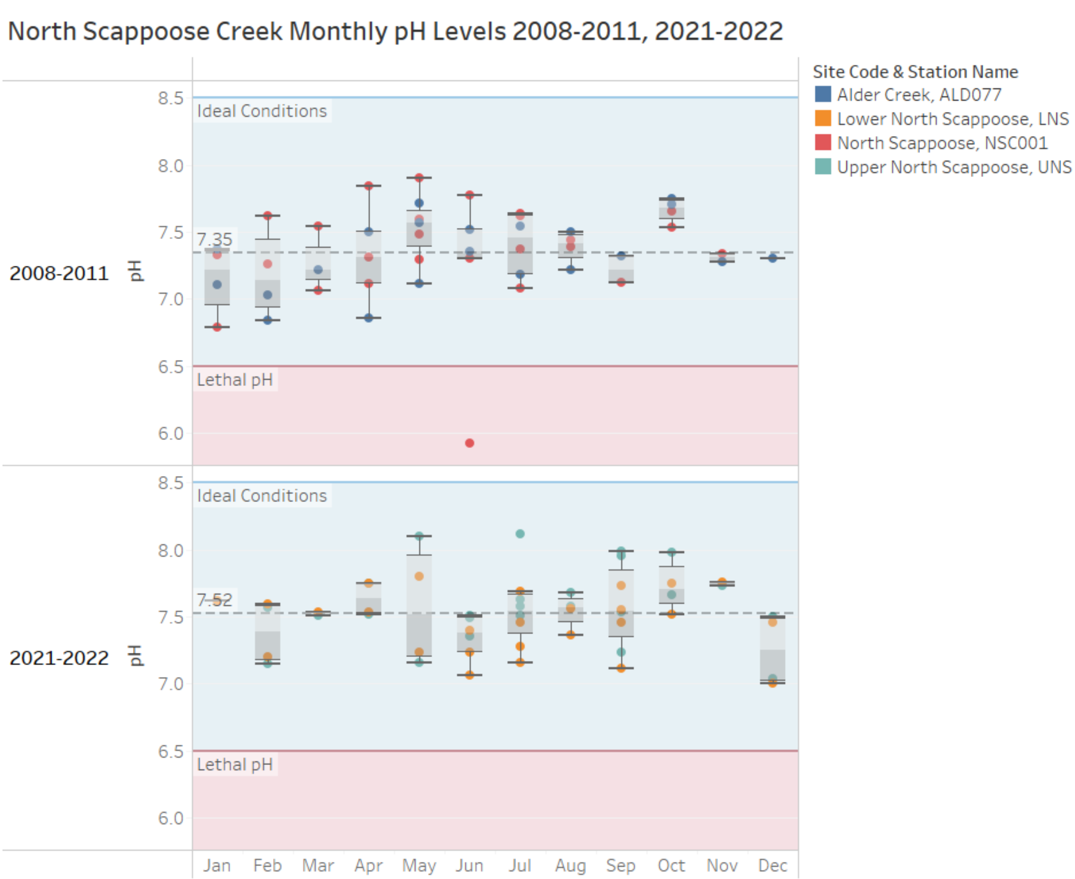


Figure 58: North Scappoose Creek watershed in-situ stream pH ranges compared across months between 2008-2011 data and 2017-2022 data. DEQ regulatory standards for lethal stream pH conditions for salmonids (<6.5) is represented as a red band. DEQ standards for ideal stream pH conditions for salmonids (6.5 – 8.5) is shown as a blue band.

Water Dissolved Oxygen (DO) Levels

Since 2021, in-situ stream DO measurements were collected using a YSI Pro-series meter, with the goal of providing additional information on stream quality. In 2022, measurements were made from January to August; no measurements were made from September to December due to instrument malfunction. These measurements were compared to 2008-2011 DO data.

Stream DO averages in the watershed ranged from 6.43mg/L (August 2022, LNS) to 16.31mg/L (April 2022, LNS) (Table 39) falling below DEQ standards for ideal stream conditions (>11mg/L) in July and August. DO levels tended to increase from upper to lower reaches of the watershed. Seasonally, elevated DO levels were observed during winter and spring months reaching peak lows during summer before climbing again in the fall. When compared to 2008-2011 data, DO levels were more variable in 2022 in the watershed (

Figure *59*).

Table 39: Summary Table of in-situ stream DO in North Scappoose Creek Watershed in 2022.

		Count of DO	Avg. DO	Min. DO	Max. DO	Std. dev. of DO
2021	Upper North Scappoose	14	11.04	7.80	13.58	1.88
	Lower North Scappoose	14	11.03	7.94	14.46	2.13
2022	Upper North Scappoose	10	11.64	6.45	15.93	2.90
	Lower North Scappoose	10	11.51	6.43	16.31	2.99

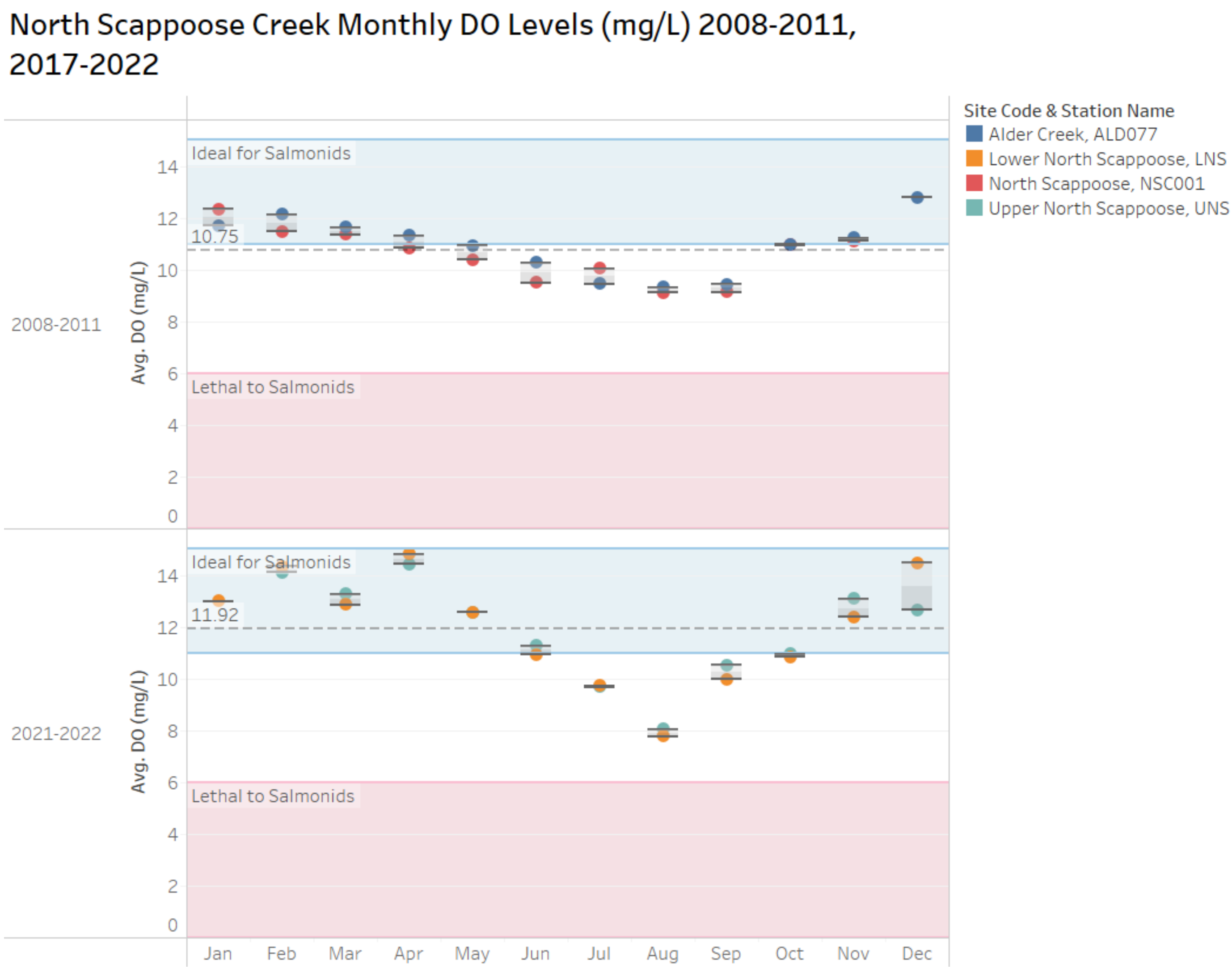


Figure 59: Monthly in-situ stream DO ranges across all monitoring locations in North Scappoose Creek watershed between 2008-2011 (top panel) and 2021-2022 (bottom panel). DEQ standards for ideal DO conditions for salmonids(>11mg/l) is depicted as a blue band in the graph. DEQ standards for Lethal conditions (<6mg/l) is depicted as a red band.

Water Conductivity Levels

Conductivity levels varied seasonally across monitoring locations within the North Scappoose Creek watershed (

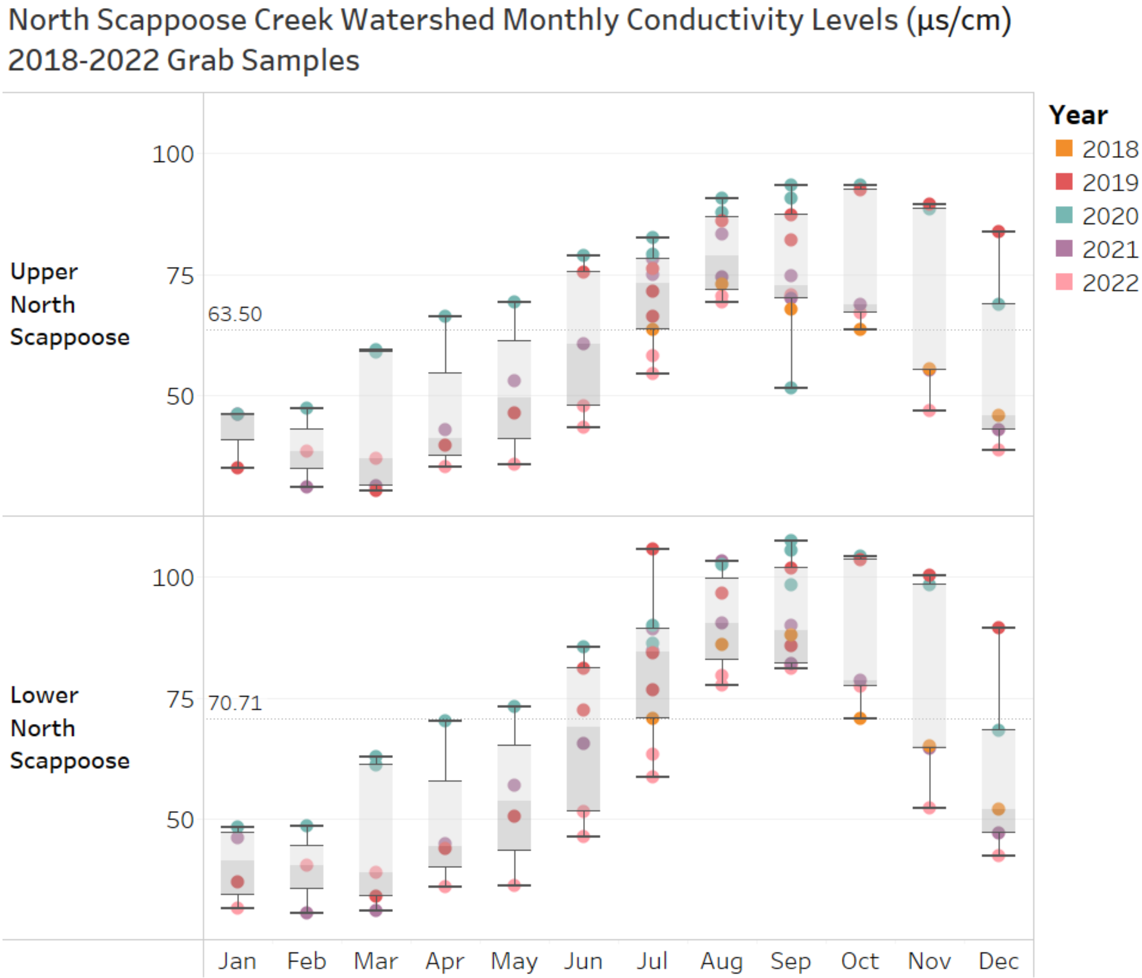


Figure 60, Table 40) in 2022. At both locations, annual increases in water conductivity were observed between April to September and declined from October to February (Figure 60). Between 2018-2022, Upper North Scappoose Creek exhibited lower overall mean conductivity levels ranging from 59-74 µs/cm compared to 67-84 µs/cm observed at the Lower North Scappoose Creek monitoring location (

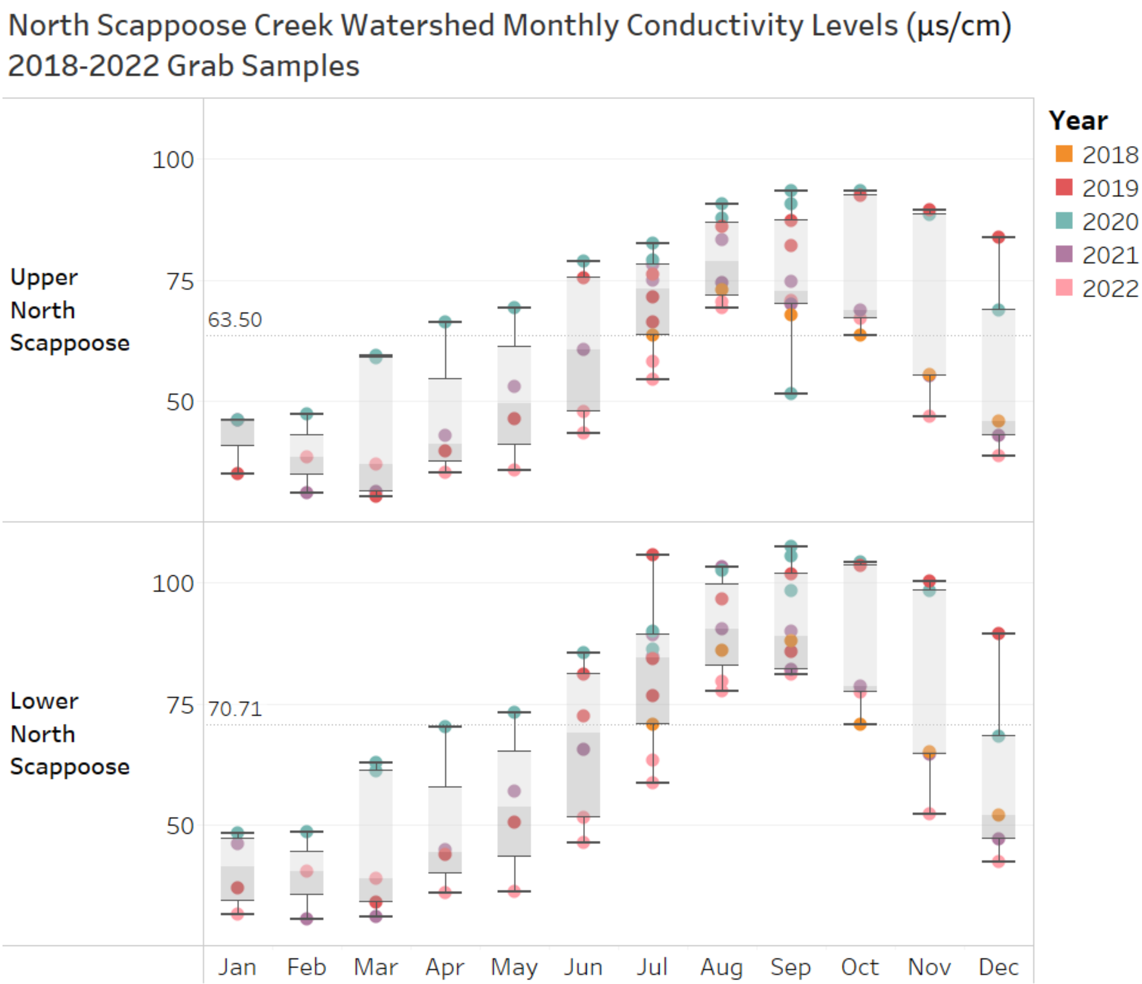


Figure 60, Table 40). These data provide baseline conductivity levels that can be used to identify new and emerging water quality issues or improvements over time. When comparing the 2018-2022 data to the 2008-2011 data, no significant shift in conductivity was observed (

Figure *61*). Pollution from runoff or increased turbidity levels from erosion can result in higher conductivity levels; however, there is no EPA or ODEQ threshold for conductivity in the region.

Table 40: Summary Table of North Scappoose Creek watershed monthly conductivity (µs/cm) data for 2018-2022 grab samples. Conductivity (µs/cm) samples broken down across months sampled and watershed sampling location. n = number of samples collected.

		n	Max	Mean	+/- SD
Upper North Scappoose	2018	6	73	62	10
	2019	14	92	69	22
	2020	17	93	74	16
	2021	15	83	59	17
	2022	15	71	52	14
Lower North Scappoose	2018	6	88	72	13
	2019	15	106	78	25
	2020	17	107	83	20
	2021	15	103	67	23
	2022	16	82	56	18

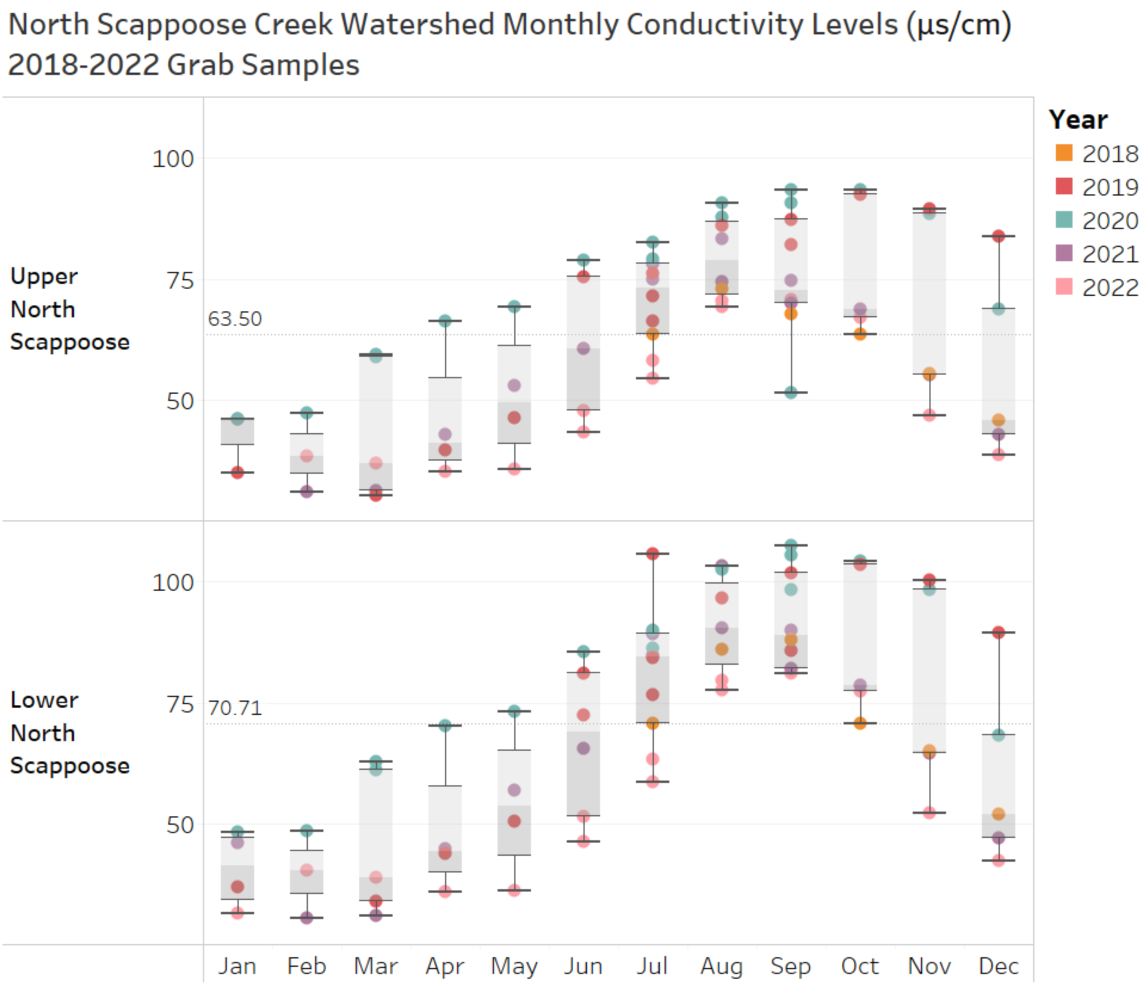


Figure 60: Conductivity levels (µs/cm) 2018-2022 Grab Samples results (boxplots) for North Scappoose Creek watershed broken down across months sampled and watershed sampling location. Sampling years ranging from 2018 to 2022 are highlighted within each boxplot. The overall mean for the study period highlighted in each graph.

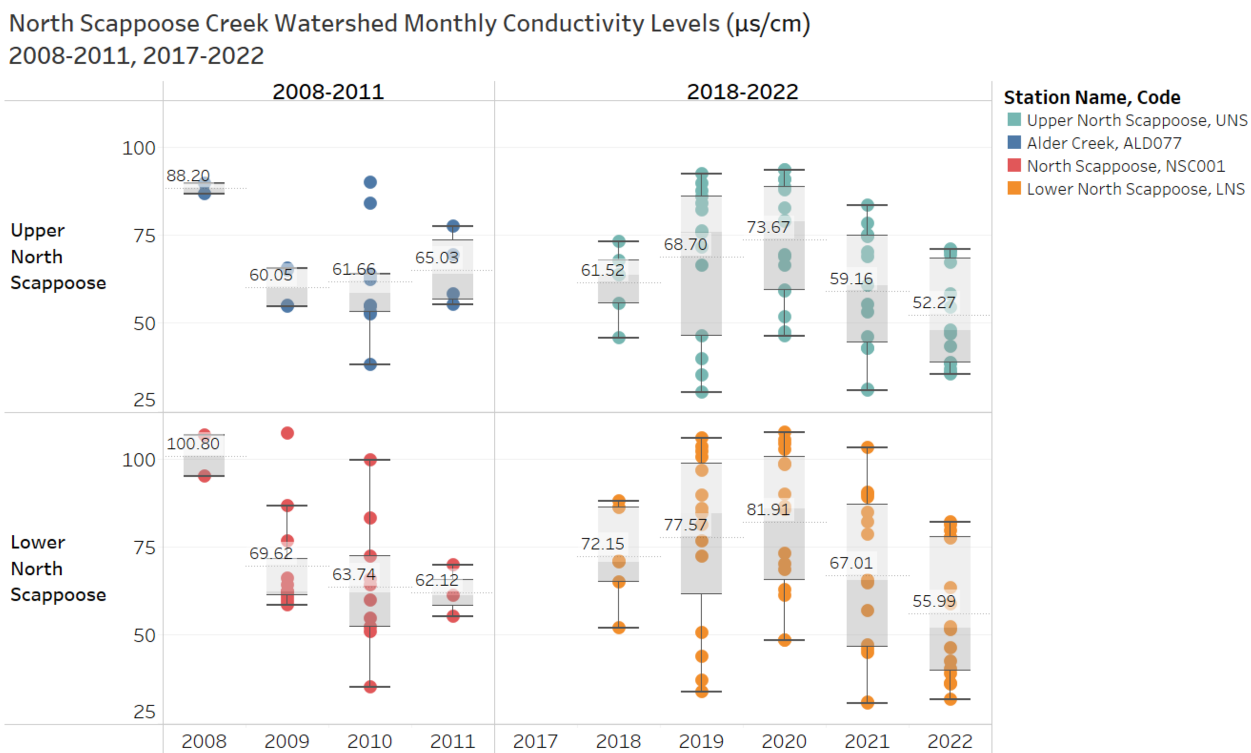


Figure 61: Conductivity levels (µs/cm) 2008-2022 Grab Samples results (boxplots) for North Scappoose Creek watershed broken down across years, with monitoring location highlighted within each boxplot. Sampling years ranging from 2008-2011 and 2018- 2022. Overall mean for each year annotated.

Water Quality Issues

Water quality issues observed in North Scappoose Watershed include high summer temperatures (>18°C) in the upper and lower watershed between June and September (Table 32). Overall elevated temperatures are likely caused by solar loading, especially within the lower reaches of the watershed, which are much more heavily developed and lack riparian shade (Figure 4). Both Upper and Lower North Scappoose have experienced a potential increase in water temperatures since the previous 2008-2011 study indicating that further action is required to prevent continued temperature issues in the basin (

Figure *53*). Low water temperatures are critical for supporting aquatic life including endangered Salmonids in the Pacific Northwest; reducing solar radiation as well as urban and agricultural runoff can help keep water temperatures down and protect these stream habitats (USGS 2021). pH and DO levels generally stayed within ODEQ standards; however, a high degree of variability was observed in 2021-2022. Additionally, elevated *E. coli* bacteria levels were observed in the watershed between August-September 2022, exceeding the EPA and ODEQ standards, as well as exceedance of the 90-day geometric mean standard between June and November in the lower reaches of the watershed (Table 4, Table 34). *E. coli* bacteria issues are indicative of animal waste runoff and can be very harmful to humans using these waterways for recreation (Pandey et al. 2014). Additional research is needed to determine the exact source of the elevated *E. coli*. Animal waste or septic tank leakage into the stream are possible sources to be investigated. Depending on the source, actions that could reduce future *E. coli* exceedance events include increasing riparian buffers, excluding livestock from the creek, increasing manure management near streams, and/or updating failed septic systems throughout the targeted reach of the watershed (Pandey et al. 2014). Given the frequency and scale of *E. coli* bacteria events in the lower watershed adding warning signs to recreational areas along the stream is recommended. No significant issues or shifts in stream water turbidity or conductivity levels were detected in North Scappoose Watershed during this study.

South Scappoose Creek

Study Area

Upper South Scappoose Creek Distribution of Monitoring Locations (2008-2011, 2017-2022)

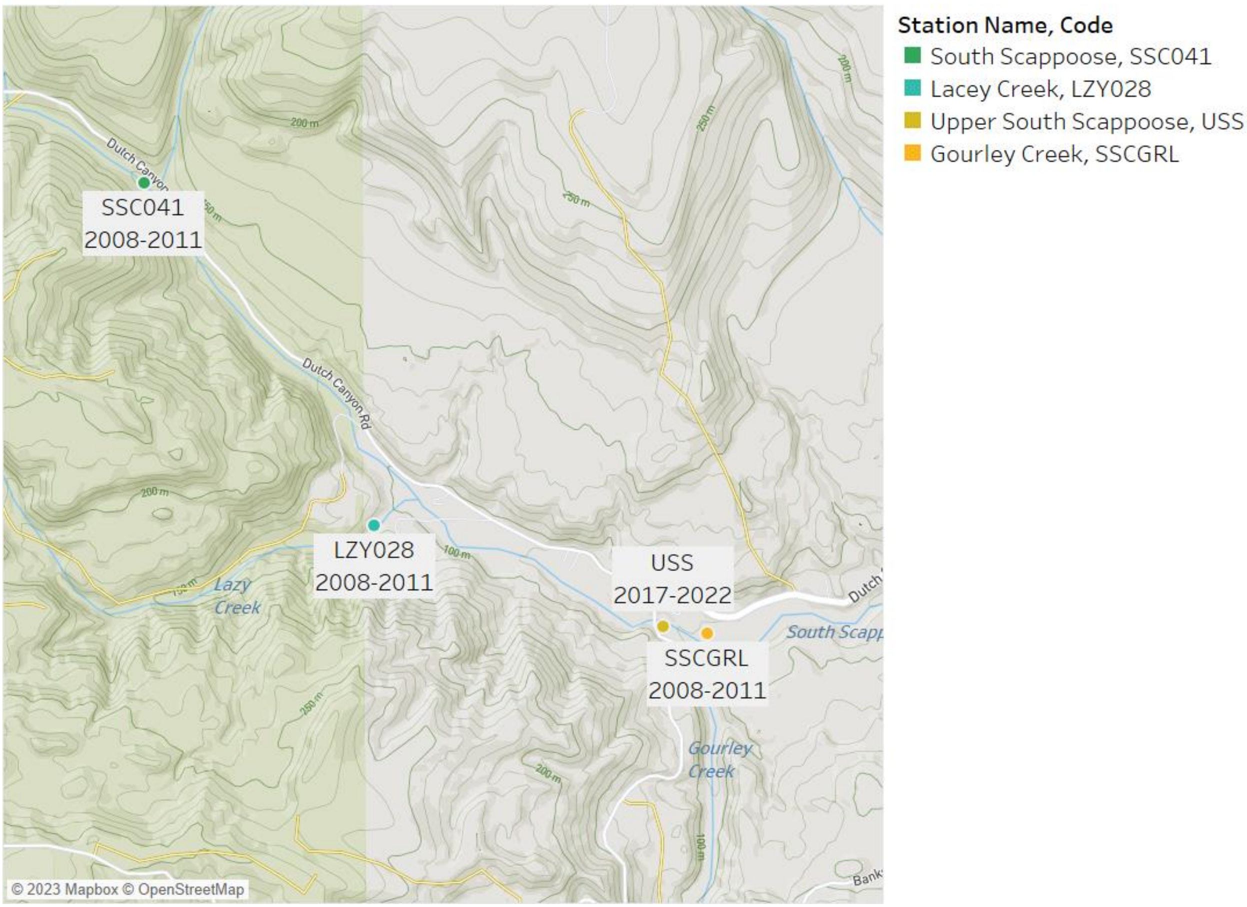


Figure 62: Focus map of Upper South Scappoose Creek monitoring locations, for an overview map, see Figure 1 & Figure 47. For specific monitoring location details see Table 1.

Lower South Scappoose Creek Distribution of Monitoring Locations (2008-2011, 2017-2022)

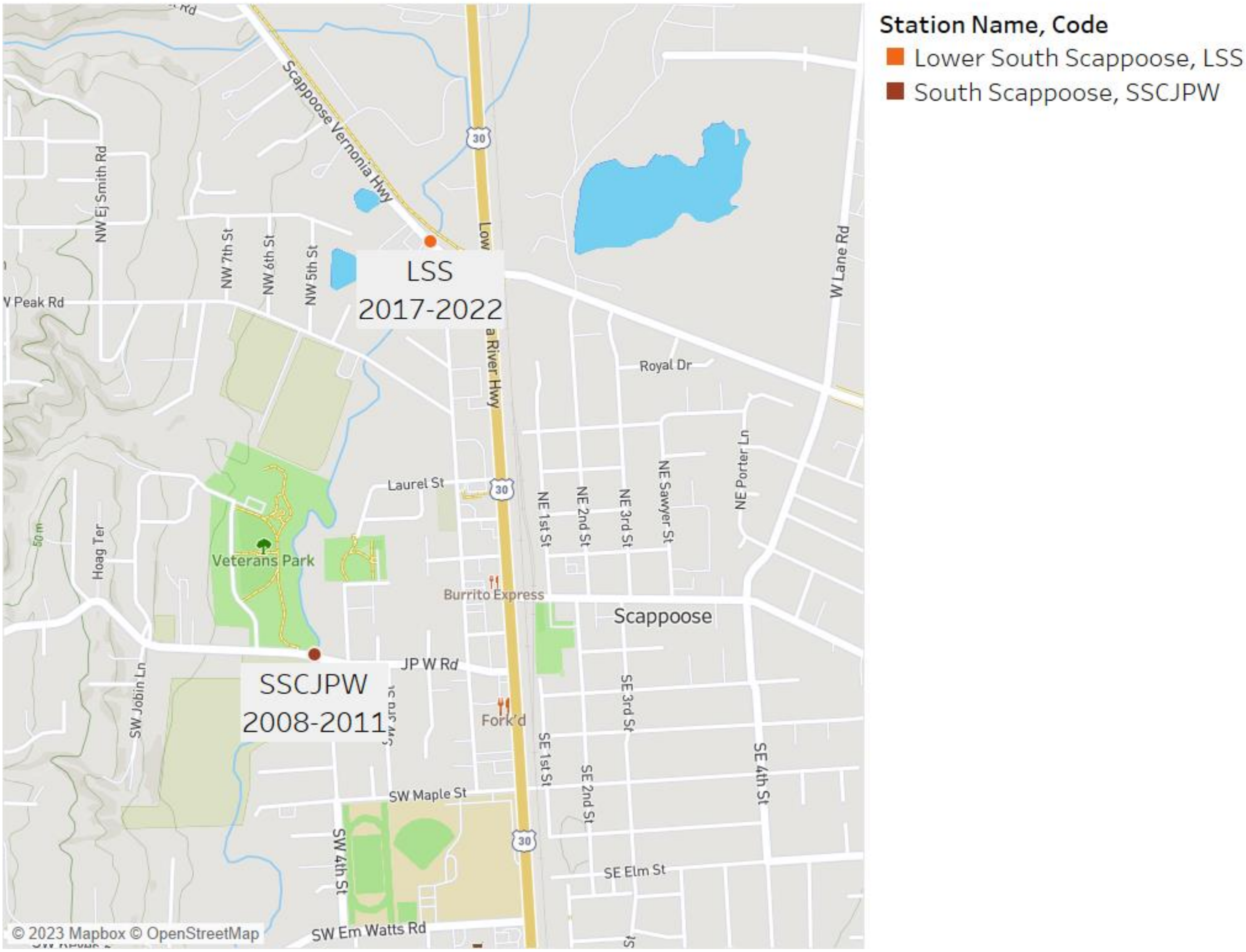


Figure 63: Focus map of Lower North and South Scappoose Creek monitoring locations; for an overview map, see Figure 1 & Figure 47. For specific monitoring location details, see Table 1.

