Okanogan Conservation District

# Palmer Lake Water Quality Monitoring – Quality Assurance Project Plan

**FINAL**
**August 2024**

TETRA TECH

# Palmer Lake Water Quality Monitoring – Quality Assurance Project Plan

**FINAL**
**August 2024**

**PRESENTED TO**

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TETRA TECH

# PROJECT TEAM SIGNATURE PAGE

## Quality Assurance Project Plan

## Palmer Lake Water Quality Monitoring

Prepared for: Okanogan Conservation District

Prepared By: Tetra Tech, Inc.

August 2024

Approval signatures indicated that each key member of the project team has reviewed this Quality Assurance Project Plan (QAPP) and agree to follow the quality control (QC) and quality assurance (QA) procedures outlined within this document.

**Approved by:**

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## ACRONYMS/ABBREVIATIONS

| Acronyms/Abbreviations | Definition |
|---|---|
| COC | Chain-of-Custody |
| DO | Dissolved Oxygen |
| DQO | Data Quality Objective |
| DUPE | Duplicate |
| Ecology | Washington State Department of Ecology |
| EIM | Environmental Information Management Database |
| MDL | Method Detection Limit |
| MQO | Measurement Quality Objective |
| Okanogan CD | Okanogan Conservation District |
| QA | Quality Assurance |
| QAPP | Quality Assurance Project Plan |
| QC | Quality Control |
| RPD | Relative Percent Difference |
| SRP | Soluble Reactive Phosphorus |
| TMDL | Total Maximum Daily Load |
| TN | Total Nitrogen |
| TP | Total Phosphorus |
| TSS | Total Suspended Solids |
| WAC | Washington Administrative Code |

## GLOSSARY OF GENERAL TERMS

| Term | Definition |
|---|---|
| Ambient | Background or away from point sources of contamination. Surrounding environmental condition. |
| Clean Water Act | A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program. |
| Conductivity | A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water. |
| Designated uses | Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each water body or segment, regardless of whether or not the uses are currently attained. |
| Dissolved Oxygen | A measure of the amount of oxygen dissolved in water. |
| Eutrophic | Nutrient rich and high in productivity resulting from human activities such as fertilizer runoff and leaky septic systems. |
| Mesotrophic | Intermediate stage between oligotrophic and eutrophic. Has a moderate amount of nutrients and plant growth. |
| Nutrient | Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms. |
| Oligotrophic | Relatively low in nutrients and plant growth. Has abundant oxygen and low organic content. Typically very clear water. |
| pH | A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7. |
| Pollution | Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life. |
| Primary contact recreation | Activities where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and water skiing. |

| Term | Definition |
|---|---|
| Sediment | Soil and organic matter that is covered with water (for example, river or lake bottom). |
| Surface waters of the state | Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands, and all other surface waters and water courses within the jurisdiction of Washington State. |
| Total Maximum Daily Load (TMDL) | A distribution of a substance in a water body designed to protect it from not meeting (exceeding) water quality standards. A TMDL is equal to the sum of all of the following: (1) individual waste load allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a margin of safety to allow for uncertainty in the waste load determination. A reserve for future growth is also generally provided. |
| Watershed | A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation. |
| 303(d) list | Section 303(d) of the federal Clean Water Act, requiring Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited estuaries, lakes, and streams that fall short of state surface water quality standards and are not expected to improve within the next two years. |

# 1.0 ABSTRACT

Palmer Lake is a large, natural kidney shaped lake (2,063-acre) located in north central Washington approximately 4 miles north of the small town of Loomis in Okanogan County. There have been growing concerns regarding the water quality in Palmer Lake with an increase in annual algae blooms and documentation of toxic algal bloom events in 2018 and 2020. The community and local agencies are also concerned with decreased water clarity in recent years, prevalent fish kills, shoreline development violations and the potential for post-fire erosion impacts to water quality. Palmer Lake is a “hidden gem” in Okanogan County and provides a wealth of outdoor recreational opportunities throughout the year, which makes protecting the water quality and overall ecological health of the lake essential.

The August 2020 Palmer Mountain Fire was part of an intense fire season that impacted much of Okanogan County and the Pacific Northwest at large. Post-fire impacts from the Palmer Mountain burned area were anticipated to have the potential to exacerbate on-going water quality problems in Palmer Lake. Community members and local agencies requested assistance from the Washington Department of Ecology (Ecology) to identify ongoing and emerging impacts to the lake and work with landowners to plan and implement water quality improvement projects. The Okanogan Conservation District (Okanogan CD) applied for and successfully was awarded a Water Quality Centennial Grant (WQC-2022-OkanCD-00064) to initiate a water quality monitoring program at Palmer Lake to help assess and better understand the current lake conditions as well as to help identify potential sources of pollution and assess algae bloom severity and nutrient cycling in the lake. This Quality Assurance Project Plan (QAPP) will guide all water quality monitoring activities and define procedures that assure the quality and integrity of data collected. The data collected as part of the monitoring program will focus on collecting baseline limnological data to help identify potential sources of nutrient (phosphorus and nitrogen) pollution and how the watershed may be impacting lake water quality. The data collected will also provide insight into identifying the key sources of nutrients and track algal biomass and lake production over the critical summer growing season.

# 2.0 BACKGROUND

## 2.1 INTRODUCTION AND PROBLEM STATEMENT

Palmer Lake is a 2,063-acre lake located in north central Washington approximately 4 miles north of the small town of Loomis in Okanogan County. The lake has a maximum depth of approximately 91 ft (28 m) (Wolcott, 1973) (Figure 1). Known as *Haipwil* to the indigenous people of the area, Palmer Lake (and Palmer Mountain) is named after James Palmer, who settled in the area in 1875 (Wilson, 1990).

The August 2020 Palmer Mountain Fire was part of an intense fire season that impacted much of Okanogan County and the Pacific Northwest at large. Post-fire impacts from the Palmer Mountain burned area were anticipated to have the potential to exacerbate on-going water quality problems in Palmer Lake, which is a popular and heavily used recreational lake. Community members and local agencies requested assistance from the Washington Department of Ecology (Ecology) to identify ongoing and emerging impacts to the lake and work with landowners to plan and implement water quality improvement projects. There have been growing concerns regarding the water quality in Palmer Lake with an increase in annual algae blooms and documentation of toxic algal bloom events in 2018 and 2020. Microcystin, a potent liver toxin produced by cyanobacteria, was detected in samples collected from Palmer Lake in August 2018 and October 2020. Toxin concentrations detected in October 2020 were above the state recreation guideline. The community and local agencies are also concerned with decreased water clarity in recent years, prevalent fish kills, shoreline development violations and the potential for post-fire erosion impacts to water quality. Palmer Lake is a “hidden gem” in Okanogan County and provides a wealth of outdoor recreational opportunities throughout the year, which makes protecting the water quality and overall ecological health of the lake essential.

The Okanogan Conservation District (Okanogan CD) applied for and successfully was awarded a Water Quality Centennial Grant (WQC-2022-OkanCD-00064) to initiate a water quality monitoring program at Palmer Lake to help assess and better understand the current lake conditions.

The primary goal of this Quality Assurance Project Plan (QAPP) is to guide all water quality monitoring activities and define procedures that assure the quality and integrity of data collected. This QAPP was developed in accordance with Ecology Publication 04-03-030, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies* (Ecology, 2004 revised 2016).

## 2.2 STUDY AREA AND SURROUNDINGS

Palmer Lake is a large, natural kidney shaped lake located at the bottom of the Sinlahekin Valley in north central Washington. The Sinlahekin Valley parallels the Okanogan Valley about 10 miles to the west. The Sinlahekin Valley is a deep narrow glacial canyon, with steep sides rising abruptly to the surrounding mountains. The Sinlahekin Valley is dotted with a number of lakes, amidst a dry-land forest setting and much of the valley is preserved as a wildlife reserve with agriculture limited to a few small farms and ranches (Figure, 2013).

Water flows north through the valley via Sinlahekin Creek into Palmer Lake and eventually into the Similkameen River (Figures 1 and 2). Palmer Creek is the outlet from Palmer Lake and connects the Sinlahekin to the Similkameen. Six miles downstream of the Canadian border, the Similkameen River meets Palmer Creek. During seasons of high flow on the Similkameen River, typically sometime between April and July, Palmer Creek will reverse direction and flow into the lake. Based on observations during a 2002 TMDL study, this appears to occur when flows in the Similkameen River are greater than 5,000 cfs (Johnson, 2002). Palmer Lake’s main tributaries are the Sinlahekin Creek, which enters the lake on the south shore, and the Similkameen River as described above. Other waterways to the east of the lake are intermittent, flowing primarily during snowmelt.

The Palmer Lake watershed encompasses approximately 293 square miles (760 square kilometers) or 187,520 acres in Okanogan County (Figure 2). The majority of the land use within the Palmer Lake watershed is undeveloped public lands and includes the Sinlahekin Wildlife Area, the Loomis State Forest, and lands owned by the Bureau of Land Management (BLM) (Figure 3). The Sinlahekin Wildlife Area is the oldest wildlife area in Washington, with the first parcels purchased in 1939 using federal Pittman-Robertson funds to preserve mule deer winter range (WDFW, 2024). Current agricultural use in the Palmer Lake watershed consists of hay/silage, orchards, and pasture lands that cover about 11,680 acres. Agricultural land uses are concentrated around the lower portions of Sinlahekin and Chopaka Creeks, the small town of Loomis, and the southern and western lands adjacent to the lake (Figure 3). There are two public access points to Palmer Lake, a Washington Department of Natural Resources (WADNR) site/campground on the north shore and a BLM site named Split Rock Day-Use Area at the south shore.

There is very little impervious surface within the Palmer Lake watershed, and it appears to be limited to the major roadways (Figure 4). The watershed land cover is mostly dominated by upland tree or forest land, with some scrub/shrub and bare land.

Sinlahekin Creek, the main inflow to Palmer Lake, originates within the Sinlahekin Wildlife Area near Blue Lake, further north from Fish Lake. Sinlahekin Creek travels through several lakes/impoundments within the wildlife area, the furthest downstream being Conners Lake (Lower Sinlahekin Impoundment), before reaching privately-owned property. There are several tributaries that feed into Sinlahekin Creek (Figure 2) including Sarsapkin Creek, Cecile Creek, Toats Coulee Creek, and Chopaka Creek. The confluence of Cecile Creek and the Sinlahekin is on private property, and it is difficult to know whether it flows year-round or if flow reaches the Sinlahekin. Toats Coulee Creek does not have an annual flow and can be fully diverted before reaching Sinlahekin Creek. After high flows dissipate in the spring, water is typically diverted from Toats Coulee to Spectacle Lake and used for irrigation purposes by the Whitestone Reclamation District. Chopaka Creek flows rarely reach Sinlahekin Creek. Chopaka Creek flows down a steep mountain side from Chopaka Lake and crosses irrigated fields where water has not been observed in its manipulated channel. Chopaka Creek may contribute groundwater to Palmer Lake, but it is unlikely that surface waters in Chopaka Creek reach either the Sinlahekin or Palmer Lake.

