AVISTA CORPORATION

LAKE SPOKANE DISSOLVED OXYGEN WATER QUALITY ATTAINMENT PLAN 2018 ANNUAL SUMMARY REPORT

WASHINGTON 401 CERTIFICATION
FERC LICENSE APPENDIX B, SECTION 5.6

SPOKANE RIVER HYDROELECTRIC PROJECT
FERC PROJECT NO. 2545

Prepared By:

AVISTA

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TABLE OF CONTENTS

TABLES

GRAPHS

FIGURES

APPENDICES

1.0 INTRODUCTION

Avista Corporation (Avista) received a new, 50-year license from the Federal Energy Regulatory Commission (FERC) on June 18, 2009 (FERC 2009) for the Spokane River Hydroelectric Project (Project). The project consists of five dams on the Spokane River, including Long Lake Hydroelectric Development (HED), which creates Lake Spokane. The license incorporates a water quality certification (Certification) issued by The Washington Department of Ecology (Ecology) under Section 401 of the Clean Water Act (Ecology 2009).

Ecology has determined that the dissolved oxygen (DO) levels in certain portions of the Spokane River and Lake Spokane do not meet Washington's water quality standards. Consequently, those portions of the river and lake are listed as impaired under Section 303d of the Clean Water Act. To address this, Ecology developed the Spokane River and Lake Spokane Dissolved Oxygen Total Maximum Daily Load Water Quality Improvement Report (issued February 12, 2010).

Avista does not discharge nutrients into either the Spokane River or Lake Spokane, however, the impoundment creating Lake Spokane increases the residence time for water flowing down the Spokane River, and thereby influences nutrients and how they affect DO levels. Reduced DO levels are largely due to the discharge of nutrients into the Spokane River and Lake Spokane. Nutrients are discharged into the Spokane River and Lake Spokane by point sources, such as waste water treatment facilities and industrial facilities, and from non-point sources, such as tributaries, groundwater, and stormwater runoff, relating largely to land-use practices. In an effort to address low DO levels and to comply with Section 5.6.C of the Certification, Avista submitted an Ecology-approved Lake Spokane Dissolved Oxygen Water Quality Attainment Plan (DO WQAP) to FERC on October 8, 2012. Avista began implementing the DO WQAP upon receiving FERC's December 19, 2012 approval.

DO WQAP

The DO WQAP addresses Avista's proportional level of responsibility, as determined in the Spokane River and Lake Spokane Dissolved Oxygen Total Maximum Daily Load (DO TMDL). It identified nine potentially reasonable and feasible measures to improve DO conditions in Lake Spokane by reducing non-point source phosphorus loading into the lake. It also incorporated an implementation schedule to analyze, evaluate, and implement such measures. In addition, it contains benchmarks and reporting sufficient for Ecology to track Avista's progress toward implementing the plan within the ten-year compliance period identified in the DO WQAP.

The DO WQAP included a prioritization of the nine reasonable and feasible mitigation measures based upon several criteria including, but not limited to, quantification of the phosphorus load reduction, DO response time, likelihood of success, practicality of implementation, longevity of load reduction, and assurance of obtaining credit. From highest to lowest priority, the following summarizes the results of the measure prioritization: reducing carp populations; managing aquatic weeds; acquiring, restoring, and enhancing wetlands; reducing phosphorus from Hangman Creek sediment loads; educating the public on improved septic system operations; reducing lawn area; providing native vegetation buffers; and converting grazing land to conservation or recreation use. One measure, which involved modifying the intake of an agricultural irrigation system, was removed from the list, as it was determined infeasible given it would create adverse effects on crop production.

Based on preliminary evaluations, Avista proposed to focus its initial efforts on two measures: reducing carp populations and aquatic weed management, which were expected to have the greatest potential for phosphorus reduction.

Avista concluded in its 2013 Annual Report, that harvesting macrophytes in Lake Spokane at senescence, would not be a reasonable and feasible mitigation measure to reduce total phosphorus in Lake Spokane. However, Avista will continue, as appropriate, to implement winter drawdowns, herbicide applications at public and community lake access sites, and bottom barrier placement to control invasive/noxious aquatic weeds within Lake Spokane. Avista may also, through adaptive management, reassess opportunities to harvest macrophytes to control phosphorus in the future.

Avista included a recommendation in its 2014 Annual Report, to implement a pilot study utilizing a combination of mechanical methods (including spring electrofishing, passive netting, and winter seining), to identify the most effective method to remove carp from Lake Spokane. Ecology approved the 2014 Annual Report and the recommendation to move forward with the carp removal pilot study. Avista has been working with Ecology and Washington Department of Fish and Wildlife (WDFW) to plan and implement the carp removal efforts, a summary of which is provided in Section 3.2 (2018 Implementation Measures) and Section 5.0 (Proposed Activities for 2019).

As required by the DO WQAP, this report provides a summary of the 2018 baseline monitoring, implementation activities, effectiveness of the implementation activities, and proposed actions for 2019.

2.0 BASELINE MONITORING

Longitudinally, the lake can be classified as having three distinct zones, which consist of a riverine, transition and lacustrine zone. Six water quality monitoring stations, LL5 through LL0, exist within these three zones (**Figure 1**). Station LL5 is the most upstream station and is located within a riverine zone, Stations LL3 and LL4 are located in the transition zone, and Stations LL0 through LL2 are located in the lacustrine zone. The vertical structure of Lake Spokane is set up by thermal stratification, largely determined by its inflow rates, atmospheric and water temperature, and location of the powerhouse intake. Within Lake Spokane's lacustrine zone, thermal stratification creates three layers (the epilimnion, metalimnion, and hypolimnion) that are generally present between late spring and early fall. The epilimnion is the uppermost layer, and the warmest due to solar radiation. The metalimnion is the transition layer between the epilimnion and the hypolimnion that contains the thermocline and is influenced by both surface and interflow inflows. The hypolimnion is the deepest layer and is present throughout the lacustrine zone.

2.1 2018 Monitoring Results

Avista contracted with Tetra Tech to complete the baseline monitoring activities during 2018. Sampling events were completed at all six established stations during May through October. The four supplemental monitoring locations identified in the Quality Assurance Project Plan Addendum, Lake Spokane Baseline Nutrient Monitoring (approved 2018) were also sampled in 2018, May through October (**Figure 1**). Nutrient monitoring (nitrogen and phosphorus) was not conducted in 2018 but in-situ DO, temperature, conductivity and pH were measured and zooplankton samples were collected at all ten monitoring locations. Results of the monitoring are summarized in **Appendix A** (Lake Spokane Annual Summary, 2018 Baseline Water Quality Monitoring Results, Tetra Tech 2019) and include the water quality conditions in Lake Spokane, as well as inflows and outflows, tables of water quality data collected for the DO WQAP, a description of the general hydrologic and climatic conditions, and an analysis of the zooplankton populations present during the 2018 sampling events. Highlights taken from the Tetra Tech Report are provided as follows.

- Weather conditions during 2018 differed from the 30-year norms reported at the Spokane International Airport, with warmer than normal temperatures in January, May, July and August, and in most of February and December. February contained a record high daily temperature and May was the fifth warmest on record.
- While precipitation in 2018 started as above normal in the beginning of the year, the annual cumulative rainfall total was 15.95 inches. The driest months were May through September and, as a result, the Spokane region experienced drought conditions during June through September. The 2018 June through September season was the third driest on record.
- Peak flows in 2018 occurred in mid-May and reached 27,800 cfs (recorded at the USGS 12422500 Spokane River at Spokane Gage). Peak flow in May were preceded by a peak in mid-April and a smaller peak occurring in early February. Lake Spokane's annual mean daily flow during 2018 was 7,821 cfs.
- Whole lake water residence time during 2018 (June through October) in Lake Spokane averaged 36.3 days. This was similar to residence time observed in 2013 (36.8 days) and was considerably shorter compared with 2015 and 2016 (70.1 and 43.3 days, respectively). Average whole reservoir residence time was 34.0 days for the past nine years (2010 through 2018). Using the DO TMDL seasonal timeframe of July through September, the whole lake

residence time was calculated at 54.3 days, which was also shorter than in 2015 (84.8 days) but slightly higher than 2010-2014 average.

- Thermal stratification began in early June at all stations, except LL4 and LL5. Stratification developed in late June at LL4 and late July at LL5. The water column remained stratified at LL4 until October and at LL5 through the middle of September. This was similar to conditions in 2016 and 2017, but contrasted with conditions in 2015, when the period of stratification was longer, coinciding with a much longer residence time.
- While the extent and depth of the hypolimnion varied throughout the summer, for most of the sampling dates the hypolimnion depth occurred at about 10 to 15 meters (m) from the surface, being shallow in June and deepening later in the summer.
- The maximum surface temperature reached almost 25°C in the lacustrine zone and just over 25°C in the upper reservoir in early August 2018. This maximum temperature is slightly higher than that observed in 2016 (23°C in August) and slightly lower or similar to those in 2015 (26°C and 25°C in early July) and 2017 (25°C in early August). Temperatures were below 20°C at depths greater than 10 m in the lacustrine zone during 2018, as was the case in 2014 to 2017.
- Conductivity varied from about 65 to 290 micro Siemens/cm (µS/cm), which was slightly lower than in 2015 and 2016 (87 to 297 and 106 to 290 µS/cm, respectively). Conductivity in 2018 was similar to that in 2017 which ranged from 68 to 283 µS/cm. The higher conductivity observed in 2015 and 2016 was likely due to lower river flows, resulting in a stronger signature from groundwater compared with inflows from the river. Lower conductivity in 2017 and 2018 coincided with higher river flows. During 2018, water with elevated conductivity (110 to 283 µS/cm), comprised the interflow zone that extended from about 6 to 18 m at stations LL3 through LL0 in July, and extended to 33 m at LL0 in late August as the denser, higher conductivity water plunged and moved through the reservoir at those depths intervals. Below 30 m, conductivity was usually less than 200 µS/cm prior to late August and early September. Based on conductivity measurements, much of the metalimnion in the lower reservoir was composed of river flow.
- The water column profiles for pH showed a range of 6.8 to 8.9 at the ten stations during 2018. The water column average range was much narrower, ranging from 7.5 to 8.0. The highest pH values occurred in the epilimnion during July at almost all the stations. High pHs were also observed in August at LL0, LL1, and LL5; in early September at station LL4 stations; in June at LL0 and LL1; and in early September at station LL4.
- Maximum epilimnetic DO concentrations ranged from 11.6 to 12.2 milligrams per liter (mg/L) at LL1 through LL5. These maximums mostly occurred in May. Maximum DO at LL0 was much higher reaching 15.3 mg/L at a 5 m depth in July, and had similar, but slightly higher, DO maximums as the other stations in May. Average water column DO ranged from 8.5 to 10.3 mg/L. Minimum DO concentrations of 0.62 mg/L occurred near the bottom of the deepest station, LL0 (~154 ft) in August.

- Transparency ranged from 1.9 to 7.1 m throughout the reservoir during 2018, with the maximum transparency occurring during late September at the lacustrine stations. Minimums occurred in May when inflow was highest.
- Based upon observations from Galen Buterbaugh, shoreline homeowner and Lake Spokane Association representative (Buterbaugh 2019), blue green algae occurrence was similar in 2018 as in 2017, with the exception of lakewide bloom in September for a duration of approximately seven days. There were a number of short duration blooms in small inshore areas in the upper portions of the lake. The dominant species in these blooms was Dolichospermum. Toxicity was not tested during any blooms in 2018.
- Rotifers and Nauplii were the most abundant zooplankton at most stations in 2018. Cladocerans were the dominant zooplankton by biomass at the deeper stations for most of the year. Cladocerans dominated biomass at LL4 in July, with relatively high levels in August and September as well. Cladoceran biomass at LL5 was relatively low and they only slightly dominated total biomass in July. *Calanoid* copepod biomass was high during the summer and into fall at LL4, but declined at LL5 with increased inflow and reduced retention time, similar to 2017. When multiplying concentrations by net haul depth, depth-corrected average seasonal cladoceran concentrations were still higher at LL4 than at other sites in 2017, while concentrations at LL5 were the lowest. Overall, density of cladocerans in 2018 was much lower than observed in 2017, with the highest biomass being observed at LL1a (35.7 µg/L) and LL3a (40.9 µg/L) in early August and October, respectively.

Measures of Improvement

Tetra Tech used several standard limnological approaches to measure the lake's DO improvement since 1977. These approaches included comparing the minimum volume-weighted hypolimnetic DO over time, determining the lake's current trophic state index, and completing a cursory habitat evaluation for rainbow trout. Results of these analyses are discussed in **Appendix A**, and are summarized below. The approaches used by TetraTech provide valuable information. Avista anticipates these or other approaches, along with the goals of the DO TMDL, will be used to determine compliance with the surface water quality standards at the end of the 10-year compliance schedule.

- The minimum volume-weighted hypolimnetic DO has substantially increased since 1977. In 1978, the City of Spokane's wastewater treatment plant implemented an 85% reduction in point-source TP in their discharge water. Prior to the TP reduction, minimum volume-weighted hypolimnetic DO ranged from 0.2 to 3.4 mg/L (1972 – 1977). Following the TP reduction, minimum volume-weighted hypolimnetic DO ranged from 2.5 to 4.5 mg/L (1978 – 1985). The current (2010 – 2018) minimum volume-weighted hypolimnetic DO ranged from 5.1 to nearly 8 mg/L, and averaged 6.2 mg/L with inflow TPs averaging 14.5 µg/L. While DO conditions have improved in Lake Spokane since 85% of point-source effluent phosphorus was removed in 1978, in 2018, DO levels still do not meet the surface water quality standard in the hypolimnion during portions of the summer critical season.

- Based upon the 2017 data, the lake's tropic state, a general measure of biological production (utilizing concentrations of TP, chl, water clarity, etc.) is mesotrophic, but is near the oligotrophic-mesotrophic boundary. The trophic state of the lake is an important index to measure, especially when evaluating the lake's habitat. A eutrophic state indicates high biological production within the lake, an oligotrophic state indicates low biological production, and mesotrophic is between those two states.

- A cursory review of Lake Spokane's aquatic habitat specific to Washington's designated aquatic life use, core summer salmonid habitat, was completed by Tetra Tech using the baseline nutrient monitoring data collected in 2018. Tetra Tech used a critical maximum temperature (18°C) and a minimum DO (6 mg/L) to compute the percent volume acceptable for growth for rainbow trout at the six stations for 2018 (Appendix A, Figures 96-101). For the majority of the summer, between 10 and 20 m, DO was usually near or above 6 mg/L at the four deepest stations (LL0, LL1, LL2, and LL3). In late August and September at LL0, DO dropped to near or below the often cited required minimum of 5 mg/L between 10 and 20 m and was even lower at deeper depths. However, at the other deep stations DO remained near or above 6 mg/L. These data suggest that rainbow trout are most likely inhabiting cooler water in the metalimnion and upper portions of the hypolimnion. Additionally, the habitat volumes for temperature and DO together, as well as separately, were shown to indicate which factor appears most limiting (**Appendix A**). Trout habitat was restricted through most of the summer by temperature, but much less by DO at the deepest lacustrine sites as the summer progressed in 2018. Trout were limited exclusively by temperature at LL5 (Appendix A, Figures 96-101). Based on the critical maximum temperature and minimum DO thresholds, results suggest that trout likely avoid the epilimnion during most of the summer due to temperatures that reached 25°C and likely seek cooler water deeper than 10 to 20 m. However, rainbow trout tracking data collected in Avista's Rainbow Trout Habitat Assessment (Section 3.2.6) show that rainbow trout were frequently found in the epilimnion during the summer of 2017 and 2018.

2.2 Monitoring Recommendations

Avista has collected baseline nutrient monitoring over the full spectrum of flows that are likely to exist in the Spokane River under current license conditions (**Figure 2**). Results of this monitoring indicate DO is largely dependent upon flow year (i.e. the volume of water in any particular year). Since forecasts project flows in the Spokane River to be average in 2019, Avista will shift focus during 2019 from baseline monitoring, to conducting more detailed analysis on the 2010-2018 water quality data in an effort to explore the relationship between rainbow trout habitat utilization in Lake Spokane and the multitude of water quality attribute information that is available from the lake. Avista will work with their partners including Ecology, Washington Department of Fish and Wildlife, Spokane Community College, Spokane County Conservation District and the Spokane Tribe, to explore the data. This detailed analysis may be helpful in understanding the complex connections between fish habitat utilization, water quality, and zooplankton/phytoplankton data available for Lake Spokane. Possible areas of focus may include a more complete quantification of nutrients removed by the floating wetlands project, comparing transparency and chlorophyll data to explore correlations, and further tracking patterns of algae blooms throughout the lake. Results of analysis could be used to more accurately assess the core summer salmonid habitat available in Lake Spokane or identify data gaps in the existing water quality data. We anticipate the results of past and future sampling will be incorporated in the CE-QUAL-W2 model as a means to extrapolate the point data to help characterize habitat in the entire reservoir.

3.0 IMPLEMENTATION ACTIVITIES

3.1 Studies

In accordance with the DO WQAP and its Revised Implementation Schedule (**Figure 3**), Avista focused its initial efforts on analyzing two measures: reducing carp populations and aquatic weed management, which were identified as having high potential for phosphorus reduction.

3.1.1 Carp Population Reduction Program

In order to investigate whether removing carp would improve water quality in Lake Spokane, a Lake Spokane Carp Population Abundance and Distribution Study consisting of a Phase I and Phase II component, was initiated during 2013 and 2014. The purpose of this study was to better understand carp population abundance, distribution, and seasonal habitat use, as well as to help define a carp population reduction program, that may benefit Lake Spokane water quality.

Three contractors were utilized to complete different components of the Phase I and II Analyses, including Golder Associates (Golder), Ned Horner LLC (Avista contract Fishery Biologist), and Tetra Tech. The results of the Phase I and II Analyses were summarized in the Lake Spokane DO WQAP 2014 Annual Summary Report (Avista 2015).

Results of the Phase I and Phase II Analyses indicate that carp removal from Lake Spokane may provide meaningful reductions in TP directly through removal of TP in carp biomass (5g of TP/kg of carp) and indirectly through the reduction of re-suspended TP from sediments that carp disturb (bioturbation). The telemetry study, conducted in 2014, defined two time periods when carp were concentrated and vulnerable to harvest; during the winter and during the spring spawning period

(May/June). The Phase II Analysis indicated that several different mechanical methods, including but not limited to, spring electrofishing, passive netting, and winter seining would be the most biologically effective and cost efficient means to reduce carp in Lake Spokane. In 2017, Avista implemented a pilot study utilizing a combination of passive netting and electrofishing to identify which is the most effective way to remove carp from Lake Spokane. Netting was found to be the most successful of the two methods and was the method used exclusively in the 2018 carp reduction program.

3.1.2 Aquatic Weed Management

There are approximately 940 acres of aquatic plants present in Lake Spokane, of which 315 acres consist of the non-native yellow floating heart and fragrant water lily (AquaTechnex 2012). In order to evaluate harvesting aquatic plants as a viable method of reducing phosphorus in the lake, Avista contracted Tetra Tech to complete a Phase I Analysis, which: 1) assessed whether harvesting would be a reasonable and feasible activity to perform in Lake Spokane; 2) refined TP concentrations of relevant weed species in Lake Spokane; and 3) quantified TP load reductions associated with selected control methods.

The results of the Phase I Analysis and Nutrient Reduction Evaluation were summarized in the Lake Spokane Dissolved Oxygen Water Quality Attainment Plan 2013 Annual Summary Report. Based upon the results, Avista concluded that harvesting aquatic plants in Lake Spokane at senescence, would not be effective in reducing TP in Lake Spokane. However, Avista will continue to implement winter drawdowns, herbicide applications at public and community lake access sites, and bottom barrier placement to control invasive/noxious aquatic weeds within the lake. Avista may also, through adaptive management, reassess opportunities to harvest aquatic plants to control phosphorus in the future.

3.2 2018 Implementation Measures

The following section highlights measures which Avista implemented, or assisted in the implementation of, in order to reduce phosphorus loading and improve DO concentrations in Lake Spokane.

3.2.1 Carp Removal

During 2018, Avista implemented the second year of its common carp (*Cyprinus carpio*) removal program on Lake Spokane. The removal effort was done in cooperation with WDFW and the Spokane Tribe of Indians, and completed under a Scientific Collection Permit issued by WDFW.

The removal effort occurred during two, four day sampling events; May 21 – 24 and June 11 – 14, and focused on sampling carp during their spring spawning behavior. Removal efforts were focused in four areas of the upper portion of Lake Spokane between McLellan Slough and the Nine Mile Recreation Area (**Figure 4**). The four areas were broken into thirty-two, 400-meter long sections. In each 400-meter section, two 200-foot nets, combined together end to end, or separated as two individual nets were deployed. All but one net was set perpendicular to the shoreline; the remaining net was set parallel to the shore to test the success of this deployment method. A total of 557 carp were collected along with 490 other fish considered by-catch (**Table 1**).

Table 1. Species, total number caught, and total number removed (per species) during the spring 2018 carp removal effort.

Species	Total Caught	Total Removed
Common carp	557	557
Brown bullhead	5	1
Black crappie	13	1
Largemouth bass	19	4
Largescale sucker	103	7
Northern pike	34	34
Northern Pikeminnow	3	1
Rainbow trout	5	4
Smallmouth bass	9	2
Tench	176	1
Walleye	123	97
Total	**1047**	**709**

All carp were weighed, measured, and checked for sex and maturity. Carp ranged in length from 18.1 to 34.2 inches and averaged 26 inches. The average carp weighed 9 lbs and ranged from 3.2 to 20.0 lbs.

Five carp were frozen and sent to ALS Environmental (Kelso Laboratory) to repeat and update the whole-body total phosphorus analysis conducted in 2014 and 2017. The remaining carp were placed into a refuse bin and transported to the Greater Wenatchee Regional Landfill for disposal. Results from the 2018 whole-body total phosphorus analysis are presented in **Appendix B**.

The 557 carp collected in 2018 totaled approximately 5,183 lbs of biomass being completely removed from the watershed. Using the average total phosphorus to weight ratio, provided in the ALS Environmental 2018 lab analysis, removal was calculated to be 27.5 lbs of total phosphorus in 2018 (**Table 2**). Combining the 2017 and 2018 carp removal sampling, a total of 114.1 lbs of total phosphorous has been removed from Lake Spokane by Avista's carp reduction program. That number does not quantify the amount of phosphorous that will no longer be re-activated in the water column by excretion or bioturbation (during the feeding and spawning behavior of these carp).

Table 2. Total number and weight of carp, along with the resulting total phosphorus, removed from Lake Spokane in 2017 and 2018.

	2017	**2018**
Total carp collected	1219	557
Total weight (lbs)	10,310	5,183
Total phosphorous removed (lbs)	86.6	27.5

3.2.2 Wetlands

Avista acquired the 109-acre Sacheen Springs property, located on the west branch of the Little Spokane River. This property contains a highly valuable wetland complex with approximately 59 acres of emergent, scrub-shrub and forested wetlands and approximately 50 acres of adjacent upland forested buffer. Several seeps, springs, perennial and annual creeks are also found on the property. The property was purchased "in fee" and during 2017, Avista pursued a conservation easement in order to protect it in perpetuity. Avista completed a detailed site-specific wetland management plan and began implementing it upon Ecology and FERC's approval in 2014. Herbicide application to control terrestrial invasive weeds was completed in 2014, 2015, and 2016 which should help improve the overall biodiversity and function of the wetland property. Activities conducted during 2018 included several site visits to monitor site conditions, identify future maintenance activities and control invasive weeds in accordance with the site-specific wetland management plan. Invasive weed control measures included herbicide treatment of 8.5 acres, primarily to control infestation of Reed canary grass an invasive species present along the access road.

Avista and the Coeur d'Alene Tribe have acquired approximately 1,022 acres on upper Hangman Creek, within the southern portion of the Coeur d'Alene Tribe Reservation in Benewah County, Idaho approximately 10 miles east of the Washington-Idaho Stateline. Site-specific wetland management plans are updated annually for approximately 500-acres of these properties and include establishing long-term, self-sustaining native emergent, scrub-shrub and/or forested wetlands, riparian habitat and associated uplands, through preservation, restoration and enhancement activities. These properties were all in agricultural use, including straightened creek beds prior to the acquisition. Given

Hangman Creek is a significant contributor of sediment and associated phosphorus loading to the Spokane River, Avista anticipates a TP load reduction from the wetland mitigation work. Since 2013, approximately 14,649 native tree and shrub species have been planted on this wetland complex.

As part of the Nine Mile Hydroelectric Development's Rehabilitation Program, Avista partnered with the Washington State Parks and Recreation Commission Parks (State Parks) to complete a wetland and shoreline restoration project on four acres within the Little Spokane Natural Area Preserve. The Natural Area Preserve is a popular location for recreation, however two invasive weed species, yellow flag iris and purple loosestrife, have severely constricted large sections of the river and adjacent shoreline. The mitigation project included herbicide treatments on four acres of yellow flag iris and purple loosestrife invasive weed species during 2014 and 2015. Additionally, in 2014 four trees were removed from the Nine Mile barge landing site and relocated to the Little Spokane River Mitigation Site for large woody debris habitat. After two consecutive years of herbicide applications the stands of invasive weeds greatly reduced by an estimated 90%-100%. Also, during 2015, Avista partnered with the Washington Department of Natural Resources to implement re-vegetation of the site which included planting 400 trees and shrubs (black cottonwoods, quaking aspens, chock cherry and red osier dogwood). Individual plants were enclosed with four foot welded wire fencing for protection from browsing and the base was wrapped with a protective sleeve for protection from small mammals, and herbicide spot treatments are completed as well. During 2018, Avista conducted several site visits to monitor site conditions and conduct maintenance activities such as, noxious weed control by mechanical and chemical means, and fence repair and removal. Avista anticipates transferring the long-term maintenance of this project back to State Parks (owner of the property) in early 2019, having fulfilled the project components.

Additionally, Avista partnered with the Stevens County Conservation District (SCCD) and Spokane Community College (SCC) to install a floating wetland in the downstream portion of Lake Spokane, adjacent to Avista owned shoreline. The purpose of the floating wetland is for potential TP removal and wave attenuation, as well as to gain information on plant species growth and fish habitat. The floating wetland was installed during April and May of 2018 and consisted of two 40-foot long log structures (each consisting of three logs bolted together), located approximately 100 feet from the shore. During June of 2018, SCC students assembled approximately 20 floating wetland platforms, anchored the platforms to the log structure, and planted the platforms with approximately 240 plants (including, but not limited to sedge, rush, willow, and bulrush species). Throughout the summer season, the SCC students monitored the site for plant survivability, presence of invasive plants, wildlife activity, fish habitat, and shoreline wave impacts. The floating wetland platform was removed in October and approximately

180 of the plants were planted along the adjacent shoreline. Three plant samples (two sedge and one rush) were submitted for total phosphorus and total nitrogen analyses in order to get a rough estimate of the total phosphorus and nitrogen removed by the plants. Additionally, basic field water quality parameters were collected, including the deployment of temperature logger arrays. The data collected from this work is currently being reviewed and consolidated. Avista, SCCD, and SCC plan to further continue and enhance the floating wetland study during 2019.

3.2.3 Native Tree Planting

Avista, in coordination with Stevens County Conservation District, planted 300 Drummond willow trees along 0.5 miles of shoreline at Avista's North Shore Campsites. Once mature, the trees will improve habitat and help reduce water temperatures along the lake's shoreline. Additionally, Avista conducted several site visits to previous tree planting locations to monitor site conditions and conduct maintenance activities such as browsing fence repair, and noxious weed control.

3.2.4 Land Protection

Avista owns over 1,000 acres of land, of which approximately 350 acres are located within 200 feet of the Lake Spokane shoreline in Spokane, Stevens, and Lincoln counties at the downstream end of the reservoir. This includes approximately 14-miles of Avista-owned shoreline that is managed in accordance with Avista's, FERC approved, Spokane River Project Land Use Management Plan (Avista 2016). For the most part this land is contiguous along the north and south shorelines and is managed primarily for conservation purposes. Specific details related to Avista's land use management activities are included in the Land Use Management Plan, a copy of which is available upon request. During 2018 Avista continued to protect this area and will pursue identifying the potential TP load that could be avoided by maintaining a 200-foot buffer along the Avista-owned lake shoreline. Avista will pursue the quantification of this activity along the wetland/restoration enhancements as the 200-foot buffer should create similar sediment-filtering effects.

3.2.5 Rainbow Trout Stocking

Avista implemented a 10-year Lake Spokane rainbow trout stocking program in 2014. As part of the program, Avista annually stocks 155,000 triploid rainbow trout (approximately six inches in length) in the lake every spring. In 2018, a combined 88,000 fish were stocked into the lake from the TumTum turnout on May 30 and 31, with the remaining 67,000 stocked into the lake on June 7. To evaluate how the fish stocking program was effecting the lake's recreational fishery, Avista conducted a creel survey over the 2018 fishing season (March – November). This is the second creel survey conducted since 2016 on Lake Spokane using these methods. Data from the 2016 survey indicated harvested rainbow trout ranged in length from 10 to 18 inches, with 40% being 15 to 16 inches. The data from the two creel surveys is being processed and will be used to assess if Avista's stocking program is enhancing the lake's recreational fishery.

3.2.6 Rainbow Trout Habitat Assessment

Floy Tags

During 2017, in an effort to gain a better understanding of how rainbow trout are performing once they are released, Avista, in cooperation with WDFW, initiated a multi-year growth and mortality study on the hatchery rainbow trout released in Lake Spokane. In 2017, Avista tagged 636 hatchery fish before they were released into the lake with colored, individually numbered ID tags and recorded each of the fish's length and weight to establish a baseline body condition for each fish before it was stocked. In 2018, Avista tagged 882 hatchery rainbow trout with the same ID tags. Growth can then be calculated if those same fish are collected a second time and the length is recorded.

In total, the length of ten tagged fish have been reported by anglers. Of these fish, growth rate averaged around 0.53 mm/d and fish tend to be around 13.5 inches after one year in the lake. Not enough tags were reported to estimate mortality.

Acoustic Tracking Study

Avista and Eastern Washington University completed a two-year tracking study during 2017 and 2018 to assess rainbow trout in Lake Spokane to gain a better understanding of habitat utilization throughout the lake. While the vast amount of data from this study is still being analyzed, the following provides key findings from the two-year tracking study (Warehime 2018).

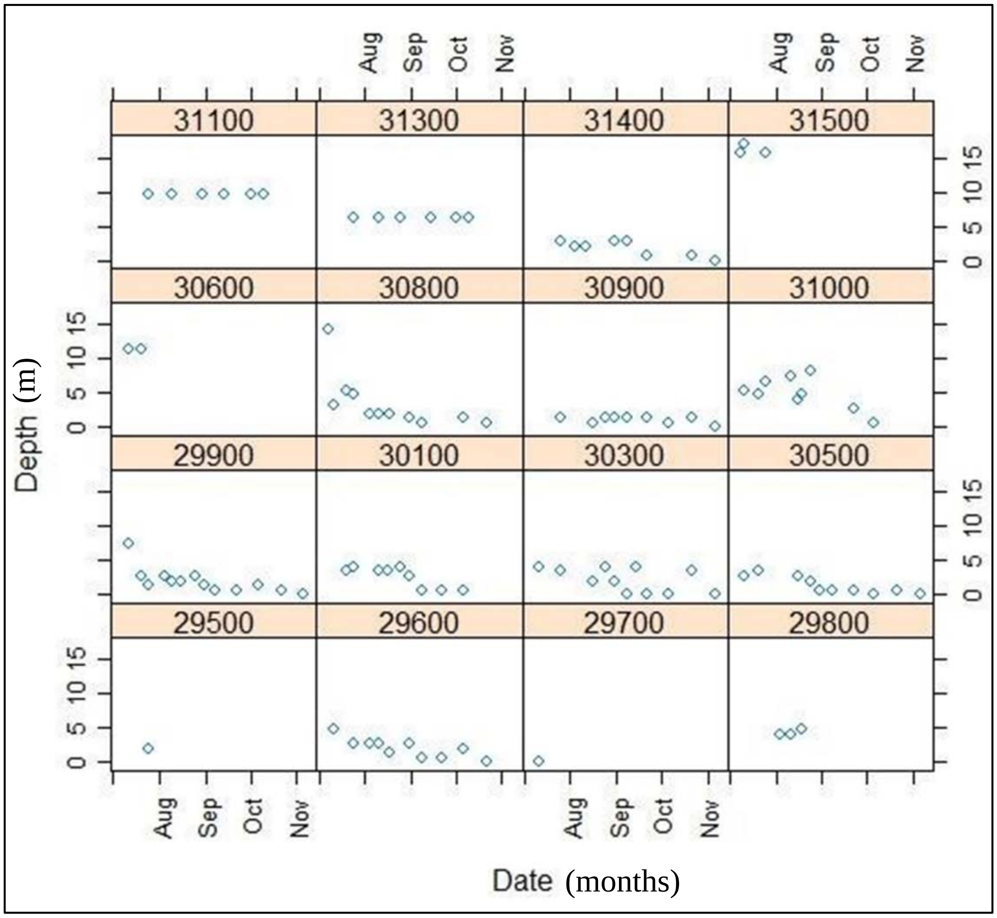
2017 Results

The acoustic tracking study began in 2017 and consisted of surgically implanting acoustic tags into the body cavity of 20 fish caught in Lake Spokane, ranging in length from 14.5 to 17.5 inches and in weight from 1.12 to 1.76. These fish were tracked from early July to early November identifying the latitude and longitude they were found at, along with their depth in the water column and the temperature they were inhabiting when tracking occurred.

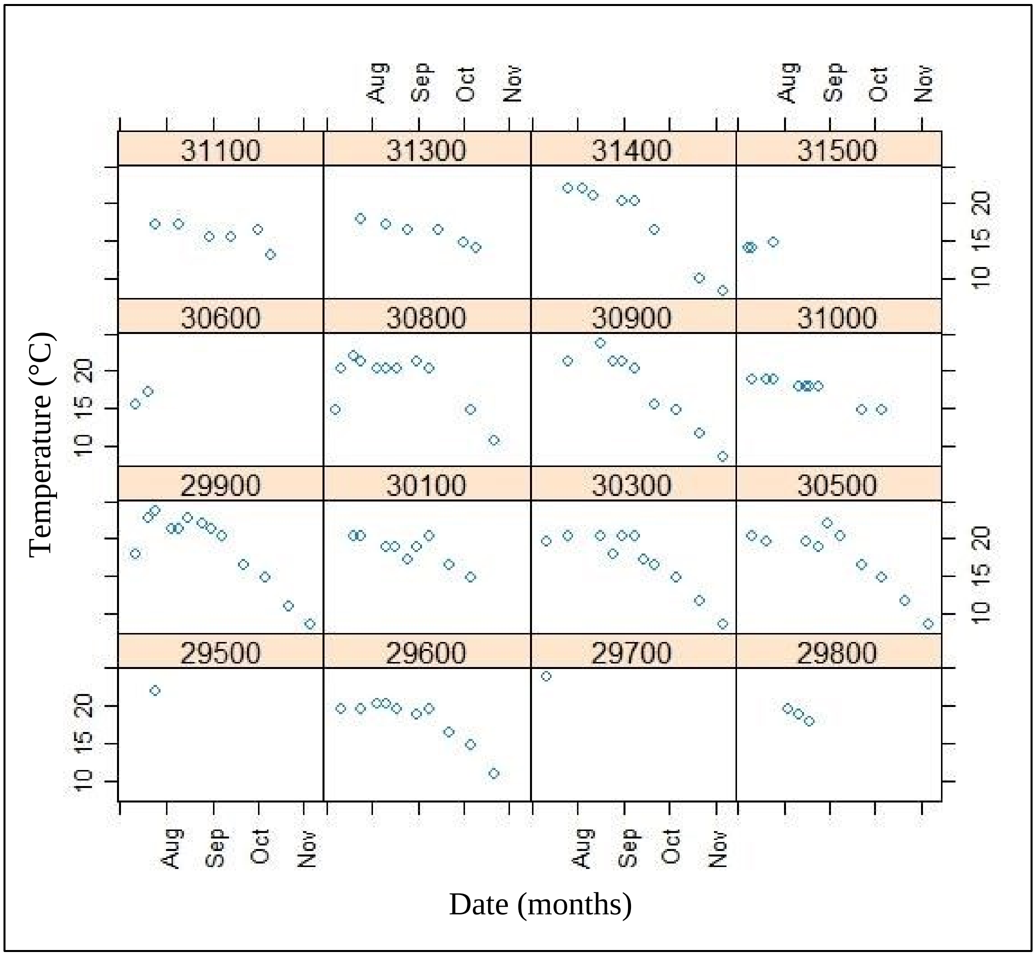
Of the 20 fish tagged during 2017, 13 were found on a consistent basis. Tagged fish were found in depths ranging between 0 – 16 meters from the surface of the water. Fish were found lower in the water column in July averaging slightly over 6 meters in depth, compared to average depths ranging from 1.8 to 3.2 meters in August through October. (**Figures 5 through 8**). **Figures 5 through 8** display the location where rainbow trout were tracked on a monthly basis during 2017. These figures identify locations and hotspots of rainbow trout presence using a symbology gradient transitioning between dark blue to dark red. In these figures, dark blue indicates no presence of rainbow trout for that month. Lighter blue transitioning into light yellow indicates individual fish had been detected at least one tracking event during the month before moving to another location. Light red into dark red indicates locations where rainbow trout were more frequently found during each tracking event.

These fish occupied water temperatures ranging from 8.4 °C in November to 23.6 °C in mid-August (**Graph 2**). Fish were frequently found above 16 °C in late summer. In fact, during one tracking event on September 8, 2017, eight fish were found, with seven of them inhabiting water that was 20.4 °C.

During 2017, the data show variation in the geographic range that fish were occupying over the course of the summer and fall (**Figures 5 through 8**). Overall, no fish were found upstream of LL4 (Suncrest Park) and fish were rarely seen below LL1. A majority of the actively moving fish stayed between LL2 and LL4. From July through mid-September, the fish were generally spread out from each other. In one sampling event in late July, and more consistently starting in mid-September, the fish were more grouped. Starting in late October, the fish began moving downstream and no fish were found upstream of LL3 during the November tracking event.



Graph 1. Depth lattice graph showing depth location of fish during the 2017 tracking event. This graph displays each individual fish, marked by its unique acoustic number (31100 through 29800). The cell below each unique number represents the fish's depth each time it was tracked throughout the 2017 season. Depth along the y-axis increases from surface water (0) to deeper segments (15 m). Date is grouped in months along the x-axis.



Graph 2. Temperature lattice graph showing temperature of the water at which the fish were found during the 2017 tracking events. The graph displays each individual fish, marked by its unique acoustic number (31100 through 29800). The date is grouped in months along the x-axis and temperature, in Celsius, increases along the y-axis. The cell below each unique number represents the temperature the fish was occupying when it was identified.

2018 Results

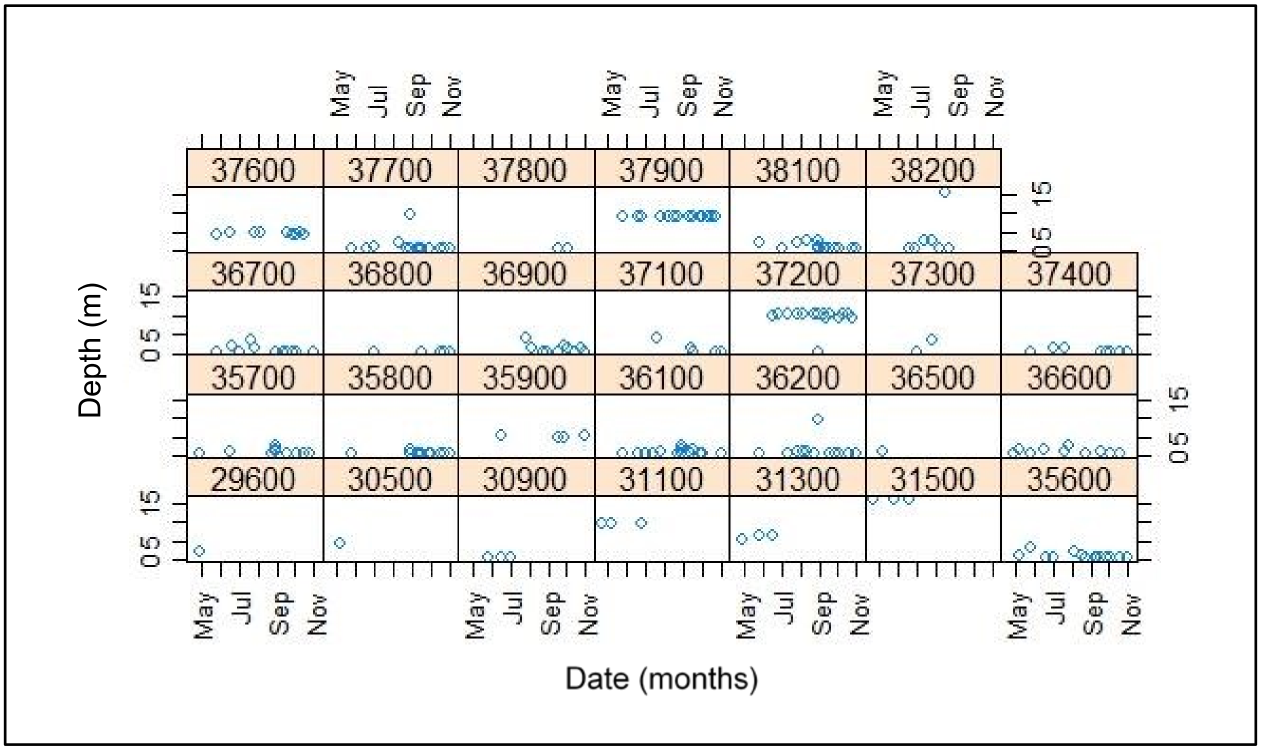
Avista implemented the second year of rainbow trout tracking in 2018. Acoustic tags were surgically implanted into the body cavity of 25 rainbow trout caught from the lake, ranging in length from 13.5 to 18.1 inches and in weight from 0.9 to 2.2 lbs. Twenty of these fish were tagged before April 24 and the remaining five were tagged on May 30. Tracking was conducted on a weekly basis starting on in April and continued until November 1. During each tracking event, the latitude and longitude of the fish was documented, along with their depth in the water column and the temperature they were inhabiting at that time.

Twenty-one of the twenty-five fish tagged in 2018 were detected at some point in 2018, along with an additional six tags detected from fish that were tagged in 2017. The 2018 tracking season began on April 11 after ten of the fish were tagged and released. This early tracking season allowed for documentation of trout movements earlier in the season compared with 2017.

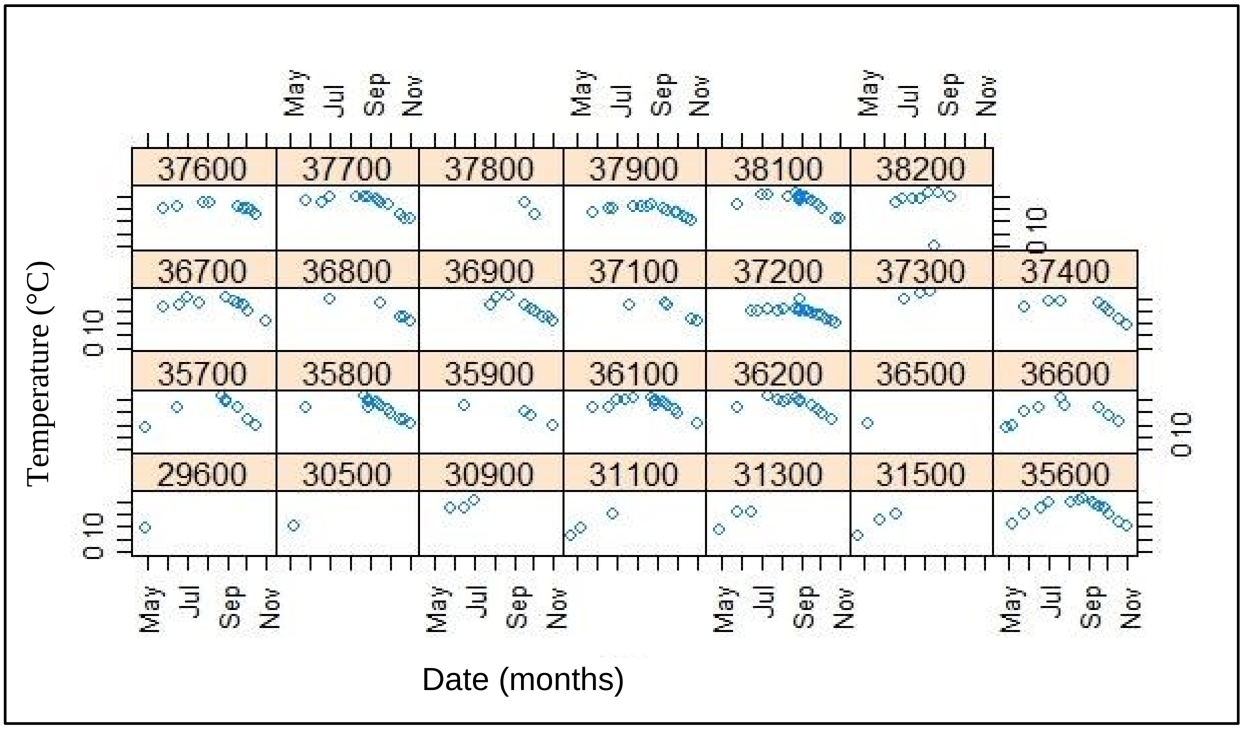
Figures 5 through 15 display the location where rainbow trout were tracked on a monthly basis during 2018. These figures identify locations and hotspots of rainbow trout presence using a symbology gradient transitioning between dark blue to dark red. In these figures, dark blue indicates no presence of rainbow trout for that month. Lighter blue transitioning into light yellow indicates individual fish had been detected at least one tracking event during the month before moving to another location. Light red into dark red indicates locations where rainbow trout were more frequently found during each tracking event.

In 2018, individual fish depth selections did not vary substantially throughout the season with two patterns emerging. Rainbow trout were either found at less than 6 meters below the surface of the water or between 6 to 15.6 meters (**Graph 3**).

Fish that remained close to the surface in July and August experienced a temperature range of 18.0 to 20.4 °C (**Graph 3**). Three fish found deeper in the water column were found at temperatures averaging 15.6 °C (37900, 37200, and 31500). In September, water temperatures began to decrease, staying at or below 19.6 °C and falling to below 14.8 °C for the remainder of the season for the fish near the surface. Overall, in 2018, a majority of fish selected depths near the surface, in the epilimnion, resulting in the fish staying at much warmer temperatures than anticipated (**Graph 4**). The temperatures in the epilimnion during the warmer months of summer reach the rainbow trout upper limits of presumed preference, which corresponds with the trends seen in 2017.



Graph 3. Depth lattice graph showing depth location of fish during the 2018 tracking event. This graph displays each individual fish, marked by its unique acoustic number (37600 through 35600). Fish on the bottom row were also tracked in 2017 with the exception of 35600. The cell below each unique number represents the fish's depth each time it was tracked throughout the 2018 season. Depth along the y-axis increases from surface water (0) to deeper segments (15 m). Date is grouped in months along the x-axis.



Graph 4. Temperature lattice graph showing temperature of the water at which the fish were found during the 2018 tracking events. The graph displays each individual fish, marked by its unique acoustic number (37600 through 35600). The date is grouped in months along the x-axis and temperature, in Celsius, increases along the y-axis. The cell below each unique number represents the temperature the fish was occupying when it was identified.

Per Ecology's request, nighttime tracking was conducted on August 23 and 24 to determine if the rainbow trout changed their depth selection in the water column diurnally or moved spatially over the course of the day and night. Tracking revealed that a majority of these fish did not move more than 300 m from their locations where they were first detected during the day. The fish that had selected depths within six meters of the water surface elevation did not change their depth selections during the night by more than 3 meters. Rainbow trout that had selected depths at 6 to 15 meters did not change their selections during the night and remained in the same depth range (**Table 3**).

Table 3. Rainbow trout depth and temperature selections from the nighttime tracking event.

Fish Number	Time	Depth (m)	Temperature (°C)
35700	21:50	4	n/a
35700	6:23	4	20.4
35800	21:46	3	17.2
35800	2:30	1	19.6
35800	5:57	< 0.68	19.6
35800	9:18	< 0.68	19.6
36100	21:51	< 0.68	18
36100	2:14	3	18
36100	6:23	3	20.4
36100	9:18	< 0.68	19.6
36200	20:57	1	19.6
36700	5:57	1	20.4
36700	9:00	< 0.68	19.6
37200	20:35	14	15.6
37200	1:23	14	15.6
37200	5:25	15	19.6
37200	8:29	15	15.6
37700	1:27	< 0.68	19.6
37700	5:25	1	19.6
38100	21:30	3	18.8
38100	2:13	4	18
38100	6:23	< 0.68	19.6

Avista's Rainbow Trout Habitat Assessment, conducted during 2017 and 2018, show that rainbow trout were frequently found in the epilimnion during the summer of 2017 and 2018, and often in water temperatures that were higher than anticipated (up to 23.6 °C). This is contrary to the information presented in the cursory review (Section 2.1), which analyzed habitat based upon literature values and existing water quality monitoring data. The cursory review suggested that rainbow trout would be utilizing deeper depths in the lake. Avista will continue to process the results of the habitat assessment and work with Ecology and WDFW to relate lake-wide water quality and habitat data to known rainbow trout occupancy data to help quantify available suitable habitat within the entire lake.

3.2.7 Bulkhead Removal

During 2018 Avista worked with several Lake Spokane shoreline landowners in Spokane County to replace existing concrete, stacked rock, riprap, or other similar hardened bulkheads with natural shoreline materials or those that utilize bioengineered products that use native vegetation, when and where possible. The 2018/2019 winter drawdown allowed construction to begin on one of these bulkhead replacement projects, the Wright Project, located just downstream of Sportsman's Paradise. When implemented, the Wright Project will help reduce non-point source phosphorus loading into Lake Spokane and will be used as a prototype to educate other Lake Spokane shoreline homeowners about how they too can improve water quality in Lake Spokane by these types of projects. Construction of this project is anticipated to be complete in January 2019, with plantings to be installed in the spring of 2019.

3.2.8 Education

Avista participated with others to support passage of a Washington law[1], effective January 2013, limiting the use of phosphorus (except for certain circumstances) in residential lawn fertilizers, which includes those adjacent to Lake Spokane in Spokane, Stevens, and Lincoln counties. Although the new law legally restricts use of fertilizer containing phosphorus, homeowner education will be important in actually reducing phosphorus loads to the lake.

During 2018, Avista participated in the SCCD's Best Management Implementation Project. This project is funded through an Ecology grant and one component includes educating Lake Spokane high school students about the water quality in the watershed. This includes discussing best management practices around the lake, such as, the benefits of natural shorelines with native vegetation buffers, proper disposal of lawn clippings and pet waste, use of phosphorus-free fertilizers, and regularly maintaining septic systems.

In addition, Avista managed a booth at the Northern Idaho/Eastern Washington Annual Lakes Conference to provide education materials for lakeshore owners and community members. Avista also staffed a booth at the Eastern Washington University Earth Day Fair, handing out educational brochures with content ranging from shoreline best management practices, water quality improvement projects, aquatic weed management,

[1] Engrossed Substitute House Bill 1489, Water Quality – Fertilizer Restrictions, Approved by Governor Christine Gregoire April 14, 2011 with the exception of Section 4 which is vetoed. Effective Date January 1, 2013.

eagles and fisheries habitat, and recreation opportunities in the Spokane River and Lake Spokane.

Avista actively participates with the Lake Spokane Association and periodically features articles regarding best management practices for shoreline homeowners in its annual Spokane River Newsletter which is distributed electronically to the Lake Spokane shoreline homeowners. In 2018, Avista partnered with the Lake Spokane Association (LSA), Washington Department of Fish and Wildlife, and other natural resource entities to attend and participate at the LSA annual meeting. Avista provided an update to Lake Spokane residents about the fisheries habitat, aquatic weed management and water quality improvement projects being conducted on the lake.

4.0 EFFECTIVENESS OF IMPLEMENTATION ACTIVITIES

Quantification of the implementation activities including wetlands, land protection, and carp removal are in progress as described for each of these activities below. Avista is currently exploring the use of Tetra Tech's STEPL modeling software as a way to quantify the cumulative effectiveness of the various implementation activities. Quantification of BMPs, even using modeling software, is highly variable and imprecise, but may provide a starting point to guide future implementation activities.

- **Carp Removal**
  Avista has removed over 1,776 carp in the last two years, totaling approximately 15,480 lbs of biomass, from Lake Spokane. This equates to 114.1 lbs of total phosphorus removed from the Spokane watershed, but does not quantify the amount of phosphorous that will no longer be re-activated in the water column through bioturbation. Additionally, 561 of the total carp removed were mature females, collected during the spring removal effort before spawning, preventing the release of hundreds of thousands of eggs into the population.

- **Wetlands**
  Avista is in the initial stages of implementing site-specific wetland management plans for the Sacheen Springs and Hangman Creek properties. As the wetland management plans are implemented Avista will work with Ecology to explore appropriate total phosphorus load reduction quantification tools.

  Additionally, Avista, SCCD and SCC plan to continue and further enhance the floating wetland study on Lake Spokane during 2019. The data collected as part of this study during 2018, and in future years, will be utilized to get a rough estimate of the total phosphorus and nitrogen removed by the floating wetland plants.

- **Land Protection**
  Avista and State Parks completed the 215 acre lease from DNR and eliminated grazing on this property in 2017. In addition, Avista owns over 1,000 acres of land, of which approximately 350 acres are located within 200 feet of Lake Spokane's shoreline in Spokane, Stevens, and Lincoln counties at the downstream end of the reservoir. During 2018 Avista continued to protect this area and will pursue quantifying TP load reduction for the 200-foot buffer and from the land protection, as these two activities should create similar sediment-filtering effects.

5.0 PROPOSED ACTIVITIES FOR 2019

The following activities are proposed for implementation in 2019.

- **Carp Removal**

  Based on the success and lessons learned in 2017 and 2018, Avista plans to remove carp again in 2019, focusing on placing gill nets in the locations that had the greatest catch success in the past two years. Electrofishing will not be conducted if removal occurs before the carp are heavily aggregated for spawning in the spring.

  Carp will be disposed of in the same fashion as in 2018. At a minimum, length and weight will be measured on all carp to quantify the amount of total phosphorus removed during the 2019 efforts.

- **Rainbow Trout Stocking**

  Avista will continue to stock 155,000 triploid rainbow trout (approximately six inches in length) in Lake Spokane on an annual basis. A creel survey was conducted on Lake Spokane in 2018, repeating the methods used for the 2016 creel survey, to assess trends in angler satisfaction and angling success associated with the stocking program. The data collected during this survey will be processed and analyzed in 2019, and used to inform the future direction of the stocking program.

- **Rainbow Trout Habitat Assessment**

  Avista will continue to process the results of the habitat assessment and work with Ecology and WDFW to relate lake-wide water quality and habitat data to known rainbow trout occupancy data to help quantify available suitable habitat within the entire lake. Avista will use these results to explore the need for further tagging in 2019 (floy and acoustic).

- **Wetlands**

  Avista will continue to implement site-specific wetland management plans for the Sacheen Springs and Hangman Creek properties.

  Additionally, Avista, SCCD and SCC plan to further continue and enhance the floating wetland study on Lake Spokane during 2019. Once the 2018 data is compiled and analyzed, Avista and its partners will meet with Ecology to discuss the results as well as plan additional data collection efforts. This may include additional analysis of total phosphorus and nitrogen removed by the plants, reductions in surface water temperatures, shoreline wave impacts and attenuation, vegetation success rates, wildlife and fisheries habitat, and invasive weed infestations.

- **Native Tree Planting**

  Avista will assess survival of the trees planted to date along the Avista-owned Lake Spokane shorelines.

- **Land Protection**

  Avista and State Parks completed the 215 acre lease of land from DNR with the intent of changing the land use. Avista will also continue to protect the 200-foot buffer on 350 acres of Avista-owned shoreline located in the lower portion of the reservoir.

- **Bulkhead Removal**

  Avista will continue working with landowners on Lake Spokane who are currently in the construction and permitting phase of bulkhead replacement projects. Avista will also explore other removal projects as they arise.

- **Education**

  Avista will continue to participate with Ecology, the Lake Spokane Association, the SCCD, and others to inform shoreline homeowners of best management practices they can implement to help protect the lake. Currently, a bulkhead removal project on Lake Spokane is underway, with agreements in place that it will be used as a prototype to educate other Lake Spokane shoreline homeowners about how they too can improve water quality in Lake Spokane by these types of projects.

6.0 SCHEDULE

Avista's implementation schedule incorporates several benchmarks and decision points important in implementing the DO WQAP. As part of the 2015 Annual Summary Report and based on Ecology's recommendation, Avista revised the DO WQAP Implementation Schedule (**Figure 3**, Revised DO WQAP Implementation Schedule) to better sync with the compliance schedule of the DO TMDL, including point- and non-point source wasteload and load reductions. The revision consisted of changing the initial implementation dates that Avista would run the CE-QUAL-W2 model (2016/2017, 2019/2020, and 2021/2022. Avista will continue to work with Ecology during 2019 to continue developing a plan to run the CE-QUAL-W2 model, as further described below.

Benchmarks and important milestones completed to date, and extending into 2020 include the following.

2012

- Prepared the DO WQAP, which identified nine potentially reasonable and feasible measures to improve DO conditions in Lake Spokane. Approval of the DO WQAP was obtained from Ecology on September 27, 2012 and from FERC on December 19, 2012.

2013 (Year 1)

- Conducted the baseline nutrient monitoring in Lake Spokane (May through October).
- Conducted the Aquatic Weed Management Phase I Analysis and Nutrient Reduction Evaluation.
- Initiated the Lake Spokane Carp Population Abundance and Distribution Study.
- Planted 300 trees on Lake Spokane.
- Assisted with a bulkhead removal on the Staggs parcel and began designing the bulkhead removal for the second property on Lake Spokane.
- Protected approximately 14-miles of Avista-owned shoreline from future development.
- Acquired 109-acres of wetland property in the Little Spokane Watershed and 656-acres in the upper Hangman Creek Watershed.
- Continued education activities targeted at Lake Spokane shoreline homeowners.

2014 (Year 2)

- Completed and submitted the 2013 DO WQAP Annual Summary Report to Ecology and FERC.
- Conducted baseline nutrient monitoring in Lake Spokane (May through October).
- Completed the Lake Spokane Carp Population Abundance and Distribution Study.
- Planned and began permitting a bulkhead removal on an Avista Lake Spokane parcel.
- Protected approximately 14-miles of Avista-owned shoreline from future development.
- Implemented site-specific wetland plans on the Sacheen Springs and Hangman Creek properties.
- Stocked 155,000 triploid rainbow trout in Lake Spokane.
- Continued education activities targeted at Lake Spokane shoreline homeowners.

2015 (Year 3)

- Completed and submitted the 2014 DO WQAP Annual Summary Report to Ecology and FERC.

- Conducted baseline nutrient monitoring in Lake Spokane (May through October).
- Worked with WDFW and Ecology in planning a carp reduction effort for 2016.
- Continued planning and permitting the bulkhead removal on an Avista Lake Spokane parcel.
- Protected approximately 14-miles of Avista-owned shoreline from future development.
- Implemented site specific wetland plans on the Sacheen Springs and Hangman Creek properties.
- Stocked 155,000 triploid rainbow trout in Lake Spokane.
- Continued education activities targeted at Lake Spokane shoreline homeowners.

2016 (Year 4)

- Completed and submitted the 2015 DO WQAP Annual Summary Report to Ecology and FERC.
- Conducted the baseline nutrient monitoring in Lake Spokane (May through October). Following monitoring, evaluated the results and success of monitoring baseline nutrient conditions in Lake Spokane and worked with Ecology to define future monitoring goals for the lake.
- Initiated carp removal activities during spring spawning. Activities were rescheduled due to timing of the hydrograph and early aquatic weed growth.
- Stocked 155,000 triploid rainbow trout in Lake Spokane.
- Continued to implement site specific wetland plans on the Sacheen Springs and Hangman Creek properties.
- Protected approximately 14-miles of Avista-owned shoreline from future development.
- Planted 13,625 trees along Lake Spokane shoreline.

2017 (Year 5)

- Submitted the DO WQAP Five Year Report to Ecology and FERC on February 1 and April 1, respectively.
- Removed carp during winter aggregation and spring spawning.
- Continued baseline nutrient monitoring in Lake Spokane.
- Initiated the Rainbow Trout Habitat Assessment.
- Completed other mitigation measures as proposed in the DO WQAP Five Year Report.
- Avista continued to work with Ecology in regard to developing a plan to run the CE-QUAL-W2 model.

2018 (Year 6)

- Submitted the 2017 DO WQAP Annual Summary Report to Ecology and FERC by February 1 and April 1, respectively.
- Continued carp removal efforts.
- Continued the Rainbow Trout Habitat Assessment.

- Collected *in-situ* and zooplankton data at all 6, plus 4 additional, water quality monitoring stations.
- Completed other mitigation measures as proposed in previous years' Annual Summary Report.
- Continued discussions of timing, objectives, and data input of potential future CE-QUAL-W2 model runs with Ecology.

2019 (Year 7)

- Submit the 2018 DO WQAP Annual Summary Report to Ecology and FERC by February 1 and April 1, respectively.
- Complete analysis of the Rainbow Trout Habitat Assessment, relating identified occupancy information to lake-wide habitat and water quality parameters to quantify available habitat.
- Evaluate water quality monitoring needs in coordination with Ecology's proposed DO TMDL 10-year assessment monitoring.
- Continue carp removal program.
- Complete other mitigation measures as proposed in previous years Annual Summary Report.
- Discuss timing, objectives, and data input of potential future CE-QUAL-W2 model runs with Ecology. This may include timing, objectives, data input, and a QA/QC plan for potential future model runs.

2020 (Year 8)

- Will submit the DO WQAP Eight Year Annual Summary Report to Ecology and FERC by February 1 and April 1, respectively.
- Evaluate benefit of carp removal program, based on 3 to 4 years of data.
- Will complete other mitigation measures as proposed in previous years Annual Summary Report.
- Will discuss timing, objectives, and data input of potential future CE-QUAL-W2 model runs with Ecology.

7.0 REFERENCES

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FIGURES

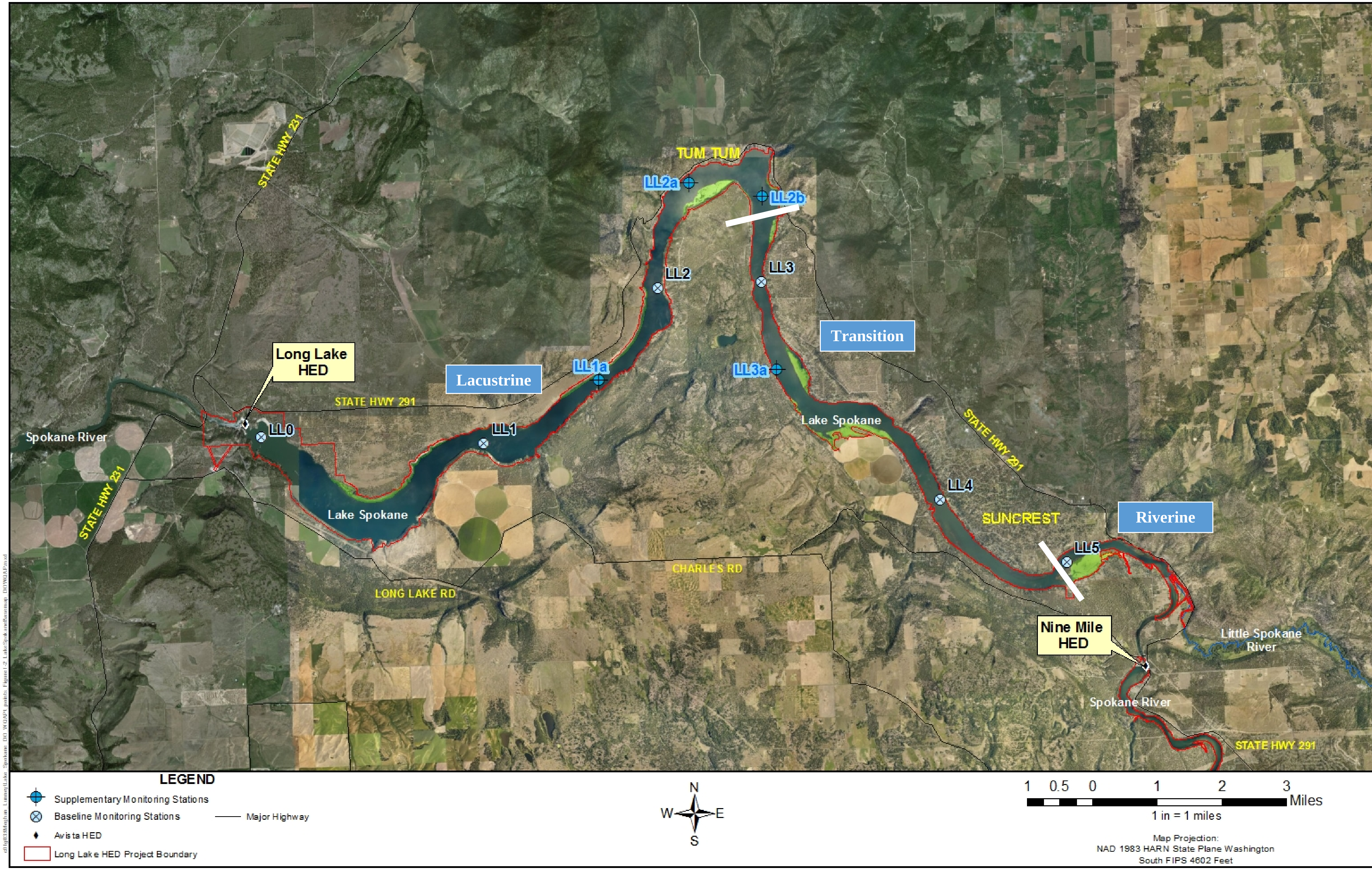

Figure 1. Location of Lake Spokane Baseline Stations and the Four Supplemental Monitoring Stations.

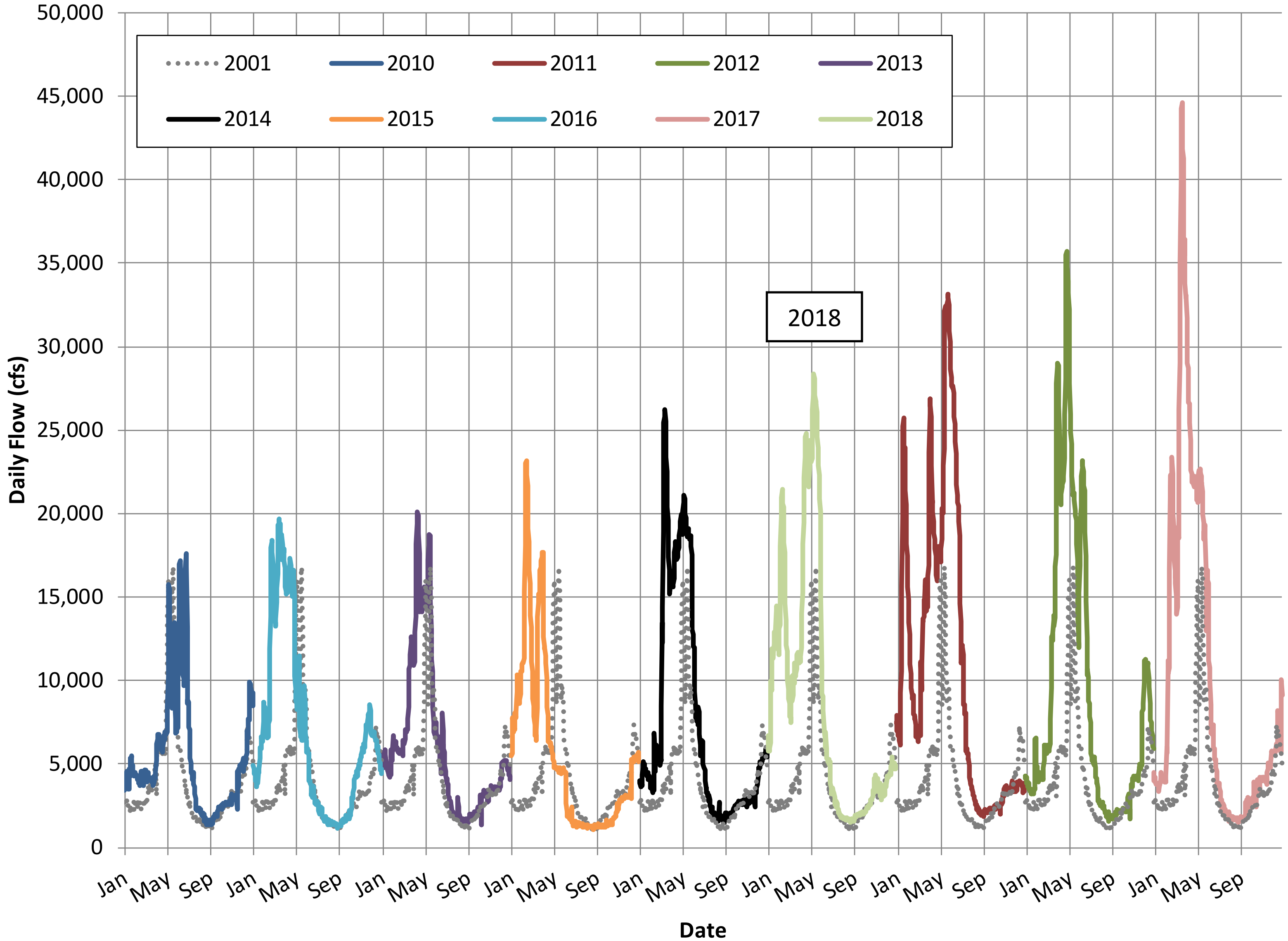

Figure 2. Total inflows into Lake Spokane 2001, 2010-2018, arranged in order of lowest to highest peak flow (Source, Tetra Tech 2018).