Water Temperature

Between 2017 and 2021, 7dMAM temperatures in the South Scappoose Creek ranged from 2.8°C to 26.1°C, highest temperatures were observed in August (Table 41). In 2022, 7dMAM temperatures ranged from 3.4°C to 24.2°C; seasonally the highest temperatures were also observed in August. The lower watershed had higher temperatures throughout the study (Figure 64). Similar to Milton and North Scappoose creeks, winter temperature trends in Upper South Scappoose and Lower South Scappoose creeks follow the same patterns (Figure 66), and lower reaches had higher temperatures throughout the study (Figure 64).

DEQ temperature standard for salmon rearing habitat is less than 18°C, and streams with temperatures higher than 18°C are considered poor quality for salmon. The maximum 7dMAM temperature in Upper South Scappoose exceeded this threshold in August 2022. Previously, there were brief periods in the summer of 2017, 2018 and 2021 where temperatures exceeded 18°C (Table 42, Figure 66). Lower South Scappoose Creek maintained temperatures above 18°C between July and September 2022 (Figure 66). When the number of days was compared across the watershed, Lower South Scappoose had a greater number of days above 18°C as compared to Upper South Scappoose during the monitoring period (Table 42).

Table 41: 7dMAM temperatures Summary from 2017 to 2022 for creeks in North Scappoose Creek Watershed. Temperatures have been color-coded according to salmonid thresholds listed in Table 4.

		Min. 7DMAM	Avg. 7DMAM	Max. 7DMAM	Number of Days over 18°	Number of Days over 25°
Upper South Scappoose	2017	4.4	12.1	18.3	5	0
	2018	3.5	11.0	18.5	13	0
	2019	3.2	10.4	17.4	0	0
	2020	6.0	12.2	17.9	0	0
	2021	5.9	13.4	21.2	43	0
	2022	3.4	10.8	18.9	6	0
Lower South Scappoose	2017	3.4	14.3	23.1	77	0
	2018	3.0	12.5	23.9	83	0
	2019	2.8	12.0	22.8	83	0
	2020	5.5	12.3	23.0	49	0
	2021	4.9	13.5	26.1	96	5
	2022	4.3	13.1	24.2	69	0

Table 42: Number of days over 18°C in the South Scappoose Creek sub-watershed between 2017 to 2022. Winter and spring months have been excluded from this table as stream temperature conditions are within ideal conditions at that time.

		June	July	August	September	October
Upper South Scappoose	2017	0	0	5	0	0
	2018	0	7	6	0	0
	2019	0	0	0	0	0
	2020	0	0	0	0	0
	2021	4	21	18	0	0
	2022	0	2	4	0	0
Lower South Scappoose	2017	0	28	31	18	0
	2018	10	31	31	11	0
	2019	12	30	31	10	0
	2020	6	21	12	10	0
	2021	17	31	31	17	0
	2022	3	22	31	13	0

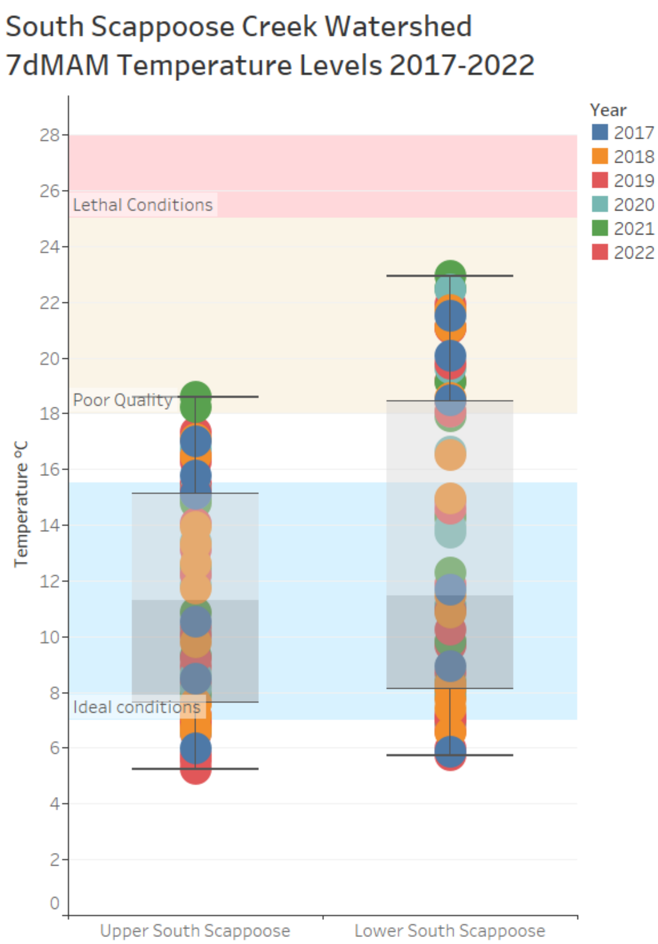


Figure 64: 7dMAM temperature variation in the South Scappoose Creek watershed, overlaid on the DEQ stream temperature standard ranges for healthy salmon habitat (Table 3). Data points represent the months monitored in a year. Ideal Conditions (7°C-15.6°C), Poor Quality (18°C-25°C), and Lethal Conditions (>25°C)

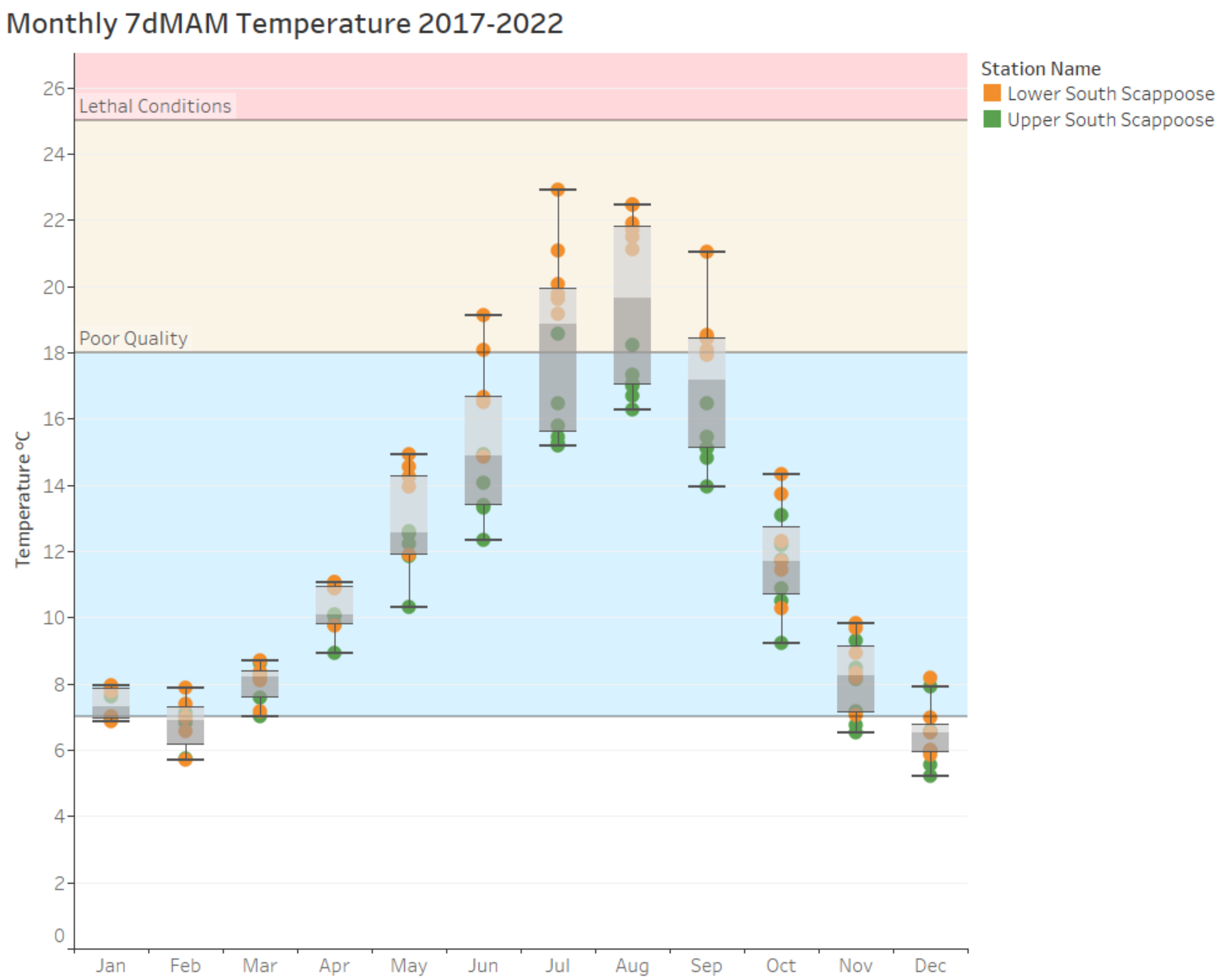


Figure 65: Monthly variation in 7dMAM temperature in the South Scappoose Creek watershed between 2017 - 2022.

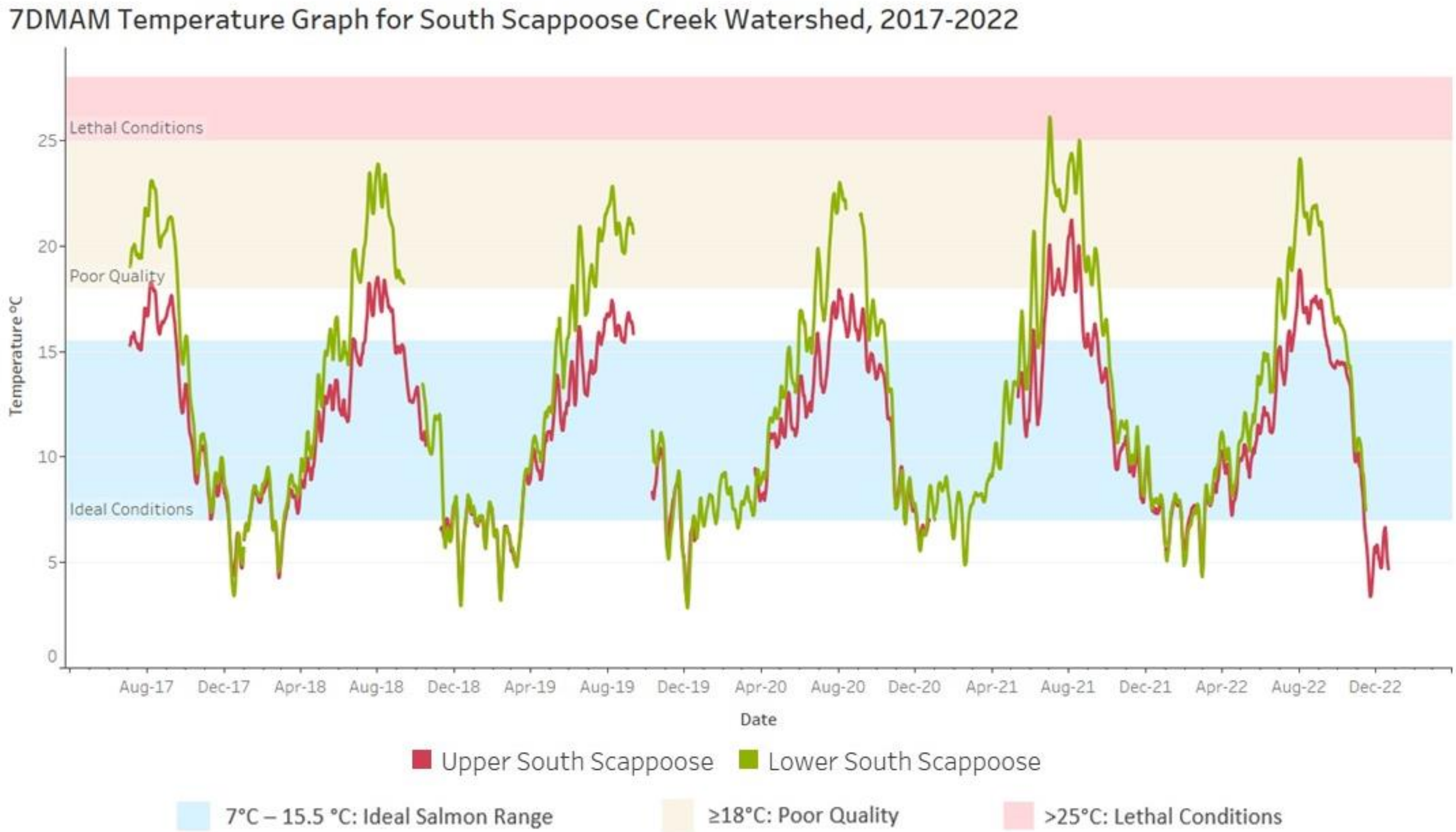


Figure 66: 7-day average maximum temperatures (7dMAM) for Upper South Scappoose and Lower South Scappoose creeks from 2017-2021 overlayed on salmonid temperature threshold ranges. See Table 4 for temperature threshold details.

When May to October 7dMAM temperature data was compared to the overlapping timeframe from 2008-2011, similar increases in temperature trends were observed (Figure 67), there was an average increase of 1.5°C in the upper watershed and a similar increase in the lower watershed of 1.4°C. However, it should be noted that a complete temperature profile is unavailable for the 2008 – 2011 dataset, and 2010 data was missing from this dataset, so we cannot definitively say whether this increase is consistent.

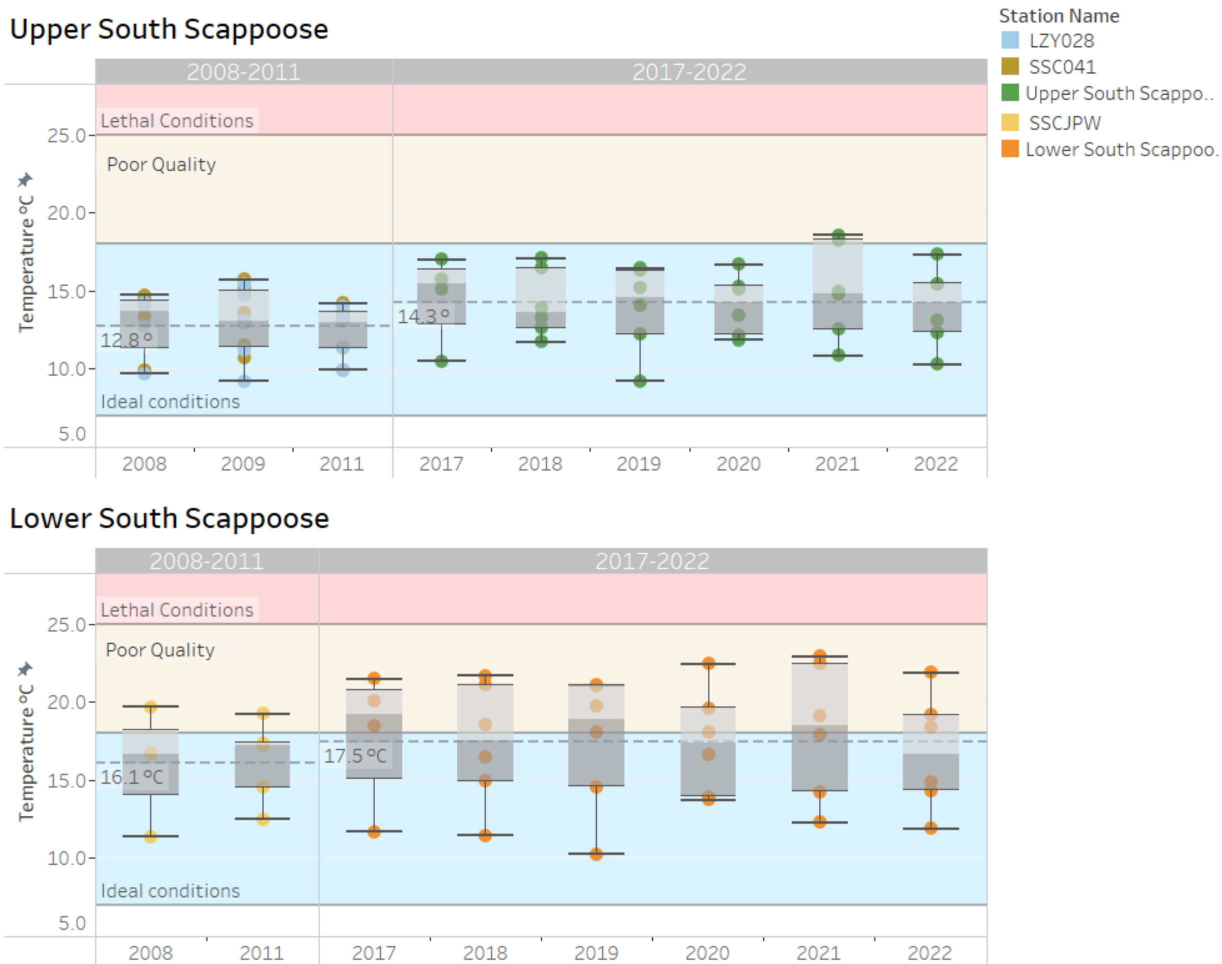


Figure 67: Monthly 7dMAM temperature comparisons between 2017-2022 data and 2008-2011 data for South Scappoose Creek Watershed. Upper South Scappoose and Lower South Scappoose have data available between May and October (2017-2022). Lazy Creek and South Scappoose Creek(SSC041) have data available for May to October of 2008, 2009, and 2011. South Scappoose (SSCJPW) has data available for May to October of 2008 and 2011.

Water Turbidity Levels

Between 2017-2022, on average, Upper and Lower South Scappoose Creek sampling locations maintained relatively low (< 4 NTU) turbidity levels (Figure 63), similar to those observed in North Scappoose Creek. Seasonally, the highest turbidity levels were recorded in the winter months (October-January), reflecting winter storm conditions and high flow events (Figure 56). In January 2022, turbidity levels exceeded 19 NTU at Lower North Scappoose during a storm event in the watershed (Figure 63

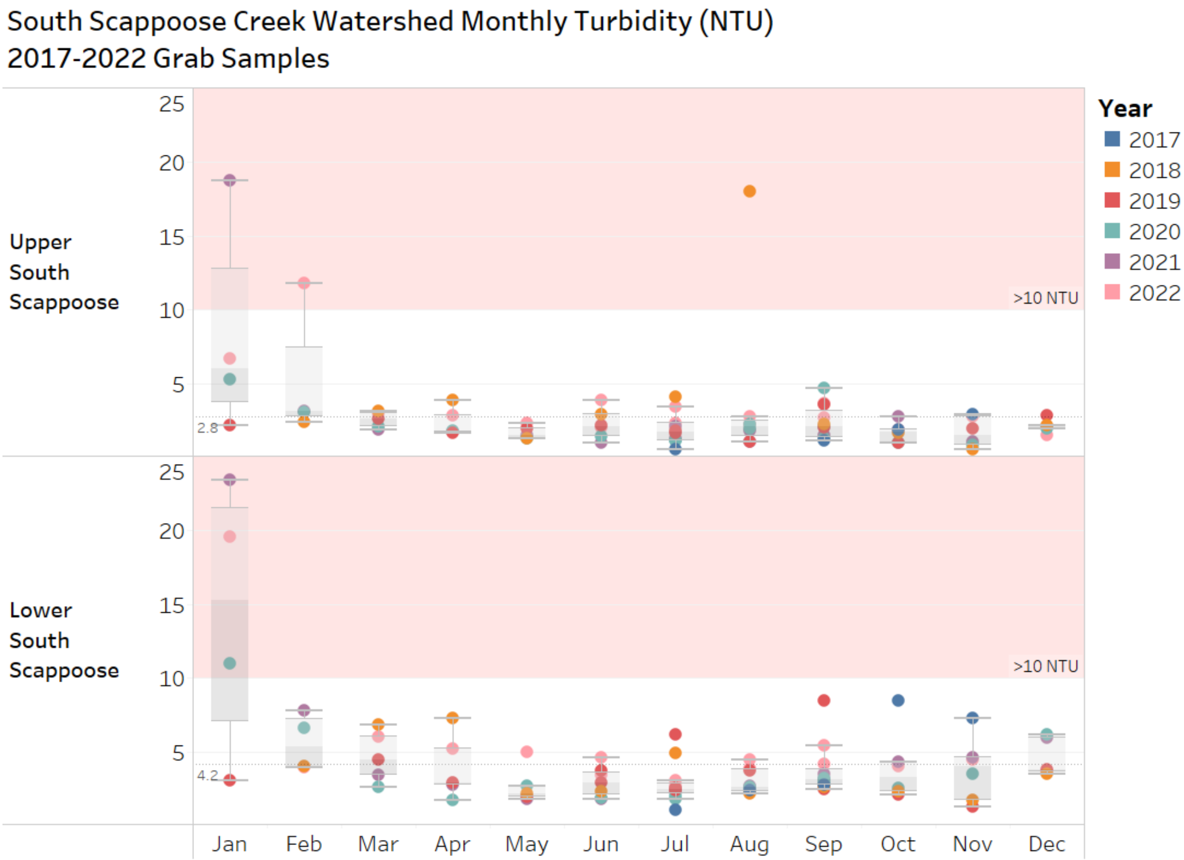


Figure 68: Turbidity (NTU) grab sampling results (boxplots) for South Scappoose Creek Watershed broken down across sampling locations and months sampled. Sampling years ranging from 2017 to 2022 are highlighted within each boxplot. 10 NTU threshold highlighted in pink. Overall mean highlighted.

. When comparing the 2017-2022 data to the 2008-2011 data, no significant shift in turbidity was observed between Upper and Lower South Scappoose Creek (Figure 69).

Table 43: Summary Table for South Scappoose Creek Watershed Monthly Turbidity (NTU), 2017-2022 Grab Samples. Grab sample data broken down across years and watershed sampling locations. n = number of samples collected—red highlights when a sample location experienced a maximum over the 10 NTU threshold.

		n	Max	Mean	+/- SD
Upper South Scappoose	2017	4	2.9	1.6	1.0
	2018	11	18.0	3.9	4.8
	2019	13	3.6	2.0	0.7
	2020	16	5.3	2.1	1.3
	2021	15	18.8	2.9	4.4
	2022	16	11.8	3.5	2.5
Lower South Scappoose	2017	5	8.5	4.4	3.3
	2018	11	7.3	3.6	1.9
	2019	15	8.5	3.5	1.8
	2020	16	11.0	3.5	2.4
	2021	15	23.4	4.8	5.4
	2022	16	19.5	5.2	3.9

South Scappoose Creek Watershed Monthly Turbidity (NTU)
2017-2022 Grab Samples

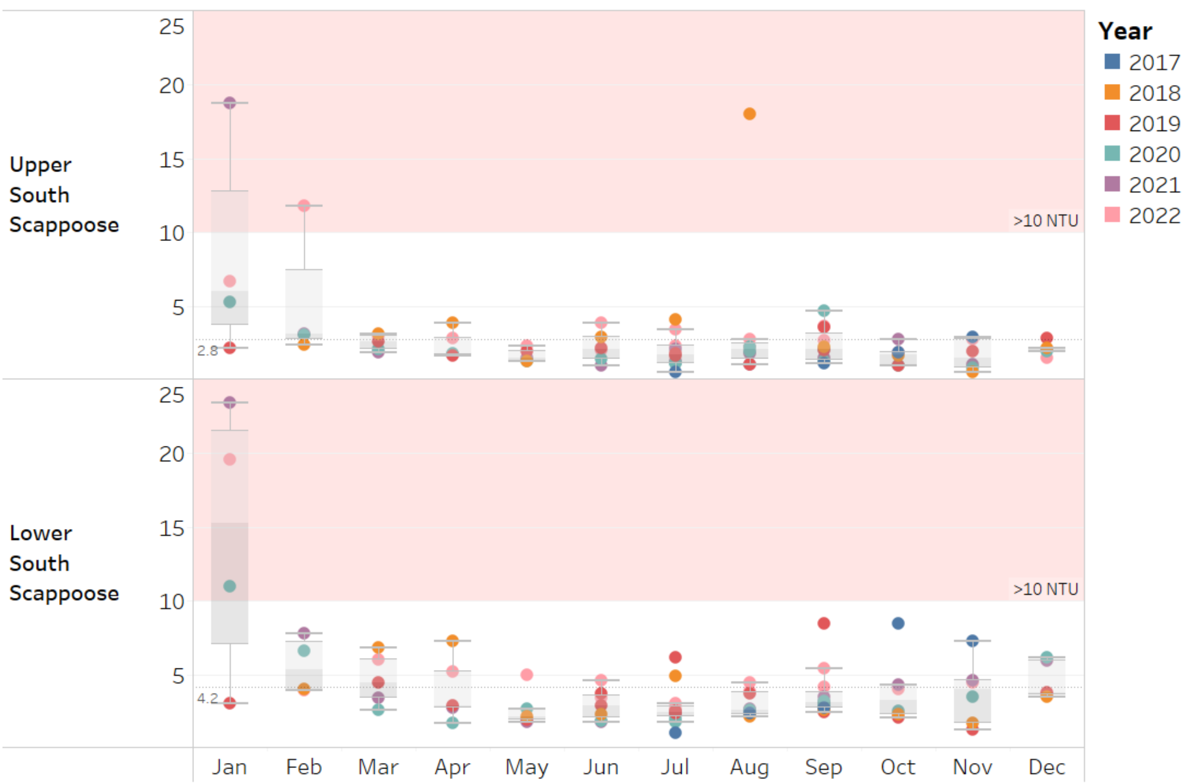


Figure 68: Turbidity (NTU) grab sampling results (boxplots) for South Scappoose Creek Watershed broken down across sampling locations and months sampled. Sampling years ranging from 2017 to 2022 are highlighted within each boxplot. 10 NTU threshold highlighted in pink. Overall mean highlighted.

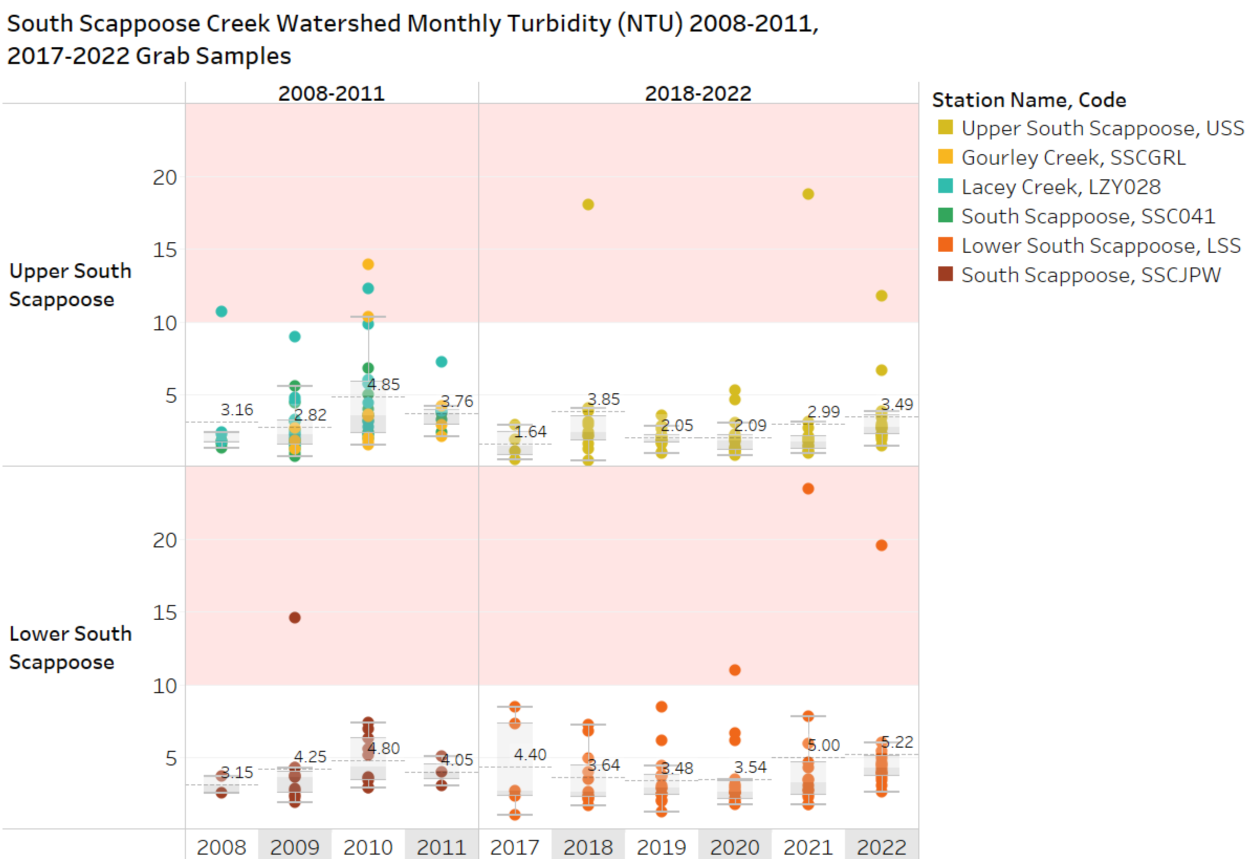


Figure 69: Turbidity (NTU) grab sampling results (boxplots) for South Scappoose Creek Watershed broken down across years sampled. Sampling locations are highlighted within each boxplot. 10 NTU threshold highlighted in pink. Overall mean for each year highlighted.

Water Bacteria Levels

In 2017, only Lower South Scappoose Creek was monitored for *E. coli* bacteria levels; during this time, elevated levels exceeding the EPA health standard <235 MPN/100 ml were detected in July and September (Table 46, Figure 70). In 2018, elevated *E. coli* bacteria levels were only detected in Lower South Scappoose Creek in June, 921 MPN/100 ml, July, 345 MPN/100 ml and August, 326 MPN/100 ml (Table 46). These bacteria events encouraged more intensive sampling since 2019, including bi-monthly sampling in the summer which allowed for the calculation of the 90-day geometric mean (Table 45). In 2022, Lower South Scappoose exceeded EPA and ODEQ health standard between July and September.

The 90-day geometric mean state-mandated water quality threshold for Oregon is 126 MPN/100. Lower South Scappoose exhibited elevated *E. coli* bacteria levels in 2019 from June-October with a geometric means ranging from 215.5-277.8 MPN/100ml and from May-November in 2020 ranging from 202.3-368.1 MPN/100ml. In 2021, this location experienced elevated *E. coli* bacteria levels from April to August with geometric means ranging from 184.3-208.4 MPN/100ml, and again from July-December with geometric means ranging between 169.9-227.6 MPN/100ml. In 2022, elevated levels were similarly observed between April and November, with geometric mean ranging from 130.9-280.2 MPN/100mL (Table 45). Upper South Scappoose Creek exhibited elevated *E. coli* bacteria levels in June-October of 2019 with a geometric means ranging from 181-317.5 MPN/100 (Table 45). Seasonally, both Upper and Lower North Scappoose monitoring locations tend to have elevated bacteria levels starting in late spring and going through the fall, coinciding with generally warmer stream temperatures (Table 46, Figure 70).

When comparing the 2017-2022 data to the 2008-2011 data, it is clear that Lower South Scappoose has historically experienced elevated *E. coli* bacteria events (Figure 71). The frequency of these events, however, appears to be increasing in Lower South Scappoose creek when comparing overall monthly maximum values between 2017-2022 to 2008-2011 (Figure 71). These water quality conditions merit continued monitoring and additional investigation into the cause of elevated *E. coli* levels to ensure they do not continue to persist or continue to decline.

Table 44: Summary table of South Scappoose Creek watershed E. coli (2017-2022) MPN/100 ml grab samples. Grab sample data broken down across years and watershed sampling locations. Sampling locations that experienced events over the EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted in red. n = number of samples collected, for monthly max data, see Table 46.

		n	Max	Mean	+/- SD
Upper South Scappoose	2017	0			
	2018	3	77	61	24
	2019	9	2,600	414	837
	2020	16	488	86	122
	2021	15	161	56	53
	2022	15	261	33	65
Lower South Scappoose	2017	4	326	228	75
	2018	3	921	531	338
	2019	11	1,200	375	377
	2020	16	1,200	253	283
	2021	15	649	174	169
	2022	16	649	185	173

Table 45: South Scappoose Creek watershed 90 Day geometric mean (5 samples or greater) of E. coli bacteria levels (MPN/100ml) across all sampling sites, those durations that are above the state-mandated threshold of 126 MPN/100 ml for the 90 days geometric mean are highlighted with red text.