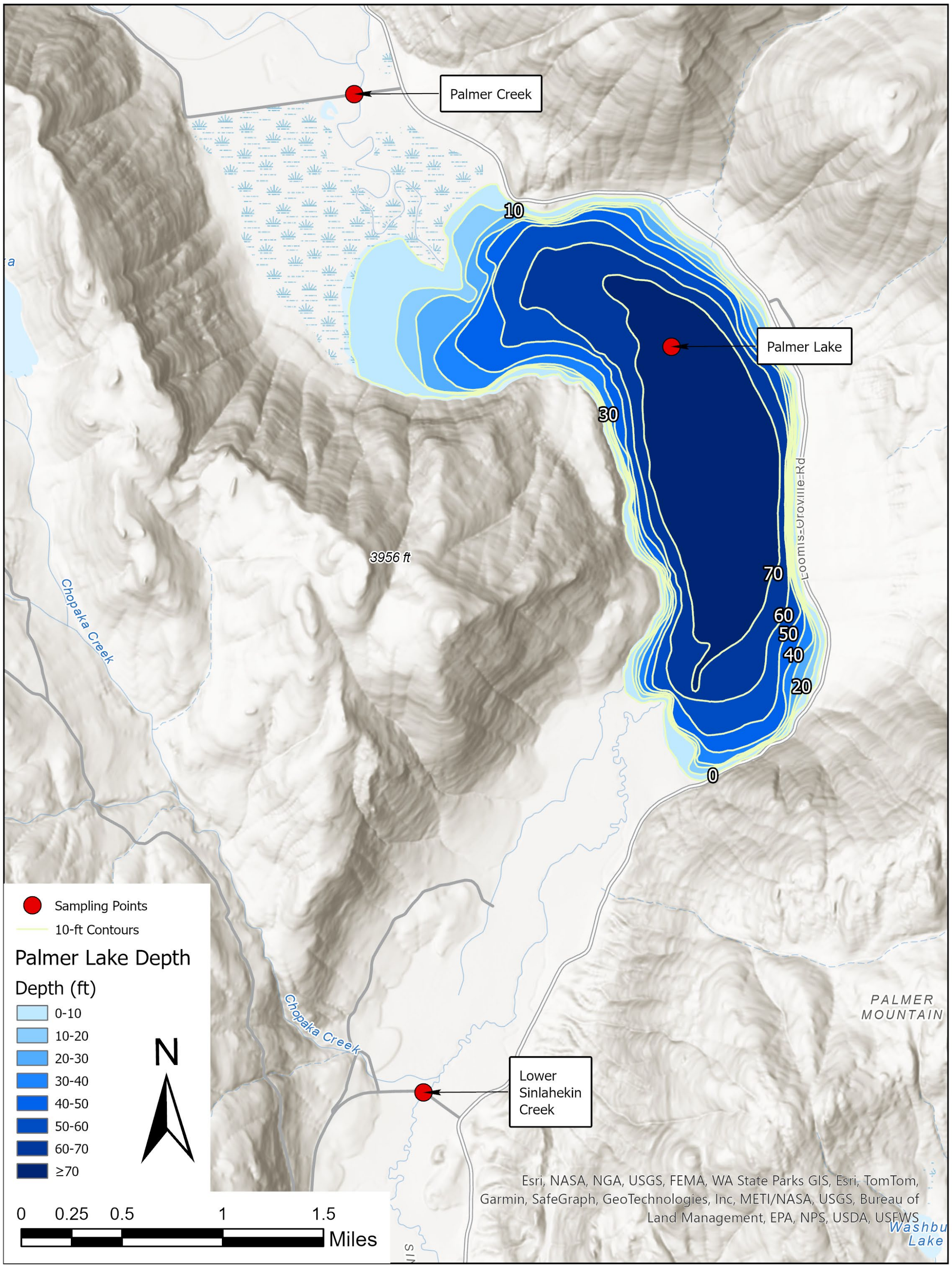


**Figure 1. Palmer Lake Bathymetry and Sampling Locations.**

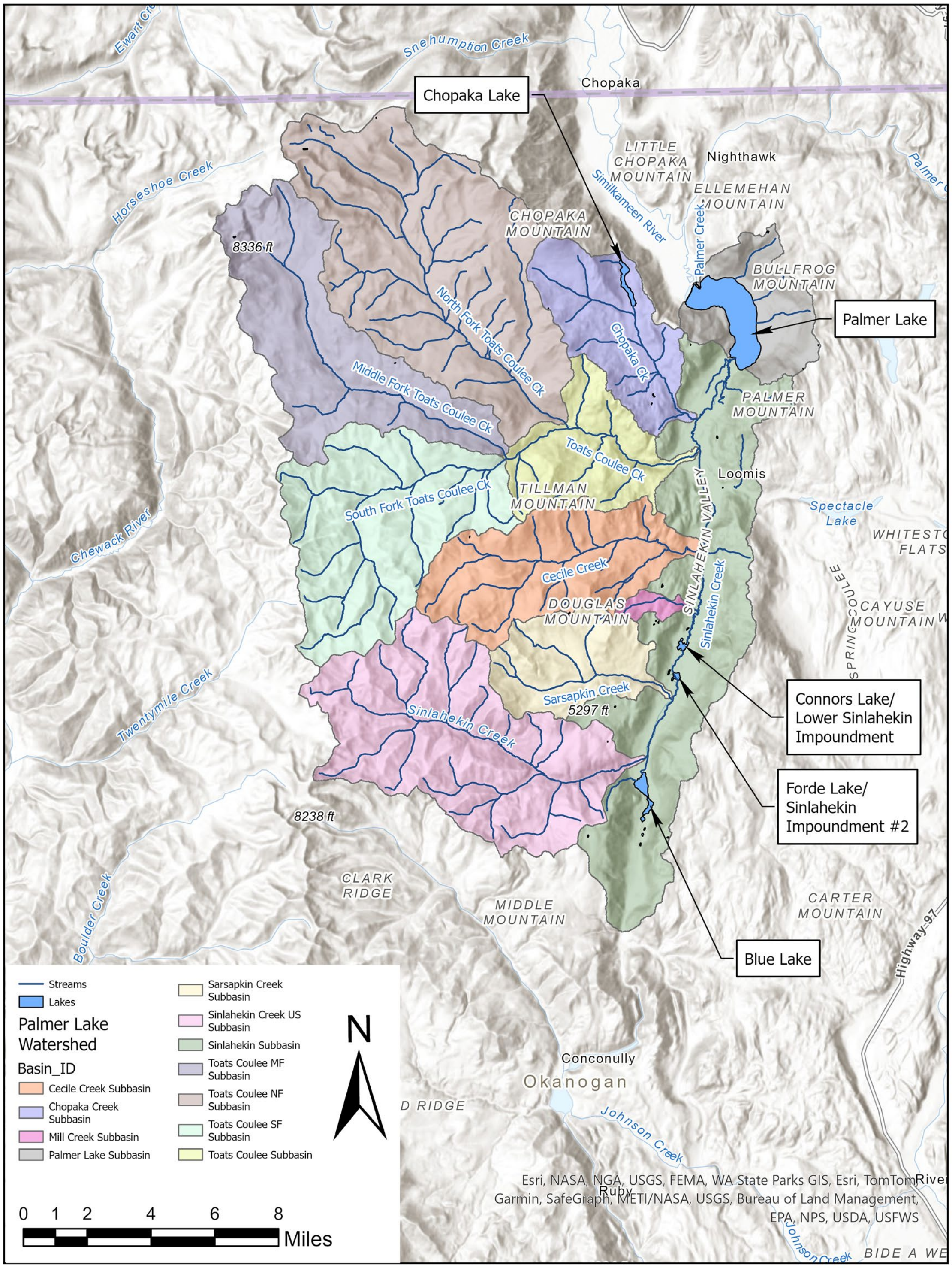


**Figure 2. Palmer Lake Watershed, Okanogan County, Washington.**

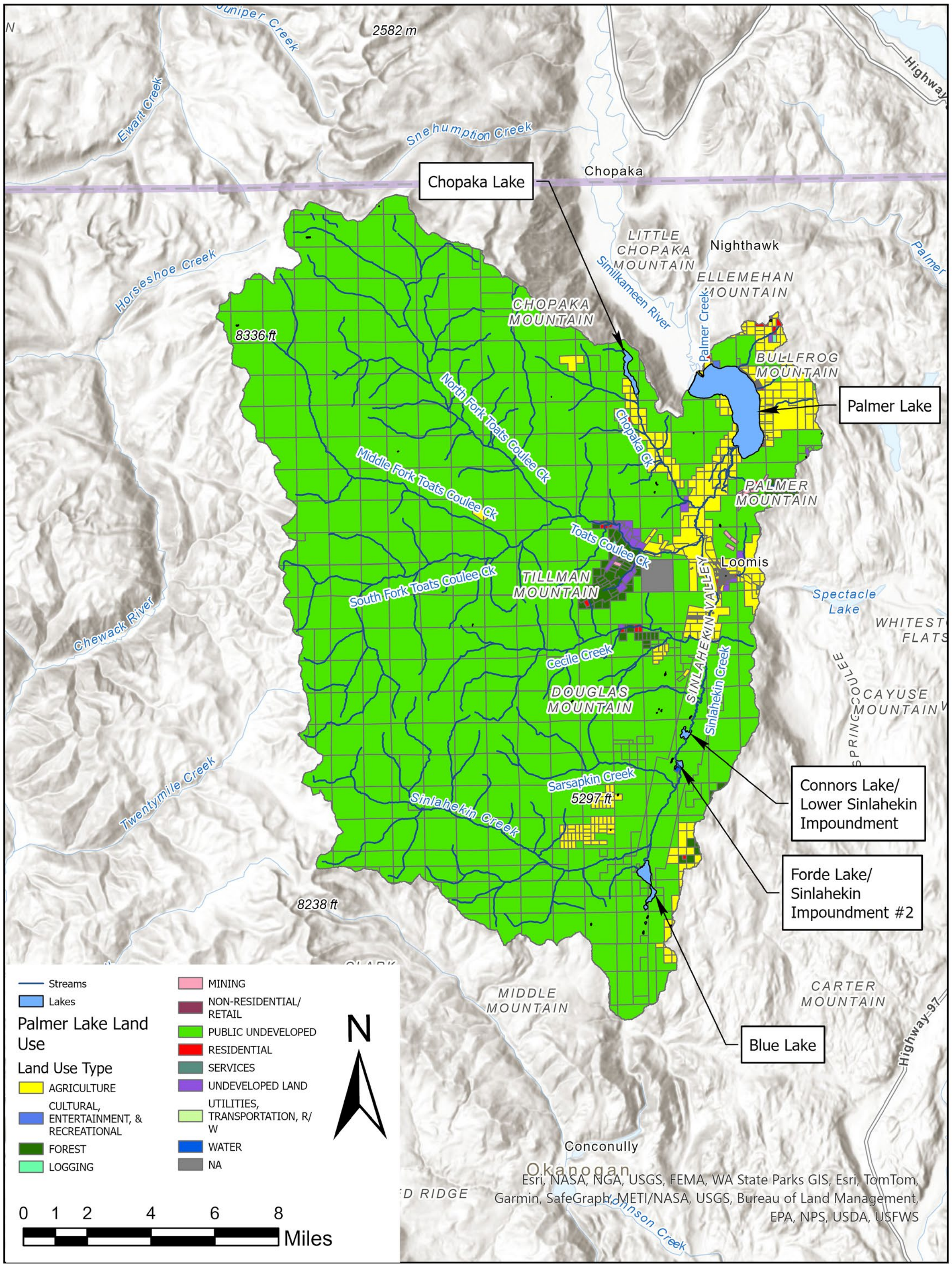


**Figure 3. Palmer Lake Watershed Land Uses, Okanogan County, Washington. Land use data from Okanogan County Public Works; Land use codes from Okanogan County Department of Revenue.**

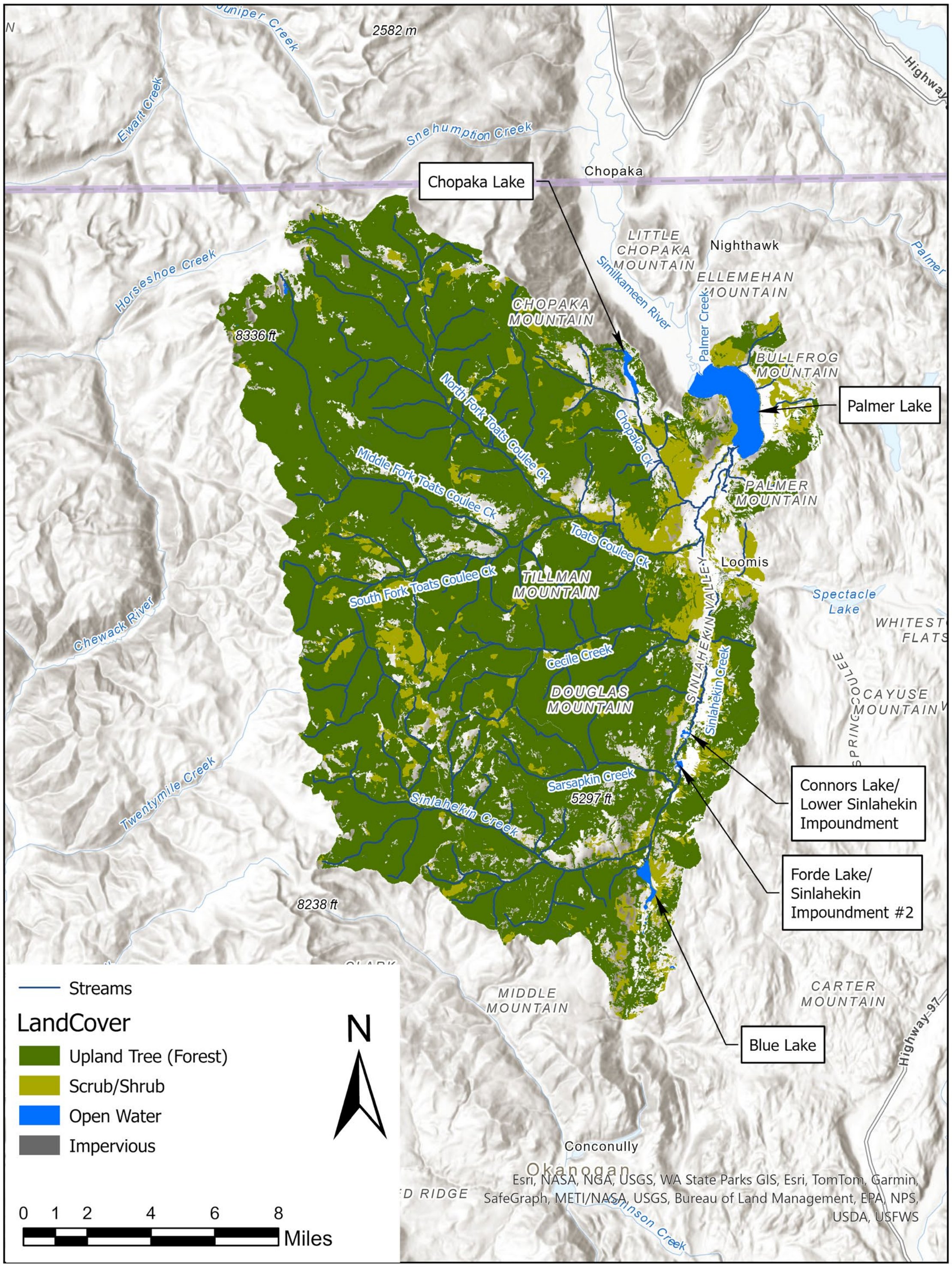


**Figure 4. Land Cover with the Palmer Lake Watershed, Okanogan County, Washington. Land cover data from NOAA's Coastal Change Analysis Program (C-CAP) 2016 Regional Land Cover Data.**

### 2.2.1 History of Study Area

The Oroville-Lower Similkameen River and Palmer Lake area was of considerable importance to the Indian people on both sides of the US-Canada border. Palmer Lake, known as *Haipwii* to the local indigenous communities, was a crucial site for food harvesting (Bouchard and Kennedy, 1984). The lake was named after James Palmer, who settled in the area around 1875. The nearby town of Loomis, Washington, founded in the 1870, along with other sites like Nighthawk and Chopaka, were primarily developed through homesteading and mining activities in the 1880's to the 1920's.

### 2.2.2 Summary of Previous Studies and Existing Data

There has been limited monitoring of Palmer Lake, its major inlet – Sinlahekin Creek, and its outlet – Palmer Creek. Table 1 summarizes the existing data and previous monitoring studies available. Most of the existing data was obtained through Ecology's EIM database. The previous studies highlighted in blue in Table 1 are most relevant to this monitoring program and are briefly summarized below.

The only available historic water quality data specific to Palmer Lake is from the statewide lake monitoring program conducted by Ecology in 1995-1998 and a single sampling event in 2010 conducted by Ecology staff during an aquatic plant survey. The statewide lake monitoring program collected samples and water column profile measurements typically twice per year, in May and August (Table 2 and Figures 5-9). The "mini" monitoring event in 2010 collected a composite sample in the epilimnion and another sample at 18 m for total phosphorus (TP) and measured Secchi disk depth (Table 2 and Figure 9).