Implementation Year[1]

Activity		2012				Year 1 2013				Year 2 2014				Year 3 2015				Year 4 2016			
		Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
DO WQAP Submittal	Submit DO WQAP to Ecology		x																		
	Receive approval from Ecology*			x																	
	Submit DO WQAP to FERC*			x																	
	Receive approval from FERC*				x																
Carp	Phase I Analysis: Identify location and population of carp							x	x	x	x	x									
	Summarize Phase I findings [2]*									x				x							
	Phase II Analysis: Evaluate harvest technology									x	x	x	x								
	Select carp removal method(s)												x								
	Summarize Phase II findings[2], consult and discuss with Ecology													x							
	Determine with Ecology whether carp population reduction is reasonable and feasible to implement in Lake Spokane*														x						
	If determined reasonable and feasible, implement measure; if not, revise implementation strategy, monitoring, and schedule*															x	x	x	x	x	x
	If implemented, monitor for nutrient reductions															x	x			x	x
Aquatic Weed Management	Phase I Analysis: Evaluate feasibility of mechanical harvesting						x	x	x												
	Nutrient reduction evaluation							x	x												
	Summarize findings[2], consult and discuss with Ecology*									x											
	Determine with Ecology whether aquatic weed harvesting is reasonable and feasible to implement in Lake Spokane*										x										
	If determined reasonable and feasible, implement measure; if not, revise implementation strategy, monitoring, and schedule*											x	x			x	x			x	x
	If implemented, monitor for nutrient reductions											x	x			x	x			x	x
	Implement yearly aquatic weed controls through separate program[3]											x	x			x	x			x	x
Other Measures	Evaluate & implement additional measures, as appropriate																				
Monitoring & Modeling	Baseline Monitoring[4]		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x
	Ongoing Habitat Analysis[5]										x	x			x	x			x	x	
	Site Specific Nutrient Reduction Analysis[6]																				
	CE-QUAL Modeling[7]																				
Compliance Reporting	DO WQAP Annual Summary Report*									x				x				x			
	Five, Eight, and Ten-Year Reports*																				

Activity		Year 5 2017				Year 6 2018				Year 7 2019				Year 8 2020				Year 9 2021				Year 10 2022			
		Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
DO WQAP Submittal	Submit DO WQAP to Ecology																								
	Receive approval from Ecology*																								
	Submit DO WQAP to FERC*																								
	Receive approval from FERC*																								
Carp	Phase I Analysis: Identify location and population of carp																								
	Summarize Phase I findings [2]*																								
	Phase II Analysis: Evaluate harvest technology																								
	Select carp removal method(s)																								
	Summarize Phase II findings[2], consult and discuss with Ecology																								
	Determine with Ecology whether carp population reduction is reasonable and feasible to implement in Lake Spokane*																								
	If determined reasonable and feasible, implement measure; if not, revise implementation strategy, monitoring, and schedule*																								
	If implemented, monitor for nutrient reductions			x	x			x	x			x	x			x	x			x	x				
Aquatic Weed Management	Phase I Analysis: Evaluate feasibility of mechanical harvesting																								
	Nutrient reduction evaluation																								
	Summarize findings[2], consult and discuss with Ecology*																								
	Determine with Ecology whether aquatic weed harvesting is reasonable and feasible to implement in Lake Spokane*																								
	If determined reasonable and feasible, implement measure; if not, revise implementation strategy, monitoring, and schedule*			x	x			x	x			x	x			x	x			x	x				
	If implemented, monitor for nutrient reductions			x	x			x	x			x	x			x	x			x	x				
	Implement yearly aquatic weed controls through separate program[3]			x	x			x	x			x	x			x	x			x	x				
Other Measures	Evaluate & implement additional measures, as appropriate	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				
Monitoring & Modeling	Baseline Monitoring[4]																								
	Ongoing Habitat Analysis[5]		x	x			x	x			x	x			x	x			x	x					
	Site Specific Nutrient Reduction Analysis[6]																								
	CE-QUAL Modeling[7]																								
Compliance Reporting	DO WQAP Annual Summary Report*					x				x								x							
	Five, Eight, and Ten-Year Reports*	x												x								x			

Notes:

(1) = Implementation Year dependent upon date of FERC approval.

(2) = Findings would be summarized in the DO WQAP Annual Summary/Report, which will be submitted to Ecology for review and approval.

(3) = Annual aquatic weed control activities implemented under the Lake Spokane and Nine Mile Reservoir Aquatic Weed Management Program.

(4) = Avista and Ecology will re-evaluate baseline nutrient monitoring program following the completeing of the 2016 season.

(5) = Ongoing in nature with periodic reporting to Ecology.

(6) = Dependent upon outcome of carp population reduction and aquatic weed management phased analyses.

(7) = Avista will continue to work with Ecology to determine the timing for future CE-QUAL model runs.

Revised Figure 3. DO WQAP Implementation Schedule (Source: Figure 3-3, DO WQAP)

Revised: March 2016

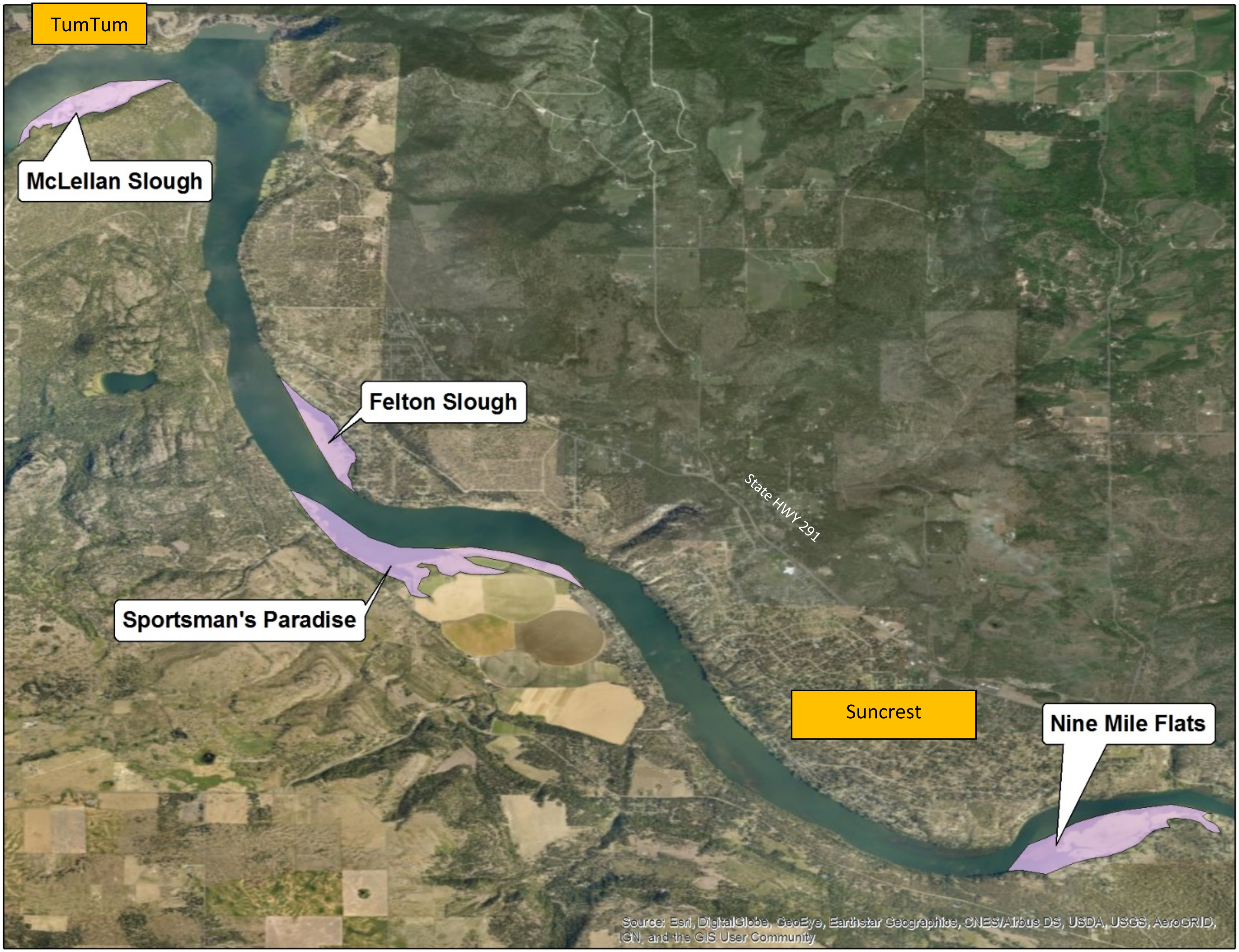

Figure 4. Lake Spokane carp removal locations (purple shaded area)

Figure 5. 2017 July habitat use of Lake Spokane.

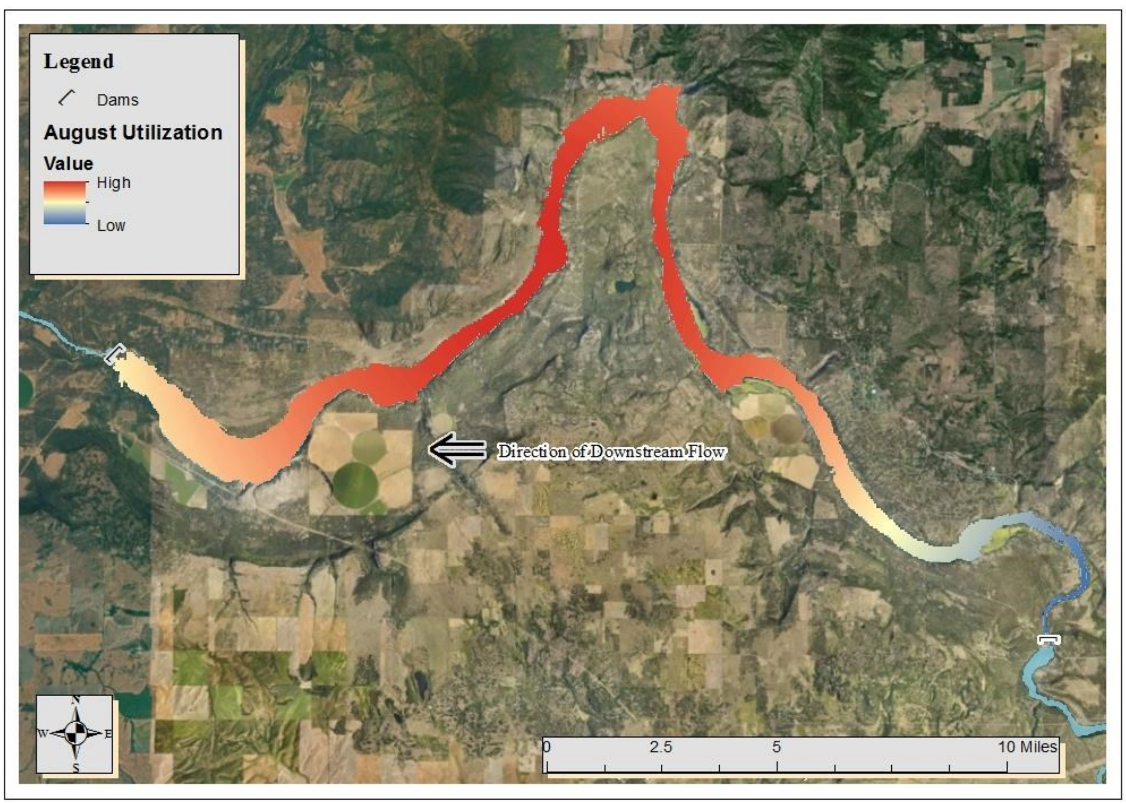

Figure 6. 2017 August habitat use of Lake Spokane.

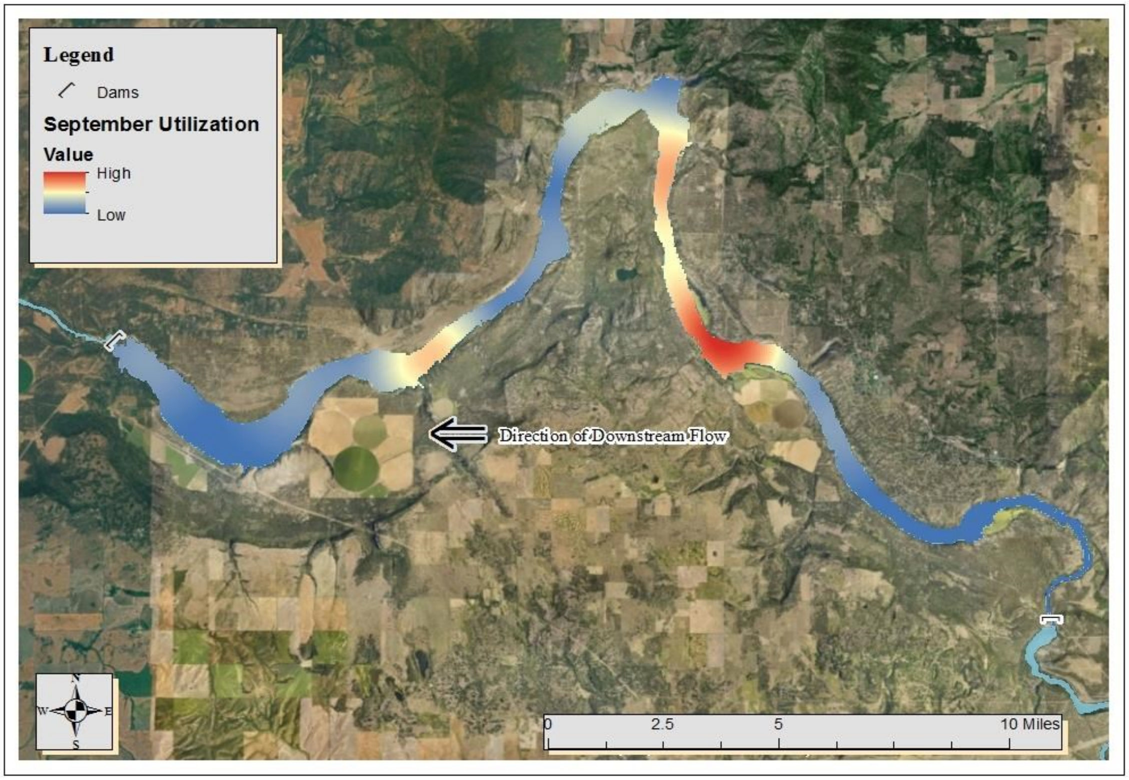

Figure 7. 2017 September habitat use of Lake Spokane.

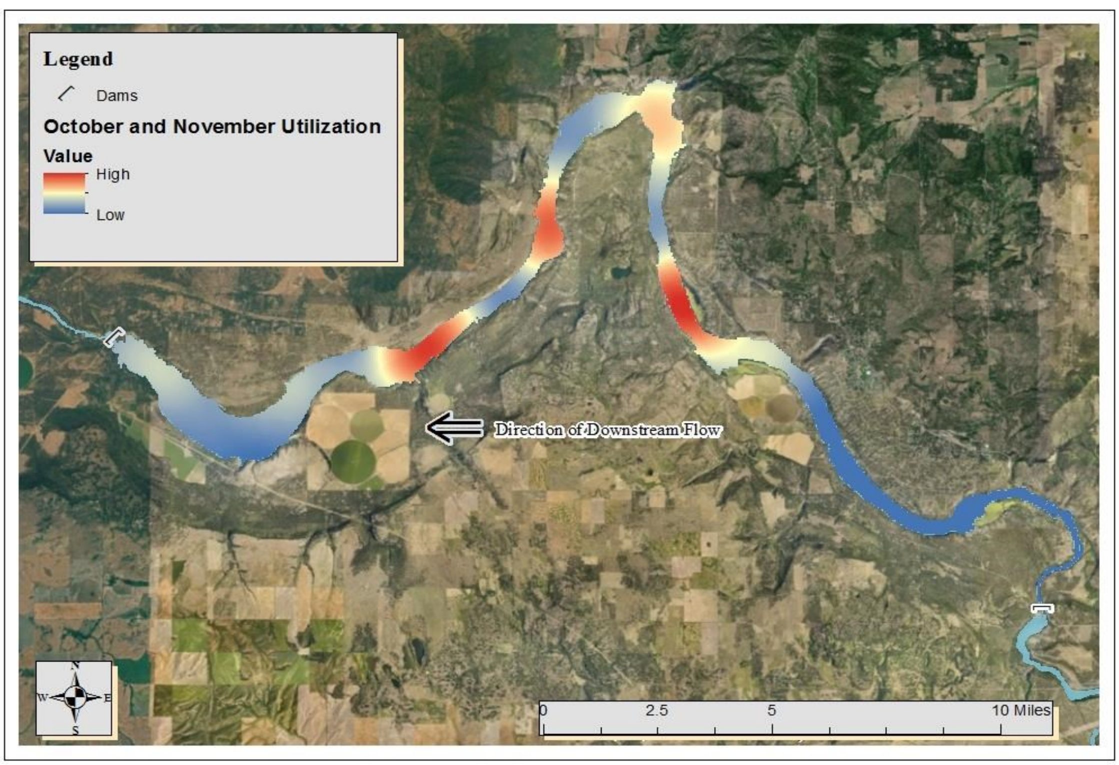

Figure 8. October and November habitat use of Lake Spokane, WA. November is included in this kernel density map due to only one tracking event occurring in November.

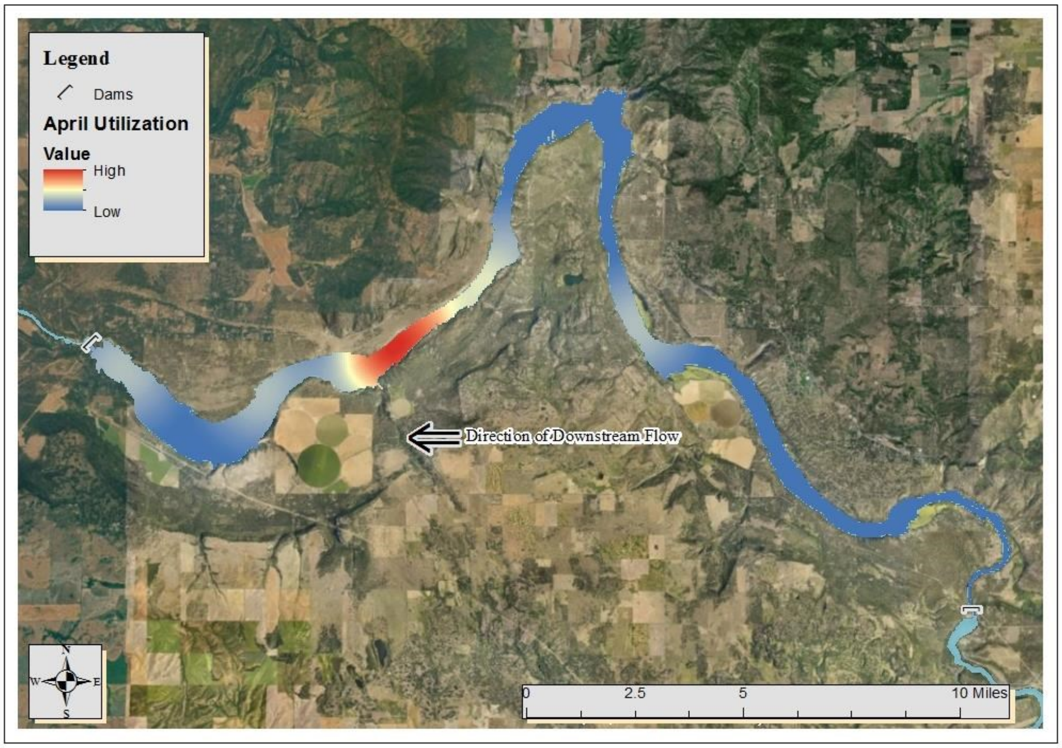

Figure 9. 2018 April habitat use of Lake Spokane. High turbidity and flows were occurring during these tracking events.

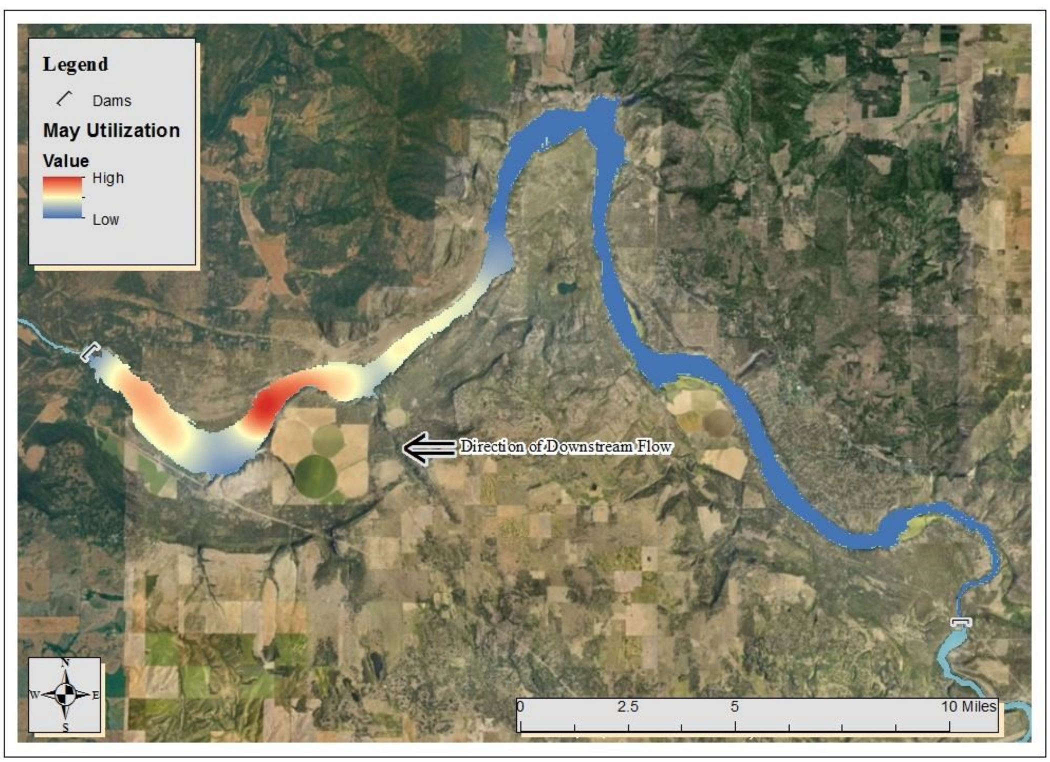

Figure 10. 2018 May habitat use of Lake Spokane. High flows and turbidity were occurring, but started to slow and settle out towards the end of the month.

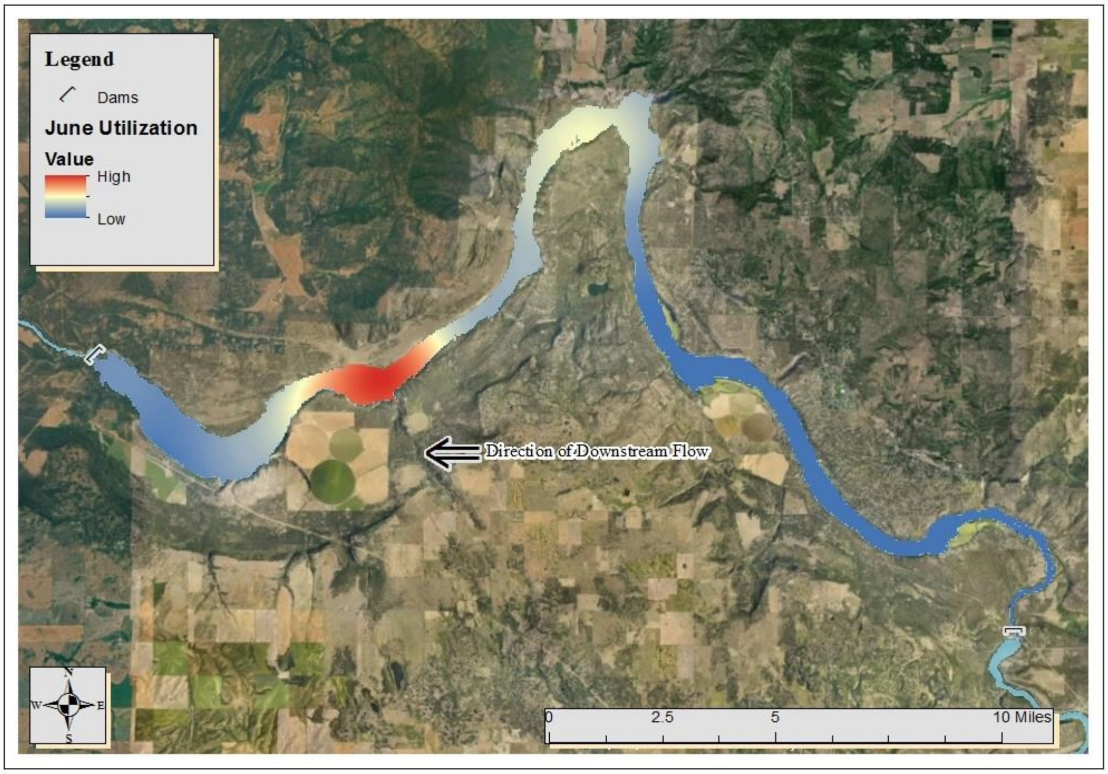

Figure 11. 2018 June habitat use of Lake Spokane.

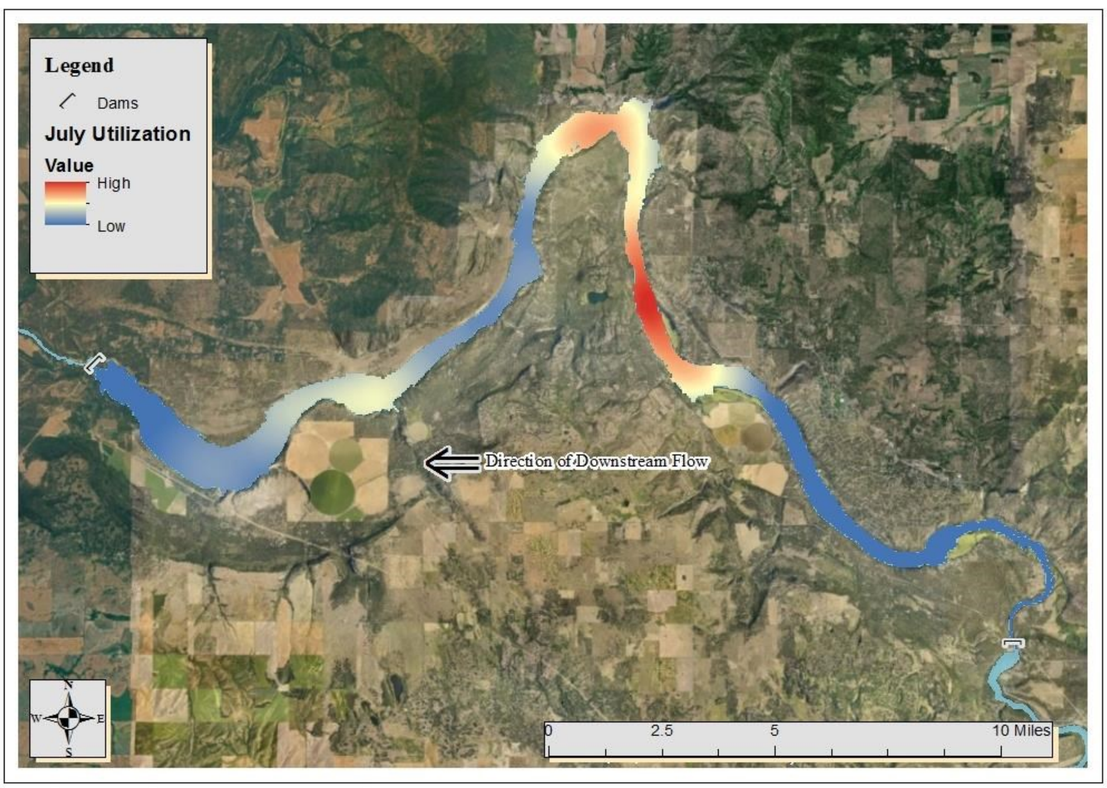

Figure 12. 2018 July habitat use of Lake Spokane.

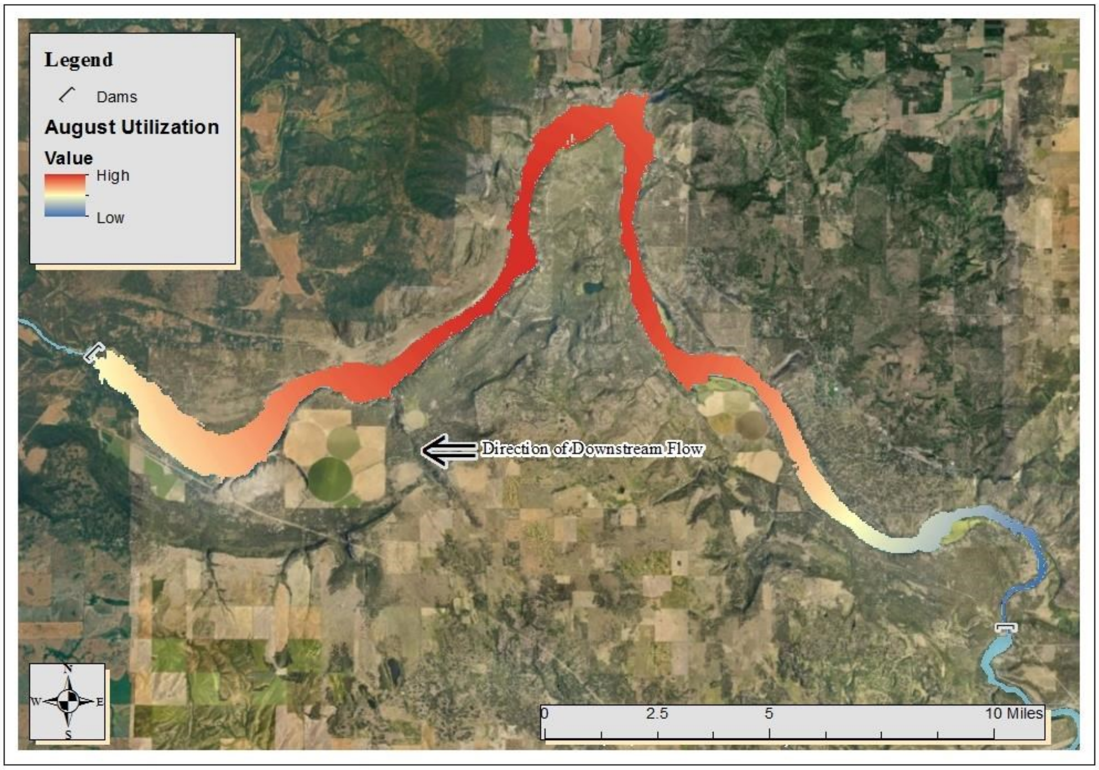

Figure 13. 2018 August habitat use of Lake Spokane.

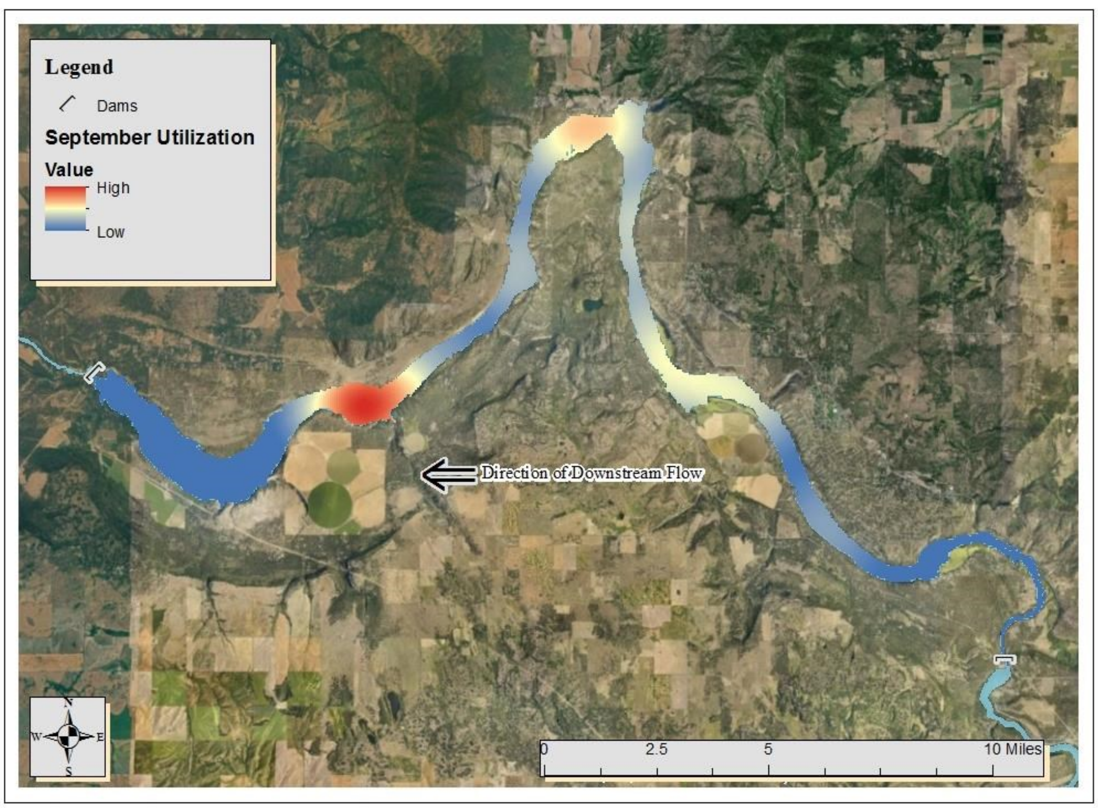

Figure 14. 2018 September habitat use of Lake Spokane.

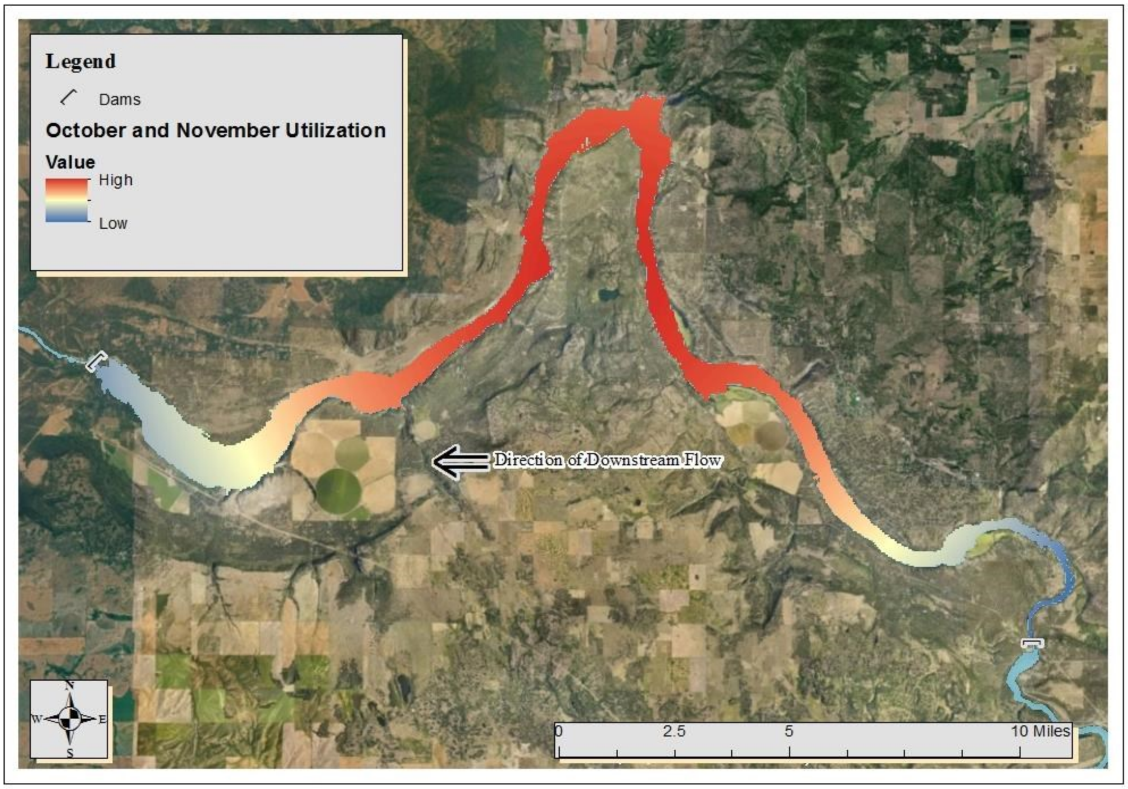

Figure 15. **2018 October habitat use of Lake Spokane. November is included in this map because there was only one tracking event on November 1st to finish out the tracking season.**

APPENDICES

APPENDIX A

Lake Spokane Annual Summary, 2018 Baseline Water Quality Monitoring Results (Tetra Tech 2019)

LAKE SPOKANE ANNUAL SUMMARY

2018 Baseline Water Quality Monitoring Results

Prepared for

AVISTA

SPOKANE, WASHINGTON

PREPARED BY:

Tetra Tech, Inc.

1212 N. Washington Street, Suite 208
Spokane, WA 99201

March 2019

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TABLE OF CONTENTS

List of Appendices

List of Tables

List of Figures

ACRONYMS AND ABBREVIATIONS

µS/cm	micro Siemens per centimeter
AHOD	areal hypolimnetic oxygen deficit
Avista	Avista Utilities
chl	chlorophyll *a*
DNR	Department of Natural Resources
DO	dissolved oxygen
Ecology	Washington Department of Ecology
EWU	Eastern Washington University
HED	Hydroelectric Development
MDL	Method detection limit
N	nitrogen
N+P	nitrogen plus phosphorus
ND	non-detect
NO_3+NO_2	Nitrate+nitrite
P	phosphorus
QAPP	Quality Assurance Project Plan
RM	river mile
SRP	soluble reactive phosphorus
TMDL	total maximum daily load
TN	total nitrogen or total persulfate nitrogen
TN:TP	total nitrogen to total phosphorus ratio
TP	total phosphorus
TSI	trophic state index

1. INTRODUCTION

Water quality problems in Lake Spokane due to eutrophication have been investigated on several occasions since the 1960s. Studies by the Washington Department of Ecology (Ecology) and Eastern Washington University (EWU) provided much of the background data for a waste allocation analysis by Harper-Owes in the 1980s (Patmont 1987). The EWU studies defined the extent of algal blooms and hypolimnetic anoxia, which led to 85% of total phosphorus (TP) reduction from the City of Spokane wastewater treatment plant effluent starting in 1977. Phosphorus reduction from wastewater greatly improved water quality in the reservoir. During the 1970s to 1980s, the EWU group, headed by Dr. R.A. Soltero, produced 14 reports documenting water quality problems before and after wastewater phosphorus reduction. This work showed the direct links between phosphorus input and algal blooms on the one hand, and the effect of that algal production on reservoir dissolved oxygen (DO) on the other (Soltero et al. 1982).

The degree of water quality improvement that occurred in the past is important to recognize in assessing the reservoir's water quality today. For example, the June-October average chlorophyll *a* (chl) decreased from 20.5 micrograms per liter (µg/L) before phosphorus reduction (5 years of data, 1972-1977) to 11.1 µg/L after (7 years of data, 1978-1985). That was in response to inflow TP decreasing from a June-October mean of 86 to 25 µg/L. Minimum, volume-weighted hypolimnetic DO increased from an average of 1.4 mg/L before (5 years of data) to 3.6 mg/L after (7 years of data) (Patmont 1987).

Improvement in water quality continued during the subsequent 15 to 20 years. By 2010 – 2014, average minimum volume weighted DO increased 80% and chl decreased 40% as average inflow TP declined 40% to 15 µg/L (5-years of data; Welch et al. 2015). These further improvements were most likely attained during the 1990s, although there are no reservoir data between 1985 and 2010 to determine an actual rate of recovery. Data during 2015 – 2017 was similar to that in 2010-2014 and did not show any further large scale improvements, which may be due to a number of variables, including weather/climate, flow and lake dynamics. The magnitude of this long-term improvement (from pre-phosphorus reduction from wastewater to 2017 will be compared with current water quality conditions determined in 2018, as well as during the nine-year period 2010 – 2018.

This report describes the monitoring effort by Tetra Tech in 2018, in coordination with and under contract to Avista Corporation (Avista), that included *in situ* profiles of temperature, DO, pH, and conductivity, as well as sampling net zooplankton. Lake Spokane water quality in 2018 will be assessed along with data from 2010 – 2017, including year-to-year variability and trends.

1.1. Report Purpose

Avista owns and operates the Long Lake Hydroelectric Development (HED) on the Spokane River. Long Lake Dam created a reservoir, Lake Spokane, in a 23-mile (37 km) stretch of the Spokane River that was, at one-time, free flowing. Portions of the river, including Lake Spokane, experience seasonal patterns in DO concentrations, some of which do not meet Washington State's water quality standards.

Table 1 lists the state water quality criteria for DO that apply to the Spokane River and Lake Spokane. In addition, the Spokane River has the following specific water quality criteria, per WAC 173-201A-130, from Long Lake Dam (RM 33.9) to Nine Mile Bridge (RM 58.0), which encompasses all of Lake Spokane:

> The average euphotic zone concentration of total phosphorus (TP) shall not exceed 25 µg/L during the period of June 1 to October 31.

Table 1. Designated Aquatic Life Uses and DO Criteria for the Spokane River as Defined in the 2006 Water Quality Standards.

Portion of the Waterbody	Aquatic Life Uses	DO Criteria
Spokane River (from Nine Mile Bridge to the Idaho Border)	Migration/Rearing/Spawning	DO shall exceed 8.0 mg/L. If "natural conditions"[1] are less than the criteria, the natural conditions[1] shall constitute the water quality criteria.
Lake Spokane (from Long Lake Dam to Nine Mile Bridge)	Core Summer Habitat	No measurable (0.2 mg/L) decrease from natural conditions[1].

[1]Washington water quality standards (WAC 173-201A-020) defines "natural conditions" or "natural background levels" as "surface water quality that was present before any human-caused pollution. When estimating natural conditions in the headwaters of a disturbed watershed, it may be necessary to use the less disturbed conditions of a neighboring or similar watershed as a reference condition."

Ecology has been working, along with several stakeholders, to address these water quality impairments through the development and implementation of a water quality improvement plan, or Spokane River and Lake Spokane Dissolved Oxygen Total Maximum Daily Load (DO TMDL) (Ecology 2010).

The DO TMDL relies on the CE-QUAL-W2 hydrodynamic and water quality model (CE-QUAL-W2 model) to assess the capacity of the Spokane River and Lake Spokane to assimilate oxygen-demanding pollutants (i.e., phosphorus, carbonaceous biological oxygen demand, and ammonia) under varying conditions (DO TMDL, page vi). Unlike point- and non-point source discharges, Avista does not discharge nutrients to either the Spokane River or Lake Spokane. Thus, it was not assigned a wasteload allocation or a load allocation. However, since the presence of the Long Lake Hydroelectric dam (HED) increases the water residence time (average amount of time water resides in Lake Spokane) and a thermally stratified water column (which is common in deep reservoirs with an interflow zone; Cooke et al. 2005), the DO TMDL process assigned Avista a "proportional level of responsibility" for reduced DO levels in Lake Spokane through a water quality modeling scenario. This responsibility is reflected in Table 7 of the DO TMDL, which was subsequently corrected (Ecology 2010; Appendix B). Table 7 in the TMDL is based on a comparison of CE-QUAL-W2 model runs for the 2001 model year.

Ecology and Avista jointly conducted a 2-year baseline sampling effort that began in May 2010 and extended through October 2011 at six lake stations and two river stations. The main purpose was to gather more recent data to verify the baseline water quality conditions from 2001, which were used in the TMDL development process, and to account for any changes in water quality in the reservoir. Ecology and Avista collaborated on a monthly sampling routine extending from June through September in 2010 and 2011 to expand the frequency of observations at the six lake monitoring stations. To do that, Avista contracted with Tetra Tech to monitor water quality in the reservoir.

Beginning in 2012, Avista took over monitoring of the six lake stations in Lake Spokane and continued that effort through 2018, with additional lake stations added in 2018. Ecology would continue to provide water quality data for the three river stations (54A090, 55B070, and 54A070). Following the 2016 monitoring season, Avista, with Tetra Tech's assistance, assessed the results and success of the baseline water quality monitoring program and DO conditions in Lake Spokane and, following that assessment, worked with Ecology and defined future monitoring goals for the reservoir.

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2. MONITORING PROGRAM

Water quality monitoring in 2018 consisted of determining *in situ* profiles of DO, temperature, conductivity, and pH and collecting samples for zooplankton analysis at all six established stations in Lake Spokane (LL0 through LL5). Data was also collected at four supplemental monitoring stations (LL1a, LL2a, LL2b, and LL3a). All water quality monitoring activities were conducted in accordance with the QAPP Addendum, which was approved by Ecology and submitted to FERC in March 2018 (Avista 2018).

Water column *in situ* profiles were determined once per month in May and October and twice per month from June through September 2018 at the six long-term in-lake locations (LL0, LL1, LL2, LL3, LL4, and LL5) and at four supplemental locations (LL1a, LL2a, LL2b, and LL3a) (Figure 1). Station LL0 is located farthest downstream in the reservoir with a depth of 48-50 meter (m). Station LL1 is located across from the Lake Spokane Campground and Boat Launch at a depth of about 34 m. Station LL1a is located approximately halfway between Station LL1 and LL2 at a depth of about 30 m. Station LL2 is down-reservoir from the City of TumTum and Sunset Bay at a depth of about 26 m. Station LL2a is adjacent to McLellan Slough at a depth of about 24.5 m. Station LL2b is further up-reservoir adjacent to Willow Bay at a depth of about 21 m. Station LL3 is just up-reservoir from Willow Bay at a depth of about 19-20 m. Station LL3a is across from Felton Slough at a depth of about 19.5 m. Station LL4 is across from Suncrest Park and boat launch at about 9 m depth. Station LL5 is the farthest up-reservoir, slightly up-reservoir from the Nine Mile Recreation Area on the north side of the river at about 6 m depth.

Longitudinally, the reservoir can be divided into three zones representing varying morphometric characteristics. The upper portion of the reservoir is considered to be the riverine zone where depths are shallow and morphological characteristics are similar to a large river. Station LL5 is within this riverine zone. Stations LL4, LL3a, and LL3 are located within the transition zone of the reservoir, where the reservoir is changing from a riverine environment to a more lacustrine environment and most of incoming particulate matter is deposited. Within the transition zone, depths are greater than in the riverine zone, but the littoral areas are still similar to those in the riverine zone. Station LL3 is approximately 19-20 m deep and has a very small hypolimnion during stratification. Stations LL0, LL1, LL1a, LL2, LL2a, and LL2b are located in the lacustrine zone, or lake-like portion of the reservoir, where there is both littoral and pelagic (shallow and deep water) environments. Water depths in the lacustrine zone are much deeper than the rest of the reservoir and that zone stratifies into three thermal/density layers; the epilimnion, metalimnion, and hypolimnion, during warmer months of the year.

The vertical structure of Lake Spokane is set up by thermal (or density) stratification, largely determined by a number of variables: water inflow rates, temperature, dissolved solids concentration (specific conductance), change in storage, climate, and location of the powerhouse intake. Within Lake Spokane's lacustrine zone, thermal stratification creates the three density layers generally between late spring and early fall. The epilimnion is the uppermost layer, and the warmest due to heating by solar radiation. The metalimnion, or thermocline interval, is the transition layer of greater temperature change between the epilimnion and the hypolimnion. The surface inflow tends to plunge in this zone forming an interflow zone. The hypolimnion is the deepest layer and is present throughout the lacustrine zone. Inflowing water that plunges in the transition zone may enter the metalimnion and/or hypolimnion, depending on the flow rate and temperature/conductivity (density) of the inflow.

The 2018 sampling schedule is summarized in Table 2. Measurements were determined in accordance with methods and procedures outlined in Avista's *Quality Assurance Project Plan for Lake Spokane Baseline Nutrient Monitoring* (QAPP), which was approved by Ecology and submitted to FERC in February 2014. This QAPP is a revised version of an earlier QAPP written by Ecology for the 2010 and 2011 monitoring efforts and amended in 2012.

Water temperature, DO, pH, and conductivity were determined *in situ* at each of the ten sampling locations by lowering a Hydrolab® multi-parameter sonde from the boat. The *in situ* measurements were determined at prescribed depths through the water column. The measurements were determined in accordance with the methods and procedures outlined in the QAPP (Tetra Tech 2014). The Hydrolab® sonde was calibrated according to manufacturer's directions and standard measurement procedures were followed.

Volume-weighted DO concentrations for each station were determined for sampling dates using CE-QUAL-W2 model segment volumes, which corresponded to 2018 monitoring stations. Volumes for model segments were obtained from Avista and Golder Associates. The monitoring stations correspond to model segments as follows:

- Station LL0: Model Segment 188, Reservoir Zone: Lacustrine
- Station LL1: Model Segment 181, Reservoir Zone: Lacustrine
- Station LL2: Model Segment 175, Reservoir Zone: Lacustrine
- Station LL3: Model Segment 168, Reservoir Zone: Transition
- Station LL4: Model Segment 161, Reservoir Zone: Transition
- Station LL5: Model Segment 157, Reservoir Zone: Riverine

Zooplankton were collected with a vertical haul at each of the ten sampling locations from 1 m off the bottom through the water column. Zooplankton samples were sent to EcoAnalysts, Inc. in Moscow, ID for analysis. Previous (prior to 2015) zooplankton analyses were performed by WATER Environmental Services, Inc.

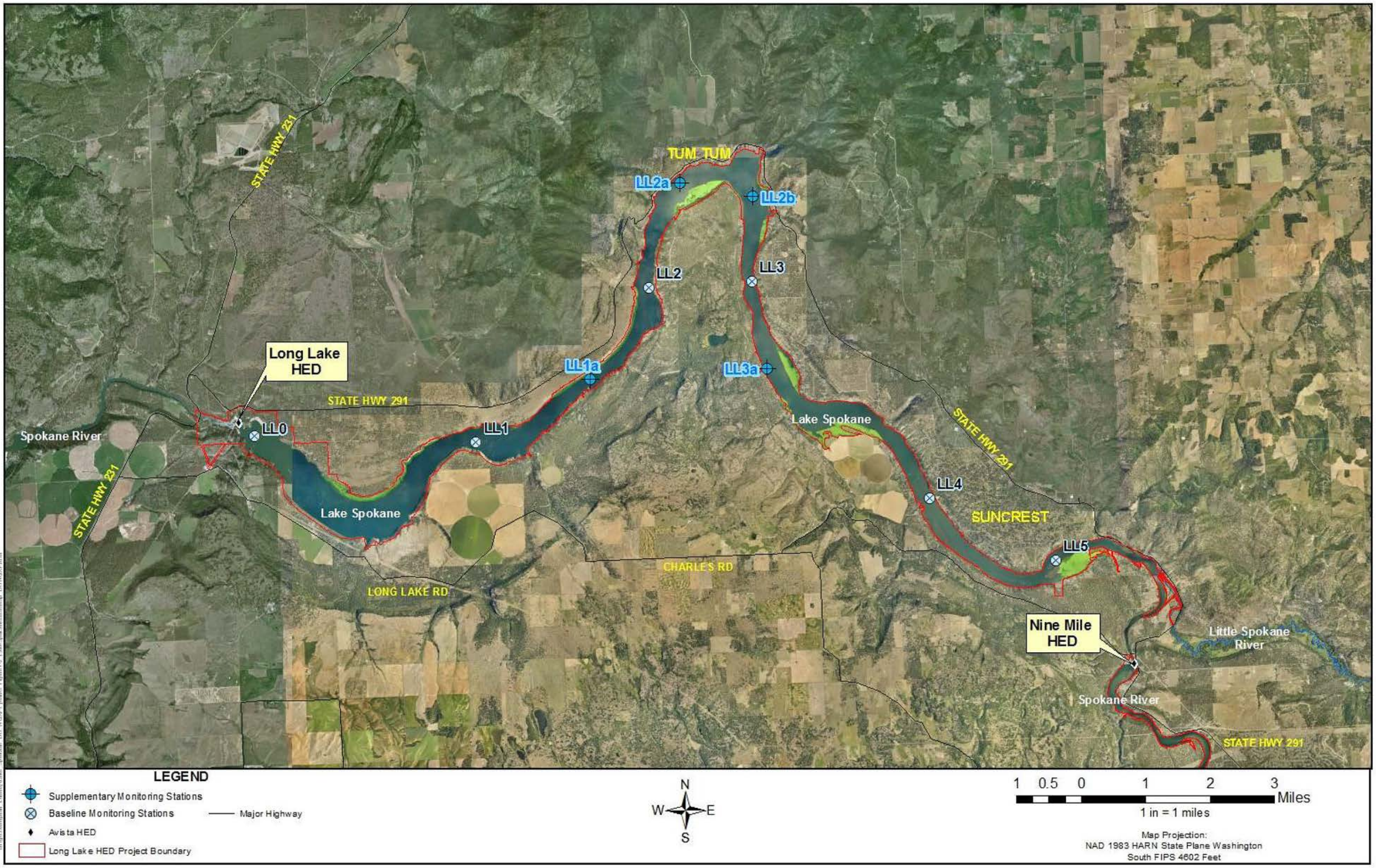

Figure 1. Lake Spokane Sampling Locations

Table 2. Lake Spokane Monitoring Schedule during 2018

Sample Date	Type of Samples Collected
May 16 – 17, 2018	*In situ* and Zooplankton
June 6 – 7, 2018	
June 19 – 20, 2018	
July 10 – 11, 2018	
July 23 – 24, 2018	
August 7 – 8, 2018	
August 28 – 29, 2018	
September 12 – 13, 2018	
September 25 – 26, 2018	
October 16 – 17, 2018	

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3. 2018 RESULTS

This section summarizes water quality constituents determined *in situ*, as well as, zooplankton data collected at the ten monitoring locations. The *in situ* data are presented in Appendix I. Zooplankton results are presented in Appendix II. Fully signed chain of custody's (COCs) for laboratory analysis are presented in Appendix III.

This section also briefly summarizes the water quality conditions of the primary inflows and outflows to/from Lake Spokane as well as a description of general hydrologic and climatic conditions in 2018.

3.1 Climatic and Hydrologic Conditions

Weather during 2018 differed from the 30-year norm reported at Spokane International Airport (Figure 2). The year started out warmer than normal with the coldest air temperature in January at just 14°F (-10°C) for the entire month. This is much warmer than January 2017 when Spokane had a record 7 days with temperatures below zero. Warmer than normal air temperature continued into early February when a record high temperature of 56°F (13.3°C) was recorded on February 8th. Colder, more winter like temperatures followed in mid to late February and normal temperatures were observed in March and April. May was the fifth warmest on record with an average temperature of 61.9°F (16.6°C). Most of July and August had above normal air temperatures with separate maximums of 97°F (36.1°C) and 103°F (39.4°C). More normal air temperature returned in September and October. December started and ended with normal temperatures but for most of the month was warmer than normal. Temperatures ranged from a high of 103°F (39.4°C) on August 9th to a low of 4°F (-15.6°C) on February 21st (Figure 2). The annual cumulative rainfall total was 15.95 inches (40.5 cm), which was below normal (Figure 2).

Precipitation was above normal during most of the beginning of the year (January and February) and in April and was well below normal in March and from May through September. The year began with slightly less than normal precipitation in early January which was followed by wetter than normal conditions in late January and February. Precipitation was 0.76 inches (1.9 cm) above normal in January and 0.27 inches (0.7 cm) above normal in February. Precipitation in March was below normal with a total of 1.30 inches (3.3 cm). This contrasts with above normal precipitation in March 2017 with a total of 4.11 inches (10.4 cm), which made it the second wettest March on record. April precipitation was 0.75 inches (1.9 cm) above normal with a total of 2.03 inches (5.2 cm). Drier than normal conditions started in May with only 1.45 inches (3.7 cm), similar to May 2017 with only 1.31 inches (3.3 cm) but significantly greater than May 2016 with only 0.78 inches (2.0 cm), which was slightly less than half the normal of 1.62 inches (4.1cm) for that month.

Similar to 2017, drought conditions in 2018 started in June with only 0.55 inches (1.4 cm) of precipitation; 0.70 inches (1.8 cm) below normal. Drought conditions continued through July and August 2018 with only 0.06 inches (0.15 cm) for July. This is similar to July 2017 when there was no measurable precipitation. July is typically a dry month, averaging only 0.64 inches (1.6 cm), but several recent Julys were more so than usual. Air temperatures in Spokane reached 90°F (32.2°C) or higher during 14 days in July, the same heat spell as in 2017. Normally, only 7 days of above 90°F temperatures occurred in July. August was also warmer than normal with an average of 70.7°F (21.5°C). The hot August resulted in 8 consecutive days of 90°F or higher. Smoke and haze were prevalent in August, from the 5th through the 26th, due to numerous wildfires in British Columbia, Washington, Oregon, Idaho, Montana, and California. Drought continued in September, which was the sixth driest on record with only 0.02 inches (0.05 cm) of precipitation. The dry streak from July 1st continued with only 0.25 inches (0.64 cm) of precipitation as the third driest July through September on record. October 2018 was only slightly warmer than normal with an average temperature of 48.1°F (8.9°C). Temperatures at the airport in 2018 did not reach the freezing mark in October.

November overall was slightly warmer and drier than normal. November mean temperature was 1.2°F (0.7°C) above the normal of 35.7°F (2.1°C) and precipitation was below normal with 1.96 inches (5.0 cm), which is 0.34 inches (0.9 cm) less than normal. December was warmer than normal with an average monthly temperature of 31.8°F (-0.1°C) despite more normal temperatures during the beginning and end of the month (Figure 2). December was also wetter than normal with a precipitation total of 2.62 inches (6.65 cm), 0.32 inches (0.81 cm) above normal, and a total snow accumulation of 12 inches (30.5 cm).

Figures 3 and 4 show inflows and outflows, respectively, during 2018. Inflows include all incoming water as calculated by Avista using midnight to midnight reservoir elevation and daily average outflow as recorded at midnight at Long Lake Dam. Inflows and outflows to/from Lake Spokane are usually very similar, with only slight differences between inflow and outflow during annual drawdown in the early part of the year. Annual drawdown did not occur in 2018, as illustrated in Figures 3 and 4 that show no difference between inflows and outflows in the early part of 2018. Maximum inflows typically occur during March, April, and May due to spring runoff. However, the magnitude and timing of peak inflows have varied greatly over the past ten years, compared to those in 2001, which was the 7Q10 for the DO TMDL (Figure 5). Peak flows in 2018 were less than in 2017 and most similar to those in 2014 (Figure 5). Peak flow in 2018 occurred in May, with two earlier peaks, one in the middle of February and one in the middle of April, similar to those in 2011 (Figure 5).

Flows in the Spokane River and the Little Spokane River were average to above average during January and early February and increased sharply in both rivers in early to mid-February (Figures 6 and 7). Peak flow in the Spokane River was slightly earlier (mid-May vs late May) than historically recorded (Figure 6). Peak flows in the Spokane River were much higher than the historical median and slightly less than the 90th percentile peak. Peak flow in the Spokane River reached 27,800 cfs in 2018. The peak 42,900 cfs in 2017, which was the 4th largest since record keeping began in 1891. Flows from June through September were below the historical median (Figure 6). The peak flow in the Little Spokane River of 1,850 cfs was well above the historical median and 90th percentile (Figure 7). Flows in the Little Spokane River remained above the historical median through the spring, and above the historical 90th percentile in the summer, and fall of 2018 (Figure 7).

Water residence time can markedly affect reservoir quality. Long residence times tend to allow for more settling of particulate matter, including phosphorus in algae, and usually greater transparency. If residence times are relatively short, on the order of 10 days or less, algal biomass accumulation may be limited. Both effects can occur in reservoirs, which usually have shorter residence times than natural lakes.

Whole reservoir water residence time during 2018 (June through October) was about 36.3 days, similar to residence time observed in 2013, but much lower than the above-normal residence times in 2015 and 2016 (Table 3). Including 2015 and 2016, whole reservoir residence time averaged 34.0 days for the past nine years (2010 through 2018). Residence times in the transition and riverine zones averaged 4.7 days in 2010 – 2014, but were much higher in 2015 at 13.2 days and in 2016 at 8.1 days (Table 3). Residence time in the transition and riverine zones in 2018 was 6.8 days, lower than that observed in 2015 and 2016 and only slightly higher than the nine year average (6.4 days). Thus, algal bloom development would be limited, on average, in these zones during normal years, especially in the spring, but would not be limited during low flow periods in August – September in most years. Bloom development may have been limited by residence time in the riverine/transition zones during the spring and early summer in 2018, but most likely not limited in late August and September when inflows decreased. Inflows and water residence times during 2010 - 2018, were separated into the seasonal timeframes consistent with the DO TMDL (Table 4). The whole reservoir residence time was 54.3 days in 2018 during the DO TMDL seasonal timeframe of July through September. That was much less than in 2015 (84.8 days) but slightly higher than 2010 – 2014 average.

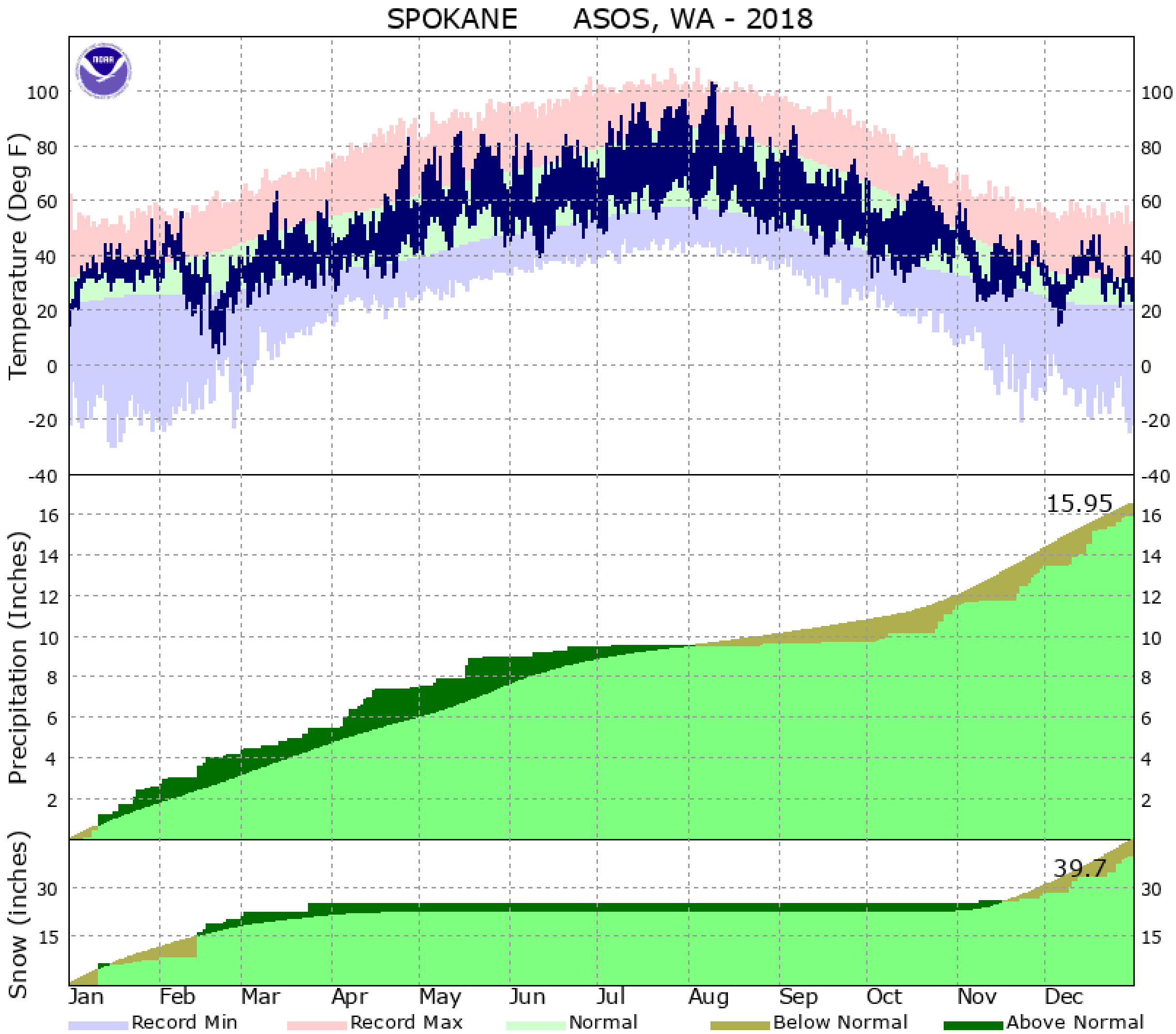

Figure 2. Air Temperature and Precipitation at Spokane International Airport for 2018

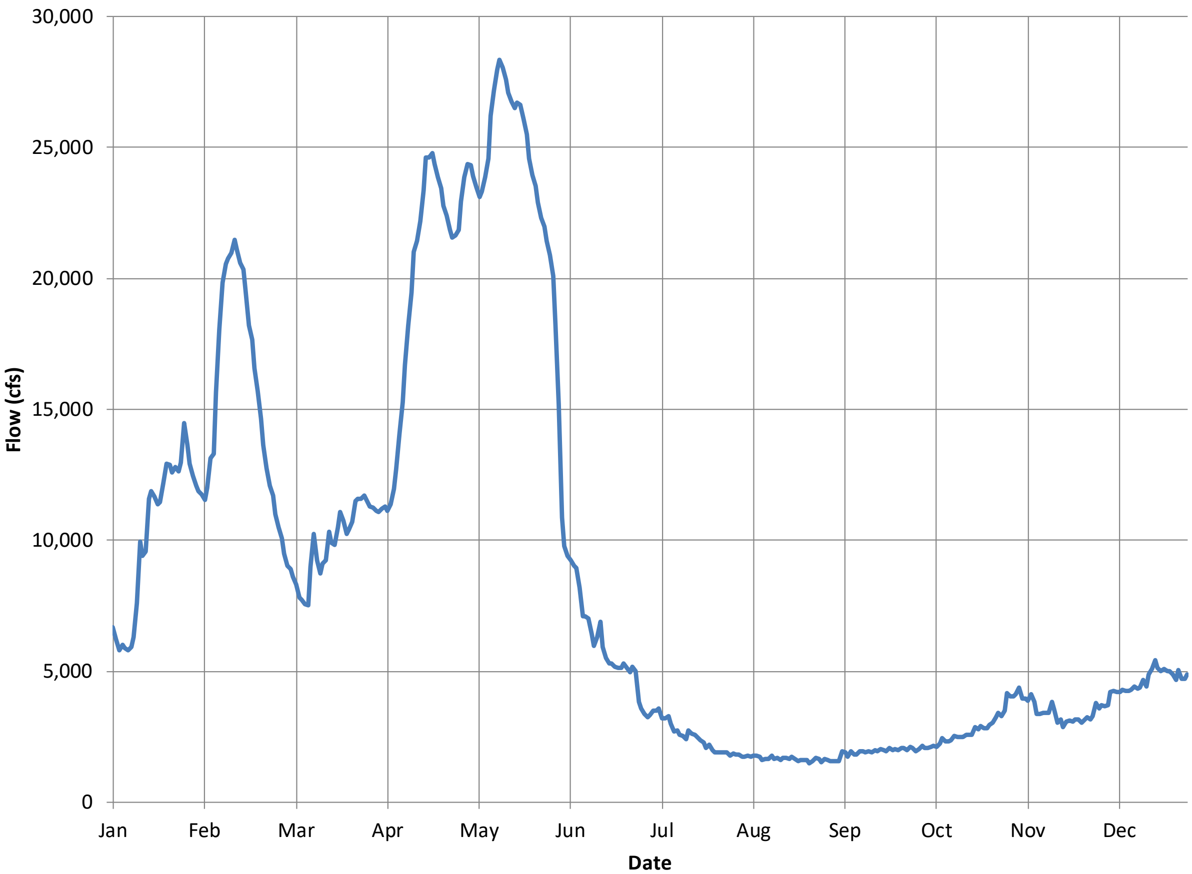

Figure 3. Total Inflow into Lake Spokane, 2018
(Inflows calculated based on midnight to midnight reservoir elevation and day average outflow at midnight as recorded at Long Lake Dam)

Figure 4. Total Outflow from Lake Spokane, 2018
(Outflows as reported at Long Lake Dam at midnight daily)

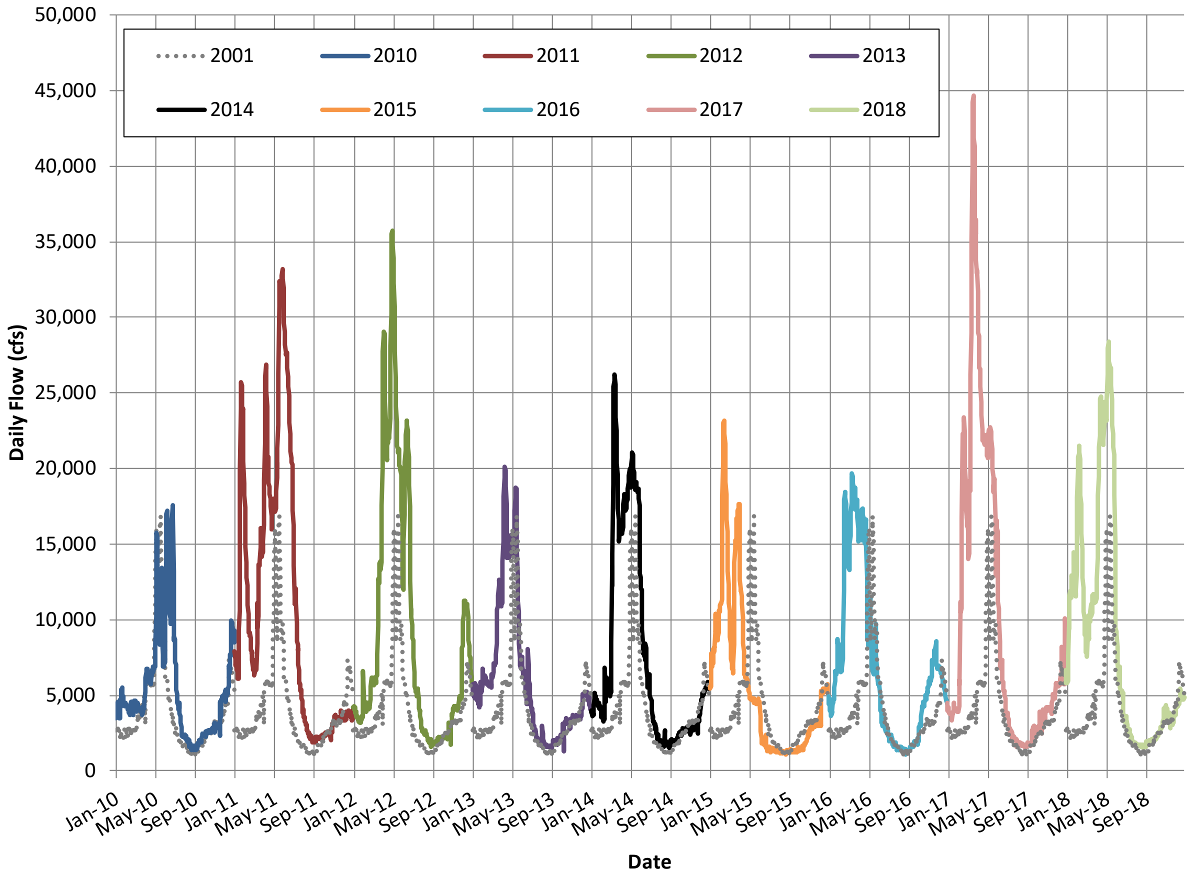

Figure 5. Total Inflows into Lake Spokane 2010-2018
(Inflows calculated based on midnight to midnight reservoir elevation and day average outflow at midnight as recorded at Long Lake Dam)

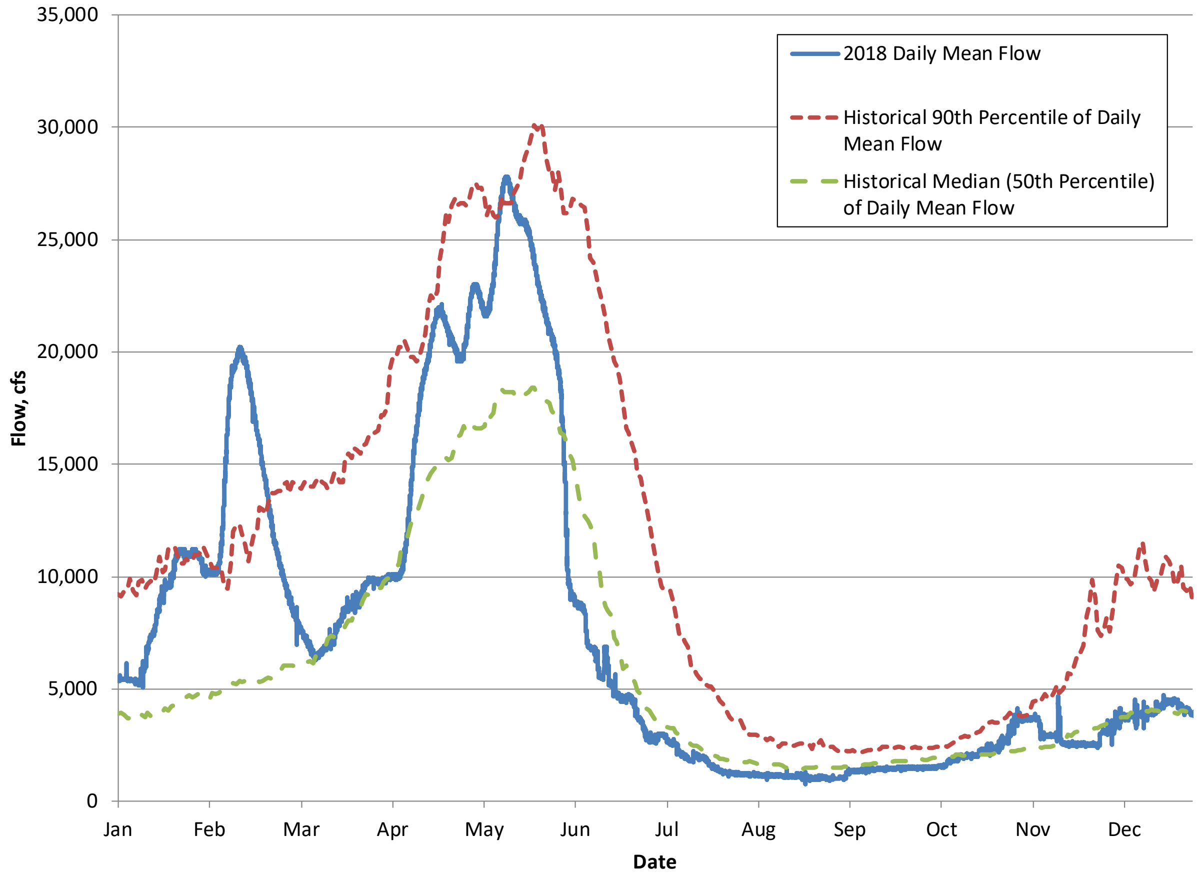

Figure 6. Spokane River at Spokane (USGS Gage # 12422500) Daily mean flow, 2018 compared to Historical Daily Mean Flow

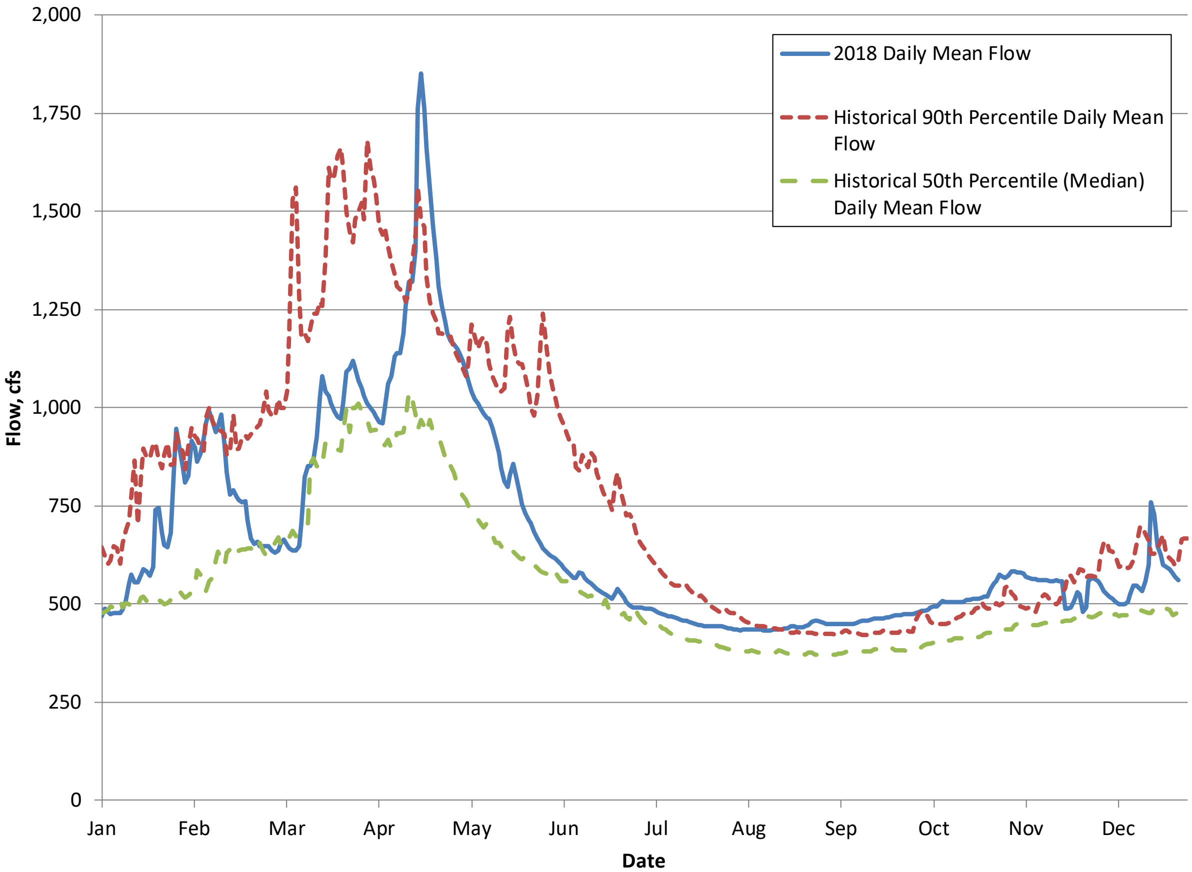

Figure 7. Little Spokane River near Dartford (USGS Gage # 12431500) Daily mean flow, 2018 compared to Historical Daily Mean Flow

Table 3. Inflows and water residence times in Lake Spokane during 2001 and 2010-2018. Residence times are for June through October.