		Apr Jul	May Aug	Jun Sep	Jul Oct	Aug Nov	Sep Dec
Upper South Scappoose	2019			317.5	181.0		
	2020		101.4	91.7	92.9	67.7	
	2021	52.7	88.5		73.8	41.0	36.5
	2022	5.2	6.9	31.0	42.7	35.9	
Lower South Scappoose	2019			277.8	215.2		
	2020		368.1	230.5	202.3	208.2	
	2021	184.3	208.4		227.6	176.0	169.9
	2022	130.9	178.3	243.5	280.2	227.6	

Table 46: South Scappoose Creek watershed monthly max *E. coli* (MPN/100 ml) grab samples. Grab sampling results for broken down across years and watershed sampling locations. Sampling locations that experienced events over the EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for *E. coli* bacteria levels are highlighted in red.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper South Scappoose	2017												
	2018						77	34	73				
	2019						68	2,600	504	343	11	19	12
	2020	1	3	3	9	114	54	133	488	192	86	17	4
	2021	11	5	3	6	128	39	127	85	161	68	5	21
	2022	5	3	2		4	23	32	37	261	19	8	2
Lower South Scappoose	2017							248	172	326	166		
	2018						921	345	326				
	2019						1,200	308	178	816	201	46	189
	2020	9	8	42	172	1,200	308	435	238	276	140	411	96
	2021	53	13	9	80	151	236	416	148	260	649	70	70
	2022	16	16	73	104	101	236	488	291	649	179	140	30

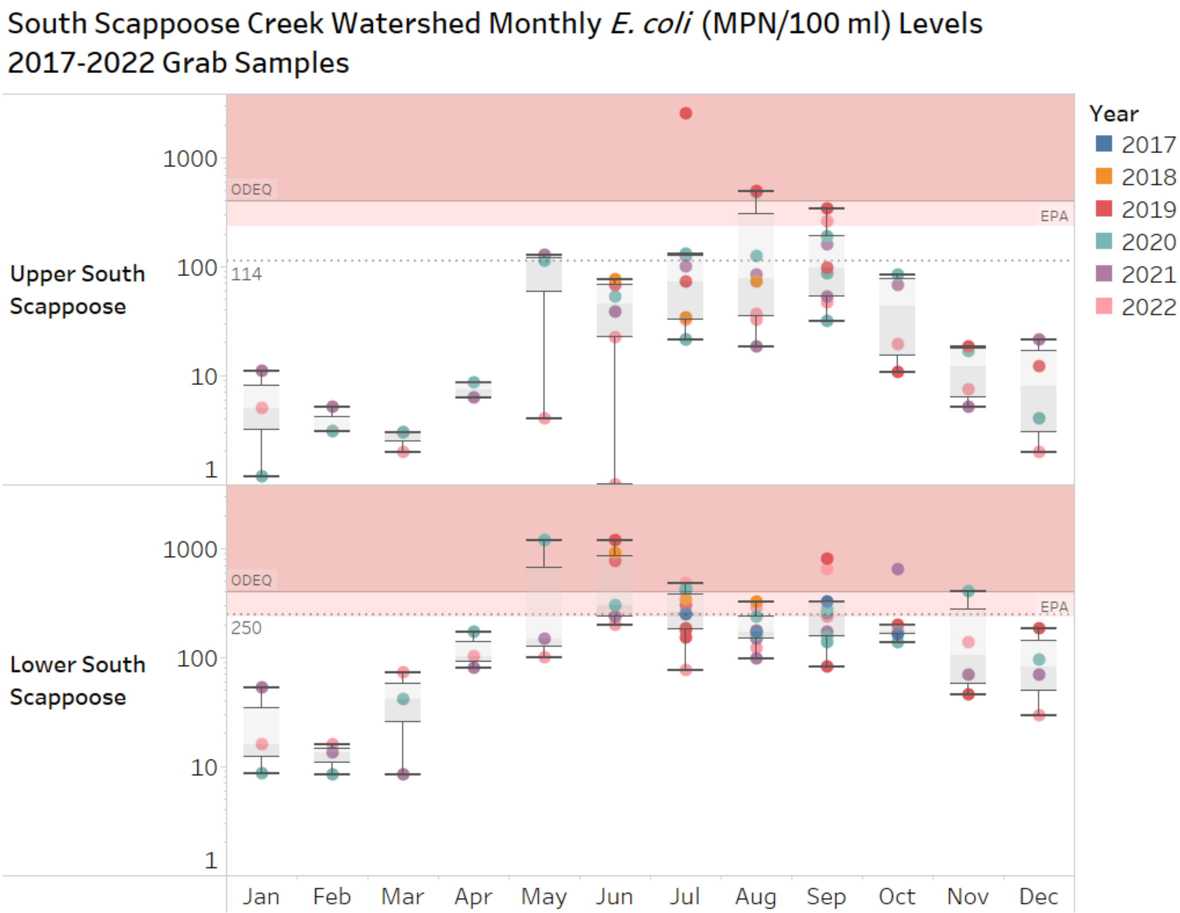


Figure 70. E. coli bacteria grab sampling results (boxplots) for South Scappoose Creek Watershed broken down across months sampled and watershed sampling locations. Sampling year ranging from 2017 to 2022 are highlighted within each boxplot. EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted on each graph. The overall mean for the study period highlighted in each graph. Logarithmic scale used on the y-axis.

South Scappoose Creek Watershed Monthly *E. coli* (MPN/100 ml) Levels
2008-2011, 2017-2022

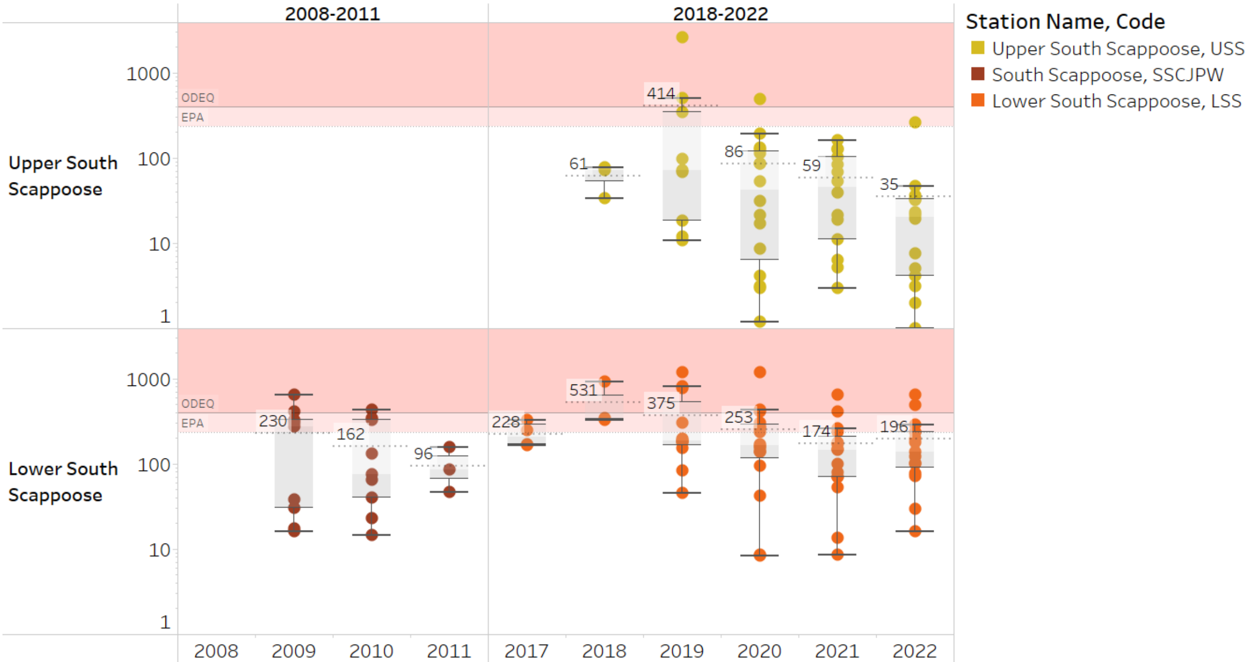


Figure 71: E. coli bacteria grab sampling results (boxplots) for South Scappoose Creek Watershed broken down across years sampled and watershed sampling locations. Sampling location highlighted within each boxplot. EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted on each graph. The overall mean for the study period highlighted in each graph. Logarithmic scale used on the y-axis.

Water pH Levels

The pH levels in the watershed ranged from 6.28 (July 2022, USS) to 8.93 (March 2022, USS), staying within DEQ regulatory standards for ideal stream conditions for salmonids (6.5 – 8.5) (Table 47, Figure 72). Seasonal trends in pH levels in 2022 were similar to those observed in 2021 - pH ranges tended to decrease from upper to lower reaches of the watershed. Compared to 2008-2011 data, pH values were highly variable in 2021 and 2022 (Figure 72).

Table 47: Summary Table of in-situ stream pH in South Scappoose Creek Watershed in 2022.

		Count of P H	Min. P H	Max. P H	Std. dev. of P H
2021	Upper South Scappoose	11.00	7.03	8.30	0.37
	Lower South Scappoose	11.00	6.50	7.66	0.31
2022	Upper South Scappoose	15.00	6.28	8.93	0.65
	Lower South Scappoose	15.00	6.80	7.82	0.29

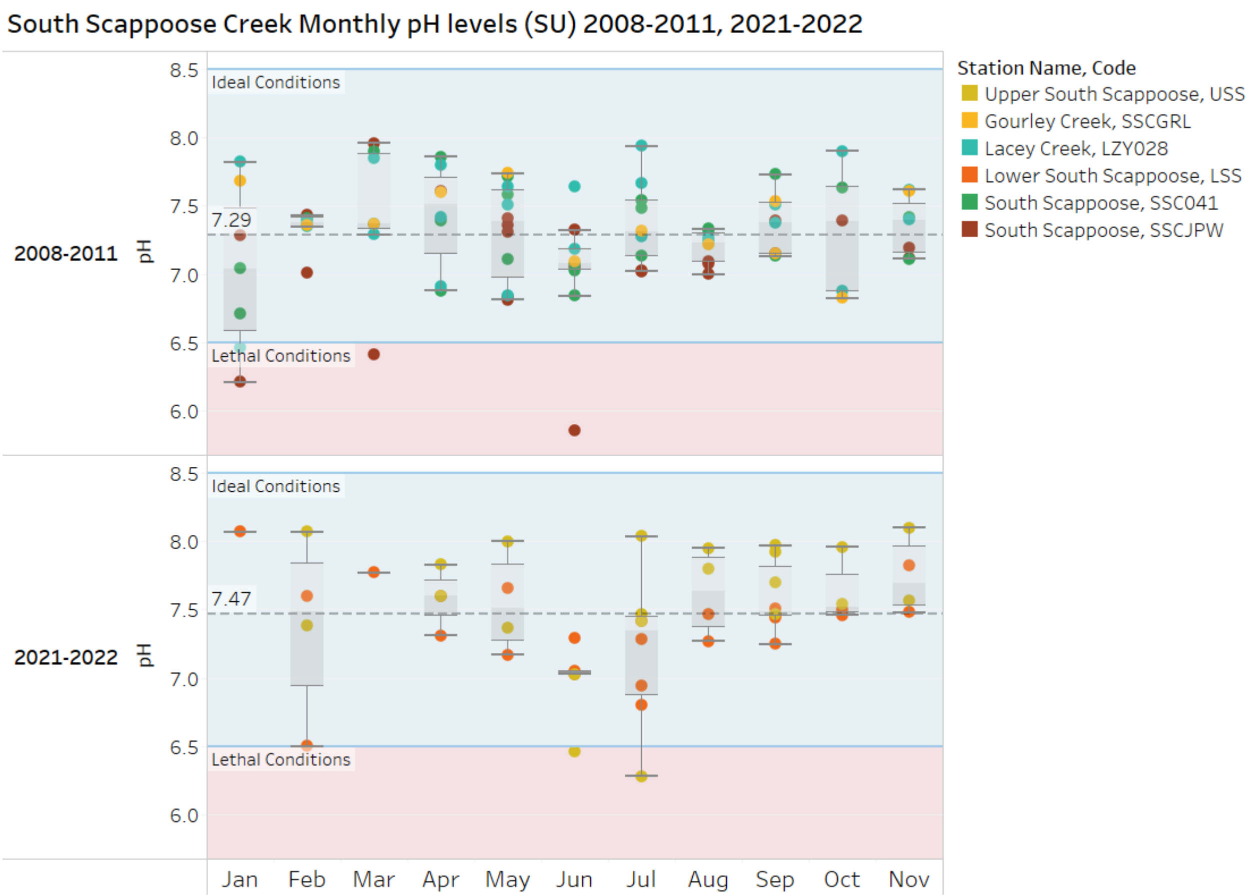


Figure 72: South Scappoose Creek watershed in-situ stream pH ranges compared across months between 2008-2011 data and 2021-2022 data. DEQ regulatory standards for lethal stream pH conditions for salmonids (<6.5) is represented as a red band. DEQ standards for ideal stream pH conditions for salmonids (6.5 – 8.5) is shown as blue band.

Water Dissolved Oxygen (DO) Levels

In 2022, in-situ stream DO measurements were collected using a YSI Pro-series meter, with the goal of providing additional information on stream quality. Measurements were made from January to August. These measurements were compared to 2008-2011 DO data.

Stream DO averages in the watershed ranged from 4.86mg/L (August 2022, LSS) to 15.5mg/L (March 2022, USS) (Table 48) falling below DEQ standards for ideal stream conditions (>11mg/L) between June and August. DO levels tended to decrease from upper to lower reaches of the watershed. Seasonally, elevated DO levels were observed during winter and spring months reaching peak lows during summer before climbing again in the fall. When compared to 2008-2011 data, DO levels were more variable and summertime levels were lower in 2021-2022 in the watershed (Figure 73).

Table 48: Summary Table of in-situ stream DO in South Scappoose Creek Watershed in 2022.

		Count of DO	Avg. DO	Min. DO	Max. DO	Std. dev. of DO
2021	Upper South Scappoose	14	11.31	9.11	13.51	1.46
	Lower South Scappoose	14	9.22	5.86	13.39	2.45
2022	Upper South Scappoose	10	12.23	7.77	15.50	2.36
	Lower South Scappoose	10	10.32	4.86	14.00	2.99

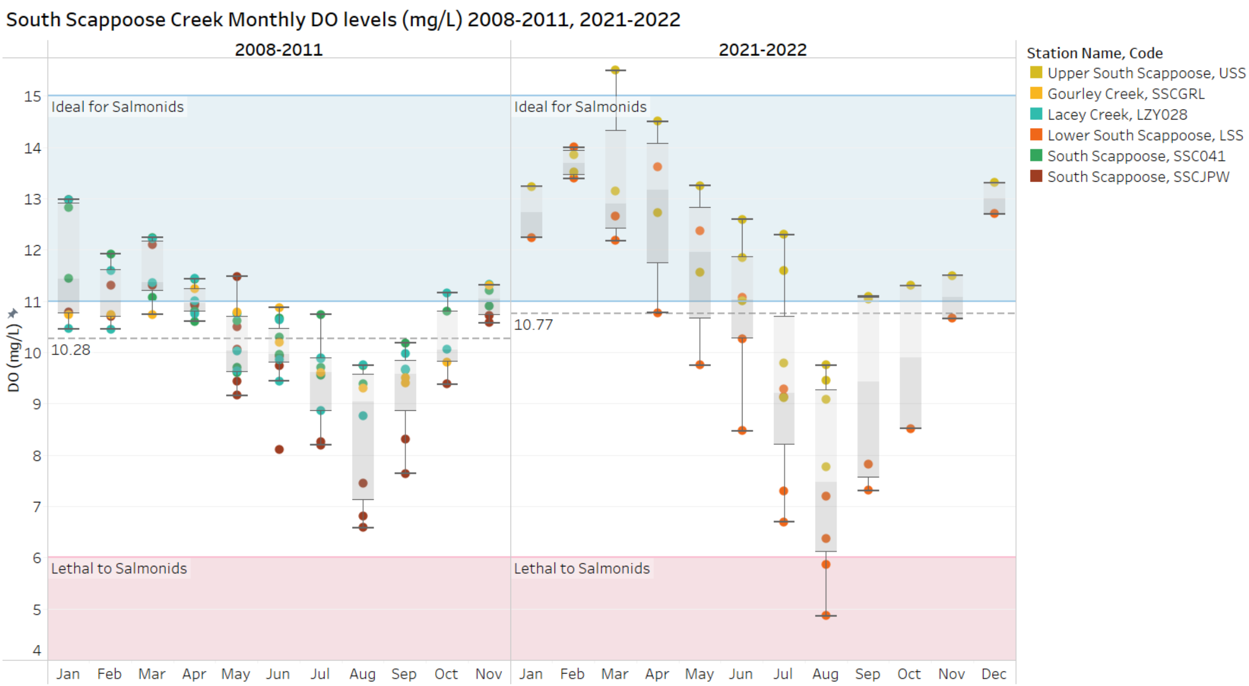


Figure 73: Monthly in-situ stream DO ranges across all monitoring locations in South Scappoose Creek watershed between 2008-2011 (left panel) and 2021-2022 (right panel). DEQ standards for ideal DO conditions for salmonids(>11mg/l) is depicted as a blue band in the graph. DEQ standards for Lethal conditions (<6mg/l) is depicted as red band.

Water Conductivity Levels

Conductivity levels varied seasonally across monitoring locations within the South Scappoose Creek watershed (Figure 74, Table 49). At both locations, seasonal increases in water conductivity were observed between April to September and declined from October to February (Figure 74, Table 49). Between 2018-2022, Upper South Scappoose Creek exhibited similar overall mean conductivity levels ranging from 64-102 µs/cm compared to 70-101 µs/cm observed at the Lower South Scappoose Creek monitoring location (Figure 74, Table 49). Average conductivity levels in 2022 were the lowest in the last 5 years across both sites. These data provide baseline conductivity levels that can be used to identify new and emerging water quality issues or improvements over time. When comparing the 2018-2022 data to the 2008-2011 data, no significant shift in conductivity was observed (

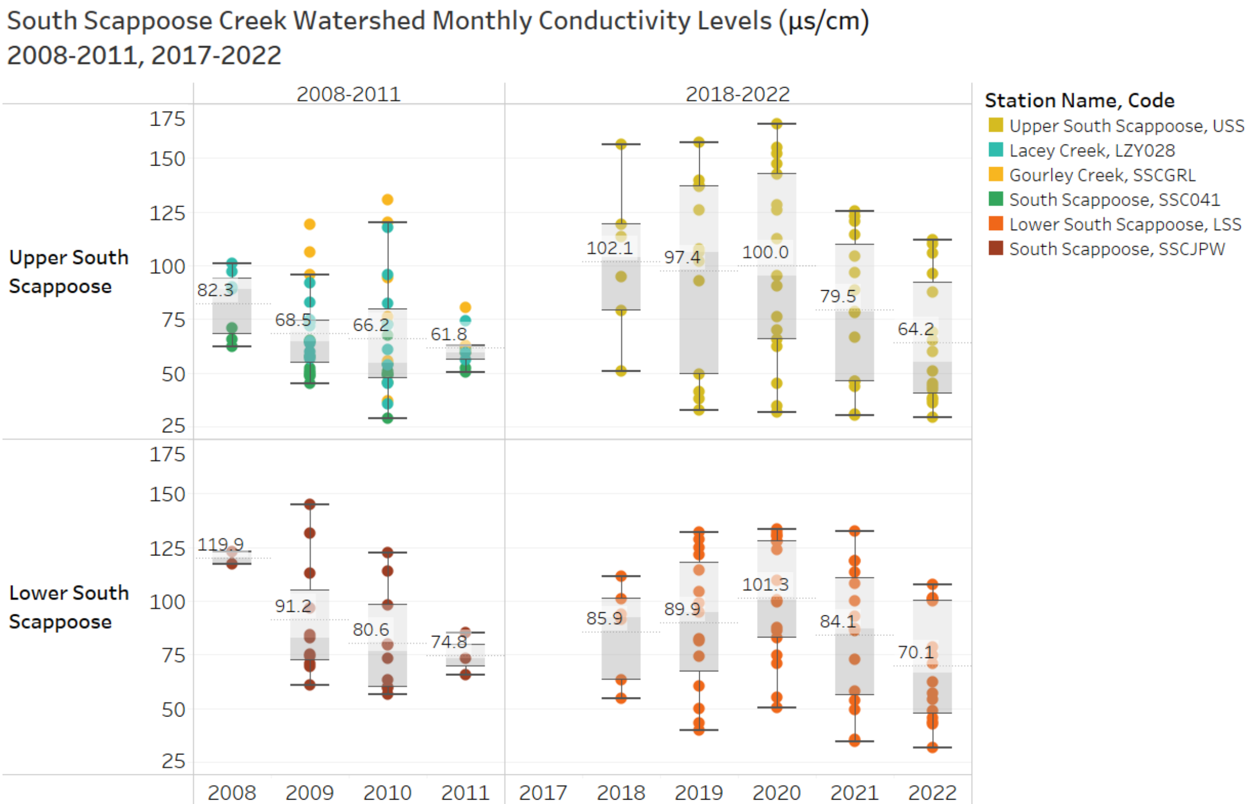


Figure 75). Pollution from runoff or increased turbidity levels from erosion can result in higher conductivity levels; however, there is no EPA or ODEQ threshold for conductivity in the region.

Table 49: Summary Table of South Scappoose Creek watershed monthly conductivity (µs/cm) data for 2018-2022 grab samples. Conductivity (µs/cm) samples broken down across months sampled and watershed sampling location. n = number of samples collected.

		n	Max	Mean	+/- SD
Upper South Scappoose	2018	6	156	102	36
	2019	13	157	97	43
	2020	17	166	100	45
	2021	15	125	79	34
	2022	16	112	64	29
Lower South Scappoose	2018	6	112	86	22
	2019	15	132	90	32
	2020	17	133	101	28
	2021	15	132	84	32
	2022	16	108	70	25

South Scappoose Creek Watershed Monthly Conductivity Levels (µs/cm)
2018-2022 Grab Samples

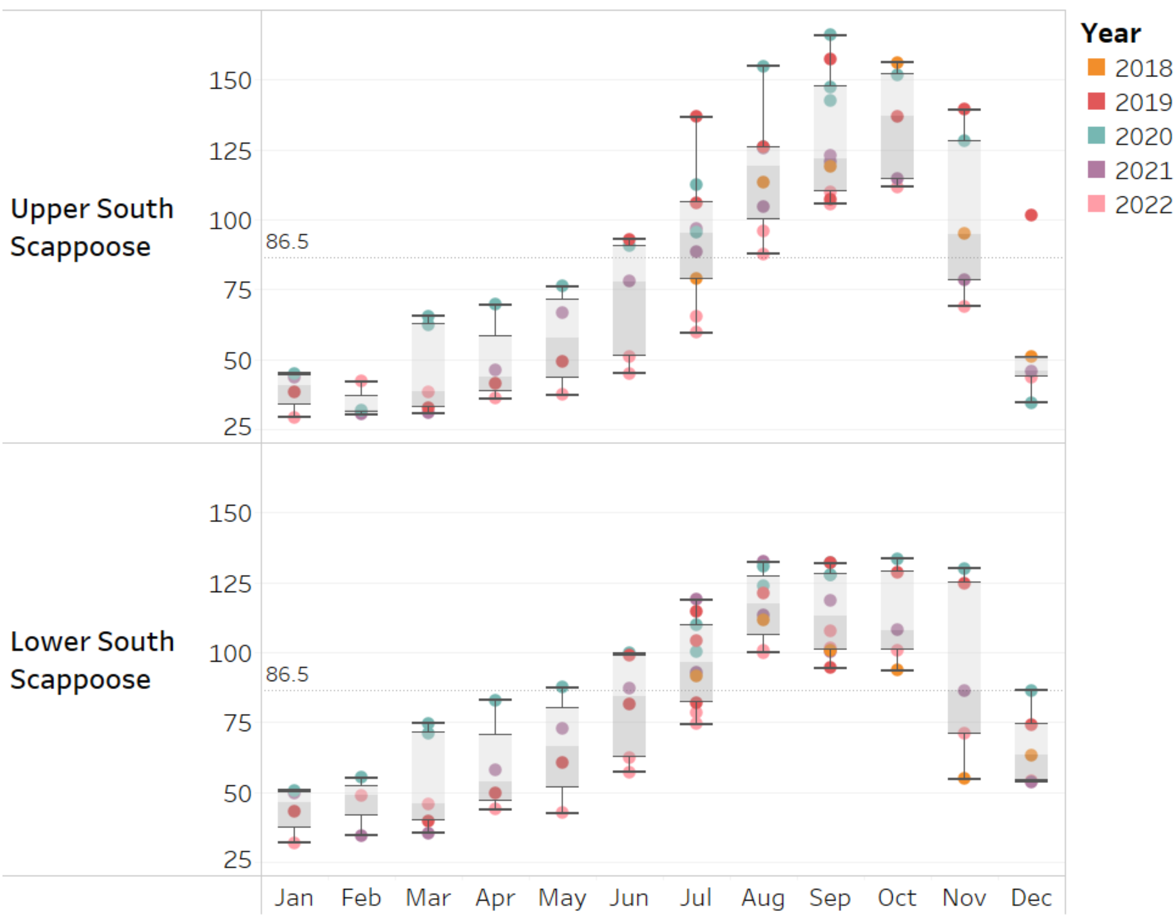


Figure 74: Conductivity levels (µs/cm) 2018-2022 Grab Samples results (boxplots) for South Scappoose Creek watershed broken down across months sampled and watershed sampling location. Sampling years ranging from 2018 to 2022 are highlighted within each boxplot. The overall mean for the study period highlighted in each graph.

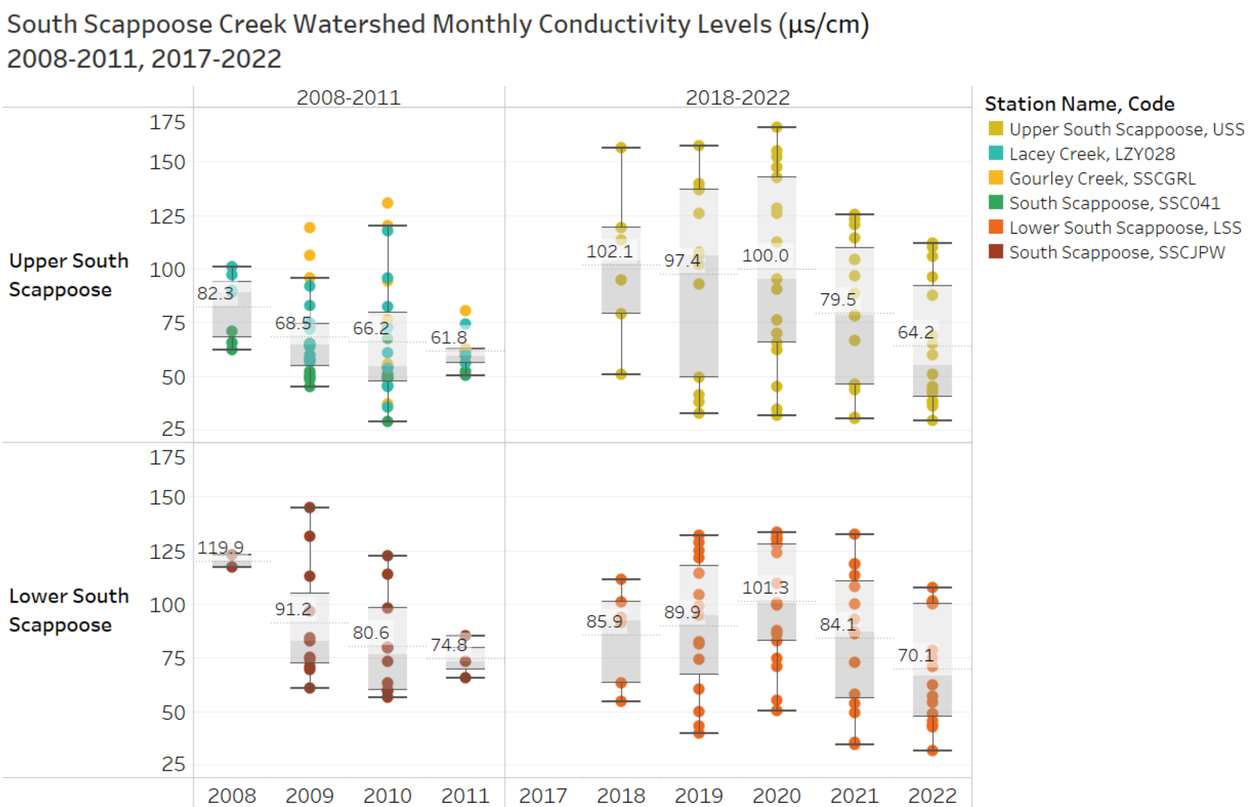


Figure 75: Conductivity levels (µs/cm) 2008-2021 Grab Samples results (boxplots) for South Scappoose Creek watershed broken down across years, with monitoring location highlighted within each boxplot. Sampling years ranging from 2008-2011 and 2018- 2021. Overall mean for each year annotated.

Water Quality Issues

Water quality issues observed in South Scappoose Watershed include high summer temperatures (>18°C) in the watershed (Figure 65). Elevated temperatures are likely caused by solar loading within the lower reaches of the watershed, which are much more heavily developed and lack riparian shade (Figure 4). Both Upper and Lower South Scappoose have experienced a potential increase in water temperatures since the previous 2008-2011 study indicating that further action is required to prevent continued temperature issues in the basin (Figure 67). Low water temperatures are critical for supporting aquatic life including endangered Salmonids in the Pacific Northwest; reducing solar radiation and reducing urban and agricultural runoff can help keep water temperatures down and protect these stream habitats (USGS 2021). pH and DO levels generally stayed within ODEQ standards; however, a high degree of variability was observed in 2021-2022. Additionally, elevated *E. coli* bacteria levels were observed in the watershed between July to September in 2022, exceeding EPA and ODEQ standards; additionally, the 90-day geometric mean exceeded ODEQ standards (126 MPN/100mL) between April and November (Table 4, Table 45). *E. coli* bacteria issues are indicative of animal waste runoff and can be very harmful to humans using these waterways for recreation (Pandey et al. 2014). Additional research is needed to determine the exact source of the elevated *E. coli* and whether this extended pattern of elevated *E. coli* is a sustained phenomenon in the watershed. Animal waste or septic tank leakage into the stream are possible sources to be investigated. Depending on the source, actions that could reduce future *E. coli* exceedance events include increasing riparian buffers, excluding livestock from the creek, increasing manure management near streams, and/or updating failed septic systems throughout the targeted reach of the watershed (Pandey et al. 2014). Given the frequency and scale of *E. coli* bacteria events adding warning signs to recreational areas along the streams, especially in the lower reaches of South Scappoose creek, is recommended. No significant issues or shifts in stream water turbidity or conductivity levels were detected in South Scappoose Watershed during this study.

MILTON AND MCNULTY INTENSIVE WATERSHED STUDY

Study Area

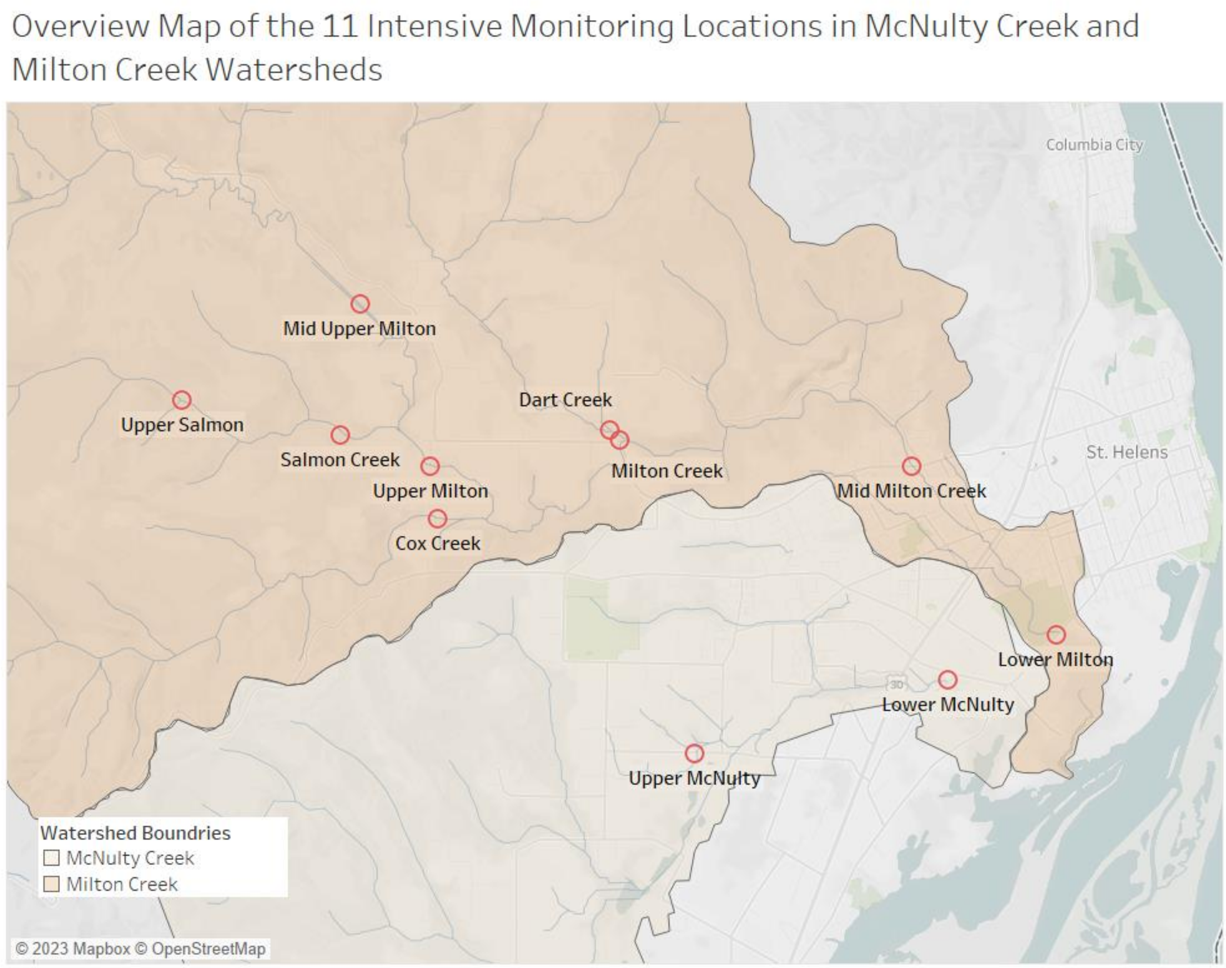


Figure 76: : Focus map of McNulty Creek and Milton Creek monitoring locations, for an overview map, see Figure 2. For specific monitoring location details see Table 2.