The historical data from the late 1990s indicates that Palmer Lake stratifies during the summer season, with the epilimnion spanning approximately between 0 and 5 m, the metalimnion between 5 and 10 m, and the hypolimnion starting at about 10 m (Figure 5). The data collected in May shows that the lake is just beginning to thermally stratify. There are no data available for October or November, but we assume that fall turnover would typically occur sometime during these months. The dissolved oxygen (DO) concentrations in the lower waters of the lake appear to decrease to anoxic or near zero levels by late summer (Figure 6).

Average summer (June, July, and August) Secchi disk depths ranged from 2.5 to 4.2 m during 1995 through 1998 which indicates mesotrophic to oligotrophic conditions, or moderate to low primary productivity (Welch and Jacoby, 2004). In July 2010, Secchi disk depth was measured at 3.4 m. Surface total phosphorus (TP) concentrations measured in May and August in the late 1990s ranged from 16 to 40.7 µg/L and were typically higher in May than in August. Hypolimnetic TP concentrations in August were higher than concentrations in surface waters indicating that perhaps there is some release of phosphorus from lake sediments under anoxic conditions. While there is not enough data to calculate a summer average TP concentration in the epilimnion, the data collected in the late 1990s would suggest that the lake was most likely mesotrophic, or moderately productive, at the time. Total phosphorus data collected in July 2010 in the epilimnion was quite low, only 12 µg/L, but the TP concentration in the hypolimnion was elevated (78 µg/L) similar to data collected in the late 1990s. Chlorophyll *a* (chla) concentrations measured in Palmer Lake during 1995 – 1997 ranged from 1.5 to 8.9 µg/L, which is typical of mesotrophic waterbodies (Welch and Jacoby, 2004).

Samples for algal toxicity were collected and submitted to the Washington State Toxic Algae program in June 2007, August 2018, and October 2020. Results of these three samples are summarized in Table 3. The October 2020 sample detected both microcystin and anatoxin-a at concentrations above the state recreational guidelines. Microcystin was detected in the June 2007 and August 2018 samples but at concentrations below the state guideline.

**Table 1. Summary of Previous Monitoring Studies and Existing Data Associated with Palmer Lake.**

| Project | Year(s) | Description | Relevant Sampling Locations | Parameters Monitored |
|---|---|---|---|---|
| Long Term Trend Monitoring – Federal-Provincial Monitoring Station (Canada) | 1974 - 2024 | Long term monitoring site on Similkameen River approximately 9 km north of U.S. Border at the Chopaka Road Bridge crossing | Similkameen River near International Boundary (BC08NL0005) | Fecal Coliform, Nutrients, Major Ions, Dissolved Metals, Total Metals, Extractable Metals, Dissolved Oxygen, Temperature, pH, Conductivity, Turbidity, Color, Residue |
| Statewide Aquatic Plant Monitoring | 1994 - 2017 | Identify aquatic plants and evaluate aquatic plant community structure. Note the existence of invasive non-native aquatic plants. | Littoral area of Palmer Lake | Secchi disk depth; Aquatic plant identification and distribution index |
| Statewide Lake Monitoring | 1995-1998 | Collect water quality data from various lakes statewide. Typically, twice per year – May and August. | Deepest point in lake (PALMERLK) | Temperature, Dissolved Oxygen, pH, Conductivity, Secchi disk depth, Total Phosphorus, Total Persulfate Nitrogen, Chlorophyll *a*, Hardness |
| Similkameen River Arsenic (Johnson, 2002) | 2000, 2001 | Quantify seasonal arsenic concentrations in the Similkameen River and to identify potential arsenic sources. | Palmer Creek at Chopaka Road Bridge | Arsenic species, Flow, pH, Temperature, Conductivity, Hardness, Total Suspended Solids |
| | 2001 | | Sinlahekin Creek at Toats Coulee Road Bridge | Arsenic species, Temperature, pH, Conductivity, Total Suspended Solids, Hardness |
| Okanogan River DDT/PCB TMDL Assessment (Peterschmidt, 2004) | 2000, 2001 | Characterize the extent and sources of DDT and PCBs in Okanogan River water, sediment and fish tissue. | Palmer Creek at Chopaka Road Bridge | DDT, DDD, DDE, Flow, Temperature, pH, Conductivity, Total Suspended Solids, Total Organic Carbon |
| Okanogan River Watershed Water Quality Summary Report (Bard et al., 2003) | 2000 - 2003 | Summary of water quality monitoring data collected in sub-watersheds of the Okanogan River. | Lower Sinlahekin Creek (@ Toats Coulee Bridge); Upper Sinlahekin Creek (near Conners Lake) | Nutrients, Alkalinity, Total Suspended Solids, Fecal Coliform, Metals, Hardness, Temperature, Dissolved Oxygen, pH, Turbidity, TDS, Conductivity, Flow, Pesticides, Macroinvertebrates |

| Project | Year(s) | Description | Relevant Sampling Locations | Parameters Monitored |
|---|---|---|---|---|
| Screening Survey of Mercury Levels in Fish Tissue | 2002 | Provide regional screening level data on mercury concentrations in edible fish tissue. | Palmer Lake | Temperature, Dissolved Oxygen, pH, Conductivity, Secchi Disk depth, Alkalinity, Hardness, TOC and Mercury (lake sediments), Fish metrics, Lipids and Mercury (fish tissue) |
| Similkameen River & Palmer Lake Investigation of Arsenic in Fish Tissue (Era-Miller, 2007) | 2006 | Investigate current levels of arsenic in fish tissue from the Similkameen River and Palmer Lake. | Palmer Lake; Sinlahekin Creek | Fish metrics, Lipids and Arsenic (fish tissue) |
| State Lake Mini-Monitoring TP and Secchi | 2010 | Collect TP and secchi disk depth during routine site visits for aquatic plant monitoring. | Palmer Lake approximately deepest location | TP, Secchi Disk depth |
| Freshwater Algal ID and Cyanobacteria Toxicity Program | 2007, 2018, 2020 | Testing for cyanobacterial toxins | Various locations within Palmer Lake | Microcystin, Anatoxin-a, Cylindrospermopsin |

**Table 2. Palmer Lake Historic Nutrient and Chlorophyll *a* Data.**

| Sample Date | Depth | TP (µg/L) | TN (µg/L) | Chla (µg/L) | TN:TP Ratio |
|---|---|---|---|---|---|
| 5/22/1995 | Epilimnion* | 37.4 | 280 | 1.5 | 7.5 |
| | Hypolimnion* | 56.3 | 459 | -- | 8.2 |
| 8/28/1995 | Epilimnion | 22.6 | 292 | 4.2 | 12.9 |
| | Hypolimnion | 37.8 | 382 | -- | 10.1 |
| 5/20/1996 | Epilimnion | 24.5 | 261 | 4.2 | 10.7 |
| | Hypolimnion | 33.5 | 280 | -- | 8.4 |
| 8/19/1996 | Epilimnion | 16 | 241 | 8.9 | 15.1 |
| | Hypolimnion | 123 | 667 | -- | 5.4 |
| 5/19/1997 | Epilimnion | 33 | 266 | -- | 8.1 |
| | Hypolimnion | 24.2 | 278 | -- | 11.5 |
| 8/18/1997 | Epilimnion | 40.7 | 226 | 3.2 | 5.6 |
| | Hypolimnion | 79.6 | 280 | -- | 3.5 |
| 7/4/2010 | 0 to 2 m composite | 12.1 | -- | -- | -- |
| | 18 m | 78 | -- | -- | -- |

*Composite samples were collected from two to three equidistant depths in each stratified layer (Smith, Parsons, and Hallock, 2000)

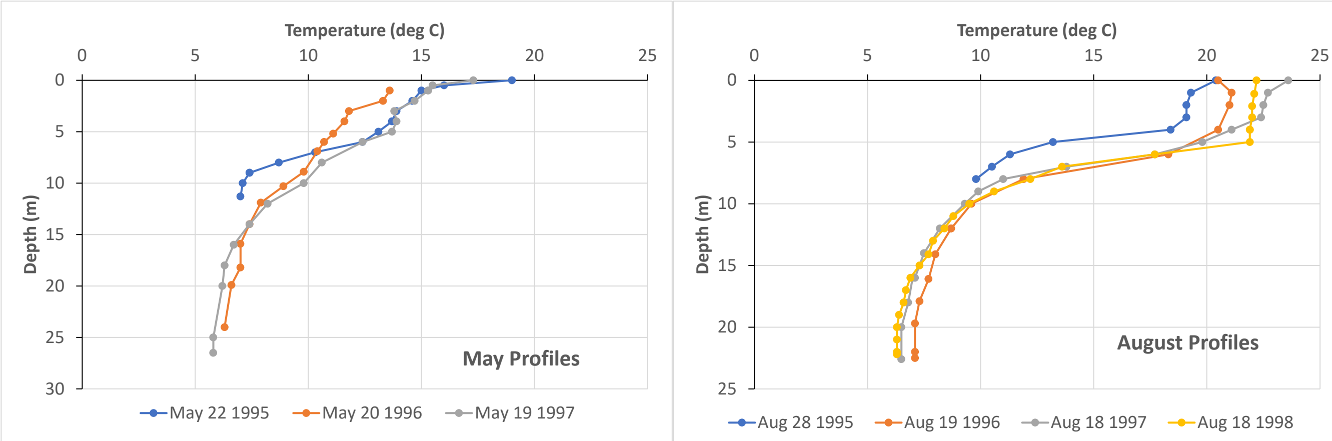


**Figure 5. Temperature Profiles in Palmer Lake, May and August 1995 – 1998.**

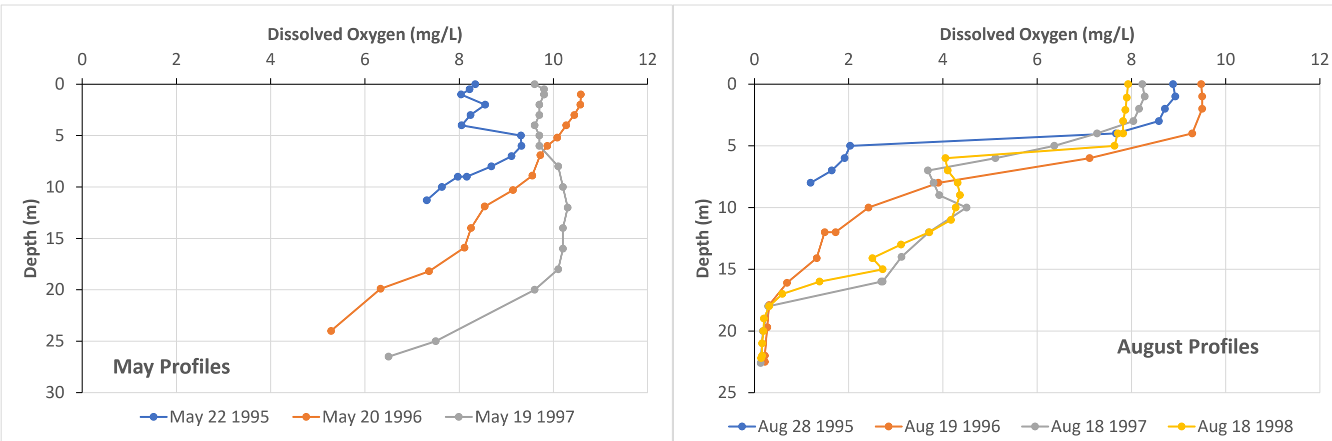


**Figure 6. Dissolved Oxygen (DO) Profiles in Palmer Lake, May and August 1995 – 1998.**

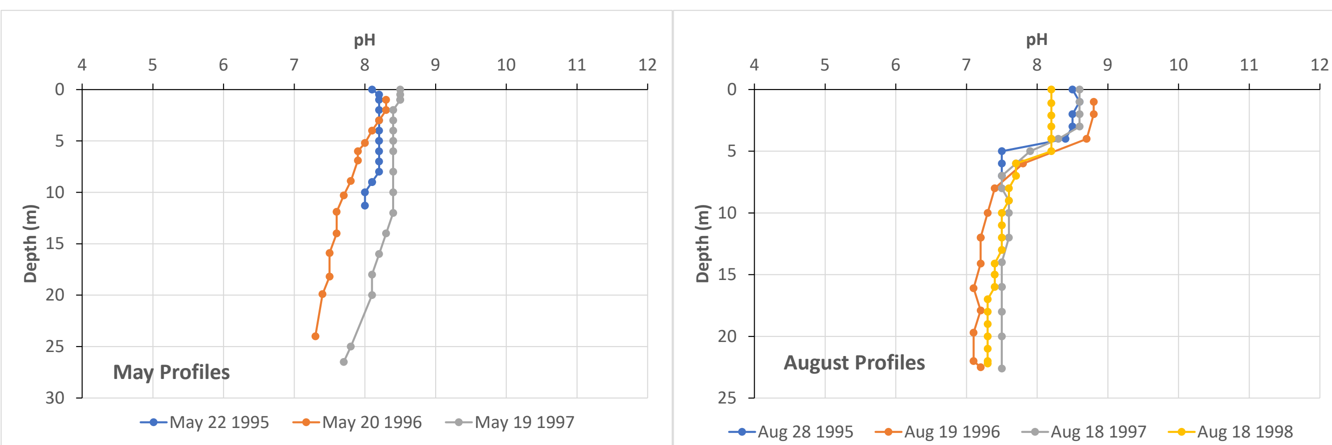


**Figure 7. pH Profiles in Palmer Lake, May and August 1995 – 1998.**

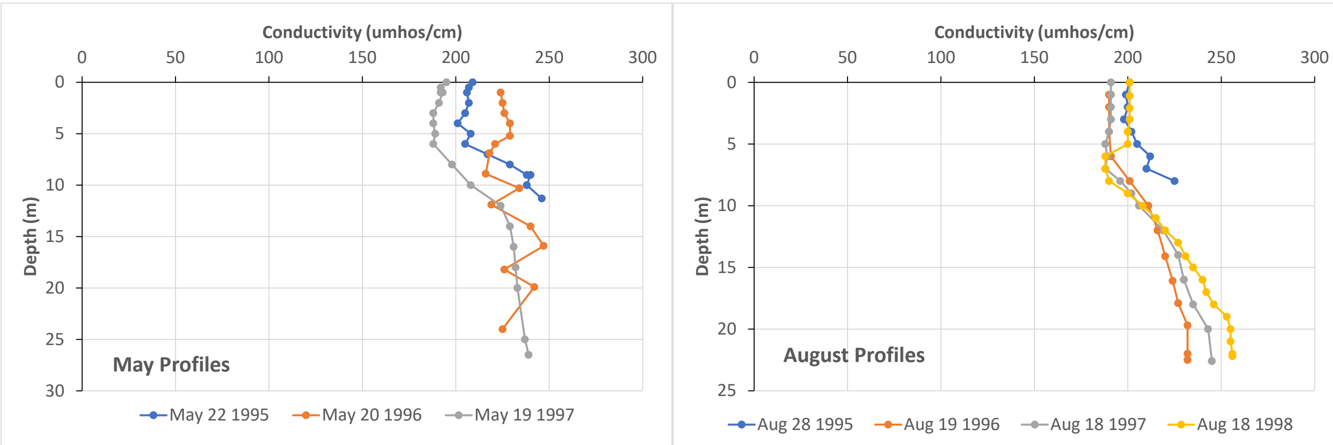


**Figure 8. Conductivity Profiles in Palmer Lake, May and August 1995 – 1998.**


**Figure 9. Palmer Lake Secchi Transparency Historical Data, 1995 – 1998 & 2010.**

**Table 3. Cyanotoxin Sample Data from Palmer Lake.**

| Sample Date | Microcystin (µg/L) | Anatoxin-a (µg/L) | Saxitoxin (µg/L) | Cylindrospermopsin (µg/L) | Cyanobacteria Species Present |
|---|---|---|---|---|---|
| 6/28/2007 | 0.072 | -- | -- | -- | unknown |
| 8/1/2018 | 0.506 | <0.010 | <0.020 | <0.025 | *Aphanizomenon sp., Dolichospermum sp* |
| 10/15/2020 | 13.8* | 1.16* | -- | -- | *Aphanizomenon sp., Dolichospermum sp., Gleotrichia sp., Microcystis sp., Limnoraphis sp.* |

*Concentrations are above Washington state recreational guideline values for microcystin (6 µg/L) and anatoxin-a (1 µg/L).