Year	Total Annual Flow Volume (cf x10^6)	Annual Mean Daily Flow (cfs)	Mean Daily Summer (June-October) Flow (cfs)	Residence Time[1] Whole Reservoir (days)	Residence Time[1] Transition/Riverine Zones (days)
2001	125,782	3,989	2,413	46.3	8.7
2010	167,113	5,299	4,671	23.9	4.5
2011	337,576	10,704	7,828	14.4	2.7
2012	293,971	9,296	5,768	19.4	3.6
2013	189,846	6,020	3,035	36.8	6.9
2014	234,999	7,452	3,581	31.3	5.9
2015	171,137	5,427	1,595	70.1	13.2
2016	216,855	6,858	2,523	43.3	8.1
2017	317,811	10,078	3,697	30.2	5.7
2018	270,253	8,570	3,089	36.3	6.8

[1]residence time = reservoir volume/outflow

Table 4. Daily flows and water residence times in Lake Spokane during 2001 and 2010-2018, using DO TDML seasonal timeframes.

Year	Mean Daily Summer Flow (cfs)				Residence Time[1] Whole Reservoir (days)				Residence Time[1] Transition/Riverine Zones (days)			
	May	June	July – Sept.	Oct.	May	June	July – Sept.	Oct.	May	June	July– Sept.	Oct.
2001	11,872	4,560	1,637	2,635	10.1	24.5	68.6	42.1	1.9	4.6	12.9	7.9
2010	10,036	13,297	2,550	2,620	11.2	8.4	43.8	42.7	2.1	1.6	8.2	8.0
2011	25,596	24,323	4,232	2,538	4.3	4.6	26.5	44.1	0.8	0.9	5.0	8.3
2012	23,667	17,333	3,092	2,520	4.8	6.5	36.1	44.4	0.9	1.2	6.8	8.3
2013	9,037	5,956	2,133	2,884	8.5	18.7	52.5	38.8	1.6	3.5	9.8	7.3
2014	19,127	8,243	2,373	2,657	5.9	13.6	47.2	41.9	1.1	2.6	8.9	7.9
2015	4,724	2,360	1,317	1,678	23.8	47.5	84.8	66.6	4.5	8.9	15.9	12.5
2016	8,101	3,865	1,677	3,735	13.8	28.8	66.8	27.7	2.6	5.4	12.5	5.2
2017	20,395	8,737	2,212	3,229	5.5	12.8	50.7	34.5	1.0	2.4	9.5	6.5
2018	24,568	6,711	2,056	2,647	4.6	16.8	54.3	42.2	0.9	3.1	10.2	7.9

[1]residence time = reservoir volume/outflow

3.2 Water Quality Conditions

3.2.1 TEMPERATURE

The maximum surface temperature reached almost 25°C in the lacustrine zone and just over 25°C in the upper reservoir in early August 2018 (Figures 8 through 17). This maximum was higher than observed at those sites in August 2016 (23°C) and slightly lower or similar to those in 2015 (26°C and 25°C in early July) and 2017 (25°C in early August). In 2014, surface maximum temperatures also occurred in August and were similar to maximums observed in 2018 (25°C). Temperatures were below 20°C at depths greater than 10 m in the lacustrine zone during 2018, as was the case during 2014 to 2017.

The onset of thermal stratification was evident in May at some of the lacustrine stations. Surface temperatures in the lacustrine zone averaged 14.8°C in May, due to the unseasonably warm spring. Surface temperatures at LL0, LL1, LL1a, LL2 and LL2a were slightly higher than the rest of the water column but not enough to result in a strong stratification. Water column temperature was uniform, around 14°C, at stations LL2b, LL3, LL3a, LL4 and LL5. That was much warmer than in 2017 with temperatures around 11°C at LL3, LL4, and LL5. Temperature near the bottom in the lacustrine zone varied from 11.9°C to 14°C, which was warmer than in 2017 (10.6 - 11.4°C), and even warmer than in 2015 (9.5°C) but similar to 2016 (11.9 - 13.8°C).

Thermal stratification began in early June at all stations except LL4 and LL5. Surface temperature at LL4 in late June was slightly higher (+0.3°C) than the rest of the water column, as stratification began to develop. Thermal stratification was not fully developed until late June at station LL4. Stratification persisted through late September and was completely destratified in October. Stratification was present from late July until the middle of September at station LL5. That pattern was similar to that in 2016 and 2017, stratification was unusually long in 2015, extending from early June through early September, due largely to the unusually long water residence time. In 2014, stratification only existed at LL5 during August, most likely due to a short water residence time.

The depth of mixing, which defines the epilimnion, was around 5 to 7 m in the lacustrine zone (LL0, LL1) during most of the summer, but typically deepened to around 10 m in late September. Gradual deepening of the mixing depth as summer ended is due to surface water cooling and increased density that reduces the energy needed to mix the water column by wind. A similar pattern of shallow mixing occurred at stations LL2 and LL3. Mixing depths at LL4 were consistently at 3 to 4 m over the summer but did not deepen in September when surface water cooled. Mixing depths at LL5 were very shallow at 1 to 2 m when stratified, with complete mixing in mid-September.

Destratification and water column turnover began in September and was nearly complete by October in the deep lacustrine zone (LL0), but water columns were still stratified at the other lacustrine and transition zone sites (LL1 through LL3a), while the shallow LL4 and LL5 sites were mixed by then. This pattern was similar to that observed in 2015, 2016, and 2017, although the period of stratification was longer in 2015, which had a long residence time.

The extent of the metalimnion and depth of the hypolimnion varied throughout the summer, which is typical in reservoirs that are strongly affected by river inflow and plunging interflows. The metalimnion is the layer with greatest temperature change with depth – typically over 5 to 10 meters in Lake Spokane. Depth of the hypolimnion is defined roughly from the inflection point, where rate of temperature change with depth begins to slow - about 10 m during the summer months and extending to the bottom (Figures 8 through 17). The hypolimnion depth began at about 10 m to 15 m for most of the period, becoming shallower in June and deepening later in the summer as the thermocline eroded. That variation was due to the river inflow plunging to different depths consistent with inflow density determined by temperature and dissolved solids. Profiles of conductivity, a surrogate of dissolved solids, show the pattern of plunging inflows, which caused much of the temperature variation in the reservoir.

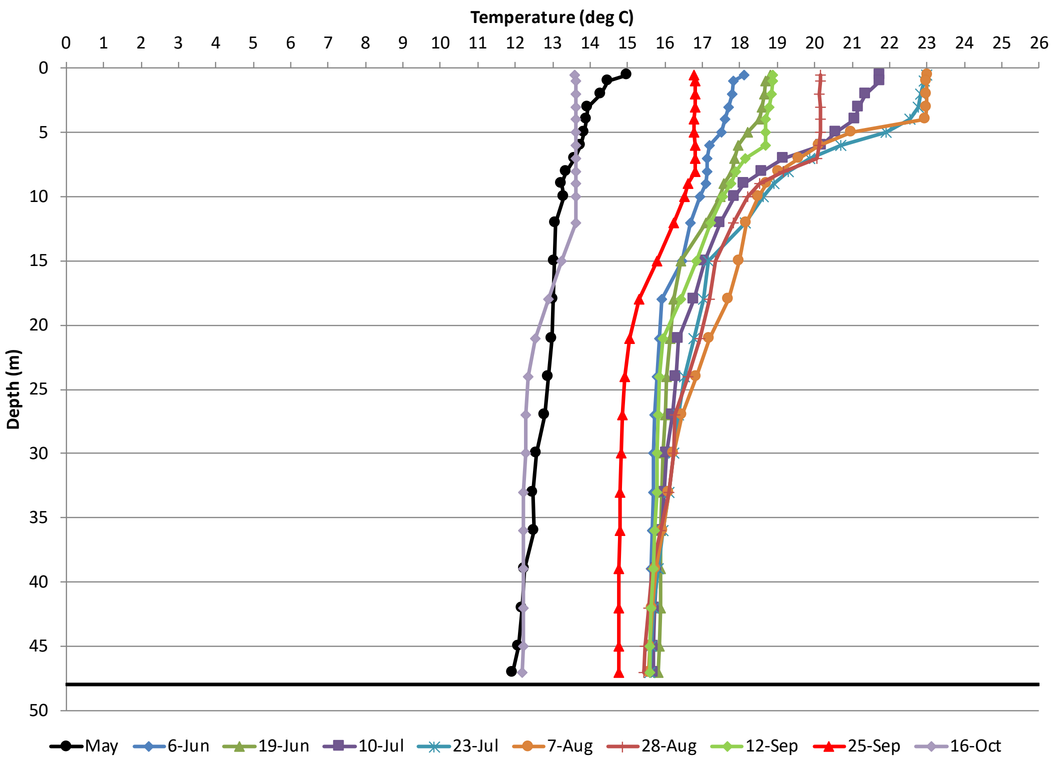

Figure 8. Temperature Profiles for Station LL0, May-October 2018

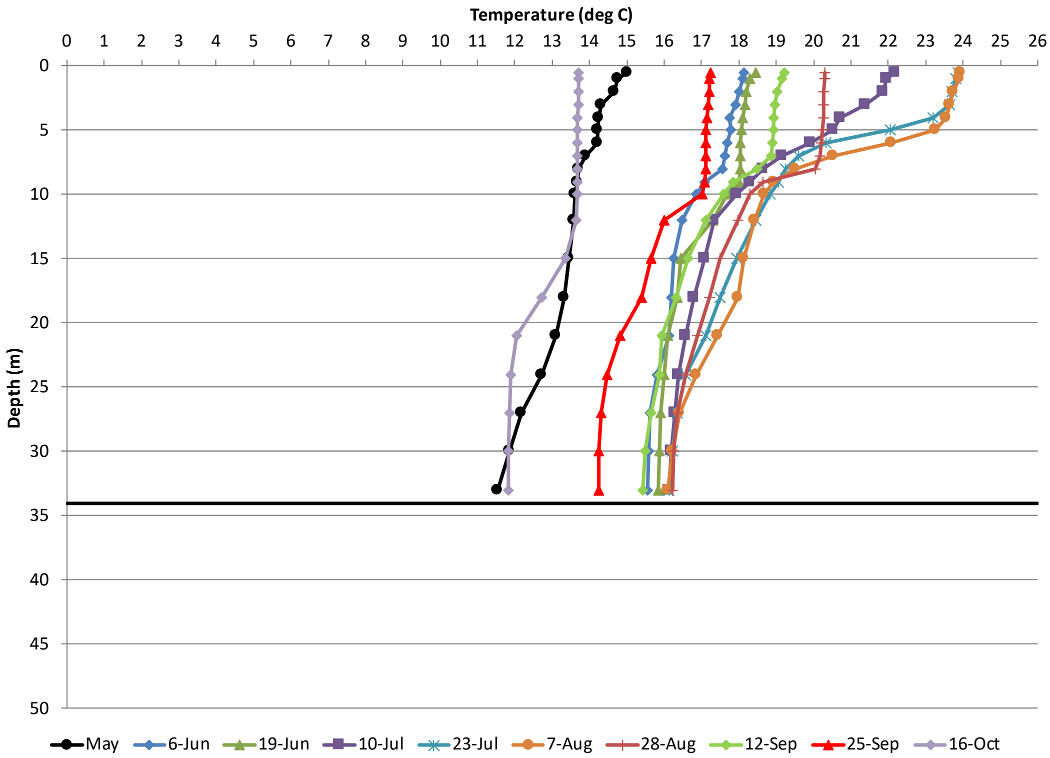

Figure 9. Temperature Profiles for Station LL1, May-October 2018

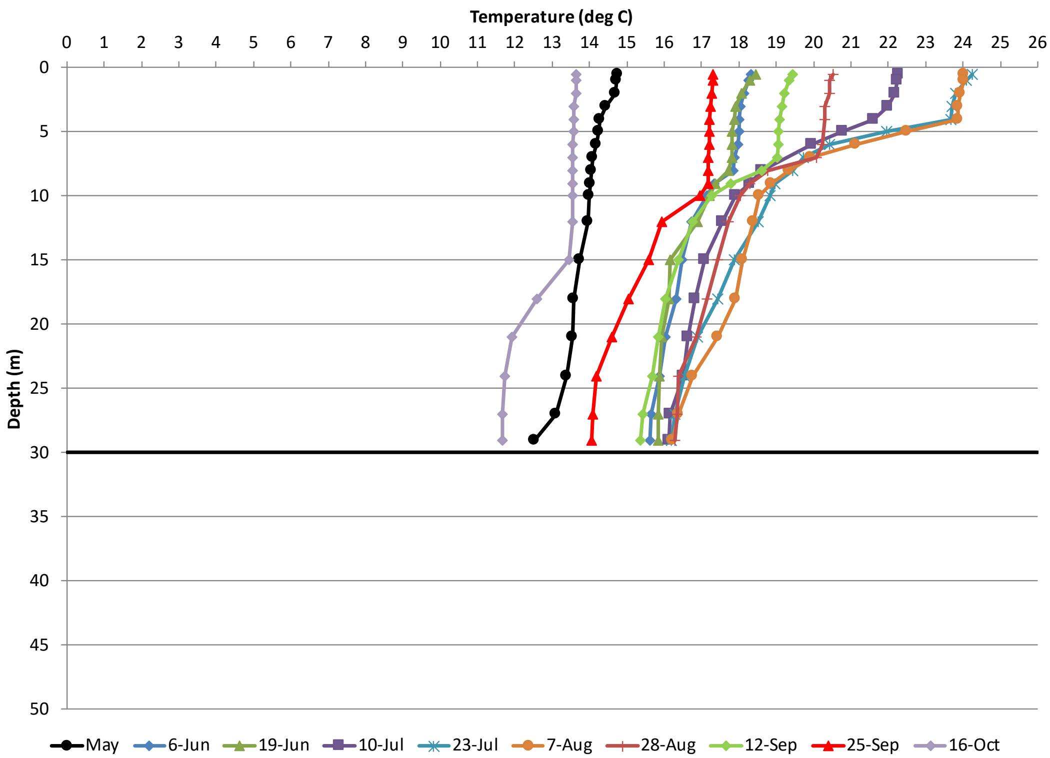

Figure 10. Temperature Profiles for Station LL1a, May-October 2018

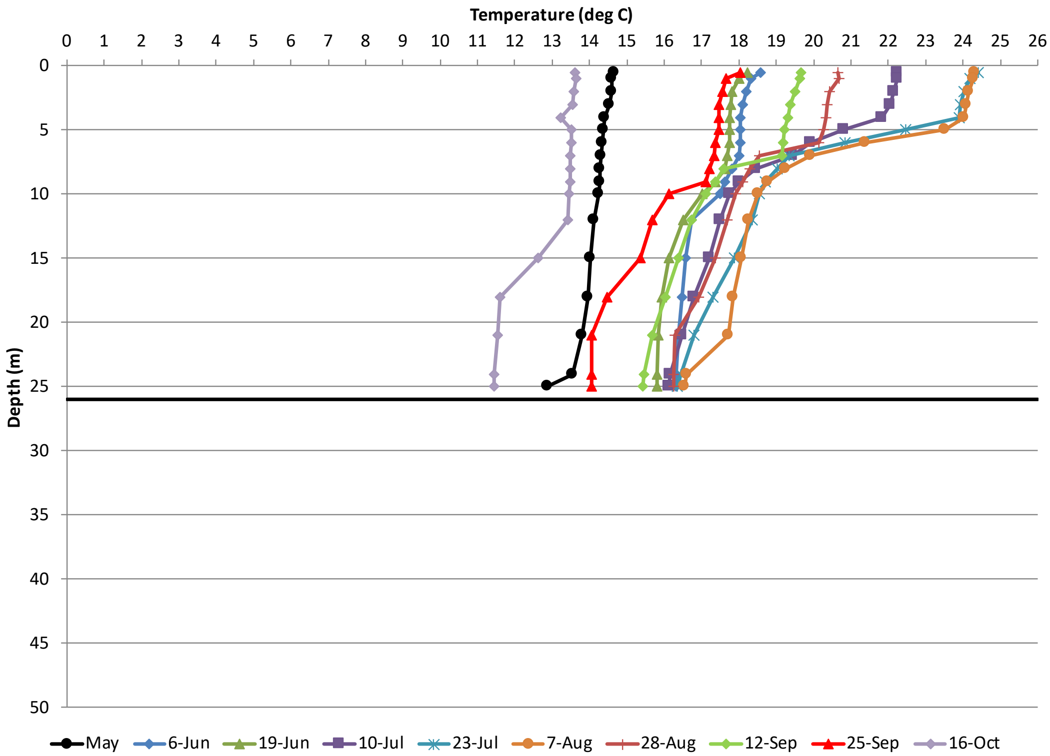

Figure 11. Temperature Profiles for Station LL2, May-October 2018

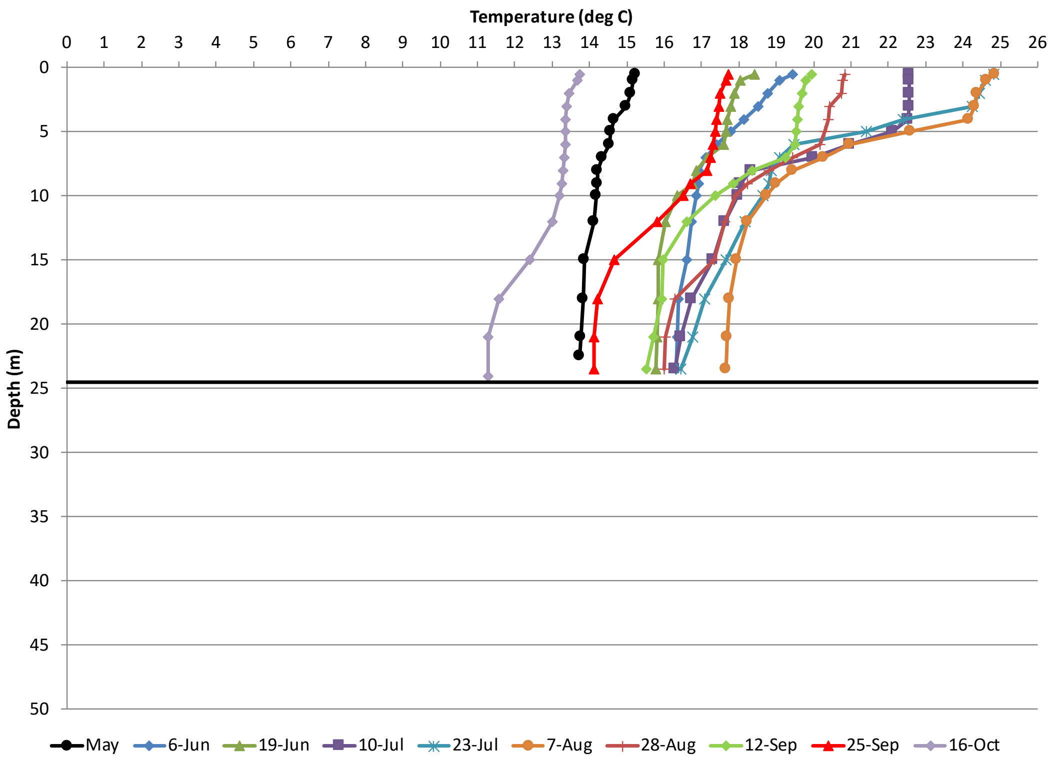

Figure 12. Temperature Profiles for Station LL2a, May-October 2018

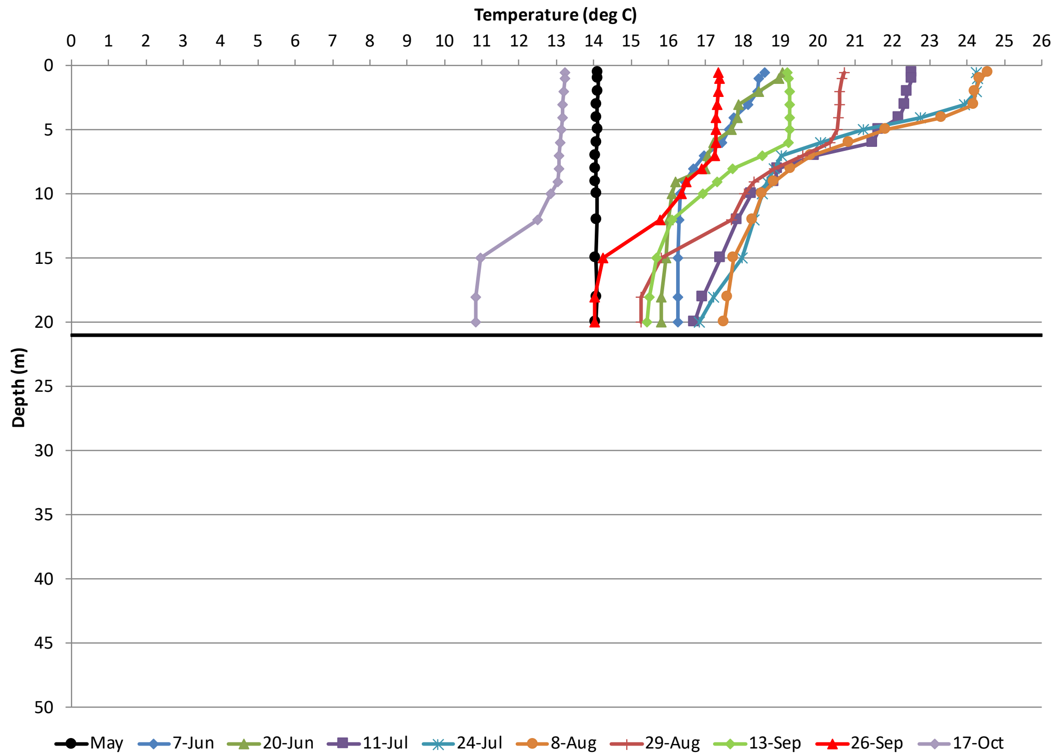

Figure 13. Temperature Profiles for Station LL2b, May-October 2018

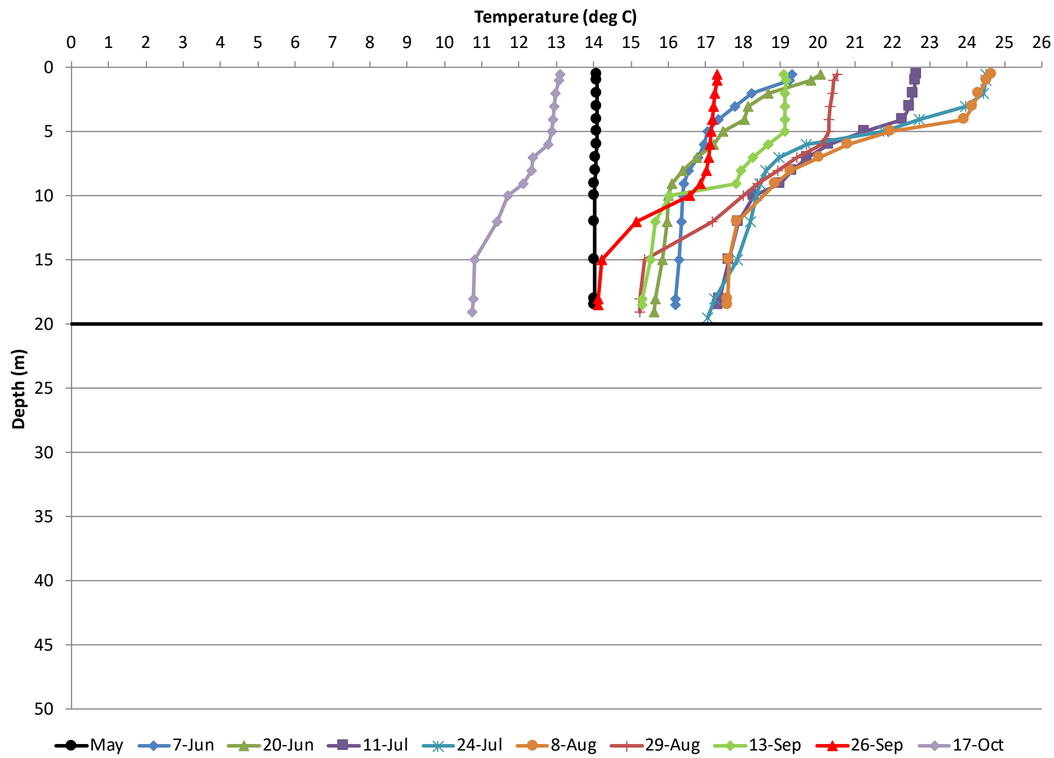

Figure 14. Temperature Profiles for Station LL3, May-October 2018

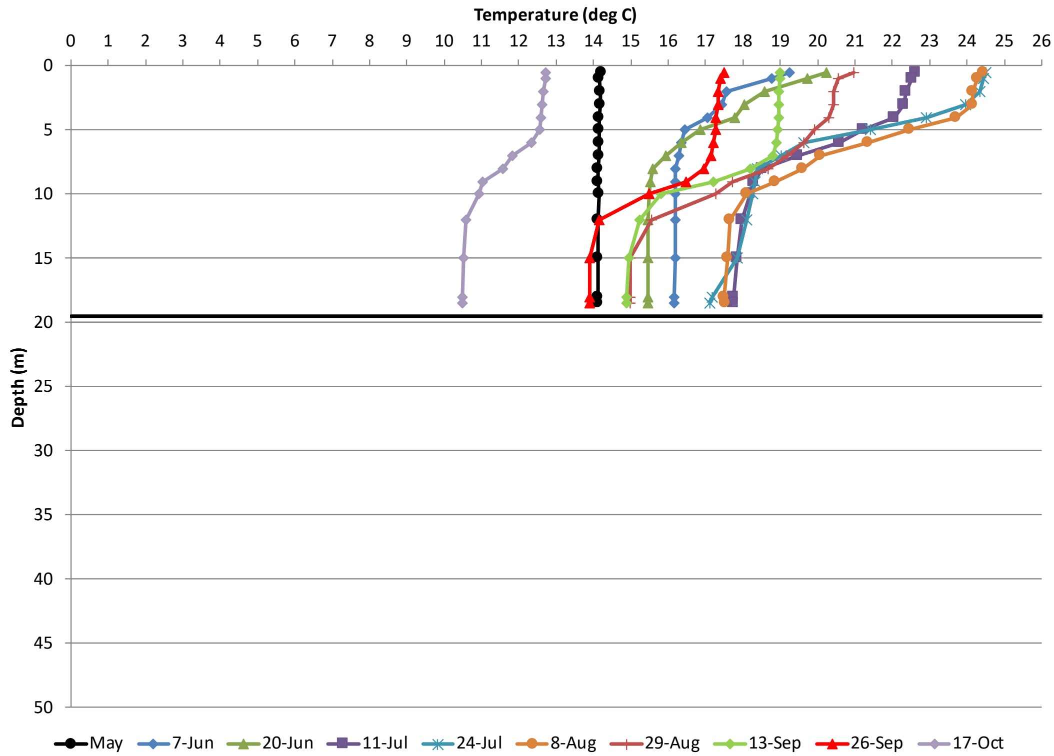

Figure 15. Temperature Profiles for Station LL3a, May-October 2018

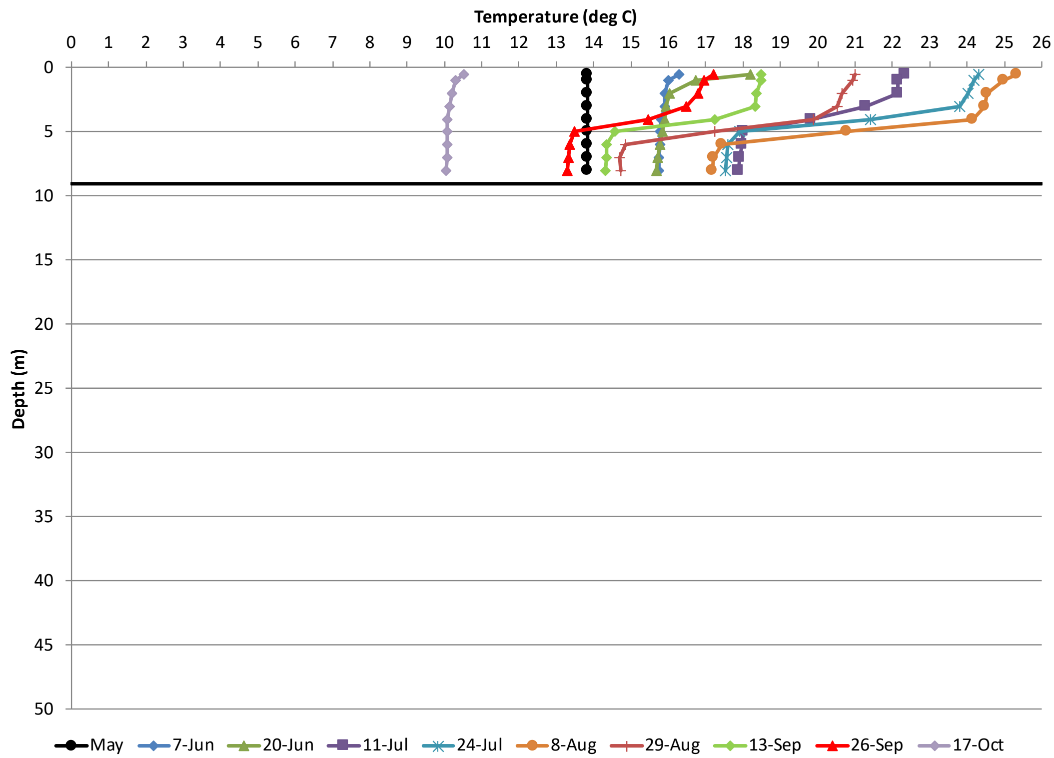

Figure 16. Temperature Profiles for Station LL4, May-October 2018

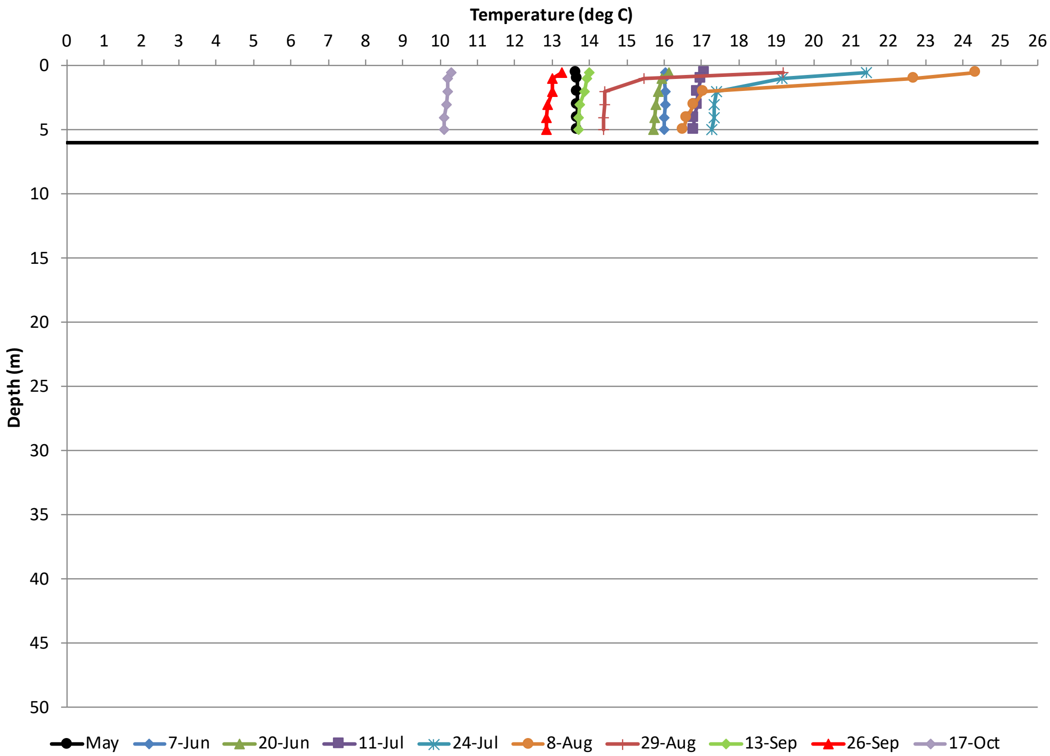

Figure 17. Temperature Profiles for Station LL5, May-October 2018

3.2.2 CONDUCTIVITY (SPECIFIC CONDUCTANCE)

Conductivity, or specific conductance, ranged from about 65 to 290 micro Siemens/cm (µS/cm) throughout the reservoir (Figures 18 to 27). Conductivity is a conservative constituent, because it is represented by the major dissolved ions (calcium, magnesium, carbonate, sulfate, etc.) that are usually not influenced by gains and losses due to physical (sedimentation) or biological processes, as is the case with nitrogen, phosphorus, and carbon. It also represents the contribution of dissolved solids to density.

Conductivity was slightly lower in 2018, at 65 to 290 µS/cm, throughout the reservoir than in both 2015 and 2016, during which conductivity ranged from 87 to 297 and 106 to 290 µS/cm, respectively. The difference was due to a concentration effect from lower river flow in 2015 and 2016 and higher river flow in 2017 and 2018. Conductivity in 2018 was similar to conductivity measured in 2017 which ranged from 68 to 283 µS/cm. During May 2018, when river flows were relatively high, conductivity was low at all sites due to dilution with low conductivity inflow. Also, conductivity was mostly uniform vertically throughout the reservoirs, as was the case in early June at LL0, LL4 and LL5. As river flow decreased through the summer, inflow conductivity in the riverine zone (LL5) steadily increased to 220 µS/cm on July 11 and peaked at 290 µS/cm on August 29 (Figure 27).

The interflow zone was easily defined by high conductivity that increased from around 110 µS/cm in June and reached a maximum of 279 µS/cm in September. The interflow zone extended from about 6 to 18 m at stations LL3 to LL0 in July and expanded to 33 m at LL0 in late August as the denser, higher conductivity water plunged and moved through the reservoir at those depth intervals. The high conductivity/density water (260-280 µS/cm) in August and early September moved along the reservoir bottom from LL5 to LL2, at depths less than or equal to 25 meters, and entered the deeper reservoir portion between 10 and 25 m. Below 30 m, conductivity was usually less than 200 µS/cm prior to late August and early September. This pattern resulted in much of the metalimnion being composed of high conductivity river inflow in the lower reservoir. Bottom water conductivity increased to 275 µS/cm at LL0 in early September due to the increased inflow and vertical mixing. River inflow in 2018 was high enough in September and October to mix high conductivity water into the deepest portions of the reservoir, as was the case in the past years, exception in 2015, when river inflow was still much lower in September and October.

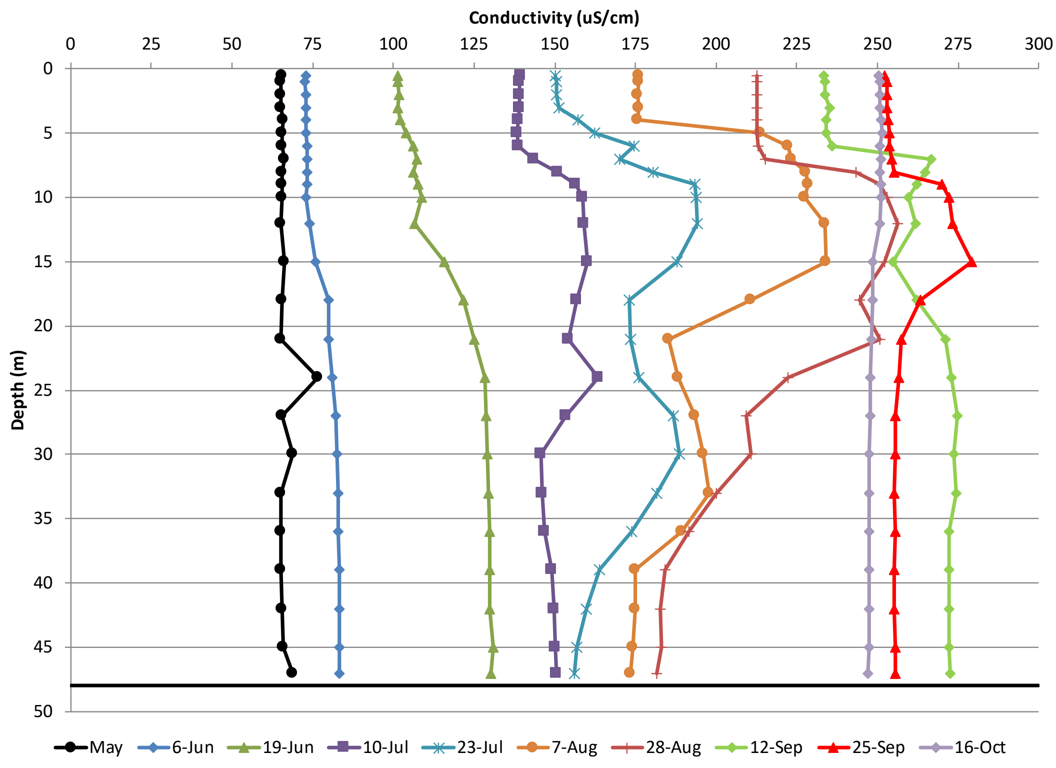

Figure 18. Conductivity Profiles for Station LL0, May-October 2018

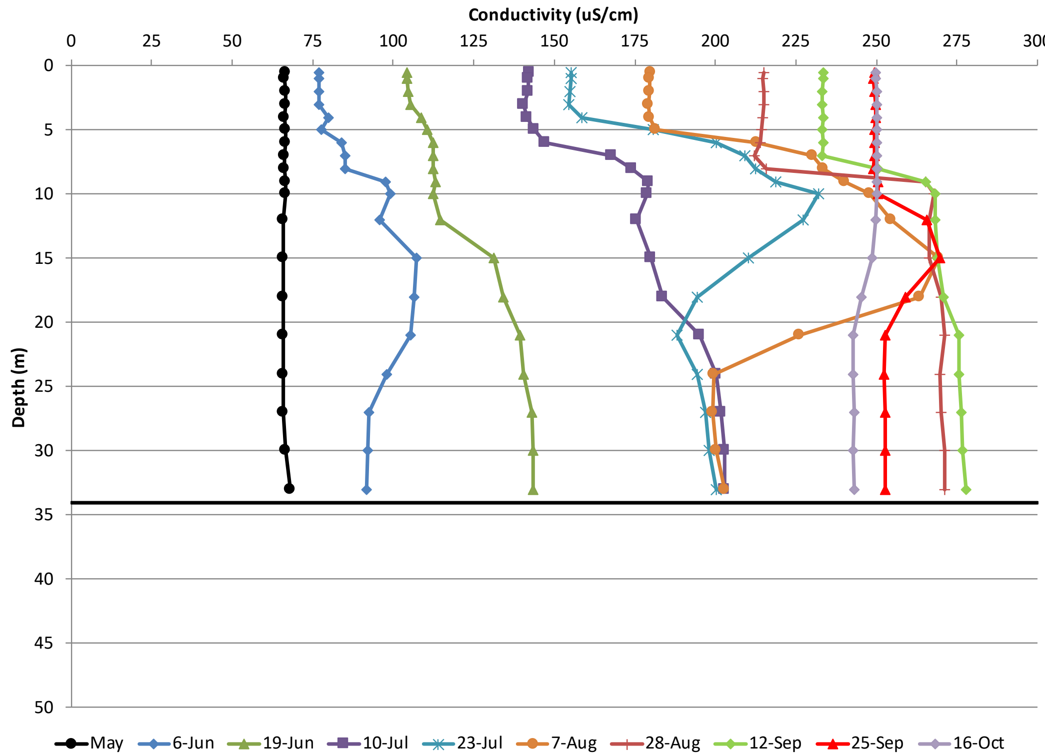

Figure 19. Conductivity Profiles for Station LL1, May-October 2018

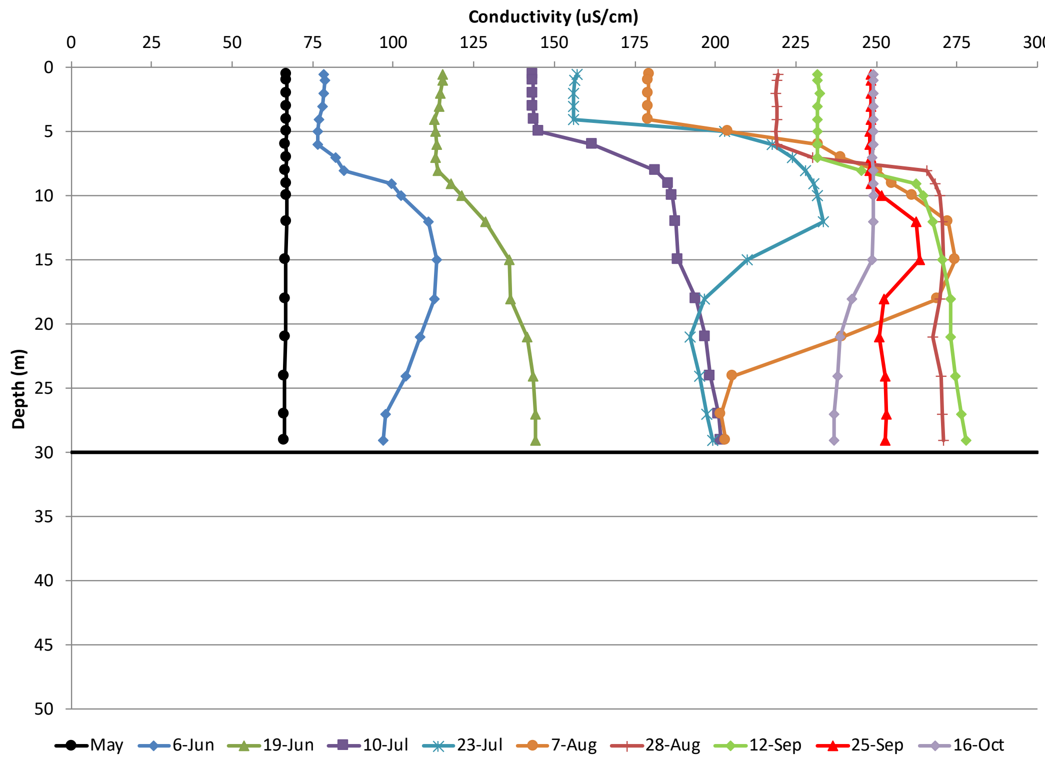

Figure 20. Conductivity Profiles at Station LL1a, May-October 2018

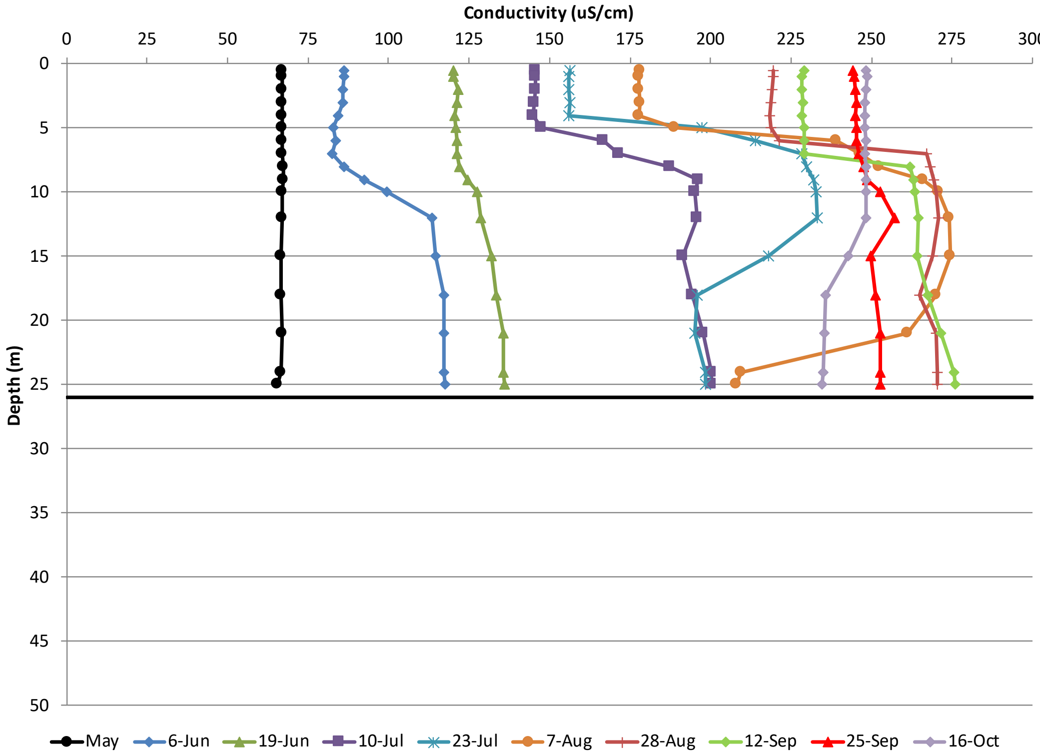

Figure 21. Conductivity Profiles at Station LL2, May-October 2018

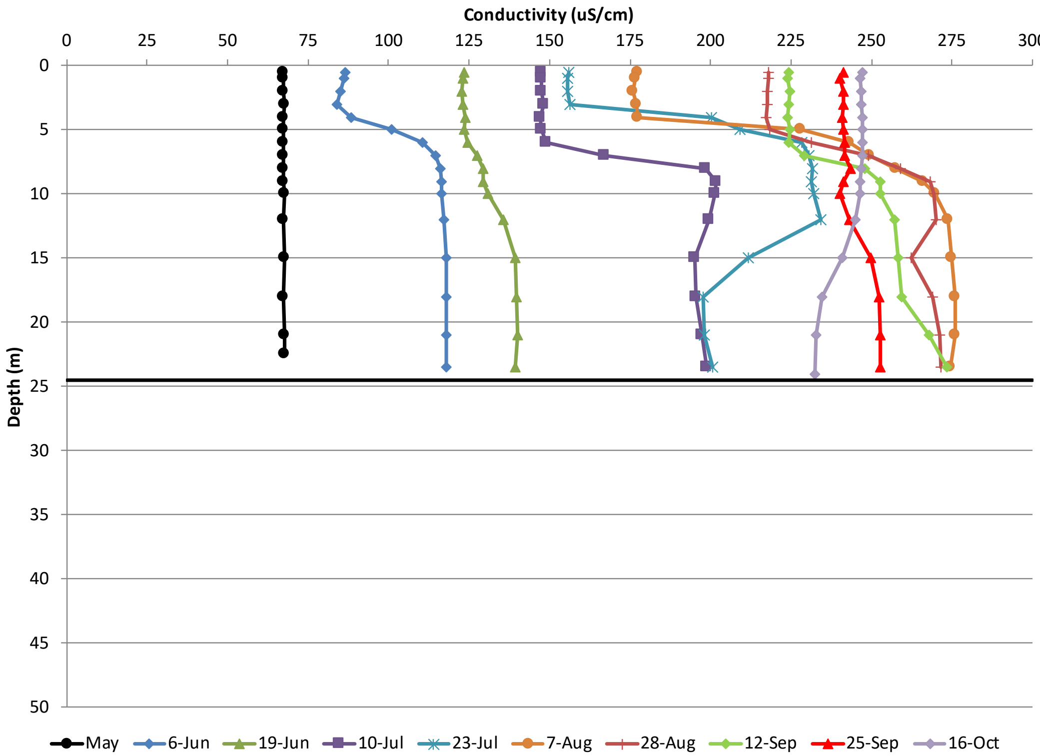

Figure 22. Conductivity Profiles at Station LL2a, May-October 2018

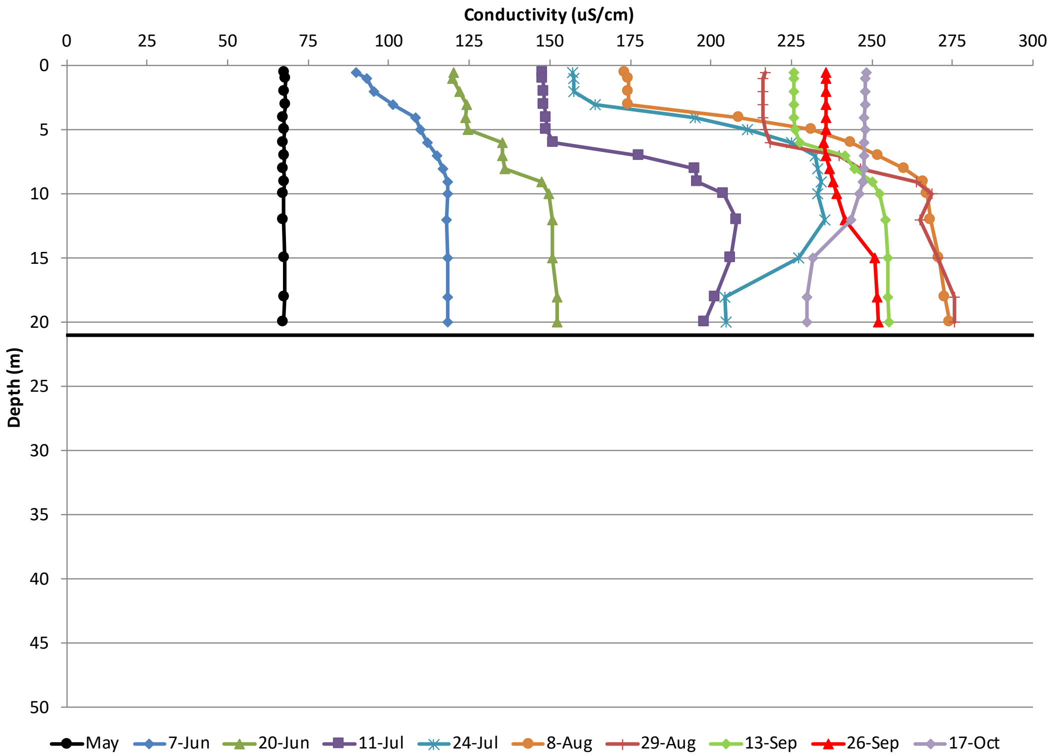

Figure 23. Conductivity Profiles at Station LL2b, May-October 2018

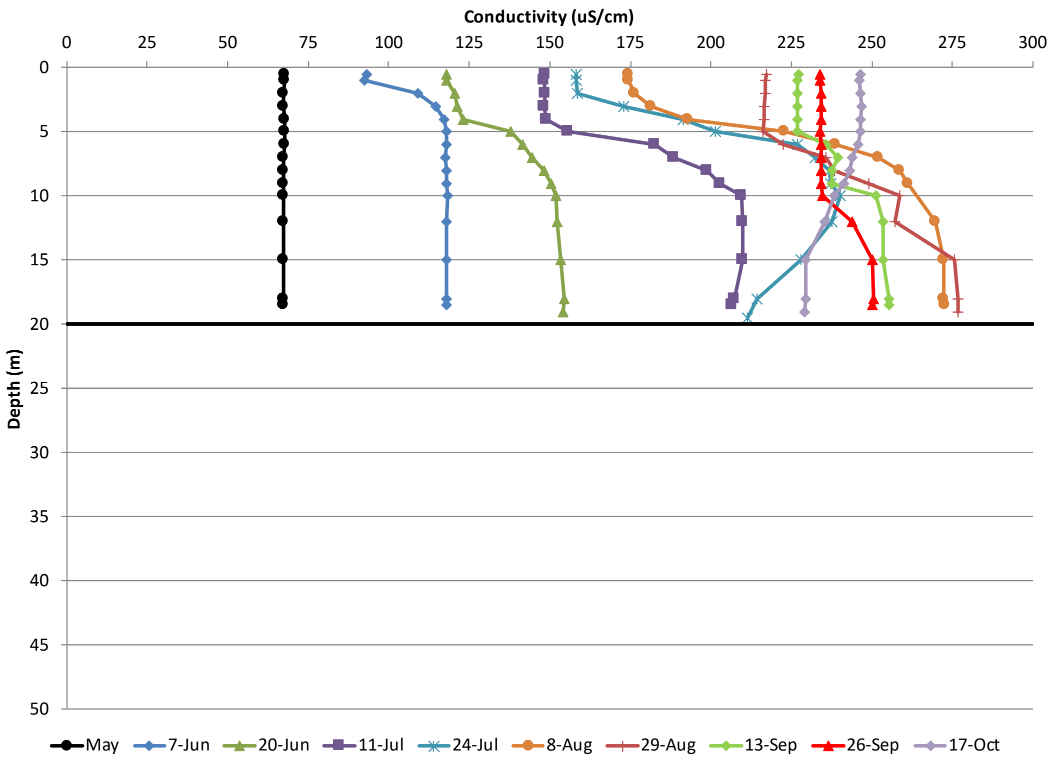

Figure 24. Conductivity Profiles at Station LL3, May-October 2018

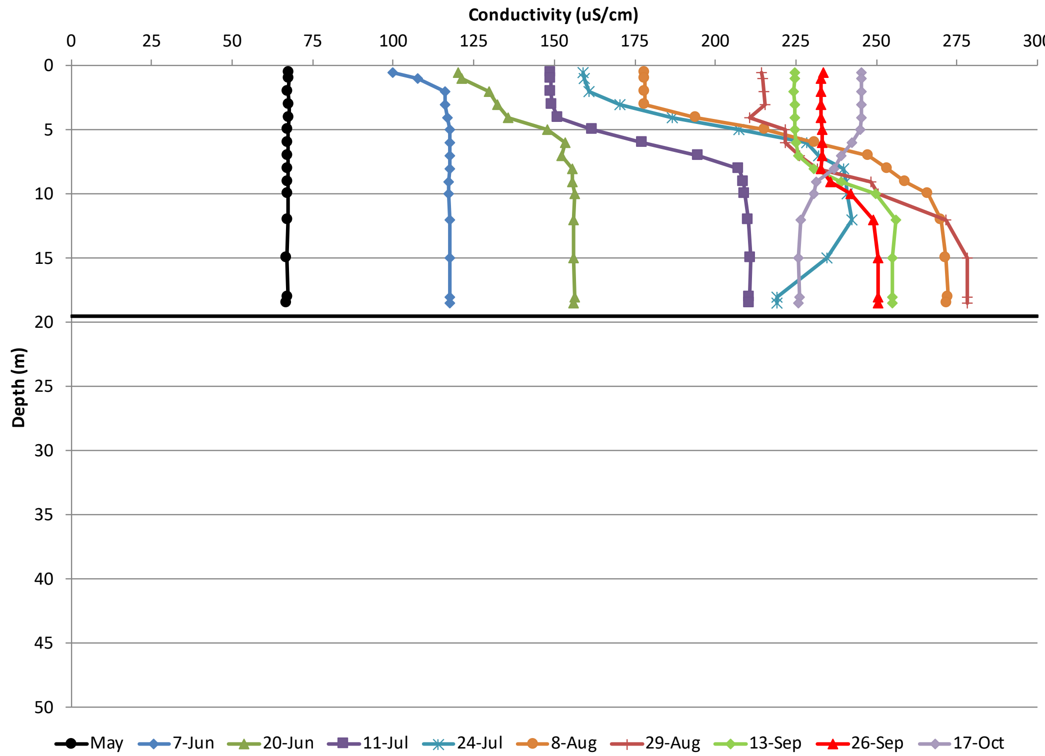

Figure 25. Conductivity Profiles at Station LL3a, May-October 2018

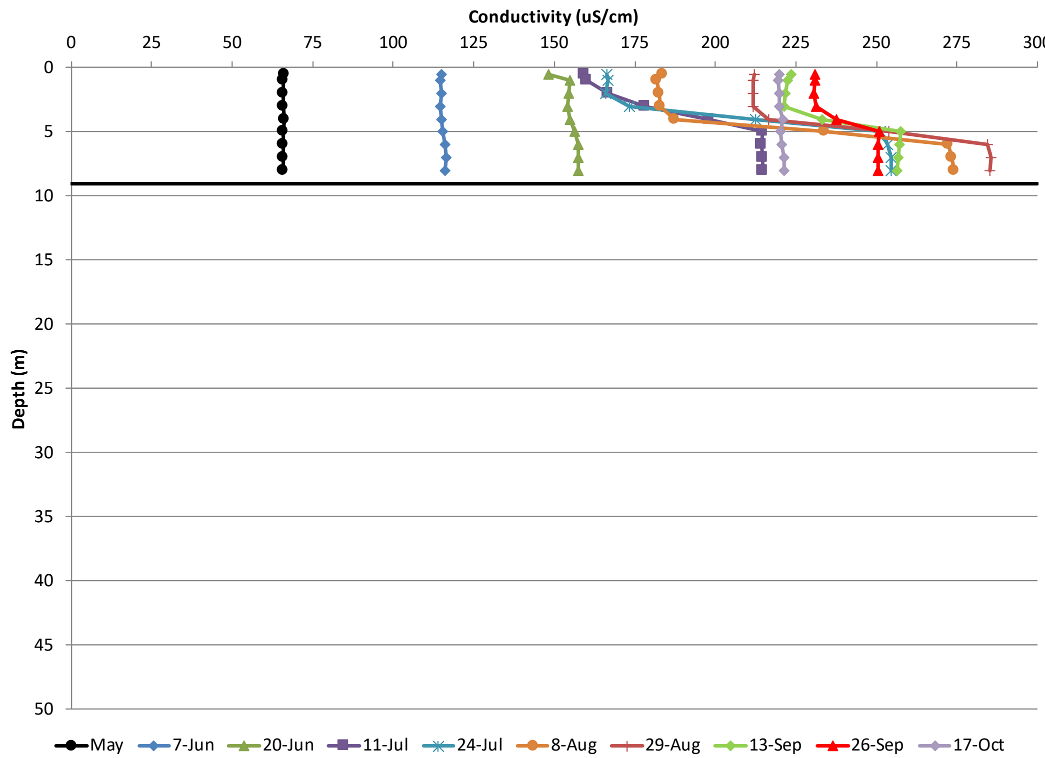

Figure 26. Conductivity Profiles at Station LL4, May-October 2018

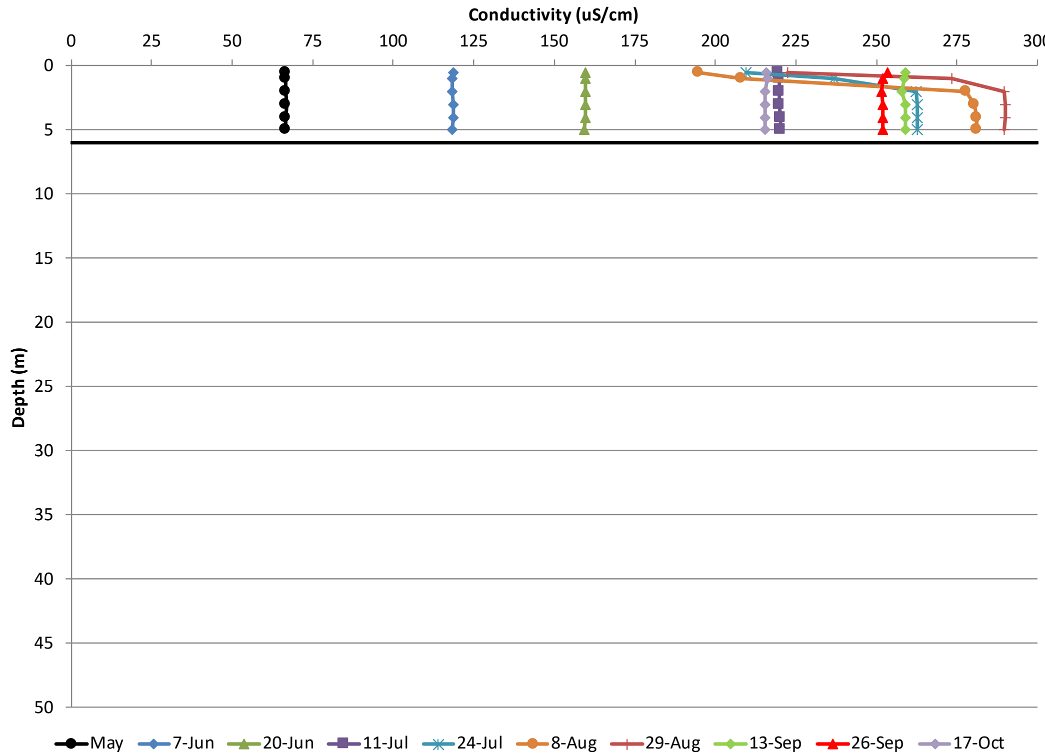

Figure 27. Conductivity Profiles at Station LL5, May-October 2018

3.2.3 DISSOLVED OXYGEN

Maximum epilimnetic DO concentration was highest (15.3 mg/L) at the deepest lacustrine sites (LL0 and LL1) in July (Figure 28 and 29). Maximum DOs were lower at other sites (LL1a-LL5), ranging from 11.6 to 12.2 mg/L (Figures 30 to 37). Maximums at most sites occurred in May when concentrations were nearly distributed evenly with depth. However, there were slightly higher epilimnetic peaks in late July. Epilimnetic DO maximums in May were slightly higher in the epilimnion at LL0 and LL1 than at the other sites (Figure 28 and 29).

Epilimnetic water was around 120 to 130% super saturated in May at all stations, most likely indicating high photosynthetic rates. Later in summer, DO was 130 to 180% super saturated in most of the lacustrine zone in July and early August and to a lesser extent at shallower sites, with peak DOs around 4 to 7 m, due to higher rates of photosynthesis. High, supersaturated DOs (>130%) did not occur at the shallow stations, LL4 and LL5. High, supersaturated DOs also occurred at LL0 in July 2013, August 2014, July 2015, to a lesser extent in August 2016, and August 2017.

The minimum DO (0.62 mg/L) during 2018 occurred near the bottom at the deepest station (LL0) in August (Figure 28). Hypolimnetic DO below 25 m declined progressively during the summer at this site before increasing in early September. The deep hypolimnetic volume was probably not exchanged/diluted appreciably by oxygenated interflow, as indicated by conductivity profiles (Figure 18), allowing DO at depth to gradually deplete. Anoxia (< 1 mg/L) was reached at LL0 in late August; occurring at the same time as in 2017. Anoxia occurred only at LL0 in 2018, but approached that criterion in early August at stations LL1 (1.5 mg/L), LL1a (1.2 mg/L), and LL2 (1.5 mg/L). Minimum DOs were also observed in late July at the bottom of stations LL2a, LL2b, LL3, and LL3a but were slightly higher (1.6 – 3.4 mg/L).

Minimum DO concentrations also occurred at the two deepest stations (LL0 and LL1) in previous years (2010 – 2017), but minimums were substantially higher in 2011 (3.2, 6.9 mg/L) than in other years; 2010 (0.1, 2.3 mg/L), 2012 (1.6, 0.5 mg/L), 2013 (0.0 and 0.9 mg/L), 2014 (0.0 mg/L), 2015 (all zero mg/L), 2016 (0.0 mg/L), and 2017 (0.0, 0.8 mg/L). Minimum DOs in 2013 through 2017 were the lowest observed during the past nine years. Average water column DO in 2018 ranged from 8.5 to 10.3 mg/L, with the lowest values at the deepest stations.

The effect of interflow on DO depletion, as indicated by conductivity profiles, was most pronounced during late July, August and September at the lacustrine zone stations, and to a lesser extent in the transition zone (LL3 and LL3a). The DO depletion in the interflow zone (approximately 10 – 20 m) in August and September in 2018 was similar to that observed in 2016 and 2017, but with less effect than in 2015. Dissolved oxygen depletion in the metalimnion (5 to 10 m) to levels less than 6 mg/L occurred at stations LL0 and LL1 in 2018, but the rate of DO depletion was less in 2016 and 2017 with 6 mg/L reached at LL0 only.

The timing of metalimnetic DO depletion was in late August and early September, similar to 2016, 2017, and 2018. In 2017, DO in the metalimnion also fell below 6 mg/L at LL3 in early September. Dissolved oxygen depletion in 2015, the long residence time year, was pronounced at multiple stations in August and September and persisted longer at LL0 starting in July. The pattern of DO depletion at LL0 persisted in 2018 until October, as was the case in 2015. Unlike 2015, October hypolimnetic DOs in the shorter residence time years of 2016, 2017, and 2018 were higher than in the interflow-affected metalimnion.

The pattern of plunging interflow effect on DO is further shown by combining profile data in the lacustrine zone from the low-flow, high conductivity summer period (Figure 38). The marked decline in DO in the metalimnion below about 6 m corresponds with high conductivity water that plunged into the upper reservoir as an interflow, usually between 6 to 24 m. This pattern is similar to that in 2014 to 2017. Algae produced in the epilimnion may have also settled and contributed to metalimnetic and hypolimnetic DO depletion.

Average water-column DO concentrations were calculated by weighting concentrations at each depth by their represented volumes. Average volume-weighted DOs were calculated for each long-term monitored station (LL0, LL1, LL2, LL3, LL4 and LL5) and sampling date using DO data from 9 m and deeper and CE-QUAL-W2 model segment volumes below 8.5 m (Avista and Golder Associates; Table 5). The purpose was to be consistent with the method Ecology used to produce Table 7 in the DO TMDL report. More specifically, the calculations were completed by the following procedure.

> *At each station, for each sampling day, recorded DO concentrations from 9 m and deeper were multiplied by their associated volumes of water, their products were summed, and*

finally divided by the total volume of water at each station from 8.5 m and deeper. The volumes of water were obtained from the CE-QUAL-W2 model segments identified in the DO TMDL.

The lacustrine zone average volume weighted DO includes concentrations from LL0, LL1, and LL2 but not the very small portion of the hypolimnion at station LL3.

The minimum individual volume weighted DO below 8.5 m was 3.8 mg/L in late August at LL0 (Table 5). That was 0.8 mg/L lower than the minimum in 2017, 0.1 mg/L lower than in 2016, 0.4 mg/L higher than in 2015 and 0.2 mg/L lower than in 2014. The minimum average volume weighted DO below 8.5 m in the lacustrine zone was also in early August at 6.4 mg/L.

Table 5. Volume-weighted hypolimnetic DO concentrations, during May-October 2018, using DO concentrations determined from 8.5 meters and deeper

Station	Volume-Weighted DO (mg/L)									
	May 16-17	June 6-7	June 19-20	July 10-11	July 23-24	August 7-8	August 28-29	September 12-13	September 25-26	October 17-16
LL0	11.9	10.1	8.7	7.6	6.9	5.5	3.8	5.7	7.4	9.1
LL1	11.8	9.9	9.2	8.2	7.7	6.3	6.9	6.8	8.3	9.7
LL2	11.7	9.8	9.3	8.8	7.3	7.4	7.6	8.1	8.8	10.2
LL3	11.7	9.6	9.6	9.0	7.3	7.6	8.7	9.3	9.7	10.3
LL4	--									
LL5	--									
Lacustrine Zone only Average (LL0, LL1, LL2)	11.8	9.9	9.1	8.2	7.3	6.4	6.1	6.9	8.1	9.7

Volume-weighted, hypolimnetic DO concentrations below 15 m were also calculated using the same procedure and model segment volumes (Table 6). The minimum individual volume weighted hypolimnetic DO (3.1 mg/L) at any site below 15 m in 2018 occurred in late August at LL0 (Table 6). That was 0.9 mg/L lower than the minimum in 2017, 0.1 mg/L higher than in 2016, 0.5 mg/L higher than in 2015 and 0.2 mg/L lower than in 2014. The minimum average volume weighted whole hypolimnetic DO in the lacustrine zone was in early August at 5.4 mg/L. That was 0.4 mg/L lower than the minimum in 2017 (5.8 mg/L), higher than in 2016 (5.1 mg/L) and 2015 (4.5 mg/L) but lower in 2014 (6.0 mg/L) and 2013 (5.8 mg/L). Water residence times in 2013, 2014, 2016, 2017 and 2018 were about half that in 2015, accounting for the higher minimums. However, timing of the minimum average DO in late August, 2016, was similar to that in 2015 (late July/late August), and in 2013 (late August), while timing in 2017 and 2018 (early August) was similar to 2014 (late July/early August).