Water Temperature

Across both watersheds, the 7dMAM in 2022 ranged from 1.7°C to 26.6°C (Table 49). Generally, temperatures increased from upper to lower reaches of the watersheds, however much variation was observed (Figure 77). DEQ temperature standard for salmon rearing habitat is less than 18°C, and streams with temperatures higher than 18°C are considered poor quality for salmon. All sites except Upper Salmon Creek had a significant number of days where temperatures exceeded 18°C between July and August; both Dart and Lower McNulty had at least 100 days over 18°C (Table 50, Table 51). Seasonally, temperatures exceeded the 18°C threshold between June and September before becoming cooler between October and December; however, Dart Creek and Lower McNulty remained warm well into October (Figure 78, Figure 79).

Table 50: 7dMAM temperatures Summary for 2022 for creeks in McNulty Creek and Milton Creek Watersheds. Temperatures have been color-coded according to salmonid thresholds listed in Table 4. Monitoring locations have been organised from high to low in the watershed as shown in Figure 76.

			Min. 7DMAM	Avg. 7DMAM	Max. 7DMAM	Number of Days over 18°	Number of Days over 25°
2022	Milton Creek	Upper Salmon Creek	5.8	13.1	19.0	9	0
		Salmon Creek	3.5	13.6	22.0	47	0
		Mid-Upper Milton	1.7	15.9	26.6	79	7
		Upper Milton	3.9	12.2	22.1	53	0
		Cox Creek	2.2	13.9	22.6	55	0
		Dart Creek	2.9	15.6	24.2	106	0
		Milton Creek	3.3	15.1	24.7	71	0
		Mid-Milton Creek	2.2	14.8	25.5	64	4
		Lower Milton	4.1	13.9	26.4	89	6
	McNulty Creek	Upper McNulty	3.4	15.7	24.5	76	0
		Lower McNulty	4.8	15.8	24.0	100	0

Table 51: Number of days over 18°C in the McNulty Creek and Milton Creek Watersheds in 2022. Winter and spring months have been excluded from this table as stream temperature conditions are within ideal conditions at that time. Monitoring locations have been organised from high to low in the watershed as shown in Figure 76.

			May	June	July	August	September	October
2022	Milton Creek	Upper Salmon Creek	0	0	4	5	0	0
		Salmon Creek	0	3	25	19	0	0
		Mid-Upper Milton	0	4	30	31	14	0
		Upper Milton	0	0	14	31	8	0
		Cox Creek	0	0	16	31	8	0
		Dart Creek	0	7	31	31	17	20
		Milton Creek	0	3	23	31	14	0
		Mid-Milton Creek	0	8	31	21	4	0
		Lower Milton	0	6	31	31	21	0
	McNulty Creek	Upper McNulty	0	3	27	31	15	0
		Lower McNulty	0	3	28	31	26	12

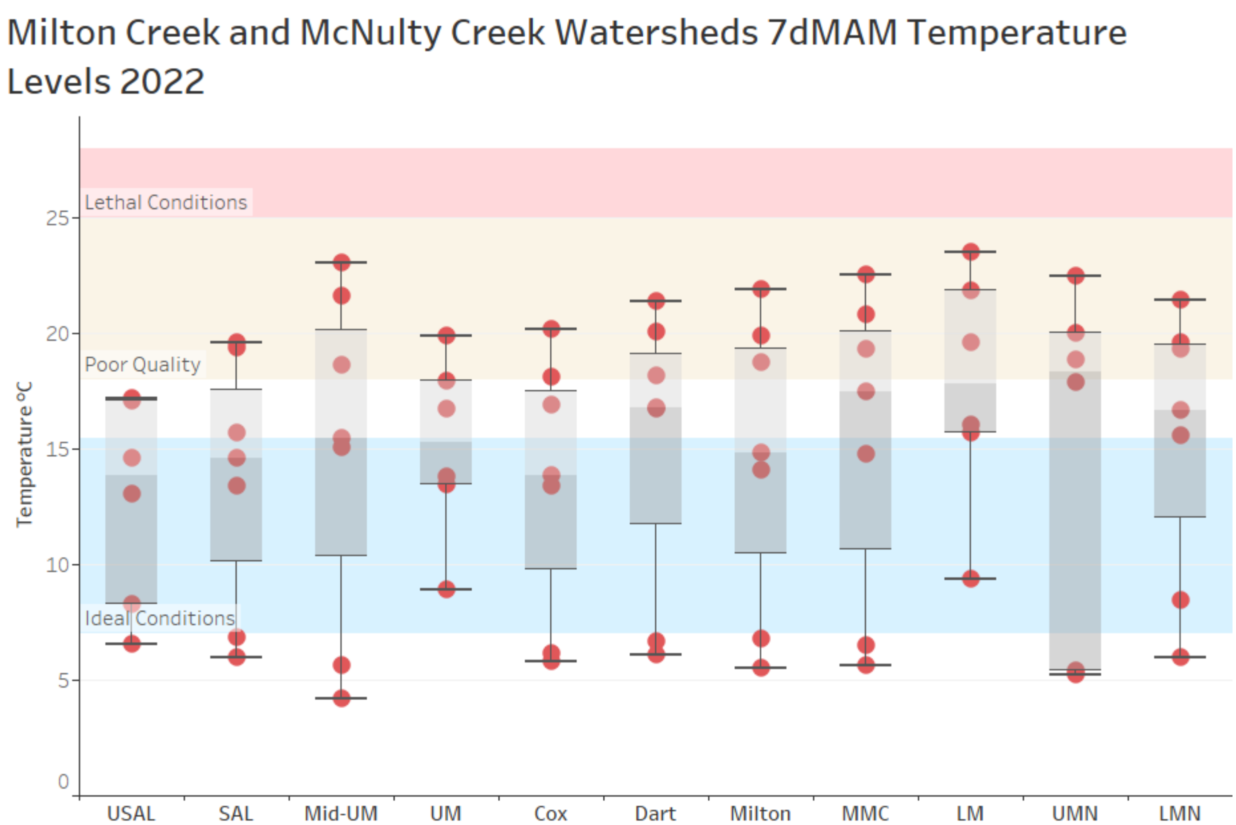


Figure 77: 7dMAM temperature variation in the McNulty and Milton Creek watersheds, overlaid on the DEQ stream temperature standard ranges for healthy salmon habitat (Table 4). Data points represent the months monitored in a year. Ideal Conditions (7°C-15.6°C), Poor Quality (18°C-25°C), and Lethal Conditions (>25°C). Monitoring locations have been organised from high to low in the watershed as shown in Figure 76.

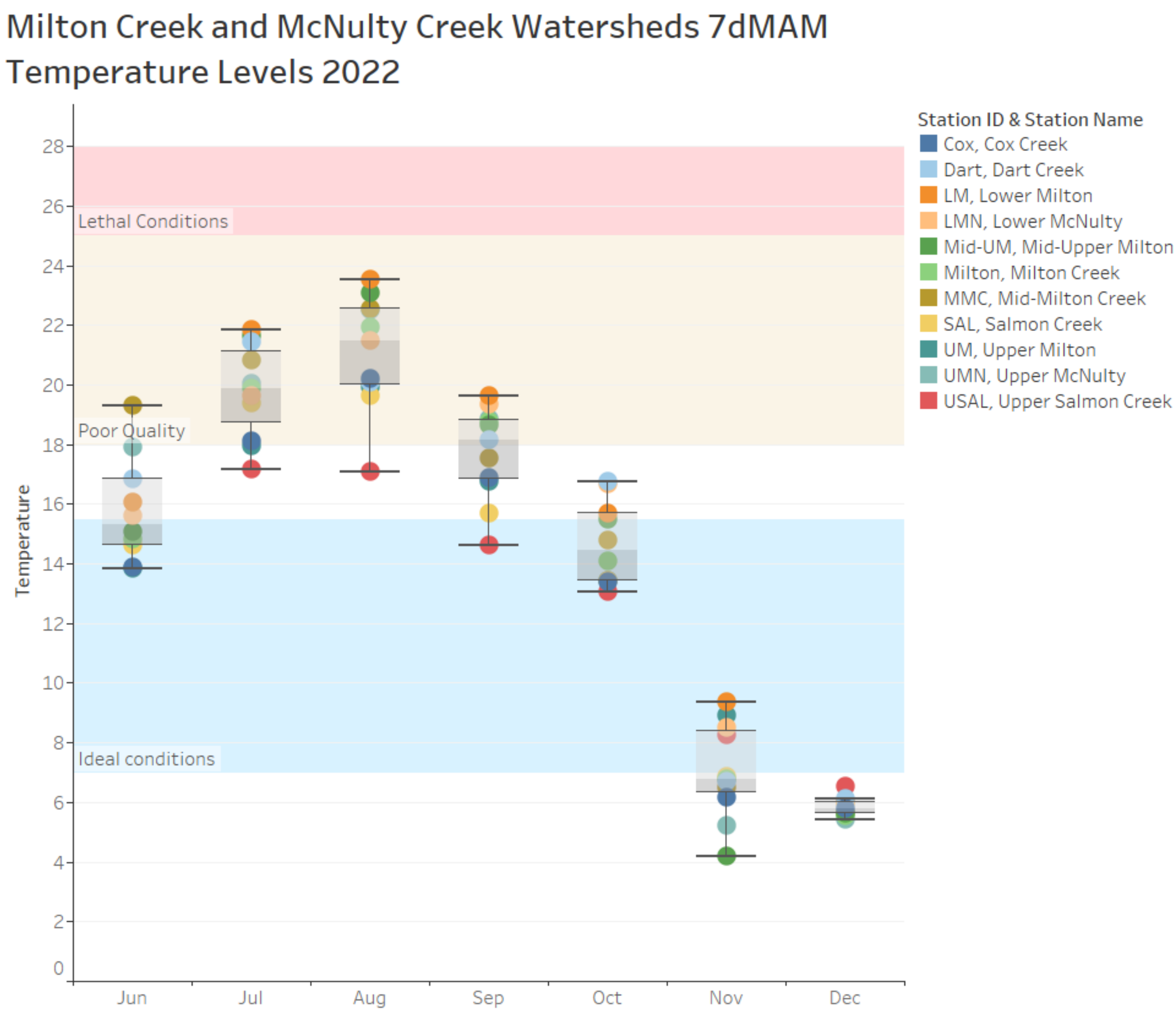


Figure 78: Monthly variation in 7dMAM temperature in the McNulty Creek and Milton Creek watersheds in 2022.

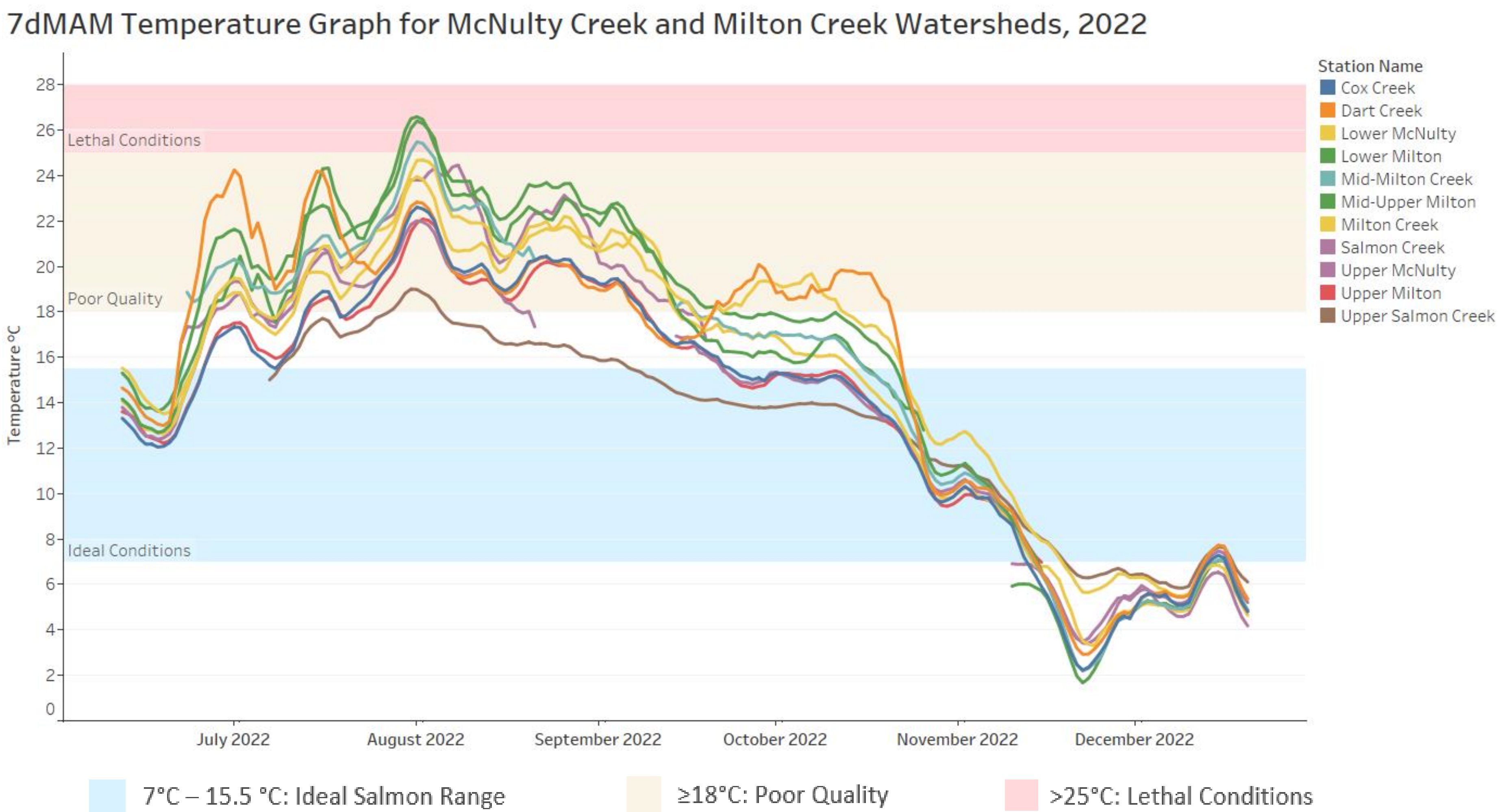


Figure 79: 7-day average maximum temperatures (7dMAM) for McNulty Creek and Milton Creek watersheds in 2022 overlayed on salmonid temperature threshold ranges. See Table 4 for temperature threshold details.

Water Turbidity Levels

2022 turbidity levels across McNulty Creek and Milton Creek were highly variable. Values ranged from 2.8 to 83.4 NTU, with an average of 8.4 NTU spanning from June-December (Table 52). Dart Creek levels averaged 10.9 NTU and Upper McNulty Creek levels averaged 20.6 NTU during the study period, both of which exceeded the <10 NTU acceptable range for salmonid habitat (Table 52). 6 of the 9 intensive monitoring locations that were added in 2022 exceeded the 10 NTU threshold at least once during the study period (Table 52). Upper McNulty had particularly high turbidity levels in June (83.4 NTU) and September (43.0 NTU), which influenced its significantly higher mean turbidity value (Figure 80).

Table 52: Summary Table for McNulty Creek and Milton Creek Watersheds Monthly Turbidity (NTU), 2022 Grab Samples. Grab sample data broken down across watershed sampling locations. n = number of samples collected—red highlights when a sample location experienced a maximum over the 10 NTU threshold. Monitoring locations have been organised from high to low in the watershed as shown in Figure 76.

			n	Max	Mean	+/- SD
2022	Milton Creek	Upper Salmon	9	8.9	6.2	1.4
		Salmon Creek	11	10.1	7.4	2.1
		Mid Upper Milton	10	9.6	6.8	1.7
		Upper Milton	11	15.2	9.3	3.5
		Cox Creek	11	21.1	7.3	5.0
		Dart Creek	11	15.8	10.9	2.9
		Milton Creek	11	10.3	6.2	1.5
		Mid Milton Creek	10	9.7	5.5	1.7
		Lower Milton	11	9.6	5.4	2.2
	McNulty Creek	Upper McNulty Creek	11	83.4	20.6	23.2
		Lower McNulty Creek	11	12.0	5.8	2.4

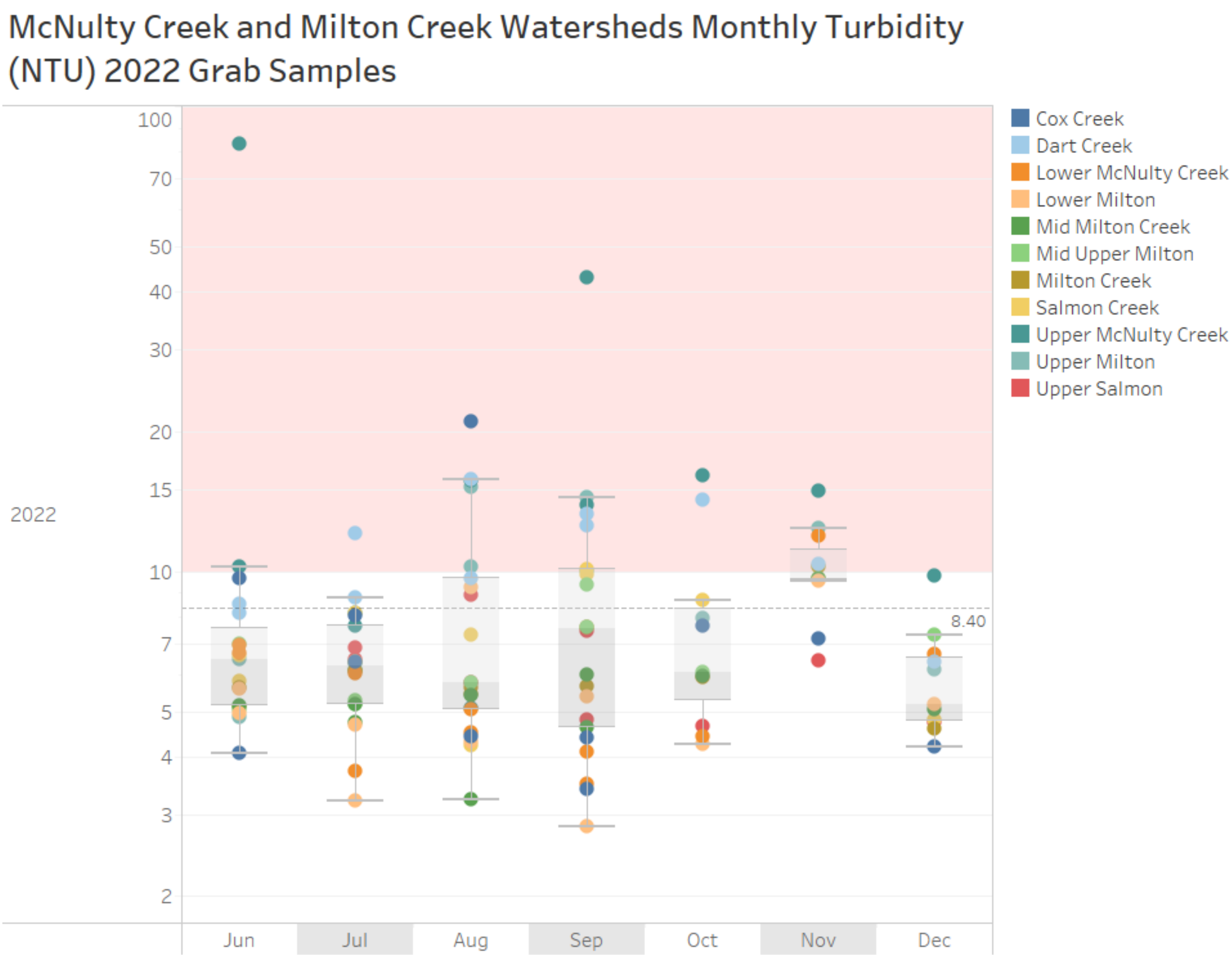


Figure 80: Turbidity (NTU) grab sampling results (boxplots) for McNulty Creek and Milton Creek Watersheds broken down across sampling locations and months sampled in 2022. 10 NTU threshold highlighted in pink. Overall mean highlighted.

Water Bacteria Levels

All monitoring locations across Milton Creek and McNulty Creek in 2022 exceeded the EPA (235 MPN/100mL) or ODEQ (406MPN/100mL) thresholds for *E. coli* bacteria levels, with maximum values ranging from 343 to 2,420 MPN/100mL (Table 53). Elevated levels primarily occurred between June and October, however Upper McNulty also had elevated levels in December (1,414 MPN/100mL) (Table 55, Figure 81).

The 90-day geometric mean state-mandated water quality threshold for Oregon is 126 MPN/100mL; other than Upper McNulty, all sites exceeded this threshold in 2022. 7 of the 9 intensive monitoring locations exceeded 126 MPN/100mL threshold between June and November (Table 54).

Table 53: Summary table of McNulty Creek and Milton Creek watershed E. coli (2022) MPN/100 ml grab samples. Grab sample data broken down across watershed sampling locations. Sampling locations that experienced events over the EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted in red. n = number of samples collected. . Monitoring locations have been organised from high to low in the watershed as shown in Figure 76.

			n	Max	Mean	+/- SD
2022	Milton Creek	Upper Salmon	9	343	106	109
		Salmon Creek	11	2,420	497	724
		Mid Upper Milton	10	488	204	143
		Upper Milton	11	365	168	94
		Cox Creek	11	1,986	416	556
		Dart Creek	11	2,420	702	894
		Milton Creek	11	489	193	134
		Mid Milton Creek	10	517	216	169
		Lower Milton	11	649	248	197
	McNulty Creek	Upper McNulty	11	1,414	242	397
		Lower McNulty	11	649	253	182

Table 54: 90 Day geometric mean (5 samples or greater) of E. coli bacteria levels (MPN/100ml) across sampling sites, those durations that are above the state-mandated threshold of 126 MPN/100 ml for the 90 days geometric mean are highlighted with red text. Monitoring locations have been organised from high to low in the watershed as shown in Figure 76.

			Jun Sep	Jul Oct	Aug Nov
2022	Milton	Upper Salmon	130.9	74.1	50.6
		Salmon Creek	267.4	468.2	505.7
		Mid Upper Milton	184.7	184.4	202.9
		Upper Milton	168.2	161.7	142.8
		Cox Creek	408.3	364.7	363.3
		Dart Creek	332.8	630.6	668.7
		Milton Creek	159.2	150.2	155.7
		Mid Milton Creek	206.5	191.9	154.6
		Lower Milton	216.1	267.4	227.6
	McNulty	Upper McNulty Creek	91.5	76.7	92.2
		Lower McNulty Creek	204.7	261.4	355.1

Table 55: McNulty Creek watershed monthly max E. coli (MPN/100 ml) grab samples. Grab sampling results for broken down across watershed sampling locations. Sampling locations that experienced events over the EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted in red. Monitoring locations have been organised from high to low in the watershed as shown in Figure 76.

			Jun	Jul	Aug	Sep	Oct	Nov	Dec
2022	Milton Creek	Upper Salmon		343	194	32	52	36	3
		Salmon Creek	53	410	2,420	1,120	461	41	7
		Mid Upper Milton	249	488	89	326	250	72	21
		Upper Milton	179	308	150	365	119	93	41
		Cox Creek	236	649	548	1,986	313	75	9
		Dart Creek	206	613	228	2,420	2,420	127	138
		Milton Creek	489	236	172	236	344	99	33
		Mid Milton Creek	111	517	139	345	221	114	29
		Lower Milton	115	517	387	649	328	104	34
	McNulty Creek	Upper McNulty Creek	249	91	152	236	12	73	1,414
		Lower McNulty Creek	199	129	649	488	352	155	186

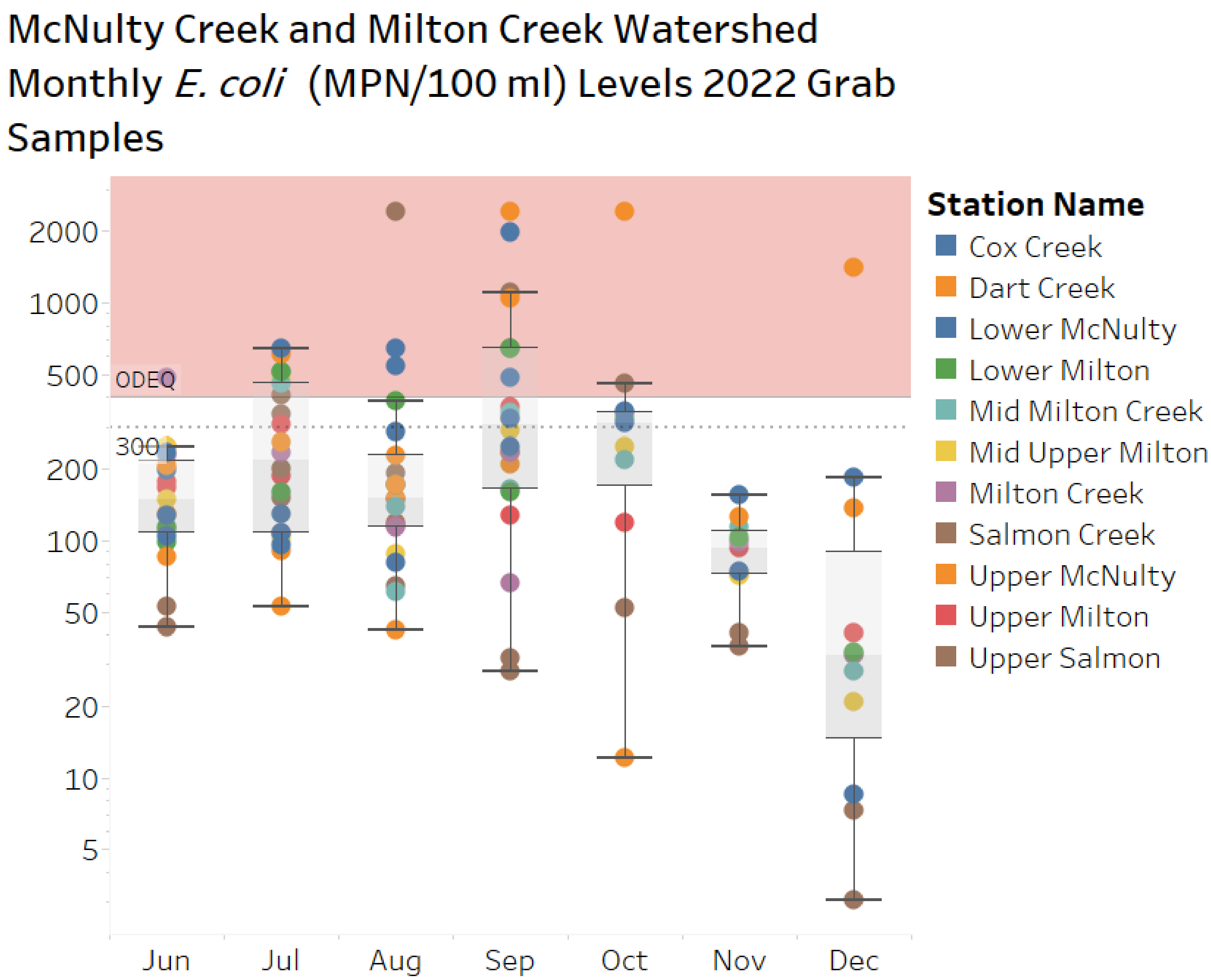


Figure 81: E. coli bacteria grab sampling results (boxplots) for McNulty Creek and Milton Creek Watersheds broken down across months sampled and watershed sampling locations. EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted on each graph. The overall mean for the study period highlighted in each graph. Logarithmic scale used on the y-axis.

Water pH Levels

In 2022, pH values ranged from 6.51 to 8.65, with Mid Milton Creek exceeding the DEQ regulatory standards for ideal stream conditions for salmonids (6.5-8.5) in July (8.65) (Table 56). Seasonally, pH levels were higher in warmer months and began to decrease in cooler months (Figure 82). Overall, pH was highly variable across both the McNulty Creek and Milton Creek watersheds, particularly during the summer months (Figure 82).

Table 56: Summary Table of in-situ stream pH in McNulty Creek and Milton Creek Watersheds in 2022. Monitoring locations have been organised from high to low in the watershed as shown in Figure 76.

			Count of P H	Min. P H	Max. P H	Std. dev. of P H
2022	Milton Creek	Upper Salmon	8	6.51	7.63	0.37
		Salmon Creek	11	6.90	7.67	0.28
		Mid Upper Milton	10	6.58	7.90	0.35
		Upper Milton	15	6.86	7.82	0.35
		Cox Creek	11	6.72	7.80	0.36
		Dart Creek	11	6.59	7.46	0.27
		Milton Creek	11	6.61	7.51	0.26
		Mid Milton Creek	10	6.80	8.65	0.54
		Lower Milton	15	6.99	8.30	0.32
	McNulty Creek	Upper McNulty	10	6.54	7.36	0.24
		Lower McNulty	11	6.82	7.94	0.29

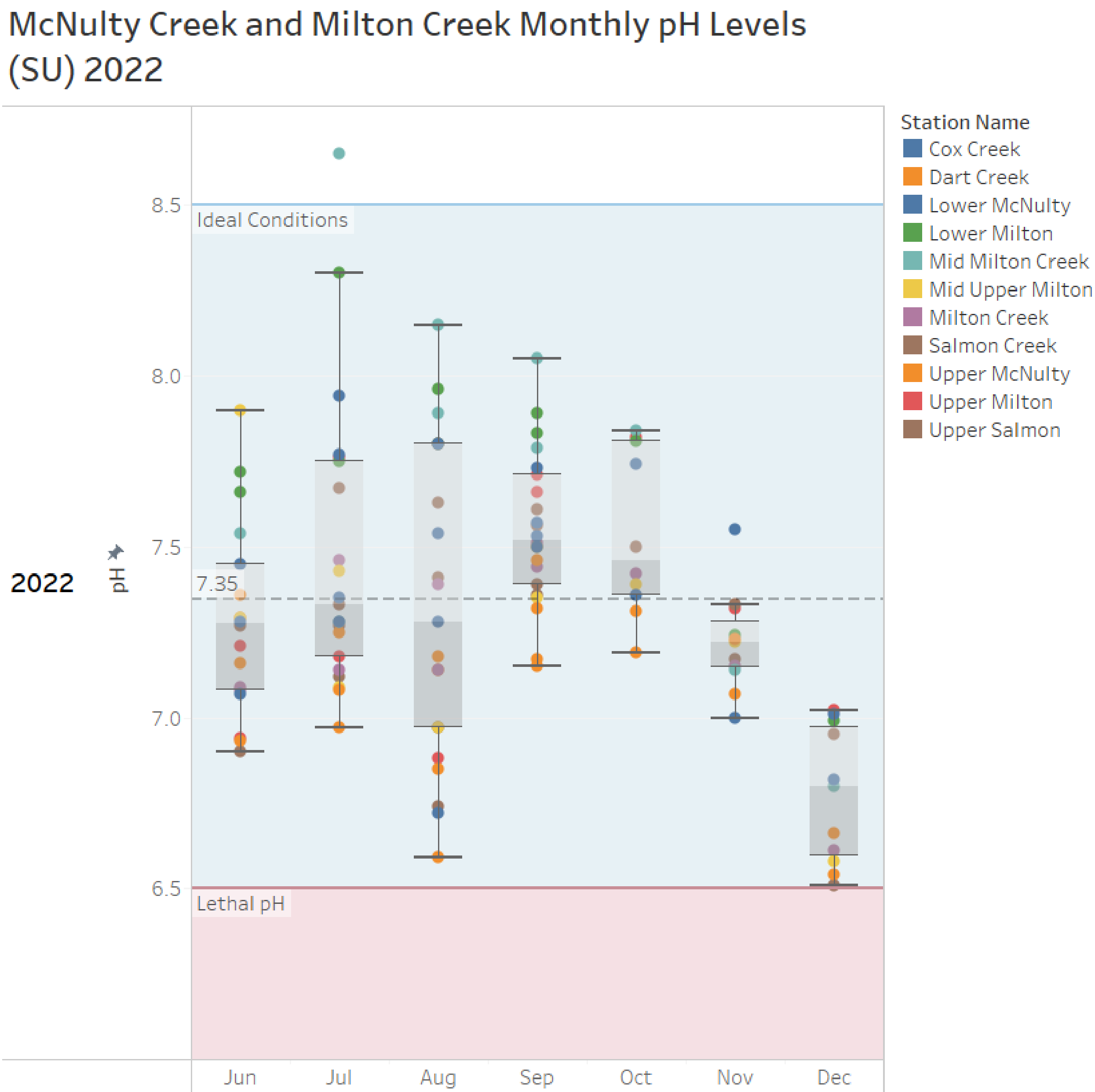


Figure 82: McNulty Creek and Milton Creek watersheds in-situ stream pH ranges across months in 2022. DEQ regulatory standards for lethal stream pH conditions for salmonids (<6.5) is represented as a red band. DEQ standards for ideal stream pH conditions for salmonids (6.5 – 8.5) is shown as blue band.