The Okanogan CD conducted routine water quality monitoring in sub watersheds of the Okanogan River between June 2000 and June 2003. The monitoring effort was a major component of the Okanogan Watershed Planning Project, which was partially funded by a Centennial Clean Water grant from Ecology (Bard et al., 2003). As part of this monitoring effort, water quality samples were collected at two sample locations on Sinlahekin Creek – Lower Sinlahekin Creek at the Toats Coulee Road bridge and Upper Sinlahekin Creek near Connors Lake. Figures 10 – 12 provide a graphical summary of some of the nutrient and TSS concentrations measured at the two Sinlahekin Creek stations in the early 2000s.

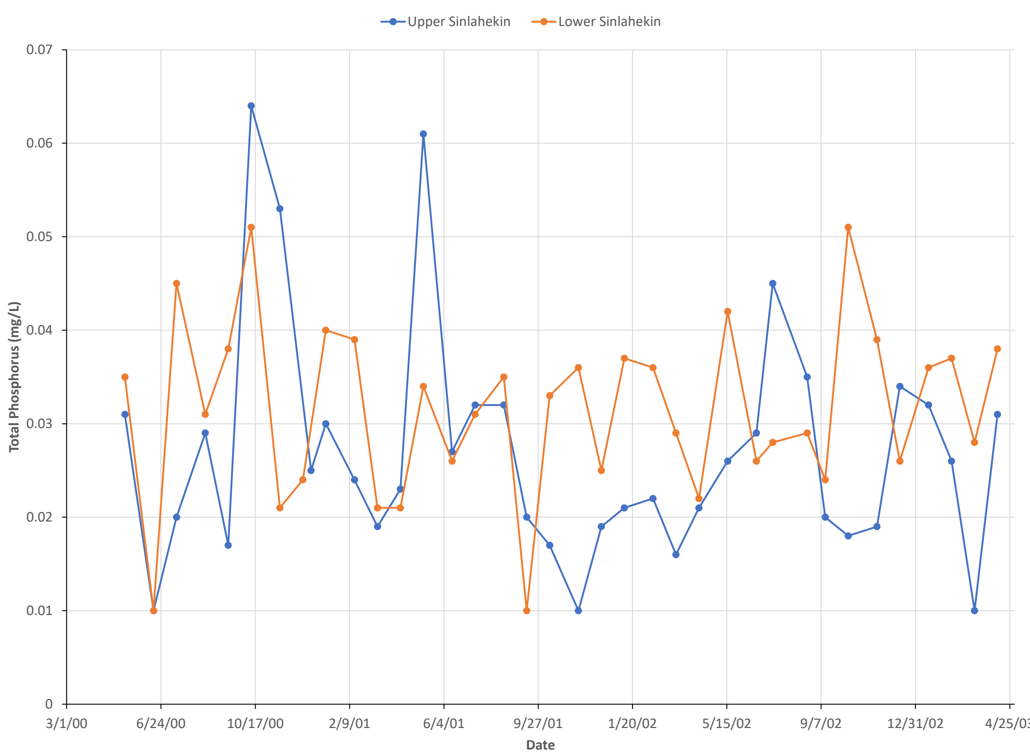


**Figure 10. TP Concentrations in Sinlahekin Creek, 2000 – 2003.**

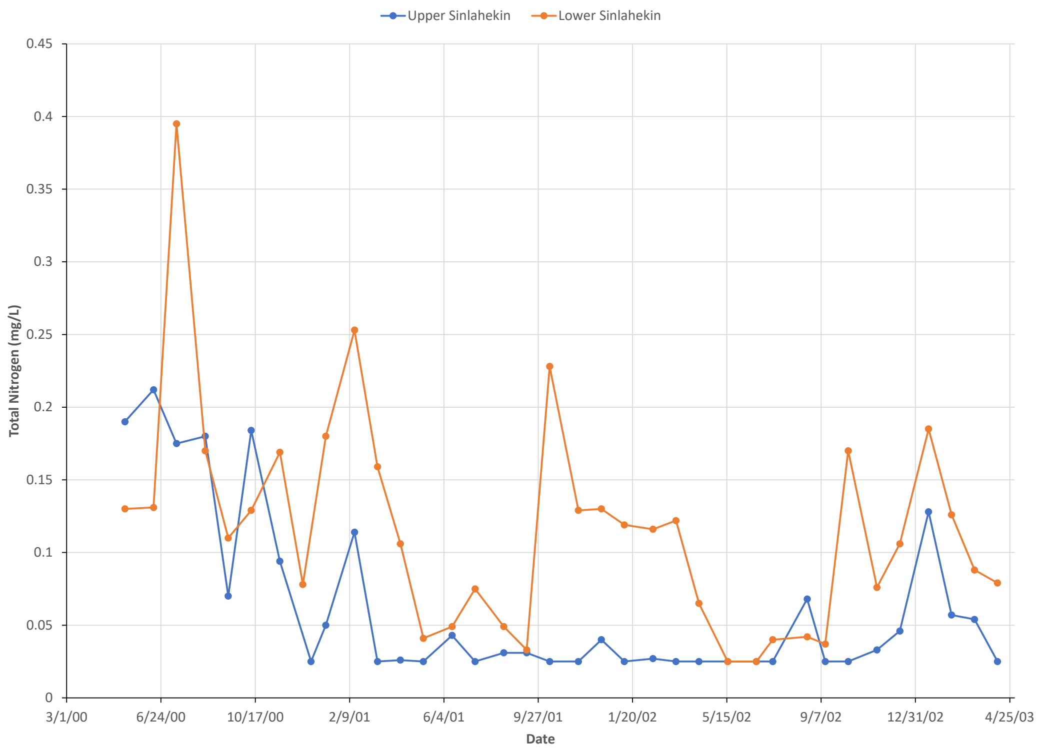


**Figure 11. TN Concentrations in Sinlahekin Creek, 2000 – 2003.**

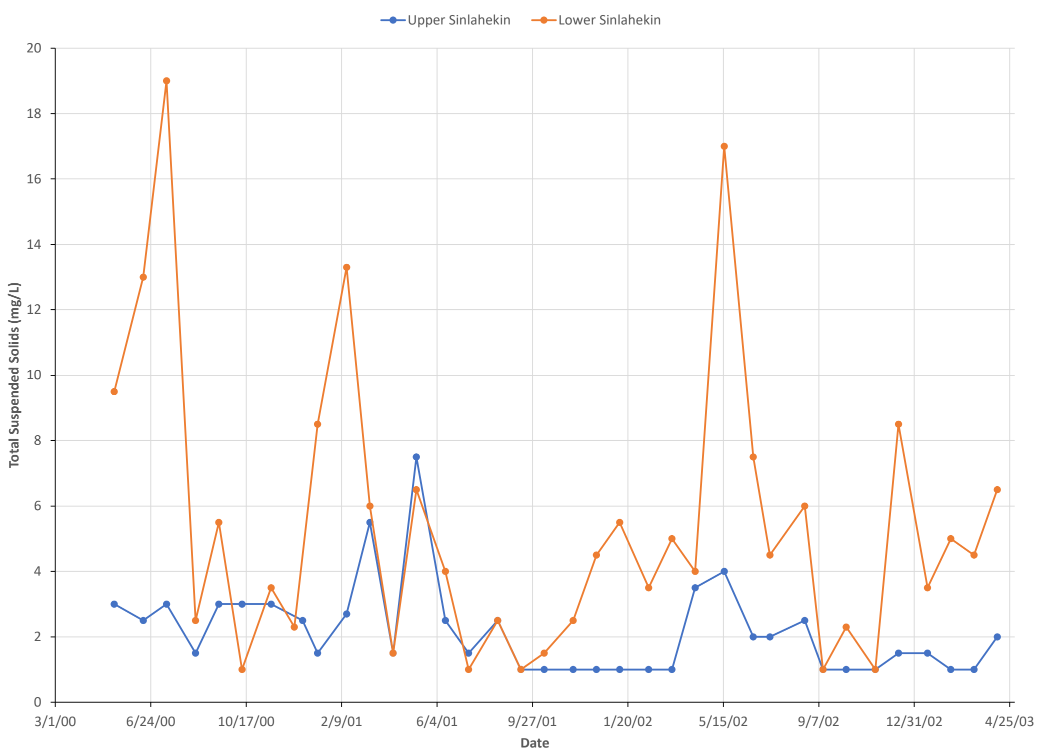


**Figure 12. TSS Concentrations in Sinlahekin Creek, 2000 – 2003.**

### 2.2.3 Water Quality Parameters of Interest and Potential Sources

Palmer Lake has recently experienced annual algae blooms, some which have been documented to be toxic, decreased water clarity, and prevalent fish kills. Nuisance and harmful algal blooms (HABs) are typically the result of excess nutrients in the lake. These excess nutrients can come from the lake's watershed and from within the lake. Based on the limited historic data, it is expected that phosphorus is the limiting nutrient in Palmer Lake, particularly in the surface waters during the summer, and that high levels of phosphorus are the primary cause of repeated nuisance algae blooms. The timing and cause of the fish kills are unknown currently but may be related to periods when the Similkameen River flows into Palmer Lake during high spring flows.

The monitoring program outlined in this QAPP will focus on identifying potential sources of nutrient (phosphorus and nitrogen) pollution and how the watershed may be impacting lake water quality. The monitoring program will also focus on data collection to assess and evaluate overall lake water quality conditions and lake health and provide a baseline limnological dataset for Palmer Lake. The data collected under this QAPP will provide insight into identifying the key sources of nutrients and track algal biomass and lake production over the critical season. Potential sources of nutrients fueling algae growth in Palmer Lake include:

- Internal loading of phosphorus from lake sediments (also commonly referred to as legacy phosphorus)
- Watershed loading of nutrients via Sinlahekin Creek, the lake's primary inlet
- Watershed loading via the Similkameen River during periods of high flow
- Shoreline land disturbances
- Shoreline septic systems
- Waterfowl (although not expected to be a significant source of nutrients to the lake)

Samples will be collected from Palmer Lake, as well as Sinlahekin Creek and Palmer Creek, and analyzed for TP, soluble reactive phosphorus (SRP), total nitrogen (TN), nitrate+nitrite nitrogen, ammonia nitrogen, alkalinity, chla, and total suspended solids (TSS). *In-situ* measurements will be recorded for water temperature, dissolved oxygen (DO), pH, conductivity, chla and phycocyanin. Water clarity (transparency) will be measured in Palmer Lake using a Secchi disk.

### 2.2.4 Regulatory Criteria or Standards

Palmer Lake's designated uses include core summer salmonid habitat, primary contact recreation, water supply uses (domestic, industrial, agricultural, and stock), wildlife habitat, harvesting, commerce and navigation, boating, and aesthetic values (WAC 173-201A-600). Applicable surface water quality criteria to support these beneficial uses are listed in Table 4. However, data collected from the monitoring program described in this QAPP will not be used for assessing regulatory compliance status.

**Table 4. Applicable Water Quality Criteria for Palmer Lake (WAC 173-201A-200 and WAC 173-201A-600).**

| Parameter | Criteria |
|---|---|
| Temperature – Highest 7-DAD Max | 16°C (60.8°F) |
| Dissolved Oxygen – 1 Day Minimum | 9.5 mg/L |
| pH | Within the range of 6.5 to 8.5, with a human-caused variation within the range of less than 0.2 units |

## 2.3 WATER QUALITY IMPAIRMENT STUDIES

In accordance with the Clean Water Act, Ecology conducts water quality assessments on waterbodies in Washington State every two years. In August 2022, the Environmental Protection Agency (EPA) Region 10 issued their final approval of Ecology's 2018 Water Quality Assessment. This assessment serves as the most current and contains a list of Category 5 impaired waterbodies of the state.

Palmer Lake is currently listed as impaired for methylmercury in fish tissue based on a 2006 study (listing ID:88795). A portion of Sinlahekin Creek between Toats Coulee Creek and Palmer Lake is currently listed as impaired for bacteria due to elevated fecal coliform in samples collected in 2001-2003 (listing ID:46024) as well as DO (listing ID:47931). Connors Lake, located in the Sinlahekin Wildlife Area on Sinlahekin Creek, is listed as impaired for arsenic in fish tissue based on samples collected in 2002 (listing ID:76538). Palmer Lake falls within the boundaries of two approved total maximum daily load (TMDLs) projects: 1) Lower Similkameen River Arsenic TMDL, and 2) Lower Okanogan River Watershed Toxics TMDL.