While DO improved in Lake Spokane during years shortly after 1977, when 85% of point-source effluent phosphorus was removed from the inflowing river, and even improved further by 2010, the DO minimums observed in 2018 still fail to meet the surface water quality standard (see Table 1) in the hypolimnion during portions of the critical summer season (See also Section 4.0).

Table 6. Volume-weighted hypolimnetic DO concentrations in Lake Spokane, during May-October 2018, using DO concentrations determined from 15 meters and deeper

Station	Volume-weighted DO (mg/L)									
	May 16-17	June 6-7	June 19-20	July 10-11	July 23-24	August 7-8	August 28-29	September 12-13	September 25-26	October 17-16
LL0	11.9	10.0	8.6	7.3	6.2	5.0	3.1	6.1	7.7	9.0
LL1	11.8	9.9	9.1	8.1	6.8	5.3	7.3	7.4	8.4	9.7
LL2	11.7	9.6	9.2	8.6	6.7	5.9	8.4	8.6	9.4	10.3
LL3	11.7	9.5	9.5	8.5	5.2	9.2	9.2	9.3	9.8	10.4
LL4	--									
LL5	--									
Lacustrine Zone only Average (LL0, LL1, LL2)	11.8	9.8	9.0	8.0	6.6	5.4	6.3	7.4	8.5	9.6
Whole Hypolimnetic Average (LL0, LL1, LL2, LL3)	11.7	9.7	9.1	8.1	6.2	6.3	7.0	7.9	8.8	9.8

Average lacustrine, volume weighted DOs were similar below 8.5 m and below 15 m in 2018, with differences of only 0.1 mg/L on average, ranging from 0.0 to 1.0 mg/L (Tables 6 and 7). Measurement sensitivity for DO with a multi-parameter sonde (Hydrolab) is ± 0.2 mg/L, so most of the observed differences are within measurement error. Average measured lacustrine DOs were slightly higher in July and early August below 8.5 m than below 15 m; this was similar to the pattern observed in 2014, 2015, 2016, and 2017. Average lacustrine DO below 8.5 m was about the same in 2018 as in 2017, 0.8 mg/L higher in 2018 than in 2016, while the 2016 level was 0.8 mg/L higher than in 2015, but was 1.4 mg/L less than those in 2014. The largest difference in DOs below 8.5 m between 2017 and 2018 was in July when average DOs in 2018 ranged from 0.5 to 0.6 mg/L higher than in 2017. This was also the case for lacustrine DOs below 15 m, which averaged (volume weighted) only 0.1 mg/L higher in 2018 than 2017 with the largest differences occurring during July. However, these small differences probably do not exceed the instrument measurement error.

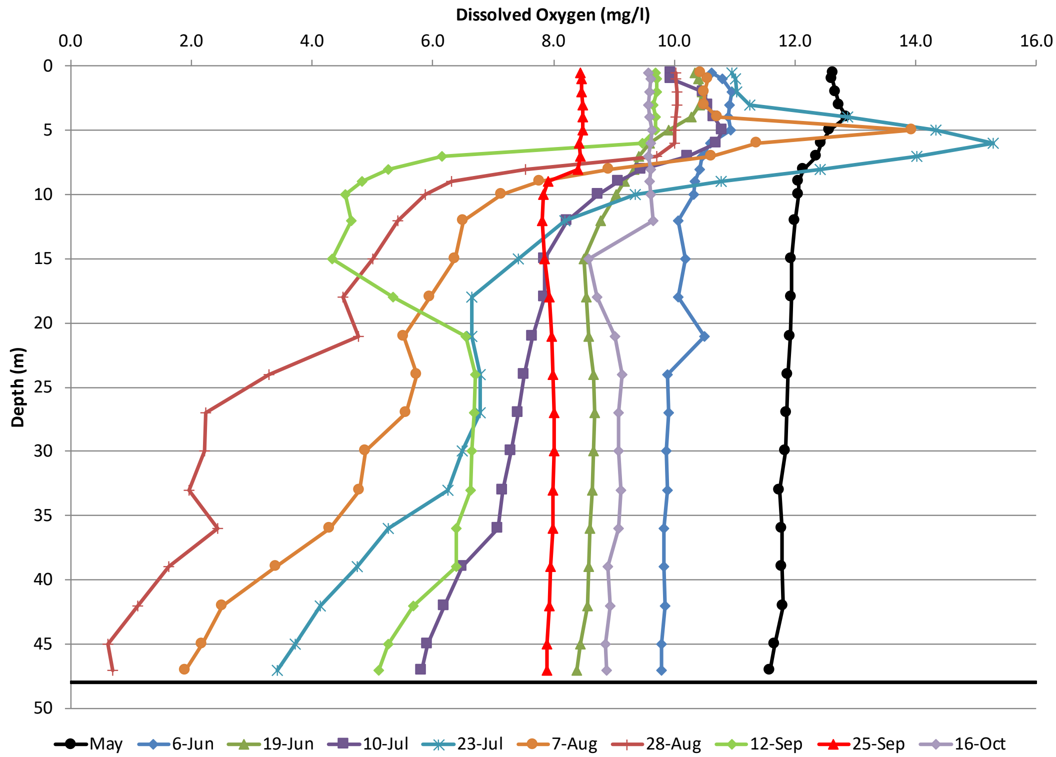

Figure 28. DO Profiles for Station LL0, May-October 2018

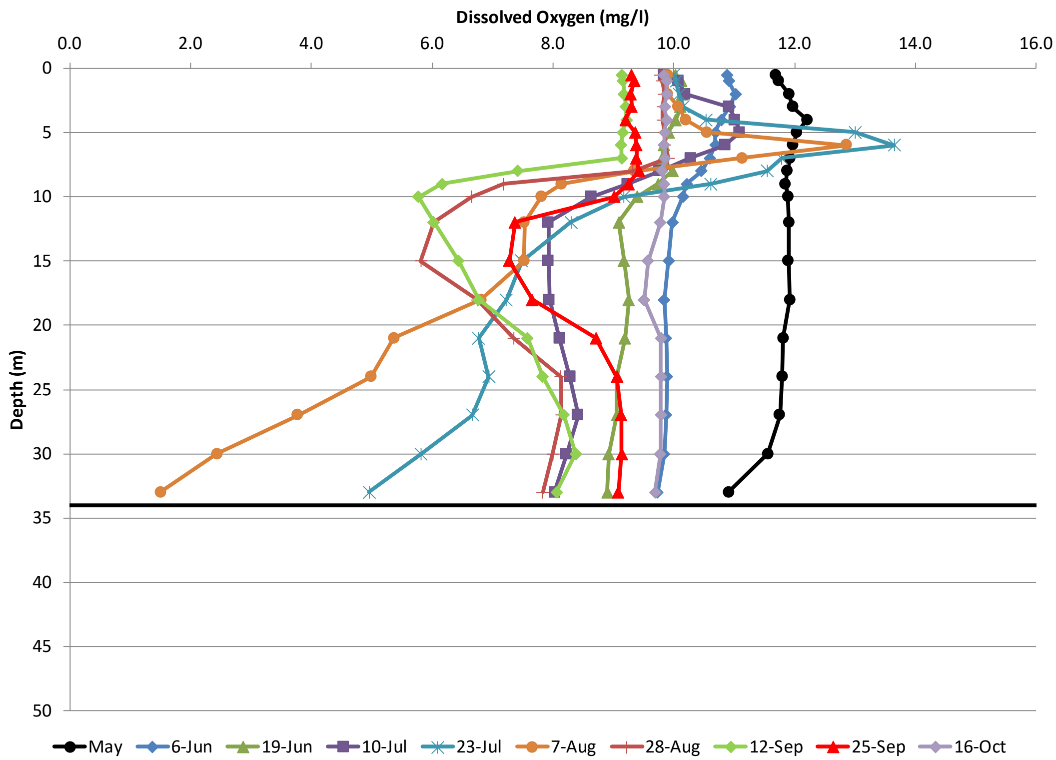

Figure 29. DO Profiles for Station LL1, May-October 2018

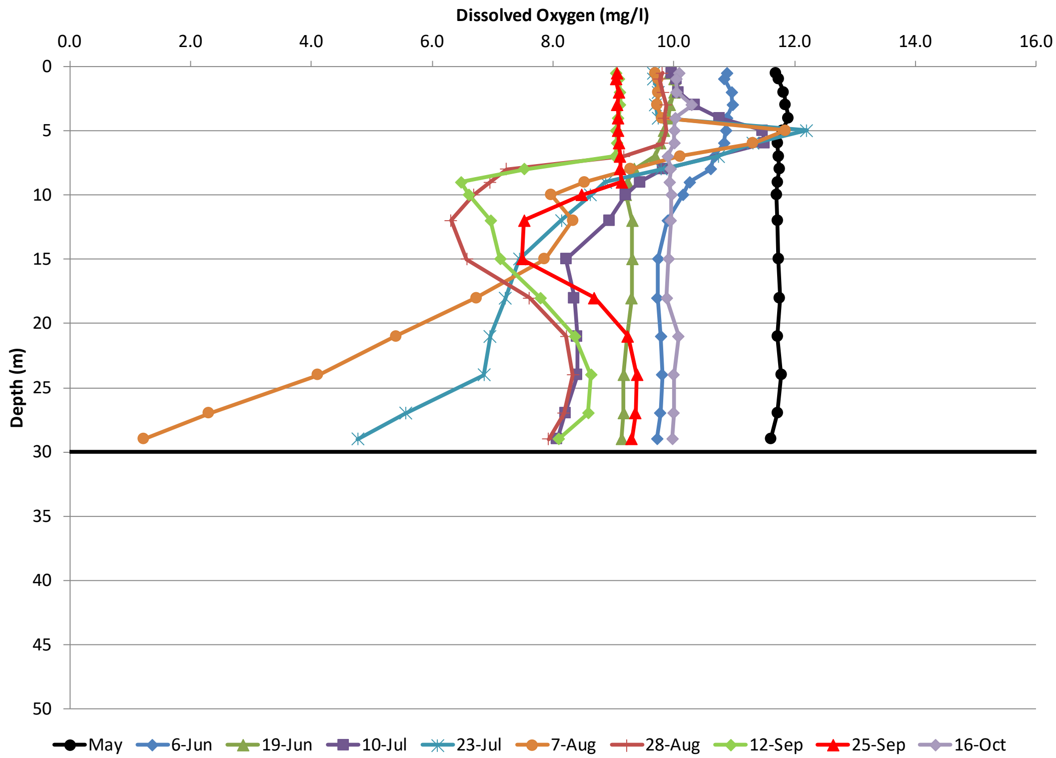

Figure 30. DO Profiles at Station LL1a, May-October 2018

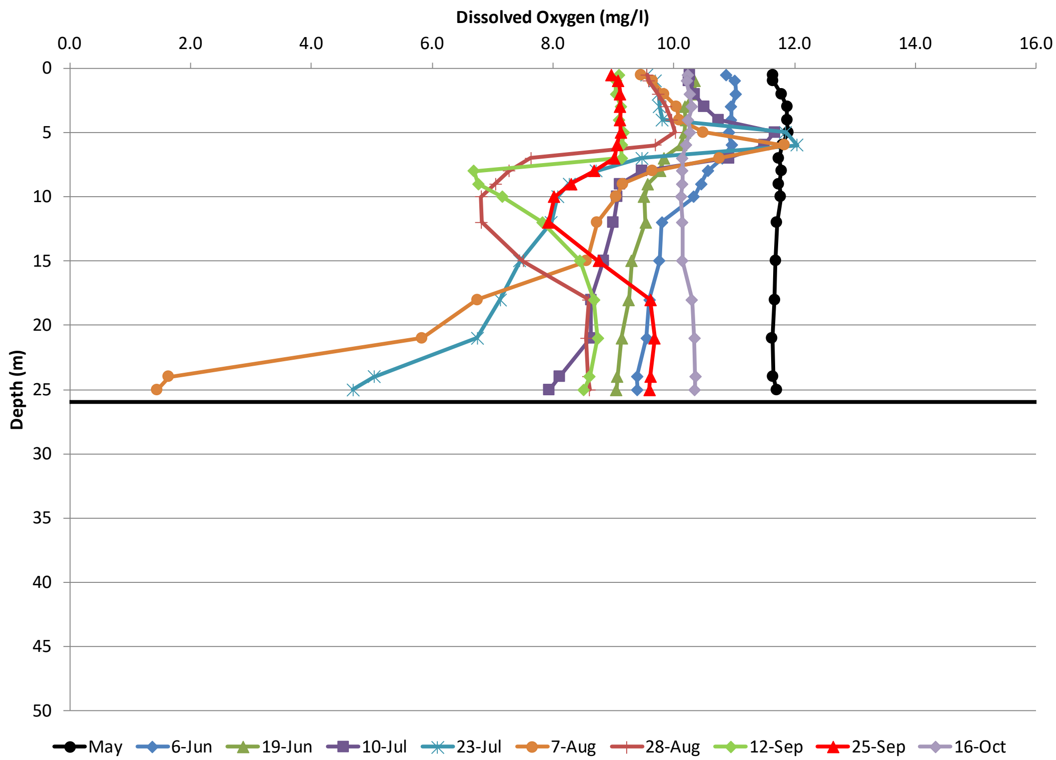

Figure 31. DO Profiles at Station LL2, May-October 2018

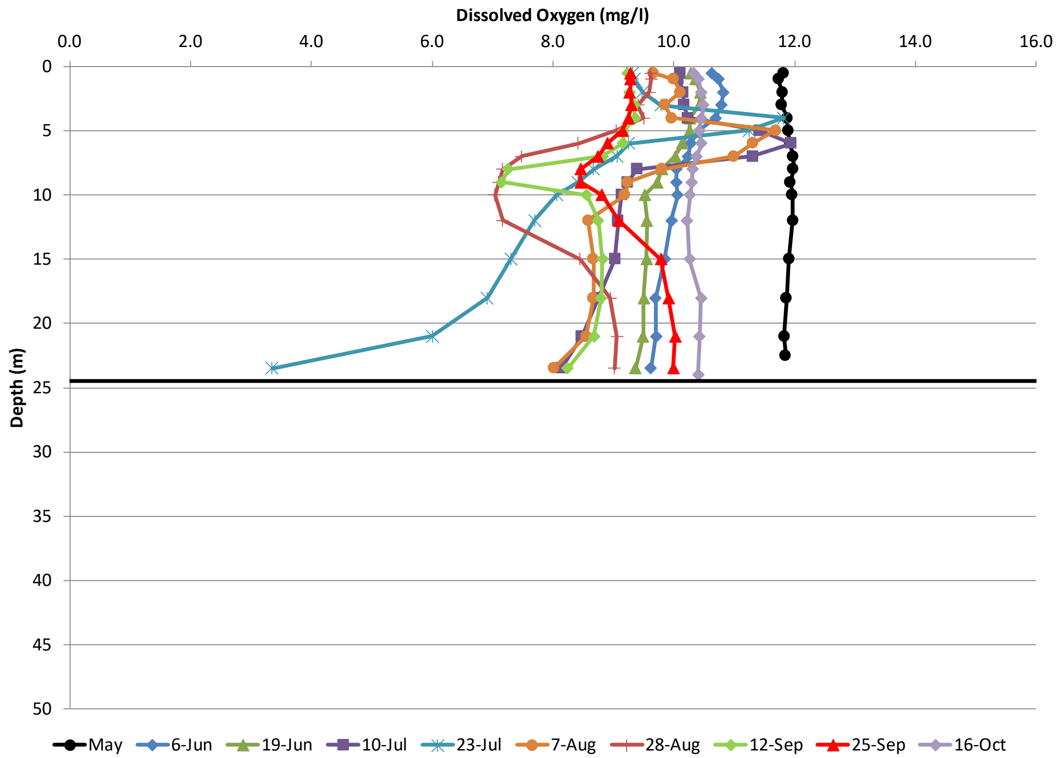

Figure 32. DO Profiles at Station LL2a, May-October 2018

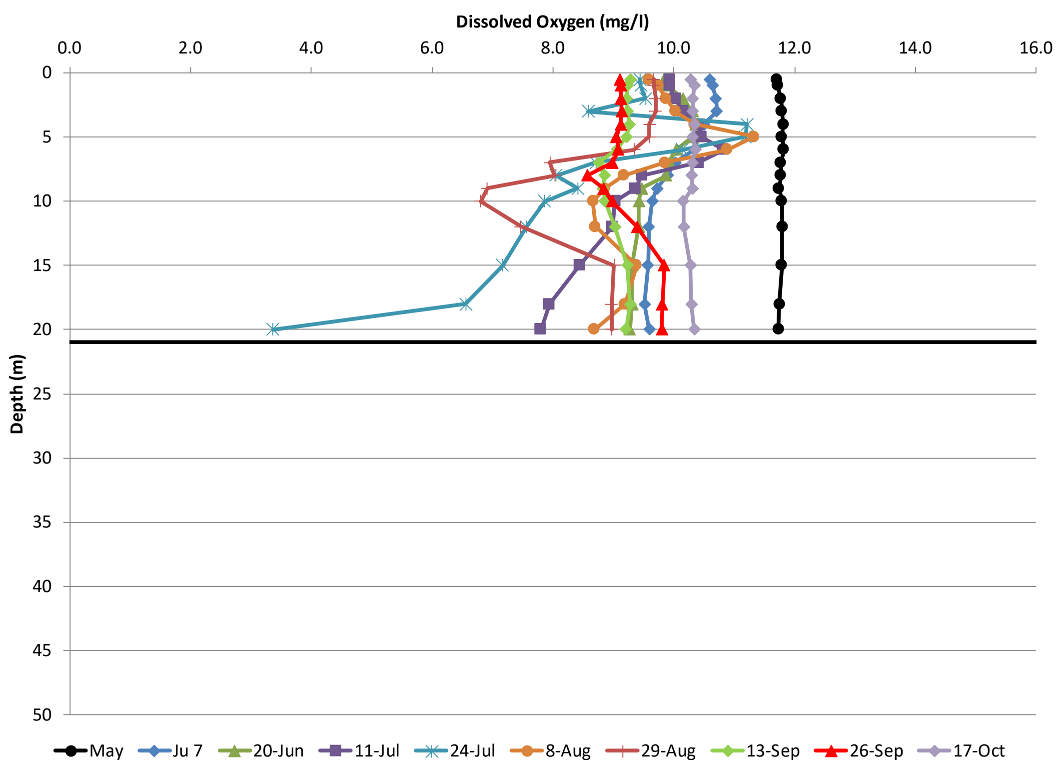

Figure 33. DO Profiles at Station LL2b, May-October 2018

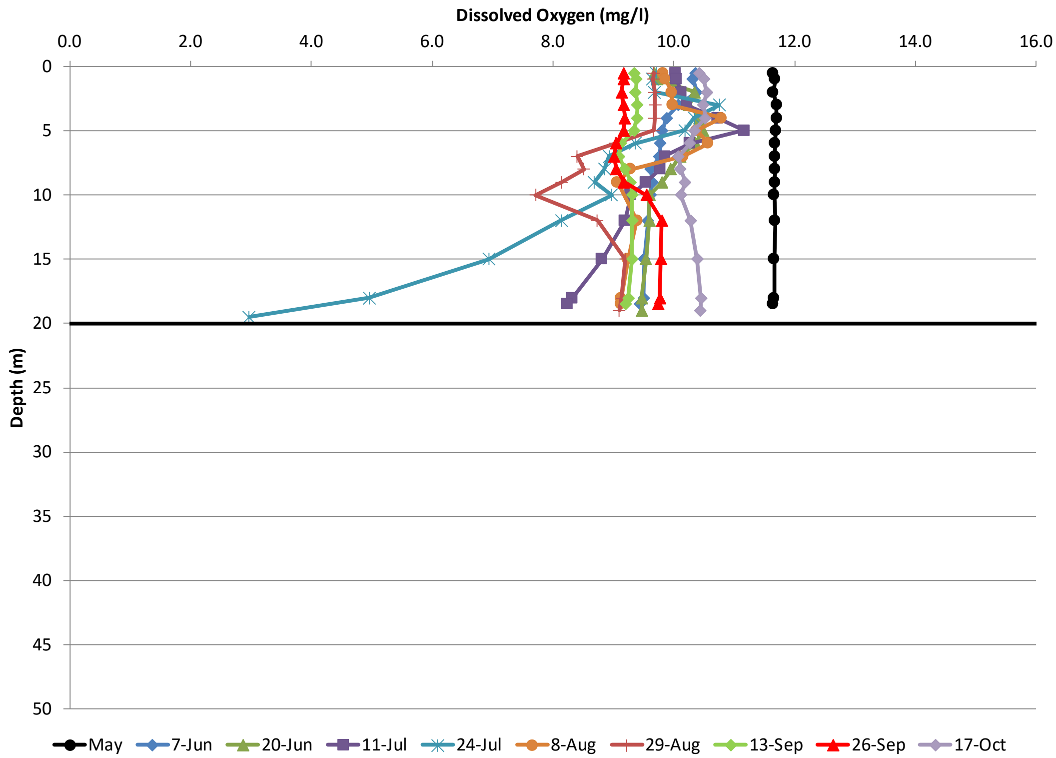

Figure 34. DO Profiles at Station LL3, May-October 2018

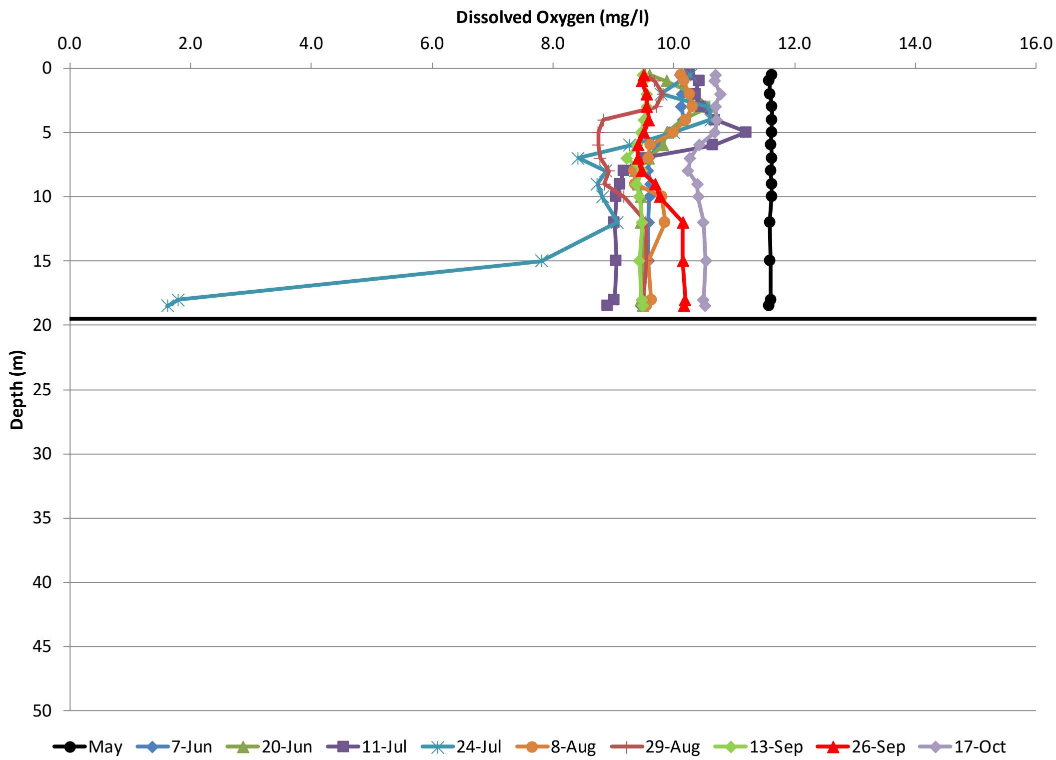

Figure 35. DO Profiles at Station LL3a, May-October 2018

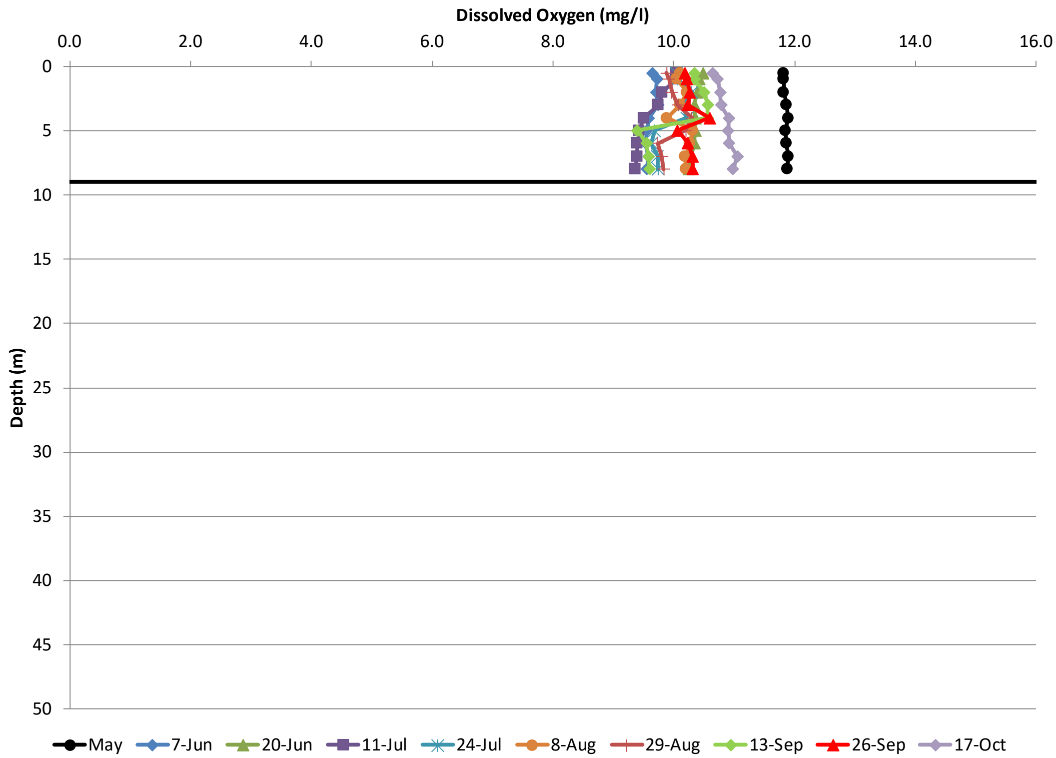

Figure 36. DO Profiles at Station LL4, May-October 2018

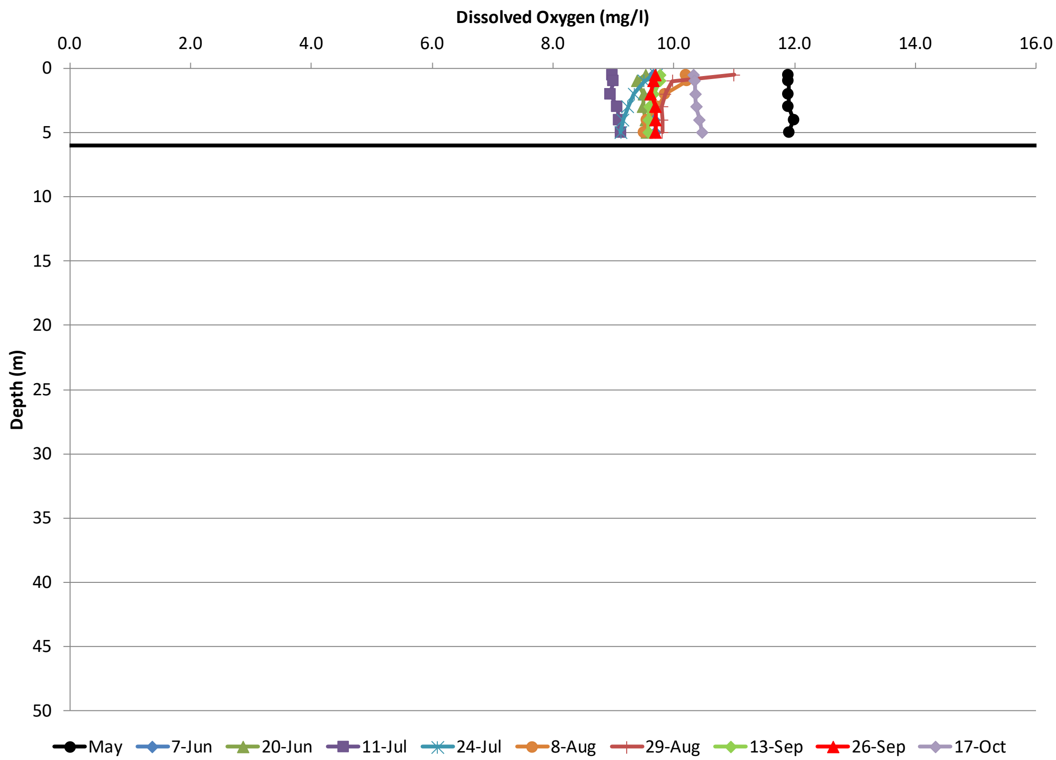

Figure 37. DO Profiles at Station LL5, May-October 2018

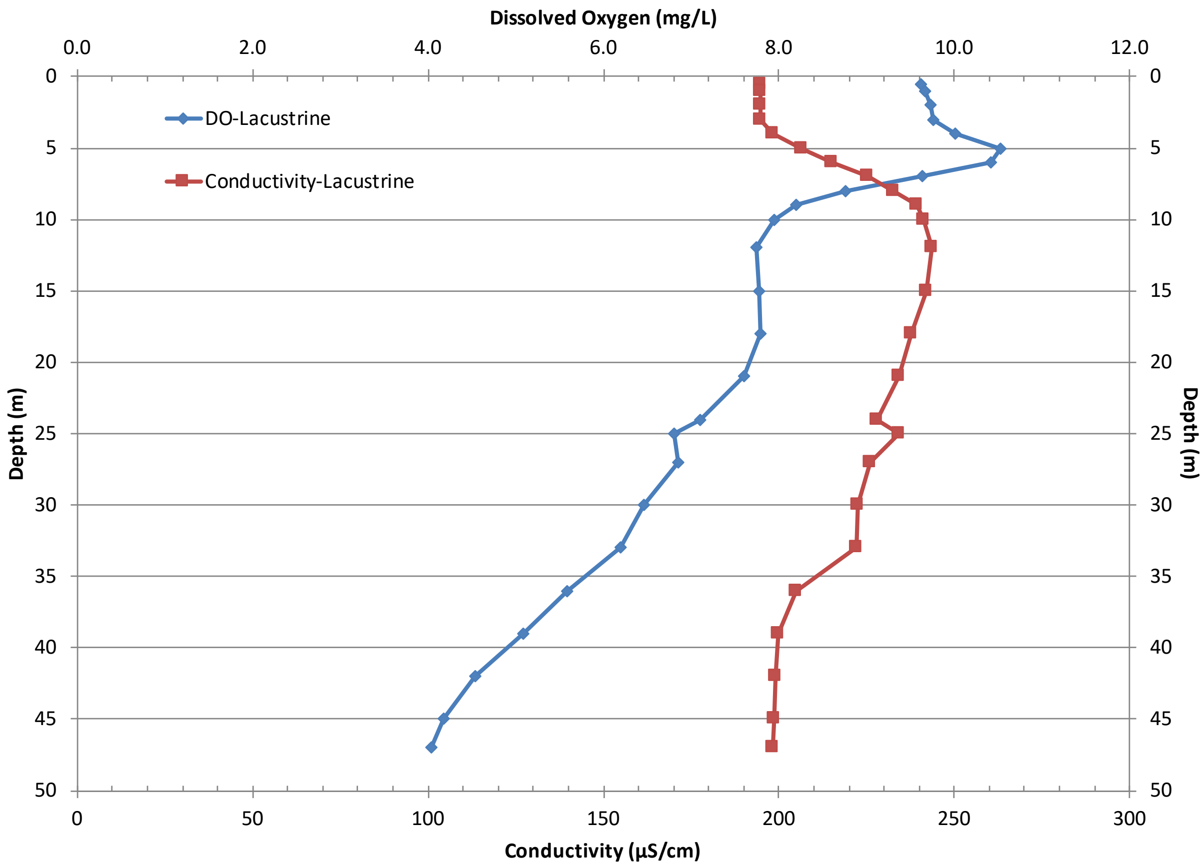

Figure 38. Average DO and Conductivity Profiles for Lacustrine Stations (LL0, LL1, LL1a, LL2, LL2a, and LL2b) from July 10th to September 26th, 2018.

3.2.4 pH

The range in pH through the water column was 6.8 to 8.9 at the ten stations during 2018 (Figures 39 through 48). The range in water column average pH was narrower, less than one pH unit (7.5 to 8.0). The highest pH levels occurred in the epilimnion during July at almost all the stations, but also in August at LL0, LL1, and LL5 and in early September at station LL4. The highest pH levels in the epilimnion were probably due to photosynthesis by phytoplankton which extract CO_2 from water faster than it can equilibrate by diffusion from the atmosphere. High rates of phytoplankton production can raise pH to levels above 10, although that has not occurred in Lake Spokane during the past eight years.

The highest epilimnetic pH levels occurred in the lacustrine zone probably because water residence time was longer than at up-reservoir sites. The lacustrine epilimnion tends to be isolated from the plunging interflow that would otherwise exchange with epilimnetic water. Levels of pH above the water quality criterion of 8.5 usually occurred within the epilimnion of almost all stations during July and August, and occasionally in early September. Levels of pH above 8.5 occurred just at the surface at station LL5 in August only. All depths where the water quality criterion of 8.5 was exceeded were well within the photic zone (see Section 3.2.7 Transparency).

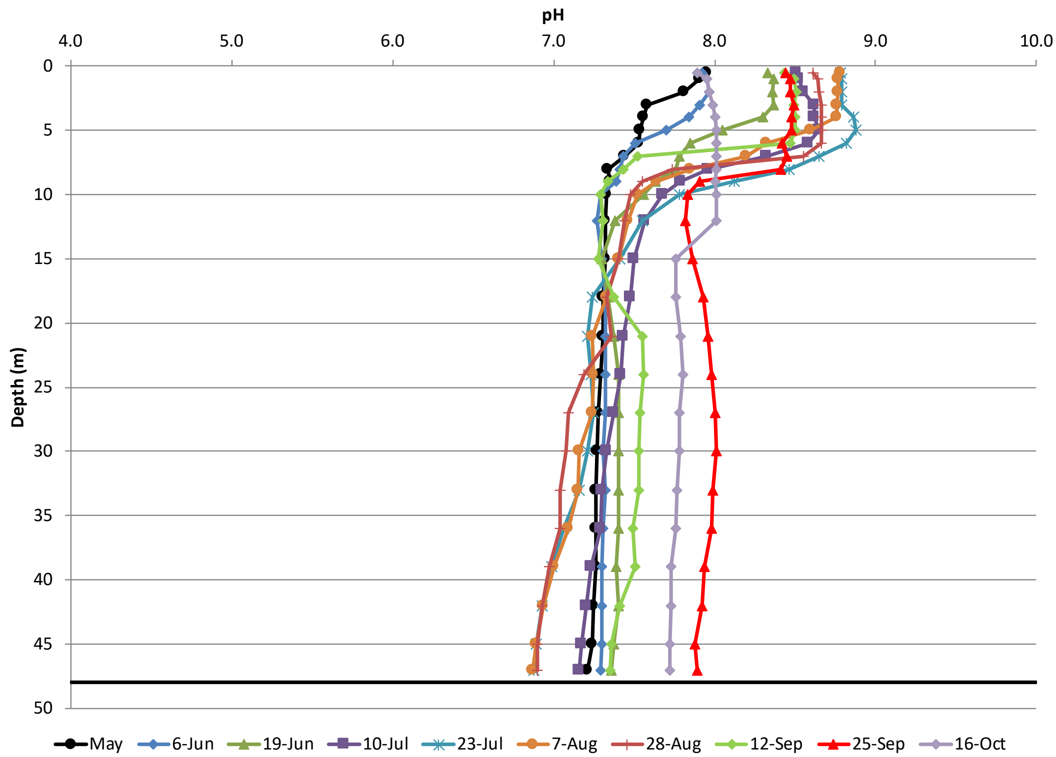

Figure 39. pH Profiles for Station LL0, May-October 2018

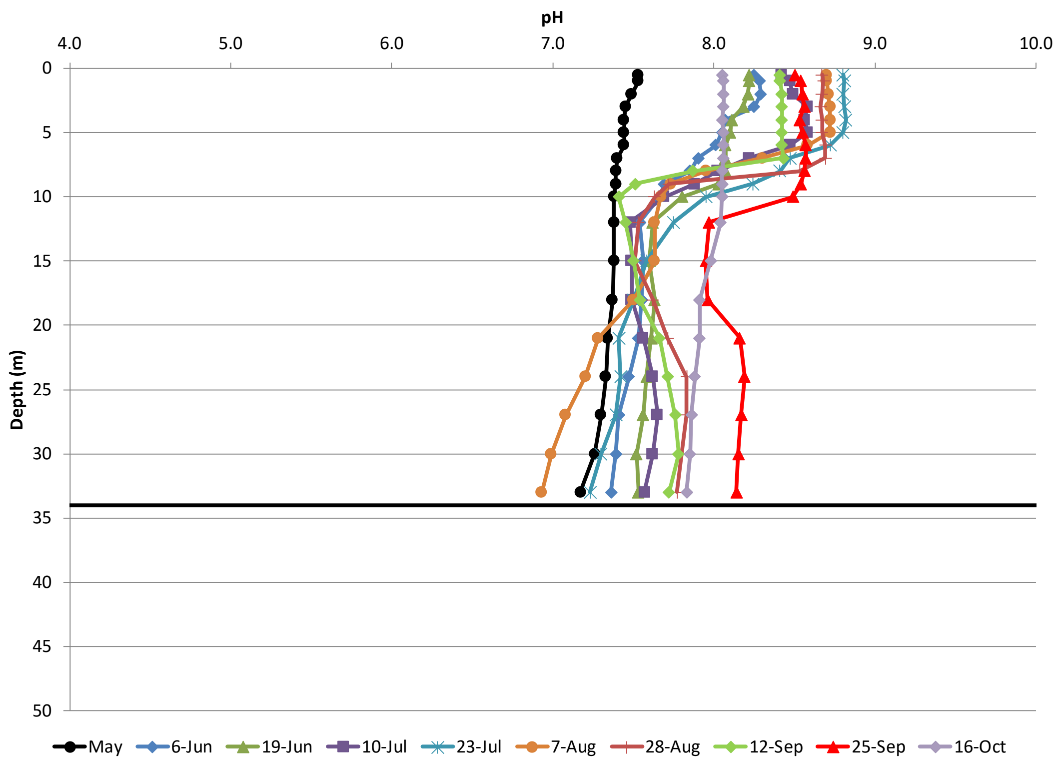

Figure 40. pH Profiles for Station LL1, May-October 2018

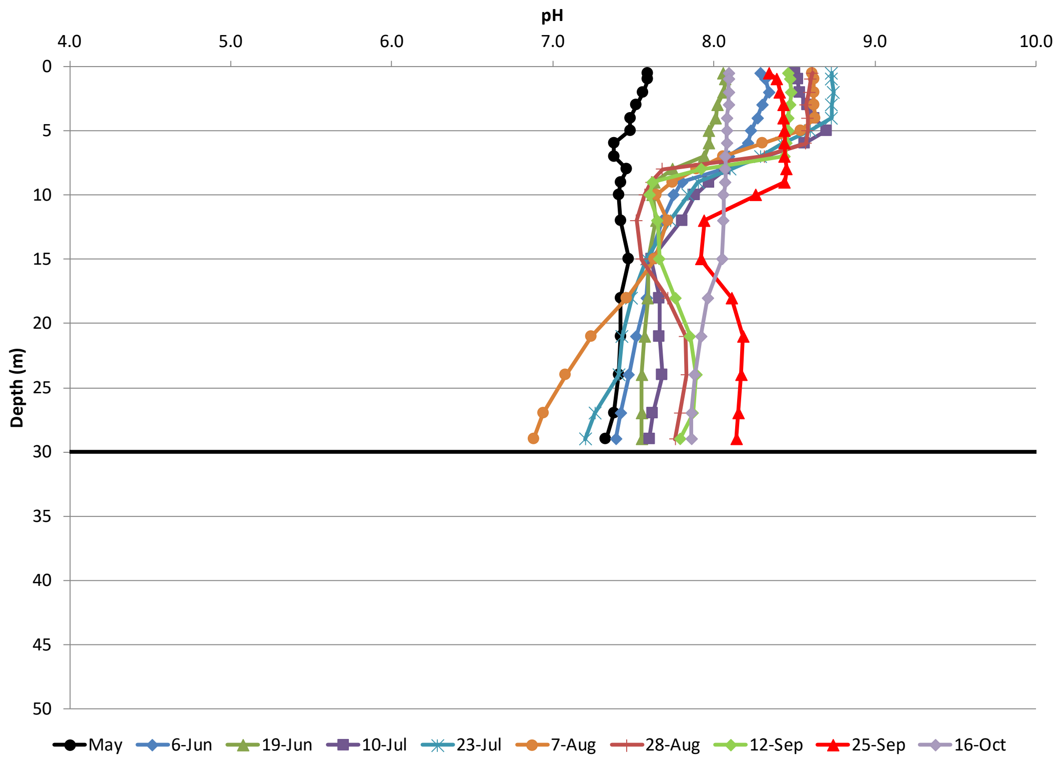

Figure 41. pH Profiles at Station LL1a, May-October 2018

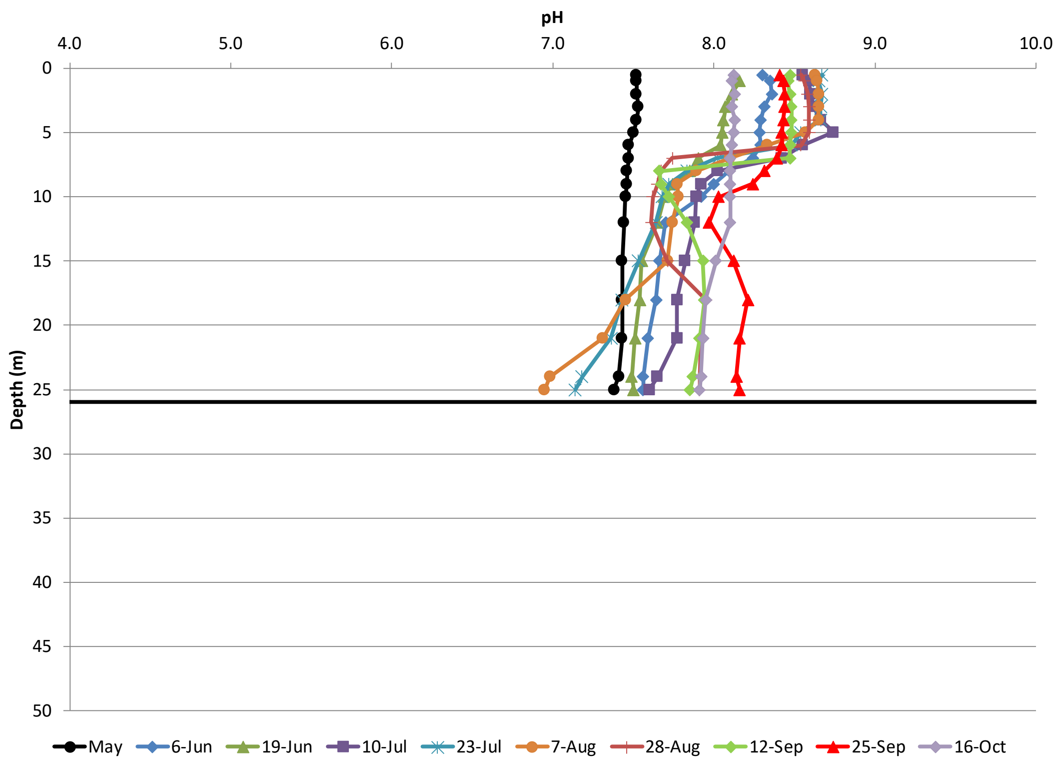

Figure 42. pH Profiles at Station LL2, May-October 2018

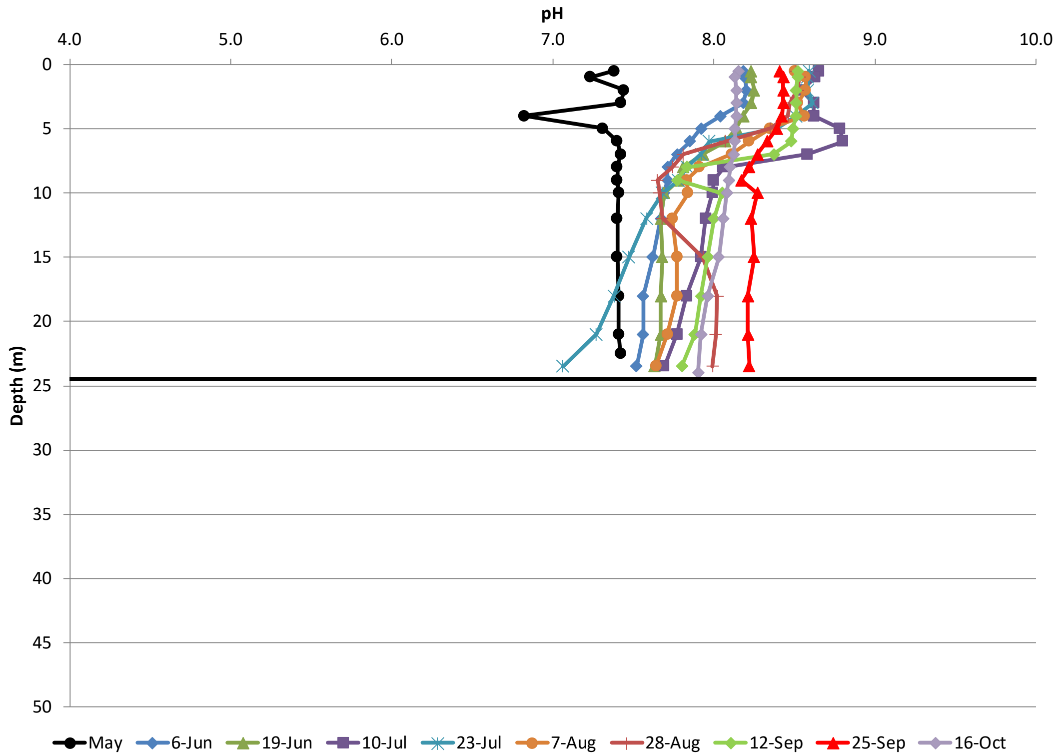

Figure 43. pH Profiles at Station LL2a, May-October 2018

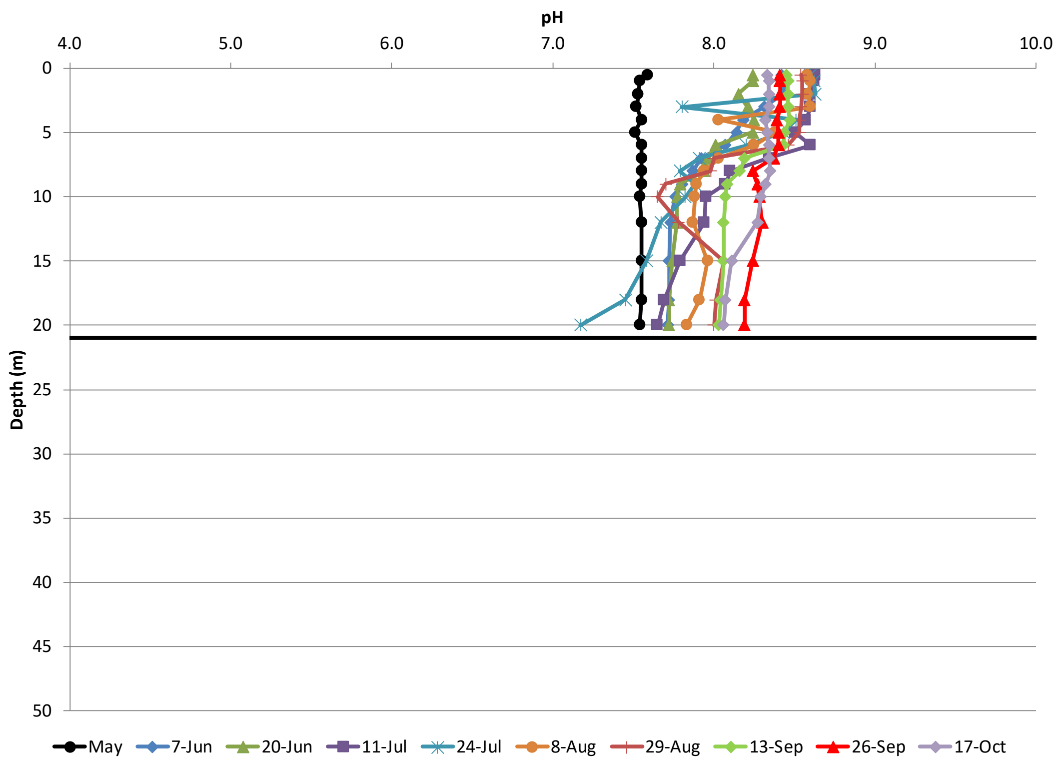

Figure 44. pH Profiles at Station LL2b, May-October 2018

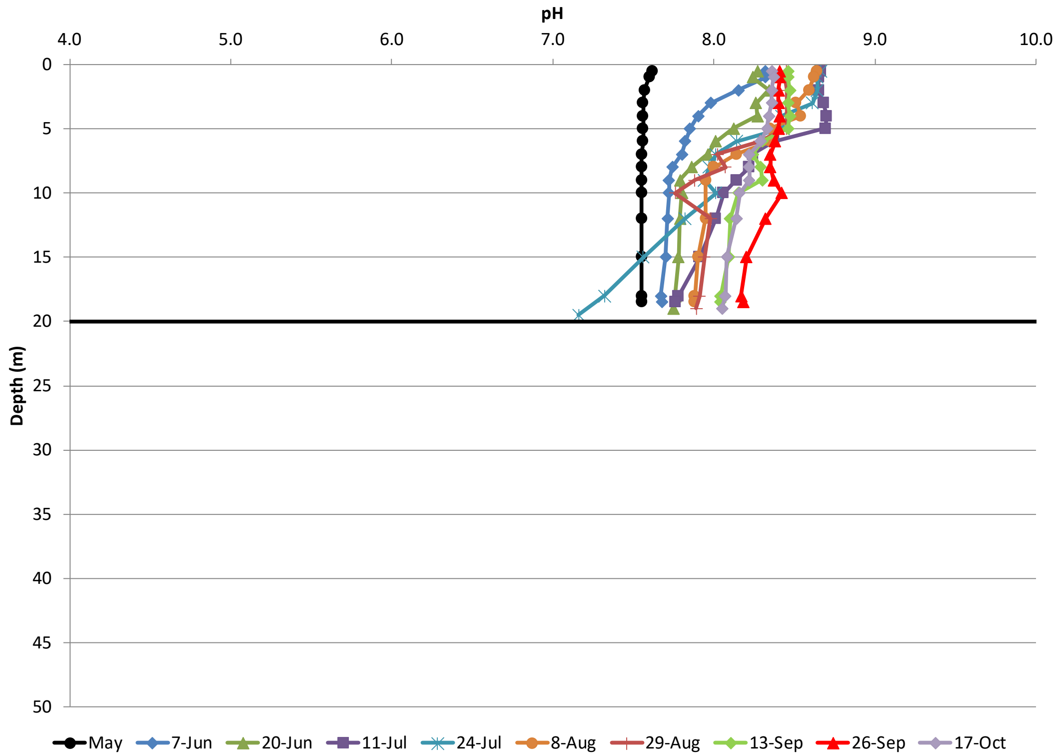

Figure 45. pH Profiles at Station LL3, May-October 2018

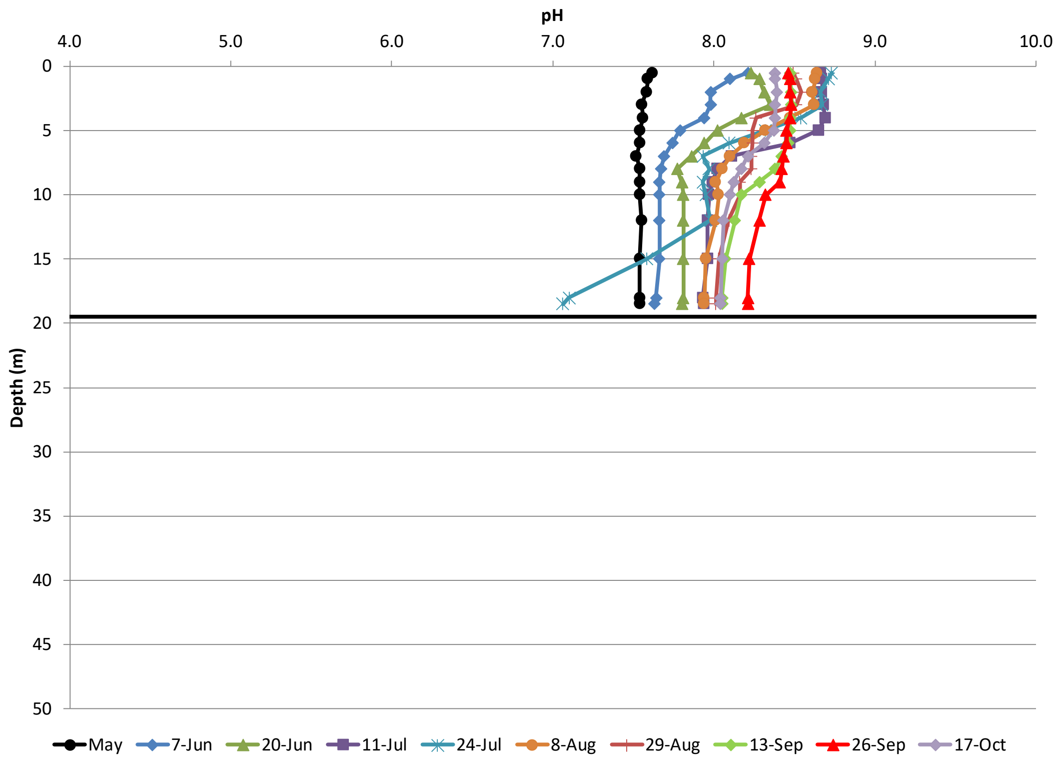

Figure 46. pH Profiles at Station LL3a, May-October 2018

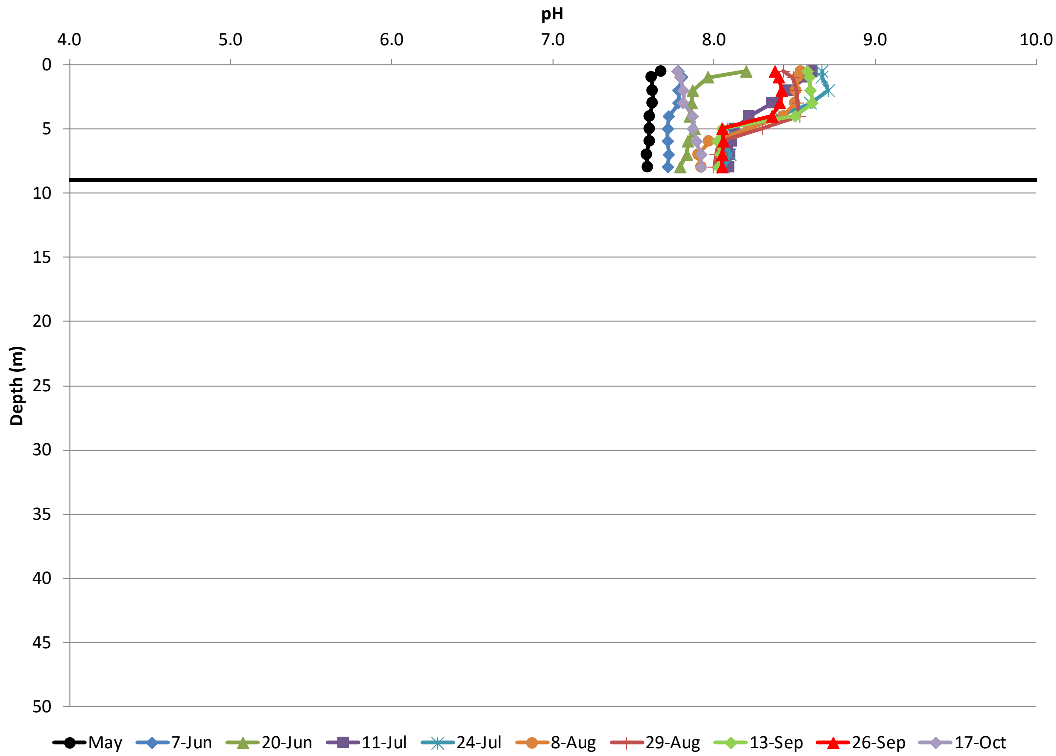

Figure 47. pH Profiles at Station LL4, May-October 2018

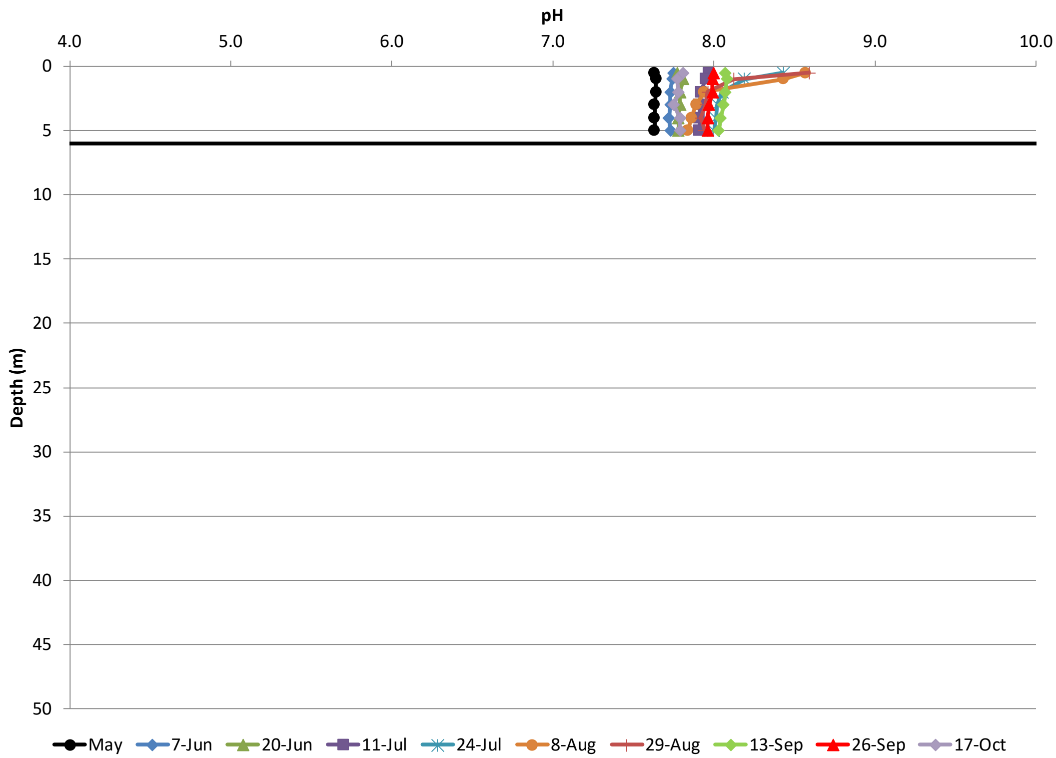

Figure 48. pH Profiles at Station LL5, May-October 2018

3.2.5 TRANSPARENCY (SECCHI DISK DEPTH)

Transparency ranged from 1.9 to 7.1 m throughout the reservoir during 2018 (Figures 49 through 58). The maximums occurred during late September at the majority of lacustrine stations and LL5, late July at LL2b, LL3, and LL3, and in October at LL4. The minimums for all stations were in May when inflow was highest and light attenuation was affected by non-algal particulate matter.

As is the case for most reservoirs with relatively large inflows carrying non-algal suspended matter, transparency increased down-reservoir with greatest transparency occurring in the lacustrine zone. Much of that trend was likely due to longer water retention time that prompts a greater loss of particulate matter through settling, as well as plunging inflows that tend to isolate the lacustrine epilimnion allowing even more settling time from the upper layer. Nevertheless, such high transparency also reflects the low phytoplankton content, which is the principal attenuator of light penetration, despite the longer epilimnetic residence time that allow phytoplankton biomass to accumulate.

Whole-reservoir, area-weighted mean transparency during June – October of 2010-2018 was 4.8 ± 0.31 m, which is greater than the meso-oligotrophic boundary of 4.0 m. In contrast, mean transparency during that period in 1971-1977, before phosphorus reduction, was 2.4 ± 0.44 m, and after reduction, 3.3 ± 0.39 m.