Water Dissolved Oxygen (DO) Levels

In 2022, DO measurements for the intensive monitoring locations were made from June-August; due to probe malfunction, DO measurements were not made from September-December.

Across the sampling period, stream DO averages across both watersheds ranged from 2.12 to 10.66 mg/L, with all measurements falling below DEQ standards for ideal stream conditions (>11mg/L) (Table 57). In August, Lower McNulty, Upper McNulty, and Dart Creek all fell below the lethal conditions threshold (<6 mg/L) (Figure 83: Monthly in-situ stream DO ranges across all monitoring locations in McNulty Creek and Milton Creek watersheds in June, July, and August 2022. DEQ standards for ideal DO conditions for salmonids(>11mg/l) is depicted as a blue band in the graph. DEQ standards for Lethal conditions (<6mg/l) is depicted as red band.Figure 83). No obvious trends were noted between upper and lower watershed locations thus far.

Table 57: Summary Table of in-situ Stream DO in McNulty Creek and Milton Creek watersheds in 2022. DEQ standards for stream DO range from Lethal conditons (<6mg/l) to ideal conditions (>11ppm). Monitoring locations have been organised from high to low in the watershed as shown in Figure 76.

			Count of DO	Avg. DO	Min. DO	Max. DO	Std. dev. of DO
2022	Milton Creek	Upper Salmon	4	7.2	6.2	8.1	0.8
		Salmon Creek	6	8.6	4.8	10.2	2.0
		Mid Upper Milton	5	9.0	7.9	10.5	1.0
		Upper Milton	6	8.1	5.5	10.1	1.7
		Cox Creek	6	9.5	6.2	10.6	1.7
		Dart Creek	6	6.1	3.6	8.9	2.4
		Milton Creek	6	8.2	5.1	10.0	1.8
		Mid Milton Creek	5	8.8	7.3	10.1	1.1
		Lower Milton	6	8.6	6.5	10.7	1.4
	McNulty Creek	Upper McNulty	5	6.0	2.1	9.6	3.7
		Lower McNulty	6	7.5	4.2	10.2	2.5

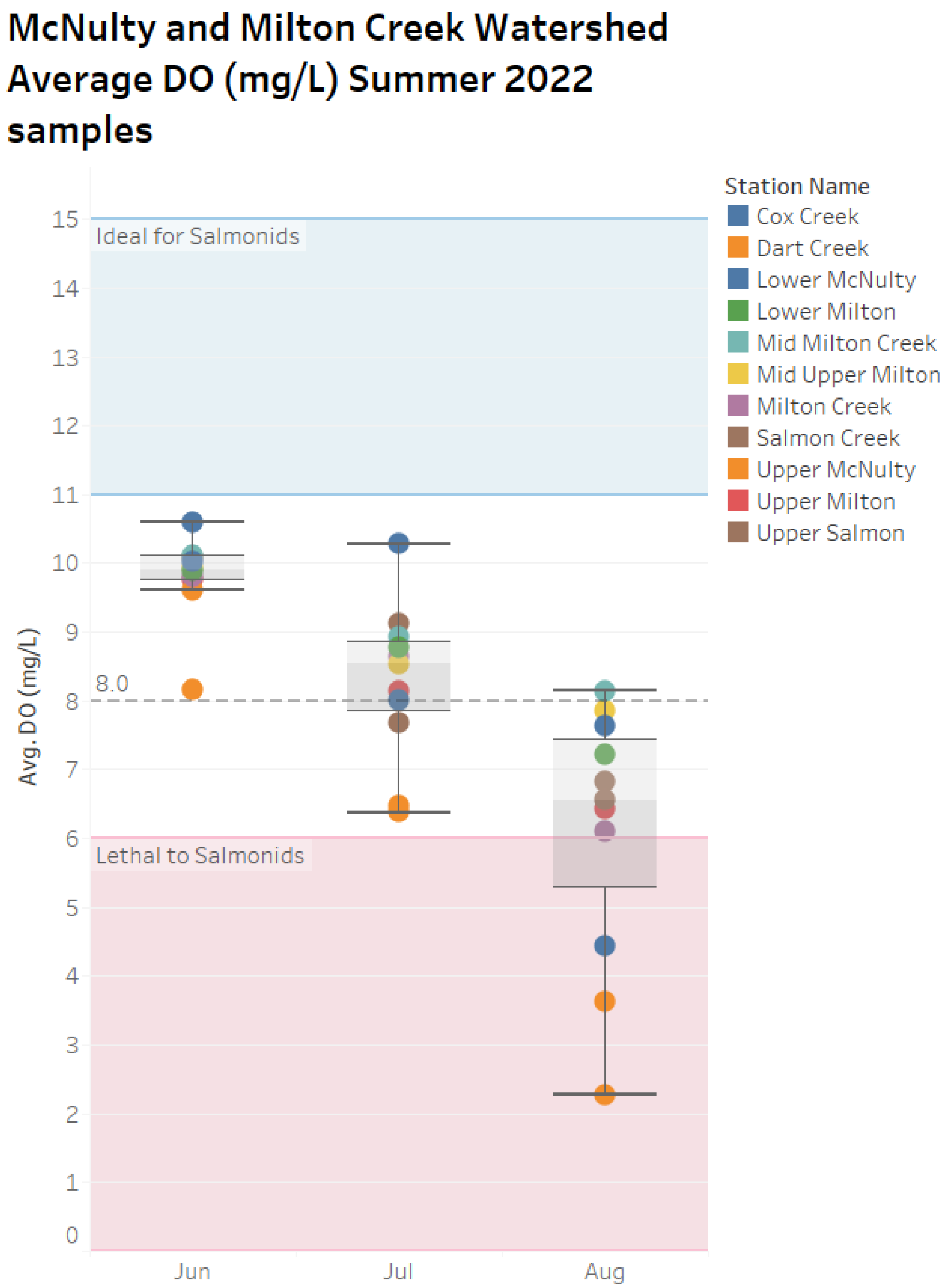


Figure 83: Monthly in-situ stream DO ranges across all monitoring locations in McNulty Creek and Milton Creek watersheds in June, July, and August 2022. DEQ standards for ideal DO conditions for salmonids(>11mg/l) is depicted as a blue band in the graph. DEQ standards for Lethal conditions (<6mg/l) is depicted as red band.

Water Conductivity Levels

Conductivity levels ranged from 27.6 µs/cm to 182.1 µs/cm (Table 58). Between the watersheds, McNulty Creek had higher conductivity levels on average than Milton Creek (Table 58, Figure 84). Conductivity levels were higher and more variable between July and October (Figure 84).

Table 58: Summary Table of McNulty Creek and Milton Creek watersheds monthly conductivity (µs/cm) data for 2022 grab samples. Conductivity (µs/cm) samples broken down across months sampled and watershed sampling location. n = number of samples collected. Monitoring locations have been organised from high to low in the watershed as shown in Figure 76.

			n	Max	Mean	+/- SD
2022	Milton Creek	Upper Salmon	9	73	54	16
		Salmon Creek	11	71	49	15
		Mid Upper Milton	10	77	57	17
		Upper Milton	11	77	58	17
		Cox Creek	11	89	65	18
		Dart Creek	11	123	78	35
		Milton Creek	11	80	60	17
		Mid Milton Creek	10	111	72	25
		Lower Milton	11	104	67	22
	McNulty Creek	Upper McNulty	11	170	106	45
		Lower McNulty	11	182	119	50

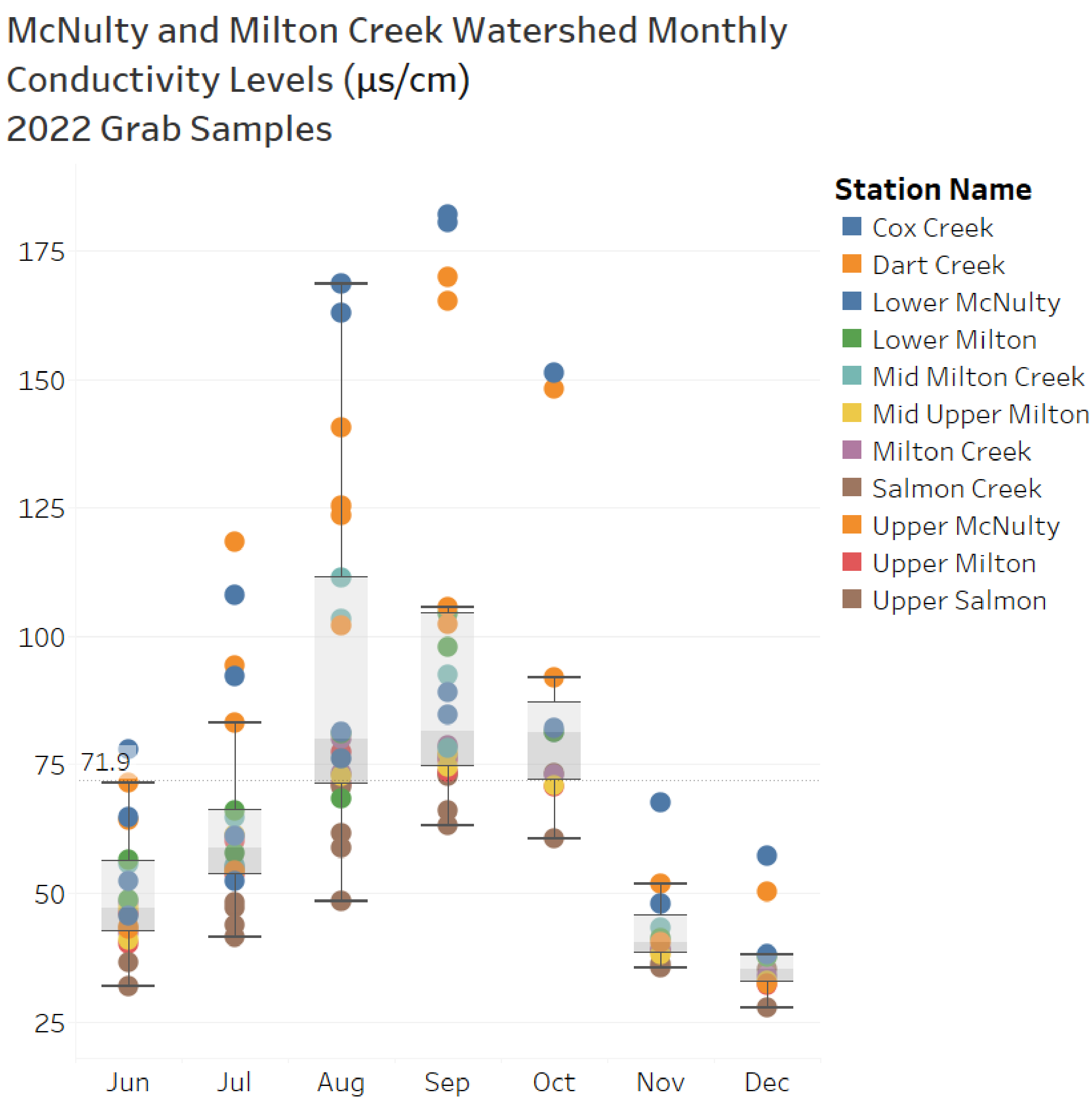


Figure 84: Conductivity Levels (µs/cm) 2022 Grab Samples results (boxplots) for McNulty Creek and Milton Creek Watersheds broken down across months sampled.

Water Quality Issues

This intensive monitoring effort is aimed at identifying potential sub-basins that may be contributing to the water quality impairments of the larger Milton Creek watershed. However, through this study, it is known that water quality issues exist throughout most of the sub-basins. Water quality issues were also identified in the adjacent McNulty Creek watershed. The max 7dMAM temperatures at the monitoring locations exceeded the 18°C threshold at all sites in Milton and exceeded the lethal habitat threshold (25°C) at Mid-Upper Milton, Mid-Milton, and Lower Milton Creek sampling locations (Table 50). Temperatures remained above 18°C well into October at Dart Creek. Overall elevated temperatures are likely caused by solar loading as the water moved through the watershed. Low water temperatures are critical for supporting aquatic life, including endangered Salmonids in the Pacific Northwest; reducing solar radiation and reducing urban and agricultural runoff can help keep water temperatures down and protect these stream habitats (USGS 2021). Average turbidity also exceeded ODEQ threshold of 10 NTU. Max turbidity exceeded 10NTU at Salmon Creek, Upper Milton, Cox Creek, and Milton Creek (Table 52). Dissolved Oxygen in the subbasins of the Milton Creek watershed fell below the ODEQ threshold for ideal salmonid conditions from June – August (Table 57). Minimum DO at Dart Creek, Milton Creek and Salmon Creek approached the lethal condition threshold (<6mg/L).

McNulty Creek watershed had similar water quality issues to the rest of the watersheds in the monitoring program. Elevated summertime temperatures crossed the 18°C threshold at upper and lower reaches of the watershed, however, these temperatures stayed elevated for longer in Lower McNulty (Table 51). Both monitoring stations at McNulty Creek exceeded ODEQ threshold for turbidity and DO, while the minimum DO at Upper McNulty fell below lethal levels (Table 52, Table 57).

E. coli levels in Milton Creek and McNulty Creek exceeded EPA (>235 MPN/100mL) and ODEQ (406 MPN/100Ml) thresholds for single events regularly throughout the intensive monitoring period (June – December 2022). Average *E. coli* levels in 2022 exceeded the ODEQ thresholds at Cox Creek, Dart Creek and Salmon Creek (Table 53). The 90-day geometric mean threshold of 126 MPN/100ml was exceeded by all 9 locations in Milton Creek Watershed between June to September, and by 8 locations (excluding Salmon creek) between July to November (Table 54). *E. coli* level at Upper McNulty stayed below the 90-day geometric mean threshold, however there were a couple of events which exceeded the ODEQ threshold during the study period.

Animal waste or septic tank leakage into the stream are possible sources to be investigated. Depending on the source, actions that could reduce future *E. coli* exceedance events include increasing riparian buffers, excluding livestock from the creek, increasing manure management near streams, and/or updating failed septic systems throughout the targeted reach of the watershed (Pandey et al. 2014). Given the frequency and scale of *E. coli* bacteria events adding warning signs to recreational areas in these watersheds is also recommended.

More data is forthcoming in the study; however, these trends warrant a closer look at species-level contribution to *E. coli* levels in Milton and McNulty Creek watersheds. eDNA analysis can help determine the origin of fecal contamination in the water, enabling targeted efforts to reduce or eliminate the sources contributing to elevated *E. coli* levels and associated water quality problems.

CONCLUSIONS AND RECOMMENDATIONS

The Columbia County water quality monitoring program was established in 2017 to track and characterize long-term trends in water temperature, turbidity, pH, DO, *E. coli*, and conductivity in Clatskanie River, Beaver Creek, Milton Creek, North Scappoose Creek, and South Scappoose Creek watersheds. A total of 13 sites were selected to provide a comprehensive overview of the County watersheds. In 2022, 2 monitoring stations were introduced at McNulty Creek as part of the long-term monitoring program. Moreover, 7 additional monitoring stations were introduced in Milton Creek watershed as part of an intensive monitoring effort, aimed at identifying subbasins contributing to water quality impairment of mainstem Milton Creek.

Through this study, we were able to identify trends similar across all watersheds in the county and certain characteristics that are unique to each watershed. Detailed maps depicting variations in water quality parameters throughout the six watersheds in the county have been included in Appendix D. Datasets that were created through an intensive monitoring effort in the Scappoose Bay Watershed from 2008 to 2011 were also used to evaluate water quality changes over time. Ongoing water quality issues have been identified and these data can be used to determine priority stream reaches for restoration.

Temperature

During the study period (2017 – 2022), upper and lower watersheds follow similar winter temperature patterns (Dec., Jan., Feb.). These patterns start diverging during mid-to-late spring, with lower watersheds recording elevated temperatures, often exceeding the ODEQ threshold for salmon rearing habitat (18°C, Table 4) during summers. The lower watersheds in the county are usually developed, pastures or residential areas where adequate stream shading is unavailable and temperatures are influenced by runoffs. The only exception to this is Lower Beaver, which recorded warmer summer temperatures compared to the Upper Beaver despite being in a residential, forested area (Figure 23). This is likely due to thermal loading as the water moved through the upper, more developed headwaters and then into the lower, forested reach. 2022 was a much cooler year compared to 2021, and water levels in the Columbia River were higher compared to previous years, owing to the late but sugnificant freshet. However, 2022 did have 3 heatwaves, with one of them lasting longer than previously recorded. Seasonally highest temperatures in the county were recorded during the month of August throughout the study when water levels are low and ambient air temperatures are highest during the monitoring years. Studies have shown that adequate shading reduces stream temperatures (Johnson, 2004).

When temperature data for overlapping months between 2017 – 2021 and 2008-2011 were compared for Milton Creek, North Scappoose Creek, and South Scappoose Creek, an elevated trend was observed in all three watersheds. Year to year regional climate variability is an influential factor for seasonal temperature conditions, however, long-term water temperature increases have also been found in the Columbia River (EPA 2018, EPA 2020), indicating an overall regional trend of warming summer water conditions are likely. Increasing riparian cover and reducing run-off will be important for ensuring long-term resilience in these streams systems, especially with the pressures of ongoing watershed development and climate change (EPA 2020).

The intensive monitoring effort in Milton and McNulty Creek watersheds revealed that summertime temperatures exceed ODEQ thresholds for poor quality habitat and lethal conditions between June and

August at almost all locations. Temperatures at Dart Creek and Lower McNulty Creek stayed above 18°C well into October 2022.

Turbidity

The highest turbidities were recorded in the headwaters of Beaver Creek, McNulty Creek and Milton Creek watersheds. For mainstem sites, South Scappoose Creek consistently had higher turbidity than most other headwater sites. Dart Creek and Upper McNulty sites in the intensive monitoring effort consistently exceeded the 10 NTU threshold in 2022. Ongoing turbidity monitoring is important for identifying erosion and stream stability issues across all watersheds. Similar to recommendations for temperature improvements, increasing riparian cover and reducing runoff can aid in reducing erosion events and sediment loading in stream environments.

E. coli Bacteria

Across all the sites, *E. coli* Bacteria levels were greatest across all watersheds between May through October. Milton Creek generally had the greatest counts of *E. coli*, followed by Lower North Scappoose and Lower South Scappoose. Since 2019, all watersheds violated the ODEQ five sample geometric mean threshold of 126 *E. coli* organisms per 100 mL and experienced individual events exceeding the 406 *E. coli* organisms per 100 mL limit. *E. coli* bacteria issues are indicative of animal waste runoff and can be very harmful to humans using these waterways for recreation (Pandey et al. 2014).

The intensive monitoring effort at Milton Creek and McNulty Creek watersheds revealed that *E. coli* exceedances were occurring throughout the watersheds, and these issues were particularly elevated in subbasins of Dart Creek, Cox Creek, and Salmon Creek. While more data is forthcoming in the study, it is clear that additional research is needed to determine the exact source of the elevated *E. coli* especially in the Milton Creek and McNulty Creek watersheds. More data is required in other watersheds to determine whether the extended timeframe of exceedances is a sustained phenomenon. Animal waste or septic tank leakage into the stream are possible sources to be investigated. Depending on the source, actions that could reduce future *E. coli* exceedance events include increasing riparian buffers, excluding livestock from the creek, increasing manure management near streams, and/or updating failed septic systems throughout the targeted reach of the watershed (Pandey et al. 2014). Given the frequency and scale of *E. coli* bacteria events adding warning signs to recreational areas along these streams, especially in the lower reaches, is recommended. Source-tracing studies in Milton and McNulty Creek watersheds is also recommended.

pH

Across all sites, pH monitoring was included in 2021. Generally, levels stayed within DEQ regulatory standards for ideal stream conditions for salmonids (6.5 – 8.5 SU). Seasonally, pH levels were low during winter months, reaching peak levels in May and then falling back down during fall months. pH ranges tended to increase from upper to lower reaches of most watersheds. There was a high degree of variability observed across all watersheds in 2021-2022.

Dissolved Oxygen (DO)

Across all sites, DO monitoring was included in 2021. Stream DO averages in the watersheds fell below DEQ standards for ideal stream conditions (>11mg/L) between June and October. DO levels tended to increase from upper to lower reaches of the watersheds. Seasonally, elevated DO levels were observed during winter and spring months reaching peak lows during summer before climbing again in the fall. A high degree of variability was observed when 2021-2022 data was compared to 2008-2011 data.

Conductivity

Across all sites, water conductivity levels were within the regional range of <150 µs/cm. Seasonal trends were also observed with conductivity levels increasing during the summer months; this is likely a result of low water levels increasing concentrations in the streams and warmer water conditions generally increasing water conductivity seasonally. These data provide baseline conductivity levels that can be used to identify new and emerging water quality issues or improvements over time. Pollution from runoff or increased turbidity levels from erosion can result in higher conductivity levels; however, there are no EPA or ODEQ thresholds for conductivity in the region.

Next Steps

This water quality monitoring report highlights several water quality impairments the Columbia County Watersheds. To address and mitigate these issues, we recommend the following:

- Given the scale of the *E. coli* issues observed, source-tracing studies such as e-DNA sampling and analyses, especially in Milton Creek and McNulty Creek watersheds is recommended. An evaluation of livestock access to streams and the septic tank systems should be considered to further help identify potential sources of *E. coli* throughout the County watersheds. Focusing on Scappoose Bay watershed sub-basins with an intensified water quality monitoring project could help decipher some of these sources.
- Further analyses of the long-term dataset is recommended to enable more effective evaluation of the impact of restoration measures and inform the development of future strategies to further improve water quality and support the recovery of ESA-listed species. For example, the monitoring data revealed a significant correlation between dissolved oxygen (DO) levels and *E. coli* concentrations (Figure 85), suggesting an issue related to Biochemical Oxygen Demand (BOD) in the streams. Continuous DO monitoring will provide a more comprehensive understanding of the spatial and temporal variations in DO levels throughout the watersheds, which can be used to pinpoint areas of concern where DO levels are consistently low and might be linked to elevated *E. coli* concentrations and other water quality issues.

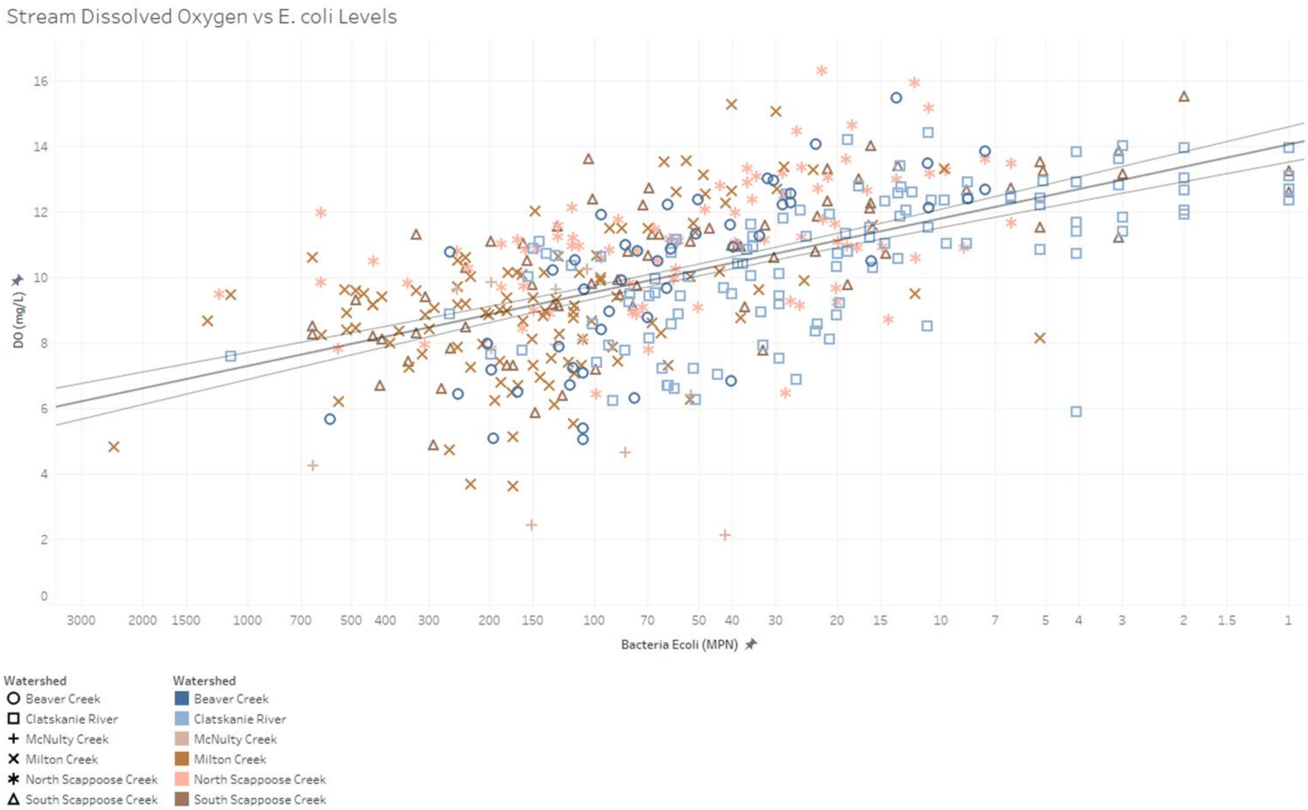


*Figure 85: Evidence of Biological Oxygen Demand (BOD) on streams within the study area. Equation: DO = -0.98*ln(Bacteria Ecoli) + 14. P-value <0.0001*

- Due to the ongoing *E. coli* issues, it is also recommended that warning signs are added to recreational areas along these streams that are accessible to the public, especially in the Lower reaches of Scappoose Watershed.
- A riparian canopy cover analysis of the Scappoose Bay, Clatskanie River, and Beaver Creek watersheds is recommended in order to identify areas where canopy gaps are increasing stream solarization. Once identified, these gaps could be addressed by restoring riparian vegetation buffers to reduce thermal loading on summer water temperatures. Targeted restoration of riparian vegetation and canopy cover could also reduce turbid and bacteria-laden run-off into these streams.
- On the ground and aerial surveys could also be used to identify cold refugia (cold water sources and seeps), which should be protected and enhanced. These surveys could also be used to identify sources of non-point source pollution such as unstable stream banks (turbidity) and livestock use of the streams (bacteria).
- Additional shading and riparian buffers need to be introduced in the lower Scappoose Bay watershed to regulate stream temperatures and *E. coli* events across all monitoring sites.
- Continued water quality monitoring efforts are required to assess the long-term shifts in water quality conditions resulting from restoration, mitigation actions, climate change and severe weather patterns, as well as developmental pressures.

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APPENDICES

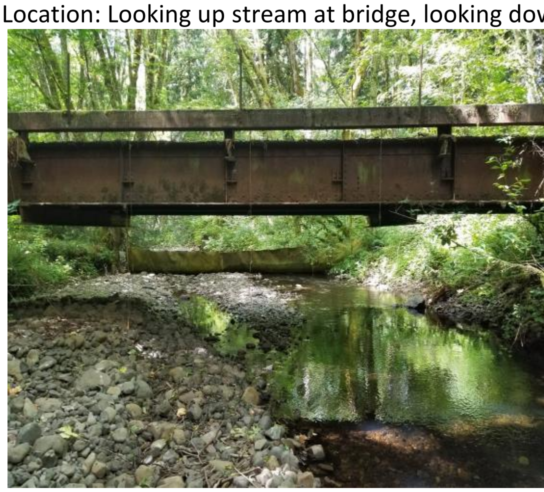
Appendix A: Monitoring Site Locations and Descriptions

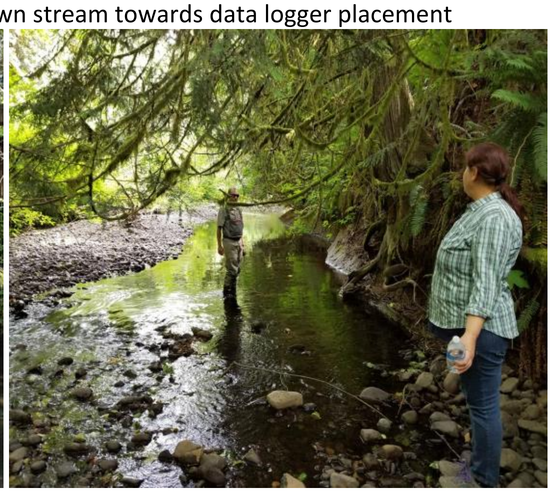
Clatskanie Watershed						
Site Code	**Site Name**	**Description**	**GPS Coordinates**	**Logger Serial Number**	**Installed Date/Time**	**Installed Temp °C**
LC	Lower Clatskanie	Data: Bacteria, Temp/WL, Turbidity	Lat: 46.080002 Long: -123.166841	20112654	8/17/2017 15:30	19.8
Site Code	**Site Name**	**Description**	**GPS Coordinates**	**Logger Serial Number**	**Installed Date/Time**	**Installed Temp °C**
MC	Middle Clatskanie	Data: Temp/WL, Turbidity Private property (must notify owner ahead of time) off of Swedetown road, walk through field behind the home, then cross through an old gate to access river. Data logger placed near an undercut bank with some overhanging roots.	Lat: 46.045193 Long: -123.095813	20112657	6/28/2017 15:28	14.6

Location Image: River access just beyond old fence gate, near bank root overhang

Site Code	Site Name	Description	GPS Coordinates	Logger Serial Number	Installed Date/Time	Installed Temp °C
CAR	Carcus	Data: Temp/WL, Turbidity Stream accessed via private drive off Swedetown Rd, data logger placed a few meters upstream of the bridge (to be out of way of impending construction).	Lat: 46.038533 Long: -123.085543	20112662	6/28/2017 15:54	14.1

Location: Looking up stream at bridge, looking down stream towards data logger placement





Matt standing near data logger placement location, under vine maple (flagged with pink tape)

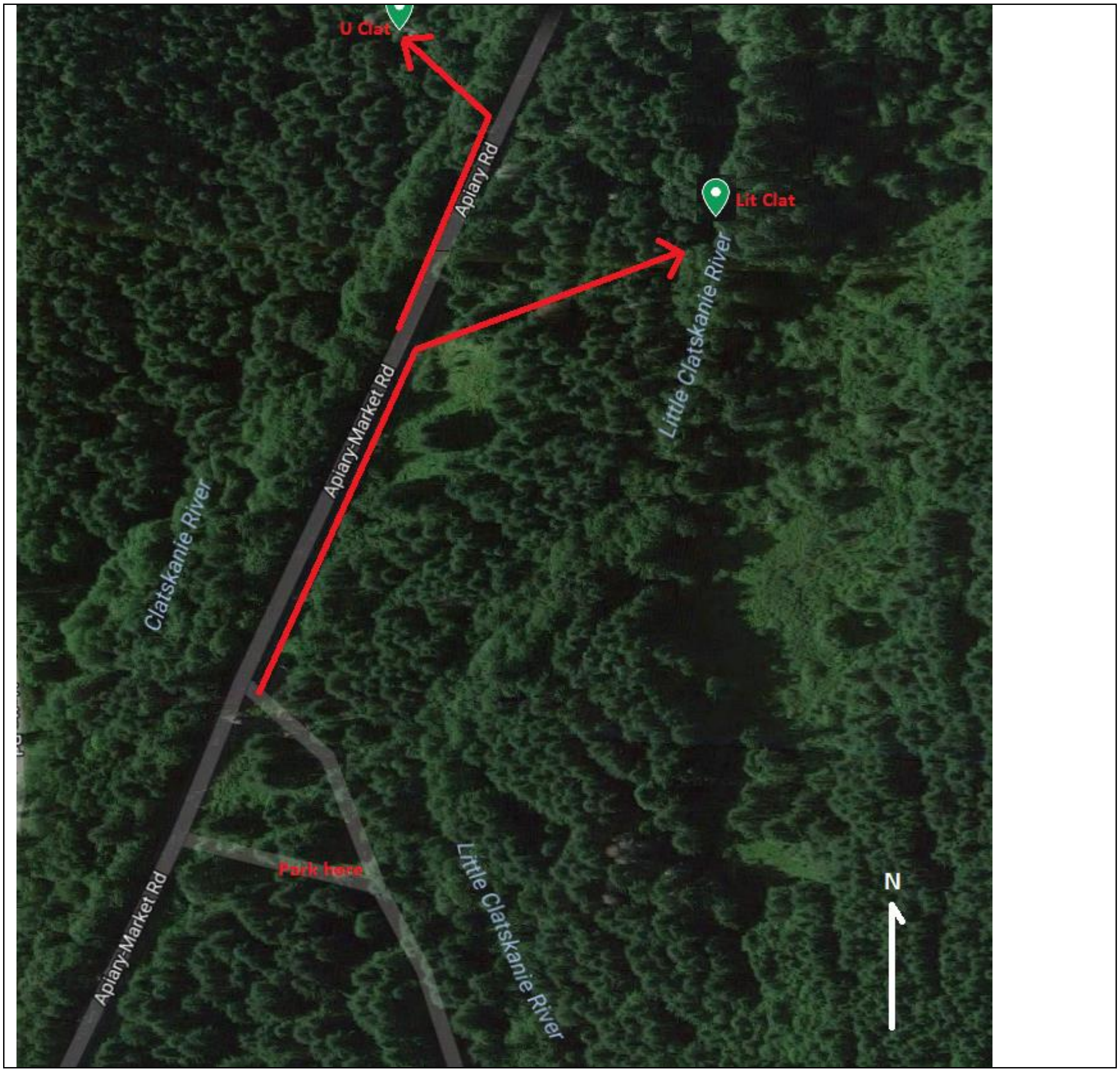
Site Code	**Site Name**	**Description**	**GPS Coordinates**	**Logger Serial Number**	**Installed Date/Time**	**Installed Temp °C**
UC	Upper Clatskanie	Data: Temp/WL, Turbidity Just north of LC location on the other side of the Apiary road. Steep descent from road to stream. Data logger near large rock on road side of river bank.	Lat: 45.987717 Long: -123.040371	20112651	6/29/2017 11:43	12.8

Location images: Data logger located near large rock along the river bank

Site Code	**Site Name**	**Description**	**GPS Coordinates**	**Logger Serial Number**	**Installed Date/Time**	**Installed Temp °C**
LitC	Little Clatskanie	Data: Temp/WL, Turbidity Park at pull out for logging road (on little Clat side of the road) along Apiary Market Rd and then access river via grassy opening along right side of roadside north of car pull out, follow pink flagging to data logger location (downstream of large data logger housing)	Lat: 45.987598 Long: -123.038492	20112659	6/29/2017 11:23	12.7

Location Images:
Grassy opening along right side of road side north of car pull out, data logger is located near flagging next to salmon berry shrub and cedar stump

Map of Upper Clat and Lit Clat locations along Apiary Market Rd



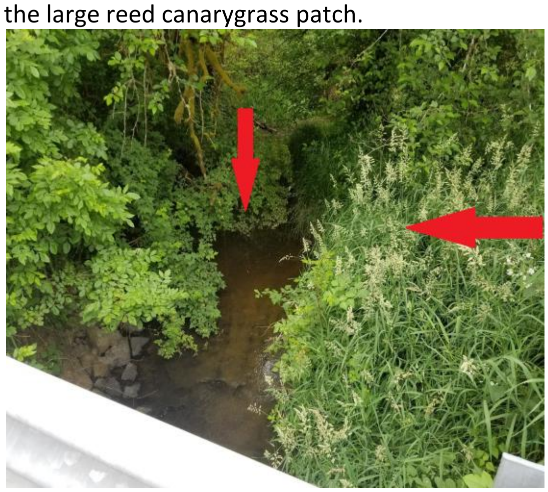
U Clat
Lit Clat
Apiary Rd
Apiary-Market Rd
Little Clatskanie River
Clatskanie River
Park here
Apiary-Market Rd
Little Clatskanie River
N

Beaver Creek Watershed							
Site Code	**Site Name**	**Description**	**GPS Coordinates**	**Logger Serial Number**	**Installed Date/Time**	**Installed Temp °C**
LB	Lower Beaver	Pull out before the bridge at Beaver Falls Rd, data logger placed at the end of a rock pile just upstream of the bridge (large current shrub on shore).	Lat: 46.108942 Long: -123.158919	20112663	6/29/2017 10:09	14.3

Location images: Park on side of the road and access stream on upstream side of bridge, data logger placed at the end of a rock pile just upstream of the bridge (large current shrub on shore). Large rock near data logger placement marked with a black X.