# 3.0 PROJECT DESCRIPTION

The Okanogan CD will conduct a water quality monitoring program to help assess and better understand the current water quality conditions in Palmer Lake, provide a baseline limnological dataset, identify potential sources of pollution, and assess algae bloom severity and nutrient cycling. The data collected as part of the monitoring program will focus on identifying potential sources of nutrient (phosphorus and nitrogen) pollution and how the watershed may be impacting lake water quality. The data collected under this QAPP will provide insight into identifying the key sources of nutrients and track algal biomass and lake production over the critical summer growing season. The data collected under this QAPP will also provide a baseline dataset for Palmer Lake.

## 3.1 PROJECT GOALS AND OBJECTIVES

The goal of this water quality monitoring program is to collect data of sufficient quality and quantity to assess lake water quality conditions and overall lake health, identify potential sources of pollution, assess and track algae bloom severity, and evaluate nutrient cycling within the lake. Specifically, the data collected as part of this monitoring program will be used to:

- Track changes in Palmer Lake water quality over the critical growing season
- Assess nutrient inputs to Palmer Lake and identify potential nutrient loading sources to the lake
- Evaluate and track algae blooms during the critical growing season
- Evaluate changes in lake water quality during high flows on the Similkameen River
- Provide basic limnological data to serve as a baseline for future studies of Palmer Lake

The objectives of this water quality monitoring program are to:

- Conduct water quality monitoring at least monthly at one station in Palmer Lake during the critical growing season, May – October.
- Conduct water quality monitoring at least monthly in the lake's major inflow, Sinlahekin Creek during the critical growing season, May – October.
- Conduct water quality monitoring at least monthly in the lake's outlet, Palmer Creek during the critical growing season, May – October. Timing of this monitoring in spring and early summer should correspond to high flows on the Similkameen River when flow is entering Palmer Lake.
- Collect continuous or weekly lake level data for Palmer Lake.
- Obtain better understanding of overall lake health through collection of observations related to aquatic vegetation, algae abundance and community, and waterfowl use (species present and estimated number of each species).

## 3.2 INFORMATION NEEDED AND SOURCES

A summary of the historic and existing data available from previous studies is summarized in Section 2.2.2 and Table 1. Additional water quality monitoring data will be collected as outlined in this QAPP. Other additional information, such as GIS shapefiles and layers will be obtained from Okanogan CD, Ecology, and other agencies, as needed.

In order to meet the project goals, samples will be collected from Palmer Lake, Sinlahekin Creek and Palmer Creek, and analyzed for various nutrients (TP, SRP, TN, nitrate+nitrite nitrogen, and ammonia nitrogen) as well as alkalinity, chla and TSS. Observations of aquatic vegetation, waterfowl use, algal abundance, and recreational uses will also be made by Okanogan CD field staff. *In-situ* measurements will be recorded for water temperature, DO, pH, conductivity, chla, and phycocyanin. Water clarity (transparency) will be measured in Palmer Lake using a Secchi disk. Flow measurements will be collected at the Sinlahekin Creek and Palmer Creek monitoring locations. Estimates of flow into and out of the lake would allow for calculation of nutrient loading, retention, and loss within the lake.

Samples will be collected for phytoplankton identification, enumeration, and biovolume and held for future analysis. Analysis of phytoplankton samples will occur only if additional funding is secured during the current monitoring period or in future monitoring periods.

## 3.3 TASKS REQUIRED

Below are the specific tasks planned to be completed to address each of the project's objectives and to obtain the necessary water quality information.

- Collect water quality samples from pre-determined depths at the historic monitoring station in Palmer Lake at least once per month during the critical growing season.
- Record *in-situ* measurements at pre-determined intervals within the lake water column of temperature, DO, pH, conductivity, and turbidity.
- In conjunction with lake sampling, collect grab samples and record field and flow measurements at the stations identified in Sinlahekin Creek, the main inflow to the lake, and Palmer Creek, the lake's outlet.
- Install a staff gauge or data logger on a non-floating dock to measure lake level either continuously or at least weekly during the ice-free season.
- Record observations during sampling events of aquatic vegetation in the littoral areas of Palmer Lake, algal abundance, and waterfowl or other aquatic life uses.

## 3.4 SYSTEMATIC PLANNING PROCESS

The preparation of this QAPP is sufficient systematic planning for this project.

# 4.0 ORGANIZATION AND SCHEDULE

Key project personnel are identified and listed below, followed by a proposed project schedule.

## 4.1 KEY INDIVIDUALS AND RESPONSIBILITIES

Table 5 below describes key personnel involved in the project and a description of their responsibilities, as well as their contract information. Water quality monitoring for Palmer Lake will be performed by Okanogan CD staff and citizen volunteers following protocols outlined in this QAPP.

**Table 5. Key Personnel and Responsibilities**

| Project Personnel | Title | Responsibilities |
|---|---|---|
| Chevelle Yeckel<br>Okanogan Conservation District<br>(509) 429-5237<br>chevelle@okanogancd.org | Riparian and Water Quality Planner | Responsible for overall Palmer Lake monitoring program.<br><br>Field Monitoring Lead |
| Brant Rosenthal Smith<br>Okanogan Conservation District<br>(509) 546-6041<br>brant@okanogancd.org | Science Data & Monitoring Coordinator | Responsible for entering and managing collected data. Assists with field monitoring activities.<br><br>Field Monitoring Assistant and Data Management Lead |
| Shannon Brattebo<br>Tetra Tech, Inc.<br>(509) 232-4312<br>Shannon.brattebo@tetratech.com | Project Manager and Technical Lead | Responsible for development of QAPP and water quality monitoring program. Provide technical assistance and training on sampling protocols. |
| Julie Conley<br>Department of Ecology<br>(509) 907-3937<br>jcon461@ecy.wa.gov | Grant Project Manager | Responsible for management of Ecology grant. |
| Christina Frans<br>Department of Ecology<br>(360) 519-2067<br>cfra461@ecy.wa.gov | Interim Quality Assurance Officer | Responsible for review and approval of QAPP. |
| LABORATORY MANAGER | TBD | Responsible for laboratory analysis of samples. Responsible for QA/QC on lab protocols and data. |

## 4.2 SPECIAL TRAINING AND CERTIFICATIONS

At least one member of the field team conducting monitoring and data collection efforts will have previous experience with the equipment being used. All field staff must read and be familiar with the QAPP prior to conducting data collection activities. Tetra Tech and the Okanogan CD will coordinate training of Okanogan CD staff and citizen volunteers on monitoring protocols outlined in this QAPP if necessary. Water quality sampling will be conducted by boat and at least one member of the field team must have experience operating a boat. If a motorboat of greater than 15 horsepower is used for monitoring the operator must have completed a boating safety course and carry a Washington State Boater Education Card. All persons on a watercraft must wear an approved personal flotation device.

## 4.3 ORGANIZATION CHART

Not applicable – See Table in Section 4.1.

## 4.4 PROPOSED PROJECT SCHEDULE

The Okanogan CD plans to begin water quality monitoring in May 2025, with the first monitoring season extending through October 2025. If additional funding becomes available, the Okanogan CD may conduct monitoring in subsequent years. Water quality monitoring will be conducted at least once per month starting no later than May and concluding in October/November. Monitoring in the lake should be conducted at least once per month during the critical growing season, although twice per month sampling is preferred. Similarly, monitoring in Sinlahekin and Palmer Creeks should also be conducted at least once per month during the summer season, but twice per month is preferred. Monitoring in the lake and Sinlahekin and Palmer Creeks should be conducted on the same day. If sufficient funds are available, it is recommended that monthly samples also be collected in Sinlahekin and Palmer Creeks outside of the summer season, November - April. The timing of monitoring in Palmer Creek, the outlet to Palmer Lake, should coincide, to the greatest extent possible, with the high flows of the Similkameen River backflowing into Palmer Creek and Palmer Lake.

The exact sampling scheduling will be coordinated between Okanogan CD staff and any participating citizen volunteers.

Table 6 summarizes a recommended annual monitoring schedule which can be adjusted based on funding.

**Table 6. Recommended Water Quality Monitoring Schedule**

| Task | Schedule |
|---|---|
| Annual OCD Staff and Citizen Volunteer Monitoring Training or Refresher | Early Spring |
| Measure Lake Level | Ice off to Ice on |
| Lake Water Quality Monitoring | May – October (at least once per month, twice per month preferred) |
| Stream Water Quality Monitoring<br>(Sinlahekin and Palmer Creeks) | May – October (at least once per month, twice per month preferred)<br>November – April (monthly if feasible) |
| QA/QC field data | Within 24 hours of sampling event |
| QA/QC laboratory data | Within 48 hours of receipt |

## 4.5 BUDGET AND FUNDING

The funding source for the development of this QAPP is a grant funded by Ecology, Agreement No. WQC-2022-OkanCD-00064, to the Okanogan CD. Water quality monitoring activities conducted under this QAPP may also be funded partially by the Agreement with Ecology, or by additional funding mechanisms or additional grant funding. For planning purposes, a summary of estimated basic annual laboratory costs is provided in Table 7. The costs provided in Table 7 are for once per month sampling from May through October for basic laboratory parameters. Table 7 also provides estimates for phytoplankton and zooplankton analysis for future planning purposes.

**Table 7. Estimated Annual Laboratory Costs for Monthly Sampling May – October.**

| Parameter | Number of Samples per Year | Number of QA Samples per Year | Total Number of Samples per Year | Cost Per Sample* | Lab Subtotal |
|---|---|---|---|---|---|
| **Palmer Lake**** | | | | | |
| Total Phosphorus | 24 | 3 | 27 | $25 | $675 |
| Soluble Reactive Phosphorus | 24 | 3 | 27 | $23 | $621 |
| Total Nitrogen | 24 | 3 | 27 | $25 | $675 |
| Nitrate+Nitrite Nitrogen | 24 | 3 | 27 | $20 | $540 |
| Ammonia-N | 24 | 3 | 27 | $20 | $540 |
| Alkalinity | 24 | 3 | 27 | $20 | $540 |
| Chlorophyll *a* | 12 | 3 | 15 | $40 | $600 |
| **Sinlahekin and Palmer Creeks** | | | | | |
| Total Phosphorus | 12 | 3 | 15 | $25 | $375 |
| Soluble Reactive Phosphorus | 12 | 3 | 15 | $23 | $345 |
| Total Nitrogen | 12 | 3 | 15 | $25 | $375 |
| Nitrate+Nitrite Nitrogen | 12 | 3 | 15 | $20 | $300 |
| Ammonia-N | 12 | 3 | 15 | $20 | $300 |
| Alkalinity | 12 | 3 | 15 | $20 | $300 |
| Total Suspended Solids | 12 | 3 | 15 | $20 | $300 |
| | | | | **Estimated Annual Laboratory Total** | **$6,486** |
| **Additional Laboratory Analysis** | | | | | |
| Phytoplankton ID, Enumeration & Biovolume | | | | $400 - $500 per sample | |

*Analysis cost per sample subject to change based on laboratory contracted by Okanogan CD. Costs per sample shown in table from IEH Analytical Laboratories quote obtained April 2024. Okanogan CD should plan for 3% escalation of laboratory costs each year.

**Samples proposed to be collected at 4 discrete depths in the lake water column – 1 m, 6 m, 15 m, and one meter from the bottom. The number of samples per year is subject to change depending on funding available. Samples depth may be reduced to just two depths (1 m and one meter from the bottom).

# 5.0 QUALITY OBJECTIVES

## 5.1 DATA QUALITY OBJECTIVES (DQOs)

Data quality objectives (DQOs) are qualitative and quantitative statements that clarify the intended use of the data, define the types of data needed to support decisions, identify the condition under which the data should be collected, and specify tolerable limits on the probability of making a decision error due to uncertainty in the data (if applicable). Data users develop DQOs to specify the data quality and quantity needed to support specific decisions.

Data, or decision, quality objectives determine when data will be used to select between management strategies or to determine compliance with a standard. The main DQO for this project is to collect water quality samples and measurements that are representative of Palmer Lake and its main inlet, Sinlahekin Creek, and its main outlet Palmer Creek. The data collected will be used to assess and evaluate Palmer Lake water quality, algae bloom severity, and nutrient cycling, as well as the lake's overall ecological health. Water samples will be analyzed using standard methods so data generated meet the measurement quality objectives (MQOs) that are described below and to ensure that data collected are comparable to historical monitoring data.

## 5.2 MEASUREMENT QUALITY OBJECTIVES (MQOs)

Measurement quality objectives are the performance or acceptance criteria for individual data quality indicators, including precision, bias, and sensitivity (Ecology, 2004 revised 2016). Industry standard field methods will be used throughout this project to minimize measurement bias (systematic error) and to improve precision (to reduce random error). All laboratory bound samples will be collected, preserved, stored, and otherwise managed using accepted procedures for maintaining sample integrity prior to analysis as outlined in this QAPP.

Measurement quality objectives are defined by precision, bias, sensitivity, comparability, representativeness, and completeness. Project specific MQOs are provided below in Tables 8 and 9.