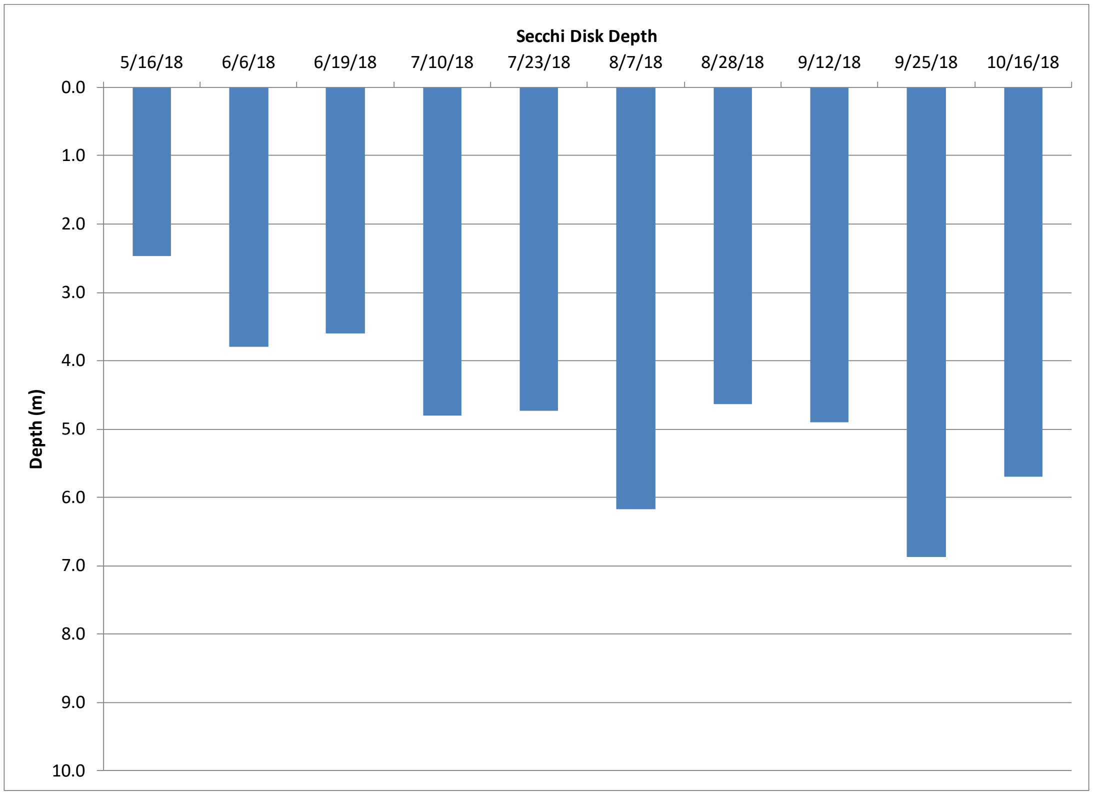

Figure 49. Secchi Disk Depths (m) for Station LL0, May-October 2018

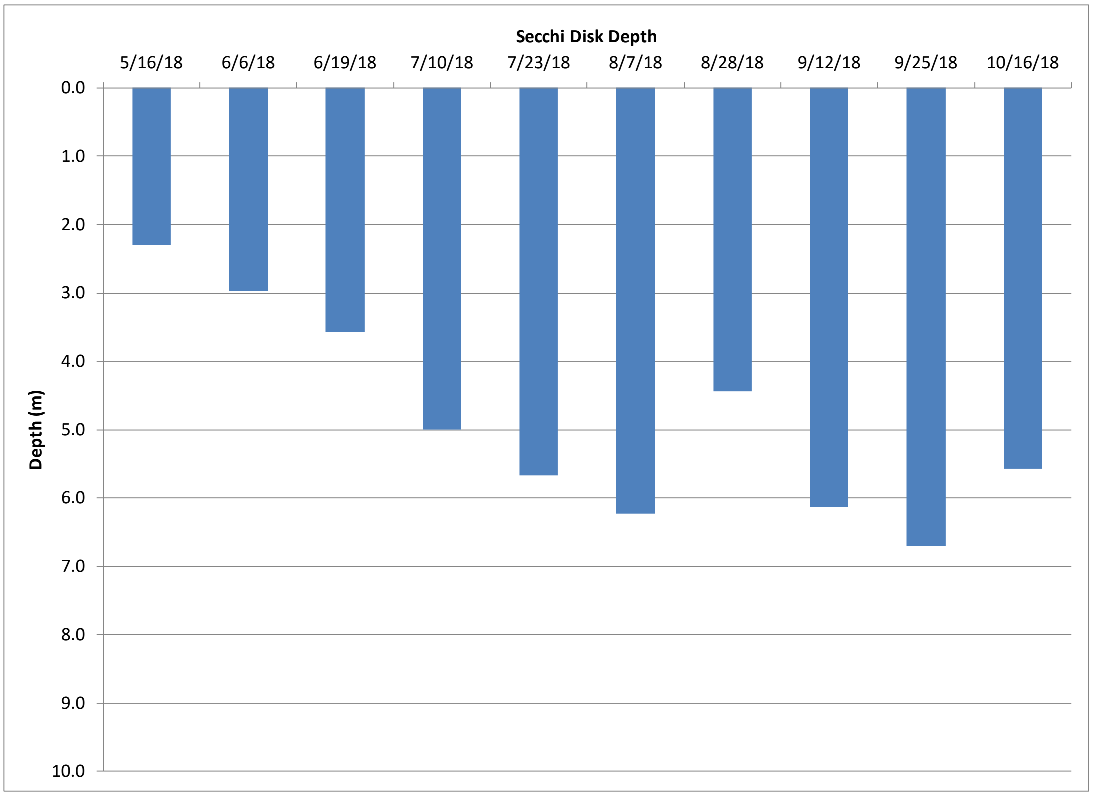

Figure 50. Secchi Disk Depths (m) at Station LL1, May-October 2018

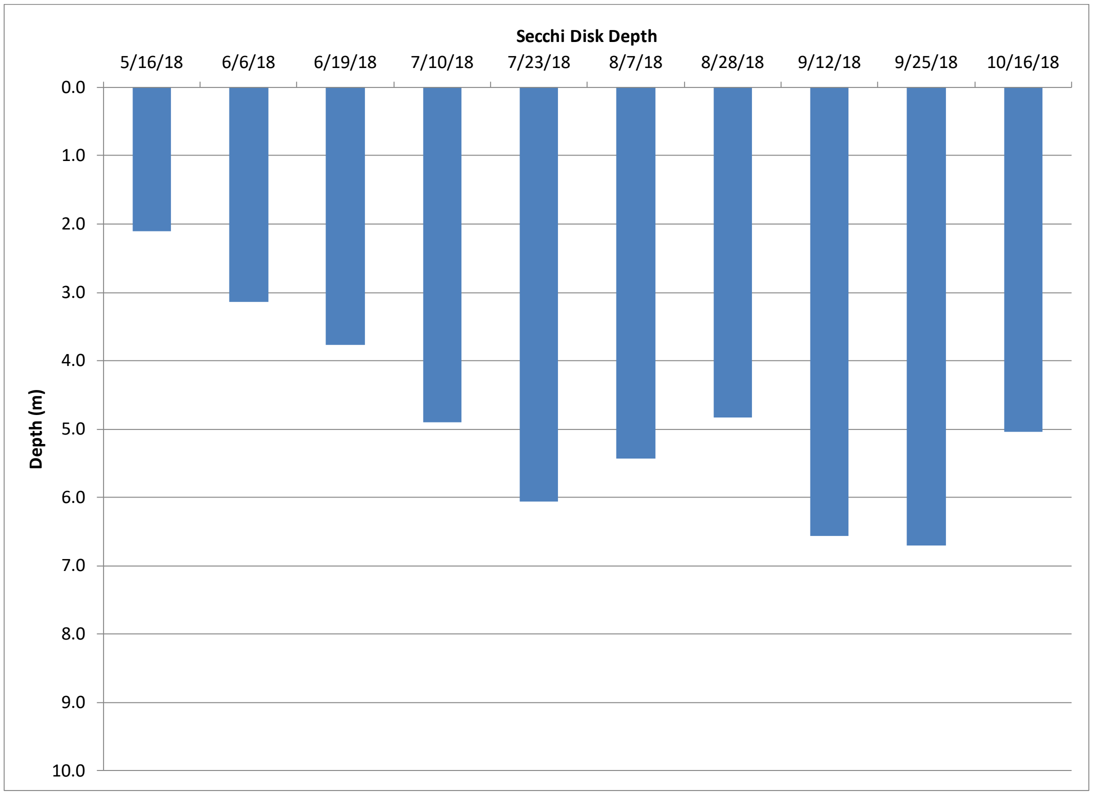

Figure 51. Secchi Disk Depths (m) at Station LL1a, May-October 2018

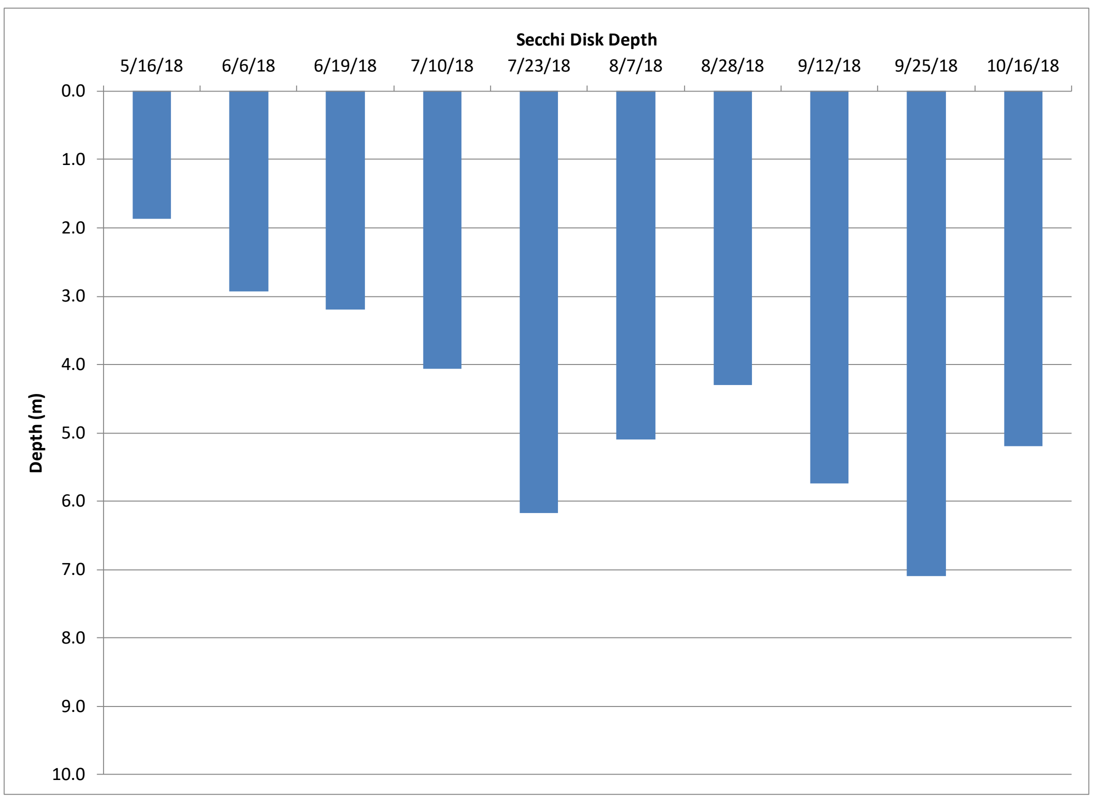

Figure 52. Secchi Disk Depths (m) at Station LL2, May-October 2018

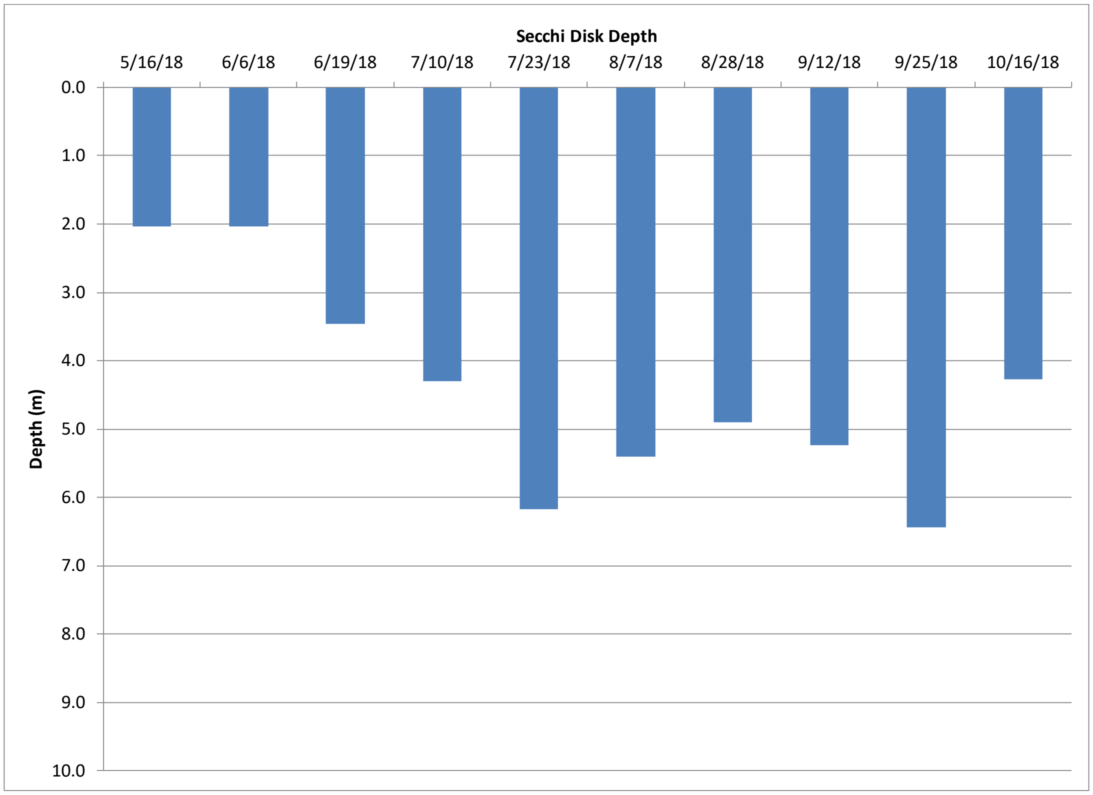

Figure 53. Secchi Disk Depths (m) at Station LL2a, May-October 2018

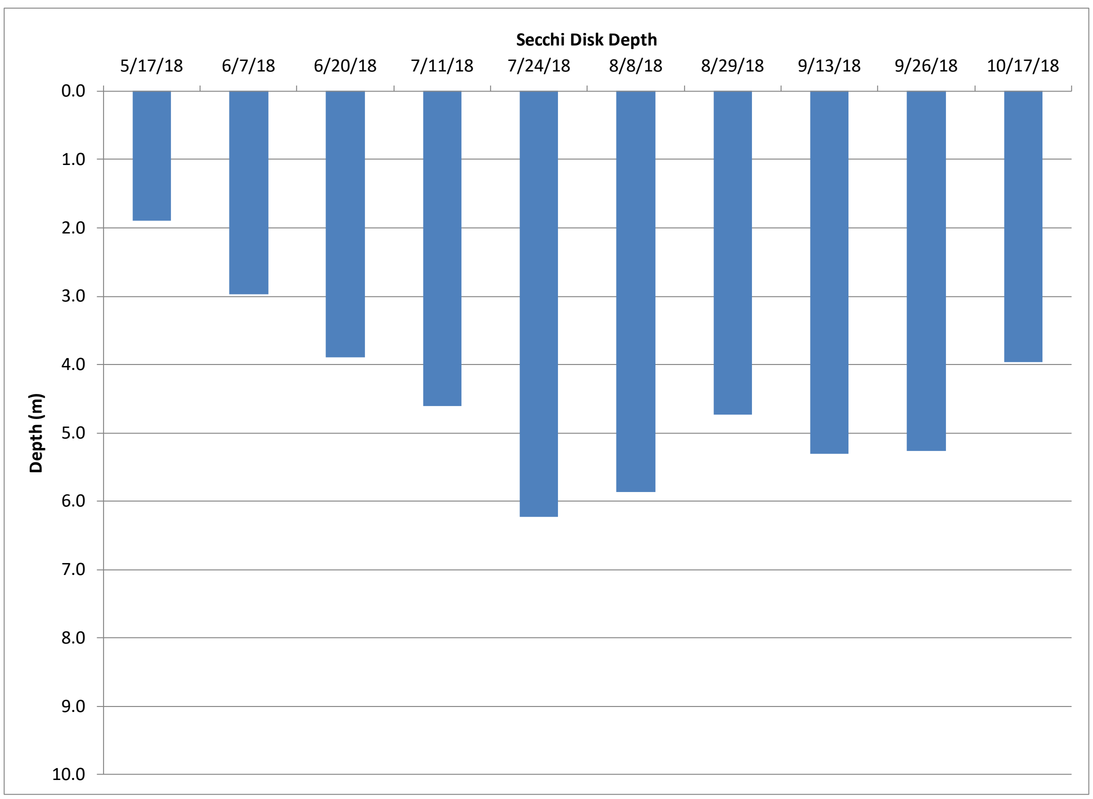

Figure 54. Secchi Disk Depths (m) at Station LL2b, May-October 2018

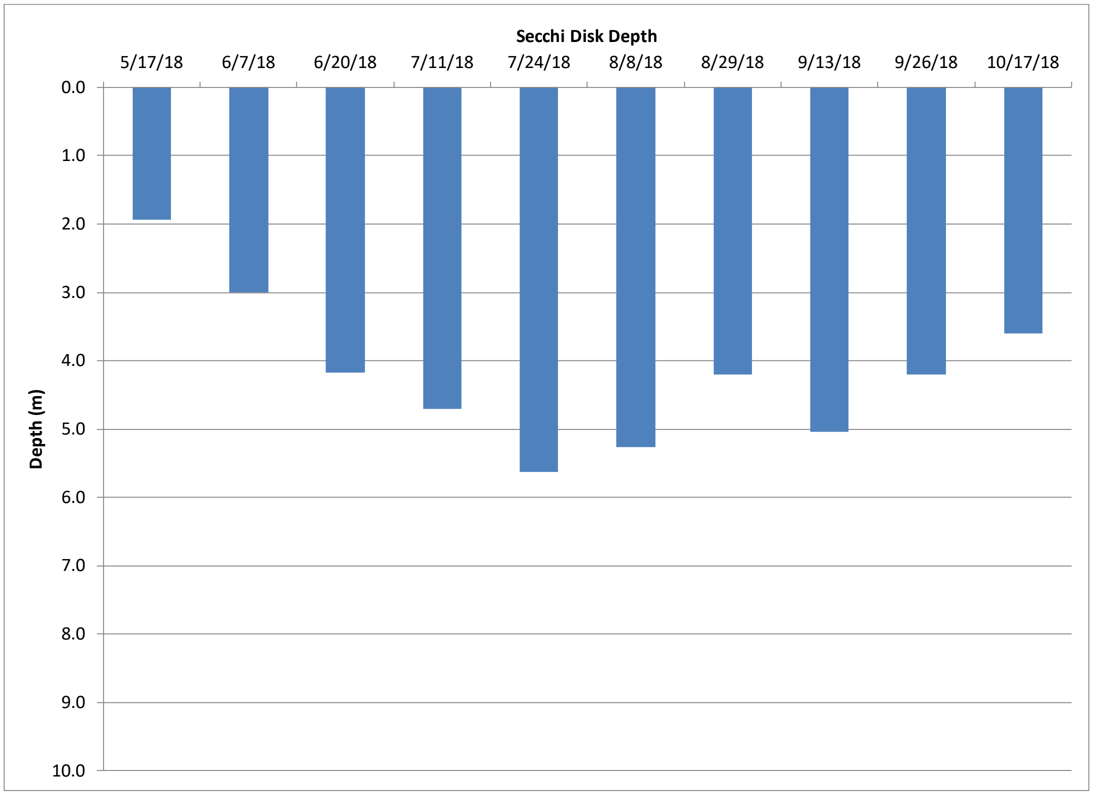

Figure 55. Secchi Disk Depths (m) at Station LL3, May-October 2018

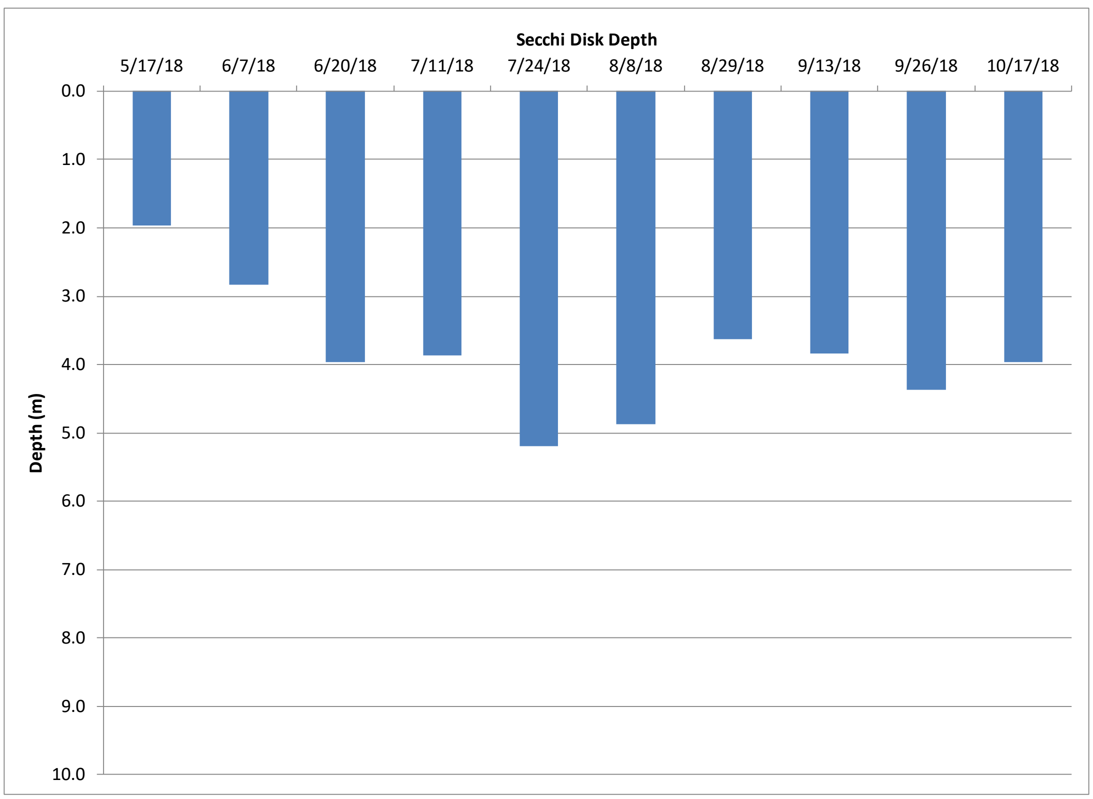

Figure 56. Secchi Disk Depths (m) at Station LL3a, May-October 2018

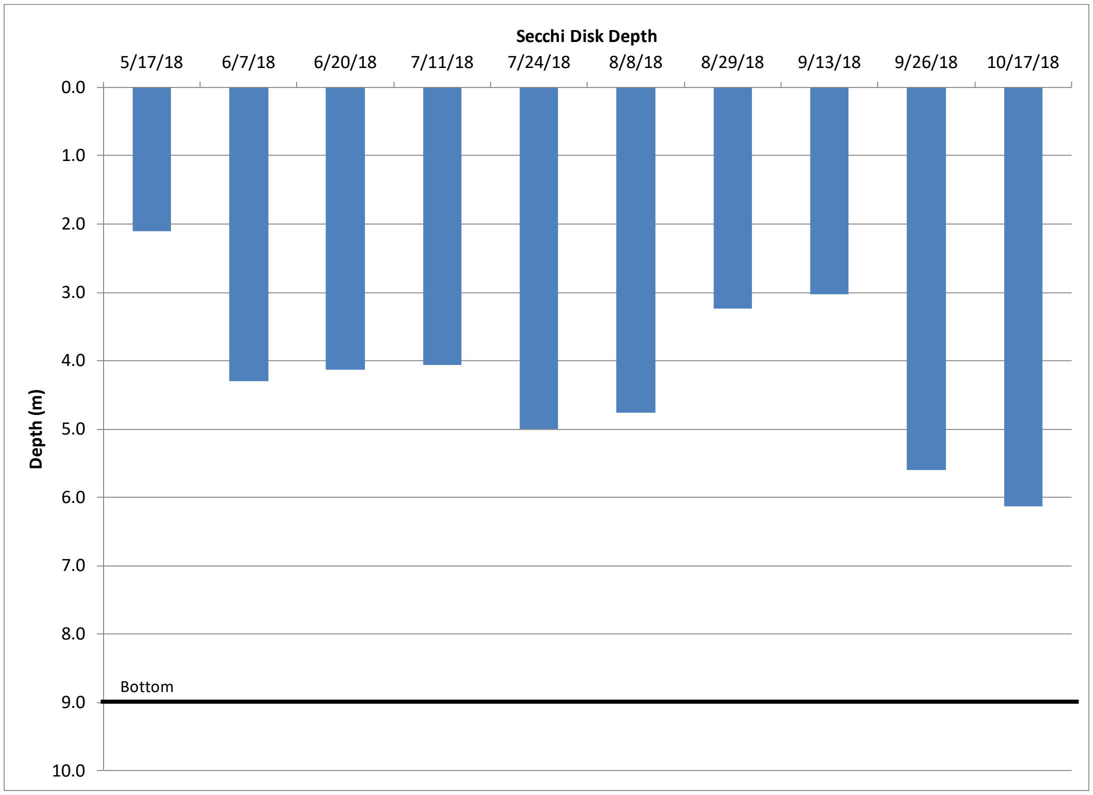

Figure 57. Secchi Disk Depths (m) at Station LL4, May-October 2018

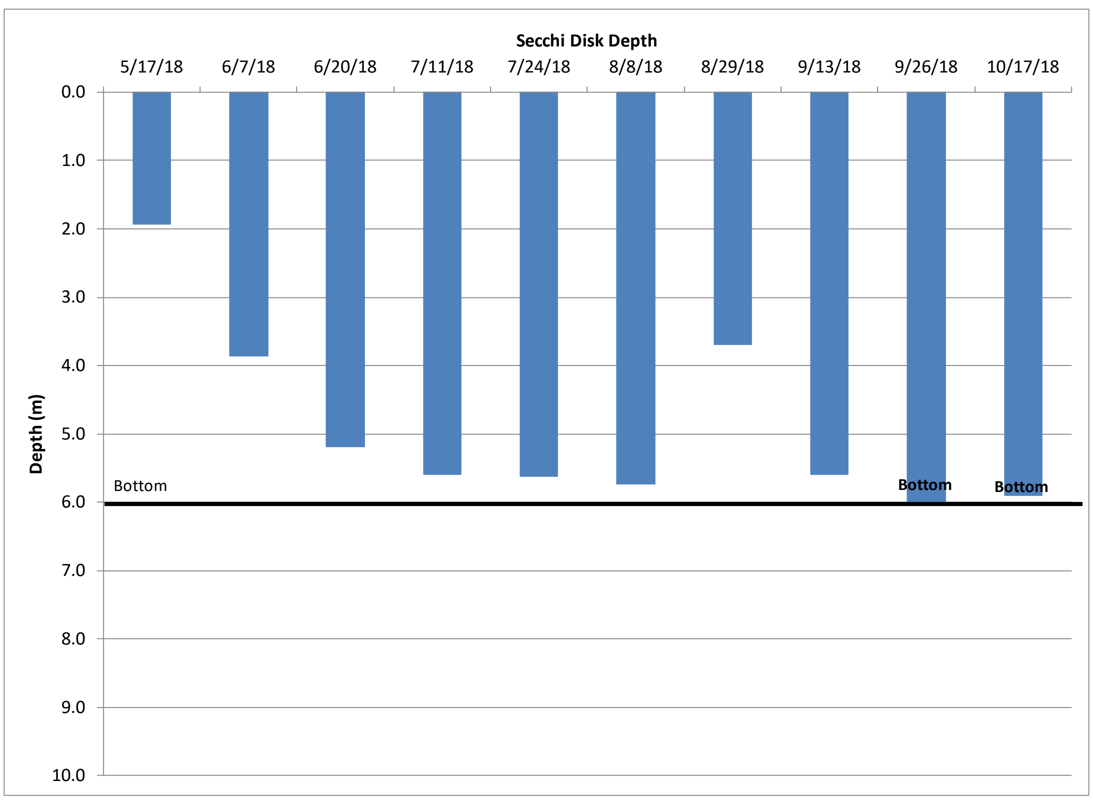

Figure 58. Secchi Disk Depths (m) at Station LL5, May-October 2018

3.2.6 ZOOPLANKTON

As usual, rotifers and nauplii dominated zooplankton density (numerical abundance) during spring and summer throughout the reservoir (Figures 59 through 78). Rotifers were least abundant in the riverine zone with highest densities exceeding 100 #/L at several sites, although rotifer densities were usually higher in spring at the deepest sites as was the case in 2013 – 2017. Rotifers are relatively small and did not contribute much to biomass. This pattern is similar to that in 2017. Nauplii were also abundant at most stations during 2018.

High rotifer densities at deeper sites in the spring are likely because they are detritus and bacteria feeders; abundance of such organic particles may occur at high concentrations in the upper hypolimnion and lower metalimnion and account for high densities despite the dilution effect of deep net hauls. High rotifer densities above 100 #/L were observed at various sites throughout the period in 2016 and 2017 as well.

Rotifer density, as well as other zooplankton species, declined sharply at station LL5 in late September and October 2018, although densities remained relatively high at LL4 in late September. The decline at LL5 corresponded to destratification of the water column and a decrease in water residence time with the start of higher inflows.

Cladocerans (*Cladocera*) are the largest zooplankters, which accounts for their dominance of biomass at most of the deeper stations (Figures 59-78). Cladocerans dominated biomass at LL4 in July 2018 with relatively high levels in August and September as well. Cladoceran biomass at LL5 was relatively low for most of the year with the exception of late July and early August when there was slightly more cladoceran biomass than other groups. *Calanoid* copepods were usually less important, especially at deeper stations, in contrast to natural lakes in which they usually dominate the biomass in the spring. *Calanoid* copepod biomass was high during the late summer and into fall at LL3a and LL4 but declined at LL5 with increased inflow and reduced retention time, similar to 2017.

Density and biomass of cladocerans, as well as other groups, were likely artificially reduced at the deeper lacustrine stations because they were sampled by net hauls from approximately 1 m off the reservoir bottom to the surface. Large mobile zooplankton are much less likely to occur in the hypolimnion where food particles, especially phytoplankton, are scarce and DO tends to be low. In fact, mobile zooplankters migrate vertically and diurnally in and out of the lighted zone. There was little pattern to cladoceran density with maximums of 3-5 #/L occurring at different times during the summer, although densities from 2-4 #/L occurred consistently at LL4 (Figure 75). Overall, density of cladocerans in 2018 was much lower than observed in 2017 when maximums densities ranged between 5 and 13 #/L. Biomass of cladocerans ranged from 0.0 to 40.9 µg/L at all stations in 2018, with the highest biomass observed at LL1a (35.7 µg/L) and LL3a (40.9 µg/L) in early August and October, respectively.

Multiplying concentrations by net haul depth, which results in density and biomass per surface area, tends to even out the dilution effect among station (Tables 7 – 13). Depth-corrected average seasonal cladoceran concentrations were higher at the deepest stations than other sites in 2018 (28-

29 x10^3/m^2; Table 7), while concentrations at LL5 were the lowest (5 x10^3/m^2; Table 7). That comparison demonstrates the dilution effect caused by sampling water volumes below the photic zone. However, densities at LL5 were rather consistently less than at LL4 over the past seven years, whether depth-corrected for depth or not. There were variations in depth-corrected densities among years. Cladoceran densities in 2018 were slightly greater than in 2017 at the deeper stations and slightly less at the shallower stations. Overall, depth-corrected average seasonal cladoceran densities in both 2017 and 2018 were lower than in any previous year (Tables 7 – 13).

Cladoceran densities and biomass varied among upper reservoir sites (LL4 – LL5) over the past seven years. Densities were highest in 2013, averaging 26 and 56 #/L and over 200 x10^3/m^2, but were much lower in other years, usually around 10 #/L or less (Tables 7 – 13). Mean densities at LL4 – LL5, corrected for net-haul depth (no/m^2), were also much lower in 2012, 2014, 2015, 2016, 2017, and 2018 than in 2013. Season (June-October) average water residence times in the transition/riverine zones may explain some of the differences in density among the years. Water residence time likely has an important effect on both phytoplankton and zooplankton density, and even more so for zooplankton, due to their slower growth rate. However, average seasonal residence time was not a good indicator of zooplankton density in the upper reservoir due to seasonal variability in hydraulic conditions. For example, all zooplankton populations were thriving well at LL5 during most of the dry, low inflow summer, but were greatly depleted in late September and October when inflows increased.

Cladoceran density was substantially less at all stations in 2018, similar to that in 2017 and 2016, in contrast to the high densities in 2013 (Tables 7 – 13). The highest summer mean cladoceran areal density in 2018 was at station LL1a with about 29 x10^3/m^2, which was slightly higher than that in 2017 at station LL4 with just over 26 x10^3/m^2. Mean areal density in 2017 at station LL4 was half that in 2016 (56 x10^3/m^2), which was half that in 2015. Densities were also low at lacustrine sites in 2017, but relatively high at deeper lacustrine sites in 2018. Mean density was over 254 x10^3/m^2 at station LL0 in 2013, which was 9 times more than in 2018, and several times greater than in other years (2014 – 2017). Very high densities occurred in 2013 at LL5 as well.

Areal densities were usually rather uniform throughout the reservoir during any years, probably reflecting year-to-years differences in phytoplankton productivity. Also, density per unit volume were not that great, compared to lakes of similar trophic status. Assuming most cladocerans are usually in the top 10m, densities were usually 2-10 #/L at LL4 and about the same in the lacustrine zone.

Cladoceran (including *Daphnia*) biomass was largest during summer at most sites in 2018, reaching a maximum of 36 µg/L in early August at LL1a (Figure 64). Biomass was also high at station LL3a in October at 41 µg/L (Figure 74). These maximums are slightly lower than in 2017 (59 µg/L) at LL4 in July, and especially lower than 146 µg/L at LL5 in 2016 and 184 µg/L at LL4 in 2015. Also, maximums were 150 µg/L or more at LL3 and LL4 in 2014, and well over 200 µg/L at LL4 and LL5 in 2013. Cladoceran biomass was highly variable from year-to-year, which is not unusual given variations in their phytoplankton food resource and predation by planktivorous fishes. However, cladoceran biomass was relatively low compared to lakes of similar trophic state.

Average May-October biomass was usually less than 5 µg/L at most sites. Average biomass of cladoceran in Lake Sammamish was 15 µg/L during 1972 and 1973 (Pederson et al. 1976).

Cladocerans are usually the most important grazers, due to their large size, with *Daphnia* being the largest and most efficient grazer on phytoplankton. *Daphnia* size ranged from 0.7 to 2.2 mm in 2018, similar to size ranges in previous years. At that large size, they are the favorite food for visually-feeding, planktivorous fish. However, *Daphnia* usually had "helmets" throughout the summer in 2014, as well as 2012 and 2013. Helmets usually indicate low predation. *Daphnia* helmets were not reported in 2015 through 2018. The presence of helmets may not be due to fish predation in this case, because a large number of catchable size trout were stocked in the reservoir beginning in June of 2014 (155,000) as well as in May of 2015 (155,000), with no such intensive stocking in 2012 or 2013 when *Daphnia* were helmeted.

Table 7. Summer Mean Density of *Cladocera* at the Ten Stations in 2018 Corrected for Depth of Net Haul to Aerial Units

Station	Net Haul Depth (m)	No./L	No./m^3	No./m^2 x10^3
LL0	47	0.60	602	28
LL1	33	0.84	840	28
LL1a	29	0.99	990	29
LL2	25	0.56	558	14
LL2a	23.5	0.82	821	19
LL2b	20	1.06	1,059	21
LL3	19	0.89	892	17
LL3a	18.5	1.02	1,021	19
LL4	8	2.16	2,164	17
LL5	5	1.07	1,074	5

Table 8. Summer Mean Density of *Cladocera* at the Six Stations in 2012 Corrected for Depth of Net Haul to Aerial Units

Station	Net Haul Depth (m)	No./L	No./m^3	No./m^2 x10^3
LL0	48	1.70	1,702	81
LL1	33	1.14	1,143	37
LL2	25	1.86	1,861	46
LL3	18	2.98	2,984	53
LL4	8	9.97	9,967	79
LL5	5	6.22	6,223	31

Table 9. Summer Mean Density of *Cladocera* at the Six Stations in 2013 Corrected for Depth of Net Haul to Aerial Units

Station	Net Haul Depth (m)	No./L	No./m^3	No./m^2 x10^3
LL0	47	5.41	5,413	254
LL1	33	4.14	4,136	136
LL2	25	4.33	4,331	108
LL3	18	5.09	5,085	91
LL4	8	25.7	25,726	205
LL5	5	56.2	56,154	280

Table 10. Summer Mean Density of *Cladocera* at the Six Stations in 2014 Corrected for Depth of Net Haul to Aerial Units

Station	Net Haul Depth (m)	No./L	No./m^3	No./m^2 x10^3
LL0	47	1.21	1,210	56
LL1	33	2.39	2,393	78
LL2	25	2.87	2,869	71
LL3	19	6.17	6,166	117
LL4	8	9.19	9,187	73
LL5	5	2.63	2,629	13

Table 11. Summer Mean Density of *Cladocera* at the Six Stations in 2015 Corrected for Depth of Net Haul to Aerial Units

Station	Net Haul Depth (m)	No./L	No./m^3	No./m^2 x10^3
LL0	47.5	0.78	781	37
LL1	33	1.00	1003	33
LL2	25	1.30	1301	32
LL3	19	3.54	3544	67
LL4	8	12.98	12977	103
LL5	5	10.31	10313	51

Table 12. Summer Mean Density of *Cladocera* at the Six Stations in 2016 Corrected for Depth of Net Haul to Aerial Units

Station	Net Haul Depth (m)	No./L	No./m^3	No./m^2 x10^3
LL0	47	0.47	475	22
LL1	33	1.15	1,152	38
LL2	25	1.43	1,426	35
LL3	19	1.90	1,897	36
LL4	8	7.05	7,051	56
LL5	5	2.21	2,213	11

Table 13. Summer Mean Density of *Cladocera* at the Six Stations in 2017 Corrected for Depth of Net Haul to Aerial Units

Station	Net Haul Depth (m)	No./L	No./m³	No./m² x10³
LL0	48	0.39	389	18
LL1	33	0.69	685	23
LL2	25	0.48	479	12
LL3	18	0.79	790	15
LL4	8	3.27	3265	26
LL5	5	1.30	1302	6.5

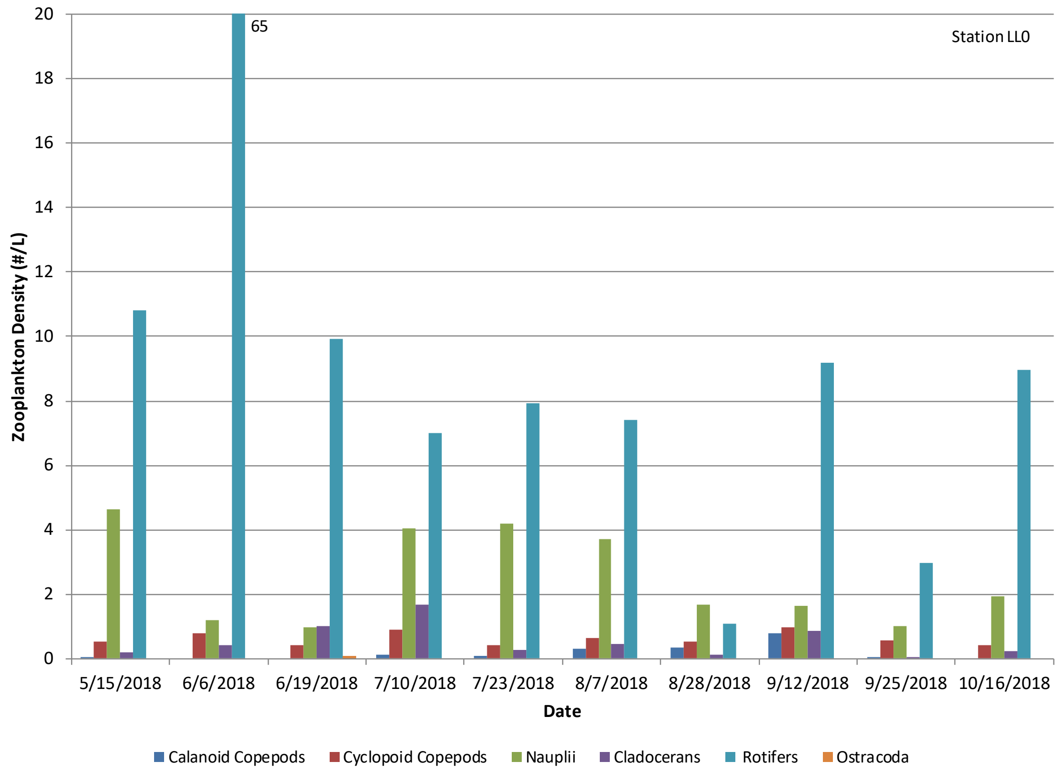

Figure 59. Zooplankton Density (#/L) at Station LL0, May-October 2018

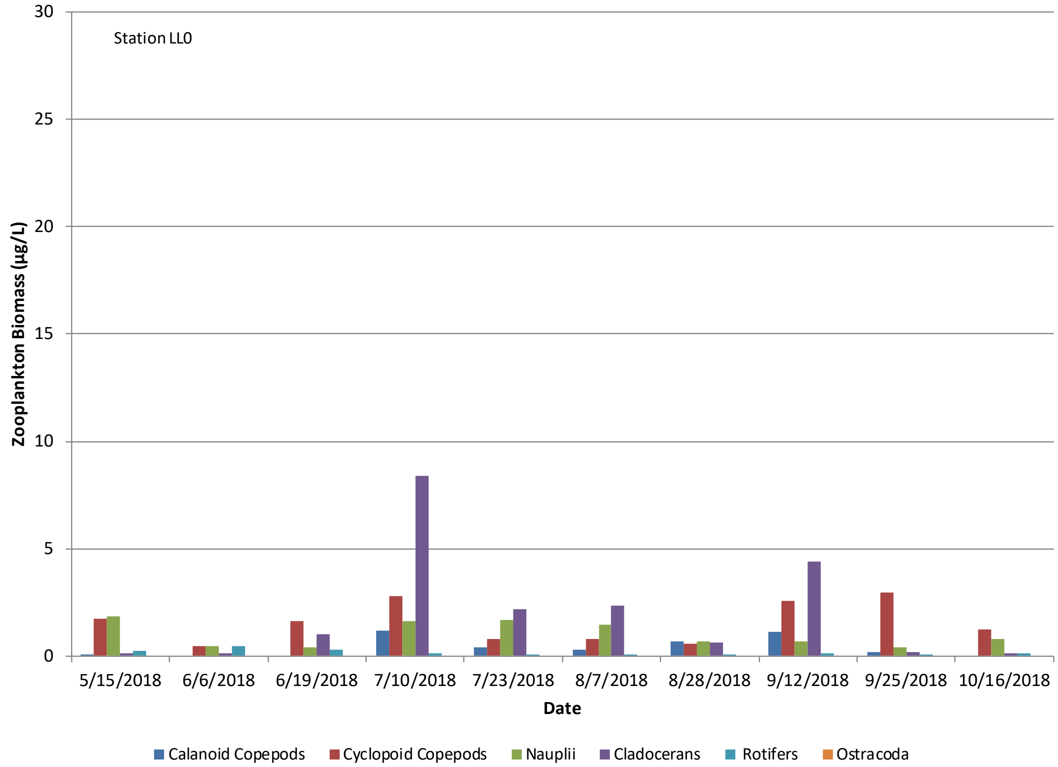

Figure 60. Zooplankton Biomass (µg/L) at Station LL0, May-October 2018

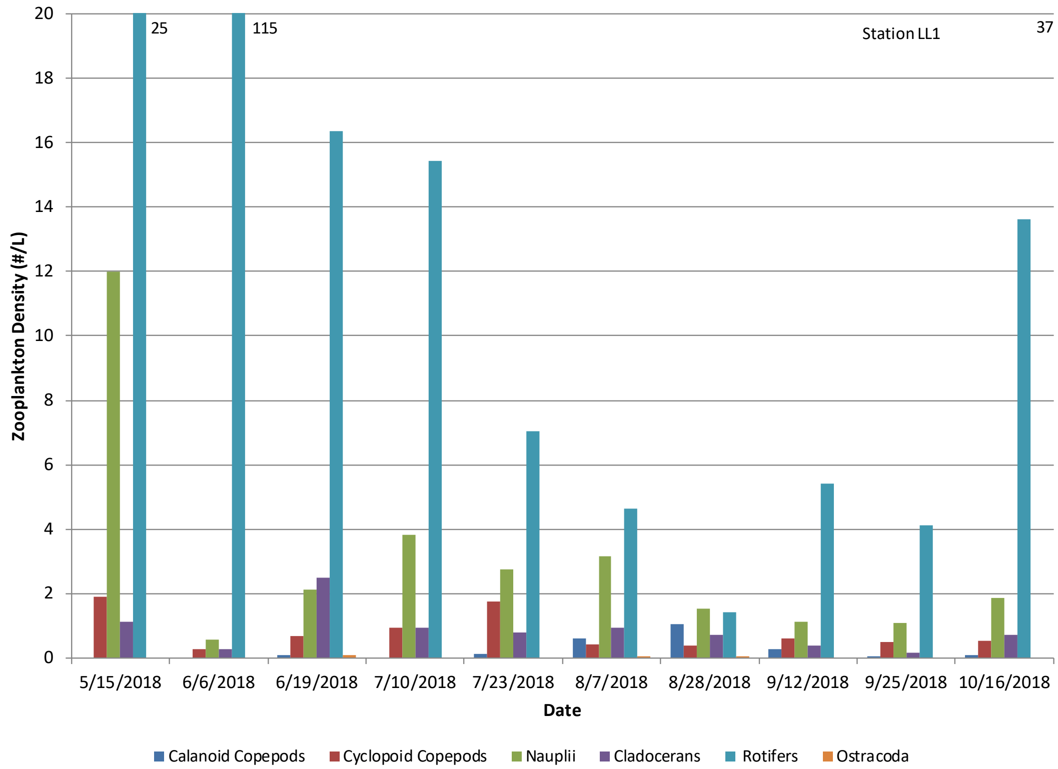

Figure 61. Zooplankton Density (#/L) at Station LL1, May-October 2018

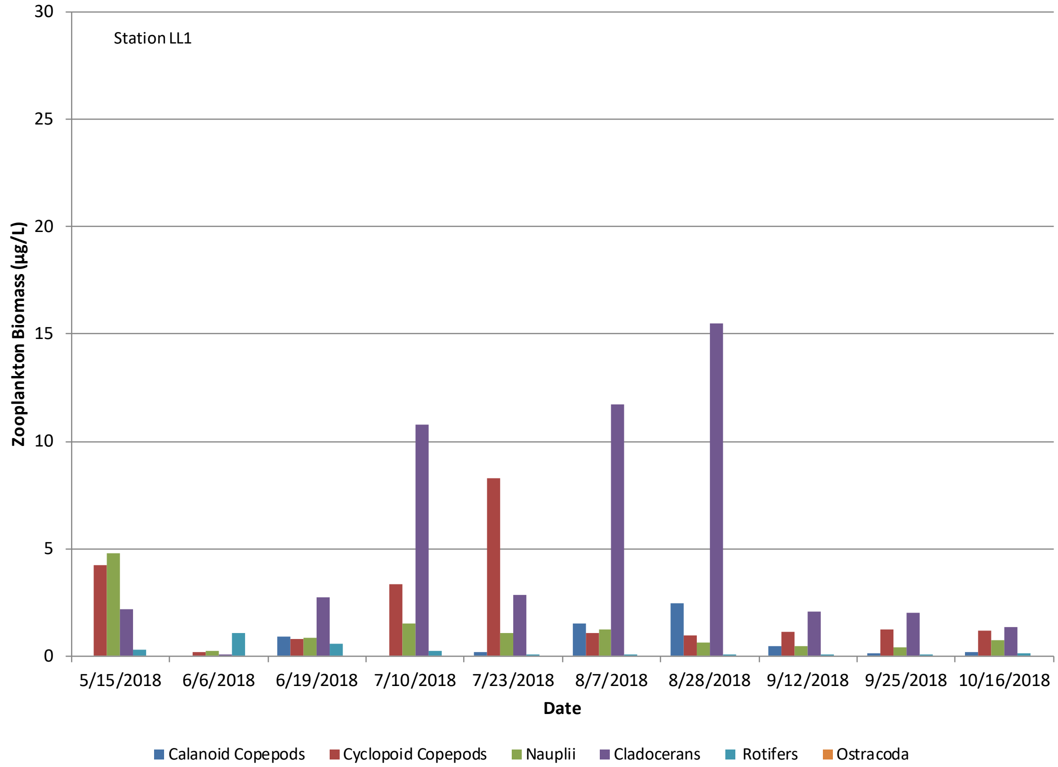

Figure 62. Zooplankton Biomass (µg/L) at Station LL1, May-October 2018

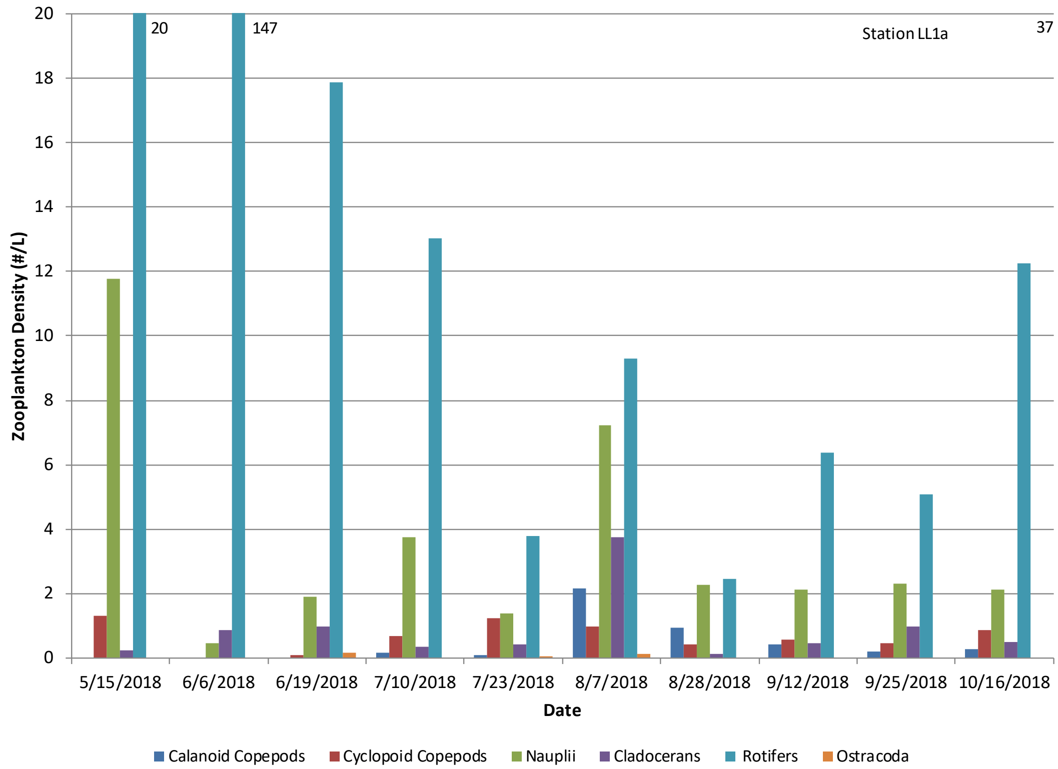

Figure 63. Zooplankton Density (#/L) at Station LL1a, May-October 2018

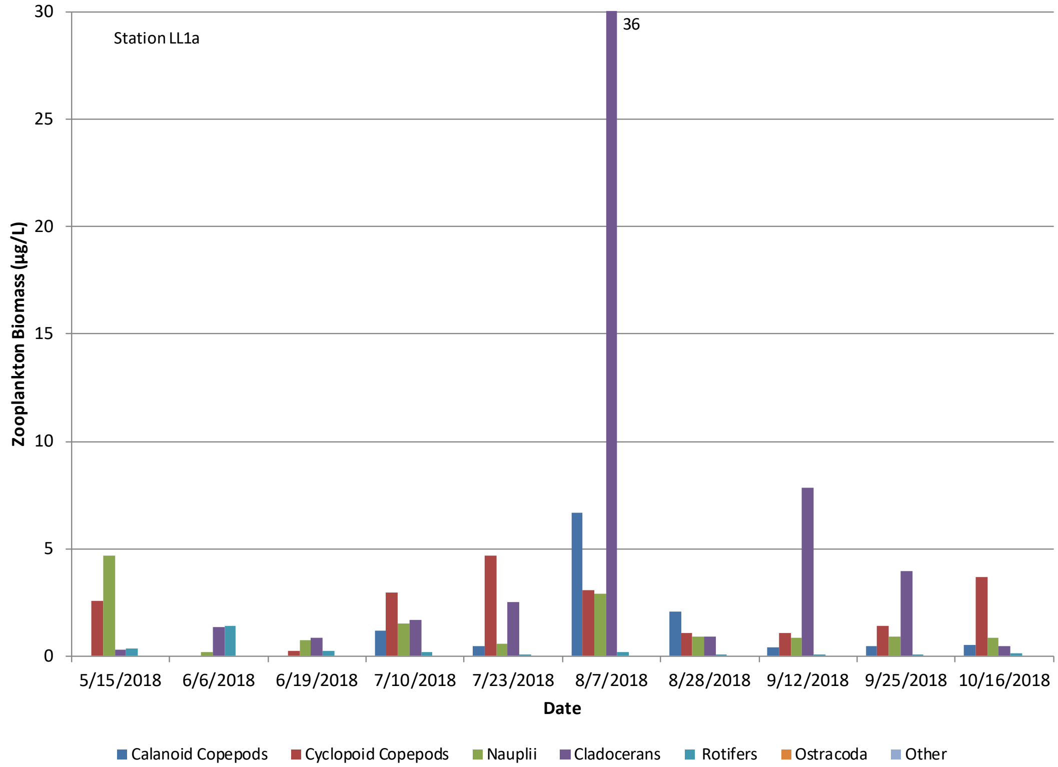

Figure 64. Zooplankton Biomass (µg/L) at Station LL1a, May-October 2018

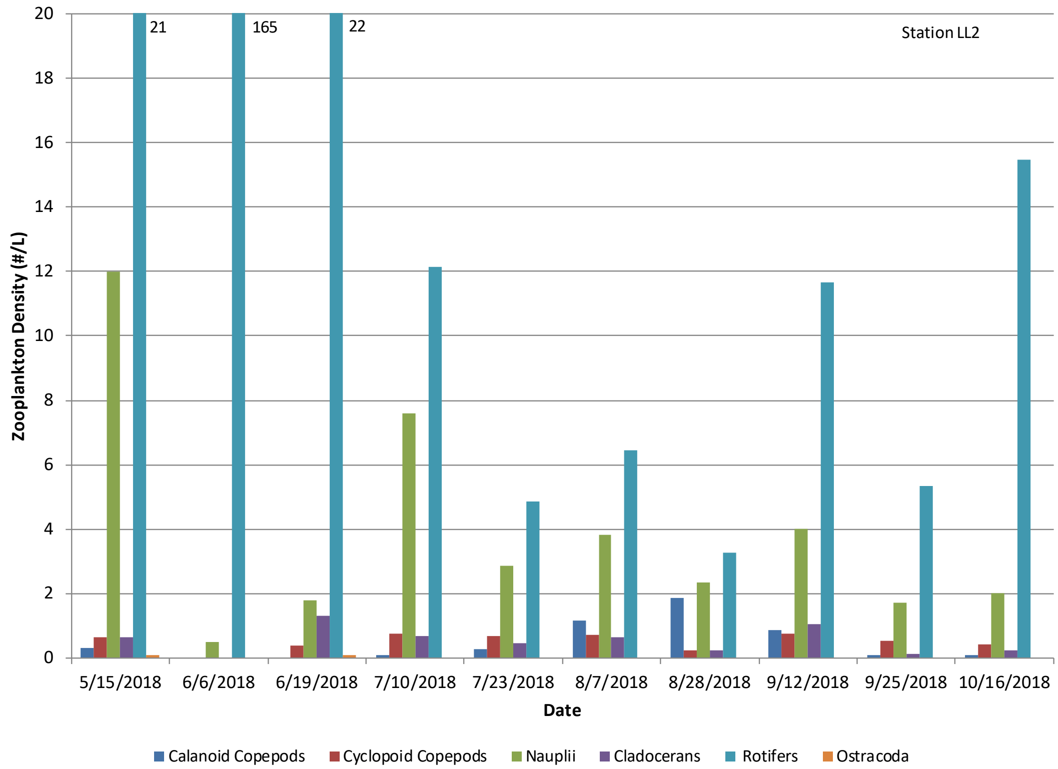

Figure 65. Zooplankton Density (#/L) at Station LL2, May-October 2018

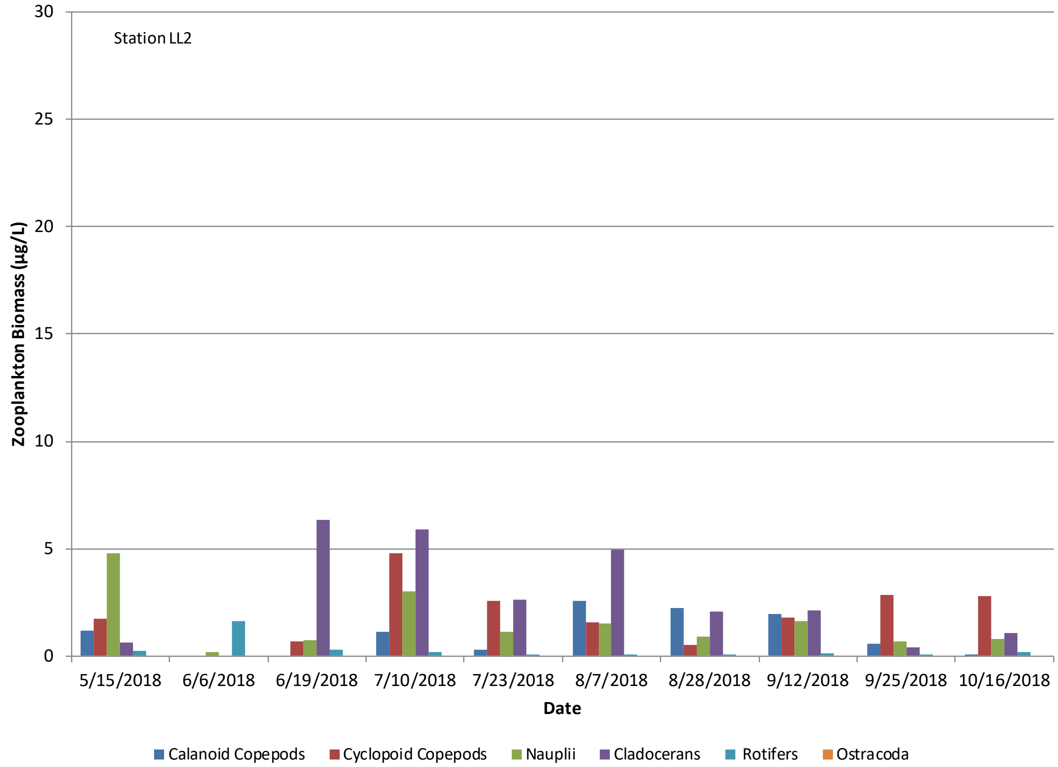

Figure 66. Zooplankton Biomass (µg/L) at Station LL2, May-October 2018

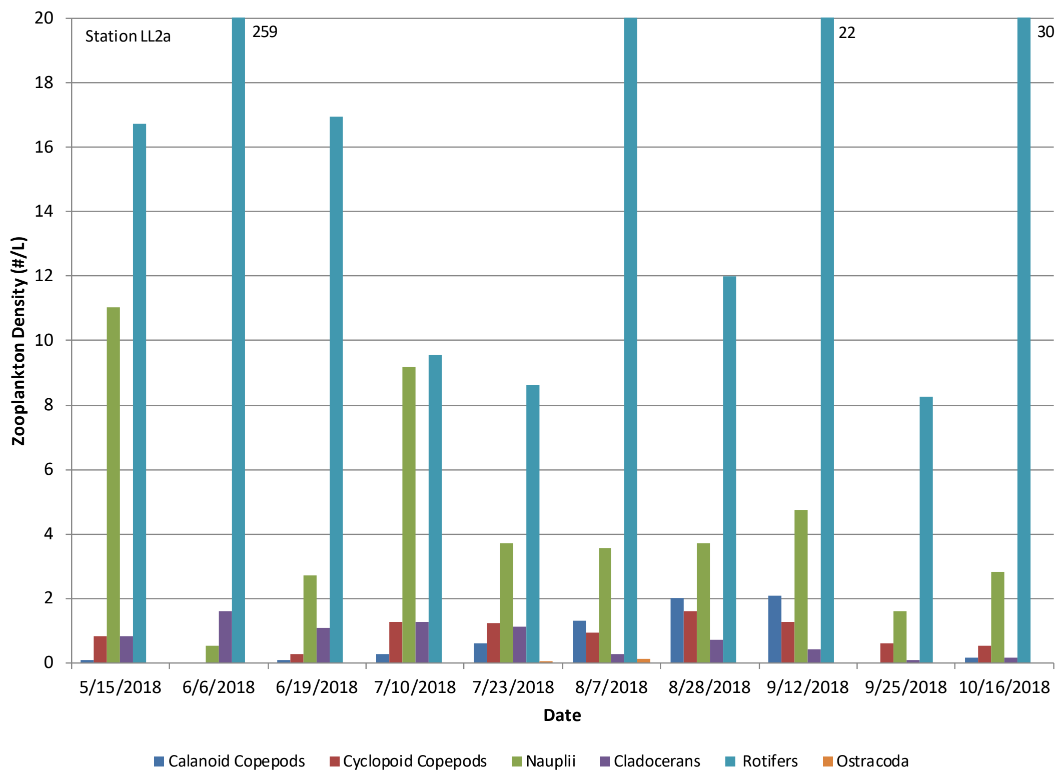

Figure 67. Zooplankton Density (#/L) at Station LL2a, May-October 2018

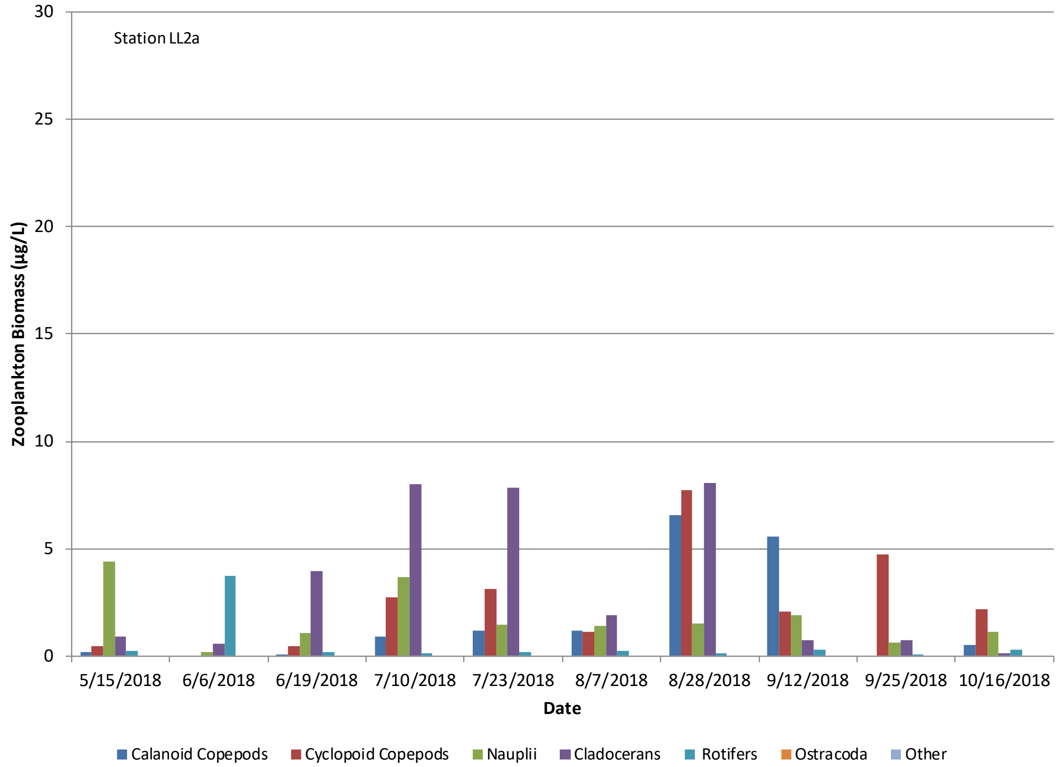

Figure 68. Zooplankton Biomass (µg/L) at Station LL2a, May-October 2018

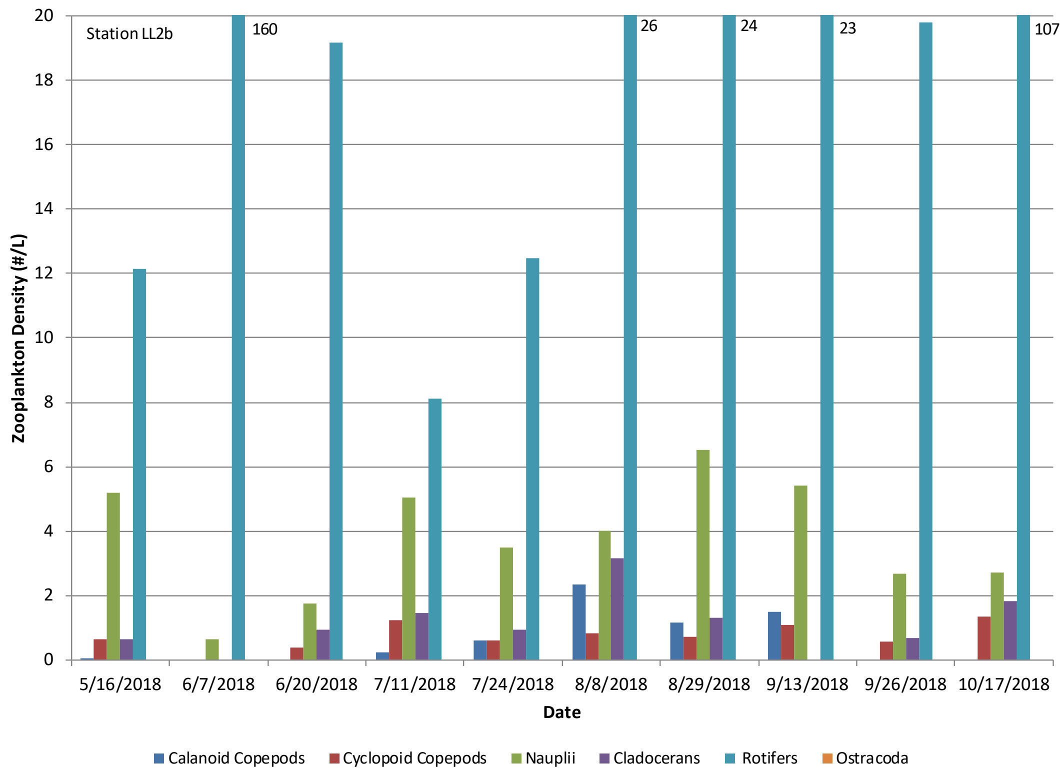

Figure 69. Zooplankton Density (#/L) at Station LL2b, May-October 2018

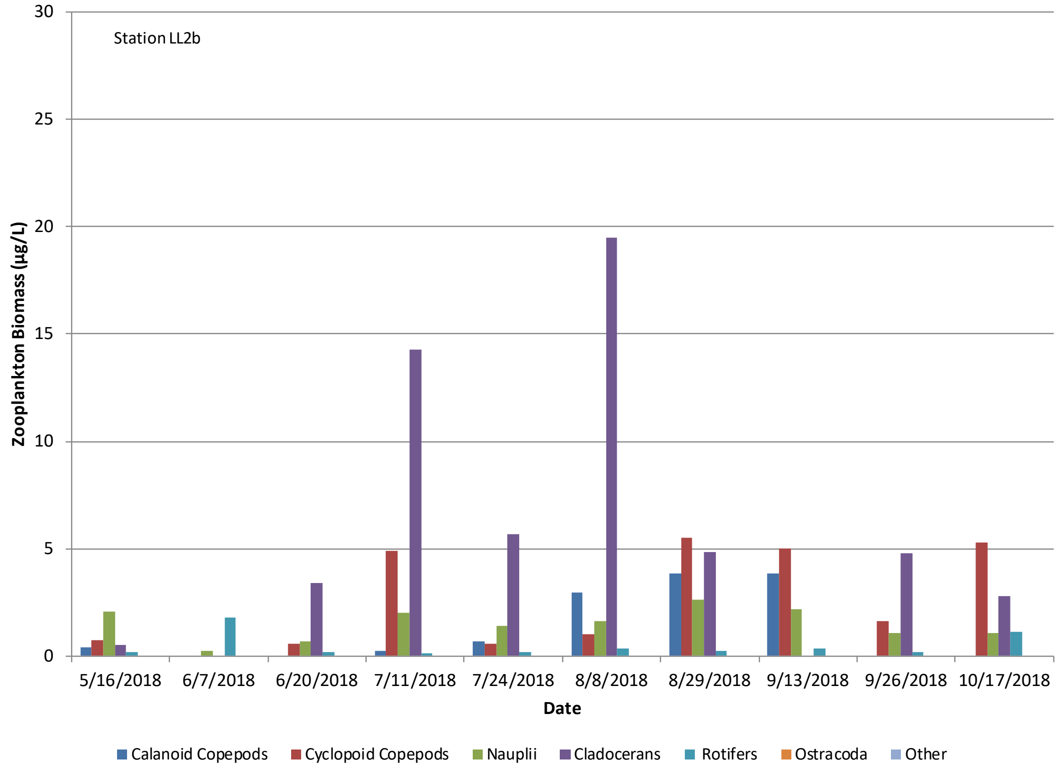

Figure 70. Zooplankton Biomass (µg/L) at Station LL2b, May-October 2018

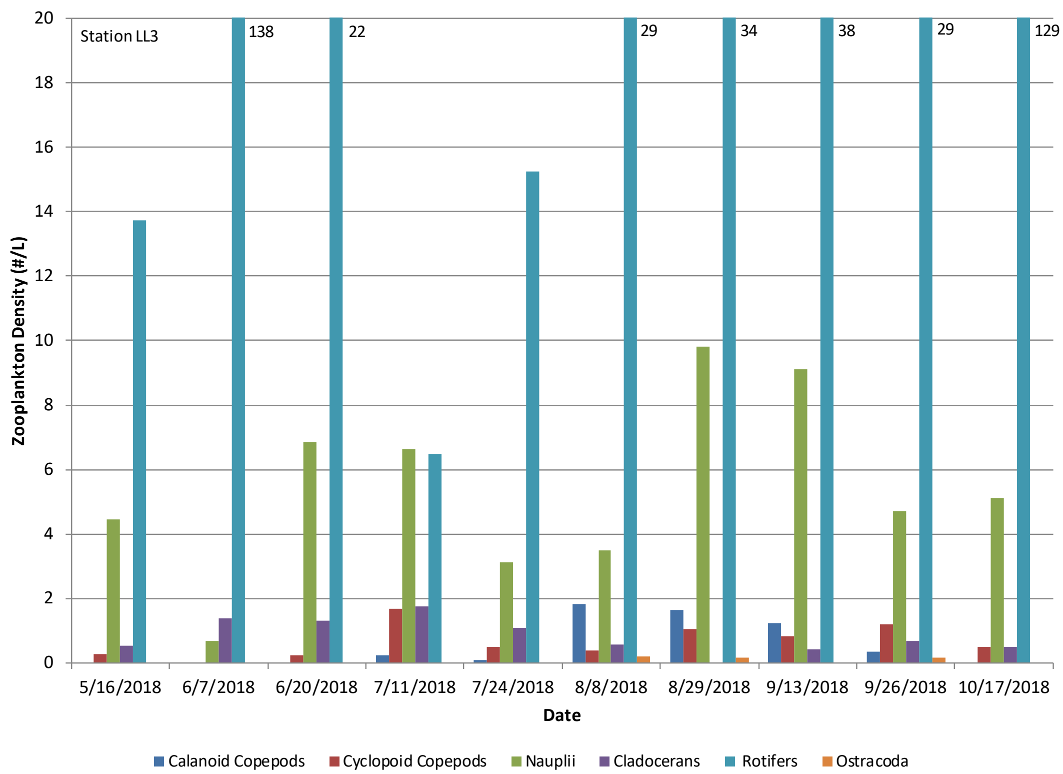

Figure 71. Zooplankton Density (#/L) at Station LL3, May-October 2018

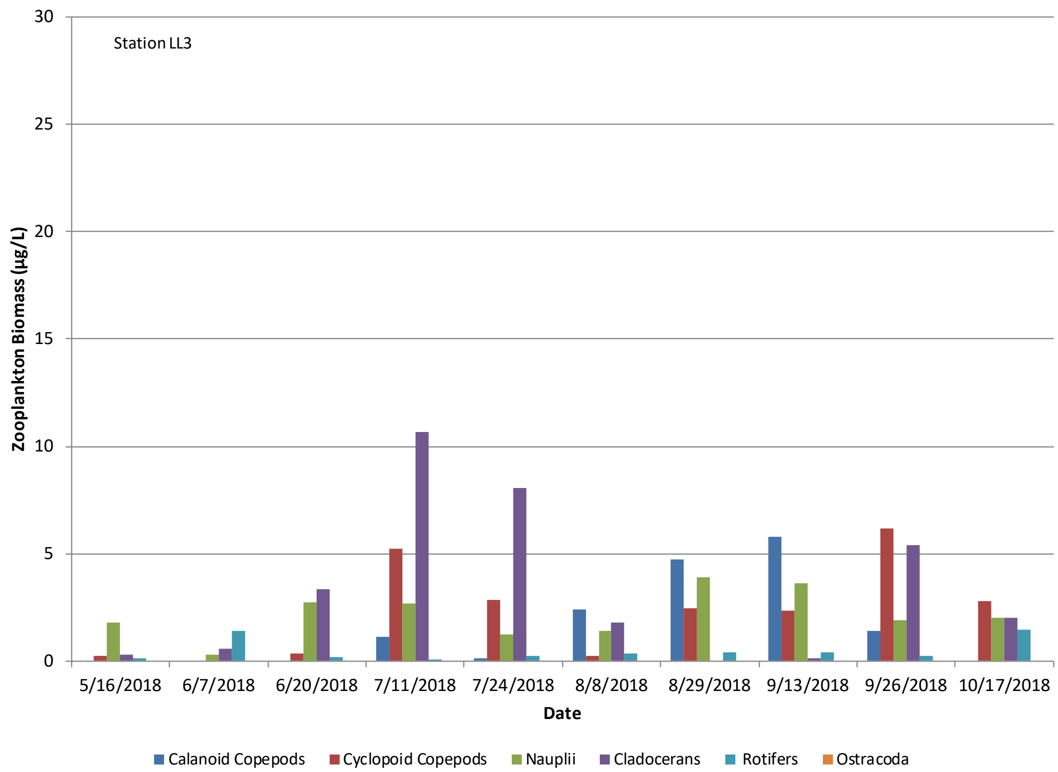

Figure 72. Zooplankton Biomass (µg/L) at Station LL3, May-October 2018

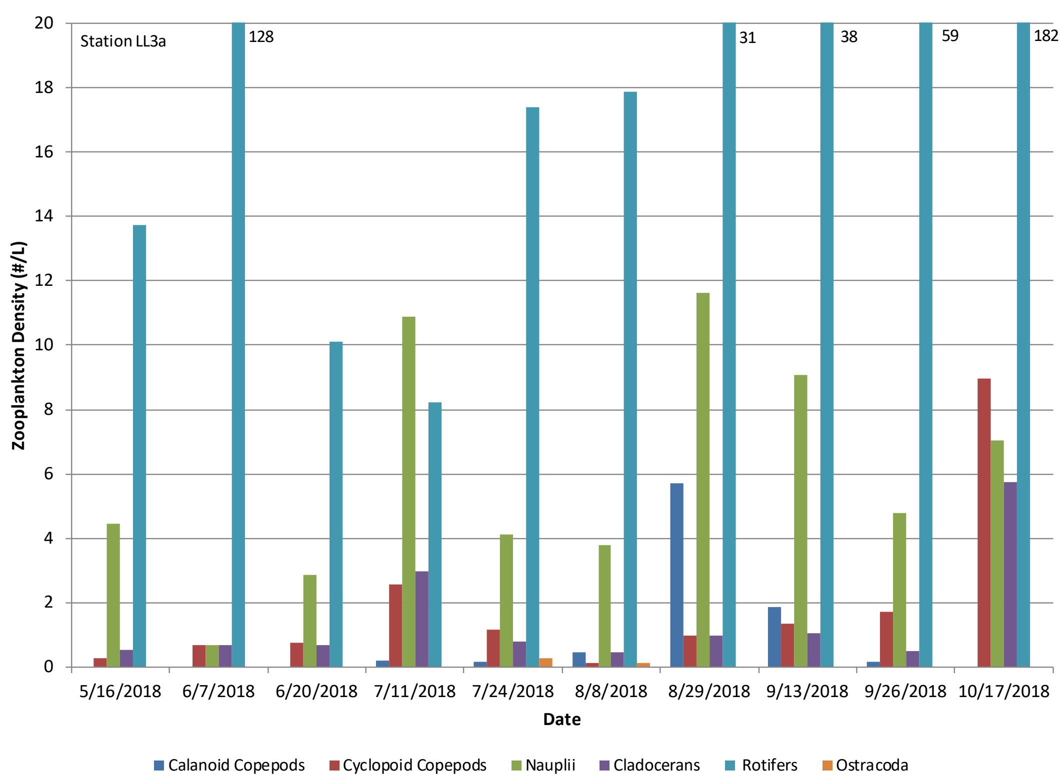

Figure 73. Zooplankton Density (#/L) at Station LL3a, May-October 2018

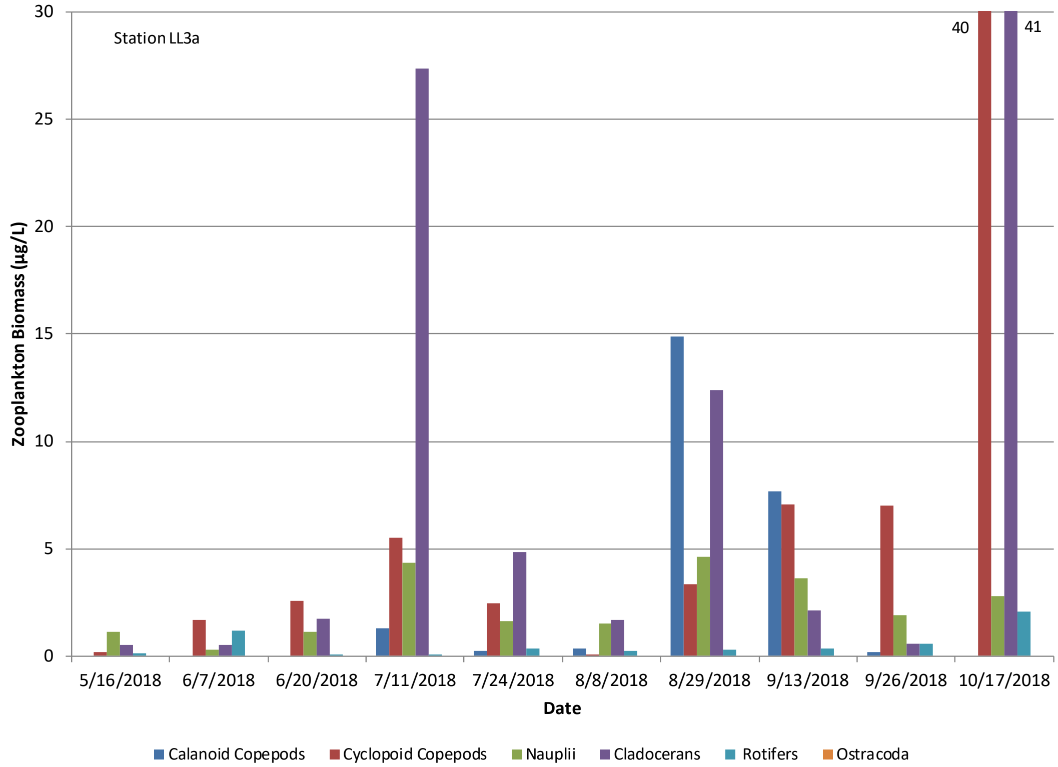

Figure 74. Zooplankton Biomass (µg/L) at Station LL3a, May-October 2018

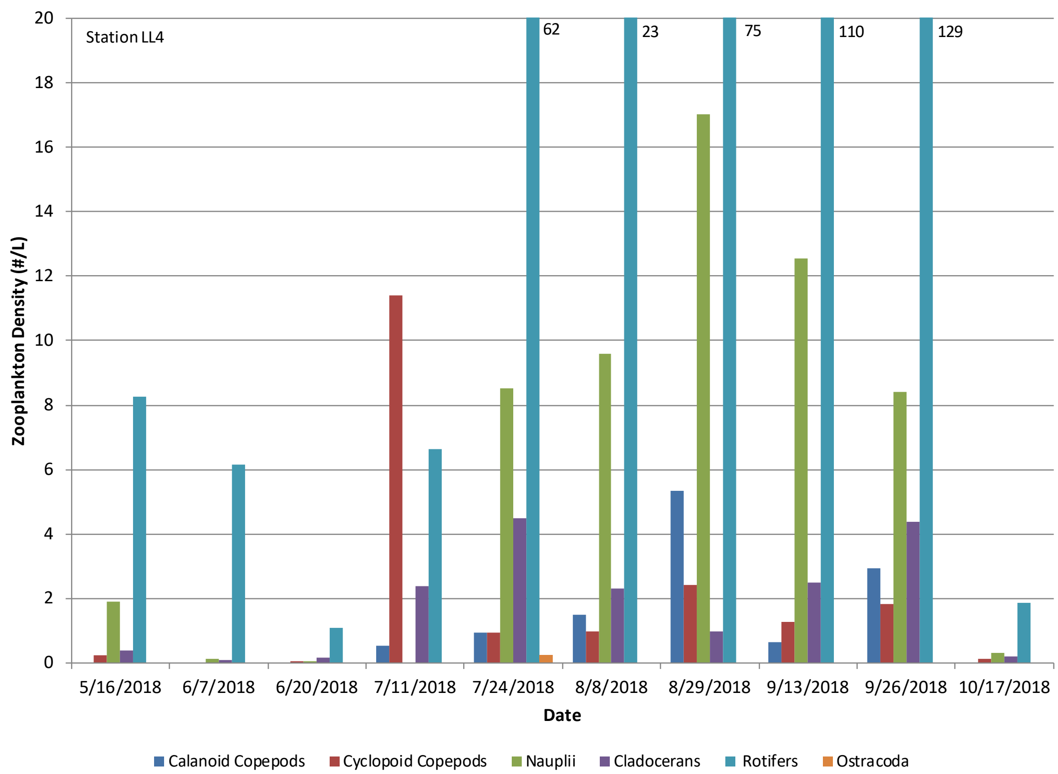

Figure 75. Zooplankton Density (#/L) at Station LL4, May-October 2018

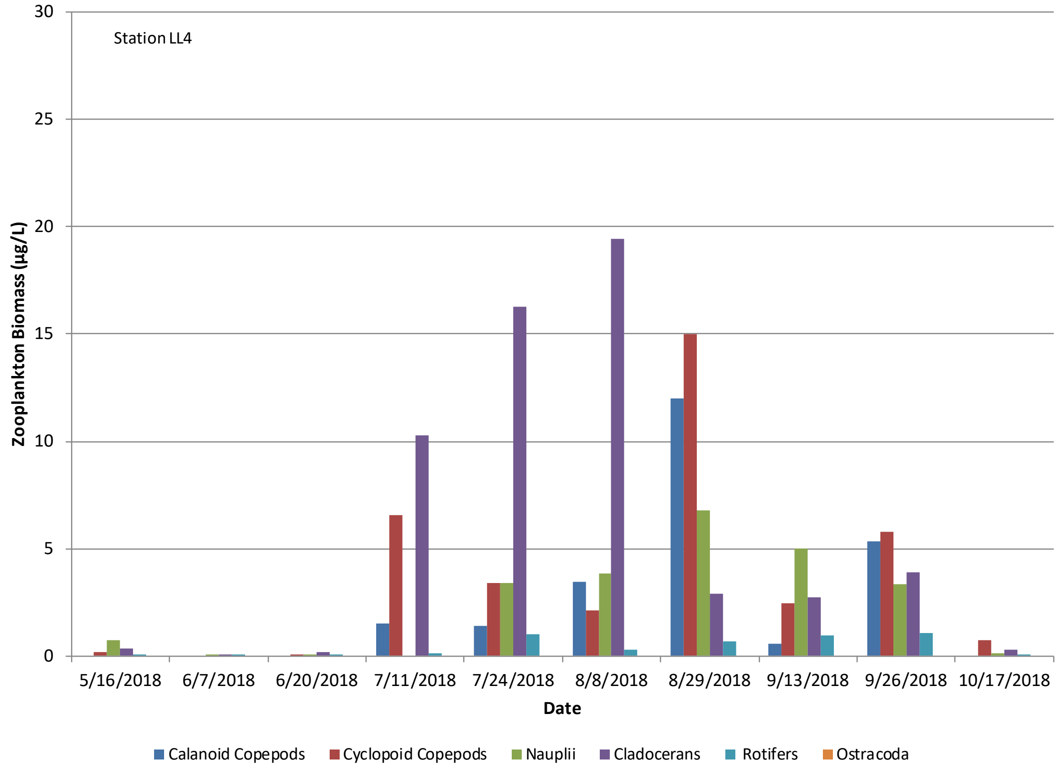

Figure 76. Zooplankton Biomass (µg/L) at Station LL4, May-October 2018

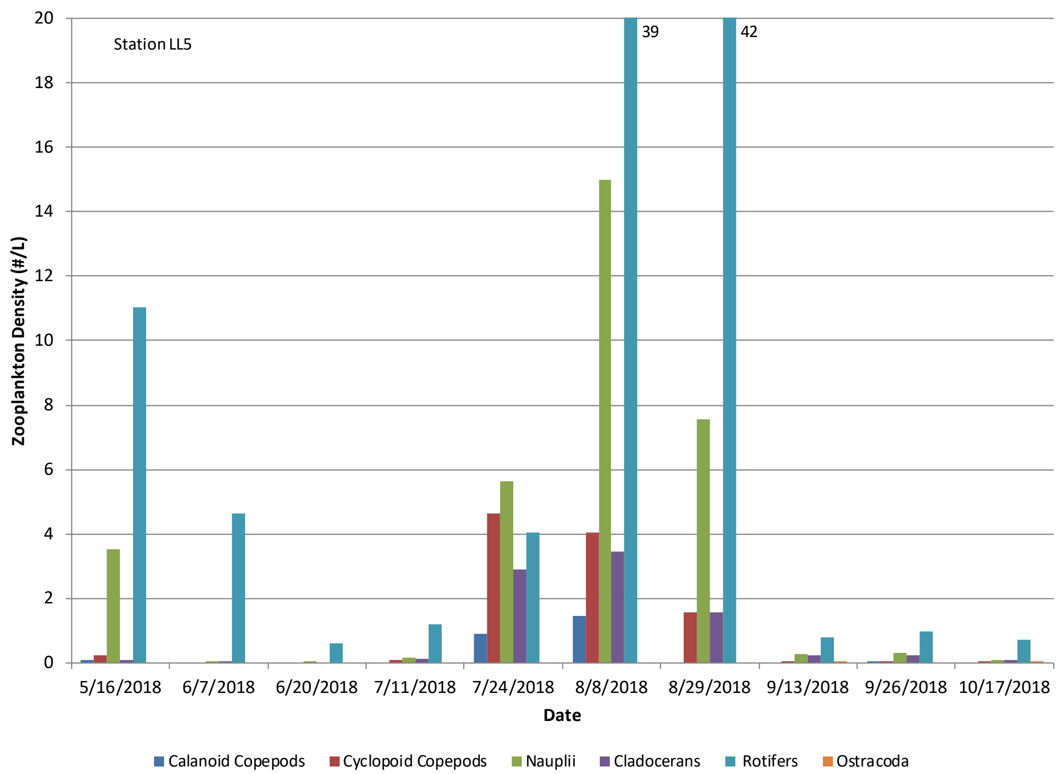

Figure 77. Zooplankton Density (#/L) at Station LL5, May-October 2018

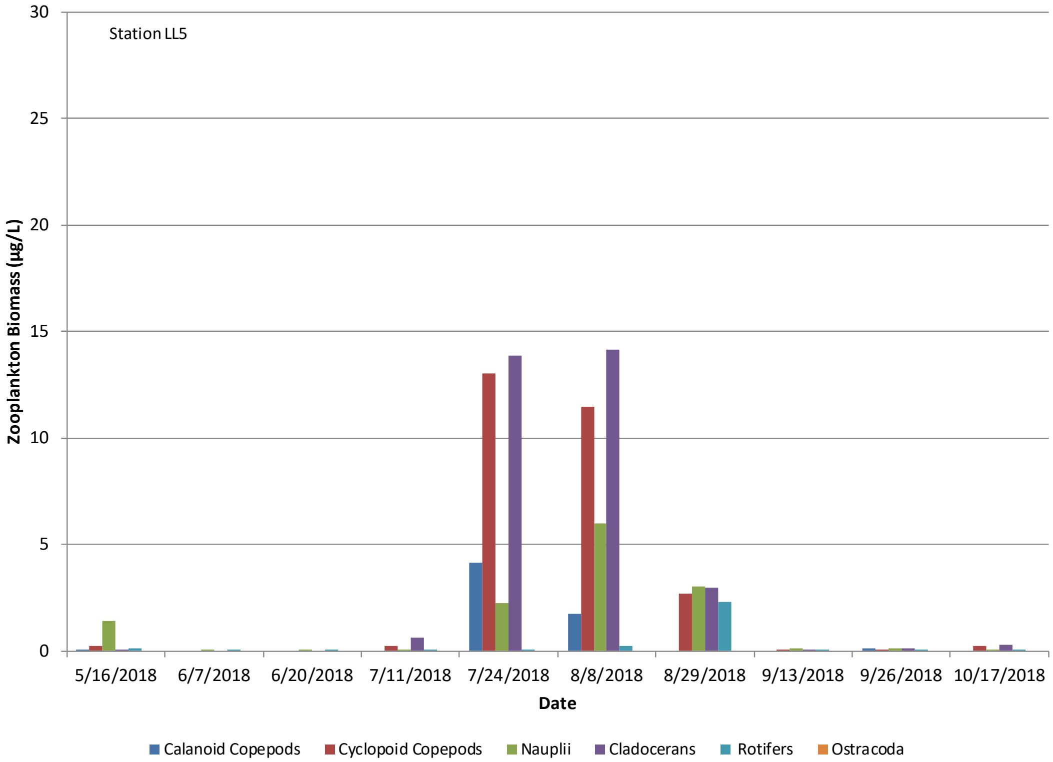

Figure 78. Zooplankton Biomass (µg/L) at Station LL5, May-October 2018

3.2.7 SPOKANE RIVER AT NINE MILE BRIDGE AND LITTLE SPOKANE RIVER NEAR MOUTH

Water quality was monitored by Ecology in the Spokane River and Little Spokane River a short distance upstream of its confluence with Lake Spokane. The Spokane River at the Nine Mile Bridge station, (54A090) is located approximately 0.1 mile downstream of Nine Mile Dam at River Mile (RM) 58. This station is a "basin" station with data collected during 2018 and published on Ecology's River and Stream Water Quality Monitoring website. Sampling was conducted in accordance with the Stream Ambient Monitoring QAPP. Data from January – November are presented in this report.