Site Code	Site Name	Description	GPS Coordinates	Logger Serial Number	Installed Date/Time	Installed Temp °C
UB	Upper Beaver UB	Data: Temp/WL, Turbidity Park just past bridge on Fernhill Road (near 73723 Fern Hill Rd), and walk down on the upstream side of the bridge through the large reed canarygrass patch. Located upstream of bridge, under a large current shrub with pink flagging marking its location	Lat: 46.062373 Long: -122.965167	20112653	6/29/2017 10:44	14.0

Location images: Park just past bridge on Fernhill Road (near 73723 Fern Hill Rd Rainier, Oregon), and walk down on the upstream side of the bridge through the large reed canarygrass patch.



Data logger located under Currant shrub on far side of stream.

Scappoose Bay Watershed: Lower Milton Creek						
Site Code	**Site Name**	**Description**	**GPS Coordinates**	**Logger Serial Number**	**Installed Date/Time**	**Installed Temp °C**
LM	Lower Milton	Data: Bacteria, Temp/WL, Turbidity Located in McCormick Park on the downstream side of the Old Portland Road Bridge - under woody debris	Lat: 45.850289 Long: -122.816039	20112656	6/28/2017 11:28	16.3

Location Image (looking down from the bridge, Matt is bending over data logger placement):

Site Code	**Site Name**	**Description**	**GPS Coordinates**	**Logger Serial Number**	**Installed Date/Time**	**Installed Temp °C**
UM	Upper Milton	Data: Temp/WL, Turbidity Downstream side of W. Kappler Rd bridge (very steep), data logger located downstream of bridge under flagged cedar tree.	Lat: 45.864193 Long: -122.886893	20112650	6/29/2017 12:58	15.4

Location images: Downstream of bridge (a bit) near the north stream bank under flagged cedar tree in pool

Scappoose Bay Watershed: North Scappoose Creek						
Site Code	**Site Name**	**Description**	**GPS Coordinates**	**Logger Serial Number**	**Installed Date/Time**	**Installed Temp °C**
LNS	Lower North Scappoose	Data: Bacteria, Temp/WL, Turbidity Pull off HWY 30 just north of bridge along Rosewood lane. Enter stream on the north bank at the railroad bridge (large patch of reed canarygrass) crossing. Data logger tided to old piling (flagged) on north bank of stream under railroad bridge.	Lat: 45.771786	20112652	6/29/2017 14:19	17.2

Location images: Pull off HWY 30 just north of bridge along Rosewood lane.

Enter stream on the north bank at the railroad bridge (large patch of reed canarygrass) crossing. Data logger tided to old piling on north bank of stream under railroad bridge.

Site Code	**Site Name**	**Description**	**GPS Coordinates**	**Logger Serial Number**	**Installed Date/Time**	**Installed Temp °C**
UNS	Upper North Scappoose	Data: Temp/WL, Turbidity Pull off close to the bridge crossing river near 30161 Scappoose Vernonia Hwy. Descend on the upstream side of the bridge on the North bank. Data logger placed on North bank under maple tree (flagged).	Lat: 45.823753 Long: -122.946923	20112655	6/29/2017 13:37	14.4

Location images: Descend on the upstream side of the bridge on the North bank. Data logger placed on North bank under maple tree (flagged).

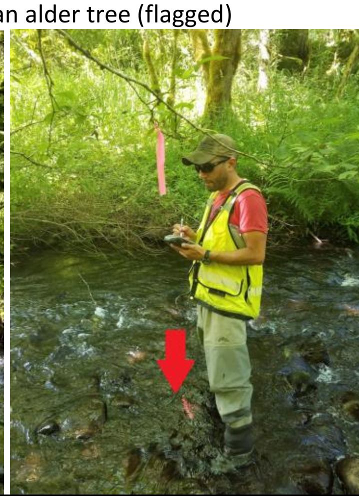
Scappoose Bay Watershed: South Scappoose Creek						
Site Code	**Site Name**	**Description**	**GPS Coordinates**	**Logger Serial Number**	**Installed Date/Time**	**Installed Temp °C**
LSS	Lower South Scappoose	Data: Bacteria, Temp/WL, Turbidity Park at the CZ trail area just off HWY 30, then decent on the south side of the bridge on the upstream side. Data logger tied to piling under bridge on south bank. Piling flagged.	Lat: 45.762739 Long: -122.880973	20112658	6/29/2017 13:59	16.3

Location images:

Site Code	Site Name	Description	GPS Coordinates	Logger Serial Number	Installed Date/Time	Installed Temp °C
USS	Upper South Scappoose	Data: Temp/WL, Turbidity Pull off on the south side of the bridge on Otto Miller Rd just past the Dutch Canyon Rd turn off (see image). Data logger located downstream of bridge under an alder tree (flagged).	Lat: 45.744219 Long: -122.961964	20112664	6/29/2017 14:44	13.7

Location images: Pull off on the south side of the bridge on Otto Miller Rd just past the Dutch Canyon Rd turn off

Data logger located downstream of bridge under an alder tree (flagged)



Appendix B: Supplemental Data Tables

Clatskanie Watershed Supplemental Data Tables

Table 59: Monthly variation in 7dMAM temperatures from 2017 to 2021 for creeks in Clatskanie Watershed. Temperatures have been color-coded according to salmonid thresholds listed in Table 4, with blue representing cooler, ideal conditions, and yellow/orange representing temperatures crossing 18°C.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Little Clatskanie	2017							15.1	16.3	14.4	9.5	8.2	5.2
	2018	6.9	6.2	6.8	9.7	13.4	13.5	16.0	16.7	13.1	9.8	7.7	6.2
	2019	6.2	4.5	6.1	10.1	13.1	14.1	15.3	16.0	16.1	15.8	6.6	5.5
	2020	7.1	6.6	6.8	10.0	12.4	13.6	14.8	15.8	14.5	11.6	7.8	6.6
	2021	6.9	6.0	7.0	10.1	12.4	14.9	17.9	14.6	14.0	9.7	8.9	8.9
Upper Clatskanie	2017							15.1	16.3	14.4	9.5	8.2	5.2
	2018	6.9	6.2	6.8	9.7	13.4	13.5	16.0	16.7	13.3	9.8	7.4	5.2
	2019				9.9	13.5	14.9	16.0	16.7	16.6		6.4	5.3
	2020	7.1	6.8	6.6	10.0	12.2	13.7	15.8	16.9	15.1	11.6	7.5	6.5
	2021	6.9	6.0	6.8	10.1	12.7	15.6	18.1	17.8	14.0	9.8	8.6	8.7
Carcus Creek	2017							15.2	16.5	14.9	10.3	8.7	6.2
	2018	7.5	6.9	7.1	8.7							7.3	6.7
	2019	6.7	5.3	6.2	9.4	11.6	13.5	15.0	15.9	16.2		7.3	6.0
	2020	7.5	7.3	7.1	9.7	11.6	13.0	14.6	15.9	14.7	11.8	8.1	7.1
	2021	7.4	6.4	7.4	9.9	11.6	14.0	16.5	16.7	14.0	10.4	9.3	
Middle Clatskanie	2017							16.8	17.8	15.6	10.3	8.6	5.8
	2018	7.3	6.7	7.1	9.7	13.7	14.5	17.4	17.9	14.3	12.0		
	2019				10.3	13.4	15.5	17.2	18.0	17.4		7.2	5.8
	2020	7.4	7.1	7.1	10.1	12.7	14.4	16.6	18.3	16.0	12.3	8.1	7.1
	2021	7.4	6.5	7.5	10.4	13.0	18.4	20.8	19.2	15.3	10.9	9.3	
Lower Clatskanie	2017								19.1	17.2	12.4		
	2018											7.4	6.9
	2019	7.0	5.4	7.0	10.7	14.7	17.4	19.0	19.0	19.1	9.0	7.3	6.1
	2020	7.6	7.3	7.5	10.8	13.9	15.8	17.9	19.7	16.9	15.6	8.3	8.7
	2021	9.6	7.3	9.3		15.0	17.6	20.7	20.0	16.6	11.7	9.6	

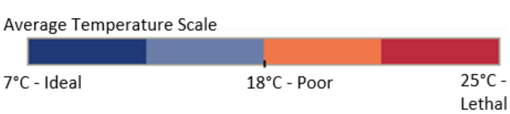


Table 60: Summary Table of Clatskanie Watershed Monthly Turbidity (NTU), 2017-2021. Grab Samples. Grab sampling results for Clatskanie watershed broken down across years and watershed sampling locations.

Summary Table: Clatskanie Watershed Monthly Mean Turbidity (NTU)
2017-2021 Grab Samples

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	Little Clatskanie							0.5		3.6	1.5	5.1	
	Upper Clatskanie							1.6		3.2	2.8	5.1	
	Carcus							0.0		0.4	2.0	2.2	
	Middle Clatskanie							0.5		0.7	1.1	3.0	
	Lower Clatskanie									0.9	1.1	4.5	
2018	Little Clatskanie		3.7	5.3	4.2	3.6	1.4	0.9	2.9	1.2	4.2	3.7	6.8
	Upper Clatskanie		3.7	4.7	4.6	3.7	2.6	3.1	1.9	5.3	2.4	3.0	7.5
	Carcus		1.8	1.4	3.1	0.8	0.9	0.6	0.5	0.8	0.7	0.7	2.4
	Middle Clatskanie		2.5	2.9	3.5	1.4	1.1	1.2	0.8	2.1	1.1	1.4	4.6
	Lower Clatskanie		2.9	3.0	4.4	1.5	1.1	1.1	0.9	2.2	0.9	1.0	4.0
2019	Little Clatskanie	3.5		4.6	3.7	3.8	5.2	2.3		1.1	1.8	2.5	7.4
	Upper Clatskanie	3.0		5.1	3.6	2.8	2.4	2.6		2.4	2.8	2.2	7.4
	Carcus	1.3		2.1	1.1	1.0	0.8	1.2		0.9	0.9	0.3	7.8
	Middle Clatskanie	2.3		3.5	1.7	1.1	1.3	1.2	1.7	1.6	2.5	0.7	3.6
	Lower Clatskanie	2.4		3.1	1.5	1.0	0.6	1.0	1.1	2.1	1.7	0.6	3.0
2020	Little Clatskanie	8.3	3.2	5.1	5.0	3.2	2.5	3.5	4.7	2.7	1.9	6.7	5.2
	Upper Clatskanie	4.7	3.2	2.9	3.2	3.3	2.7	2.5	2.3	3.4	2.2	5.4	4.6
	Carcus	2.7	1.8	1.6	1.0	1.5	3.3	4.2	1.9	2.2	0.5	2.1	1.5
	Middle Clatskanie	3.5	2.8	2.0	1.6	1.5	1.2	0.9	0.9	1.2	1.7	2.5	2.7
	Lower Clatskanie	3.8	3.3	1.4	1.6	1.0	1.1	0.6	0.8	1.5	0.7	2.3	3.6
2021	Little Clatskanie	7.8	4.4	3.0	3.9	6.3	4.0	1.4	2.3	2.4	3.4	3.6	4.3
	Upper Clatskanie	5.3	3.5	2.9	2.7	2.9	2.6	2.2	2.2	2.8	2.5	5.6	4.3
	Carcus	3.6	4.6	1.6	1.3	1.2	1.1	1.1	2.3	0.6	0.5	2.1	5.6
	Middle Clatskanie	5.6	3.0	2.9	1.6	1.4	0.8	1.2	1.2	1.1	1.0	9.4	2.9
	Lower Clatskanie	5.6	3.0	3.4	1.9	1.7	0.9	1.0	1.2	1.4	1.5	9.7	2.8

Table 61: Summary Table of Clatskanie Watershed Monthly E. coli (2017-2021) MPN/100 ml Grab Samples. E. coli bacteria grab sampling results for Clatskanie watershed broken down across years and watershed sampling locations. Sampling locations that experienced events over the EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted in red.

Summary Table: Milton Creek Watershed Monthly Max *E. coli* (MPN/100 ml) 2017-2021 Grab Samples

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Little Clatskanie	2017												
	2018												
	2019						140	50		23	6	4	10
	2020	15	9	3	35	9	87	27	345	105	126	91	53
	2021	23	8	2		11	261	64	89	79	96	15	15
Upper Clatskanie	2017												
	2018												
	2019						144	41		59	22	2	10
	2020	3	3	3	6	14	60	54	365	150	19	58	43
	2021	5	1	3		20	54	62	30	60	16	4	5
Carcus	2017												
	2018												
	2019						5	18		126	10	0	0
	2020	8	2	9	1	3	16	21	29	114	15	12	15
	2021	5	2	1	2	3	5	57	30	39	11	3	28
Middle Clatskanie	2017												
	2018												
	2019						2,490	166	46	99	15	13	20
	2020	185	7	9	99	31	36	58	156	248	248	153	28
	2021	26	4	2	2	36	37	70	101	130	144	13	13
Lower Clatskanie	2017									44	69		
	2018												
	2019						35	271	111	132	19	15	13
	2020	13	8	14	27	76	41	82	77	190	36	127	23
	2021	20	6	6	26	19	30	82	91	79	150	58	29

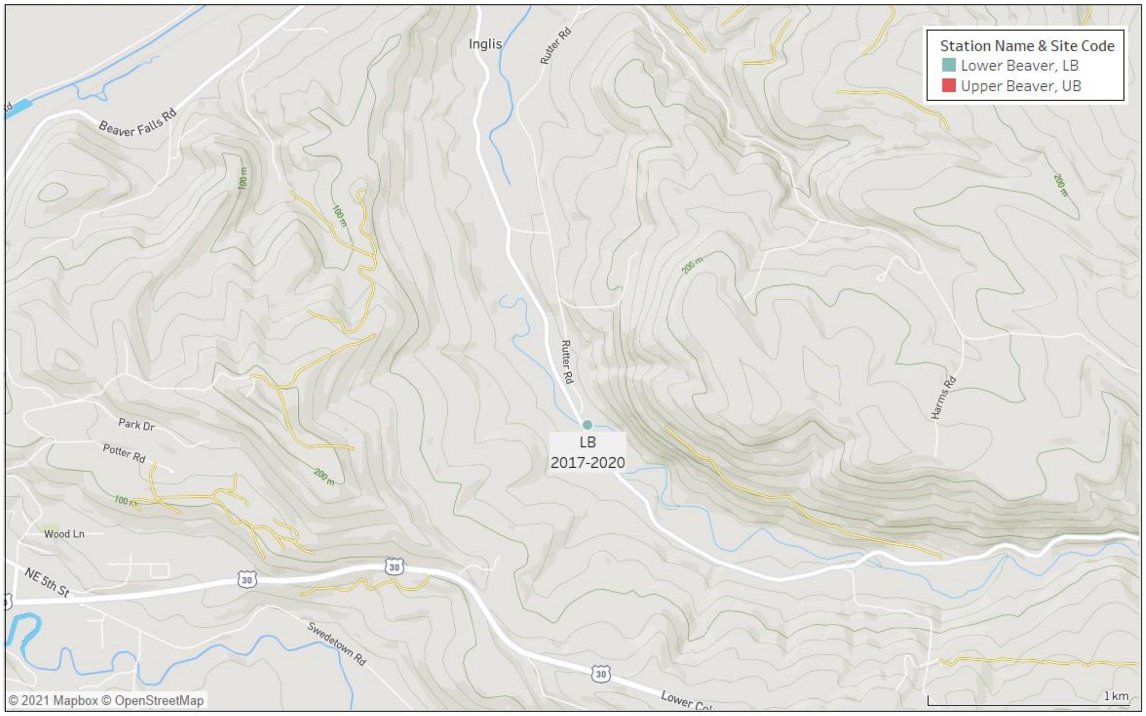
Table 62: Summary Table of Clatskanie Watershed Monthly Mean Conductivity Levels (µs/cm) 2018-2021. Grab samples results for Clatskanie watershed broken down across years and watershed sampling locations.

Clatskanie Watershed Monthly Mean Conductivity (µs/cm)
2018-2021 Grab Samples

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018	Little Clatskanie							77.3	84.7	81.8	64.6	54.5	31.1
	Upper Clatskanie							73.5	79.8	66.3	63.7	48.4	32.4
	Carcus							52.8	56.7	54.0	50.6	35.8	28.6
	Middle Clatskanie							68.7	72.6	68.8	64.0	48.6	32.8
	Lower Clatskanie							83.1	88.2	84.9	79.5	63.0	41.2
2019	Little Clatskanie	24.7		25.7	33.1	59.5	78.5	71.4		102.9	89.9	76.8	62.2
	Upper Clatskanie	24.7		24.9	32.0	56.3	71.3	70.6		109.4	91.0	78.5	67.3
	Carcus	23.3		23.2	28.4	47.4	63.6	58.7		71.4		62.3	55.5
	Middle Clatskanie	26.6		27.1	34.3	57.1	71.4	85.3	95.1	93.2		88.2	73.7
	Lower Clatskanie	33.2		33.5	43.8	70.4	85.9	93.3	104.4	104.1		103.3	86.9
2020	Little Clatskanie	38.0	38.0	33.9	55.6	48.8	63.3	78.5	100.9	107.4	84.1	56.1	50.2
	Upper Clatskanie	34.3	34.1	40.3	54.8	55.5	63.8	73.6	95.1	94.8	91.4	37.3	45.4
	Carcus	33.3	31.2	32.3	44.8	48.8	49.8	56.4	67.8	72.8	130.7	43.6	14.6
	Middle Clatskanie	39.4	38.3	41.5	63.7	63.2	69.6	77.7	100.2	100.3	98.2	59.4	49.9
	Lower Clatskanie	44.1	43.2	61.4	68.7	72.8	83.4	87.6	105.9	110.9	107.0	67.4	57.6
2021	Little Clatskanie	36.9	23.9	24.9	37.5	50.9	59.0	79.5	89.3	81.4	67.3	36.1	29.4
	Upper Clatskanie	33.7	22.3	23.1	37.5	50.4	58.5	77.2	84.3	73.3	67.4	42.5	29.8
	Carcus	32.8	20.6	21.8	31.0	39.8	44.7	55.7	61.2	59.7	54.7	38.3	27.0
	Middle Clatskanie	37.8	24.2	25.8	43.9	55.1	61.8	81.5	92.9	84.6	76.6	48.9	32.8
	Lower Clatskanie	42.3	26.4	30.6	47.4	63.6	72.9	90.1	97.3	92.3	105.3	56.7	38.1

Beaver Creek Watershed Supplemental Data Tables

Beaver Creek Monitoring Locations (2017-2020)



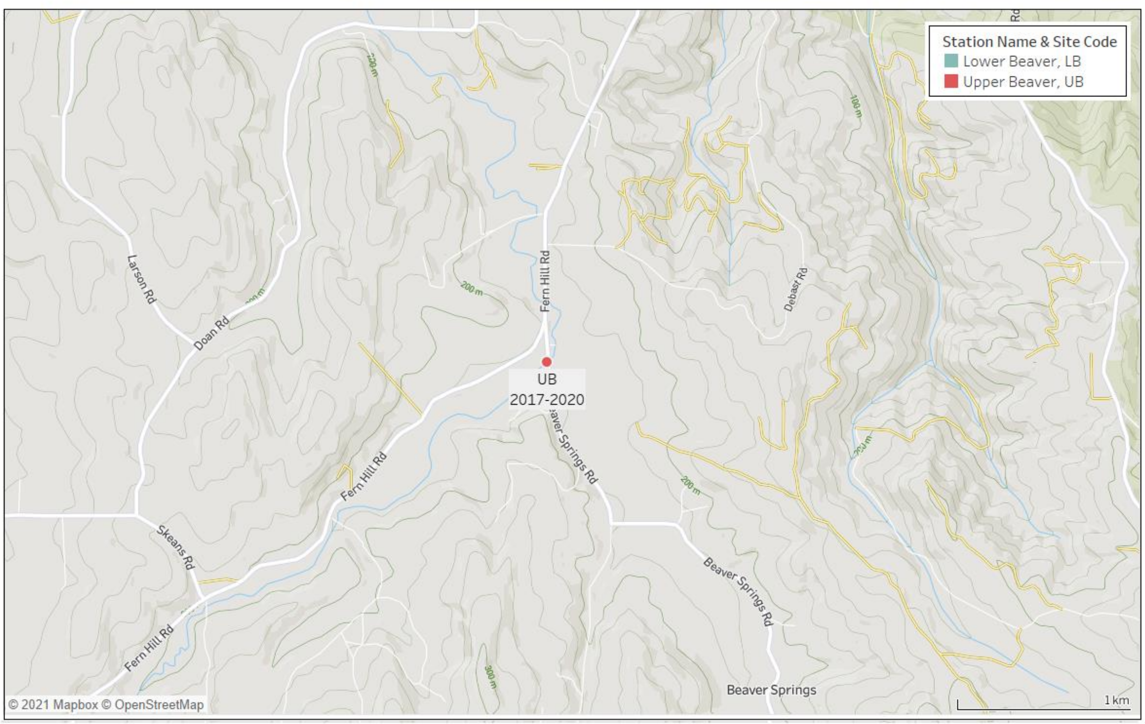


Figure 86: Beaver Creek Monitoring Locations, focused maps higlighting near by road and waterways.

Table 63: Monthly variation in 7dMAM temperatures from 2017 to 2021 for creeks in Beaver Creek Watershed. Temperatures have been color-coded according to salmonid thresholds listed in Table 4, with blue representing cooler, ideal conditions and yellow/orange representing temperatures crossing 18°C.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Beaver	2017							16.7	18.1	15.5	9.8	8.5	5.8
	2018	7.4	6.8	7.2	10.0	14.2	14.8	17.4	17.8	14.0	10.2	7.6	6.3
	2019	6.7	5.0	6.6	10.2	13.8	15.4	17.0	17.3	17.5	8.5	6.0	5.6
	2020	7.5	7.2	7.2	10.4	13.2	14.9	16.2	17.4	15.4	12.2	8.1	7.1
	2021	7.5	6.5	7.3	10.4	13.0	15.7	18.2	17.9	15.1			
Lower Beaver	2017							18.8	19.6	16.8	10.8	8.7	5.4
	2018	7.3	6.7	7.1	10.1	14.8	16.1	19.4	19.2	15.3	11.5	8.0	6.3
	2019	6.5	4.6	6.5	10.6	14.3	16.6	18.4	19.3		9.2	7.0	5.8
	2020	7.6	7.2	7.4	10.8	13.8	15.8	17.8	19.5	17.0	12.8	8.2	7.1
	2021	7.4	6.4	7.5	11.0	13.8	17.3	20.1	19.5	16.0	11.1	9.5	9.6

Average Temperature Scale

7°C - Ideal 18°C - Poor 25°C - Lethal

Table 64: Summary Table of Beaver Creek Watershed Monthly Turbidity (NTU), 2018-2021. Grab Samples. Grab sampling results for Clatskanie watershed broken down across years and watershed sampling locations. Mean monthly turbidity levels over the 10 NTU threshold are highlighted in red.

Summary Table: Beaver Watershed Monthly Mean Turbidity (NTU)
2017-2021 Grab Samples

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Beaver	2017							8.9		10.8	6.9	5.0	
	2018		5.4	5.0	6.2	6.6	5.4	11.2	6.0	8.5	5.8	5.0	6.1
	2019	5.3		6.2	4.7	4.9	7.1	8.5	12.3	9.5	8.0	5.6	7.2
	2020	5.6	4.4	4.3	4.4	4.9	6.5	5.4	9.1	8.7	8.3	9.8	4.8
	2021	6.3	5.1	3.7	5.9	5.5	7.1	14.4	7.9	9.9	7.2	8.0	7.5
Lower Beaver	2017							1.1	1.2	1.3	1.5	5.9	
	2018		4.1	4.7	5.3	3.0	1.4	1.4	1.4	4.5	2.4	3.1	6.7
	2019	3.8		5.9	4.0	2.7	1.6	2.6		1.8	2.2	2.0	6.2
	2020	5.9	3.9	3.6	3.3	4.1	3.8	2.1	3.3	2.7	3.2	4.6	5.4
	2021	8.2	4.6	2.9	4.3	3.1	2.8	2.5	2.1	2.6	2.8	3.5	6.9

Table 65: Summary Table of Beaver Creek Watershed Monthly Mean Conductivity Levels (µs/cm) 2018-2021. Grab samples results for Clatskanie watershed broken down across years and watershed sampling locations.

Beaver Creek Watershed Monthly Mean Conductivity (µs/cm)
2018-2021 Grab Samples

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Beaver	2018								84.50	73.40	59.40	46.10	36.70
	2019	32.50		32.70	39.80	59.70	43.40	83.20	95.50	90.70	86.30	70.70	68.70
	2020	51.20	50.30	54.15	58.10	61.50	70.40	79.60	98.65	94.07	83.60	59.80	53.80
	2021	51.80	33.60	32.90	39.10	51.10	74.30	79.45	84.65	75.30	71.80	46.30	36.10
Lower Beaver	2018							99.40	109.40	96.80	86.40	57.80	40.10
	2019	34.00		35.90	46.40	72.50	89.70	103.60		128.50	117.70	90.00	81.00
	2020	53.20	53.60	50.75	68.30	71.80	84.00	96.75	125.95	122.60	110.20	69.00	58.70
	2021	53.10	34.80	35.20	47.70	63.80	75.00	98.85	113.30	102.65	97.90	58.10	39.00

Milton Creek Watershed Supplemental Data Tables

Table 66: Monthly variation in 7dMAM temperatures from 2017 to 2021 for Upper Milton and Lower Milton creeks. Temperatures have been color-coded according to salmonid thresholds listed in Table 4, with blue representing cooler, ideal conditions, and yellow/orange representing temperatures crossing 18°C. Temperatures close to or exceeding lethal conditions have been represented in red.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Milton (UM)	2017							18.4	19.6	16.7	10.4	8.4	5.6
	2018	7.7	7.1	7.5	10.0	14.4	15.5	18.9	19.3	15.1	10.9	7.5	6.2
	2019	6.7	5.2	6.6	10.4	14.0	16.5	17.8	18.7	19.2		6.8	5.6
	2020	7.9	7.6	7.3	10.6	13.2	18.2	17.6	19.0	16.3	12.7	7.4	6.6
	2021	7.9	6.9	7.5	10.5	13.3	17.2	20.2	19.9	15.8	10.9	9.0	
Lower Milton (LM)	2017							22.4	22.8	19.3	12.1	9.0	5.6
	2018	7.7	7.3	8.0	10.9	17.2	19.1	23.2	22.7	17.8	12.8	8.6	6.4
	2019	6.8	5.4	7.8	11.9	17.0	19.7	21.2	21.8	22.0		7.5	5.9
	2020	7.9	7.6	8.5	12.6	16.0	18.1	21.0	22.7	19.1	14.2	8.3	6.8
	2021	7.9	6.8	8.5	13.3	16.2	21.1	24.1	19.5	18.3	12.6	9.8	

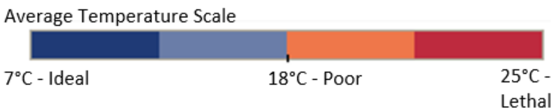


Table 67: Milton Creek Watershed Monthly Turbidity (NTU), 2008-2021. Grab Samples. Grab sampling results for Clatskanie watershed broken down across years and watershed sampling locations. Mean monthly turbidity levels over the 10 NTU threshold are highlighted in red.

Summary Table: South Scappoose Creek Watershed Monthly Mean Turbidity (NTU)
2008-2021 Grab Samples

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Milton	Milton Creek, MIL024	2008							3.5		2.9			
		2009	6.7			3.5		2.9	2.6	3.5	2.8	2.8	6.3	
		2010	7.9	4.9	5.0	13.8	6.9	6.8	5.2	5.3	4.0			
		2011				7.3	6.4	5.2	5.3					
	Salmon Creek, SAL148	2008							8.8		9.4	10.0		
		2009	4.5	6.9	5.2	5.0		7.4	9.5	15.6	14.3	6.5	6.5	
		2010	7.7	4.5	7.0	4.9	6.6	8.4	9.0	14.0	14.3			
		2011					6.1	7.8	11.5					
	Upper Milton, UM	2017							5.1		9.6	5.4	11.5	
		2018		4.8	6.6	6.5	5.1	6.4	8.8	5.4	6.7	7.0	3.8	9.8
		2019	5.6		8.0	4.8	5.7	5.3	5.3	11.5	7.9	5.4	2.8	7.4
		2020	9.5	5.6	4.5	4.1	4.3	5.2	7.0	6.7	5.6	6.3	6.6	5.5
		2021	13.7	5.7	3.7	4.6	4.7	5.4	5.6	5.4	4.3	14.5	5.1	7.8
Lower Milton	Lower Milton, LM	2017							2.3	2.5	3.0	3.0	7.6	
		2018		4.8	5.6	6.0	4.5	5.1	5.0	3.2	3.5	4.8	4.5	8.7
		2019	4.6		7.3	4.3	4.0	3.5	6.5	11.0	8.0	2.9	1.9	10.9
		2020	11.4	5.4	3.8	4.0	4.5	3.9	3.5	4.5	7.5	3.8	4.3	7.9
		2021	16.4	8.3	6.2	3.4	2.7	5.4	4.2	2.9	6.4	3.2	10.4	9.9
	Milton Creek, MIL002	2008							4.2		5.8			
		2009	6.5			3.9	6.2	4.6	4.3	5.4	6.2	5.2	8.7	
		2010	13.0	7.8	7.0	15.3	10.2	6.8	5.7		5.7			
		2011				10.9	6.1	6.2	6.1					

Table 68: Summary Table of Milton Creek Watershed Turbidity (NTU), 2008-2021. Grab Samples. Grab sampling results for Clatskanie watershed broken down across years and watershed sampling locations. Mean monthly turbidity levels over the 10 NTU threshold are highlighted in red.