**Table 8. Measurement Quality Objectives for Multi-parameter Sonde Calibration Checks.**

| Parameter | Units | Accept | Qualify | Reject |
|---|---|---|---|---|
| pH | std. units | < or = ± 0.2 | > ± 0.2 and < or = ± 0.8 | > ± 0.8 |
| Conductivity | *u*S/cm | < or = ± 5% | > ± 5% and < or = ± 15% | > ± 15% |
| Temperature | ° C | < or = ± 0.2 | > ± 0.2 and < or = ± 0.8 | > ± 0.8 |
| Dissolved Oxygen | % saturation | < or = ± 5% | > ± 5% and < or = ± 15% | > ± 15% |
| Dissolved Oxygen | mg/L | < or = ± 0.3 | > ± 0.3 and < or = ± 0.8 | > ± 0.8 |
| Chlorophyll *a* | RFU | < or = ± 1.0 | > ± 1.0 and < or = ± 2.0 | > ± 2.0 |
| Phycocyanin | RFU | < or = ± 1.0 | > ± 1.0 and < or = ± 2.0 | > ± 2.0 |

**Table 9. Measurement Quality Objectives**

| Parameter | Method | Expected Range of Values | Check Standard (LCS) | Duplicate Samples | Matrix Spikes/Matrix Spike Duplicates | Method Detection Limits |
|---|---|---|---|---|---|---|
| | | | % Recovery | RPD | % Recovery, RPD | |
| **Laboratory** | | | | | | |
| Chlorophyll a | SM-10200H | 1 to 25 µg/L | NA | ±20% | NA | 0.1 µg/L |
| Total Nitrogen (Total Persulfate Nitrogen) | SM-4500NC | 0.5 to 50 mg/L | 90-110% | ±20% | 90-110% | 0.050 mg/L |
| Total Phosphorus | SM-4500PF | 0.005 to 0.25 mg/L | 90-110% | ±20% | 90-110% | 0.002 mg/L |
| Soluble Reactive Phosphorus | SM-4500PF | 0.001 to 0.05 mg/L | 85-115% | ±20% | 85-115% | 0.001 mg/L |
| Nitrate+Nitrate-N | SM-4500NO3F | 0.01 to 30 mg/L | 85-115% | ±20% | 85-115% | 0.010 mg/L |
| Ammonia - N | SM-4500NH3H | 0.01 to 30 mg/L | 85-115% | ±20% | 85-115% | 0.010 mg/L |
| Alkalinity | SM-2320B | 1 to 100 mg $CaCO_3$/L | 85-115% | ±20% | 85-115% | 1.0 mg $CaCO_3$/L |
| Total Suspended Solids | SM2540-D | 0.99 to 50 mg/L | 75-125% | ±10% | 75-125% | 0.99 mg/L |

## 5.2.1 Targets for Precision, Bias, and Sensitivity

Precision - Precision is defined as the degree to which a set of observations or measurements of the same property conform when obtained under similar conditions. Precision is usually expressed as standard deviation, variance, or range, in either absolute or relative terms. Precision will be assessed on the analyses of laboratory and field duplicates. Laboratory duplicates for assessment of precision will be analyzed at no less than a 5 percent frequency of the total number of samples submitted to the laboratory.  Field duplicate samples will be collected at a rate of one per 10 samples, or every other sampling event, for those parameters measured in the laboratory. Duplicate field measurements will be recorded at one sampling location or depth per sampling event. The specific location or depth designated for collection of a field duplicate sample will be determined prior to the beginning of each sampling event.

For sample results which exceed the method detection limit (MDL), the relative percent difference (RPD) will be less than or equal to acceptable percentages outlined in Table 9 above. No criteria are presented for duplicates which are below the MDL, as these data are provided for informational purposes only.  For instance, where one result is below the MDL, professional judgment will be used in determining the compliance of the data to project requirements.

Bias – Bias provides an indication of the accuracy of the analytical data. Bias will be assessed based on analyses of method blanks, matrix spikes (MS), and laboratory control samples (LCS). Check samples will be used by the laboratory to provide compliance criteria for bias. The percent recovery of the MS, LCS, and standard reference materials are defined above in Table 8 for each parameter. The use of matrix spike recovery will provide additional information regarding method performance on actual samples. The laboratory and the person primarily responsible for data quality review and validation, will use professional judgment regarding reanalysis triggered by matrix spike recovery.

Sensitivity – Sensitivity is a measure of the capability of a method to detect a substance. It is commonly described as a detection limit. In a regulatory setting, the MDL is often used to describe sensitivity. Targets for field and laboratory measurement sensitivity required for this project are listed in Table 8.

### 5.2.2 Targets for Comparability, Representativeness, and Completeness

Comparability – Comparability is a measure of the confidence with which one dataset can be compared to another. This is a qualitative assessment and is addressed primarily in sampling design through use of comparable sampling procedures or, for monitoring programs, through consistent sampling of stations over time. For this project standard sampling procedures will be followed, and samples will be collected from the same location in the lake that was sampled by Ecology personnel in the late 1990s and samples will be collected from the same inlet and outlet locations on Sinlahekin and Palmer Creeks that was used by Okanogan CD staff in 2000-2003. In the laboratory, comparability is assured through the use of comparable analytical procedures and ensuring that project staff are trained in the proper application of the procedures. Within-study comparability will be assessed through analytical performance (quality control samples).

Representativeness - Sample representativeness is the degree to which data accurately and precisely represents a characteristic of a population. Representativeness will be addressed at two distinct steps of the data collection process. During sample collection, the use of generally accepted sampling procedures in a consistent manner throughout the project will help ensure that samples are representative of the point where the sample was taken. During subsampling in the laboratory, samples will be mixed by inverting several times to ensure that the analytical subsample is representative of the sample container contents.

The degree to which the sample point represents the entire lake water column will also be assessed through the collection of samples at different depths in the lake from May through October. Lakes may have a high natural variability with depth, particularly during summer months. Historical vertical temperature profiles show that this is the case for Palmer Lake during the summer. Depending on the parameter, samples will be collected and analyzed from different depths of the water column as discussed in the sampling plan.

Completeness - Completeness is a measure of the amount of valid data needed to meet the project's objectives. Completeness will be judged by the amount of valid data compared to data expected as detailed in the QA plan. Valid data are those data in compliance with the data quality criteria as presented in this section, and in compliance with required holding times. While the goal for the above criteria is 100 percent completeness, a level of 95 percent completeness is considered acceptable. However, at any time where data are not complete, decisions regarding resampling and/or reanalysis will be made by the Okanogan CD. These decisions will consider the project data quality objectives as presented above.

## 5.3 ACCEPTANCE CRITERIA FOR QUALITY OF EXISTING DATA

Existing water quality data for Palmer Lake which was collected by Ecology staff or volunteer monitors was collected for the state's Lake Water Quality Assessment Program and were previously evaluated to determine whether data quality objectives for the program were met. Methods used by Ecology staff for data quality evaluations are detailed in the *Lake Water Quality Assessment Program Quality Assurance Project Plan* (Hallock, 1995). Existing water quality data collected under the Lake Water Quality Assessment Program were downloaded from Ecology's EIM system.

Existing water quality data for the Sinlahekin and Palmer Creek stations and monitoring program conducted by the Okanogan CD was collected following a detailed water quality monitoring standard operating procedure document, however it is unclear whether the data was evaluated or reviewed based on data quality objectives or QA/QC requirements. The Okanogan CD will review the existing water quality data for the Sinlahekin and Palmer Creeks prior to any use and use professional judgement on the use of any historical data.

## 5.4 MODEL QUALITY OBJECTIVES

Not applicable.

# 6.0 STUDY DESIGN

## 6.1 STUDY BOUNDARIES

Water quality data for this project will be collected from Palmer Lake, its main inlet – Sinlahekin Creek, and its outlet – Palmer Creek. The selected monitoring locations are shown in Figure 1 and summarized in Table 10.

Palmer Lake is a natural kidney shaped lake located in north central Washington approximately 4 miles north of the small town of Loomis in Okanogan County. Palmer Lake lies at an elevation of 1,145 ft (349 m) above sea level. The lake has a surface area of approximately 2,063 acres and a maximum depth of 91 ft (28 m) (Wolcott, 1973). Lake water level fluctuates naturally throughout the year with highest water levels typically occurring in June.

Sinlahekin Creek is the primary inlet to Palmer Lake and drains into the lake from the south. Palmer Creek is the outlet to Palmer Lake and drains out of the lake through a marshy area from the north shore. Six miles downstream of the Canadian border, the Similkameen River meets Palmer Creek. During seasons of high flow on the Similkameen River, Palmer Creek will reverse direction, essentially becoming the Similkameen River and flow into Palmer Lake.

**Table 10. Palmer Lake Sampling Locations.**

| Location Name | Location ID | Description | Latitude | Longitude |
|---|---|---|---|---|
| Palmer Lake | PALMERLK | Deepest point in the lake | 48.905 | -119.62222 |
| Lower Sinlahekin Creek (inlet) | SINLAHEKIN | Sinlahekin Creek at the Toats Coulee Road Bridge | 48.85170 | -119.65046 |
| Palmer Creek (outlet) | PALMERCRK | Palmer Creek at the Chopaka Road Bridge | 48.9236 | -119.65591 |

## 6.2 FIELD DATA COLLECTION

### 6.2.1 Sampling Locations and Frequency

Water quality samples and field measurement profiles will be collected from Palmer Lake in one location, at the deepest point. The lake sampling location is the same as the historical sampling location used by Ecology staff in the late 1990s. Samples and measurements will be collected from the lake station at least once per month from May through October. During each monitoring event, samples will be collected from discrete depths throughout the water column (1 m, 6 m, 15 m, and one meter above the bottom). Water column profiles of temperature, DO, pH, conductivity, chla, and phycocyanin will also be recorded at predetermined intervals throughout the water column. In conjunction with lake sampling, grab samples and measurements of field parameters and flow will also be collected at the lower Sinlahekin Creek and Palmer Creek sampling locations (Table 10). Timing of monitoring events in May and/or June will correspond with periods of high flow on the Similkameen River such that data and samples are collected when the Similkameen (Palmer Creek) is flowing into the lake.

### 6.2.2 Field Parameters and Laboratory Analytes to be Measured

Table 11 summarizes the distribution of proposed sampling frequency and parameters to be measured or analyzed at each monitoring location and/or depth. The field crew will measure water temperature, DO, pH, conductivity, chla and phycocyanin *in-situ* using a multi-parameter water quality sonde at pre-determined intervals. Field parameters will be measured just below the surface (0.5 m), then at one-meter intervals through 10 m, then at two-meter intervals. The last measurement will be collected at a depth of one meter from the lake bottom and will change each sampling event based on the water depth at the time of sampling. Generally field measurements will be collected at the following depths:

- 0.5 m
- 1 m
- 2 m
- 3 m
- 4 m
- 5 m
- 6 m
- 7 m
- 8 m
- 9 m
- 10 m
- 12 m
- 14 m
- 16 m
- 18 m
- 20 m
- 22 m
- 1 meter off the bottom

Secchi disk transparency will be measured at the lake monitoring station. Field staff will collect three Secchi disk depth measurements with a standard black and white Secchi disk. The average of these three measurements will be determined as the Secchi disk depth reading. Lake level will be recorded at least weekly to continuously throughout the ice-free season. Lake level will be either measured manually using a staff gauge installed on a non-floating dock or continuously through the use of a data logger installed on a non-floating dock.

Water samples will be collected and analyzed for TP, SRP, TN, Nitrate+nitrite, ammonia-N, alkalinity, and chla at the lake monitoring station. Discrete depth samples will be collected at the lake monitoring station (Table 11). The number of discrete depth samples may be adjusted depending on available funding. The Okanogan CD will also collect samples for phytoplankton analysis and hold for future analysis if/when funding becomes available in the future. Samples for phytoplankton analysis will be collected from 1 m below the surface.

At the Sinlahekin Creek and Palmer Creek sampling locations, samples will be collected and analyzed for TP, SRP, TN, Nitrate+nitrite, ammonia-N, alkalinity, and TSS. Flow measurements will be collected at each creek sampling location in conjunction with sampling.

**Table 11. Palmer Lake Water Quality Monitoring Plan.**

| Sampling Location | Parameters | Monitoring Schedule and Sample Depths (m) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Palmer Lake | Secchi Disk Depth | | | | | X | X | X | X | X | X | | |
| | Temperature, DO, pH, Conductivity, Chlorophyll *a*, Phycocyanin | | | | | X | X | X | X | X | X | | |
| | TP, SRP, Alkalinity, TN, Nitrate+nitrite, Ammonia-N | | | | | X (1, 6, 15, B-1) | X (1, 6, 15, B-1) | X (1, 6, 15, B-1) | X (1, 6, 15, B-1) | X (1, 6, 15, B-1) | X (1, 6, 15, B-1) | | |
| | Chlorophyll *a* | | | | | X (1, 6) | X (1, 6) | X (1, 6) | X (1, 6) | X (1, 6) | X (1, 6) | | |
| | Phytoplankton* | | | | | X (1) | X (1) | X (1) | X (1) | X (1) | X (1) | | |
| | Lake Level | | | At least weekly during ice-free period | | | | | | | | | |
| Lower Sinlahekin Creek & Palmer Creek | Temperature, DO, pH, Conductivity, Chlorophyll *a*, Phycocyanin | * | * | * | * | X | X | X | X | X | X | * | * |
| | TP, SRP, Alkalinity, TN, Nitrate+nitrite, Ammonia-N | * | * | * | * | X (Grab) | X (Grab) | X (Grab) | X (Grab) | X (Grab) | X (Grab) | * | * |
| | TSS | * | * | * | * | X (Grab) | X (Grab) | X (Grab) | X (Grab) | X (Grab) | X (Grab) | * | * |
| | Discharge (Flow) | * | * | * | * | X | X | X | X | X | X | * | * |

X = at least once per month; B-1 = sample collected at one meter above the bottom; Grab = sample collected from just below the surface in well mixed portion of creek

*Sample will be collected but held for future analysis if additional funding becomes available

## 6.3 MODELING AND ANALYSIS DESIGN

Not applicable.

## 6.4 ASSUMPTIONS IN RELATION TO OBJECTIVES AND STUDY AREA

This QAPP and monitoring program is designed to collect data of high quality for the purposes of providing a baseline limnological dataset, evaluating lake water quality and overall lake health, and to assess algae bloom severity and nutrient cycling in Palmer Lake. It is assumed that the Okanogan CD will obtain permission to collect samples at the designated locations on both Sinlahekin and Palmer Creeks. It is also assumed that all samples collected from the Sinlahekin and Palmer Creeks can be collected from the streambank or water depths will be such that field crews are able to safely wade into either creek. It is assumed that the Okanogan CD will collect samples and measure field parameters at the Palmer Lake monitoring location from a boat.