Water quality data available for the Spokane River at Nine Mile Bridge for 2018 are summarized below in Tables 14 and 15. The data are preliminary and have not been finalized by Ecology. Shaded values indicate exceedance of water quality standards or represent a strong contrast with historical data, according to Ecology's website.

Table 14. Water Quality Data from the Spokane River at Nine Mile Bridge during 2018.

Date	Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Conductivity (µmhos/cm)
1/9/2018	5.3	11.5	8.04	119
2/6/2018	5	13.2	7.80	77
3/6/2018	4.8	12.7	7.94	121
4/10/2018	7.5	12.7	7.39	80
5/8/2018	11.7	11.9	7.44	58
6/5/2018	16	9.7	7.9	109
7/10/2018	18.3	8.5	8.24	197
8/7/2018	16.6	9.7	8.41	274
9/11/2018	14.5	9.8	8.36	246
10/16/2018	10.7	10.3	8.19	203
11/6/2016	10.3	10.0	7.65	134

Note: Shaded values indicate an exceedance of water quality standards or strong contrast to historical results.

Table 15. Conventional Water Quality Data from the Spokane River at Nine Mile Bridge during 2018.

Date	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO_3+NO_2 (µg/L)
1/9/2018	47.6	**24.8**	1,320	1,210
2/6/2018	40.6	12.7	705	594
3/6/2018	17.1	6.8	849	749
4/10/2018	36.3	**10.3**	549	444
5/8/2018	14.5	6.6	**51**	168
6/5/2018	13.5	5.5	531	460
7/10/2018	13.4	8.4	1,190	1,160
8/7/2018	12.4	8.1	1,840	1,710
9/11/2018	11.2	7.8	1,760	1,590
10/16/2018	12.7	7.9	1,380	1,310
11/6/2018	10.6	4.9	831	753

Note: Shaded values indicate an exceedance of water quality standards or strong contrast to historical results.

The Little Spokane River station (55B070) is located at RM 1.1 near its mouth and is a long-term site. Sampling at this station was conducted in accordance with the Stream Ambient Monitoring QAPP.

Water quality data are summarized for the Little Spokane River for 2018 (Tables 16 and 17). The data are preliminary and have not been finalized by Ecology. Shaded values indicate exceedance of water quality standards or a strong contrast with historical data.

Table 16. Water Quality Data from the Little Spokane River near Mouth during 2018.

Date	Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Conductivity (µmhos/cm)
1/9/2018	6.8	**9.6**	7.73	269
2/6/2018	6.0	10.1	7.88	209
3/6/2018	6.3	10.5	8.08	244
4/10/2018	9.1	**9.3**	**7.72**	187
5/8/2018	15.4	**8.1**	7.82	184
6/5/2018	14.7	**9.2**	8.41	251
7/10/2018	15.9	8.6	8.23	274
8/7/2018	15.4	No data	8.32	283
9/11/2018	12.2	9.2	8.22	285
10/16/2018	8.3	9.8	No data	286
11/6/2018	8.9	9.6	7.89	275

Note: Shaded values indicate an exceedance of water quality standards or strong contrast to historical results.

Table 17. Conventional Water Quality data from the Little Spokane River near Mouth during 2018.

Date	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NO_3+NO_2 (µg/L)
1/9/2018	25.1	15.2	1,310	1,260
2/6/2018	54.8	31.4	1,130	900
3/6/2018	29.6	15.1	1,210	1,060
4/10/2018	45.7	22.5	689	496
5/8/2018	53.7	33.1	846	610
6/5/2018	No data	13.3	1,050	914
7/10/2018	13.9	9.2	1,100	1,050
8/7/2018	12.2	10.0	1,240	1,130
9/11/2018	10.3	9.7	1,280	1,117
10/16/2018	12.0	9.9	1,310	1,250
11/6/2018	16.0	12.0	1,290	1,180

Note: Shaded values indicate an exceedance of water quality standards or strong contrast to historical results.

3.2.8 SPOKANE RIVER DOWNSTREAM OF LONG LAKE DAM

This site is also a “basin” station with data from October 2009 through September 2010 (Water Year 2010). There are no data from 2018.

3.2.9 DO – TEMPERATURE RELATED FISH HABITAT

The following section provides a cursory review of fish habitat in Lake Spokane with regards to DO and temperature, using criteria from selected literature sources. Dissolved oxygen and temperature criteria for cold-water fish habitat was compared with existing conditions at the six long-term lake stations in Lake Spokane in 2018. Dissolved oxygen and temperature criteria were also compared to existing conditions at the 2018 additional monitoring stations, LL1a, LL2a, LL2b, and LL3a. To obtain site specific water quality limitations to fish habitat in Lake Spokane, a more thorough analysis is being conducted by Avista. The ten sites should adequately represent DO and temperature conditions normally encountered by rainbow trout throughout the reservoir.

Coldwater fish can be “squeezed” in summer between epilimnetic water that is too warm and deeper layers that are sufficiently cool but with DO that is too low. The threat to cold water species, such as rainbow trout, can be assessed by determining the depth intervals with temperature and DO that are within the optimum ranges for growth. For rainbow trout, the maximum of the optimum temperature range for growth is 18°C and the minimum for the DO range is 6 mg/L (USFWS 1984). Their preferred temperature is 14°C (Welch and Jacoby 2004). The minimum DO required is usually cited as 5 mg/L, recognizing that higher DO levels also occur (EPA 1986; USFWS 1984).

Using the USFWS criteria, trout probably would have avoided the epilimnion during most of the summer due to temperature that reached slightly above 25°C and preferred to seek cooler water deeper than 10 to 20 m (Figures 8 to 17). Between 10 and 20 m, DO was usually near or above 6 mg/L throughout the water column during most of the summer at the deepest stations. In late August and September, DO dropped at LL0 to below the often cited required minimum of 5 mg/L between 10 and 20 m and was even lower at deeper depths (Figure 28). However, at the other deep stations DO remained near or above 6 mg/L providing adequate growth conditions throughout the water column during late summer (Figures 29 to 35). These data suggest that rainbow trout were most likely inhabiting cooler water in the metalimnion and upper portions of the hypolimnion, where DO is likely adequate.

The percent of the reservoir volume suitable for growth of rainbow trout was computed at the ten monitoring stations in 2018, using the critical maximum temperature (18°C) and minimum DO (6.0 mg/L; Figures 79 – 88). Percent of total volume suitable for trout growth are shown for temperature and DO together, as well as separately.

Trout habitat was limited through most of the summer by temperature, but much less by DO at the deepest lacustrine sites as the summer progressed (Figures 79-84).. Trout were restricted exclusively by temperature at the transition and riverine sites (Figures 85-88). This was similar to 2016 and 2017 as well as 2015. Total volume of acceptable habitat in 2018 at the deeper stations was similar to 2016 and 2017, with just slightly more available habitat in the early summer. Total volume of available habitat in 2018 was larger than that in 2015, most likely due to the lower inflow, longer residence time, and slightly warmer water temperature in 2015.

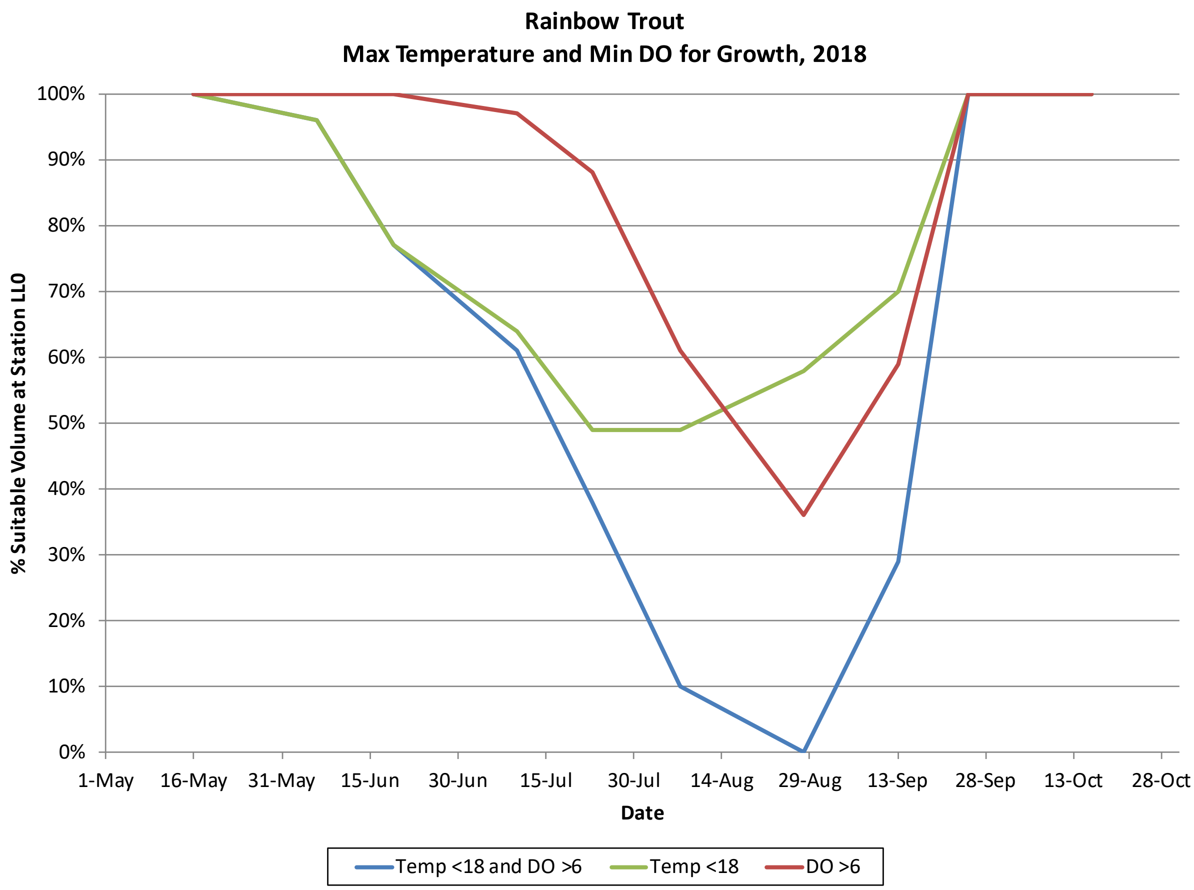

Figure 79. Volume of Suitable Habitat for Rainbow Trout at Station LL0 in 2018; Maximum Temperature = 18°C and Minimum DO = 6.0 mg/L for Growth.

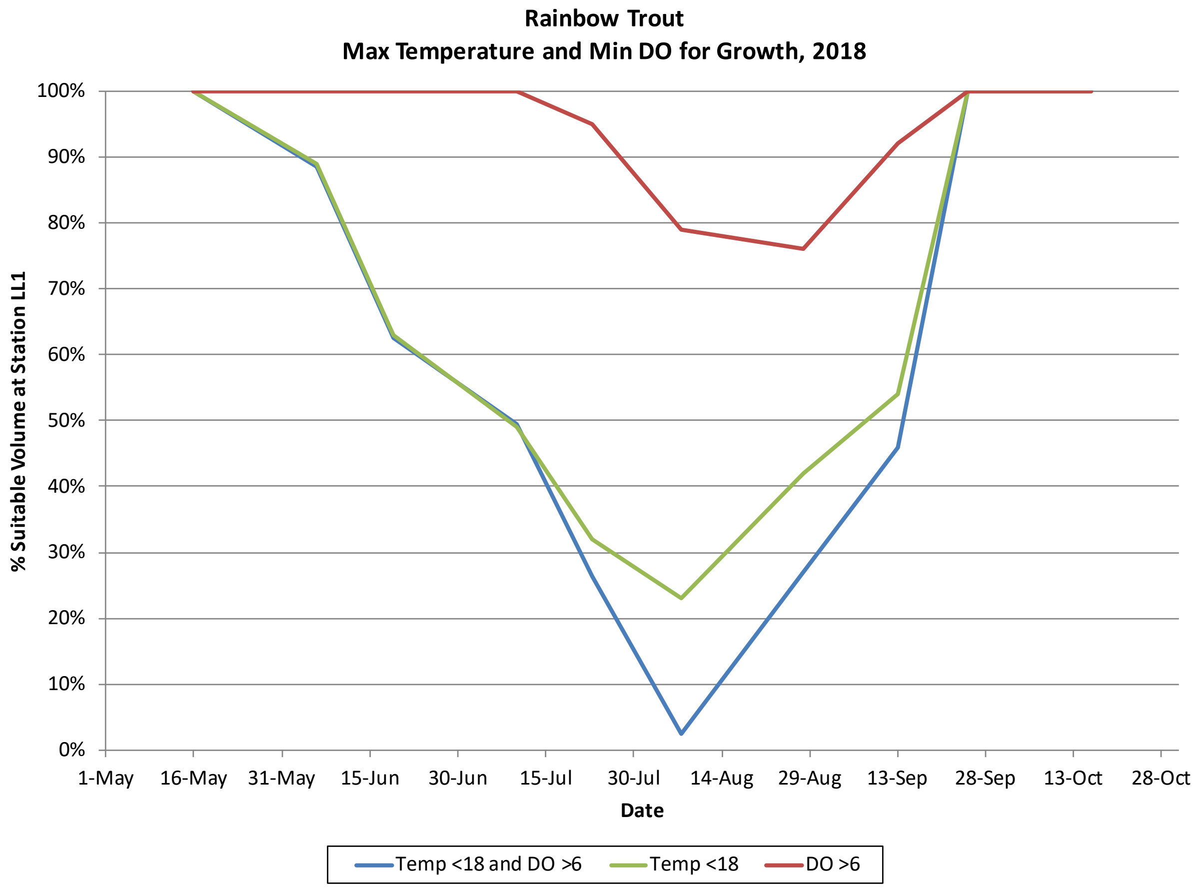

Figure 80. Volume of Suitable Habitat for Rainbow Trout at Station LL1 in 2018; Maximum Temperature = 18°C and Minimum DO = 6.0 mg/L for Growth.

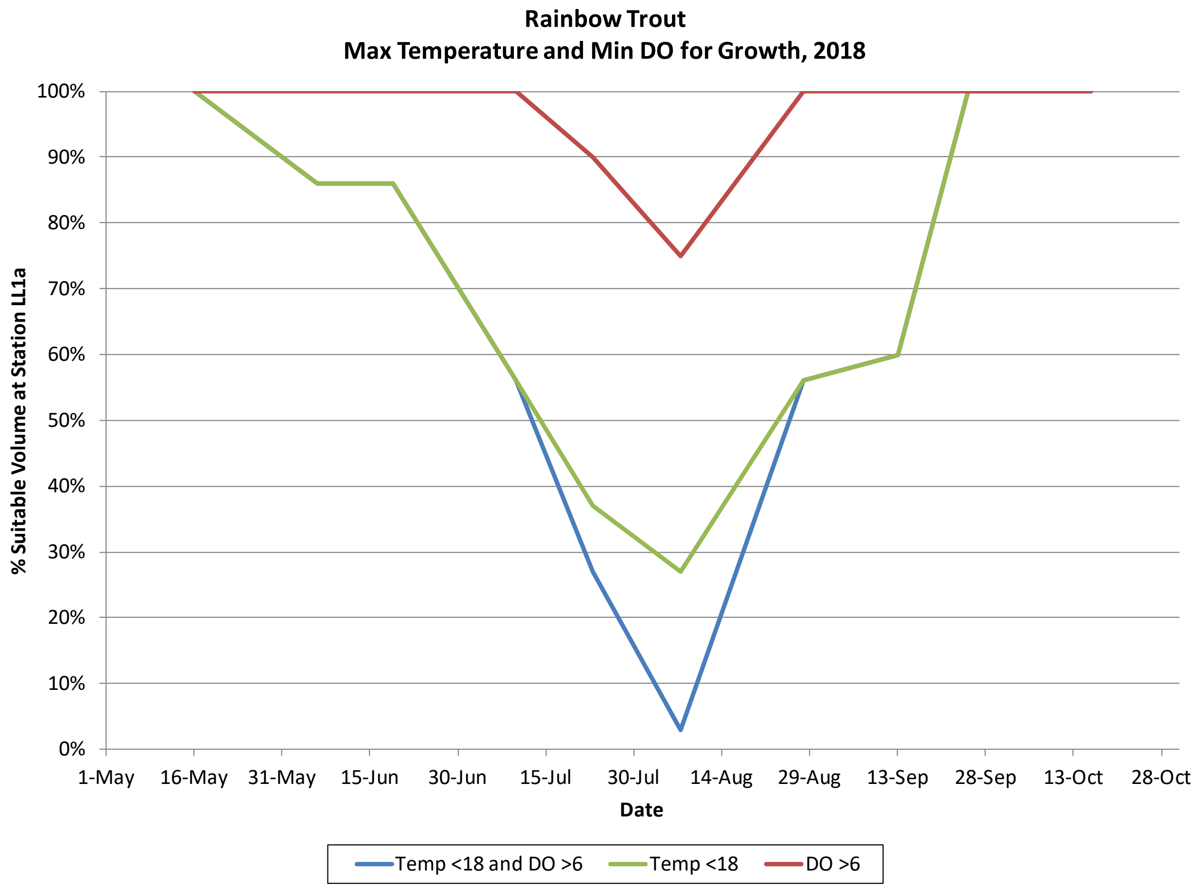

Figure 81. Volume of Suitable Habitat for Rainbow Trout at Station LL1a in 2018; Maximum Temperature = 18°C and Minimum DO = 6.0 mg/L for Growth.

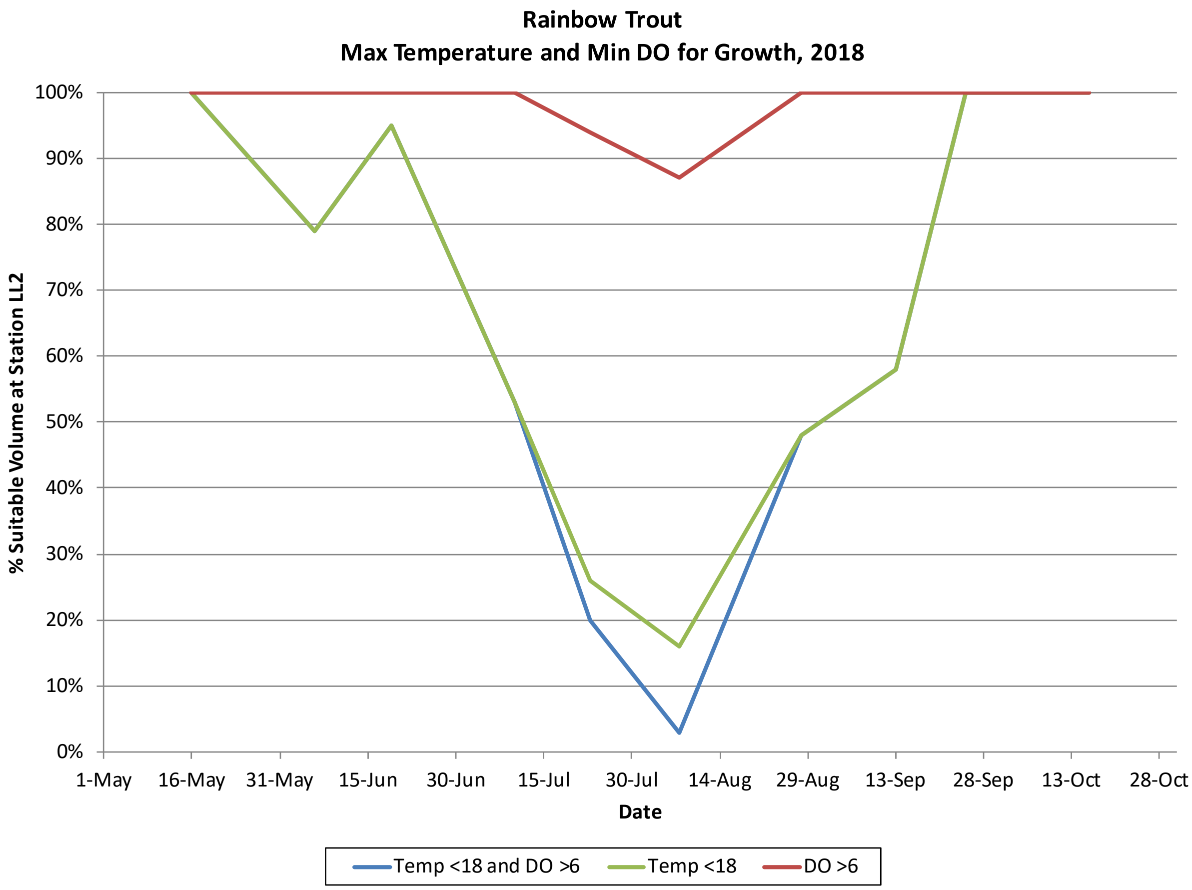

Figure 82. Volume of Suitable Habitat for Rainbow Trout at Station LL2 in 2018; Maximum Temperature = 18°C and Minimum DO = 6.0 mg/L for Growth.

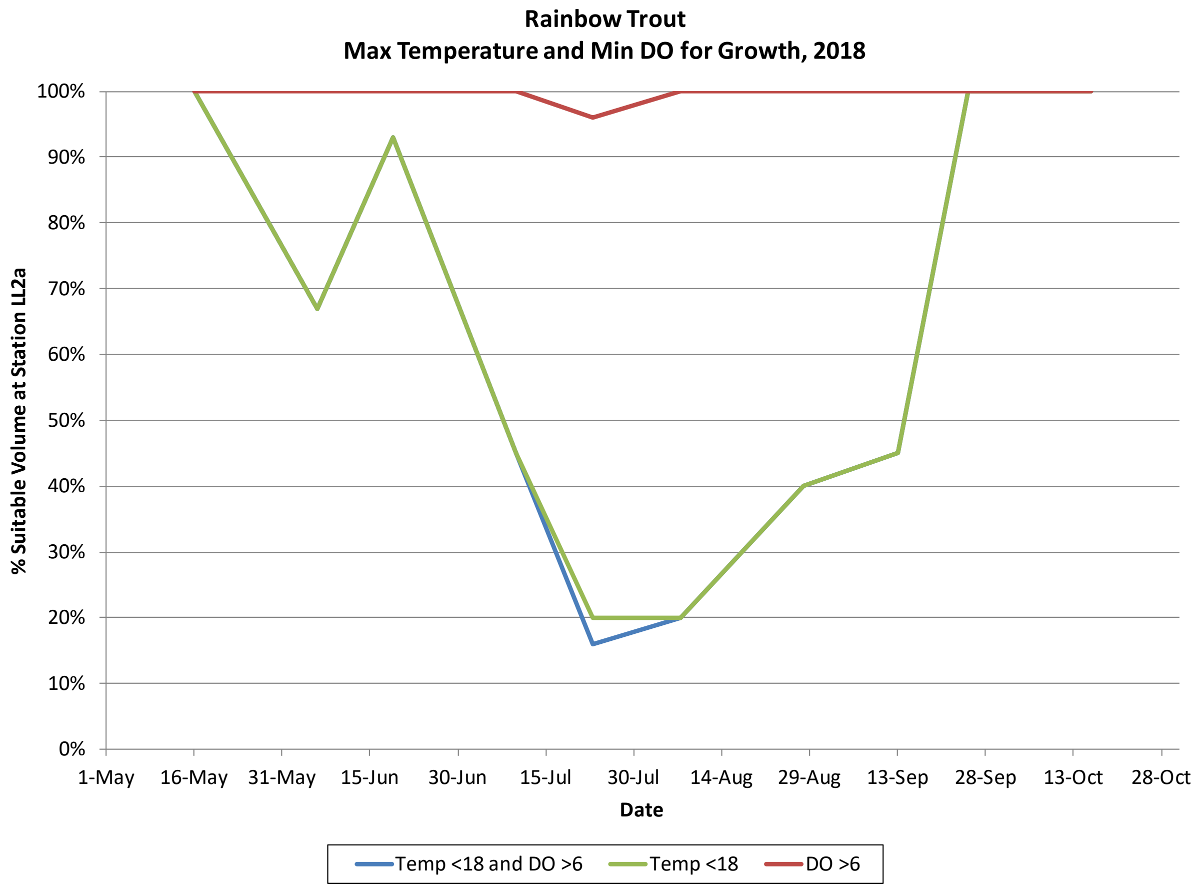

Figure 83. Volume of Suitable Habitat for Rainbow Trout at Station LL2a in 2018; Maximum Temperature = 18°C and Minimum DO = 6.0 mg/L for Growth.

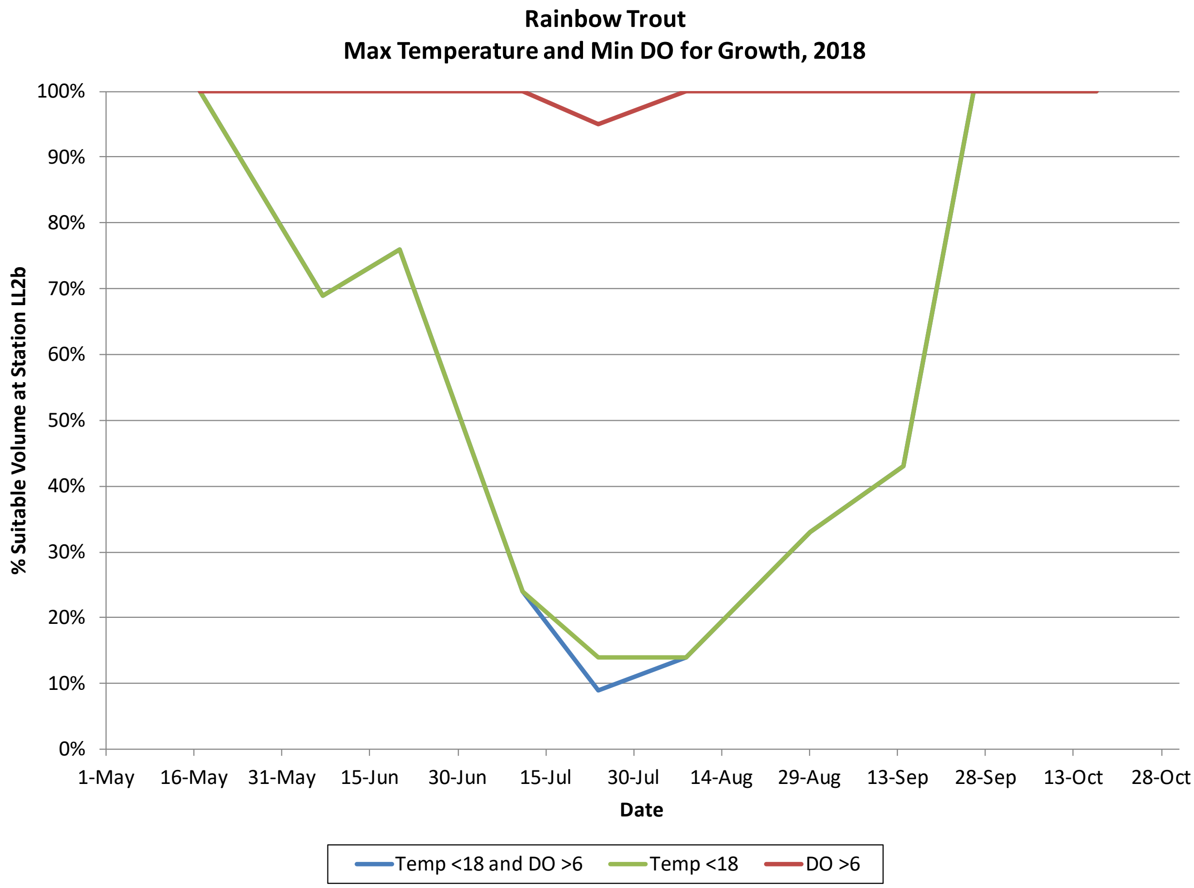

Figure 84. Volume of Suitable Habitat for Rainbow Trout at Station LL2b in 2018; Maximum Temperature = 18°C and Minimum DO = 6.0 mg/L for Growth.

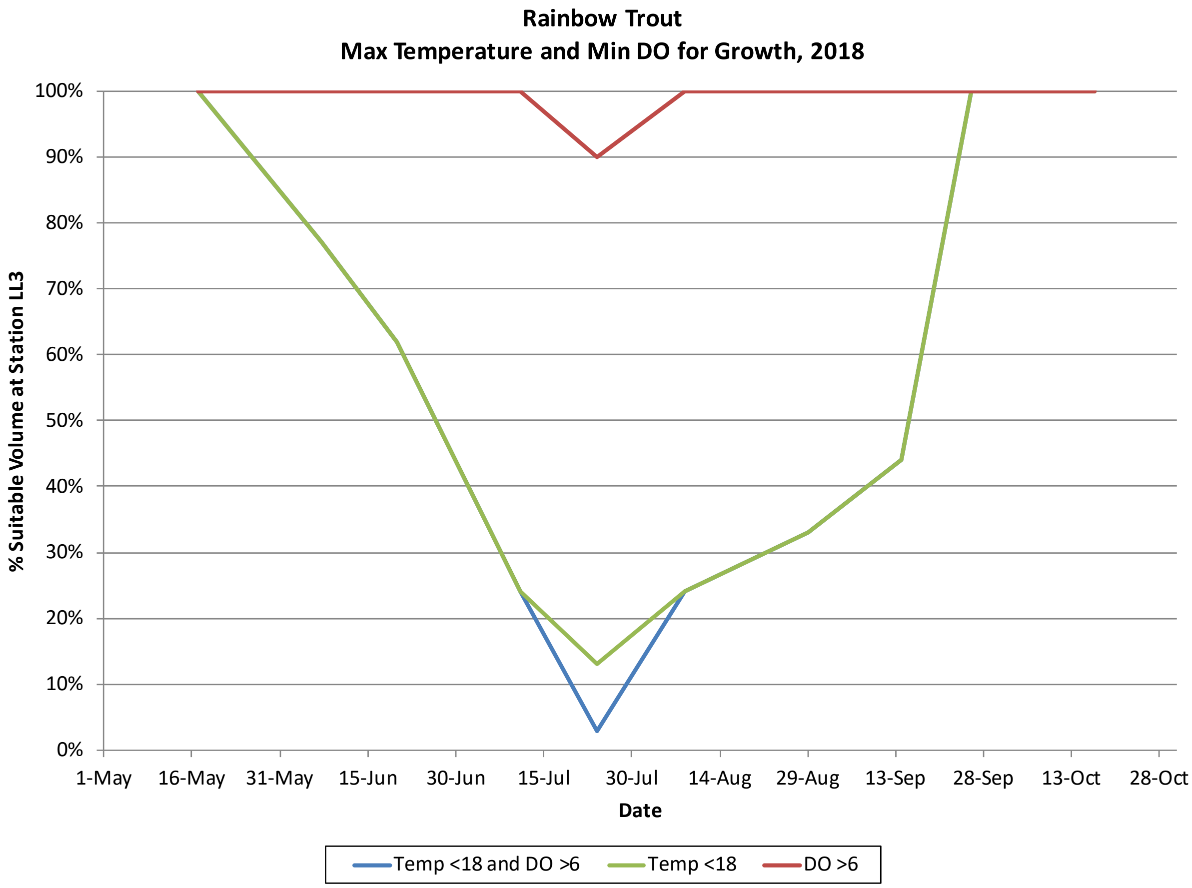

Figure 85. Volume of Suitable Habitat for Rainbow Trout at Station LL3 in 2018; Maximum Temperature = 18°C and Minimum DO = 6.0 mg/L for Growth.

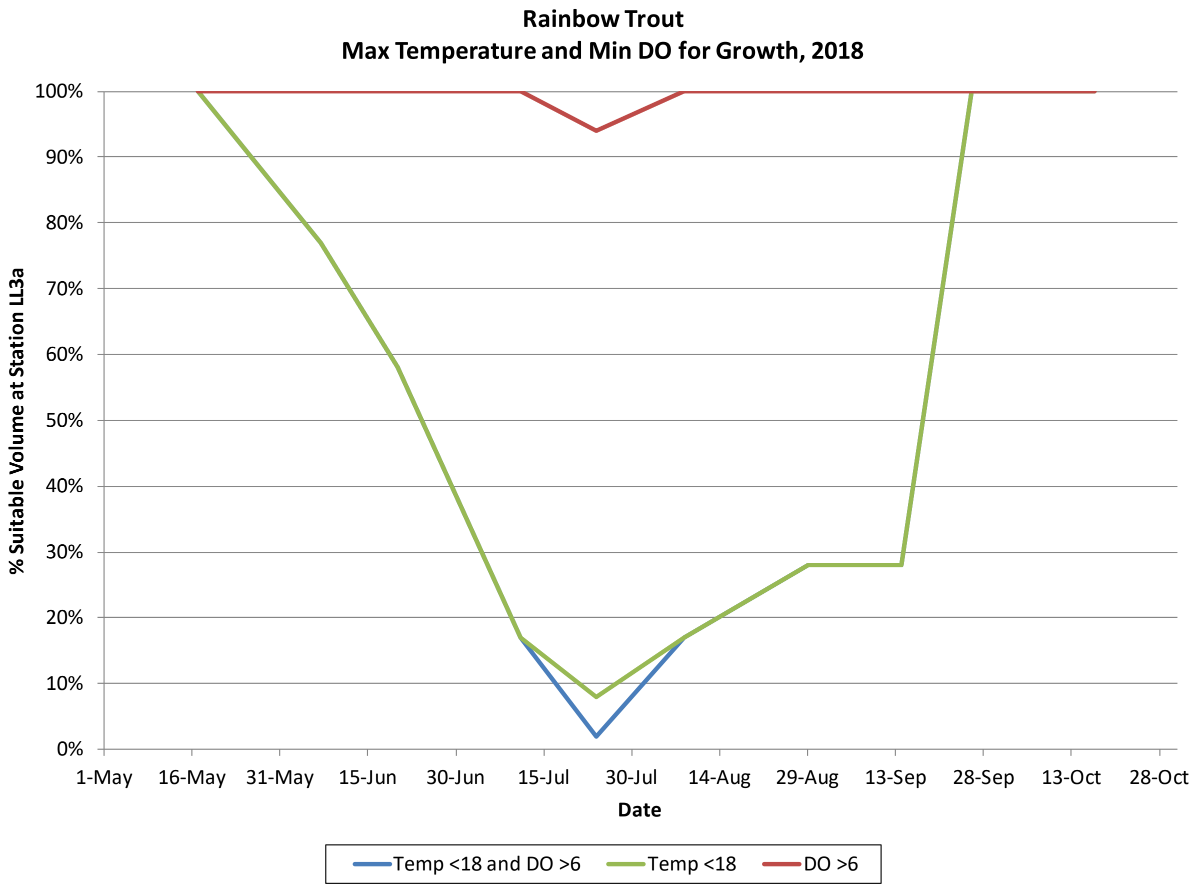

Figure 86. Volume of Suitable Habitat for Rainbow Trout at Station LL3a in 2018; Maximum Temperature = 18°C and Minimum DO = 6.0 mg/L for Growth.

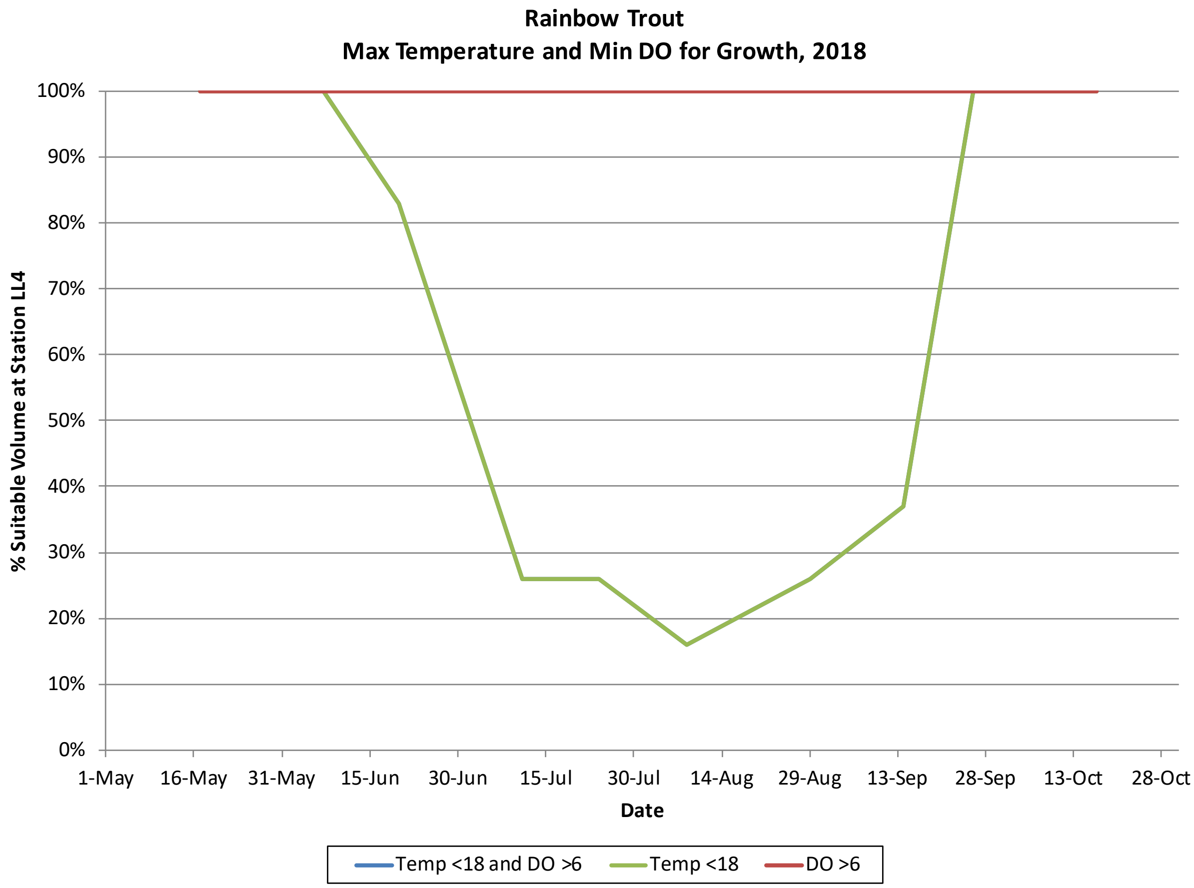

Figure 87. Volume of Suitable Habitat for Rainbow Trout at Station LL4 in 2018; Maximum Temperature = 18°C and Minimum DO = 6.0 mg/L for Growth.

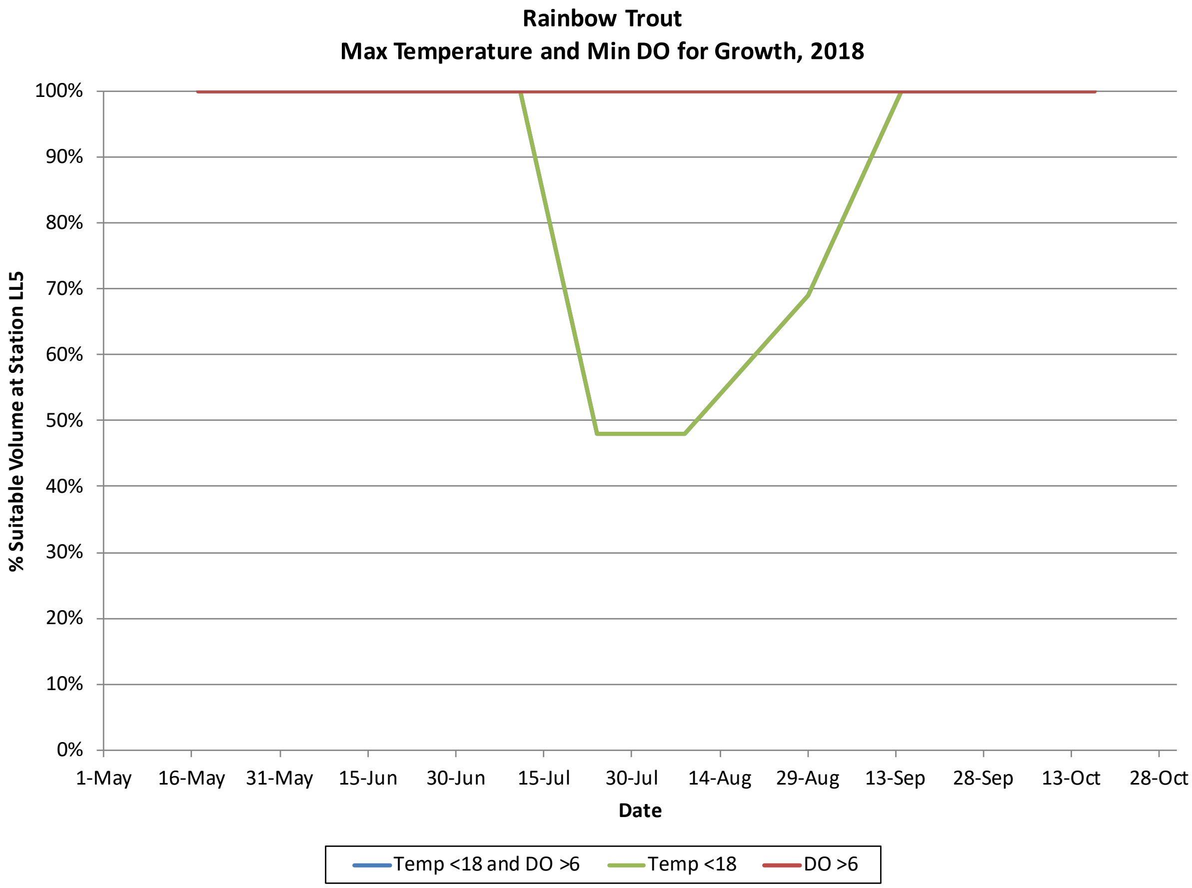

Figure 88. Volume of Suitable Habitat for Rainbow Trout at Station LL5 in 2018; Maximum Temperature = 18°C and Minimum DO = 6.0 mg/L for Growth.

3.3 2018 Quality Assurance

Quality assurance review of field and laboratory data was conducted in accordance with the guidelines and requirements outlined in the *Quality Assurance Project Plan for Lake Spokane Baseline Nutrient Monitoring* (QAPP). Replicate field measurements were compared to the measurement quality objectives (MQOs) as stated in the QAPP. If data warranted qualification based on the guidelines in the QAPP, qualifiers such as "J – result is considered an estimate", were assigned to the associated data in the database prepared for Ecology's Environmental Information Management (EIM) along with a comment describing why the data needed qualification.

In 2018, most parent and replicate field measurements met QAPP guidelines for relative percent difference (RPD). On July 10th, temperature measurements at station LL2a at 8 m did not meet the field replicate RPD guidelines (± 0.3°C) and both parent and replicate measurement were qualified with a J. On August 7th at station LL2, parent and replicate temperature measurements also did not meet the RFP guidelines and were qualified with a J. On October 16th, the Hydrolab MS5 sonde failed calibration checks as outlined in the QAPP for pH measurements. Data for pH from stations LL0, LL1, LL1a, LL2, and LL2a from that date were adjusted by -1.0 units, which was equivalent to the calibration drift observed at the end of the day. These pH data were also qualified with a J.

Within the database prepared for EIM, laboratory data were qualified using the following qualifiers; "JG = Analyte was positively identified, and its value may be greater than the reported estimate" and "JL = Analyte was positively identified, and its value may be less than the reported estimate". For 2018, there were 7 Winkler results that were qualified as "JG" and 1 Winkler result that was qualified as "JL" due to RPDs outside of the QAPP acceptable criteria with the DO concentrations measured by the Hydrolab MS5 sonde. Out of the 160 Winkler samples that were shipped to the laboratory, 10 samples were not analyzed due to broken bottles upon receipt.

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4. DISCUSSION OF WATER QUALITY IN LAKE SPOKANE (2010 – 2018)

4.1 Temperature

Water and air temperature data were analyzed to determine if there were long-term trends in temperature. Air temperature in the Pacific NW has increased over the past several decades. Air temperature during 1952 – 1965 was similar to 1972 – 1985, but increased slightly by 1°C, on average, for June – October during 2010 – 2018 (Table 18). Surface water temperature should have increased also, especially in reservoirs that tend to retain heat. Not surprisingly, the data indicate that surface temperature in Lake Spokane has increased slightly more than 1°C since the 1970s – 1980s. Average temperature with depth throughout the reservoir during June – October is shown for 2010 – 2018, compared with those during 1972 – 1985 (Patmont 1987; Figures 89 and 90). Note that there is only a small area that averaged greater than 19°C during 1972 – 1985, but the 19°C isopleth and portions of the 20°C isopleth encompassed nearly the whole reservoir surface during 2010 – 2018. Also, mean temperature in the top 5 m of the lacustrine zone, determined from numerical data, averaged 19.8°C during 2010 – 2018, and 20.2°C at the surface (Table 19). That was about 1°C warmer than in 1972 – 1985. Lacustrine surface and epilimnion average water temperatures were slightly lower in 2018 than those observed in 2017 and in most cases were the lowest average temperatures observed since 2011 (Table 19).

Temperature in the Spokane River at Riverside showed no consistent trend from 1980 to 2016 (Figure 91). The June – October mean for 2010 – 2018 was 15.8°C, which was only 0.7°C higher than the overall mean for 1982 – 2017 (15.1°C ± 1.2°C). Average November – May temperature varied slightly more over the time period of record with a mean of 6.1°C ± 0.8°C.

Table 18. Average annual and June – October Air Temperature at Spokane International Airport.

Time Period	Annual Average (°C)	June – October Average (°C)
1952 - 1965	8.6 (±0.9)	16.4 (±1.0)
1972 - 1985	8.3 (±0.6)	16.1 (±0.6)
2010 - 2018	9.1 (±0.9)	17.2 (±0.9)

Table 19. Average Water Temperatures in Lacustrine Zone of Lake Spokane, June – October 2010 – 2018.

Year	LL0			LL1			LL2		
	Surface	Epi (0-5 m)	Hypo (15 m+)	Surface	Epi (0-5 m)	Hypo (15 m+)	Surface	Epi (0-5 m)	Hypo (15 m+)
2010	19.1	18.7	14.9	19.3	18.9	15.3	19.4	19.0	15.5
2011	18.7	18.2	14.8	19.6	19.1	15.8	19.8	19.1	15.7
2012	19.9	19.4	14.7	20.0	19.7	15.3	20.0	19.5	15.8
2013	20.3	20.0	14.6	21.0	20.6	15.5	21.3	20.8	15.6
2014	20.8	20.3	15.3	21.2	20.8	15.9	21.4	20.8	16.2
2015	20.8	20.5	12.5	21.2	20.9	14.5	21.3	21.1	15.5
2016	19.7	19.4	14.8	20.3	19.8	15.6	20.4	20.0	15.8
2017	20.3	19.9	15.3	20.7	20.3	15.8	20.7	20.3	16.0
2018	19.3	19.1	15.6	19.7	19.4	15.8	20.0	19.7	15.7
Mean	19.9	19.5	14.7	20.3	19.9	15.5	20.5	20.0	15.8
STDEV	0.7	0.8	0.9	0.7	0.7	0.4	0.7	0.8	0.2

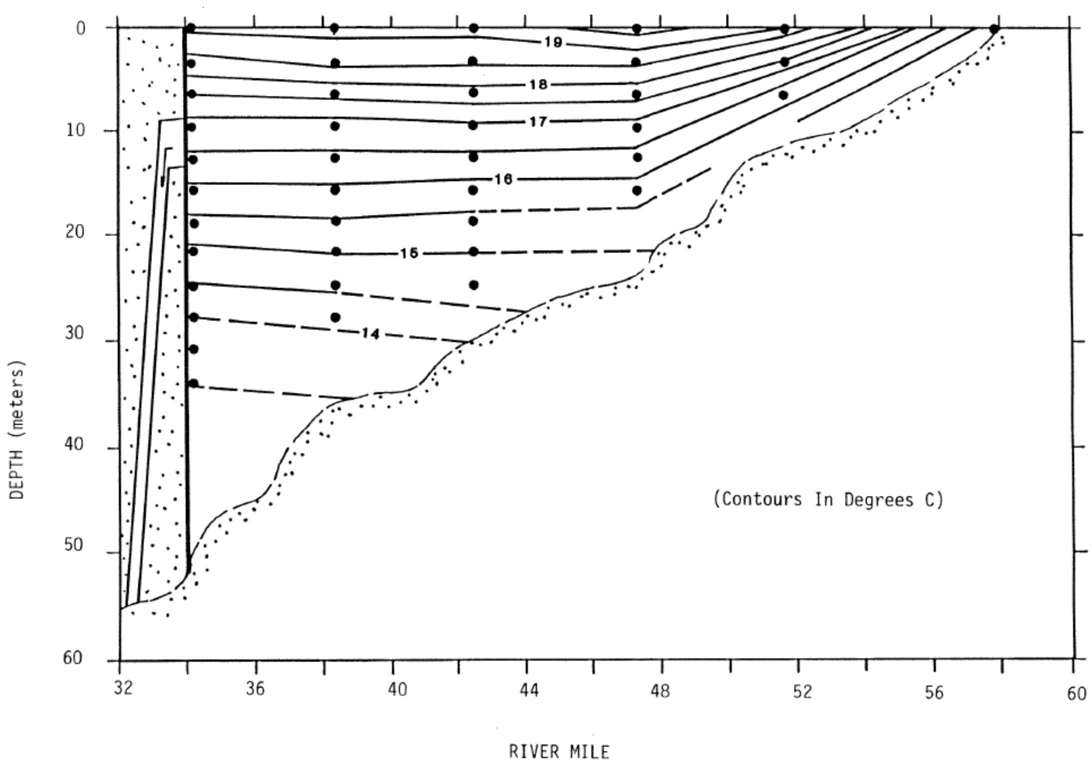

Figure 89. Average June – October temperature contours in Lake Spokane, 1972 – 1985 (Patmont 1987).

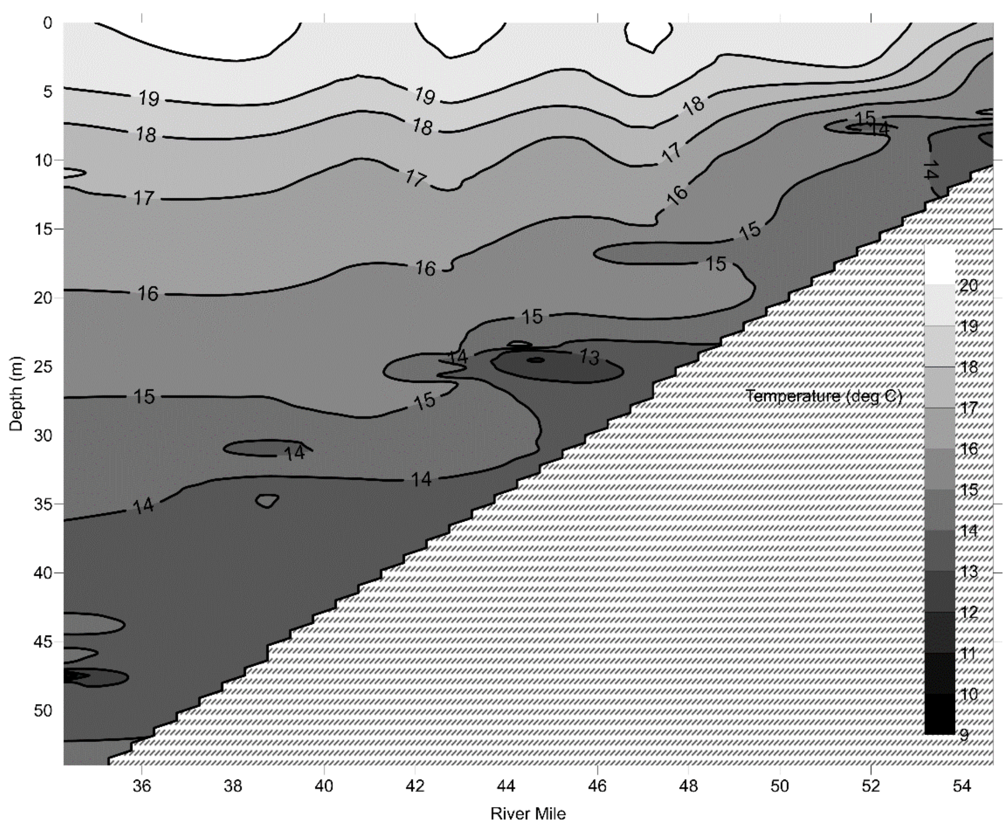

Figure 90. Average June – October temperature contours in Lake Spokane, 2010 – 2018.

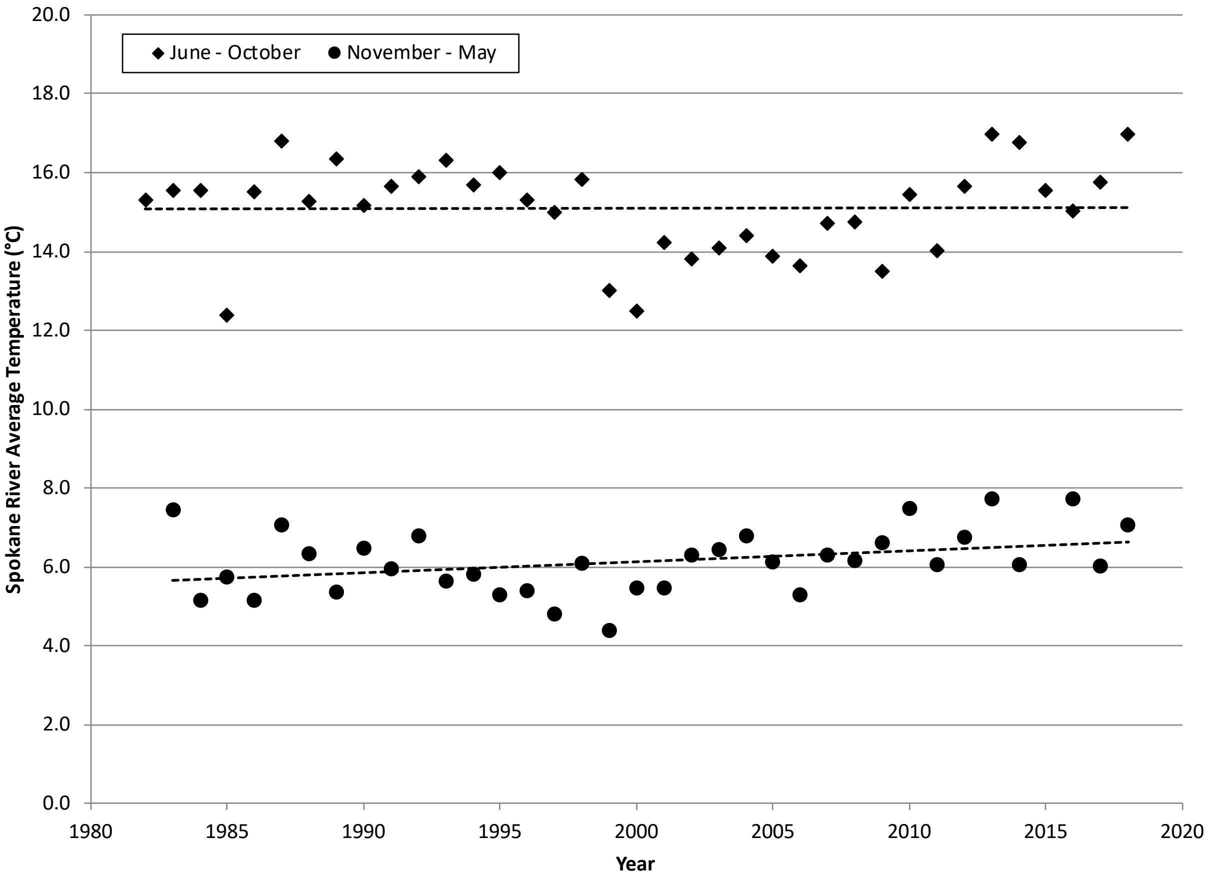

Figure 91. Seasonal average temperatures in the Spokane River at Riverside State Park, 1982-2018. Note that the 2018 average only includes data from June, July and August; data for September and October not available at the time of analysis.

4.2 Dissolved Oxygen

The reservoir's DO resource has remained consistently improved during the past nine years as inflow TP remained relatively low. That improved condition occurred as the reservoir's trophic state also improved from a hypereutrophic to meso-oligotrophic after 85% of point source effluent TP was removed in 1977 (Welch et al. 2015). The dependence of minimum hypolimnetic DO on TP is shown in Figure 92, which was modified from Patmont (1987). During 1972 to 1977, minimum volume weighted hypolimnetic DO (below 15 m) ranged from 0.2 to 3.4 mg/L, with a mean of 1.4 mg/L. After phosphorus reduction, minimum volume weighted hypolimnetic DO gradually increased to a mean of 2.5 mg/L during 1978 to 1981, and then to 4.5 mg/L during 1982 to 1985, as inflow TP declined from 85 to 25 µg/L (Patmont 1987). Almost three generations later, minimum volume weighted hypolimnetic DO, calculated using volumes from Patmont (1987) and DO data from the lacustrine zone, averaged 6.2 mg/L during 2010 to 2018 at inflow TPs averaging 14.5 µg/L. Inflow TP was determined as the riverine zone volume weighted TP concentration at LL5 for 2010-2017 and flow-weighted average inflow TP concentrations from Nine Mile and

Little Spokane for 2018 during the same period. While minimum hypolimnetic DO has remained consistent, there has been some variation (± 12%) during the past nine years (Figure 92).

The year-to-year variability in minimum DO in Figure 92 was likely due to water inflow and residence time, with higher inflows, and shorter residence times, producing higher DO minimums in the 1970s through 1980s (Patmont 1987). Specifically, the high minimum volume weighted hypolimnetic DOs in 1974 – 1975 had the highest June – October inflows during 1960 to 1985. Nevertheless, the principal control on minimum volume weighted hypolimnetic DO over the large range in inflow TP, from immediately before to after phosphorus reduction, was inflow TP (Figure 92), with a lesser effect from residence time (Figure 93). However, over the past nine years, with consistently low inflow TP, minimum volume weighted hypolimnetic DO appears to be more dependent on the wide range in residence time. Minimum volume weighted hypolimnetic DO during 2010-2018 ranged from 5.1 mg/L to nearly 8 mg/L, while summer volume weighted riverine TP (surrogate for flow-weighted inflow TP) ranged from only 11.4 to 20 µg/L, and the two variables now appear to be independent of each other ($r^2 = 0.26$). Instead, it appears that minimum hypolimnetic DO was strongly related to June-October water residence time ($r^2 = 0.84$). Residence times ranged from about 24 to 70 days during 2010, 2013, 2014, 2015, 2016, 2017, and 2018, corresponding with the lowest minimum volume weighted hypolimnetic DOs, while residence times of about 14 to 19 days in 2011 and 2012 were associated with the highest minimum hypolimnetic DOs (Figures 92 and 93). However, the lowest minimum volume weighted hypolimnetic DO during recent years was 5.1 mg/L which occurred in 2015, which also had the highest June through October mean inflow TP (20 µg/L), and the longest June – October water residence time of about 70 days. Nevertheless, there was a full 1 mg/L difference in minimum DO in 2013 and 2015 at essentially the same TP, further suggesting greater current dependence of DO on residence time.

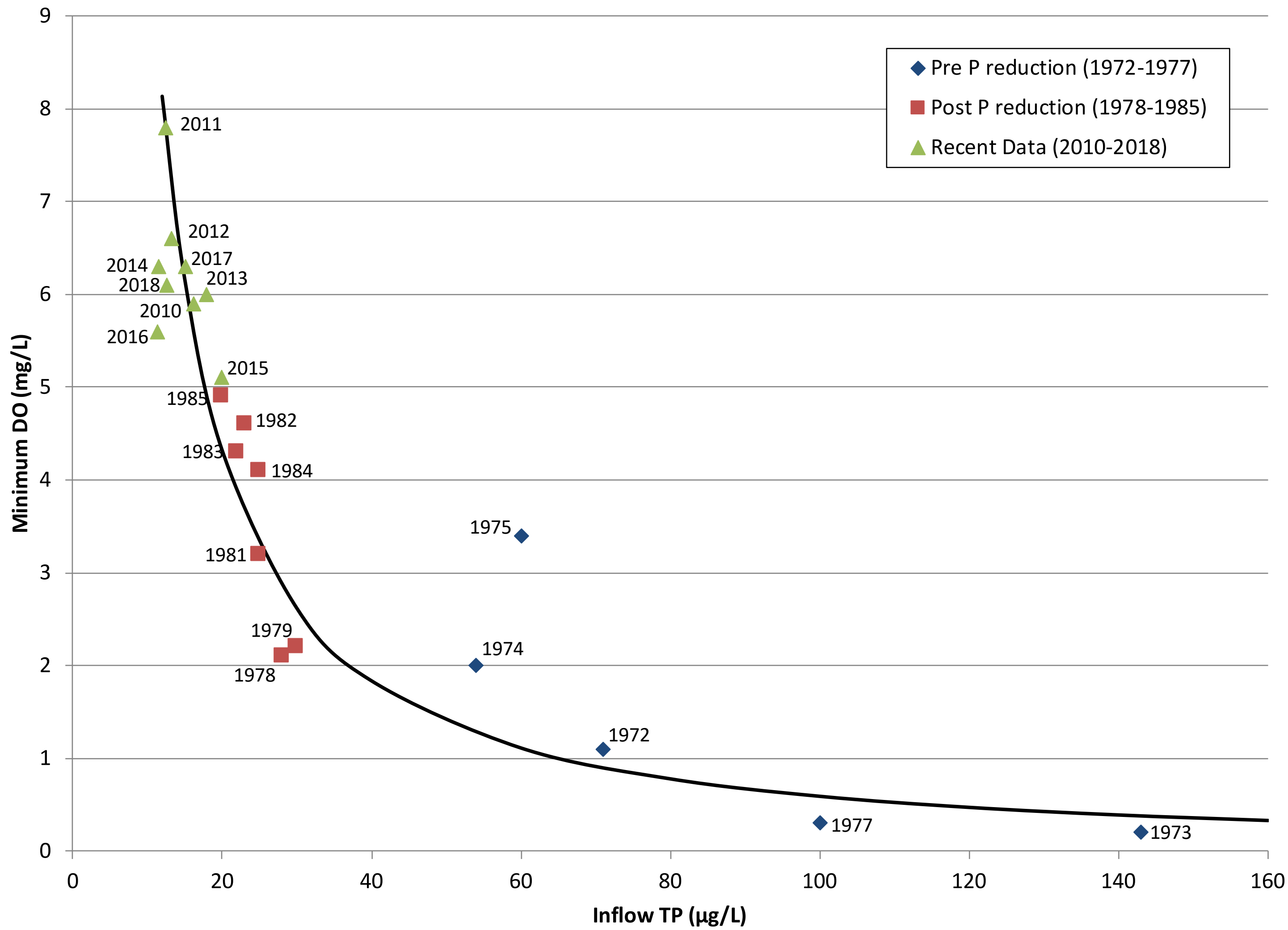

Figure 92. Volume-weighted mean inflow TP concentration related to minimum v-w hypolimnetic DO concentration during June-October before and after advanced wastewater treatment TP reduction in 1977. Concentrations from 1972 through 1985 were from observed loading at Nine Mile Dam (Patmont 1987). Mean inflow TP concentrations from 2010-2017 were taken as v-w mean TP concentrations at Station LL5, in lieu of loading data from Nine Mile Dam. Inflow TP in 2018 was calculated as the flow-weighted average from observations at Nine Mile and Little Spokane River. Equation for the line: $y = 175.4587x^{-1.2360}$, $r^2 = 0.84$.