Summary Table: Milton Creek Watershed Turbidity Levels (NTU)
2008-2021 Grab Samples

			n	Max	Mean	+/- SD
Upper Milton	Milton Creek, MIL024	2008	2	3.5	3.2	0.5
		2009	8	6.7	3.9	1.7
		2010	9	13.8	6.7	2.9
		2011	4	7.3	6.0	1.0
	Salmon Creek, SAL148	2008	4	13.1	9.6	2.6
		2009	10	15.6	8.1	3.9
		2010	11	14.3	8.2	3.3
		2011	3	11.5	8.5	2.8
	Upper Milton, UM	2017	4	11.5	7.9	3.1
		2018	11	9.8	6.5	1.7
		2019	14	11.5	6.3	2.6
		2020	16	9.5	6.0	1.5
		2021	15	14.5	6.4	3.3
Lower Milton	Lower Milton, LM	2017	5	7.6	3.7	2.2
		2018	11	8.7	5.1	1.5
		2019	15	13.5	5.9	3.8
		2020	16	12.5	5.5	2.8
		2021	15	16.4	6.2	3.9
	Milton Creek, MIL002	2008	2	5.8	5.0	1.1
		2009	9	8.7	5.7	1.5
		2010	8	15.3	8.9	3.6
		2011	5	10.9	7.1	2.1

Table 69: Milton watershed monthly max E. coli (MPN/100 ml) grab samples. Grab sampling results for broken down across years and watershed sampling locations. Sampling locations that experienced events over the EPA

(235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted in red. n = number of samples collected.

Summary Table: Milton Creek Watershed Monthly Max *E. coli* (MPN/100 ml)
2008-2021 Grab Samples

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Milton	Milton Creek, MIL024	2008												
		2009			5					68				
		2010						12		248				
		2011												
	Upper Milton, UM	2017												
		2018						62	90	36				
		2019						121	411	219	365	72	24	78
		2020	120	5	13	26	228	214	326	119	192	38	205	36
		2021	18	40	42	70	96	141	135	186	1,300	115	25	83
Lower Milton	Milton Creek, MIL002	2008							248					
		2009			210		228	326	187	365	129	525		
		2010	38	51	16		140	435	87	435	126			
		2011				144	34	115	166					
	Lower Milton, LM	2017							248	61	1,046	365		
		2018						67	291	322				
		2019						488	185	138	980	166	86	219
		2020	28	25	59	156	167	219	387	205	461	365	111	147
		2021	308	29	24	52	162	179	248	133	1,120	178	91	148

Table 70: Summary table of Milton Creek watershed E. coli (MPN/100 ml) grab samples. Grab sampling results for broken down across years and watershed sampling locations. Sampling locations that experienced events over the EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted in red. n = number of samples collected.

Summary Table: Milton Creek Watershed Monthly Max *E. coli* (MPN/100 ml)
2008-2021 Grab Samples

			n	Max	Mean	+/- SD
Upper Milton	Milton Creek, MIL024	2008	0			
		2009	2	68	37	45
		2010	2	248	130	167
		2011	0			
	Upper Milton, UM	2017	0			
		2018	3	90	63	27
		2019	10	411	173	141
		2020	16	326	117	93
		2021	15	1,300	191	316
Lower Milton	Milton Creek, MIL002	2008	1	248	248	
		2009	7	525	281	134
		2010	8	435	166	171
		2011	4	166	115	58
	Lower Milton, LM	2017	4	1,046	430	429
		2018	3	322	227	139
		2019	11	980	259	263
		2020	16	461	187	124
		2021	15	1,120	209	268

Table 71: Milton Creek Watershed Monthly Mean Conductivity Levels (µs/cm) 2008-2021. Grab samples results for watershed broken down across years and watershed sampling locations.

Milton Creek Watershed Monthly Mean Conductivity (µs/cm)
2008-2021 Grab Samples

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Milton	Milton Creek, MIL024	2008							88.9		98.0			
		2009	44.2		47.4	54.7	50.8	74.4	60.4	73.2	98.8	89.7	65.5	
		2010	40.1	53.1	50.2	49.2		57.6	76.3	85.5	91.2			
		2011				46.0	50.6	65.9	69.9					
	Salmon Creek, SAL148	2008							71.4		76.3	66.7		
		2009	41.7	43.4	40.8	35.5		49.7	77.7	83.3	82.8	49.9	42.5	
		2010	24.7	26.3	4.6	40.0	41.7	47.9	60.3	74.1	81.3			
		2011					45.6	54.7	64.6					
	Upper Milton, UM	2018							65.5	78.5	73.6	47.8	49.6	37.1
		2019	28.4		28.4	36.1	42.8	67.5	70.4	84.1	83.2	84.2	77.0	70.0
		2020	38.5	40.2	49.6	57.5	62.8	66.7	75.5	91.3	94.2	89.8	72.9	55.9
		2021	38.1	25.7	26.6	37.4	49.8	56.1	78.2	83.3	71.3	67.7	47.3	34.2
Lower Milton	Milton Creek, MIL002	2008							88.7		102.3			
		2009	49.0		57.6	59.6	29.9	66.6	80.8		99.3	90.4	77.0	
		2010	44.7	54.0	51.9	56.0	51.1	58.7	72.3	91.7	95.5			
		2011				46.7	51.0	61.7	69.7					
	Lower Milton, LM	2018							71.1	107.8	105.5	67.1	53.0	44.2
		2019	34.3		33.8	38.4	71.4	64.7	80.1	97.4	87.9	92.1	56.3	74.4
		2020	41.3	43.5	52.0	60.9	73.9	70.2	76.3	113.7	96.4	95.5	104.4	64.8
		2021	42.1	27.2	29.0	45.3	54.0	89.7	89.7	95.3	99.8	106.5	52.3	41.4

Table 72: Summary Table of Milton Creek Watershed Conductivity Levels (µs/cm) 2008-2021. Grab samples results for watershed broken down across years and watershed sampling locations.

Summary Table: Milton Creek Watershed Conductivity Levels (µs/cm)
2008-2021 Grab Samples

			n	Max	Mean	+/- SD
Upper Milton	Milton Creek, MIL024	2008	2	98	93	6
		2009	10	99	66	18
		2010	8	91	63	19
		2011	4	70	58	12
	Salmon Creek, SAL148	2008	4	76	70	6
		2009	10	83	55	19
		2010	11	81	44	22
		2011	3	65	55	10
	Upper Milton, UM	2018	6	79	59	16
		2019	14	89	64	21
		2020	17	98	71	20
		2021	15	89	57	21
Lower Milton	Milton Creek, MIL002	2008	2	102	95	10
		2009	9	99	68	22
		2010	9	96	64	18
		2011	5	70	56	9
	Lower Milton, LM	2018	6	108	75	27
		2019	15	97	70	21
		2020	17	131	78	26
		2021	15	121	70	30

North Scappoose Creek Watershed Supplemental Data Tables

Table 73: Monthly variation in 7dMAM temperatures from 2017 to 2021 for Upper North Scappoose and Lower North Scappoose creeks. Temperatures have been color-coded according to salmonid thresholds listed in Table 4, with blue representing cooler, ideal conditions and yellow/orange representing temperatures crossing 18°C. Temperatures close to or exceeding lethal conditions have been represented in red.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper North Scappoose (UNS)	2017							18.1	18.8	16.1	9.8	8.1	5.3
	2018	7.2	6.5	7.0	9.5	13.7	15.1	18.4	19.0	14.7	10.5	7.0	5.9
	2019	6.4	5.0	6.1	9.8	13.3	16.0	15.9				6.1	5.1
	2020			7.7	9.7	12.7	14.6	17.0	18.2	15.9	12.0	7.4	6.6
	2021	7.4	6.4	7.1	9.8	13.0	16.8	19.5	19.3	15.2	12.2		
Lower North Scappoose (LNS)	2017							20.5	21.5	18.2	11.4	8.6	5.4
	2018	7.5	6.9	7.5	10.0	14.9	16.7	21.1	21.0	16.9	12.2	8.1	6.3
	2019	6.6	5.3	6.9	10.7	14.8	18.1	19.5	20.6	21.3		7.4	5.1
	2020			9.4	11.4	14.3	16.6	19.4	21.0	17.8	13.4	8.1	6.9
	2021	7.8	6.8	8.1	11.7	14.7	19.3	22.5	21.8	17.8	13.7		

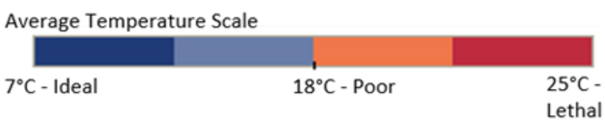


Table 74: North Scappoose Watershed Monthly Turbidity (NTU), 2008-2021. Grab Samples. Grab sampling results for Clatskanie watershed broken down across years and watershed sampling locations. Mean monthly turbidity levels over the 10 NTU threshold are highlighted in red.

Summary Table: North Scappoose Creek Watershed Monthly Mean Turbidity (NTU)
2017-2021 Grab Samples

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper North Scappoose	Alder Creek, ALD077	2008								2.1		4.0		2.9
		2009	5.1									2.1	2.5	
		2010	8.3	4.8	5.2	5.6	4.4	3.2	3.0	2.3	2.6			
		2011				4.4	3.8	2.8	4.3					
	Upper North Scappoose, UNS	2017							1.6		2.4	2.0	4.9	
		2018		3.6	4.1	5.3	1.9	2.2	3.0	2.0	2.3	1.8	1.7	3.6
		2019	3.4		7.0	3.1	1.8	1.9	3.3	2.2	3.1	1.6	1.1	3.2
		2020	8.9	5.4	2.5	2.0	2.7	4.9	1.9	2.9	3.5	2.5	2.7	3.4
		2021	18.8	5.6	3.7	2.0	1.8	1.5	2.4	1.8	2.9	2.9	2.8	3.5
Lower North Scappoose	Lower North Scappoose, LNS	2017							1.1	1.3	1.3	1.3	5.2	
		2018		4.3	4.6	5.0	2.0	1.8	3.0	1.9	2.5	2.2	1.0	3.8
		2019	3.1		5.8	2.4	2.0	4.7	2.5	2.0	4.2	1.7	0.8	4.8
		2020	10.1	4.3	2.3	2.0	3.5	1.7	2.0	1.9	3.1	1.8	1.4	3.9
		2021	16.5	5.5	3.1	2.0	2.1	1.5	2.3	2.1	3.3	2.1	2.1	3.5
	North Scappoose, NSC001	2008							1.9			1.4		
		2009	2.6	11.2	3.4	2.1	2.6	1.6	6.4	3.8		1.4	2.1	
		2010	7.3	4.9	5.3	5.4	4.2	5.2	2.5	2.0	2.7			
		2011					3.3	3.2						

Table 75: Summary Table of North Scappoose Creek Watershed Turbidity (NTU), 2008-2021. Grab Samples. Grab sampling results for Clatskanie watershed broken down across years and watershed sampling locations. Mean monthly turbidity levels over the 10 NTU threshold are highlighted in red.

Summary Table: North Scappoose Creek Watershed Turbidity Levels (NTU)
2017-2021 Grab Samples

			n	Max	Mean	+/- SD
Upper North Scappoose	Alder Creek, ALD077	2008	3	4.0	3.0	0.9
		2009	3	5.1	3.2	1.6
		2010	10	8.3	4.4	1.8
		2011	4	4.4	3.8	0.7
	Upper North Scappoose, UNS	2017	4	4.9	2.7	1.5
		2018	11	5.3	2.9	1.2
		2019	14	7.0	2.9	1.9
		2020	16	8.9	3.4	1.8
		2021	15	18.8	3.8	4.3
Lower North Scappoose	Lower North Scappoose, LNS	2017	5	5.2	2.0	1.8
		2018	11	5.0	2.9	1.3
		2019	15	7.2	3.2	2.0
		2020	16	10.1	3.0	2.1
		2021	15	16.5	3.6	3.7
	North Scappoose, NSC001	2008	2	1.9	1.6	0.4
		2009	11	11.2	4.0	3.7
		2010	10	7.3	4.4	1.7
		2011	2	3.3	3.2	0.0

Table 76: North Scappoose Creek watershed monthly max E. coli (MPN/100 ml) grab samples. Grab sampling results for broken down across years and watershed sampling locations. Sampling locations that experienced events over the EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted in red. n = number of samples collected.

Summary Table: North Scappoose Creek Watershed Monthly Max *E. coli* (MPN/100 ml)
2008-2021 Grab Samples

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper North Scappoose	Alder Creek, ALD077	2008								160		61		44
		2009	23										25	
		2010		6	20	15	59	20	50	78	38			
		2011					18	147	345					
	Upper North Scappoose, UNS	2017												
		2018						226	133	15				
		2019						133	261	29	365	38	25	34
		2020	13	6	47	105	411	238	186	308	91	88	67	17
		2021	22	8	11	36	613	435	199	27	249	116	34	16
Lower North Scappoose	Lower North Scappoose, LNS	2017							101	90	365	166		
		2018						83	107	63				
		2019						1,990	687	156	96	65	21	65
		2020	39	12	32	70	45	308	201	517	179	99	42	16
		2021	28	6	10	36	116	66	161	308	231	158	35	26
	North Scappoose, NSC001	2008							20			32		
		2009	19		22				48			75	57	
		2010	20	9	19	12	79	613	26	76				
		2011				67	127	1,203						

Table 77: Summary table of South Scappoose Creek watershed E. coli (MPN/100 ml) grab samples. Grab sampling results for broken down across years and watershed sampling locations. Sampling locations that experienced events over the EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted in red. n = number of samples collected.

Summary Table: North Scappoose Creek Watershed Monthly Max *E. coli* (MPN/100 ml)
2008-2021 Grab Samples

			n	Max	Mean	+/- SD
Upper North Scappoose	Alder Creek, ALD077	2008	3	160	88	63
		2009	2	25	24	2
		2010	9	78	36	23
		2011	3	345	170	165
	Upper North Scappoose, UNS	2017	0			
		2018	3	226	125	106
		2019	10	365	103	119
		2020	16	411	111	117
		2021	15	613	127	179
Lower North Scappoose	Lower North Scappoose, LNS	2017	4	365	181	127
		2018	3	107	84	22
		2019	11	1,990	325	585
		2020	16	517	134	137
		2021	15	308	110	90
	North Scappoose, NSC001	2008	2	32	26	9
		2009	5	75	44	24
		2010	9	613	99	194
		2011	3	1,203	466	639

Table 78: North Scappoose Creek Watershed Monthly Mean Conductivity Levels (µs/cm) 2008-2021. Grab samples results for watershed broken down across years and watershed sampling locations.

North Scappoose Creek Watershed Monthly Mean Conductivity (µs/cm)
2008-2021 Grab Samples

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper North Scappoose	Alder Creek, ALD077	2008								86.7				89.7
		2009	54.9	65.0								65.6	54.8	
		2010	52.6	54.8	54.9	53.2	51.1	62.3	63.0	83.9	89.8			
		2011				55.2	58.2	69.4	77.3					
	Upper North Scappoose, UNS	2018							63.5	73.0	67.8	63.5	55.5	45.8
		2019	35.1		30.4	39.8	46.3	75.5	71.3	85.9	84.7	92.4	89.5	83.8
		2020	46.2	47.4	59.2	66.2	69.2	78.9	80.8	89.2	78.5	93.3	88.5	68.7
		2021	46.1	31.0	31.3	42.8	53.0	60.6	76.5	78.9	72.4	68.9	55.2	42.9
Lower North Scappoose	Lower North Scappoose, LNS	2018							70.8	86.1	88.1	70.7	65.1	52.1
		2019	37.1		34.0	43.9	50.6	76.8	88.9	96.6	93.9	103.4	100.4	89.5
		2020	48.4	48.5	62.0	70.2	73.1	85.5	88.1	102.6	103.7	104.3	98.3	68.4
		2021	46.0	30.7	31.0	45.0	56.9	65.6	86.9	96.9	86.0	78.6	64.6	47.2
	North Scappoose, NSC001	2008							95.1			106.5		
		2009	64.3	62.3	60.6	59.7	58.6	66.0	74.4	107.1		76.7	61.7	
		2010	50.8	35.3	54.6	52.2	62.7	64.2	72.2	83.0	99.6			
		2011				55.2	61.2	70.0						

Table 79: Summary Table of North Scappoose Creek Watershed Conductivity Levels (µs/cm) 2008-2021. Grab samples results for watershed broken down across years and watershed sampling locations.

Summary Table: North Scappoose Creek Watershed Conductivity Levels (µs/cm)
2008-2021 Grab Samples

			n	Max	Mean	+/- SD
Upper North Scappoose	Alder Creek, ALD077	2008	2	90	88	2
		2009	4	66	60	6
		2010	10	90	62	15
		2011	4	77	65	10
	Upper North Scappoose, UNS	2018	6	73	62	10
		2019	14	92	69	22
		2020	17	93	74	16
		2021	15	83	59	17
Lower North Scappoose	Lower North Scappoose, LNS	2018	6	88	72	13
		2019	15	106	78	25
		2020	17	107	83	20
		2021	15	103	67	23
	North Scappoose, NSC001	2008	2	107	101	8
		2009	11	107	70	15
		2010	10	100	64	18
		2011	3	70	62	7

South Scappoose Creek Watershed Supplemental Data Tables

Table 80: Monthly variation in 7dMAM temperatures from 2017 to 2021 for Upper South Scappoose and Lower South Scappoose creeks. Temperatures have been color-coded according to salmonid thresholds listed in Table 4, with blue representing cooler, ideal conditions and yellow/orange representing temperatures crossing 18°C. Temperatures close to or exceeding lethal conditions have been represented in red.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper South Scappoose (USS)	2017							15.8	17.0	15.0	10.4	8.5	5.9
	2018	7.7	7.1	7.6	9.8	12.6	13.3	16.5	17.0	13.9	11.7	6.8	6.5
	2019	6.9	5.7	7.1	10.1	12.3	14.1	15.2	16.3	16.5	9.1	7.1	5.3
	2020			8.6	10.2	11.9	13.4	15.3	16.7	15.1	12.1	8.1	6.5
	2021					12.6	15.0	18.6	18.1	14.8	10.8	9.3	
Lower South Scappoose (LSS)	2017							20.2	21.5	18.4	11.6	8.9	5.8
	2018	7.8	7.3	8.2	10.9	15.0	16.6	21.2	21.6	18.5	11.5	8.3	6.5
	2019	7.0	5.7	7.2	11.0	14.6	18.1	19.8	21.1	21.0	10.2	7.0	6.0
	2020	7.9	7.8	8.2	11.1	14.0	16.7	19.7	22.4	18.1	13.7	8.2	7.0
	2021	8.0	7.0	8.4	11.1	14.3	19.3	22.9	22.4	17.9			

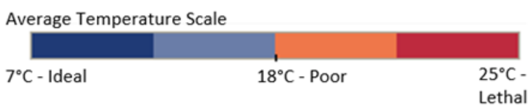


Table 81: South Scappoose Watershed Monthly Turbidity (NTU), 2008-2021. Grab Samples. Grab sampling results for Clatskanie watershed broken down across years and watershed sampling locations. Mean monthly turbidity levels over the 10 NTU threshold are highlighted in red.

Summary Table: South Scappoose Creek Watershed Monthly Mean Turbidity (NTU)
2017-2021 Grab Samples

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper South Scappoose	Gourley Creek, SSCGRL	2009									2.8	1.9	1.3	
		2010	13.9	10.3	3.5			3.6	1.8	2.1	1.6			
		2011				4.3	2.1	3.0						
	Lacey Creek, LZY028	2008							2.4	1.8		10.7	2.3	
		2009	3.2	4.8	4.6	2.4	9.0	2.1	2.3		1.7	3.3	1.5	
		2010	12.3	9.8	6.0	3.6	5.7	4.5	2.8	3.2	2.3			
		2011				7.2	3.8	3.9						
	South Scappoose, SSC041	2008							1.4	1.9			1.7	
		2009	5.6	4.4	2.6	1.9	3.2	1.8	1.6		1.0	0.8	1.3	
		2010	5.0		4.0	3.6	6.9	3.3	2.5	2.3	2.0			
		2011				3.7	2.5	3.3						
	Upper South Scappoose, USS	2017							0.6		1.2	1.9	2.9	
		2018		2.4	3.2	3.9	1.3	3.0	4.1	18.0	2.3	1.6	0.5	2.2
		2019	2.2		2.6	1.7	1.9	2.2	1.7	1.1	2.8	1.0	2.0	2.8
		2020	5.3	3.1	2.1	1.8	1.3	1.4	1.2	2.1	2.7	1.0	0.8	1.9
		2021	18.8	3.2	1.9	1.8	1.5	1.0	1.7	1.4	1.4	2.8	1.1	2.1
Lower South Scappoose	Lower South Scappoose, LSS	2017							1.1	2.4	2.7	8.5	7.3	
		2018		4.0	6.8	7.3	2.2	2.4	4.9	2.2	2.6	2.3	1.7	3.5
		2019	3.1		4.5	2.9	2.0	3.3	3.7	3.8	5.5	2.1	1.3	3.8
		2020	11.0	6.7	2.6	1.8	2.7	1.9	2.0	2.4	3.0	2.6	3.5	6.2
		2021	23.4	7.8	3.4	2.8	1.8	1.8	2.4	2.7	3.3	4.3	4.6	5.9
	South Scappoose, SSCJPW	2008								3.7			2.6	
		2009	4.3	14.6	3.7	1.9	2.9	2.7	3.8	4.3	3.7	2.4	2.3	
		2010	7.4	6.3	5.2	7.0	4.5	3.6	3.6	2.9	2.9			
		2011					4.5	3.1						

Table 82: Summary Table of South Scappoose Creek Watershed Turbidity (NTU), 2008-2021. Grab Samples. Grab sampling results for Clatskanie watershed broken down across years and watershed sampling locations. Mean monthly turbidity levels over the 10 NTU threshold are highlighted in red.

Summary Table: South Scappoose Creek Watershed Turbidity Levels (NTU)
2017-2021 Grab Samples

			n	Max	Mean	+/- SD
Upper South Scappoose	Gourley Creek, SSCGRL	2009	3	2.8	2.0	0.7
		2010	7	13.9	5.3	4.9
		2011	3	4.3	3.1	1.1
	Lacey Creek, LZY028	2008	4	10.7	4.3	4.3
		2009	10	9.0	3.5	2.2
		2010	9	12.3	5.6	3.4
		2011	3	7.2	5.0	1.9
	South Scappoose, SSC041	2008	3	1.9	1.6	0.3
		2009	10	5.6	2.4	1.6
		2010	8	6.9	3.7	1.6
		2011	3	3.7	3.2	0.6
	Upper South Scappoose, USS	2017	4	2.9	1.6	1.0
		2018	11	18.0	3.9	4.8
		2019	13	3.6	2.0	0.7
		2020	16	5.3	2.1	1.3
		2021	15	18.8	2.9	4.4
Lower South Scappoose	Lower South Scappoose, LSS	2017	5	8.5	4.4	3.3
		2018	11	7.3	3.6	1.9
		2019	15	8.5	3.5	1.8
		2020	16	11.0	3.5	2.4
		2021	15	23.4	4.8	5.4
	South Scappoose, SSCJPW	2008	2	3.7	3.1	0.8
		2009	11	14.6	4.2	3.5
		2010	10	7.4	4.8	1.7
		2011	3	5.1	4.0	1.0

Table 83: South Scappoose watershed monthly max E. coli (MPN/100 ml) grab samples. Grab sampling results for broken down across years and watershed sampling locations. Sampling locations that experienced events over the EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted in red. n = number of samples collected.

Summary Table: South Scappoose Creek Watershed Monthly Max *E. coli* (MPN/100 ml) 2008-2021 Grab Samples

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper South Scappoose	Gourley Creek, SSCGRL	2009												
		2010												
		2011												
	Lacey Creek, LZY028	2008												
		2009												
		2010												
		2011												
	South Scappoose, SSC041	2008											3	
		2009												
		2010												
		2011												
	Upper South Scappoose, USS	2017												
		2018						77	34	73				
		2019						68	2,600	504	343	11	19	12
		2020	1	3	3	9	114	54	133	488	192	86	17	4
		2021	11	5	3	6	128	39	127	85	161	68	5	21
Lower South Scappoose	Lower South Scappoose, LSS	2017							248	172	326	166		
		2018						921	345	326				
		2019						1,200	308	178	816	201	46	189
		2020	9	8	42	172	1,200	308	435	238	276	140	411	96
		2021	53	13	9	80	151	236	416	148	260	649	70	70
	South Scappoose, SSCJPW	2008												
		2009	17	326	16	38		411	649	276		308	31	
		2010	23	15	65	40	131	75	435	345	326			
		2011					157	86						

Table 84: Summary table of South Scappoose Creek watershed E. coli (MPN/100 ml) grab samples. Grab sampling results for broken down across years and watershed sampling locations. Sampling locations that experienced events over the EPA (235 MPN/100) and ODEQ (406 MPN/100) thresholds for E. coli bacteria levels are highlighted in red. n = number of samples collected.

Summary Table: South Scappoose Creek Watershed Monthly Max *E. coli* (MPN/100 ml)
2008-2021 Grab Samples

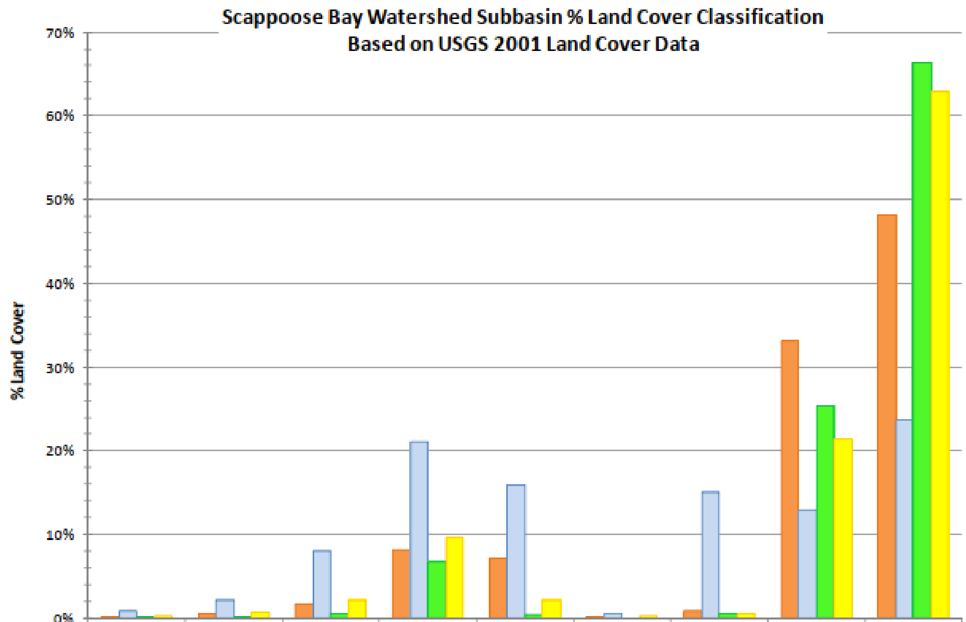
			n	Max	Mean	+/- SD
Upper South Scappoose	Gourley Creek, SSCGRL	2009	0			
		2010	0			
		2011	0			
	Lacey Creek, LZY028	2008	0			
		2009	0			
		2010	0			
		2011	0			
	South Scappoose, SSC041	2008	1	3	3	
		2009	0			
		2010	0			
		2011	0			
	Upper South Scappoose, USS	2017	0			
		2018	3	77	61	24
		2019	9	2,600	414	837
		2020	16	488	86	122
		2021	15	161	56	53
Lower South Scappoose	Lower South Scappoose, LSS	2017	4	326	228	75
		2018	3	921	531	338
		2019	11	1,200	375	377
		2020	16	1,200	253	283
		2021	15	649	174	169
	South Scappoose, SSCJPW	2008	0			
		2009	9	649	230	222
		2010	9	435	162	161
		2011	3	157	96	56

Table 85: South Scappoose Creek watershed Monthly Mean Conductivity Levels (µs/cm) 2008-2021. Grab samples results for watershed broken down across years and watershed sampling locations.

South Scappoose Creek Watershed Monthly Mean Conductivity (µs/cm)
2008-2021 Grab Samples

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper South Scappoose	Gourley Creek, SSCGRL	2009									119.1	106.4	95.7	
		2010	45.7	55.8	36.9			76.0	94.3	130.5	120.0			
		2011				59.2	62.9	80.5						
	Lacey Creek, LZY028	2008							90.0	97.3		101.0	89.2	
		2009	56.8	64.5	60.0	72.0	58.0	63.6	91.8		74.9	73.7	82.8	
		2010	45.3	53.8	35.7	60.9	45.5	72.2	82.6	117.6	95.8			
		2011				56.1	59.2	74.3						
	South Scappoose, SSC041	2008							65.6	70.8			62.1	
		2009	48.8	52.2	50.7	57.4	45.1	48.6	65.0		73.9	50.0	64.5	
		2010	28.9		49.4	51.0	54.0	48.9	49.2	67.5	72.8			
		2011				50.6	52.4	61.4						
	Upper South Scappoose, USS	2018							78.8	113.2	118.9	156.1	94.8	50.9
		2019	38.2		32.7	41.2	49.3	93.0	121.4	125.8	132.3	137.0	139.4	101.7
		2020	45.0	32.0	63.9	69.7	76.2	90.5	103.9	140.2	151.9	151.8	127.9	34.5
		2021	43.5	30.5	30.9	46.3	66.5	77.8	92.5	114.9	121.8	114.5	78.4	45.9
Lower South Scappoose	Lower South Scappoose, LSS	2018							91.3	111.5	100.8	93.6	54.9	63.2
		2019	43.0		39.8	49.9	60.4	90.1	100.2	121.3	113.2	128.6	124.7	74.1
		2020	50.6	55.3	72.9	82.8	87.4	99.6	105.0	127.2	129.1	133.4	130.0	86.3
		2021	49.5	34.6	35.5	58.0	72.7	87.0	105.7	122.8	109.4	107.9	86.3	53.8
	South Scappoose, SSCJPW	2008								122.7			117.1	
		2009	69.4	82.6	70.9	60.8	74.2	84.3	113.0	131.3	144.9	96.8	75.0	
		2010	56.4	59.5	63.2	59.7	76.4	79.8	97.9	113.8	122.6			
		2011					69.6	85.2						

Appendix C: Scappoose Bay Watershed Landcover Classification



Subbasin	Developed, High Intensity	Developed, Medium Intensity	Developed, Low Intensity	Developed, Open Space	Crops/ Pasture	Open Water	Wetlands	Vegetation (Shrub & Herb)	Forest
Milton Creek	0.2%	0.6%	1.7%	8.2%	7.2%	0.0%	0.9%	33.2%	48.2%
Honeyman/McNulty Creek	0.8%	2.2%	8.1%	21.0%	15.9%	0.5%	15.0%	12.9%	23.6%
North Scappoose Creek	0.0%	0.1%	0.5%	6.7%	0.4%	0.0%	0.6%	25.4%	66.3%
South Scappoose Creek	0.3%	0.6%	2.1%	9.6%	2.1%	0.3%	0.6%	21.4%	63.0%

Figure 87: Percent land cover in Scappoose bay watersheds based on USGS 2001 Land cover data. Open water, developed high intensity, developed medium intensity and developed low intensity are represented as classified by the USGS; developed open space includes developed open space and barren land classifications; crops/pastures include hay/pasture and cultivated crops classifications; forests include evergreen, deciduous and mixed forest classifications; vegetation includes herbaceous and shrub/scrub classifications; wetlands include emergent herbaceous wetlands and woody wetlands classifications.

Appendix D: Maps depicting variations in Water Quality Parameters in Columbia County

Map of Long-term Monitoring Locations and # Days over 18 °C in 2022

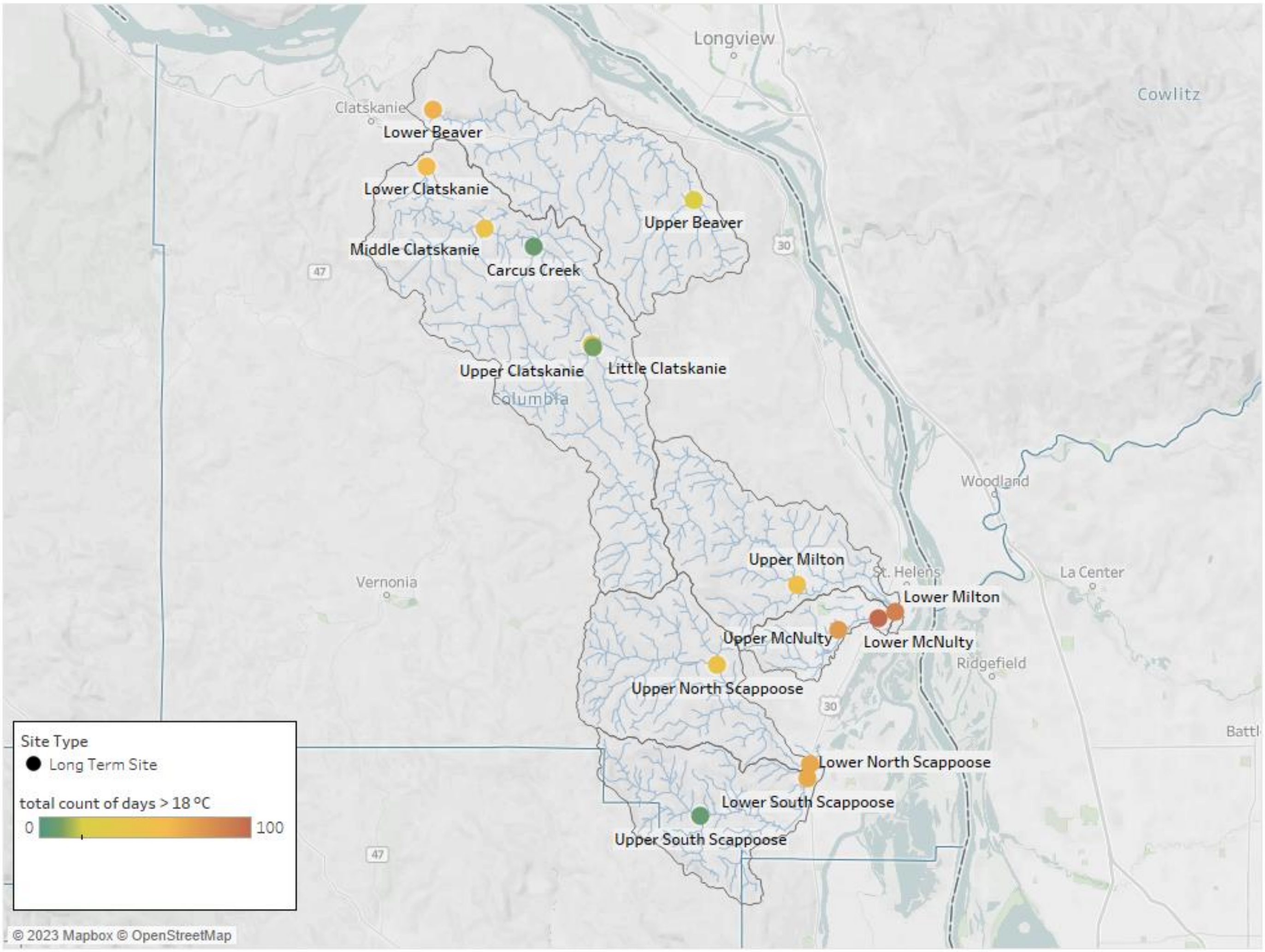


Figure 88: This map describes the count of days over 18 °C in 2022.