## 6.5 POSSIBLE CHALLENGES AND CONTINGENCIES

### 6.5.1 Logistical Problems

Potential problems associated with logistics of the monitoring program include access and permissions to access sampling locations at Sinlahekin and Palmer Creeks, which are on private property. Monitoring at the Sinlahekin and Palmer Creek sampling locations could be conducted from the bridges if necessary. If access is not obtained to these monitoring locations, flow measurements may not be able to be collected. Another potential logistical issue is determining a suitable location and gaining access to a non-floating dock to install either a staff gauge or data logger to measure lake level. Weather is another potential logistical issue, high winds could delay sampling, however, because field personnel are relatively close to the lake decisions can be made prior to mobilization on delays in sampling due to weather related issues. Another logistical challenge is the remoteness of Palmer Lake and the sampling locations. Okanogan CD field staff will need to conduct all monitoring events very early in the day to allow for sufficient time to deliver samples to a courier to transport the collected water quality samples to the laboratory to meet sample hold times. Another option would be for field staff to conduct all sample preparation, preservation, and filtering, as applicable, in the field prior to delivering samples to a courier for transport to the laboratory.

### 6.5.2 Practical Constraints

All monitoring activities will need to be conducted with at least two people present for safety reasons. Recruiting and training citizen volunteers may not be fruitful or sustainable. The Okanogan CD has a limited number of staff which have multiple responsibilities. Scheduling field staff to conduct the monitoring may be challenging. Funding to conduct the monitoring program is limited and additional funding may or may not become available to complete a full season’s worth of monitoring.

### 6.5.3 Schedule Limitations

Given that samples will be collected at least monthly provides some flexibility within the specific sampling schedule to allow for some of the practical constraints. Logistical issues may lead to sampling events that may not be evenly spaced. Sampling events are most critical during the period of stratification (May – October) and during times of high flow on the Similkameen River. Determining access and permission to access the Sinlahekin and Palmer Creek sampling locations may delay the start of data collection efforts. This is also the same for installation of the staff gauge or data logger in the lake.

# 7.0 FIELD PROCEDURES

## 7.1 INVASIVE SPECIES EVALUATION

Field staff will follow Ecology's SOP070 on minimizing the spread of invasive species (Parsons, 2022). Palmer Lake, Sinlahekin Creek and Palmer Creek are not areas of extreme concern. Areas of extreme concern have, or may have, invasive species like New Zealand mud snails that are particularly hard to clean off equipment and are especially disruptive to native ecological communities. There is minimal field sampling equipment required for this project, however, all equipment that is used will be inspected and cleaned with water prior to use to ensure invasive species are not introduced to Palmer Lake or its inlet or outlet. Equipment used by Okanogan CD staff will mostly be dedicated to this project and other monitoring within the watershed, so threat of the spread invasive species is low. Regardless, after sampling activities, field equipment will be inspected for aquatic plants/animals prior to storage to prevent accidental introduction to another waterbody.

## 7.2 MEASUREMENT AND SAMPLING PROCEDURES

Prior to the initiation of the water quality monitoring program field staff will review relevant Ecology SOPs to ensure samples and field measurements are collected properly. Relevant Ecology or EPA SOPs include EAP033 – Hydrolab® DataSonde® and MiniSonde® Multiprobes, Version 2.1 (Anderson, 2016), EAP015 – Manually Obtaining Surface Water Samples (Joy, 2006), EAP109, Version 1.1 – Estimating Stream Discharge (Wolfe, 2019) and EPA National Lakes Assessment 2022 Field Operations Manual (USEPA, 2022). Field staff upon arrival at the lake or creek sampling stations will record the following information on water-proof field datasheets or within a waterproof field notebook. Field datasheets will be prepared by the field crew lead prior to each sampling event. Detailed information on the field datasheets will include:

- Date
- Arrival time at station
- Field Staff initials
- Station characteristics (i.e. depth of water at sampling location)
- Number/type of samples collected
- Weather observations
- Number and description of photographs taken
- In-situ field measurements
- Algae and aquatic plant presence/absence and abundance
- Waterfowl or aquatic life observed
- Unusual conditions (presence of oil sheen, nuisance conditions, changes in land use, odors, etc.)

### 7.2.1 Field Measurement Procedures

*Palmer Lake Sampling* – Okanogan CD field staff will collect profiles of water temperature, DO, pH, conductivity, chal, and phycocyanin at the lake monitoring station using a multi-parameter water quality sonde. Field measurement profiles will consist of discrete measurements recorded at depth intervals defined in Section 6.2.2. Field measurements will be collected just below the surface (0.5 m), then at one-meter intervals until 10 m, then at two-meter intervals to the bottom of the lake. The last measurement will be collected 1 meter off the bottom (B-1). Calibration of the multi-parameter water quality sonde will be completed by field staff each morning of a sampling event according to the manufacturer's instructions using known calibration solutions. Field staff will ensure that calibration solutions are within the labeled expiration dates. When sampling activities are completed for the day, field staff will perform calibration checks on the water quality sonde. Calibration data sheets or notes will be kept by field staff. Field replicate measurements will be recorded for at least one depth per profile each sampling event.

Water transparency, or water clarity, will be monitored at the lake sampling station using a Secchi disk. Okanogan CD field staff will collect 3 Secchi disk depth measurements at the lake sampling location using a standard black and white Secchi disk. Measurements will be collected from the shady side of the boat without the use of sunglasses. Field staff will lower the Secchi disk into the water column until it disappears from view. Once the Secchi disk is no longer visible, field staff will slowly raise the disk until it becomes visible again. The depth at which the disk is just visible through the water column is recorded. This is repeated two more times. The average of the three measurements will be determined as the Secchi disk depth reading for that location and sampling event.

*Sinlahekin and Palmer Creeks Sampling* – Okanogan CD field staff will measure water temperature, DO, pH, conductivity, chla, and phycocyanin at each creek sampling locations using a multi-parameter water quality sonde. Field staff will collect field measurements either by wading into the creek, downstream of the targeted sampling location, or from shore by placing the sonde into the creek. Measurements should be collected in a well-mixed area of each creek. Okanogan CD field staff will measure flow at each creek sampling location using the "Timed Float Method" as described in Ecology SOP EAP109 (Wolfe, 2019). The "Timed Float Method" uses a neutrally buoyant object, such as a whiffle ball or plastic golf ball, and known distance to estimate stream velocity. Field staff will measure the wetted width and depth of a representative cross-section of the stream. The estimated stream velocity and cross-section will be used to calculate stream flow.

## 7.2.2 Sampling Procedures

*Palmer Lake Sampling* – Okanogan CD field staff will collect water samples at the lake monitoring stations at discrete depths (1 m, 6 m, 15 m, and B-1). The number of discrete depths may be adjusted depending on available funding. Samples will be collected using a Van Dorn sampling bottle with graduated rope to ensure that samples are collected from the correct depths. The Van Dorn bottle will be rinsed with surface water prior to sample collection. The process of lowering the open sampler to depth will also provide a local-water rinse prior to sample collection. The deepest sample, B-1, will be collected first. Field staff will ensure that the valves are closed on both ends of the Van Dorn sampler prior to lowering through the water column.

All samples collected will be emptied from the Van Dorn bottle into pre-cleaned containers supplied by the laboratory. Sample bottles that do not contain preservative should be rinsed three times with a small amount of water collected at depth prior to filling. All sample containers will be pre-labeled prior to sample collection. Sample parameters, containers, volumes, preservation requirements and holding times are listed in Table 12. Soluble reactive phosphorus samples will be field filtered using laboratory supplied syringe filters and syringes. Chlorophyll *a* samples will not be field filtered but instead will be delivered to the contract laboratory within 48 hours of sample collection for filtration and processing.

All water samples collected from the lake station will be analyzed for TP, SRP, TN, nitrate+nitrite, ammonia-N, and alkalinity. Samples collected from 1 and 6 m will also be analyzed for chla. Phytoplankton samples will be collected at the lake sampling location at 1 m depth using the Van Dorn sample bottle. Phytoplankton samples will be preserved with Lugol's solution (10 to 15 drops).

All samples will be immediately put in a cooler with ice after collection.

*Sinlahekin and Palmer Creeks Sampling* – Okanogan field staff will collect grab water samples at each creek monitoring location. Water samples will be collected by field staff by directly submerging the sample bottles into the water at each location. Field staff will wade into the creek, approaching from downstream of the targeted location, or collect the sample from the shore. Sample collection should occur in a well-mixed flowing portion of the stream and as close to mid-depth as possible. All creek water samples will be analyzed for TP, SRP, TN, nitrate+nitrite, ammonia-N, alkalinity, and TSS. Soluble reactive phosphorus samples will be field filtered using laboratory supplied syringe filters and syringes. All samples will immediately be put in a cooler and cooled with ice.

## 7.3 CONTAINERS, PRESERVATION METHODS, HOLDING TIMES

Table 12 summarizes the sample containers, preservation, and holding times required to meet the goals and objectives of this project.

**Table 12. Sample containers, Preservation, and Holding Times.**

| Parameter | Matrix | Container* | Preservation | Maximum Holding Time |
|---|---|---|---|---|
| Total Phosphorus | Water | 125 mL clear HDPE | Cool to 4°C | 28 days |
| Soluble Reactive Phosphorus | Water | 125 mL clear HDPE | Cool to 4°C; Filter within 24 hours | 48 hours after filtration |
| Total Nitrogen | Water | 125 mL clear HDPE | Cool to 4°C | 28 days |
| Nitrate+Nitrite | Water | 125 mL clear HDPE | Cool to 4°C | 28 days |
| Ammonia-Nitrogen | Water | 125 mL clear HDPE | Cool to 4°C | 28 days |
| Alkalinity | Water | 125 mL clear HDPE | Cool to 4°C | 28 days |
| Total Suspended Solids | Water | 1 L clear HDPE | Cool to 4°C | 7 days |
| Chlorophyll *a* | Water | 1 L amber HDPE | Cool to 4°C; Filter within 48 hours | 28 days after filtration and freezing |
| Phytoplankton | Water | 500 mL amber HDPE | Cool to 4°C; Lugol's solution | None specified for preserved samples |

## 7.4 EQUIPMENT DECONTAMINATION

Field staff may encounter cyanotoxins (in Palmer Lake) or bacteria (Sinlahekin Creek) while conducting sampling activities. No other exposure of equipment to toxic chemicals or high levels of contamination is anticipated. Equipment that will be used at multiple sampling locations will be decontaminated between locations to prevent the spread of invasive species, to ensure sample quality assurance and quality control, and to keep the equipment in good working order. Equipment decontamination will consist of rinsing equipment with local-water at the sampling location and, if necessary, with distilled water at the end of each sampling day. The multi-parameter water quality sonde can be rinsed with distilled water but sensors should be kept in clean tap water or a solution as recommended by the manufacturer.

## 7.5 SAMPLE ID

Each sample bottle will have a waterproof sample identification label or tag. All sample bottles will be labeled with an indelible marker before the time of collection. If the laboratory provides sample labels that are not waterproof, labels may need to be marked after sample collection, particularly for stream grab samples. The sample ID for all samples will include the location ID (Table 9) and sample depth (for lake samples) followed by the date samples were collected. For example, a sample collected at 1 m at the Palmer Lake station on July 15, 2024 will have the sample ID; PALMERLK-1m-07152024. Duplicate samples will be labeled with a blind sample identification ID with the date of collection (i.e. DUPE-07152024). Special analyses to be performed and any pertinent remarks will also be recorded on the label.

## 7.6 CHAIN-OF-CUSTODY (COC)

Maintaining environmental samples under chain-of-custody is standard practice. All samples will be accompanied with a Chain-of-Custody (COC) form. The COC form acts as a record of sample shipment/delivery and a catalog of the contents of each cooler, in addition to maintaining a complete record of evidentiary custody transfer. The COC will contain the following at a minimum:

- Field Staff Initials
- Project Name
- Page Number (i.e. 1 of 1)
- Sample ID
- Collection Date and Time
- Number of containers
- Type of analysis required
- Laboratory recipient signature
- Laboratory receipt date and time

Okanogan CD field staff will use COC forms provided by the contracted laboratory and ensure they contain all the above information.

## 7.7 FIELD LOG REQUIREMENTS

A field log is an important component of many projects and is used to document sampling event activities and observations. Standardized forms or field datasheets and/or a bound, waterproof notebook with pre-numbers pages should be used by Okanogan CD field staff for a field log. Permanent and waterproof ink will be used for all entries into the field log or field datasheets. Corrections to notes in the field log will be made with a single line strikethrough and initialed and dated by the personnel making the correction. For all sampling events, filed datasheets/field log shall include the following entries at a minimum:

- Name and location of project
- Field personnel

- Sequence of events
- Any changes or deviations from the QAPP
- Environmental conditions
- Date, time, location, sample ID and description of each sample collected
- Field instrument calibration procedures
- Field measurement results
- Identity of QC samples collected
- Detailed observations including but not limited to water appearance, biological activity, aquatic life activity, changes in land uses, or unusual odors
- Unusual circumstances that might affect interpretation of results

## 7.8 OTHER ACTIVITIES

Samples should be collected between Monday and Wednesday to ensure the laboratory has adequate time to process the samples upon receipt.

# 8.0 LABORATORY PROCEDURES

## 8.1 LAB PROCEDURES TABLE

All samples will be sent to and analyzed by an Ecology-accredited analytical laboratory for analyses of water quality parameters (Table 13). The contracted laboratory will analyze all samples according to the methods and MDLs outlined in Table 13 and will observe standard laboratory quality control procedures. The contract laboratory QMP is on file with Ecology detailing their quality assurance procedures. Standard laboratory turnaround time is 30 days. Any issues regarding analytical data quality will be resolved through regular communication with the laboratory project manager and the Okanogan CD project manager.