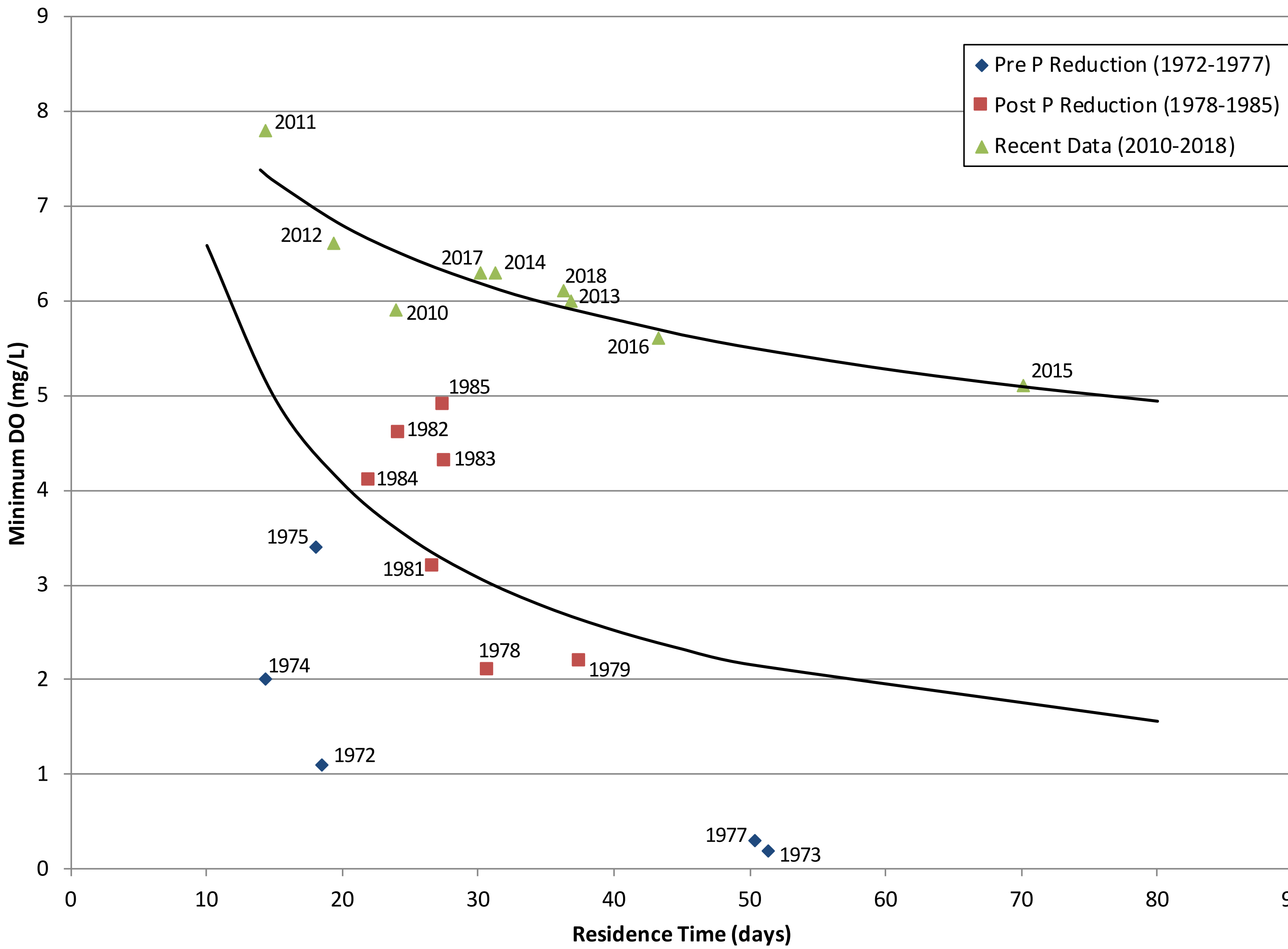

Figure 93. Mean hydraulic residence time (June-October) related to minimum v-w hypolimnetic (below 15 m) DO before and after wastewater TP reduction in 1977. Residence time was calculated using reservoir outflows gaged by USGS (1972-1985) and Avista (2010-2018) at Long Lake Dam. Equation for line for all years: $y = 32.525x^{-0.694}$, $r^2 = 0.09$. Equation for line for 2010-2018: $y = 13.583x^{-0.231}$, $r^2 = 0.84$.

4.3 Phosphorus

Phosphorus samples were not collected in Lake Spokane during 2018. However, samples were collected by Ecology in the Spokane River (Nine Mile and Riverside stations) and Little Spokane River a short distance upstream of its confluence with Lake Spokane. Table 23 summarizes TP from 2010 through 2018 in both the Spokane River (two Ecology monitoring stations upstream of Lake Spokane) and Little Spokane River as well as LL4 and LL5 (2010-2017). There was no apparent trend in mean summer TP at any site during the nine years. Also, TP at LL5 was only slightly higher than that in the river inflow at Nine Mile, which was expected given the higher Little Spokane River concentration.

Table 23. Summer (June – September) mean TP concentrations (µg/L) in the Spokane River compared to summer mean volume-weighted TP concentrations in Lake Spokane at LL4 and LL5. Volume weighted TPs for 2010 and 2011 at LL4 and LL5 are based on composite samples.

Year	Spokane River @ Riverside State Park	Spokane River @ Nine Mile	Little Spokane River near Mouth	Lake Spokane @ LL5	Lake Spokane @ LL4
2010	24	18.1	19.3	15.9	15.9
2011	15.4	--	21.6	12.5	11.9
2012	10.6	--	19.6	13.4	18.0
2013	14.3	12.9	17.5	19.0	19.9
2014	11.9	12.6	14.6	11.9	16.1
2015	21.3	15.4	107[1]	21.1	22.1
2016	15.5	11.1	11.9	11.4	14.5
2017	20.0	13.1	19.3	15.7	14.9
2018	15.6	12.6	12.1[2]	No data	No data
Mean	16.5	13.7	27.0	15.1	16.7
STDEV	4.4	2.3	30.2	3.5	3.2

[1]June – September average for 2015 includes a very high value, 397 µg/L, which was measured on June 2nd, 2015. This value corresponds with an extreme precipitation and runoff event in the Little Spokane River watershed. The summer average for the Little Spokane River without this value is 17.7 µg/L.
[2]Summer average does not include data from June. No TP data reported for Little Spokane Station for June 2018.

4.4 Nitrogen

Nitrogen samples were not collected in Lake Spokane during 2018. Ecology, however, continued to collect nitrogen samples in the Spokane River (Nine Mile and Riverside stations) as well as in the Little Spokane River, upstream of the its confluence. Total N concentrations have been increasing in the Spokane River for several decades (Figure 95). Mean (June – October) TN in the Spokane River at Riverside State Park, just downstream of the City of Spokane WWTP effluent discharge, has increased from 697 in 1997 to a peak of 2,293 µg/L in 2015 while dissolved inorganic nitrogen (DIN) increased from 420 µg/L in 1978 to a peak of 2,130 µg/L in 2015. The higher TN and DIN concentrations in 2015 and 2016 may be partly due to low river flows and greater influence of groundwater. This most likely was also the case during low river flows in summer 2018. However, the near doubling of TN from around 800 µg/L in the 1990s to near 1,500 µg/L since then was not likely due to a concentration effect of low flow. Average June – October flow in the Spokane River differed by only 7% from the 1990s to 2000 – 2018, while TN increased by 37% between the same time periods. Data observations indicate nitrogen has increased while TP concentrations in the river have steadily decreased since the 1990s (Figure 95).

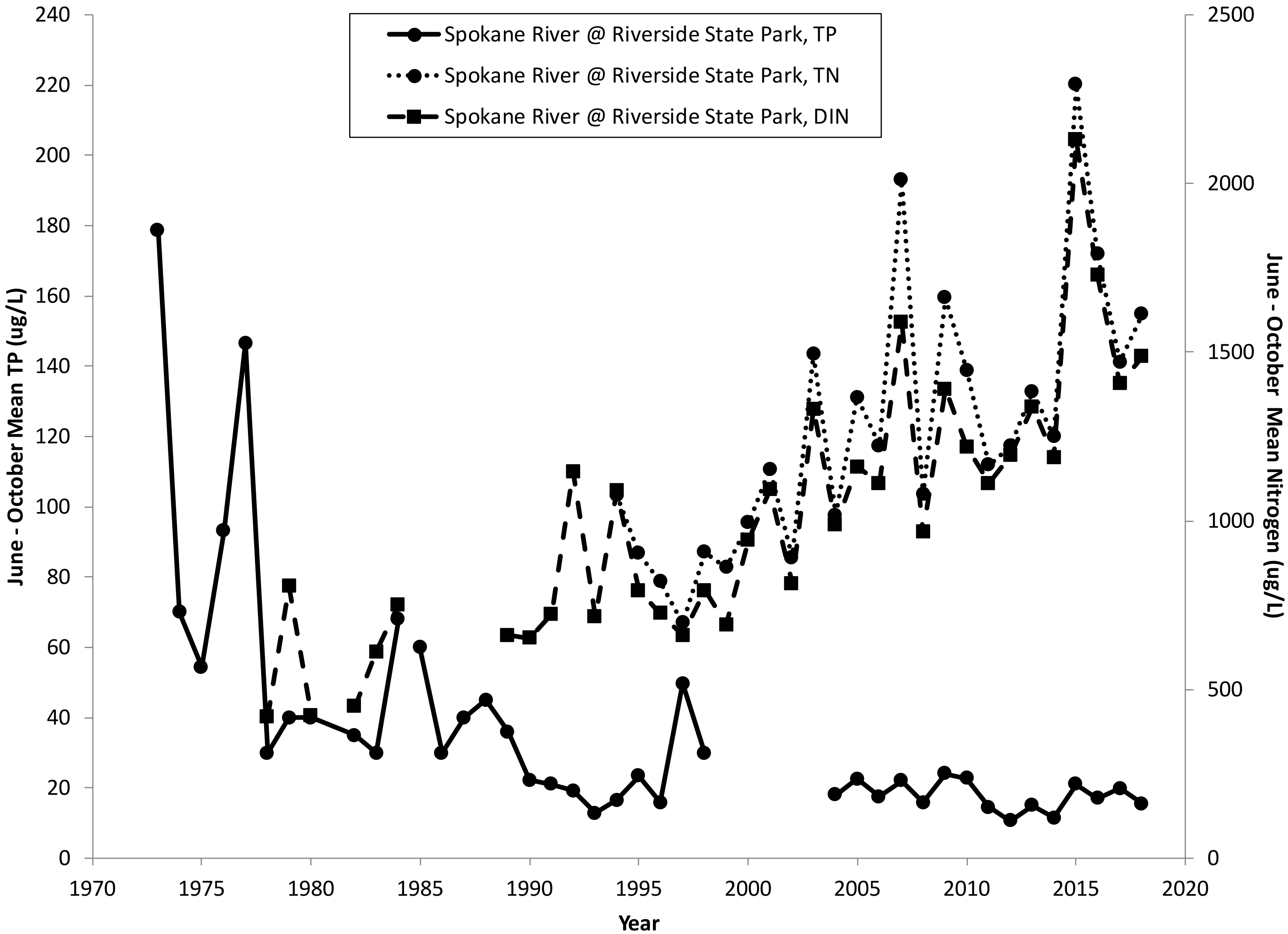

Figure 95. Mean (June – October) TN, DIN, and TP in the Spokane River at Riverside State Park.

4.5 DO, Temperature and Fish Habitat

The percent of reservoir volume acceptable for growth of rainbow trout due to temperature and DO is shown for each station from 2010 through 2018 (Figures 96 through 101). The USFW temperature (≤ 18°C) and DO (≥ 6.0 mg/L) criterion for rainbow trout growth were used to construct the habitat volume diagrams.

The lowest average inflow and longest water residence time (70 days) was in 2015, which was also the year with the least volume of acceptable trout habitat in the reservoir (Table 3 and Figures 96 through 101). On the other hand, available habitat was greatest during 2011, which had the shortest residence time (14 days). That was consistent with the current dependence of minimum hypolimnetic DO on water residence time. Available habitat volumes were intermediate during other years, with residence times in between those years (~20 – 40). In 2018, available habitat was slightly greater or about the same in spring and early summer than in previous years with similar residence times (~30 – 40 days; 2013, 2014, 2016 and 2017). Available habitat was greater from late summer and into fall at the majority of stations in 2018 than in previous years with similar residence times and greater than available habitat observed in 2011 at some stations (LL2-LL5).

The data suggest that temperature restricted habitat for rainbow trout far more than DO during spring and early summer at all sites and that temperature continued to be more restrictive than DO for the rest of much of the year at the shallower sites. While DO was restrictive at LL0 later in the summer, there was little restrictive effect from DO at other sites. Temperature and DO habitat became very restrictive for trout at LL0 during late July, August and early September when either no or a small percent of favorable habitat volume existed with temperatures less than 18°C and DO greater than 6 mg/L or only a very small percent of favorable habitat volume. The greater restriction by DO at LL0 than at other sites was due to longer residence times of largely isolated bottom water, given the much longer water residence times in 2016 as well as in 2015. The data suggest there was more acceptable habitat available farther upstream at LL1, LL2, and LL3.

In 2018, acceptable habitat at LL4 increased to near 2010 and 2011 levels, with at least a small portion of the water column containing suitable habitat throughout the summer. In previous years, water temperatures at LL4 restricted acceptable habitat to at least one time period where no acceptable habitat existed in the water column. In 2018, the bottom couple meters at LL4 remained below 18°C and was slightly above 14°C in late August and early September. The cold water observed at the bottom of LL4 is most likely due to the greater influence of groundwater on river inflows late in the summer.

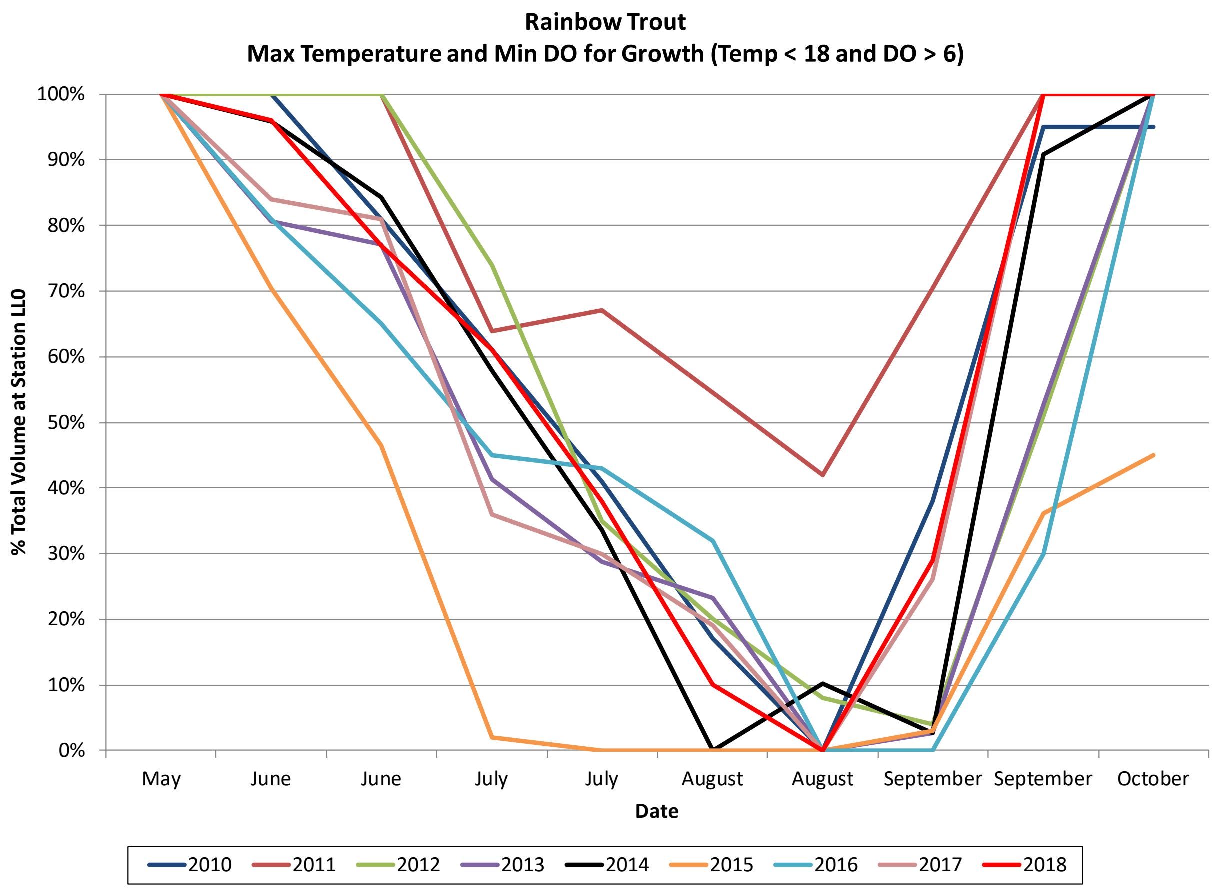

Figure 96. Habitat Conditions at Station LL0 for Rainbow Trout in 2010 – 2018, Based on Maximum Temperature (18°C) and Minimum DO (6.0 mg/L) for Growth.

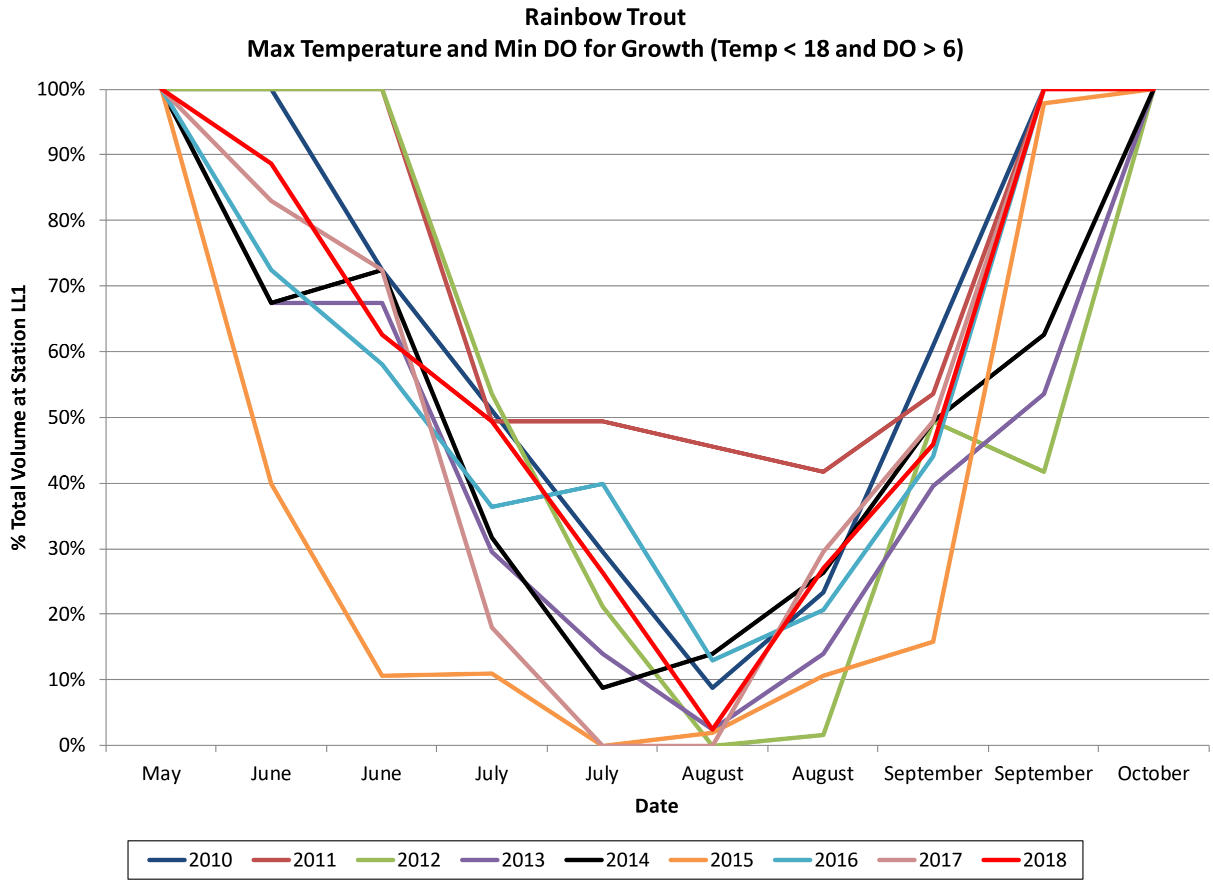

Figure 97. Habitat Conditions at Station LL1 for Rainbow Trout in 2010 – 2018, Based on Maximum Temperature (18°C) and Minimum DO (6.0 mg/L) for Growth.

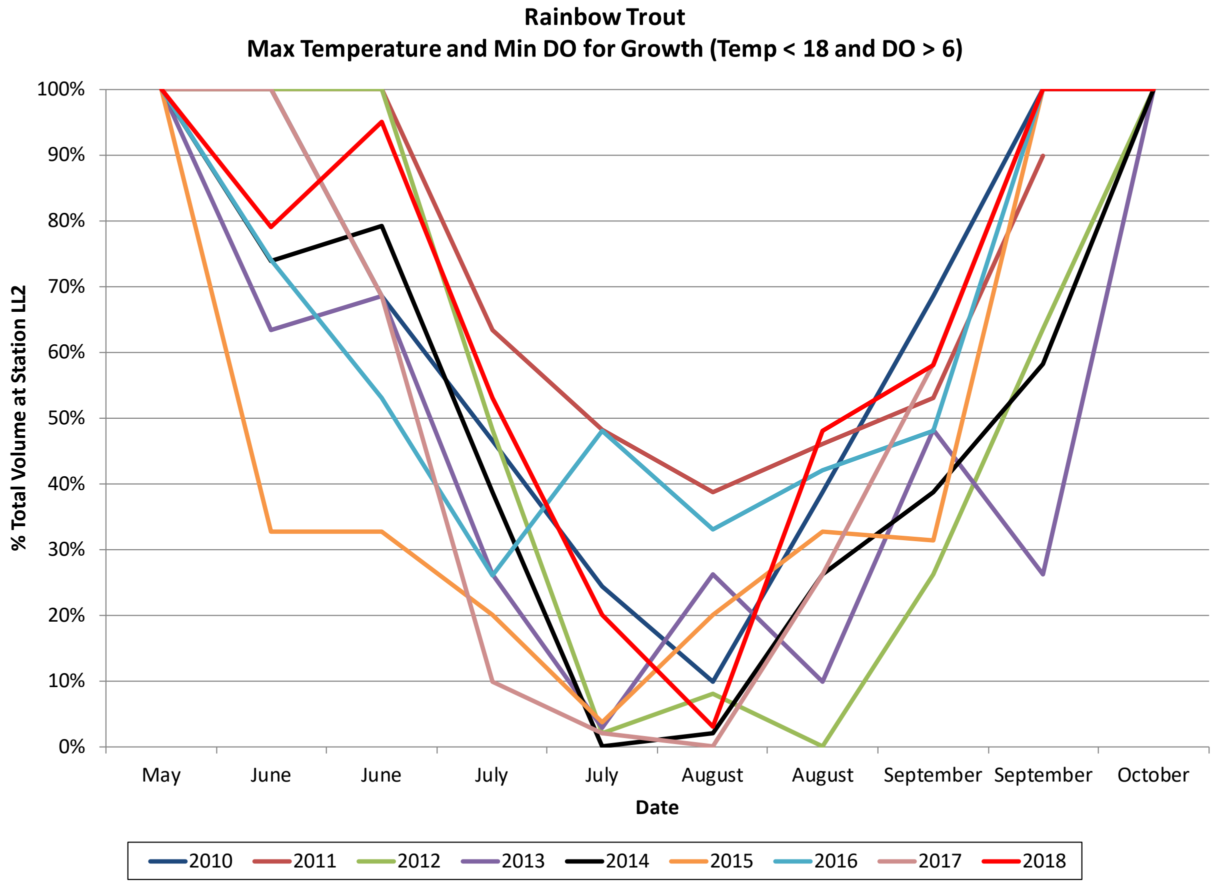

Figure 98. Habitat Conditions at Station LL2 for Rainbow Trout in 2010 – 2018, Based on Maximum Temperature (18°C) and Minimum DO (6.0 mg/L) for Growth.

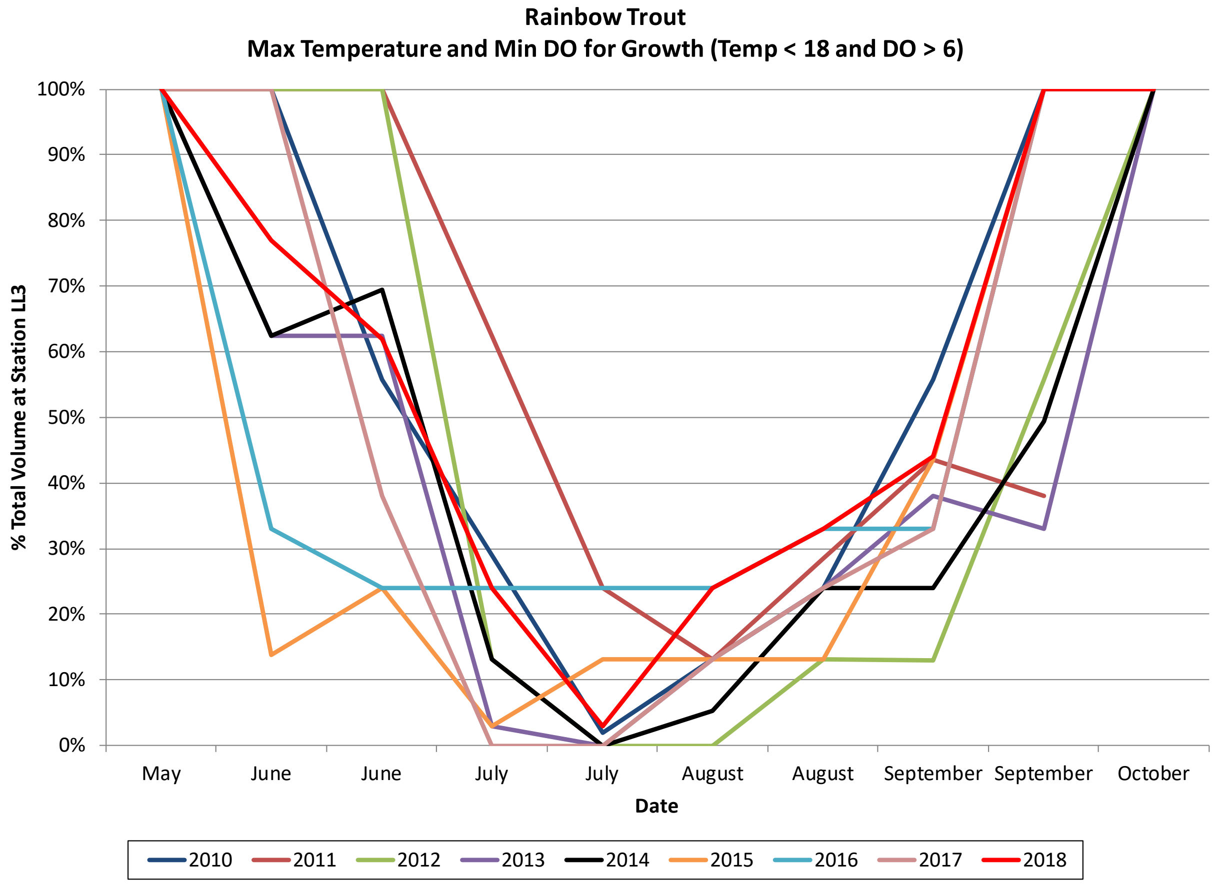

Figure 99. Habitat Conditions at Station LL3 for Rainbow Trout in 2010 – 2018, Based on Maximum Temperature (18°C) and Minimum DO (6.0 mg/L) for Growth.

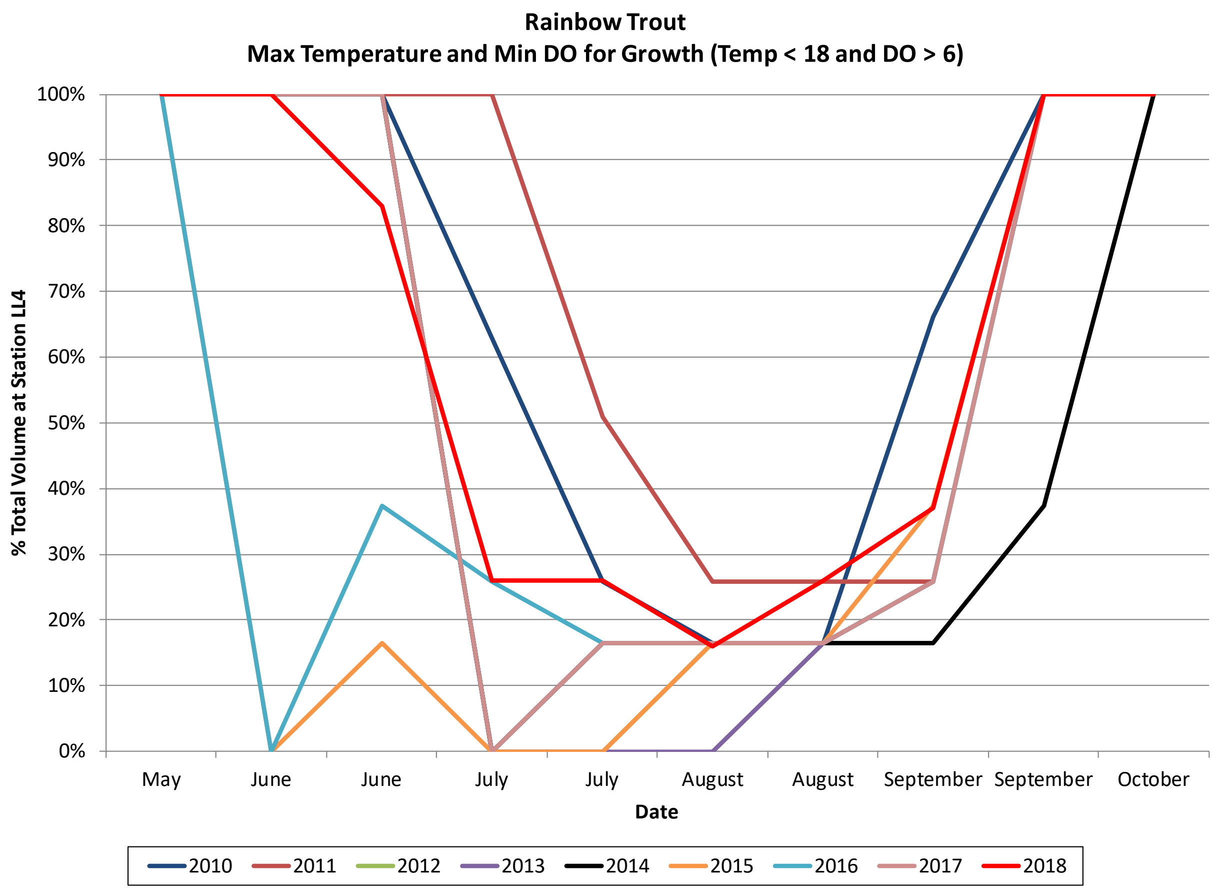

Figure 100. Habitat Conditions at Station LL4 for Rainbow Trout in 2010 – 2018, Based on Maximum Temperature (18°C) and Minimum DO (6.0 mg/L) for Growth.

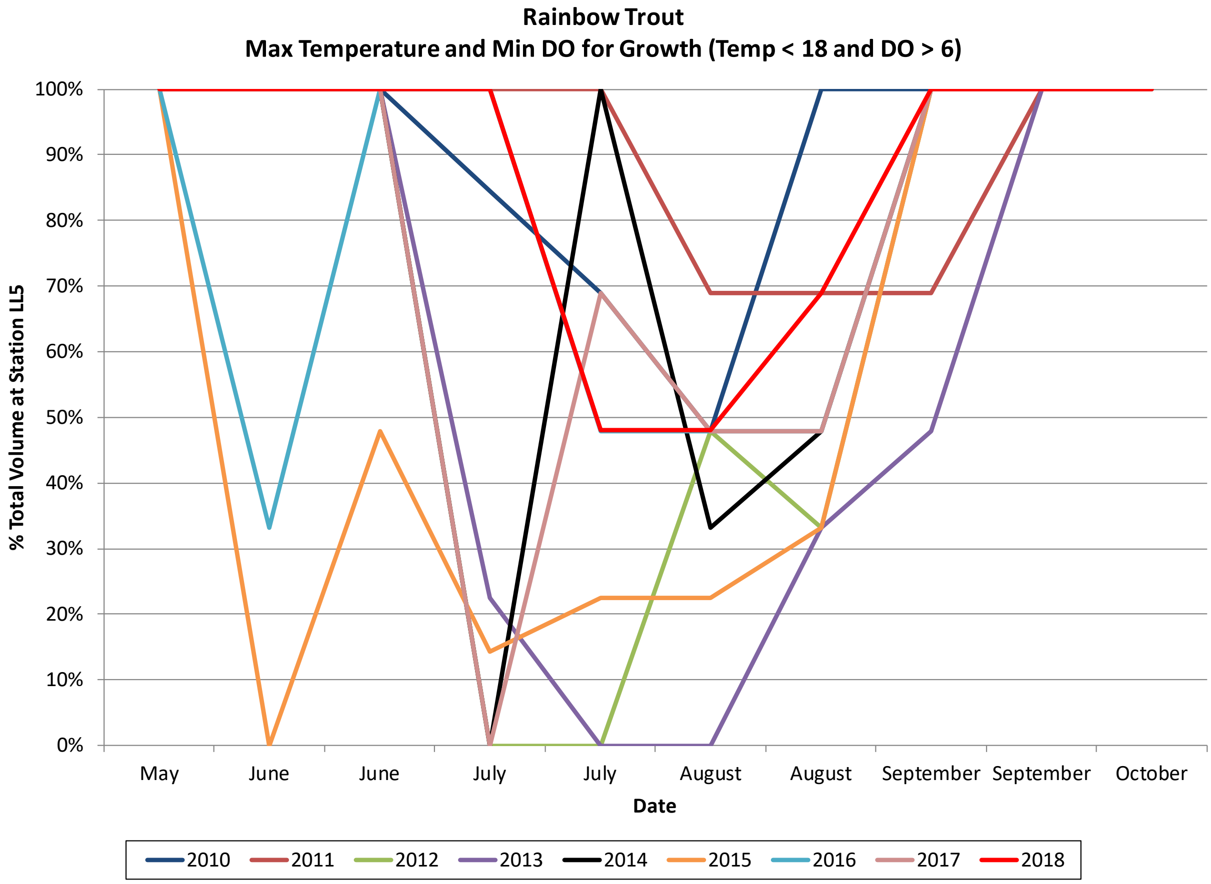

Figure 101. Habitat Conditions at Station LL5 for Rainbow Trout in 2010 – 2018, Based on Maximum Temperature (18°C) and Minimum DO (6.0 mg/L) for Growth.

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APPENDIX I – Lake Spokane *In Situ* Monitoring Data

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Table A-1. Station LL0 *In Situ* Water Quality Data, 2018

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
5/16/2018	0.5	9:07	14.98	7.95	65.4	12.63	132.7		2.5
5/16/2018	1		14.48	7.91	65.1	12.61	131		
5/16/2018	2		14.28	7.81	65.2	12.67	131		
5/16/2018	3		13.95	7.58	65.1	12.74	130.8		
5/16/2018	4		13.89	7.56	65.9	12.85	131.8		
5/16/2018	5		13.83	7.54	65.4	12.58	128.9	bottle broke	
5/16/2018	6		13.76	7.53	65.5	12.44	127.3		
5/16/2018	7		13.58	7.44	66.4	12.35	125.8		
5/16/2018	8		13.35	7.34	65.5	12.13	122.9		
5/16/2018	9		13.22	7.35	65.4	12.05	121.8		
5/16/2018	9*		13.29	7.33	65.3	12.05	121.9		
5/16/2018	10		13.2	7.33	65.4	12.05	121.8		
5/16/2018	12		13.09	7.32	65.3	12.01	121		
5/16/2018	15		13.05	7.32	66.1	11.95	120.4	11.1	
5/16/2018	18		13.02	7.31	65.5	11.94	120.1		
5/16/2018	21		12.98	7.31	65.2	11.93	119.9		
5/16/2018	24		12.88	7.29	76.6	11.89	119.3		
5/16/2018	27		12.78	7.28	65.4	11.86	118.5		
5/16/2018	30		12.57	7.27	68.7	11.85	118		
5/16/2018	33		12.47	7.26	65.1	11.74	116.7		
5/16/2018	33*		12.49	7.27	66.5	11.79	117.2		
5/16/2018	36		12.31	7.26	65.3	11.78	116.7		
5/16/2018	39		12.26	7.26	65.3	11.79	116.6		
5/16/2018	42		12.18	7.25	65.6	11.8	116.4		
5/16/2018	45		12.09	7.24	65.9	11.66	114.8		
5/16/2018	47		11.94	7.21	68.7	11.58	113.7		
6/6/2018	0.5	9:15	18.12	7.92	72.9	10.62	118.6		3.8
6/6/2018	1		17.84	7.95	72.6	10.79	119.9		
6/6/2018	2		17.78	7.97	72.8	10.96	121.7		
6/6/2018	3		17.69	7.91	72.8	10.91	120.9		
6/6/2018	4		17.6	7.84	72.8	10.9	120.5		
6/6/2018	5		17.51	7.7	72.8	10.93	120.6	10.2	
6/6/2018	6		17.2	7.51	73.1	10.59	116.1		
6/6/2018	7		17.14	7.43	73.2	10.45	114.5		
6/6/2018	8		17.11	7.41	73.4	10.42	114		
6/6/2018	9		17.1	7.39	73.3	10.35	113.2		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
6/6/2018	9*		17.08	7.38	73.3	10.36	113.4		
6/6/2018	10		16.93	7.29	72.9	10.33	112.6		
6/6/2018	12		16.69	7.27	73.9	10.07	109.3		
6/6/2018	15		16.44	7.3	75.8	10.18	109.8		
6/6/2018	18		15.9	7.32	79.8	10.06	107.3		
6/6/2018	21		15.85	7.32	80	10.5	107.1		
6/6/2018	24		15.79	7.32	81.2	9.88	105.2	10.0 at 25 meters	
6/6/2018	27		15.72	7.32	82.3	9.91	105.3		
6/6/2018	30		15.69	7.31	82.5	9.86	104.8		
6/6/2018	33		15.68	7.32	82.9	9.88	104.9		
6/6/2018	33*		15.68	7.31	82.9	9.87	104.8		
6/6/2018	36		15.67	7.31	82.9	9.83	104.3		
6/6/2018	39		15.64	7.3	83.3	9.82	104.1		
6/6/2018	42		15.63	7.3	83.1	9.84	104.4		
6/6/2018	45		15.63	7.3	83.3	9.79	103.9		
6/6/2018	47		15.62	7.29	83.2	9.79	103.8		
6/19/2018	0.5	9:00	18.81	8.33	101.3	10.34	116.7		3.6
6/19/2018	1		18.69	8.37	101.3	10.4	117.1		
6/19/2018	2		18.65	8.36	101.6	10.45	117.5		
6/19/2018	3		18.59	8.37	101.5	10.42	117.1		
6/19/2018	4		18.52	8.3	102	10.29	115.4		
6/19/2018	5		18.2	8.05	103.8	9.9	110.3	9.89	
6/19/2018	6		17.96	7.85	106.3	9.59	106.3		
6/19/2018	7		17.86	7.78	107.3	9.42	104.2		
6/19/2018	8		17.79	7.76	106.2	9.34	103.3		
6/19/2018	9		17.57	7.63	107.6	9.18	101		
6/19/2018	9*		17.56	7.62	107.8	9.18	101		
6/19/2018	10		17.46	7.56	108.9	9.03	99.1		
6/19/2018	12		17.09	7.38	106.4	8.77	95.5		
6/19/2018	15		16.41	7.3	115.9	8.5	91.3	8.6	
6/19/2018	18		16.23	7.34	121.7	8.55	91.5		
6/19/2018	21		16.14	7.37	125.1	8.59	91.8		
6/19/2018	24		16.03	7.4	128.2	8.66	92.2		
6/19/2018	27		16	7.4	128.6	8.69	92.5		
6/19/2018	30		15.95	7.4	129.1	8.66	92.1		
6/19/2018	33		15.91	7.4	129.5	8.64	91.8		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
6/19/2018	33*		15.91	7.4	129.5	8.66	92		
6/19/2018	36		15.88	7.4	130	8.61	91.4		
6/19/2018	39		15.88	7.39	130	8.59	91.2		
6/19/2018	42		15.87	7.4	130	8.56	90.9		
6/19/2018	45		15.84	7.37	130.8	8.44	89.5		
6/19/2018	47		15.83	7.36	130.3	8.39	89		
7/10/2018	0.5	9:10	21.74	8.51	139.4	9.94	119		4.8
7/10/2018	1		21.74	8.52	139.1	9.94	119		
7/10/2018	2		21.35	8.55	139.1	10.47	124.5		
7/10/2018	3		21.17	8.62	139.2	10.56	125.1		
7/10/2018	4		21.07	8.62	138.8	10.65	125.8		
7/10/2018	5		20.58	8.65	138.4	10.8	126.4	10.5	
7/10/2018	6		20.2	8.58	138.8	10.7	124.3		
7/10/2018	7		19.17	8.32	143.5	10.23	116.3		
7/10/2018	8		18.58	7.96	150.8	9.45	106.2		
7/10/2018	9		18.11	7.79	156.4	9.08	101.2		
7/10/2018	9*		18.1	7.79	156.1	9.14	101.7		
7/10/2018	10		17.86	7.68	158.5	8.73	96.6		
7/10/2018	12		17.47	7.57	159.2	8.23	90.5		
7/10/2018	15		17.05	7.5	160	7.86	85.6	8.02	
7/10/2018	18		16.77	7.48	156.8	7.86	85.1		
7/10/2018	21		16.36	7.43	154.4	7.66	82.3		
7/10/2018	24		16.31	7.42	163.3	7.51	80.6		
7/10/2018	27		16.19	7.37	153.5	7.42	79.3		
7/10/2018	30		16.04	7.33	145.8	7.3	77.8		
7/10/2018	33		15.97	7.3	146.1	7.16	76.2		
7/10/2018	33*		15.96	7.3	145.7	7.15	76.1		
7/10/2018	36		15.9	7.29	146.7	7.07	75.1		
7/10/2018	39		15.77	7.23	149.2	6.48	68.7		
7/10/2018	42		15.73	7.2	149.7	6.19	65.6		
7/10/2018	45		15.7	7.17	150.2	5.92	62.7		
7/10/2018	47		15.68	7.16	150.5	5.81	61.5		
7/23/2018	0.5	9:05	22.98	8.78	150.2	10.96	134.1		4.7
7/23/2018	1		22.91	8.79	150.4	11.02	134.6		
7/23/2018	2		22.82	8.79	150.6	11.04	134.6		
7/23/2018	3		22.78	8.79	151.3	11.24	137		
7/23/2018	4		22.54	8.86	157	12.87	156.1		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
7/23/2018	5		21.91	8.88	162.4	14.34	171.9	no data broken	
7/23/2018	6		20.69	8.82	174.5	15.29	178.9		
7/23/2018	7		19.87	8.65	170.2	14.02	161.4		
7/23/2018	8		19.29	8.46	180.4	12.41	141.3		
7/23/2018	9		18.92	8.12	193.4	10.78	121.8		
7/23/2018	9*		19.03	8.15	190.7	10.79	122.2		
7/23/2018	10		18.62	7.78	193.6	9.35	105		
7/23/2018	12		18.13	7.55	194	8.19	91		
7/23/2018	15		17.17	7.41	188	7.42	81.7	7.71	
7/23/2018	18		17.04	7.24	173.2	6.64	72.2		
7/23/2018	21		16.78	7.21	173.4	6.64	71.7		
7/23/2018	24		16.52	7.23	176.2	6.79	73		
7/23/2018	27		16.35	7.25	186.7	6.79	72.8		
7/23/2018	30		16.24	7.21	188.5	6.49	69.4		
7/23/2018	33		16.1	7.16	181.6	6.25	66.6		
7/23/2018	33*		16.1	7.17	180.3	6.25	66.6		
7/23/2018	36		15.93	7.06	173.8	5.27	56		
7/23/2018	39		15.81	6.99	163.9	4.75	50.3		
7/23/2018	42		15.7	6.93	159.6	4.14	43.7		
7/23/2018	45		15.64	6.89	156.9	3.72	39.2		
7/23/2018	47		15.6	6.88	156.1	3.43	36.1		
8/7/2018	0.5	9:20	23.01	8.78	176	10.44	128.2		6.2
8/7/2018	1		22.99	8.77	176	10.55	129.6		
8/7/2018	2		23	8.77	175.7	10.5	128.9		
8/7/2018	3		22.99	8.76	175.9	10.49	128.9		
8/7/2018	4		22.96	8.76	175.7	10.72	131.5		
8/7/2018	5		20.97	8.6	213.7	13.93	164.5	12.6	
8/7/2018	6		20.11	8.32	222.2	11.37	132.1		
8/7/2018	7		19.59	8.2	223.5	10.62	122		
8/7/2018	8		19.05	7.85	227.8	8.92	101.4		
8/7/2018	9		18.73	7.64	228.6	7.77	87.8		
8/7/2018	9*		18.73	7.62	229.2	7.8	88.1		
8/7/2018	10		18.49	7.52	227.3	7.14	80.2		
8/7/2018	12		18.19	7.46	233.7	6.5	72.6		
8/7/2018	15		18	7.4	234.2	6.36	70.7		
8/7/2018	18		17.7	7.33	210.6	5.96	65.9		
8/7/2018	21		17.19	7.24	185.2	5.51	60.3		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
8/7/2018	24		16.85	7.25	188.4	5.74	62.4		
8/7/2018	27		16.47	7.24	193.3	5.55	59.8		
8/7/2018	30		16.23	7.16	196	4.89	52.5		
8/7/2018	33		16.11	7.15	197.9	4.79	51.2	5.27	
8/7/2018	33*		16.1	7.14	198.2	4.76	50.9		
8/7/2018	36		15.96	7.09	189.3	4.3	45.9		
8/7/2018	39		15.75	7	174.9	3.4	36.1		
8/7/2018	42		15.66	6.94	174.8	2.52	26.7		
8/7/2018	45		15.6	6.89	174	2.18	23.1		
8/7/2018	47		15.55	6.87	173.5	1.91	20.2		
8/28/2018	0.5	9:15	20.14	8.61	212.5	10.02	115.8		4.6
8/28/2018	1		20.14	8.64	212.7	10.03	116.2		
8/28/2018	2		20.13	8.65	212.5	10.04	116.3		
8/28/2018	3		20.14	8.66	212.7	10.04	116.4		
8/28/2018	4		20.14	8.66	212.7	10.03	116.2		
8/28/2018	5		20.14	8.66	212.8	10.01	115.9	7.89	
8/28/2018	6		20.13	8.66	213.1	10	115.9		
8/28/2018	7		20.05	8.55	215.2	9.71	112.3		
8/28/2018	8		19.15	7.74	243.2	7.53	85.6		
8/28/2018	9		18.54	7.55	250.7	6.31	70.8		
8/28/2018	9*		18.58	7.55	250.8	6.35	71.4		
8/28/2018	10		18.21	7.48	253	5.88	65.4		
8/28/2018	12		17.84	7.44	256.4	5.42	59.9		
8/28/2018	15		17.36	7.4	252	5.01	54.8		
8/28/2018	18		17.19	7.33	244.3	4.52	49.3		
8/28/2018	21		16.94	7.36	250.6	4.77	51.8		
8/28/2018	24		16.61	7.19	222.1	3.28	35.3		
8/28/2018	27		16.26	7.09	209.4	2.24	24		
8/28/2018	30		16.22	7.08	210.9	2.21	23.7		
8/28/2018	33		16.09	7.04	200	1.96	20.8		
8/28/2018	33*		16.08	7.04	199.8	1.92	20.5		
8/28/2018	36		15.89	7.04	191.5	2.43	25.8		
8/28/2018	39		15.66	6.97	184	1.63	17.2		
8/28/2018	42		15.55	6.93	182.5	1.11	11.7	1.39	
8/28/2018	45		15.47	6.9	182.9	0.62	6.5		
8/28/2018	47		15.45	6.9	181.4	0.69	7.3		
9/13/2018	0.5	11:35	18.89	8.43	233.5	9.69	110.3		4.9
9/13/2018	1		18.87	8.49	233.7	9.7	110.3		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
9/13/2018	2		18.83	8.51	233.6	9.7	110.2		
9/13/2018	3		18.77	8.49	235	9.64	109.4		
9/13/2018	4		18.7	8.5	234.1	9.68	109.7		
9/13/2018	5		18.68	8.5	234.1	9.68	109.7		
9/13/2018	6		18.68	8.47	235.8	9.48	107.4		
9/13/2018	7		18.14	7.52	266.5	6.16	69.1		
9/13/2018	8		17.89	7.43	264.9	5.27	58.8		
9/13/2018	9		17.77	7.34	262	4.82	53.6	4.85	
9/13/2018	9*		17.76	7.34	262.6	4.91	54.6		
9/13/2018	10		17.54	7.29	259.6	4.55	50.4		
9/13/2018	12		17.23	7.31	261.6	4.64	51		
9/13/2018	15		16.85	7.28	254.7	4.34	47.4		
9/13/2018	18		16.42	7.37	262.1	5.34	57.8		
9/13/2018	21		15.96	7.55	271.2	6.54	70.1		
9/13/2018	24		15.84	7.56	272.8	6.71	71.7		
9/13/2018	27		15.82	7.54	274.6	6.68	71.3	broke	
9/13/2018	30		15.79	7.53	273.7	6.65	70.9		
9/13/2018	33		15.78	7.53	274.5	6.63	70.7		
9/13/2018	33*		15.78	7.54	274.2	6.64	70.8		
9/13/2018	36		15.72	7.49	272.3	6.39	68		
9/13/2018	39		15.7	7.51	272.3	6.38	68		
9/13/2018	42		15.62	7.41	272.3	5.67	60.3		
9/13/2018	45		15.59	7.36	272.1	5.27	56		
9/13/2018	47		15.58	7.35	272.5	5.1	54.2		
9/25/2018	0.5	9:04	16.76	8.44	252.2	9.05	97.3		6.9
9/25/2018	1		16.82	8.47	252.9	9.06	97.5		
9/25/2018	2		16.8	8.47	252.9	9.06	97.5		
9/25/2018	3		16.81	8.49	252.9	9.12	98.2		
9/25/2018	4		16.78	8.48	253.3	9.06	97.4		
9/25/2018	5		16.78	8.48	253.7	9.07	97.6	8.32	
9/25/2018	6		16.8	8.42	253.7	9.04	97.3		
9/25/2018	7		16.8	8.45	254.3	8.94	96.2		
9/25/2018	8		16.79	8.41	255.1	8.77	94.4		
9/25/2018	9		16.63	7.91	269.8	6.67	71.5		
9/25/2018	9*		16.67	7.93	268.4	6.89	74		
9/25/2018	10		16.53	7.83	272	6.39	68.4		
9/25/2018	12		16.24	7.82	273.2	6.35	67.5		
9/25/2018	15		15.79	7.86	279.2	6.75	71.1	6.89	

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
9/25/2018	18		15.32	7.93	263.3	7.38	77		
9/25/2018	21		15.05	7.96	257.5	7.57	78.5		
9/25/2018	24		14.92	7.98	256.5	7.88	81.5		
9/25/2018	27		14.85	8	255.4	8.05	83		
9/25/2018	30		14.82	8.01	255.4	8.01	82.6		
9/25/2018	33		14.8	7.99	255.1	8.08	83.4		
9/25/2018	33*		14.8	8	255.2	8.1	83.5		
9/25/2018	36		14.79	7.98	255.4	8.02	82.7		
9/25/2018	39		14.78	7.94	255.2	7.84	80.8		
9/25/2018	42		14.77	7.92	255.2	7.64	78.7		
9/25/2018	45		14.76	7.88	255.4	7.39	76.2		
9/25/2018	47		14.76	7.89	255.5	7.27	74.9		
10/16/2018	0.5	9:00	13.6	7.89	250.4	9.57	95.4		5.7
10/16/2018	1		13.61	7.95	250.7	9.6	95.7		
10/16/2018	2		13.62	7.97	250.7	9.59	95.6		
10/16/2018	3		13.63	7.99	250.8	9.57	95.6		
10/16/2018	4		13.61	8	251	9.59	95.7		
10/16/2018	5		13.62	8.01	251.3	9.63	96.1	9.01	
10/16/2018	6		13.61	8.01	250.8	9.61	95.8		
10/16/2018	7		13.62	8.01	251	9.57	95.5		
10/16/2018	8		13.62	8.01	250.7	9.6	95.8		
10/16/2018	9		13.63	8	251	9.58	95.5		
10/16/2018	9*		13.62	8.01	251	9.61	95.8		
10/16/2018	10		13.62	8.01	251	9.6	95.8		
10/16/2018	12		13.62	8.01	250.8	9.64	96.1		
10/16/2018	15		13.22	7.76	248.6	8.58	84.9	8.85	
10/16/2018	18		12.88	7.76	248.6	8.71	85.5		
10/16/2018	21		12.53	7.79	248.2	9.02	87.8		
10/16/2018	24		12.33	7.8	247.8	9.14	88.6		
10/16/2018	27		12.28	7.78	247.8	9.08	87.9		
10/16/2018	30		12.27	7.78	247.5	9.08	87.9		
10/16/2018	33		12.23	7.77	247.4	9.12	88.2		
10/16/2018	33*		12.22	7.75	247.3	9.06	87.6		
10/16/2018	36		12.21	7.76	247.2	9.08	87.7		
10/16/2018	39		12.2	7.73	247.3	8.9	86		
10/16/2018	42		12.2	7.73	247.5	8.93	86.2		
10/16/2018	45		12.2	7.72	247.3	8.86	85.6		
10/16/2018	47		12.19	7.72	247.1	8.88	85.8		

*QA/QC measurement for Hydrolab
**Secchi disk depths average of 3 measurements

Table A-2. Station LL1 *In Situ* Water Quality Data, 2018

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
5/16/2018	0.5	10:13	15.01	7.53	66.6	11.69	122.8		2.3
5/16/2018	1		14.74	7.53	66.3	11.74	122.7		
5/16/2018	2		14.66	7.49	66.4	11.91	124.3		
5/16/2018	3		14.32	7.45	66.6	11.97	123.9		
5/16/2018	4		14.24	7.44	66.3	12.21	126.2		
5/16/2018	4*		14.27	7.45	66.2	12.05	124.6		
5/16/2018	5		14.2	7.44	66.6	12.04	124.3	9.32	
5/16/2018	6		14.2	7.44	66.7	11.97	123.6		
5/16/2018	7		13.9	7.4	66.2	11.93	122.4		
5/16/2018	8		13.69	7.39	66.1	11.88	121.4		
5/16/2018	9		13.66	7.39	66.4	11.85	120.9		
5/16/2018	10		13.62	7.38	66.4	11.89	121.2		
5/16/2018	12		13.58	7.38	66	11.91	121.4		
5/16/2018	15		13.45	7.38	66	11.9	120.9		
5/16/2018	18		13.31	7.37	66	11.92	120.6		
5/16/2018	21		13.1	7.34	65.7	11.81	119	9.17	
5/16/2018	21*		13.09	7.35	65.7	11.86	119.5		
5/16/2018	24		12.71	7.33	65.7	11.8	117.9		
5/16/2018	27		12.18	7.3	65.7	11.76	116.1		
5/16/2018	30		11.85	7.26	66.6	11.56	113.2		
5/16/2018	33		11.55	7.17	68.1	10.91	106.2		
6/6/2018	0.5	10:19	18.14	8.25	77	10.88	121.6		3.0
6/6/2018	1		18.11	8.28	76.8	10.91	121.9		
6/6/2018	2		17.99	8.29	76.8	11.02	122.9		
6/6/2018	3		17.91	8.25	77.1	10.93	121.6		
6/6/2018	4		17.75	8.07	79.9	10.78	119.6		
6/6/2018	4*		17.85	8.16	77.6	10.82	120.2		
6/6/2018	5		17.78	8.05	77.8	10.69	118.6	10	
6/6/2018	6		17.7	8.01	83.8	10.69	118.5		
6/6/2018	7		17.61	7.9	85.1	10.59	117.1		
6/6/2018	8		17.55	7.85	85.2	10.46	115.5		
6/6/2018	9		17.07	7.69	97.7	10.21	111.7		
6/6/2018	10		16.87	7.66	98.9	10.15	110.5		
6/6/2018	12		16.46	7.54	95.8	9.98	107.8		
6/6/2018	15		16.25	7.56	107.3	9.91	106.5		
6/6/2018	18		16.18	7.55	106.3	9.84	105.7		
6/6/2018	21		16.11	7.53	105.4	9.87	105.8	broke	

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
6/6/2018	21*		16.11	7.53	105.4	9.86	105.7		
6/6/2018	24		15.8	7.47	97.8	9.89	105.2		
6/6/2018	27		15.62	7.41	92.5	9.87	104.6		
6/6/2018	30		15.58	7.39	92	9.84	104.3		
6/6/2018	33		15.54	7.36	91.6	9.73	103		
6/19/2018	0.5	9:55	18.46	8.22	104.3	10.03	112.5		3.6
6/19/2018	1		18.28	8.22	104.1	10.13	113.1		
6/19/2018	2		18.19	8.21	104.7	10.14	113.1		
6/19/2018	3		18.17	8.18	105.3	10.11	112.6		
6/19/2018	4		18.09	8.11	108.7	10.03	111.6		
6/19/2018	4*		18.1	8.13	108	9.99	111.1		
6/19/2018	5		18.08	8.1	110.5	9.91	110.2	9.69	
6/19/2018	6		18.05	8.07	112.3	9.83	109.2		
6/19/2018	7		18.04	8.07	112.3	9.81	109		
6/19/2018	8		18.04	8.07	112.4	9.98	108.9		
6/19/2018	9		18.01	8.03	113	9.74	108.2		
6/19/2018	10		17.7	7.8	112.4	9.39	103.6		
6/19/2018	12		17.3	7.62	114.7	9.09	99.4		
6/19/2018	15		16.44	7.6	131.1	9.18	98.6		
6/19/2018	18		16.34	7.63	134.1	9.26	99.3		
6/19/2018	21		16.1	7.61	139.2	9.19	98.1	8.91	
6/19/2018	21*		16.09	7.59	139.4	9.12	97.3		
6/19/2018	24		16	7.58	140.6	9.06	96.5		
6/19/2018	27		15.89	7.56	143.2	9.06	96.3		
6/19/2018	30		15.86	7.52	143.3	8.92	984.7		
6/19/2018	33		15.85	7.53	143.5	8.9	94.4		
7/10/2018	0.5	10:10	22.19	8.42	142.3	9.83	118.7		5.0
7/10/2018	1		21.96	8.47	141.9	10.08	121.2		
7/10/2018	2		21.86	8.49	142.1	10.18	122.2		
7/10/2018	3		21.38	8.58	140.6	10.92	129.8		
7/10/2018	4		20.71	8.56	141.7	11.01	129.1		
7/10/2018	4*		20.84	8.58	140.9	11	129.3		
7/10/2018	5		20.53	8.58	143.6	11.09	129.6	9.98	
7/10/2018	6		19.93	8.47	147.2	10.85	125.3		
7/10/2018	7		19.15	8.22	167.8	10.28	116.9		
7/10/2018	8		18.63	8.02	174.2	9.76	109.8		
7/10/2018	9		18.29	7.88	179.1	9.24	103.3		
7/10/2018	10		17.95	7.69	178.8	8.63	95.8		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
7/10/2018	12		17.33	7.48	175.5	7.93	86.9		
7/10/2018	15		17.08	7.49	180.1	7.93	86.4		
7/10/2018	18		16.79	7.49	183.7	7.94	86		
7/10/2018	21		16.57	7.56	195	8.11	87.5	8.26	
7/10/2018	21*		16.56	7.56	195.8	8.09	87.2		
7/10/2018	24		16.37	7.62	200.4	8.28	88.9		
7/10/2018	27		16.28	7.65	201.6	8.42	90.2		
7/10/2018	30		16.18	7.62	202.7	8.23	88.1		
7/10/2018	33		16.12	7.57	203	8.03	85.8		
7/23/2018	0.5	10:10	23.85	8.8	155.2	9.99	124.2		5.7
7/23/2018	1		23.79	8.81	155.3	10.04	124.8		
7/23/2018	2		23.71	8.8	154.9	10.09	125.1		
7/23/2018	3		23.65	8.81	154.4	10.16	125.9		
7/23/2018	4		23.19	8.82	158.7	10.54	129.4		
7/23/2018	4*		23.17	8.81	157.8	10.43	128.1		
7/23/2018	5		22.04	8.8	180.6	13	156.2	12	
7/23/2018	6		20.32	8.72	200.4	13.65	158.6		
7/23/2018	7		19.61	8.47	209	11.79	135.1		
7/23/2018	8		19.26	8.41	212.6	11.54	131.3		
7/23/2018	9		19.05	8.24	218.6	10.62	120.3		
7/23/2018	10		18.82	7.95	232.1	9.17	103.4		
7/23/2018	12		18.45	7.75	227.4	8.3	92.9		
7/23/2018	15		17.93	7.58	210.1	7.48	82.8		
7/23/2018	18		17.49	7.5	194.4	7.23	79.3		
7/23/2018	21		17.11	7.41	188.2	6.77	73.7	7.16	
7/23/2018	21*		17.05	7.41	188.3	6.81	74.1		
7/23/2018	24		16.58	7.42	194.2	6.94	74.7		
7/23/2018	27		16.36	7.39	196.9	6.67	71.4		
7/23/2018	30		16.22	7.3	198	5.82	62.2		
7/23/2018	33		16.12	7.23	200.2	4.96	52.8		
8/7/2018	0.5	10:15	23.94	8.7	179.8	9.9	123.8		6.2
8/7/2018	1		23.89	8.7	179.6	9.87	123.3		
8/7/2018	2		23.73	8.71	179.5	9.9	123.1		
8/7/2018	3		23.65	8.72	179.4	10.08	125.3		
8/7/2018	4		23.54	8.72	179.5	10.2	126.6		
8/7/2018	4*		23.55	8.72	179.2	10.21	126.7		
8/7/2018	5		23.26	8.72	181.6	10.55	130.2	9.18	
8/7/2018	6		22.07	8.58	212.7	12.86	155.2		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
8/7/2018	7		20.52	8.3	230.2	11.13	130.3		
8/7/2018	8		19.5	7.95	233.4	9.35	107.3		
8/7/2018	9		18.93	7.73	240.3	8.15	92.5		
8/7/2018	10		18.66	7.67	247.9	7.81	88.1		
8/7/2018	12		18.43	7.63	254.6	7.53	84.5		
8/7/2018	15		18.13	7.63	269.2	7.52	83.9		
8/7/2018	18		17.96	7.5	263.3	6.81	75.7		
8/7/2018	21		17.43	7.28	226.3	5.37	59.1	6	
8/7/2018	21*		17.4	7.26	224.1	5.3	58.3		
8/7/2018	24		16.85	7.2	199.7	4.99	54.2		
8/7/2018	27		16.41	7.08	199.3	3.78	40.6		
8/7/2018	30		16.23	6.99	200.3	2.44	26.1		
8/7/2018	33		16.1	6.93	202.9	1.51	16.2		
8/28/2018	0.5	10:35	20.31	8.67	215	9.78	113.7		4.4
8/28/2018	1		20.31	8.68	214.7	9.81	114		
8/28/2018	2		20.28	8.67	215.1	9.84	114.3		
8/28/2018	3		20.28	8.66	214.9	9.82	114.1		
8/28/2018	4		20.26	8.67	214.8	9.82	114		
8/28/2018	4*		20.27	8.67	214.9	9.83	114.2		
8/28/2018	5		20.24	8.67	214.5	9.84	114.3	7.68	
8/28/2018	6		20.21	8.69	213.8	9.86	114.4		
8/28/2018	7		20.17	8.69	212.1	9.91	114.9		
8/28/2018	8		20.03	8.53	215.7	9.32	107.7		
8/28/2018	9		18.64	7.72	265.3	7.18	80.7		
8/28/2018	10		18.29	7.63	267.8	6.65	74.2		
8/28/2018	12		17.97	7.53	266.3	6.03	66.8		
8/28/2018	15		17.49	7.51	266.5	5.81	63.8		
8/28/2018	18		17.21	7.62	270.2	6.75	73.7		
8/28/2018	21		16.89	7.71	271.2	7.35	79.7	7.08	
8/28/2018	21*		16.89	7.7	271.2	7.35	79.7		
8/28/2018	24		16.56	7.83	269.8	8.13	87.6		
8/28/2018	27		16.34	7.83	270.2	8.14	87.4		
8/28/2018	30		16.24	7.8	271.2	8	85.6		
8/28/2018	33		16.21	7.77	271.2	7.83	83.7		
9/13/2018	0.5	12:35	19.21	8.41	233.5	9.14	104.7		6.1
9/13/2018	1		19.15	8.41	233.4	9.16	104.8		
9/13/2018	2		19.03	8.42	233.1	9.18	104.8		
9/13/2018	3		18.97	8.42	233.1	9.21	105		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
9/13/2018	4		18.94	8.42	233.4	9.22	105		
9/13/2018	4*		18.94	8.43	233	9.23	105.1		
9/13/2018	5		18.92	8.42	233	9.15	104.2	broke	
9/13/2018	6		18.91	8.42	233.7	9.13	103.9		
9/13/2018	7		18.88	8.43	233	9.14	103.9		
9/13/2018	8		18.49	7.87	250.4	7.41	83.6		
9/13/2018	9		17.84	7.51	265.2	6.16	68.6		
9/13/2018	10		17.59	7.41	268.1	5.77	63.9		
9/13/2018	12		17.1	7.45	268.1	6.03	66.1		
9/13/2018	15		16.64	7.5	268.9	6.44	70		
9/13/2018	18		16.32	7.54	270.8	6.77	73		
9/13/2018	21		15.94	7.66	275.5	7.58	81.1	broke	
9/13/2018	21*		15.97	7.66	275.2	7.51	80.5		
9/13/2018	24		15.87	7.71	275.5	7.83	83.7		
9/13/2018	27		15.65	7.76	276.2	8.18	87		
9/13/2018	30		15.5	7.78	276.7	8.38	88.8		
9/13/2018	33		15.42	7.72	277.9	8.06	85.3		
9/25/2018	0.5	10:05	17.24	8.5	249.3	9.3	101.1		6.7
9/25/2018	1		17.22	8.54	249.1	9.34	101.4		
9/25/2018	2		17.2	8.55	249.5	9.29	100.9		
9/25/2018	3		17.17	8.56	249.6	9.3	100.9		
9/25/2018	4		17.15	8.53	249.9	9.2	99.7		
9/25/2018	4*		17.15	8.53	249.8	9.23	100.1		
9/25/2018	5		17.12	8.55	249.5	9.36	101.3	8.54	
9/25/2018	6		17.11	8.57	249.5	9.38	101.6		
9/25/2018	7		17.1	8.57	249.3	9.38	101.6		
9/25/2018	8		17.1	8.56	249	9.42	102		
9/25/2018	9		17.08	8.54	250.7	9.25	100.1		
9/25/2018	10		17.01	8.49	250.4	9.01	97.4		
9/25/2018	12		16.01	7.97	265.6	7.37	78		
9/25/2018	15		15.66	7.95	269.6	7.28	76.5		
9/25/2018	18		15.4	7.96	259.1	7.66	80		
9/25/2018	21		14.81	8.16	252.9	8.71	89.8	8.26	
9/25/2018	21*		14.8	8.15	252.8	8.77	90.4		
9/25/2018	24		14.47	8.19	252.2	9.06	92.8		
9/25/2018	27		14.32	8.17	252.6	9.13	93.2		
9/25/2018	30		14.24	8.15	252.9	9.14	93.1		
9/25/2018	33		14.24	8.14	252.7	9.08	92.5		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
10/16/2018	0.5	10:14	13.69	8.05	249.8	9.83	98.2		5.6
10/16/2018	1		13.69	8.06	249.8	9.88	98.7		
10/16/2018	2		13.69	8.06	250	9.88	98.7		
10/16/2018	3		13.69	8.06	250.1	9.85	98.4		
10/16/2018	4		13.68	8.05	250.1	9.88	98.7		
10/16/2018	4*		13.68	8.06	250.1	9.85	98.3		
10/16/2018	5		13.68	8.06	250.1	9.85	98.3	9.84	
10/16/2018	6		13.67	8.06	250.2	9.84	98.2		
10/16/2018	7		13.67	8.06	250.3	9.86	98.5		
10/16/2018	8		13.67	8.05	250	9.81	97.9		
10/16/2018	9		13.67	8.05	250.2	9.84	98.3		
10/16/2018	10		13.67	8.05	250	9.84	98.3		
10/16/2018	12		13.64	8.04	249.7	9.78	97.6		
10/16/2018	15		13.34	7.98	248.7	9.57	94.8		
10/16/2018	18		12.73	7.91	245.4	9.51	92.9		
10/16/2018	21		12.05	7.91	242.6	9.79	94.3	9.32	
10/16/2018	21*		12.05	7.91	242.6	9.81	94.5		
10/16/2018	24		11.9	7.88	242.7	9.79	94		
10/16/2018	27		11.86	7.86	243.1	9.79	93.9		
10/16/2018	30		11.84	7.85	242.7	9.78	93.7		
10/16/2018	33		11.83	7.83	243.1	9.69	92.8		