Map of Long-term Monitoring Locations and # Days over 18 °C between 2017-2022

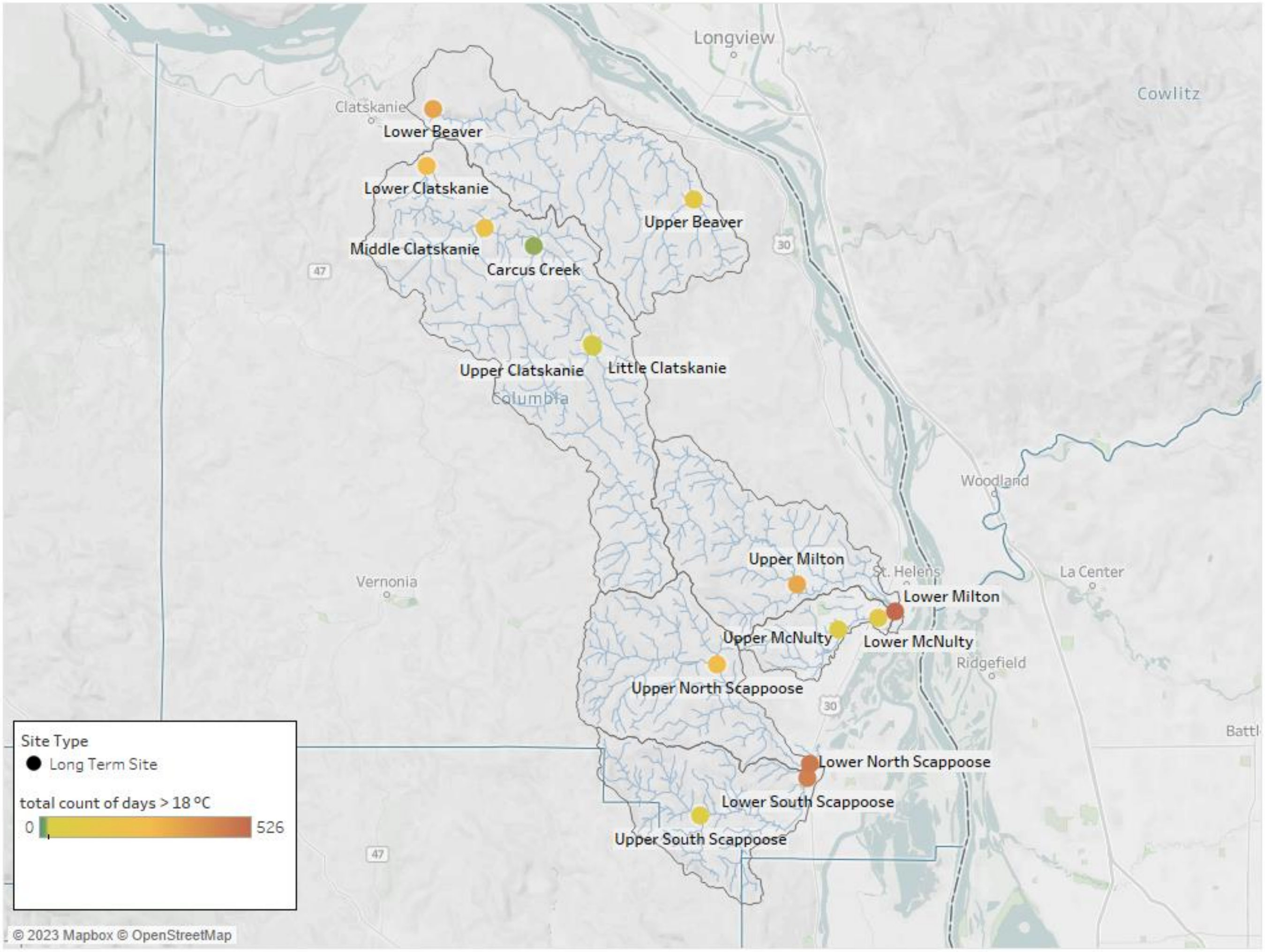


Figure 89: This map describes the count of days over 18 °C from 2017-2022.

Map of Long-term Monitoring Locations and # Days over 25 °C in 2022

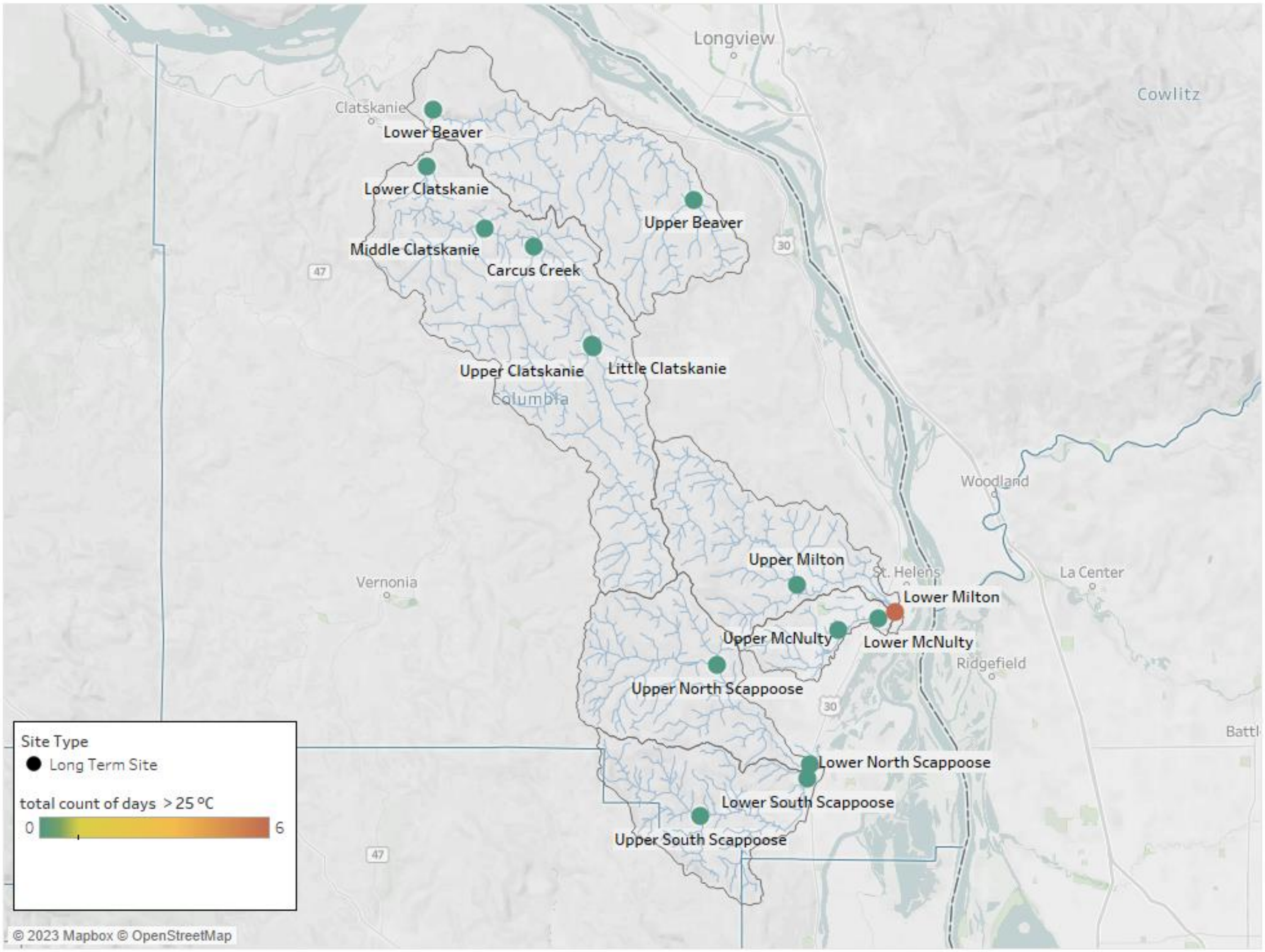


Figure 90 This map describes the count of days over 25 °C in 2022.

Map of Long-term Monitoring Locations and # Days over 25 °C between 2017-2022

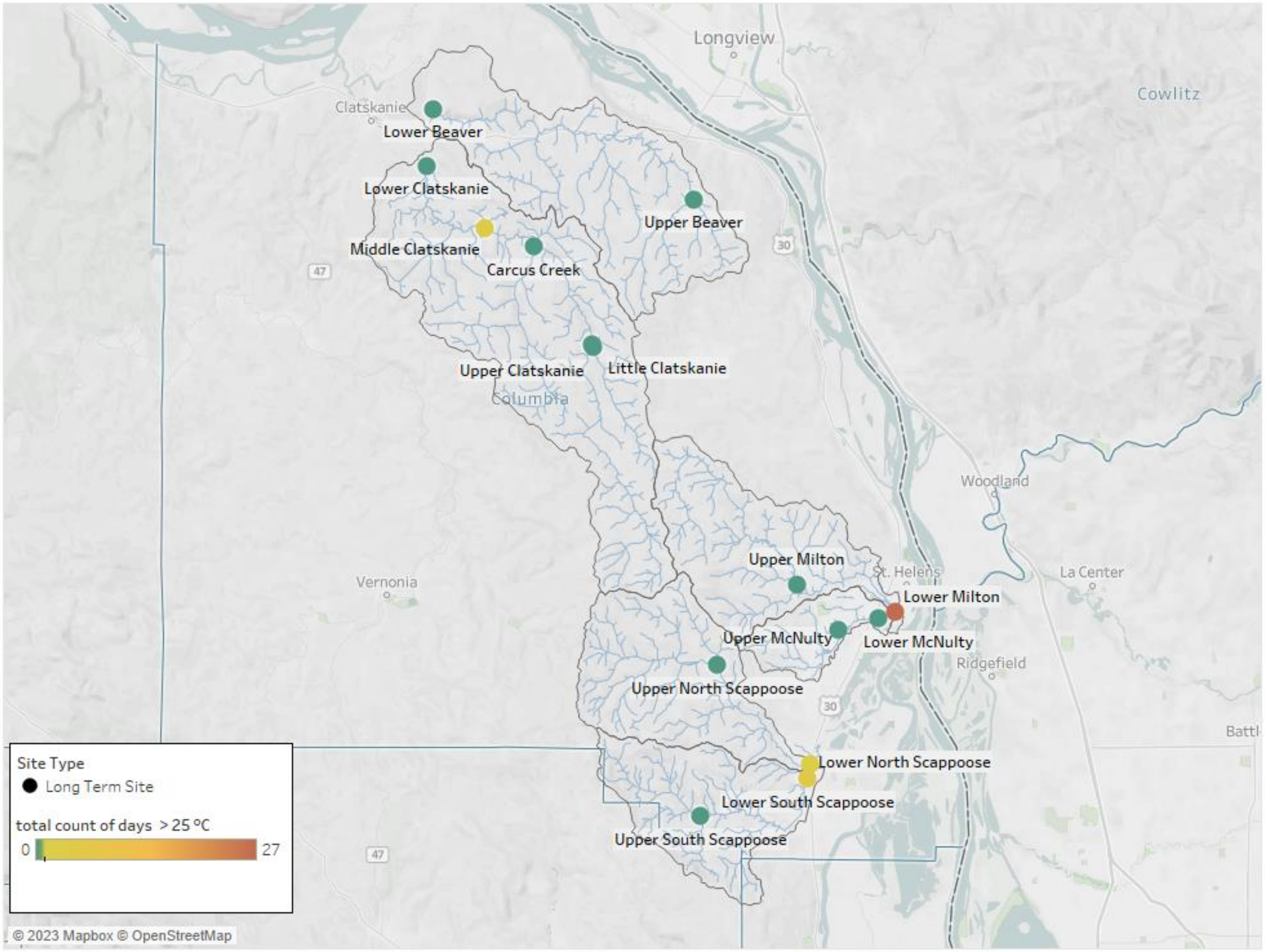


Figure 91: This map describes the count of days over 25 °C from 2017-2022.

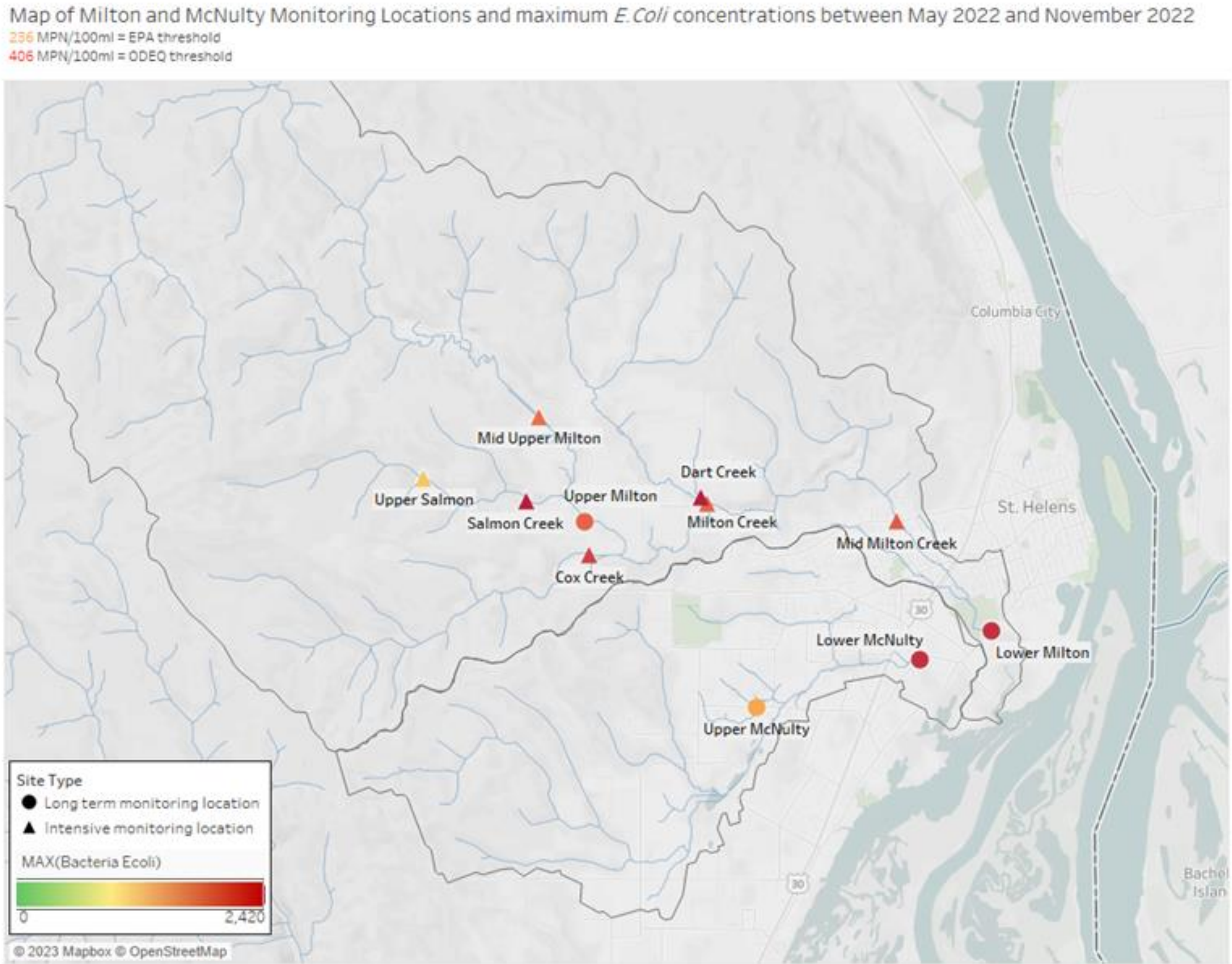


Figure 92: Map of Milton and McNulty Creeks' max Bacteria Levels. May 2022-Nov 2022.

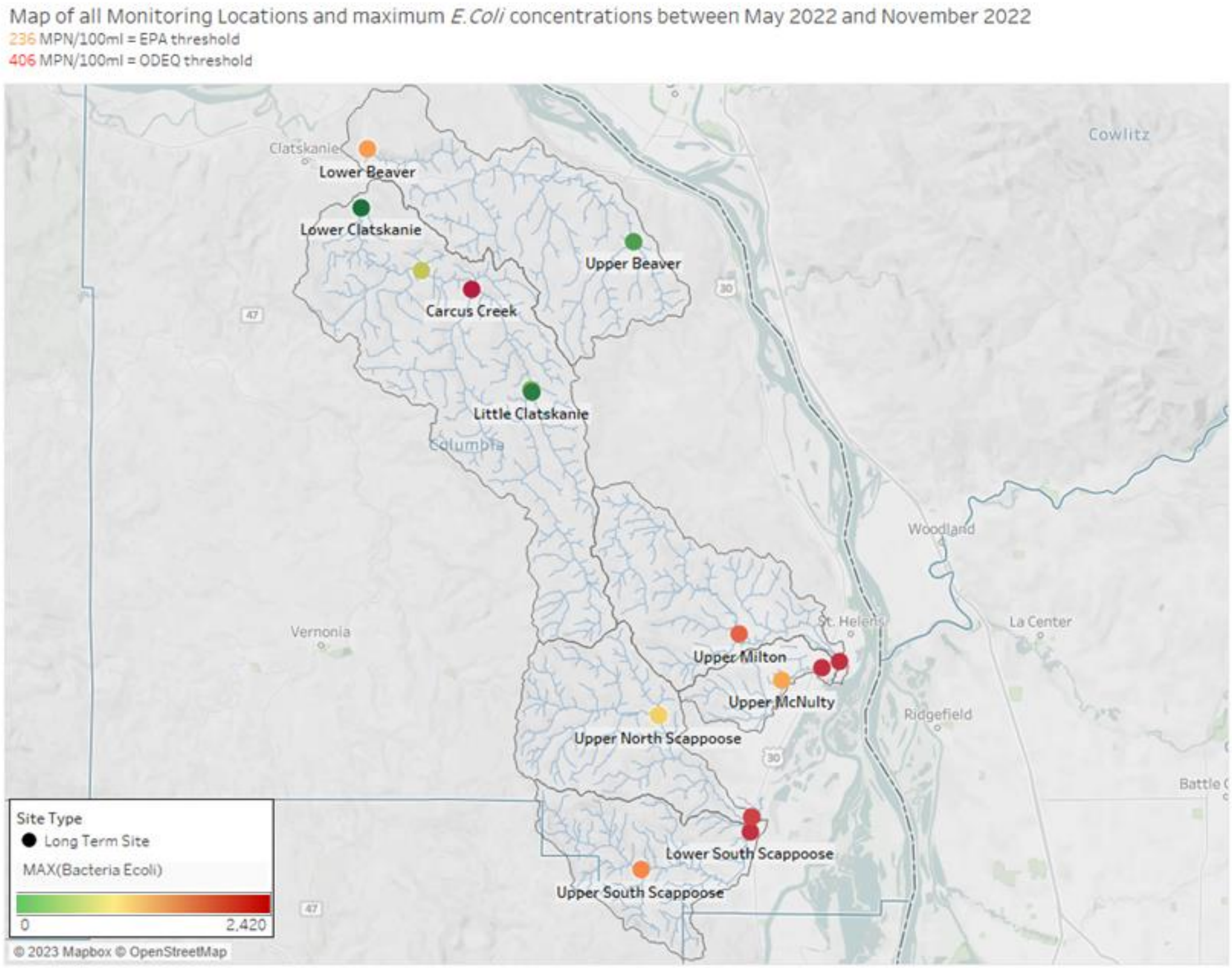


Figure 93: Map of long-term status and trend sites maximum bacteria levels observed. May 2022-Nov 2022.

Map of all Monitoring Locations and maximum *E.Coli* concentrations between May 2017 and November 2022
236 MPN/100ml = EPA threshold
406 MPN/100ml = ODEQ threshold

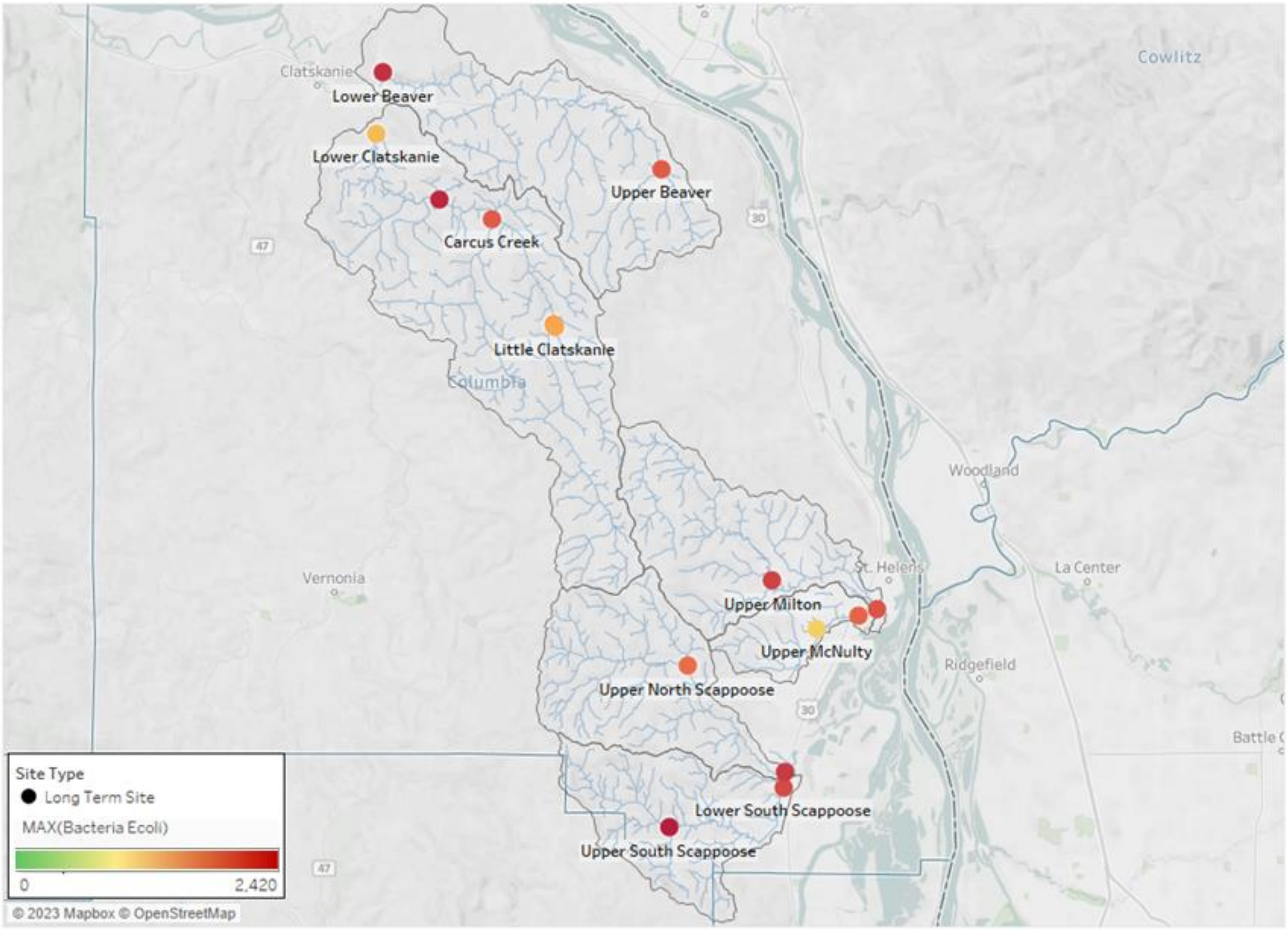


Figure 94: Map of long-term status and trend sites maximum bacteria levels observed. May 2017-Nov 2022.

Map of Long-term Monitoring Locations and # of times where DO is < 6 mg/l in 2022

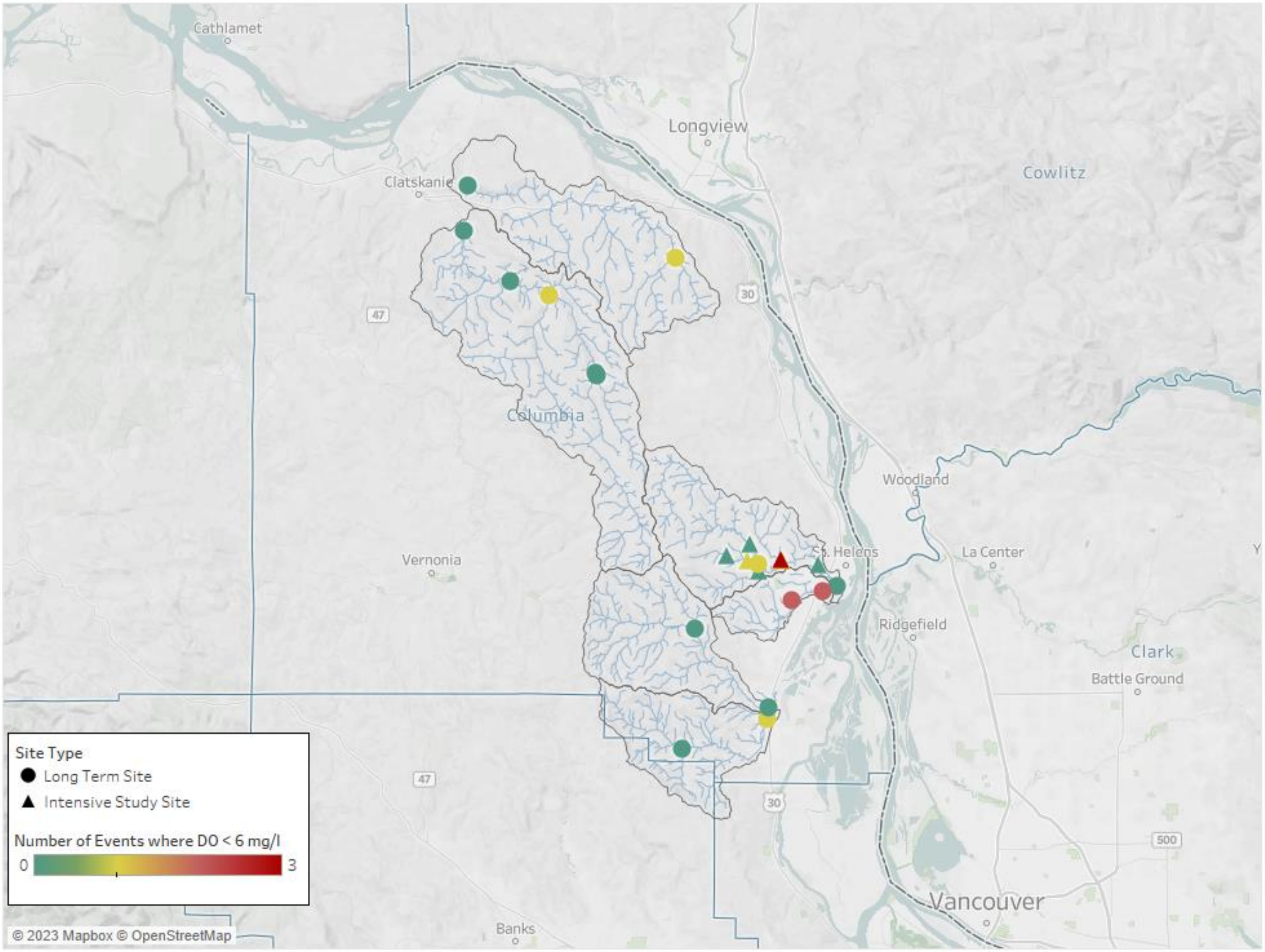


Figure 95: Map of monitoring locations highlighted by dissolved oxygen.

Map of Long-term Monitoring Locations and # of times where Turbidity > 10 NTU in 2022

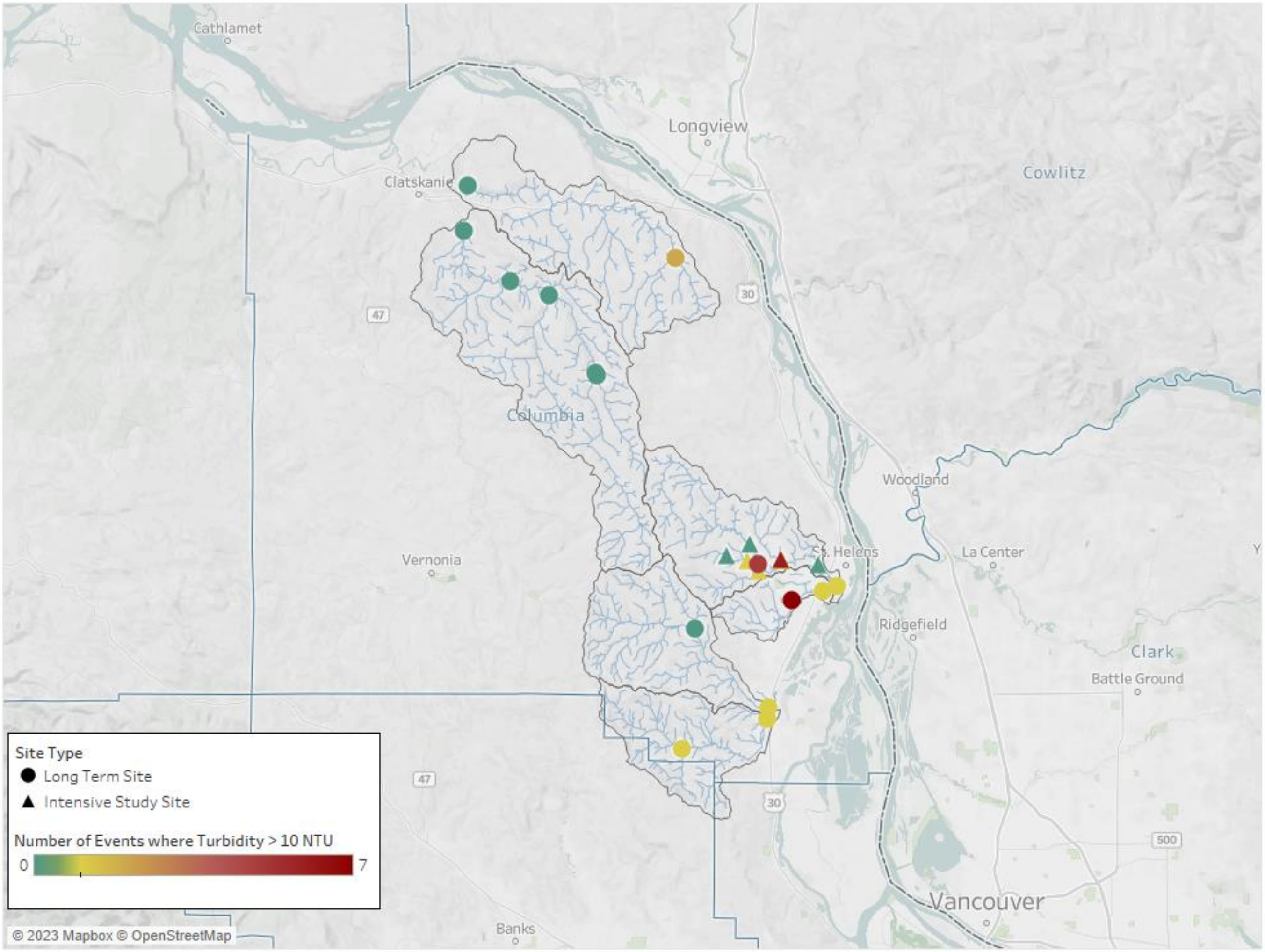


Figure 96: Map of all monitoring locations highlighted by turbidity.