**Table 13. Analytical Methods for Surface Water Samples**

| Parameter | Sample Matrix | # of Samples | Field Filtered | Analytical Method | Method Detection Limits |
|---|---|---|---|---|---|
| Chlorophyll a | Water | Lake: 12 + 3 field duplicates | No | SM-10200H | 0.1 µg/L |
| Total Phosphorus | Water | Lake: 24 + 3 field duplicates Creeks: 12 + 3 field duplicates | -- | SM-4500PF | 0.002 mg/L |
| Soluble Reactive Phosphorus | Water | Lake: 24 + 3 field duplicates Creeks: 12 + 3 field duplicates | Yes | SM-4500PF | 0.001 mg/L |
| Total Nitrogen (Total Persulfate Nitrogen) | Water | Lake: 24 + 3 field duplicates Creeks: 12 + 3 field duplicates | -- | SM-4500NC | 0.050 mg/L |
| Nitrate+Nitrate-N | Water | Lake: 24 + 3 field duplicates Creeks: 12 + 3 field duplicates | -- | SM-4500NO3F | 0.010 mg/L |
| Ammonia - N | Water | Lake: 24 + 3 field duplicates Creeks: 12 + 3 field duplicates | -- | SM-4500NH3H | 0.010 mg/L |
| Alkalinity | Water | Lake: 24 + 3 field duplicates Creeks: 12 + 3 field duplicates | -- | SM-2320B | 1.0 mg $CaCO_3$/L |
| Total Suspended Solids | Water | Creeks: 12 + 3 field duplicates | -- | SM2540-D | 0.99 mg/L |
| Phytoplankton | Water | Lake: TBD | -- | Microscopy | NA |

TBD = to be determined based on available funding

## 8.2 SAMPLE PREPARATION METHOD(S)

Okanogan CD field staff will filter samples for SRP analysis in the field. The contract laboratory will filter chla samples upon receipt. If the chla samples are not received by the contract laboratory within 48 hours of sample collection Okanogan CD field staff will need to filter chla samples in the field.

## 8.3 SPECIAL METHOD REQUIREMENTS

There are no special method requirements that will be used for this project.

## 8.4 LABORATORIES ACCREDITED FOR METHODS

Contract laboratories have not been determined at the time of QAPP development. Okanogan CD will contract with laboratories that are accredited by Ecology for the analytical methods listed in Table 13.

# 9.0 QUALITY CONTROL PROCEDURES

Quality control activities in the field will include adherence to documented procedures and the comprehensive documentation of sample collection information included on field datasheets. A rigidly enforced chain-of-custody program will ensure sample integrity and identification. The chain-of-custody procedure documents the handling of each sample from the time the sample is collected to the arrival of the sample at the laboratory.

Standard protocols for measuring surface water will be followed throughout the monitoring effort. All field measurement equipment (multi-parameter water quality sonde) will be cleaned and inspected prior to use to verify that it is working properly. The multi-parameter water quality sonde will be calibrated according to the manufacturers' instructions at the beginning of each sampling day and will be checked for drift at the end of each sampling day. All pertinent information about the multi-parameter water quality sonde will be recorded either on the field datasheets or on a calibration data sheet.

Field measurements collected during each sampling event will conform to the quality control parameters listed below in Table 14. Quality control measurements will be taken at intervals summarized in Table 15. Field measurement profiles of temperature, DO, pH, conductivity, chla, and phycocyanin will not be replicated in their entirety but instead one depth per profile will be replicated.

Accurate records of dates, times, field staff name(s), sampling location, and other observations will be assured through the use of standardized field datasheets specifically designed for this monitoring effort. All field datasheets will be checked by the field crew lead at the completion of sampling and prior to leaving the site to ensure all measurements and sampling-related data were accurately recorded.

Field duplicates will consist of a sample, collected, and labeled in a similar manner as a regular sample. The sample ID for a field duplicate will include the date of collection (i.e. DUPE-07152024). The field duplicate will be a blind duplicate and the laboratory will not know the sample location of the duplicate. Okanogan CD field staff will ensure that the location at which the field duplicate was collected is noted on the field datasheets or in the field log. The duplicate will be submitted to the laboratory and processed in exactly the same manner as a regular sample. Field duplicates will be collected at every other sampling event.

All samples will be analyzed by an accredited commercial laboratory contracted with Okanogan CD. The contracted laboratory must be accredited by Ecology and participate in audits and inter-laboratory studies by Ecology and EPA. Performance and system audits should have verified the performance of the laboratory standard operating procedures, which include preventative maintenance and data reduction procedures.

The contract laboratory should routinely perform quality control procedures for a variety of projects. These procedures should include but are not limited to: duplicates (relative percent difference), spikes (percent recovery), duplicate samples, and laboratory blanks. Laboratory results include a quality control report for each batch of samples analyzed for this project. These routine laboratory quality control procedures will be used to demonstrate laboratory precision and accuracy and that the measurement quality objectives have been met. If quality control requirements are not met, then all those analyses will be repeated with fresh reagents and new standards. If analysis still fails to meet quality control requirements that sample will be declared invalid and not used in the data analysis.

The contract laboratory will inform the Okanogan CD project manager or principal field investigator as soon as possible if any sample is lost, damaged, mislabeled, or is a result outside of the expected range.

## 9.1 TABLE OF FIELD AND LABORATORY QUALITY CONTROL

Table 14 summarizes the quality control requirements for the multi-parameter sonde. Table 15 summarizes the field and laboratory quality control requirements for this project.

**Table 14. Multi-Parameter Water Quality Sonde Quality Control Requirements.**

| Parameter | Replicate Samples | Field Calibration Check Standards | Calibration Drift End Check |
|---|---|---|---|
| Dissolved Oxygen | RPD ≤ 20% | NA | ± 5% |
| Temperature | ± 0.3°C | NA | NA |
| Conductivity | RPD ≤ 10% | ± 10% | ± 10% |
| pH | ± 0.2 units | ± 0.2 units | ±0.3 units |
| Chlorophyll *a* | RPD ≤ 10% | NA | ± 1.0 units |
| Phycocyanin | RPD ≤ 10% | NA | ± 1.0 units |

**Table 15. Quality Control Samples, Types, and Frequency.**

| Parameter | Field Replicates | Check Standard | Method Blank | Field Duplicates | Matrix Spikes/Matrix Spike Duplicates |
|---|---|---|---|---|---|
| **Laboratory Analyses** | | | | | |
| Total Phosphorus | NA | 1/batch | 1/batch | 1 every other sampling event | 1/20 samples |
| Soluble Reactive Phosphorus | NA | 1/batch | 1/batch | 1 every other sampling event | 1/20 samples |
| Total Nitrogen (Total Persulfate Nitrogen) | NA | 1/batch | 1/batch | 1 every other sampling event | 1/20 samples |
| Nitrate+Nitrate-N | NA | 1/batch | 1/batch | 1 every other sampling event | 1/20 samples |
| Ammonia - N | NA | 1/batch | 1/batch | 1 every other sampling event | 1/20 samples |
| Alkalinity | NA | 1/batch | 1/batch | 1 every other sampling event | 1/20 samples |
| Total Suspended Solids | NA | 1/batch | 1/batch | 1 every other sampling event | 1/20 samples |
| Chlorophyll *a* | NA | NA | NA | 1 every other sampling event | NA |

## 9.2 CORRECTIVE ACTION PROCESSES

Results from quality control samples enable the assessment of quality assurance parameters to meet data accuracy and precision requirements. Any data falling outside the acceptable criteria as defined in the procedures will be investigated for source of error and potentially qualified as described in Section 12 Data Verification and Section 13 Data Quality (Usability) Assessment. If monitoring activities are found to be inconsistent with this QAPP, field staff will be asked to review the QAPP and relevant SOPs, and additional sampling may be conducted to replace unacceptable data. If the source of error arises from analytical procedure, the laboratory will take corrective action as outlined in the lab's QA/QC plan, which may include re-analysis of samples and revision of analytical procedures. The Okanogan CD project manager may also ask the laboratory for re-analysis of samples if MQOs are not met.

# 10.0 DATA MANAGEMENT PROCEDURES

## 10.1 DATA RECORDING AND REPORTING REQUIREMENTS

Field measurement data will be recorded on field datasheets and/or in the field log book. Before leaving the sampling locations, Okanogan CD field staff will review the field datasheets and/or field log book for missing or improbable measurements. Okanogan CD field staff will enter field-generated data into an EXCEL spreadsheet as soon as possible upon returning from the field. The lead field crew will check data entry against the field datasheets and/or field log book for errors and omissions. All field data will be evaluated against the MQOs and field quality control requirements.

Laboratory results will be reviewed upon receipt for missing and/or improbable data and evaluated against the MQOs and quality control requirements. The laboratory results will be checked against the COC. The data quality control reviewer will review the laboratory QA/QC data. Based on the data quality control review, samples results associated with minor quality control issues will be considered estimates and assigned a “J” data qualifier. Sample results associated with major quality control issues will be rejected and assigned a “R” data qualifier. Estimated values may be used for data evaluation purposes, whereas rejected data may not be used.

## 10.2 LABORATORY DATA PACKAGE REQUIREMENTS

The contracted laboratory will provide data packages in both PDF format and in an EIM compatible, readily usable EXCEL format. All data packages will be accompanied with the final COC, in pdf format. Each data package will include a case narrative summary indicating if there were any issues with sample analysis and QA/QC information. The laboratory will be required to provide all relevant quality control data.

## 10.3 ELECTRONIC TRANSFER REQUIREMENTS

All laboratory results, including QC sample results, will be provided electronically to the Okanogan CD project manager.

## 10.4 EIM DATA UPLOAD PROCEDURES

Projects funded by or submitting data to Ecology must submit the data formatted for entry into Ecology’s EIM data system. Okanogan CD staff will upload all water quality data associated with this project into Ecology’s EIM data system following completion of a sampling season. EIM data inputs will be peer reviewed and corrected if necessary.

# 11.0 AUDITS AND REPORTS

This section outlines procedures to be used to ensure that this QAPP is implemented correctly, and the data generated from this monitoring program is of sufficient quality to meet the project objectives.

## 11.1 FIELD, LABORATORY, AND OTHER AUDITS

There is no need for an official field audit for this project. However, there could be a field consistency review by the person responsible for data quality review and validation at any time during this project. The aim of this review would be to improve field work consistency. Reviews of field measurements and field notes should occur as soon as possible following a sampling event. This project will use only Ecology-accredited laboratories, which undergo audits from Ecology's Laboratory Accreditation Unit (LAU) every 3 years.

## 11.2 RESPONSIBLE PERSONNEL

Ecology's LAU is responsible for auditing analytical laboratories. The Okanogan CD project manager and/or field crew lead is responsible for review of field measurements and field notes.

## 11.3 FREQUENCY AND DISTRIBUTION OF REPORTS

At the time of the development of this QAPP, there has been no decision made on the frequency and distribution of reports summarizing data results collected as part of this project.

## 11.4 RESPONSIBILITY FOR REPORTS

Any reports that are developed from data collected from this monitoring program will be the responsibility of the Okanogan CD.

# 12.0 DATA VERIFICATION

Data verification requires confirmation by examination or provision of objective evidence that the requirements of these specified QC acceptance criteria are met.  Each step of the data collection and analysis process must be evaluated and its conformance to the protocols established in this QAPP verified.

## 12.1 FIELD DATA VERIFICATION, REQUIREMENTS, AND RESPONSBILITIES

The lead Okanogan CD field personnel will verify all field data prior to leaving the sampling locations. This involves checking the field data sheets and/or field log book for omissions or outliers. If field measurement data are missing or a measurement is determined to be an outlier, the measurement will be repeated. After each sampling event, Okanogan CD staff will compare all field data to MQOs and quality control requirements to determine compliance with this QAPP. Field data should be reviewed shortly after being collected to ensure any potential issues with data quality are identified and corrected prior to the next sampling event. Based on this assessment the field sample data will be accepted, accepted with qualifications, or rejected.

## 12.2 LABORATORY DATA VERIFICATION

Staff at the contracted laboratory will review all laboratory analysis for this monitoring effort to verify that the methods and protocols specified in the QAPP were followed; that all instrument calibrations, quality control checks, and intermediate calculations were performed appropriately; and that the final reported data are consistent, correct, and complete, with no omissions or errors.

Evaluation criteria will include the acceptability of instrument calibrations, procedural blanks, spike sample analysis, precision data, laboratory control sample analysis, and the appropriateness of assigned data qualifiers, if any.

Okanogan CD staff will review the laboratory data packages and case narratives upon receipt from the laboratory to determine if the results met the MQOs for bias, precision, and accuracy for that sampling event and to ensure that all analyses specified on the COC form were performed. Okanogan CD staff will check to ensure that all laboratory analytical methods meet the requirements listed in this QAPP. Laboratory data should be reviewed shortly upon receipt to ensure any potential issues with data quality are identified and corrected prior to the next sampling event. Field duplicate results will be evaluated and compared to the quality objectives. Based on these assessments, the sample data will be accepted, accepted with appropriate qualifications, or rejected.

## 12.3 VALIDATION REQUIREMENTS

Not applicable.

# 13.0 DATA QUALITY (USABILITY) ASSESSMENT

## 13.1 PROCESS FOR DETERMINING PROJECT OBJECTIVES WERE MET

After all laboratory and field data are verified, Okanogan CD staff will thoroughly examine the data package to determine if the MQOs have been met. The entire data package (laboratory and field) will be examined to determine if all the criteria for MQOs, completeness, representativeness, and comparability have been met. If the criteria outlined in this QAPP have not been met, Okanogan CD staff will decide if affected data should be qualified or rejected. Okanogan CD staff will determine how qualified data will be used in any technical analysis.

Data qualifiers that could be used for this project include the following:

- J – result is an estimate
- R – result is rejected
- U – sample result was a non-detect or below the MDL
- B – the analyte was found in an associated blank, as well as in the sample

## 13.2 TREATMENT OF NON-DETECTS

Any sample results that are non-detects will be included in any project analysis or data evaluation. Non-detect results will be set as the MDL for that particular analysis for any assessment purposes.

## 13.3 DATA ANALYSIS AND PRESENTATION METHODS

Both field and laboratory data will be complied in EXCEL. Data will be presented in various ways depending on the data evaluation being completed. Summary statistics for all data will be generated using EXCEL. Both summary data and raw data will be presented both tabular and graphically.

## 13.4 SAMPLING DESIGN EVALUATION

The Okanogan CD project manager will decide whether both field and laboratory data meet the MQOs, criteria for completeness, representativeness, and comparability, and whether meaningful conclusions can be drawn from the dataset. If so, the sampling design will be considered effective.

## 13.5 DOCUMENTATION OF ASSESSMENT

Final lab reports, including data qualifiers, and copies of all field datasheets or pages from field log book will be provided in an Appendix to any report that is developed based on the data collected from this monitoring program. All non-conformances to the QAPP, the corrective action, and the impact to data quality will be discussed in any report. A summary of data verification activities and results will be presented including data completeness, summary of data flags, and the usability of the data for its intended purpose.

# 14.0 REFERENCES

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