*QA/QC measurement for Hydrolab
**Secchi disk depths average of 3 measurements

Table A-3. Station LL1a *In Situ* Water Quality Data, 2018

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
5/16/2018	0.5	10:58	14.76	7.59	66.8	11.69	122.2		2.1
5/16/2018	1		14.71	7.59	66.8	11.73	122.5		
5/16/2018	2		14.7	7.56	67.1	11.82	123.4		
5/16/2018	2*		14.65	7.55	66.8	11.79	123		
5/16/2018	3		14.44	7.52	66.8	11.85	123		
5/16/2018	4		14.29	7.48	67.1	11.9	123.1		
5/16/2018	5		14.26	7.48	66.9	11.8	122.1	10.5	
5/16/2018	6		14.17	7.38	66.7	11.72	120.9		
5/16/2018	7		14.08	7.38	66.9	11.73	120.9		
5/16/2018	8		14.05	7.46	66.7	11.75	121		
5/16/2018	9		14.02	7.42	67	11.72	120.6		
5/16/2018	10		14	7.41	66.8	11.7	120.3		
5/16/2018	12		13.97	7.42	66.8	11.72	120.4		
5/16/2018	15		13.75	7.47	66.7	11.73	119.9		
5/16/2018	18		13.57	7.42	66.4	11.76	119.7		
5/16/2018	18*		13.59	7.44	66.5	11.75	119.8		
5/16/2018	21		13.56	7.42	66.5	11.72	119.3	11.5	
5/16/2018	24		13.38	7.41	66.3	11.78	119.5		
5/16/2018	27		13.1	7.38	66.1	11.72	118.1		
5/16/2018	29		12.52	7.33	66.1	11.61	115.5		
6/6/2018	0.5	10:58	18.33	8.29	78.3	10.88	122.1		3.1
6/6/2018	1		18.25	8.32	78.6	10.84	121.5		
6/6/2018	2		18.13	8.34	78.5	10.96	122.5		
6/6/2018	2*		18.11	8.32	78.5	10.98	122.6		
6/6/2018	3		18.03	8.3	78	10.97	122.4		
6/6/2018	4		18.01	8.27	77.1	10.88	121.3		
6/6/2018	5		17.99	8.23	76.6	10.86	121	10.7	
6/6/2018	6		17.98	8.21	76.5	10.83	120.7		
6/6/2018	7		17.87	8.09	82	10.67	118.7		
6/6/2018	8		17.85	8.05	84.7	10.61	117.9		
6/6/2018	9		17.32	7.8	99.4	10.26	112.8		
6/6/2018	10		17.16	7.75	102.4	10.15	111.2		
6/6/2018	12		16.73	7.68	111	9.9	107.5		
6/6/2018	15		16.47	7.6	113.5	9.74	105.2		
6/6/2018	18		16.31	7.58	112.7	9.73	104.7		
6/6/2018	18*		16.27	7.57	112.5	9.71	104.4		
6/6/2018	21		16.04	7.52	108.3	9.79	104.8	8.84	

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
6/6/2018	24		15.86	7.47	103.8	9.81	104.6		
6/6/2018	27		15.64	7.42	97.6	9.78	103.8		
6/6/2018	29		15.6	7.39	96.7	9.72	103.1		
6/19/2018	0.5	10:50	18.46	8.06	115.4	9.93	111.2		3.8
6/19/2018	1		18.3	8.07	115.5	10.01	111.8		
6/19/2018	2		18.06	8.06	114.6	10.01	111.3		
6/19/2018	2*		17.99	8.07	114.6	10.04	111.5		
6/19/2018	3		17.91	8.02	114.4	9.94	110.1		
6/19/2018	4		17.87	8.01	112.9	9.91	109.8		
6/19/2018	5		17.82	7.97	113.2	9.83	108.7	9.49	
6/19/2018	6		17.82	7.97	113.4	9.78	108.2		
6/19/2018	7		17.8	7.94	113	9.69	107.2		
6/19/2018	8		17.72	7.74	113.9	9.34	103.1		
6/19/2018	9		17.38	7.63	117.9	9.23	101.2		
6/19/2018	10		17.21	7.62	121.4	9.21	100.6		
6/19/2018	12		16.88	7.64	128.5	9.31	101		
6/19/2018	15		16.15	7.59	135.9	9.31	99.5		
6/19/2018	18		16.11	7.59	136.5	9.3	99.3		
6/19/2018	18*		16.1	7.59	135.9	9.33	99.6		
6/19/2018	21		15.92	7.57	141.5	9.23	98.1	9.12	
6/19/2018	24		15.86	7.55	143.4	9.17	97.3		
6/19/2018	27		15.83	7.55	144.2	9.17	97.3		
6/19/2018	29		15.83	7.55	144	9.14	97		
7/10/2018	0.5	10:58	22.26	8.5	143.4	9.96	120.4		4.9
7/10/2018	1		22.24	8.52	143.3	10.04	121.4		
7/10/2018	2		22.19	8.53	143.3	10.08	121.7		
7/10/2018	2*		22.17	8.53	143.4	10.08	121.8		
7/10/2018	3		21.98	8.58	143.4	10.34	124.3		
7/10/2018	4		21.6	8.62	143.8	10.75	128.4		
7/10/2018	5		20.79	8.7	145.1	11.47	134.7	10	
7/10/2018	6		19.94	8.56	161.7	11.5	132.8		
7/10/2018	7								
7/10/2018	8		18.61	8.07	181.5	9.82	110.4		
7/10/2018	9		18.28	7.97	185.4	9.44	105.5		
7/10/2018	10		17.9	7.88	186.5	9.2	101.9		
7/10/2018	12		17.56	7.8	187.7	8.93	98.3		
7/10/2018	15		17.07	7.61	188.4	8.22	89.6		
7/10/2018	18		16.84	7.66	193.9	8.35	90.6		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
7/10/2018	18*		16.84	7.65	193	8.38	90.9		
7/10/2018	21		16.63	7.66	196.8	8.4	90.7	8.34	
7/10/2018	24		16.5	7.68	198.6	8.4	90.5		
7/10/2018	27		16.17	7.62	201.2	8.2	87.6		
7/10/2018	29		16.13	7.6	201.7	8.07	86.2		
7/23/2018	0.5	11:00	24.26	8.73	156.9	9.66	121.1		6.1
7/23/2018	1		24.1	8.73	156.3	9.67	120.8		
7/23/2018	2		23.79	8.74	156	9.75	121.2		
7/23/2018	2*		23.77	8.74	155.7	9.69	120.3		
7/23/2018	3		23.71	8.73	155.9	9.7	120.4		
7/23/2018	4		23.69	8.73	155.8	9.74	120.8		
7/23/2018	5		21.94	8.6	202.9	12.2	146.3	10.6	
7/23/2018	6		20.43	8.42	217.7	11.31	131.7		
7/23/2018	7		19.74	8.29	224.1	10.74	123.3		
7/23/2018	8		19.44	8.1	227.9	9.79	111.8		
7/23/2018	9		18.97	7.9	230.7	8.87	100.4		
7/23/2018	10		18.84	7.84	231.6	8.62	97.2		
7/23/2018	12		18.5	7.73	233.4	8.14	91.2		
7/23/2018	15		17.89	7.58	210	7.44	82.4		
7/23/2018	18		17.43	7.49	196.7	7.21	79		
7/23/2018	18*		17.41	7.48	196.3	7.15	78.3		
7/23/2018	21		16.89	7.43	192.1	6.96	75.4	7.05	
7/23/2018	24		16.54	7.41	195.3	6.86	73.7		
7/23/2018	27		16.3	7.26	197.5	5.56	59.5		
7/23/2018	29		16.19	7.2	199.2	4.77	50.9		
8/7/2018	0.5	11:00	24.04	8.61	179.5	9.7	121.5		5.4
8/7/2018	1		24.03	8.62	179.1	9.74	122		
8/7/2018	2		23.93	8.62	179.3	9.75	121.9		
8/7/2018	2*		23.97	8.65	178.8	9.79	122.5		
8/7/2018	3		23.88	8.62	179.3	9.72	121.5		
8/7/2018	4		23.86	8.63	179.3	9.8	122.3		
8/7/2018	5		22.51	8.54	203.8	11.85	144.2	10.4	
8/7/2018	6		21.13	8.3	232	11.31	134		
8/7/2018	7		19.91	8.06	239	10.1	116.9		
8/7/2018	8		19.34	7.89	250.4	9.28	106.2		
8/7/2018	9		18.86	7.74	254.9	8.53	96.6		
8/7/2018	10		18.54	7.64	261.1	7.97	89.7		
8/7/2018	12		18.38	7.71	272.4	8.33	93.4		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
8/7/2018	15		18.11	7.63	274.6	7.86	87.6		
8/7/2018	18		17.9	7.46	268.9	6.73	74.7		
8/7/2018	18*		17.88	7.44	267	6.78	75.3		
8/7/2018	21		17.44	7.24	239.3	5.4	59.4		
8/7/2018	24		16.77	7.08	205.3	4.11	44.6		
8/7/2018	27		16.39	6.94	201.9	2.31	24.8		
8/7/2018	29		16.22	6.88	203.1	1.22	13	2.14	
8/28/2018	0.5	11:15	20.51	8.61	219.6	9.81	114.4		4.8
8/28/2018	1		20.42	8.6	219.2	9.76	113.7		
8/28/2018	2		20.43	8.59	218.7	9.82	114.4		
8/28/2018	2*		20.36	8.58	219.1	9.8	114.1		
8/28/2018	3		20.31	8.57	219.1	9.87	114.7		
8/28/2018	4		20.31	8.58	219.1	9.84	114.4		
8/28/2018	5		20.26	8.58	218.6	9.87	114.6	7.7	
8/28/2018	6		20.25	8.57	219.3	9.81	113.9		
8/28/2018	7		20.06	8.31	230.1	9.18	106.2		
8/28/2018	8		18.76	7.68	265.8	7.23	81.5		
8/28/2018	9		18.28	7.61	268.4	6.96	77.6		
8/28/2018	10		18.04	7.57	269.8	6.68	74.2		
8/28/2018	12		17.71	7.52	270.4	6.31	69.6		
8/28/2018	15		17.42	7.55	271	6.57	72		
8/28/2018	18		17.13	7.71	269.9	7.61	82.9		
8/28/2018	18*		17.09	7.72	269.2	7.65	83.3		
8/28/2018	21		16.87	7.82	267.5	8.22	89.1	7.43	
8/28/2018	24		16.38	7.83	270.1	8.33	89.4		
8/28/2018	27		16.34	7.79	270.5	8.18	87.7		
8/28/2018	29		16.3	7.76	270.8	7.93	85		
9/12/2018	0.5	13:25	19.43	8.46	231.7	9.05	104.1		6.6
9/12/2018	1		19.35	8.47	231.5	9.09	104.4		
9/12/2018	2		19.22	8.48	232.3	9.11	104.3		
9/12/2018	2*		19.22	8.47	231.4	9.15	104.8		
9/12/2018	3		19.14	8.47	231.8	9.11	104.2		
9/12/2018	4		19.09	8.46	231.6	9.08	103.7		
9/12/2018	5		19.06	8.46	231.7	9.04	103.2	8.49	
9/12/2018	6		19.05	8.45	231.8	9.07	103.6		
9/12/2018	7		19.03	8.44	231.8	9.03	103		
9/12/2018	8		18.62	7.92	245.2	7.53	85.2		
9/12/2018	9		17.77	7.62	262.4	6.48	72		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
9/12/2018	10		17.27	7.6	264.7	6.61	72.7		
9/12/2018	12		16.76	7.65	267.4	6.97	75.9		
9/12/2018	15		16.39	7.66	270.5	7.13	77		
9/12/2018	18		16.02	7.76	273	7.79	83.5		
9/12/2018	18*		16.07	7.75	273	7.73	82.9		
9/12/2018	21		15.84	7.85	273.1	8.36	89.3	8.37	
9/12/2018	24		15.68	7.89	274.4	8.63	91.8		
9/12/2018	27		15.43	7.87	276.4	8.58	90.8		
9/12/2018	29		15.36	7.79	278	8.09	85.5		
9/25/2018	0.5	10:45	17.29	8.34	248.4	9.07	98.6		6.7
9/25/2018	1		17.29	8.39	248.4	9.04	98.3		
9/25/2018	2		17.27	8.41	248.4	9.09	98.8		
9/25/2018	2*		17.27	8.44	248.2	9.05	98.4		
9/25/2018	3		17.23	8.43	248.2	9.07	98.5		
9/25/2018	4		17.22	8.43	248.4	9.08	98.6		
9/25/2018	5		17.21	8.44	248	9.08	98.6	8.03	
9/25/2018	6		17.2	8.44	248.1	9.09	98.7		
9/25/2018	7		17.18	8.44	248.3	9.11	98.9		
9/25/2018	8		17.18	8.45	248.1	9.11	98.9		
9/25/2018	9		17.17	8.44	248.4	9.14	99.2		
9/25/2018	10		16.95	8.26	251.5	8.47	91.4		
9/25/2018	12		15.93	7.94	262.2	7.52	79.5		
9/25/2018	15		15.57	7.92	263.6	7.49	78.5		
9/25/2018	18		15.04	8.11	252.5	8.69	90.1		
9/25/2018	18*		15.06	8.09	252.7	8.63	89.5		
9/25/2018	21		14.6	8.18	250.8	9.24	94.9	8.6	
9/25/2018	24		14.19	8.17	252.7	9.39	95.5		
9/25/2018	27		14.09	8.15	253	9.37	95.1		
9/25/2018	29		14.07	8.14	252.7	9.3	94.4		
10/16/2018	0.5	10:40	13.64	8.09	249	10.09	100.7		5.0
10/16/2018	1		13.65	8.09	248.9	10.04	100.2		
10/16/2018	2		13.63	8.09	249	10.05	100.3		
10/16/2018	2*		13.62	8.09	249.1	10.05	100.2		
10/16/2018	3		13.59	8.09	249	10.3	100		
10/16/2018	4		13.58	8.08	249.1	10.02	99.8		
10/16/2018	5		13.57	8.08	249	10.01	99.7	9.67	
10/16/2018	6		13.56	8.08	248.9	10.01	99.7		
10/16/2018	7		13.55	8.07	248.8	9.9	98.6		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
10/16/2018	8		13.55	8.07	248.9	9.95	99		
10/16/2018	9		13.55	8.07	248.9	9.93	98.9		
10/16/2018	10		13.54	8.06	249	9.96	99.2		
10/16/2018	12		13.53	8.06	248.9	9.95	99		
10/16/2018	15		13.45	8.05	248.6	9.91	98.5		
10/16/2018	18		12.58	7.96	242.3	9.88	96.2		
10/16/2018	18*		12.48	7.95	242.5	9.91	96.3		
10/16/2018	21		11.92	7.92	238.6	10.08	96.8	9.42	
10/16/2018	24		11.73	7.88	237.9	10	95.6		
10/16/2018	27		11.67	7.86	236.8	10	95.5		
10/16/2018	29		11.66	7.86	236.7	9.98	95.2		

*QA/QC measurement for Hydrolab
**Secchi disk depths average of 3 measurements

Table A-4. Station LL2 *In Situ* Water Quality Data, 2018

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
5/16/2018	0.5	11:49	14.67	7.52	67.1	11.65	121.6		1.9
5/16/2018	1		14.59	7.52	66.8	11.65	121.3		
5/16/2018	2		14.6	7.52	67.1	11.78	122.8		
5/16/2018	3		14.52	7.53	67.1	11.88	123.5		
5/16/2018	4		14.41	7.52	66.8	11.88	123.4		
5/16/2018	5		14.37	7.5	66.9	11.89	123.2	10.7	
5/16/2018	5*		14.38	7.49	66.8	11.82	122.5		
5/16/2018	6		14.33	7.47	67.1	11.8	122.2		
5/16/2018	7		14.3	7.47	66.8	11.74	121.2		
5/16/2018	8		14.29	7.46	67.2	11.78	121.9		
5/16/2018	9		14.29	7.46	67.3	11.74	121.4		
5/16/2018	10		14.24	7.45	66.9	11.77	121.6		
5/16/2018	12		14.11	7.44	67.1	11.71	120.7		
5/16/2018	15		14.03	7.43	66.7	11.69	120.3		
5/16/2018	18		13.95	7.43	66.7	11.67	119.9		
5/16/2018	21		13.8	7.43	66.8	11.63	119.3	11.3	
5/16/2018	24		13.54	7.41	66.5	11.65	118.6		
5/16/2018	24*		13.53	7.41	66.7	11.68	119		
5/16/2018	25		12.89	7.38	65.6	11.7	117.4		
6/6/2018	0.5	11:35	18.58	8.3	86.1	10.86	122.6		2.9
6/6/2018	1		18.33	8.35	86.1	11.01	123.6		
6/6/2018	2		18.21	8.36	85.6	11.03	123.5		
6/6/2018	3		18.1	8.31	85.8	10.95	122.3		
6/6/2018	4		18.04	8.29	84.2	10.95	122.2		
6/6/2018	5		18.03	8.28	83	10.91	121.7	10.1	
6/6/2018	5*		18.03	8.29	83.5	10.91	121.7		
6/6/2018	6		18.05	8.29	83.7	10.96	122.3		
6/6/2018	7		18.01	8.24	82.4	10.81	120		
6/6/2018	8		17.81	8.09	86.2	10.56	117.3		
6/6/2018	9		17.63	8	92.6	10.45	115.6		
6/6/2018	10		17.48	7.92	99.4	10.33	113.9		
6/6/2018	12		16.72	7.7	113.6	9.8	106.4		
6/6/2018	15		16.58	7.66	114.5	9.76	105.6	8.85	
6/6/2018	18		16.46	7.64	117.3	9.6	103.7		
6/6/2018	21		16.38	7.59	117.2	9.55	103		
6/6/2018	24		16.33	7.56	117.3	9.39	101.1		
6/6/2018	24*		16.33	7.56	117.8	9.4	101.3		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
6/6/2018	25		16.33	7.56	117.7	9.4	101.2		
6/19/2018	0.5	11:20	18.24	8.12	120.3	10.25	114.4		3.2
6/19/2018	1		18.01	8.16	120.2	10.35	114.9		
6/19/2018	2		17.81	8.11	121.5	10.33	114.2		
6/19/2018	3		17.78	8.07	121.2	10.18	112.5		
6/19/2018	4		17.76	8.06	120.4	10.2	112.7		
6/19/2018	5		17.76	8.05	120.9	10.18	112.5	9.7	
6/19/2018	5*		17.75	8.04	120.7	10.12	111.7		
6/19/2018	6		17.74	8.04	121.3	10.12	111.8		
6/19/2018	7		17.68	7.9	121.3	9.83	108.4		
6/19/2018	8		17.61	7.85	122	9.78	107.7		
6/19/2018	9		17.36	7.74	124.7	9.57	104.8		
6/19/2018	10		17.01	7.69	127.5	9.51	103.4		
6/19/2018	12		16.52	7.65	128.8	9.53	102.6		
6/19/2018	15		16.12	7.55	131.8	9.3	99.3	9.02	
6/19/2018	18		15.93	7.54	133.6	9.26	98.4		
6/19/2018	21		15.83	7.51	135.5	9.14	97		
6/19/2018	24		15.81	7.49	135.7	9.07	96.1		
6/19/2018	24*		15.81	7.49	135.7	9.03	95.8		
6/19/2018	25		15.81	7.5	136.1	9.05	96.6		
7/10/2018	0.5	11:40	22.25	8.55	145.5	10.26	124.1		4.1
7/10/2018	1		22.25	8.59	145.5	10.25	124		
7/10/2018	2		22.16	8.6	145.6	10.34	124.7		
7/10/2018	3		22.04	8.62	145.1	10.51	126.6		
7/10/2018	4		21.82	8.66	144.7	10.74	128.8		
7/10/2018	4*		21.78	8.67	145.2	10.86	130		
7/10/2018	5		20.82	8.74	147.5	11.67	137.2	10.9	
7/10/2018	6		19.93	8.55	166.5	11.5	132.9		
7/10/2018	7		19.43	8.42	171.5	10.91	124.8		
7/10/2018	8		18.46	8.02	187.2	9.47	106.1		
7/10/2018	9		17.99	7.92	196.4	9.11	101.2		
7/10/2018	10		17.74	7.89	195.3	9.07	100.2		
7/10/2018	12		17.49	7.88	195.8	9	99		
7/10/2018	15		17.22	7.82	191.4	8.84	96.7	8.36	
7/10/2018	18		16.79	7.77	194.5	8.63	93.5		
7/10/2018	21		16.46	7.77	197.6	8.63	92.9		
7/10/2018	24		16.16	7.65	200.2	8.11	86.7		
7/10/2018	24*		16.15	7.65	200	8.13	86.9		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
7/10/2018	25		16.13	7.6	200.2	7.94	84.8		
7/23/2018	0.5	11:45	24.4	8.67	156.2	9.55	120		6.2
7/23/2018	1		24.19	8.65	156	9.69	121.3		
7/23/2018	2		24.01	8.67	156.1	9.75	121.7		
7/23/2018	3		23.94	8.66	156.2	9.76	121.6		
7/23/2018	4		23.89	8.66	156.1	9.81	122.1		
7/23/2018	5		22.45	8.54	197.2	11.85	143.6	no data broken	
7/23/2018	5*		22.35	8.53	197.6	11.96	144.5		
7/23/2018	6		20.85	8.48	214.1	12.04	141.4		
7/23/2018	7		19.34	8.02	228.3	9.47	107.9		
7/23/2018	8		19.02	7.83	229.8	8.71	98.5		
7/23/2018	9		18.72	7.72	231.9	8.27	93.1		
7/23/2018	10		18.56	7.68	232.9	8.08	90.7		
7/23/2018	12		18.37	7.64	233.3	7.97	89		
7/23/2018	15		17.88	7.53	218.2	7.45	82.4	7.51	
7/23/2018	18		17.3	7.43	196	7.13	77.9		
7/23/2018	21		16.8	7.36	195.1	6.75	73		
7/23/2018	24		16.45	7.18	198.3	5.04	54.1		
7/23/2018	24*		16.5	7.18	197.9	5.16	55.4		
7/23/2018	25		16.35	7.14	198.5	4.69	50.3		
8/7/2018	0.5	11:35	24.3	8.63	178.1	9.45	119		5.1
8/7/2018	1		24.27	8.64	177.9	9.65	121.4		
8/7/2018	2		24.16	8.65	177.9	9.83	123.4		
8/7/2018	3		24.08	8.65	178	10.05	126		
8/7/2018	4		24.01	8.65	177.8	10.09	126.3		
8/7/2018	5		23.51	8.57	188.8	10.49	130.1	9.46	
8/7/2018	5*		23.13	8.56	203.7	11.34	139.6		
8/7/2018	6		21.39	8.33	238.9	11.83	140.9		
8/7/2018	7		19.9	8.1	246.4	10.76	124.4		
8/7/2018	8		19.25	7.89	252.2	9.64	110.1		
8/7/2018	9		18.76	7.77	265.9	9.15	103.4		
8/7/2018	10		18.51	7.78	270.8	9.05	101.8		
8/7/2018	12		18.26	7.74	274.2	8.73	97.7		
8/7/2018	15		18.08	7.71	274.5	8.56	95.4	8.04	
8/7/2018	18		17.84	7.45	270.1	6.75	74.9		
8/7/2018	21		17.71	7.31	261.3	5.84	64.6		
8/7/2018	24		16.61	6.98	209.7	1.64	17.8		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
8/7/2018	24*		16.6	6.95	209.7	1.48	16		
8/7/2018	25		16.53	6.95	208.2	1.45	15.7		
8/28/2018	0.5	11:55	20.66	8.54	219.5	9.56	111.9		4.3
8/28/2018	1		20.69	8.56	219.6	9.59	112.3		
8/28/2018	2		20.41	8.58	219.3	9.74	113.4		
8/28/2018	3		20.36	8.59	218.7	9.87	114.8		
8/28/2018	4		20.32	8.59	218.4	9.96	115.8		
8/28/2018	5		20.26	8.59	218.9	10.02	116.4	8.51	
8/28/2018	5*		20.25	8.58	218.5	9.9	115		
8/28/2018	6		20.14	8.54	221.5	9.69	112.3		
8/28/2018	7		18.55	7.74	267	7.63	85.7		
8/28/2018	8		18.29	7.67	268.4	7.27	21.2		
8/28/2018	9		18.09	7.65	269.5	7.05	78.4		
8/28/2018	10		17.9	7.62	270.1	6.81	75.4		
8/28/2018	12		17.69	7.61	271	6.82	75.2		
8/28/2018	15		17.38	7.71	268.9	7.51	82.2	6.95	
8/28/2018	18		16.91	7.95	265	8.59	93.2		
8/28/2018	21		16.3	7.92	270	8.55	91.6		
8/28/2018	24		16.25	7.91	270.4	8.58	91.8		
8/28/2018	24*		16.25	7.92	270.4	8.58	91.8		
8/28/2018	25		16.24	7.91	270.6	8.61	92.1		
9/12/2018	0.5	14:05	19.65	8.47	229	9.09	105		5.7
9/12/2018	1		19.63	8.46	228.5	9.04	104.4		
9/12/2018	2		19.5	8.47	228.4	9.04	104.1		
9/12/2018	3		19.36	8.48	228.6	9.13	104.9		
9/12/2018	4		19.3	8.48	228.4	9.1	104.4		
9/12/2018	5		19.23	8.48	229.1	9.18	105.2	8.01	
9/12/2018	5*		19.24	8.48	229.2	9.18	105.2		
9/12/2018	6		19.18	8.47	229	9.14	104.6		
9/12/2018	7		19.14	8.47	229	9.14	104.5		
9/12/2018	8		17.6	7.66	262.1	6.69	74.2		
9/12/2018	9		17.38	7.67	262.9	6.76	74.6		
9/12/2018	10		17.1	7.72	263.5	7.17	78.7		
9/12/2018	12		16.73	7.83	264.7	7.82	85.1		
9/12/2018	15		16.38	7.93	264.1	8.45	91.3	broke	
9/12/2018	18		16.03	7.94	267.5	8.68	93		
9/12/2018	21		15.67	7.91	271.7	8.74	93		
9/12/2018	24		15.45	7.87	275.7	8.61	91.2		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
9/12/2018	24*		15.45	7.87	275.7	8.63	91.5		
9/12/2018	25		15.42	7.85	276	8.51	90.1		
9/25/2018	0.5	11:25	18.03	8.41	244.1	8.97	99		7.1
9/25/2018	1		17.64	8.43	244.5	9.08	99.4		
9/25/2018	2		17.57	8.44	245.1	9.11	99.6		
9/25/2018	3		17.46	8.44	245.2	9.11	99.4		
9/25/2018	4		17.47	8.43	245	9.11	99.4		
9/25/2018	5		17.47	8.42	245.4	9.12	99.5	8.83	
9/25/2018	5*		17.37	8.42	245.2	9.13	99.4		
9/25/2018	6		17.37	8.42	245.4	9.06	98.6		
9/25/2018	7		17.32	8.39	246.1	9.02	98.1		
9/25/2018	8		17.21	8.31	247.6	8.68	94.2		
9/25/2018	9		17.1	8.24	248.7	8.3	89.9		
9/25/2018	10		16.12	8.03	252.7	8.02	85.1		
9/25/2018	12		15.67	7.97	257.2	7.93	83.3		
9/25/2018	15		15.36	8.12	249.6	8.76	91.4	8.27	
9/25/2018	18		14.48	8.21	251.1	9.61	98.4		
9/25/2018	21		14.07	8.16	252.8	9.68	98.3		
9/25/2018	24		14.04	8.14	252.8	9.61	97.5		
9/25/2018	24*		14.04	8.15	253	9.59	97.3		
9/25/2018	25		14.04	8.16	252.6	9.6	97.4		
10/16/2018	0.5	11:20	13.6	8.12	248.4	10.23	102		5.2
10/16/2018	1		13.64	8.11	248.5	10.21	101.9		
10/16/2018	2		13.59	8.13	248.3	10.26	102.3		
10/16/2018	3		13.55	8.11	248	10.3	102.6		
10/16/2018	4		13.23	8.13	248	10.24	102		
10/16/2018	5		13.51	8.12	248	10.27	102.2	9.77	
10/16/2018	5*		13.5	8.11	247.9	10.19	101.4		
10/16/2018	6		13.5	8.11	248.2	10.2	101.5		
10/16/2018	7		13.49	8.1	248	10.14	100.8		
10/16/2018	8		13.48	8.1	248.2	10.14	100.7		
10/16/2018	9		13.47	8.1	248.3	10.14	100.8		
10/16/2018	10		13.45	8.1	248.2	10.12	100.6		
10/16/2018	12		13.43	8.1	248.2	10.14	100.7		
10/16/2018	15		12.63	8.01	242.6	10.14	98.9	10.5	
10/16/2018	18		11.59	7.95	235.9	10.3	98.1		
10/16/2018	21		11.54	7.93	235.5	10.34	94.4		
10/16/2018	24		11.45	7.92	235	10.36	98.3		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
10/16/2018	24*		11.43	7.92	234.6	10.32	98		
10/16/2018	25		11.43	7.91	234.8	10.35	98.3		

*QA/QC measurement for Hydrolab
**Secchi disk depths average of 3 measurements

Table A-5. Station LL2a *In Situ* Water Quality Data, 2018

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
5/16/2018	0.5	12:49	15.23	7.38	67.4	11.81	124.7		2.0
5/16/2018	1		15.16	7.23	67.3	11.73	123.7		
5/16/2018	2		15.1	7.44	67.2	11.8	124.3		
5/16/2018	3		14.97	7.42	67.5	11.79	123.8		
5/16/2018	4		14.67	6.82	67.2	11.88	124		
5/16/2018	5		14.57	7.31	67.4	11.89	123.8	11.2	
5/16/2018	6		14.54	7.4	67.4	11.92	124		
5/16/2018	7		14.34	7.42	67.3	11.98	124.1		
5/16/2018	8		14.22	7.4	67.4	11.98	123.7		
5/16/2018	8*		14.2	7.4	67.2	11.93	123.2		
5/16/2018	9		14.21	7.4	67.4	11.93	123.2		
5/16/2018	10		14.18	7.41	67.6	11.96	123.5		
5/16/2018	12		14.13	7.4	67.3	11.97	123.5		
5/16/2018	15		13.87	7.4	67.6	11.91	122.1	10.3	
5/16/2018	18		13.82	7.41	67.3	11.87	121.5		
5/16/2018	21		13.77	7.41	67.5	11.83	121		
5/16/2018	22.5		13.75	7.42	67.5	11.85	121.2		
6/6/2018	0.5	12:14	19.44	8.18	86.7	10.63	122		2.0
6/6/2018	1		19.08	8.19	86.1	10.74	122.4		
6/6/2018	2		18.76	8.2	85	10.82	122.5		
6/6/2018	3		18.51	8.18	84	10.78	121.5		
6/6/2018	4		18.14	8.04	88.4	10.7	119.7		
6/6/2018	5		17.78	7.92	100.8	10.42	115.6	9.57	
6/6/2018	6		17.41	7.85	110.5	10.28	113.2		
6/6/2018	7		17.11	7.77	114.5	10.24	112		
6/6/2018	8		16.93	7.71	116	10.05	109.6		
6/6/2018	8*		16.93	7.71	115.9	10.05	109.6		
6/6/2018	9		16.91	7.71	116.4	10.04	109.4		
6/6/2018	10		16.85	7.69	116.5	10.06	109.5		
6/6/2018	12		16.74	7.67	117.2	9.96	108.2		
6/6/2018	15		16.6	7.62	117.8	9.85	106.7	9.2	
6/6/2018	18		16.38	7.56	118	9.7	104.5		
6/6/2018	21		16.36	7.56	117.8	9.71	104.6		
6/6/2018	23.5		16.31	7.52	117.9	9.62	103.6		
6/19/2018	0.5	12:05	18.41	8.23	123.4	10.28	115.2		3.5
6/19/2018	1		18.04	8.23	123.2	10.36	115.1		
6/19/2018	2		17.88	8.25	122.6	10.44	115.6		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
6/19/2018	3		17.79	8.23	123.2	10.42	115.1		
6/19/2018	4		17.7	8.18	123.8	10.27	113.3		
6/19/2018	5		17.65	8.14	123.4	10.26	113.1	9.79	
6/19/2018	6		17.59	8.07	124.6	10.14	111.6		
6/19/2018	7		17.14	7.93	127.5	10.02	109.2		
6/19/2018	8		16.85	7.81	129.3	9.8	106.3		
6/19/2018	8*		16.86	7.81	129.3	9.8	106.2		
6/19/2018	9		16.77	7.78	129.3	9.73	105.3		
6/19/2018	10		16.34	7.69	130.7	9.52	102.1		
6/19/2018	12		16.04	7.67	135.6	9.56	101.8		
6/19/2018	15		15.85	7.68	139.3	9.55	101.4	9.22	
6/19/2018	18		15.83	7.67	139.8	9.5	100.8		
6/19/2018	21		15.8	7.67	140.2	9.49	100.6		
6/19/2018	23.5		15.76	7.63	139.4	9.37	99.3		
7/10/2018	0.5	12:25	22.56	8.65	147.5	10.11	123		4.3
7/10/2018	1		22.56	8.63	147.4	10.08	122.6		
7/10/2018	2		22.56	8.54	147.5	10.16	123.5		
7/10/2018	3		22.55	8.62	148.3	10.17	123.6		
7/10/2018	4		22.53	8.62	147.1	10.24	124.5		
7/10/2018	5		22.1	8.78	147.3	11.42	137.6	9.86	
7/10/2018	6		20.97	8.8	149.1	11.95	140.9		
7/10/2018	7		19.98	8.58	166.9	11.31	130.8		
7/10/2018	8		18.32	8.06	198.3	9.39	105		
7/10/2018	8*		18.66	8.09	189.9	9.32	150.1		
7/10/2018	9		18.03	8	201.7	9.24	102.7		
7/10/2018	10		17.98	7.99	201.5	9.14	101.5		
7/10/2018	12		17.62	7.95	199.5	9.08	100.1		
7/10/2018	15		17.3	7.92	195.2	9.03	98.8	9.16	
7/10/2018	18		16.74	7.83	195.6	8.75	94.7		
7/10/2018	21		16.44	7.77	197.4	8.48	91.2		
7/10/2018	23.5		16.28	7.69	198.8	8.14	87.3		
7/23/2018	0.5	12:25	24.82	8.59	155.9	9.31	117.9		6.2
7/23/2018	1		24.61	8.58	155.7	9.35	118		
7/23/2018	2		24.45	8.58	155.7	9.48	119.2		
7/23/2018	3		24.26	8.61	156.5	9.79	122.6		
7/23/2018	4		22.4	8.51	200.4	11.82	143.1		
7/23/2018	5		21.4	8.39	209.2	11.24	133.3	10.7	
7/23/2018	6		19.47	7.97	228.4	9.26	105.8		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
7/23/2018	7		19.1	7.92	230.6	9.06	102.7		
7/23/2018	8		18.86	7.83	231.7	8.67	97.9		
7/23/2018	8*		18.86	7.82	231.5	8.64	97.5		
7/23/2018	9		18.81	7.78	231.4	8.42	94.9		
7/23/2018	10		18.65	7.68	232.2	8.06	90.6		
7/23/2018	12		18.16	7.58	234.4	7.7	85.6		
7/23/2018	15		17.65	7.47	211.6	7.3	80.4	7.11	
7/23/2018	18		17.07	7.38	197.7	6.91	75.1		
7/23/2018	21		16.76	7.27	198	6	64.8		
7/23/2018	23.5		16.45	7.06	200.7	3.35	35.9		
8/7/2018	0.5	12:10	24.85	8.5	177.3	9.66	122.8		5.4
8/7/2018	1		24.62	8.57	176.7	10	126.6		
8/7/2018	2		24.38	8.57	175.8	10.11	127.5		
8/7/2018	3		24.31	8.52	177	9.85	123.9		
8/7/2018	4		24.16	8.56	177.5	9.97	124.8		
8/7/2018	5		22.58	8.35	228	11.69	142.4	10.6	
8/7/2018	6		20.98	8.22	243.1	11.31	133.6		
8/7/2018	7		20.27	8.11	249.3	11	128.1		
8/7/2018	8		19.43	7.91	257.6	9.81	112.4		
8/7/2018	8*		19.41	7.91	257.5	9.84	112.7		
8/7/2018	9		19	7.83	266.2	9.24	105		
8/7/2018	10		18.74	7.84	269.9	9.19	103.8		
8/7/2018	12		18.23	7.74	273.9	8.58	95.9		
8/7/2018	15		17.93	7.77	275	8.67	96.4	8.9	
8/7/2018	18		17.76	7.77	276	8.67	96.1		
8/7/2018	21		17.69	7.71	275.9	8.55	94.6		
8/7/2018	23.5		17.64	7.64	274.4	8.01	88.5		
8/28/2018	0.5	12:50	20.85	8.51	218.2	9.61	112.9		4.9
8/28/2018	1		20.78	8.53	218	9.63	113		
8/28/2018	2		20.73	8.52	217.8	9.6	112.5		
8/28/2018	3		20.42	8.47	217.7	9.41	109.7		
8/28/2018	4		20.38	8.46	217.4	9.5	110.6		
8/28/2018	5		20.29	8.35	218.4	9.05	105.1	8.63	
8/28/2018	6		20.17	8.07	231.3	8.42	97.6		
8/28/2018	7		19.44	7.81	249	7.48	85.5		
8/28/2018	8		18.81	7.74	258.9	7.17	90.9		
8/28/2018	8*		18.82	7.75	258.7	7.26	91.9		
8/28/2018	9		18.23	7.65	268.1	7.1	79.1		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
8/28/2018	10		17.92	7.66	269.4	7.04	78		
8/28/2018	12		17.61	7.68	270.1	7.17	78.9		
8/28/2018	15		17.33	7.93	262.3	8.45	92.5	7.87	
8/28/2018	18		16.29	8.02	269.1	8.95	95.8		
8/28/2018	21		16.03	8.01	271.2	9.06	96.4		
8/28/2018	23.5		16.01	7.99	271.7	9.02	96		
9/12/2018	0.5	14:45	19.96	8.52	224.2	9.24	107.5		5.2
9/12/2018	1		19.78	8.52	224	9.29	107.7		
9/12/2018	2		19.68	8.51	224.6	9.27	107.2		
9/12/2018	3		19.61	8.51	224.2	9.34	107.8		
9/12/2018	4		19.58	8.51	223.9	9.36	108		
9/12/2018	5		19.54	8.49	224.5	9.18	105.8	8.47	
9/12/2018	6		19.5	8.48	224.2	9.15	105.4		
9/12/2018	7		19.25	8.37	229	8.82	101.1		
9/12/2018	8		18.34	7.83	248	7.26	81.6		
9/12/2018	8*		18.3	7.82	248.7	7.21	81		
9/12/2018	9		17.86	7.77	252.7	7.15	79.7		
9/12/2018	10		17.37	8.05	252.6	8.56	94.4		
9/12/2018	12		16.6	8	257.3	8.75	95		
9/12/2018	15		15.98	7.96	258.1	8.82	94.5	8.39	
9/12/2018	18		15.93	7.92	259.5	8.8	94.1		
9/12/2018	21		15.7	7.88	267.9	8.68	92.5		
9/12/2018	23.5		15.51	7.8	273.3	8.24	87.4		
9/25/2018	0.5	11:58	17.73	8.41	241.2	9.28	101.8		6.4
9/25/2018	1		17.66	8.43	240.3	9.29	101.8		
9/25/2018	2		17.51	8.43	241.2	9.27	101.3		
9/25/2018	3		17.45	8.43	241.2	9.3	101.5		
9/25/2018	4		17.41	8.42	241.1	9.25	100.8		
9/25/2018	5		17.38	8.39	241.3	9.15	99.6	8.78	
9/25/2018	6		17.31	8.33	241.8	8.9	96.8		
9/25/2018	7		17.24	8.27	241.7	8.75	95.1		
9/25/2018	8		17.15	8.22	243.4	8.46	91.7		
9/25/2018	8*		17.15	8.22	243.6	8.46	91.7		
9/25/2018	9		16.71	8.17	241.3	8.46	90.8		
9/25/2018	10		16.5	8.27	240.2	8.81	94.2		
9/25/2018	12		15.82	8.23	243.2	9.09	95.8		
9/25/2018	15		14.65	8.25	249.6	9.79	100.7	8.85	
9/25/2018	18		14.22	8.21	252.3	9.91	100.9		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
9/25/2018	21		14.12	8.21	252.6	10.02	101.8		
9/25/2018	23.5		14.11	8.22	252.7	9.99	101.5		
10/16/2018	0.5	12:00	13.73	8.15	247.1	10.33	103.2		4.3
10/16/2018	1		13.66	8.13	246.5	10.4	103.8		
10/16/2018	2		13.44	8.14	246.9	10.46	103.9		
10/16/2018	3		13.4	8.14	247	10.49	104.1		
10/16/2018	4		13.37	8.14	247.1	10.46	103.7		
10/16/2018	5		13.37	8.13	247.2	10.42	103.3	10.5	
10/16/2018	6		13.35	8.13	247.3	10.46	103.7		
10/16/2018	7		13.33	8.12	247.1	10.38	102.9		
10/16/2018	8		13.3	8.1	247	10.31	102.1		
10/16/2018	8*		13.32	8.11	247.2	10.41	103.2		
10/16/2018	9		13.26	8.09	246.5	10.3	101.9		
10/16/2018	10		13.21	8.08	246.4	10.27	101.5		
10/16/2018	12		12.99	8.06	244.8	10.22	100.5		
10/16/2018	15		12.41	8.03	240.8	10.26	99.6	9.58	
10/16/2018	18		11.56	7.96	234.6	10.45	99.5		
10/16/2018	21		11.28	7.92	232.8	10.43	98.7		
10/16/2018	24		11.29	7.9	232.5	10.4	98.4		

*QA/QC measurement for Hydrolab
**Secchi disk depths average of 3 measurements

Table A-6. Station LL2b *In Situ* Water Quality Data, 2018

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
5/17/2018	0.5	9:21	14.13	7.59	67.8	11.71	120.6		1.9
5/17/2018	1		14.13	7.54	67.9	11.72	120.7		
5/17/2018	2		14.11	7.53	67.6	11.77	121.2		
5/17/2018	3		14.09	7.52	67.9	11.79	121.3		
5/17/2018	4		14.08	7.55	67.4	11.81	121.5		
5/17/2018	5		14.11	7.51	67.6	11.79	121.4	11.2	
5/17/2018	6		14.08	7.55	67.4	11.82	121.6		
5/17/2018	7		14.07	7.55	67.7	11.77	121.1		
5/17/2018	8		14.05	7.55	67.3	11.77	120.9		
5/17/2018	9		14.05	7.55	67.6	11.74	120.7		
5/17/2018	9*		14.05	7.54	67.3	11.76	120.8		
5/17/2018	10		14.08	7.54	67.3	11.79	121.2	11.3	
5/17/2018	12		14.1	7.55	67.4	11.8	121.5		
5/17/2018	15		14.07	7.55	67.7	11.79	121.2		
5/17/2018	18		14.1	7.55	67.7	11.75	120.9		
5/17/2018	20		14.04	7.54	67.3	11.73	120.6		
6/7/2018	0.5	8:42	18.59	8.42	89.7	10.59	119.9		3.0
6/7/2018	1		18.41	8.44	93.3	10.64	120		
6/7/2018	2		18.39	8.43	95.3	10.7	120.6		
6/7/2018	3		18.13	8.31	101.3	10.71	120.1		
6/7/2018	4		17.74	8.18	108.3	10.5	16.7		
6/7/2018	5		17.61	8.14	109.8	10.41	115.5	8.57	
6/7/2018	6		17.43	8.07	112.1	10.34	114.3		
6/7/2018	7		16.94	7.92	114.9	10.02	109.6		
6/7/2018	8		16.67	7.87	116.9	9.9	107.7		
6/7/2018	9		16.44	7.8	118.2	9.72	105.2		
6/7/2018	9*		16.44	7.79	118.2	9.76	105.7		
6/7/2018	10		16.32	7.76	118.2	9.64	104.1	8.4	
6/7/2018	12		16.27	7.73	118	9.59	103.4		
6/7/2018	15		16.25	7.72	118.2	9.57	103.2		
6/7/2018	18		16.25	7.72	118.4	9.52	102.6		
6/7/2018	20		16.25	7.71	118.4	9.6	103.5		
6/20/2018	0.5	8:50	19.04	8.24	120.3	9.84	111.6		3.9
6/20/2018	1		18.96	8.24	119.9	9.89	112		
6/20/2018	2		18.41	8.15	122.1	10.15	113.7		
6/20/2018	3		17.87	8.21	124.3	10.31	114.1		
6/20/2018	4		17.86	8.25	124	10.36	114.2		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
6/20/2018	5		17.7	8.24	124.4	10.32	113.8	10.1	
6/20/2018	6		17.21	8.01	135.4	10.04	109.6		
6/20/2018	7		17.05	7.96	135.2	9.93	108.2		
6/20/2018	8		16.98	7.94	136	9.87	107.3		
6/20/2018	9		16.18	7.79	147.5	9.47	101.3		
6/20/2018	9*		16.28	7.78	145.7	9.46	101.3		
6/20/2018	10		16.08	7.77	149.6	9.42	100.5	9.46	
6/20/2018	12		16	7.77	150.7	9.42	100.3		
6/20/2018	15		15.93	7.74	150.9	9.31	99		
6/20/2018	18		15.81	7.72	152.3	9.31	98.7		
6/20/2018	20		15.81	7.72	152.3	9.27	98.3		
7/11/2018	0.5	8:45	22.54	8.63	148	9.94	120.6		4.6
7/11/2018	1		22.54	8.62	147.9	9.93	120.4		
7/11/2018	2		22.41	8.6	148.3	10.02	121.3		
7/11/2018	3		22.35	8.6	148.2	10.15	122.7		
7/11/2018	4		22.18	8.57	148.8	10.41	125.5		
7/11/2018	5		21.63	8.5	148.9	10.45	124.6	9.79	
7/11/2018	6		21.48	8.6	151.1	10.82	128.6		
7/11/2018	7		19.91	8.34	177.9	10.41	119.9		
7/11/2018	8		18.93	8.1	195	9.47	107.1		
7/11/2018	9		18.83	8.07	195.9	9.37	105.7		
7/11/2018	9*		18.81	8.06	196.2	9.38	105.8		
7/11/2018	10		18.22	7.95	203.8	9.03	100.5	8.98	
7/11/2018	12		17.83	7.94	208.2	8.99	99.3		
7/11/2018	15		17.4	7.79	206.3	8.44	92.4		
7/11/2018	18		16.93	7.69	201.3	7.94	86.1		
7/11/2018	20		16.71	7.65	198	7.8	84.2		
7/24/2018	0.5	8:35	24.24	8.6	157.2	9.44	118.5		6.2
7/24/2018	1		24.28	8.62	157.3	9.45	118.7		
7/24/2018	2		24.25	8.63	157.4	9.53	119.7		
7/24/2018	3		23.92	7.8	164.2	8.58	107.1		
7/24/2018	4		22.75	8.51	195.3	11.21	136.9		
7/24/2018	5		21.22	8.43	211.4	11.19	132.6	9.74	
7/24/2018	6		20.06	8.2	225	10.14	117.5		
7/24/2018	7		19.02	7.91	232.6	8.71	98.8		
7/24/2018	8		18.83	7.79	233	8.05	91		
7/24/2018	9		18.63	7.88	234.1	8.41	94.6		
7/24/2018	9*		18.6	7.88	233.9	8.43	94.9		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
7/24/2018	10		18.51	7.82	233.3	7.86	88.3	7.98	
7/24/2018	12		18.3	7.67	235.4	7.56	84.5		
7/24/2018	15		17.96	7.58	227.1	7.17	79.7		
7/24/2018	18		17.21	7.45	204.3	6.56	71.7		
7/24/2018	20		16.84	7.17	204.8	3.37	36.6		
8/8/2018	0.5	10:25	24.57	8.58	173.5	9.58	121.3		5.9
8/8/2018	1		24.34	8.6	174.5	9.74	122.9		
8/8/2018	2		24.22	8.58	174.5	9.87	124.3		
8/8/2018	3		24.18	8.6	174.3	10.02	126		
8/8/2018	4		23.34	8.03	208.8	10.35	128.1		
8/8/2018	5		21.82	8.38	231.3	11.33	136.3	9.69	
8/8/2018	6		20.84	8.25	243.6	10.89	128.5		
8/8/2018	7		19.83	8.03	252	9.86	114.1		
8/8/2018	8		19.28	7.94	260.3	9.17	104.9		
8/8/2018	9		18.84	7.89	266	8.86	100.4		
8/8/2018	9*		18.87	7.89	265.3	8.94	101.5		
8/8/2018	10		18.5	7.88	267.3	8.66	97.5	6.58	
8/8/2018	12		18.27	7.87	268.2	8.7	97.5		
8/8/2018	15		17.74	7.96	270.9	9.38	104		
8/8/2018	18		17.59	7.91	272.6	9.19	101.6		
8/8/2018	20		17.5	7.83	274.1	8.69	95.8		
8/29/2018	0.5	10:15	20.7	8.54	216.8	9.67	114.3		4.7
8/29/2018	1		20.66	8.55	216.1	9.67	114.1		
8/29/2018	2		20.59	8.55	216.1	9.7	114.3		
8/29/2018	3		20.57	8.54	216.1	9.7	114.3		
8/29/2018	4		20.55	8.53	216	9.6	113.1		
8/29/2018	5		20.52	8.53	216.8	9.6	113	8.26	
8/29/2018	6		20.32	8.46	218.3	9.34	109.5		
8/29/2018	7		19.61	8	239.9	7.95	92		
8/29/2018	8		18.84	7.98	246.6	8.03	91.4		
8/29/2018	9		18.28	7.7	263.8	6.91	77.8		
8/29/2018	9*		18.17	7.69	264.9	6.93	77.8		
8/29/2018	10		18.03	7.65	268.8	6.8	76.1	6.59	
8/29/2018	12		17.69	7.78	264.9	7.47	83.1		
8/29/2018	15		15.8	8.06	270.4	9.01	96.3		
8/29/2018	18		15.28	8.01	275.7	8.97	94.8		
8/29/2018	20		15.25	8	275.7	8.97	94.8		
9/13/2018	0.5	8:35	19.17	8.45	225.6	9.29	106.2		5.3

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
9/13/2018	1		19.2	8.46	225.8	9.24	105.7		
9/13/2018	2		19.24	8.46	225.8	9.22	105.6		
9/13/2018	3		19.24	8.46	225.9	9.23	105.6		
9/13/2018	4		19.24	8.47	225.9	9.27	106.2		
9/13/2018	5		19.26	8.44	226.1	9.22	105.5	broke	
9/13/2018	6		19.23	8.43	227.6	9.06	103.6		
9/13/2018	7		18.51	8.19	241.5	8.76	98.8		
9/13/2018	8		17.73	8.16	244.6	8.85	98.2		
9/13/2018	9		17.31	8.08	250.1	8.83	97.1		
9/13/2018	9*		17.3	8.1	250.3	8.81	96.9		
9/13/2018	10		16.91	8.07	252.4	8.86	96.6	8.12	
9/13/2018	12		16.1	8.06	254.2	9.03	96.8		
9/13/2018	15		15.67	8.06	254.8	9.23	98.1		
9/13/2018	18		15.48	8.04	255	9.28	98.3		
9/13/2018	20		15.42	8.03	255.3	9.21	97.3		
9/26/2018	0.5	10:42	17.35	8.41	235.7	9.11	99.3		5.3
9/26/2018	1		17.36	8.41	235.6	9.12	99.4		
9/26/2018	2		17.33	8.41	235.6	9.13	99.4		
9/26/2018	3		17.29	8.41	235.6	9.14	99.4		
9/26/2018	4		17.28	8.39	235.7	9.12	99.2		
9/26/2018	5		17.27	8.4	235.6	9.05	98.4	8.1	
9/26/2018	6		17.26	8.4	235.1	9.08	98.7		
9/26/2018	7		17.23	8.37	235.9	8.99	97.6		
9/26/2018	8		16.88	8.24	236.9	8.57	92.5		
9/26/2018	9		16.49	8.27	237.9	8.84	94.5		
9/26/2018	9*		16.49	8.28	238	8.85	94.7		
9/26/2018	10		16.35	8.28	239.1	8.98	95.8	7.56	
9/26/2018	12		15.76	8.3	241.7	9.39	98.9		
9/26/2018	15		14.24	8.24	250.9	9.84	100.3		
9/26/2018	18		14.02	8.19	251.8	9.81	99.5		
9/26/2018	20		14.01	8.19	252	9.8	99.4		
10/17/2018	0.5	10:30	13.24	8.33	248.2	10.28	102.1		4.0
10/17/2018	1		13.23	8.34	247.9	10.34	102.7		
10/17/2018	2		13.2	8.34	247.8	10.32	102.4		
10/17/2018	3		13.17	8.34	247.8	10.32	102.3		
10/17/2018	4		13.15	8.32	247.7	10.34	102.5		
10/17/2018	5		13.13	8.33	248.1	10.32	102.3	9.69	
10/17/2018	6		13.11	8.34	247.6	10.36	102.6		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
10/17/2018	7		13.08	8.34	247.4	10.31	102		
10/17/2018	8		13.07	8.35	247.5	10.3	101.9		
10/17/2018	9		13.03	8.32	247.2	10.31	101.9		
10/17/2018	9*		13.03	8.32	247.1	10.26	101.6		
10/17/2018	10		12.86	8.29	246.1	10.16	100	10.3	
10/17/2018	12		12.51	8.27	243.5	10.17	99.4		
10/17/2018	15		10.97	8.11	231.5	10.28	96.9		
10/17/2018	18		10.84	8.07	230	10.29	96.8		
10/17/2018	20		10.83	8.06	230	10.34	97.2		

*QA/QC measurement for Hydrolab
**Secchi disk depths average of 3 measurements

Table A-7. Station LL3 *In Situ* Water Quality Data, 2018

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
5/17/2018	0.5	9:56	14.08	7.62	67.7	11.64	119.7		1.9
5/17/2018	1		14.09	7.6	67.7	11.68	120.2		
5/17/2018	2		14.09	7.57	67.4	11.65	119.9		
5/17/2018	3		14.08	7.56	67.4	11.7	120.4		
5/17/2018	4		14.09	7.56	67.7	11.7	120.4		
5/17/2018	5		14.08	7.56	67.7	11.69	120.3	11	
5/17/2018	6		14.09	7.56	67.6	11.68	120.2		
5/17/2018	7		14.07	7.55	67.3	11.67	120		
5/17/2018	8		14.04	7.55	67.2	11.68	120.1		
5/17/2018	9		14.03	7.55	67.4	11.67	119.9		
5/17/2018	9*		14.04	7.55	67.6	11.66	119.8		
5/17/2018	10		14.02	7.55	67.2	11.66	119.7	10.9	
5/17/2018	12		14.02	7.55	67.4	11.68	120		
5/17/2018	15		14.02	7.55	67.4	11.66	119.7		
5/17/2018	18		14.02	7.55	67.4	11.66	119.7		
5/17/2018	18.5		14.02	7.55	67.4	11.65	119.6		
6/7/2018	0.5	9:15	19.31	8.32	93	10.36	118.9		3.0
6/7/2018	1		19.26	8.32	92.6	10.32	118.4		
6/7/2018	2		18.22	8.15	109.2	10.38	116.6		
6/7/2018	3		17.79	7.98	114.5	10.07	112.1		
6/7/2018	4		17.34	7.9	117.1	9.88	109		
6/7/2018	5		17.05	7.85	118	9.81	107.5	8.04	
6/7/2018	6		16.94	7.82	118	9.78	107		
6/7/2018	7		16.79	7.8	117.6	9.76	106.5		
6/7/2018	8		16.53	7.74	118.1	9.62	104.4		
6/7/2018	9		16.4	7.72	117.8	9.64	104.2		
6/7/2018	9*		16.39	7.72	117.8	9.61	103.9		
6/7/2018	10		16.39	7.72	118.2	9.61	103.9	8.19	
6/7/2018	12		16.36	7.71	117.8	9.57	103.4		
6/7/2018	15		16.29	7.7	117.9	9.51	102.6		
6/7/2018	18		16.19	7.67	117.8	9.5	102.3		
6/7/2018	18.5		16.18	7.68	118.1	9.44	101.6		
6/20/2018	0.5	9:28	20.09	8.27	118	9.68	112.2		4.2
6/20/2018	1		19.83	8.24	118	9.72	112		
6/20/2018	2		18.66	8.34	120.4	10.35	116.4		
6/20/2018	3		18.14	8.26	121.1	10.25	114		
6/20/2018	4		18.05	8.27	123.2	10.43	115.9		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
6/20/2018	5		17.45	8.12	137.7	10.49	115.2	9.84	
6/20/2018	6		17.21	8.01	141.6	10.36	113.1		
6/20/2018	7		16.76	7.96	144.6	10.1	109.3		
6/20/2018	8		16.37	7.86	148.1	9.95	106.8		
6/20/2018	9		16.09	7.79	150.4	9.81	104.7		
6/20/2018	9*		16.1	7.8	150.5	9.56	102		
6/20/2018	10		16.01	7.8	152	9.6	102.2	9.44	
6/20/2018	12		15.96	7.79	152.2	9.6	102.2		
6/20/2018	15		15.84	7.78	153.2	9.54	101.3		
6/20/2018	18		15.64	7.76	154.5	9.47	100.1		
6/20/2018	19		15.63	7.75	154.2	9.48	100.2		
7/11/2018	0.5	9:20	22.66	8.66	148.4	10.02	121.8		4.7
7/11/2018	1		22.63	8.65	148.3	10.05	122.1		
7/11/2018	2		22.55	8.65	148.4	10.12	122.8		
7/11/2018	3		22.48	8.68	148.2	10.21	123.7		
7/11/2018	4		22.26	8.7	149	10.72	129.4		
7/11/2018	5		21.26	8.69	155.6	11.16	132	10.4	
7/11/2018	6		20.29	8.37	182.5	10.27	119.2		
7/11/2018	7		19.74	8.24	188.4	9.85	113.1		
7/11/2018	8		19.32	8.22	198.9	9.77	111.3		
7/11/2018	9		19	8.14	202.9	9.54	108		
7/11/2018	9*		18.97	8.13	202.9	9.54	108		
7/11/2018	10		18.28	8.06	209.4	9.29	103.6	9.52	
7/11/2018	12		17.88	8.01	209.8	9.19	101.7		
7/11/2018	15		17.63	7.91	209.9	8.81	97		
7/11/2018	18		17.38	7.78	207.4	8.32	91.1		
7/11/2018	18.5		17.34	7.76	206.7	8.24	90.1		
7/24/2018	0.5	9:15	24.5	8.66	158.3	9.71	122.5		5.6
7/24/2018	1		24.51	8.64	158	9.64	121.7		
7/24/2018	2		24.44	8.64	158.6	9.68	122		
7/24/2018	3		23.97	8.61	173.1	10.75	134.3		
7/24/2018	4		22.73	8.42	191.4	10.34	126.2		
7/24/2018	5		21.75	8.43	201.3	10.18	121.9	9.62	
7/24/2018	6		19.68	8.14	226.8	9.36	107.6		
7/24/2018	7		18.97	8.01	232.4	8.93	101.2		
7/24/2018	8		18.61	7.97	236.7	8.85	99.6		
7/24/2018	9		18.44	7.94	237.3	8.69	97.4		
7/24/2018	9*		18.43	7.93	237.3	8.65	97		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
7/24/2018	10		18.34	8.01	240	8.97	100.4	9.11	
7/24/2018	12		18.2	7.82	237.6	8.14	90.9		
7/24/2018	15		17.85	7.56	228	6.94	76.9		
7/24/2018	18		17.24	7.32	214.4	4.96	54.3		
7/24/2018	19.5		17.05	7.16	211.2	2.97	32.3		
8/8/2018	0.5	10:55	24.66	8.64	174.4	9.82	124.7		5.3
8/8/2018	1		24.54	8.62	174.5	9.86	124.9		
8/8/2018	2		24.3	8.59	176.1	9.97	125.7		
8/8/2018	3		24.15	8.51	181.5	9.98	125.4		
8/8/2018	4		23.94	8.54	192.8	10.79	135.1		
8/8/2018	5		21.96	8.35	222.8	10.38	125.2	9.21	
8/8/2018	6		20.82	8.35	238.8	10.57	124.6		
8/8/2018	7		20.03	8.14	251.9	10.16	117.9		
8/8/2018	8		19.28	8	258.5	9.29	106.2		
8/8/2018	9		18.86	7.95	261.4	9.07	102.9		
8/8/2018	9*		18.85	7.94	262.5	9.02	102.3		
8/8/2018	10							8.65	
8/8/2018	12		17.85	7.95	269.7	9.39	104.3		
8/8/2018	15		17.61	7.9	272.3	9.24	102.2		
8/8/2018	18		17.6	7.88	272.3	9.13	100.9		
8/8/2018	18.5		17.59	7.88	272.5	9.12	100.8		
8/29/2018	0.5	10:55	20.51	8.45	217.1	9.67	113.9		4.2
8/29/2018	1		20.43	8.44	217	9.66	113.5		
8/29/2018	2		20.4	8.45	216.8	9.68	113.7		
8/29/2018	3		20.34	8.45	216.6	9.69	113.7		
8/29/2018	4		20.31	8.45	216.4	9.68	113.5		
8/29/2018	5		20.29	8.45	216.2	9.67	113.3	7.99	
8/29/2018	6		20.12	8.28	222.5	9.03	105.5		
8/29/2018	7		19.44	8.02	235.9	8.4	96.8		
8/29/2018	8		18.93	8.07	238.4	8.51	97.1		
8/29/2018	9		18.4	7.88	249.1	8.15	92		
8/29/2018	9*		18.43	7.93	248.4	8.22	92.9		
8/29/2018	10		18.01	7.76	258.7	7.71	86.3	7.36	
8/29/2018	12		17.18	7.98	257.3	8.73	96		
8/29/2018	15		15.36	7.94	275.5	9.2	97.4		
8/29/2018	18		15.24	7.91	276.7	9.14	96.5		
8/29/2018	19		15.23	7.89	276.9	9.1	96.1		
9/13/2018	0.5	9:10	19.1	8.46	227.2	9.34	106.6		5.0

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
9/13/2018	1		19.14	8.46	226.9	9.38	107.1		
9/13/2018	2		19.13	8.47	226.9	9.37	107		
9/13/2018	3		19.13	8.46	226.8	9.4	107.3		
9/13/2018	4		19.12	8.47	226.9	9.39	107.2		
9/13/2018	5		19.12	8.46	226.9	9.34	106.7	8.45	
9/13/2018	6		18.67	8.3	235.8	9.13	103.3		
9/13/2018	7		18.27	8.24	239.3	9.09	102.1		
9/13/2018	8		17.95	8.29	237.5	9.19	102.5		
9/13/2018	9		17.82	8.3	237.5	9.29	103.3		
9/13/2018	9*		17.82	8.29	237.3	9.29	103.3		
9/13/2018	10		16.03	8.15	251.2	9.31	99.7	8.65	
9/13/2018	12		15.64	8.1	253.5	9.31	98.9		
9/13/2018	15		15.53	8.09	253.5	9.31	98.6		
9/13/2018	18		15.31	8.04	255.5	9.25	97.5		
9/13/2018	18.5		15.3	8.04	255.4	9.21	97.2		
9/26/2018	0.5	11:15	17.3	8.41	234	9.17	99.8		4.2
9/26/2018	1		17.29	8.41	233.9	9.17	99.8		
9/26/2018	2		17.24	8.4	234.1	9.14	99.4		
9/26/2018	3		17.21	8.4	234.1	9.17	99.6		
9/26/2018	4		17.18	8.41	234.1	9.19	99.7		
9/26/2018	5		17.14	8.4	233.8	9.17	99.5	8.22	
9/26/2018	6		17.11	8.38	234.2	9.05	98.1		
9/26/2018	7		17.07	8.35	234.4	9.01	97.5		
9/26/2018	8		17.01	8.35	234.1	9.05	97.9		
9/26/2018	9		16.85	8.37	234.3	9.18	99		
9/26/2018	9*		16.85	8.36	234.4	9.17	98.9		
9/26/2018	10		16.57	8.42	234.8	9.55	102.3	7.9	
9/26/2018	12		15.15	8.32	243.8	9.8	101.9		
9/26/2018	15		14.22	8.2	250.1	9.79	99.8		
9/26/2018	18		14.12	8.17	250.6	9.77	99.3		
9/26/2018	18.5		14.12	8.18	250.3	9.75	99.3		
10/17/2018	0.5	10:55	13.11	8.36	246.4	10.42	103.3		3.6
10/17/2018	1		13.07	8.37	246.2	10.5	103.9		
10/17/2018	2		12.98	8.36	246.5	10.55	104.1		
10/17/2018	3		12.94	8.36	246.8	10.49	103.5		
10/17/2018	4		12.91	8.34	246.4	10.52	103.8		
10/17/2018	5		12.87	8.33	246.6	10.34	101.8	Broke	
10/17/2018	6		12.77	8.29	245.7	10.27	101		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
10/17/2018	7		12.38	8.22	243.7	10.08	98.2		
10/17/2018	8		12.35	8.22	243.2	10.11	98.5		
10/17/2018	9		12.1	8.22	241.3	10.19	98.6		
10/17/2018	9*		12.08	8.22	241	10.18	98.5		
10/17/2018	10		11.7	8.16	238.2	10.12	97.1	10.4	
10/17/2018	12		11.41	8.14	235.5	10.28	97.9		
10/17/2018	15		10.82	8.08	229.4	10.39	97.6		
10/17/2018	18		10.76	8.07	229.6	10.45	98.1		
10/17/2018	19		10.74	8.05	229.2	10.44	98		

*QA/QC measurement for Hydrolab
**Secchi disk depths average of 3 measurements

Table A-8. Station LL3a *In Situ* Water Quality Data, 2018

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
5/17/2018	0.5	10:33	14.23	7.62	67.6	11.62	119.9		2.0
5/17/2018	1		14.16	7.59	67.6	11.58	119.4		
5/17/2018	2		14.17	7.58	67.4	11.59	119.4		
5/17/2018	3		14.17	7.55	67.7	11.63	119.8		
5/17/2018	4		14.14	7.56	67.6	11.62	119.6		
5/17/2018	5		14.14	7.54	67.2	11.62	119.7	11	
5/17/2018	6		14.15	7.54	67.3	11.61	119.6		
5/17/2018	7		14.14	7.52	67.4	11.63	119.8		
5/17/2018	8		14.13	7.54	67.4	11.61	119.5		
5/17/2018	9		14.12	7.54	67.2	11.62	119.7		
5/17/2018	9*		14.13	7.54	67	11.6	119.4		
5/17/2018	10		14.14	7.54	67.4	11.62	119.7	11	
5/17/2018	12		14.11	7.55	67.2	11.59	119.3		
5/17/2018	15		14.11	7.54	67.1	11.6	119.3		
5/17/2018	18		14.11	7.54	67.2	11.61	119.4		
5/17/2018	18.5		14.11	7.54	67.1	11.58	119.1		
6/7/2018	0.5	9:46	19.26	8.21	99.7	10.21	117.2		2.8
6/7/2018	1		18.76	8.1	107.4	10.15	115.3		
6/7/2018	2		17.55	7.98	115.9	10.14	112.3		
6/7/2018	3		17.44	7.98	115.9	10.13	112		
6/7/2018	4		17.06	7.94	116.9	10.16	111.4		
6/7/2018	5		16.43	7.79	117.6	9.93	107.4	8.29	
6/7/2018	6		16.36	7.74	117.7	9.73	105.2		
6/7/2018	7		16.27	7.69	117.7	9.59	103.4		
6/7/2018	8		16.2	7.67	117.5	9.57	103.1		
6/7/2018	9		16.19	7.66	117.3	9.62	103.6		
6/7/2018	9*		16.2	7.67	117.5	9.59	103.2		
6/7/2018	10		16.19	7.66	117.3	9.6	103.3	8	
6/7/2018	12		16.19	7.66	117.7	9.58	103.1		
6/7/2018	15		16.19	7.66	117.7	9.58	103.1		
6/7/2018	18		16.17	7.64	117.4	9.47	101.9		
6/7/2018	18.5		16.15	7.63	117.5	9.46	101.7		
6/20/2018	0.5	10:05	20.24	8.23	120.2	9.6	111.5		4.0
6/20/2018	1		19.74	8.28	121.3	9.88	113.7		
6/20/2018	2		18.58	8.31	129.8	10.34	116.2		
6/20/2018	3		18.05	8.35	132.4	10.57	117.4		
6/20/2018	4		17.78	8.17	135.8	10.14	112.1		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
6/20/2018	5		16.87	8.02	147.9	9.89	107.3	9.64	
6/20/2018	6		16.34	7.94	153.2	9.82	105.3		
6/20/2018	7		15.93	7.86	152.4	9.59	101.9		
6/20/2018	8		15.58	7.77	155.5	9.37	98.9		
6/20/2018	9		15.51	7.8	155.5	9.41	99.1		
6/20/2018	9*		15.51	7.79	155.4	9.44	99.4		
6/20/2018	10		15.48	7.81	156.4	9.45	99.5	9.33	
6/20/2018	12		15.47	7.81	156.1	9.46	99.6		
6/20/2018	15		15.47	7.81	156.1	9.51	100.2		
6/20/2018	18		15.47	7.81	156.5	9.45	99.5		
6/20/2018	18.5		15.47	7.8	156.1	9.49	100		
7/11/2018	0.5	10:00	22.61	8.66	149.1	10.27	124.8		3.9
7/11/2018	1		22.52	8.67	148.9	10.42	126.3		
7/11/2018	2		22.38	8.67	148.9	10.36	125.3		
7/11/2018	3		22.29	8.68	149.2	10.45	126.1		
7/11/2018	4		22.05	8.69	151.3	10.68	128.4		
7/11/2018	5		21.23	8.65	161.9	11.2	132.5	10.5	
7/11/2018	6		20.6	8.47	177.5	10.65	124.5		
7/11/2018	7		19.48	8.11	194.6	9.48	108.4		
7/11/2018	8		18.5	8.02	207.4	9.17	102.7		
7/11/2018	9		18.3	7.99	208.7	9.11	101.6		
7/11/2018	9*		18.33	8	208.4	9.14	102		
7/11/2018	10		18.2	7.97	209.2	9.05	100.8	8.54	
7/11/2018	12		17.97	7.96	210.4	9.02	99.9		
7/11/2018	15		17.84	7.96	211	9.05	100		
7/11/2018	18		17.74	7.93	210.6	9.02	99.4		
7/11/2018	18.5		17.76	7.94	210.6	8.91	89.3		
7/24/2018	0.5	9:45	24.5	8.73	159	10.28	129.8		5.2
7/24/2018	1		24.44	8.71	159.3	10.1	127.3		
7/24/2018	2		24.35	8.66	160.9	9.79	123.2		
7/24/2018	3		23.97	8.67	170.5	10.59	132.3		
7/24/2018	4		22.92	8.54	186.8	10.61	129.9		
7/24/2018	5		21.42	8.32	207.2	10	119	9.58	
7/24/2018	6		19.63	8.09	228.3	9.27	106.5		
7/24/2018	7		19.02	7.93	232.2	8.42	95.6		
7/24/2018	8		18.39	7.97	239.8	8.88	99.4		
7/24/2018	9		18.32	7.93	240.4	8.73	97.6		
7/24/2018	9*		18.3	7.93	240.3	8.73	97.6		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
7/24/2018	10		18.25	7.95	240.9	8.82	98.5	8.8	
7/24/2018	12		18.11	7.98	242.4	9.07	101		
7/24/2018	15		17.83	7.58	234.5	7.81	86.4		
7/24/2018	18		17.18	7.1	219.1	1.8	19.7		
7/24/2018	18.5		17.12	7.06	219.3	1.62	17.7		
8/8/2018	0.5	11:30	24.44	8.64	178	10.12	127.9		4.9
8/8/2018	1		24.29	8.63	178	10.17	128.1		
8/8/2018	2		24.16	8.61	178.2	10.26	129		
8/8/2018	3		24.14	8.62	178.1	10.31	129.5		
8/8/2018	4		23.71	8.47	193.9	10.2	127.2		
8/8/2018	5		22.45	8.32	215.4	10	121.7	9.86	
8/8/2018	6		21.36	8.19	230.8	9.61	114.6		
8/8/2018	7		20.07	8.1	247.7	9.58	111.3		
8/8/2018	8		19.61	8.05	253.4	9.34	107.5		
8/8/2018	9		18.86	8.01	259	9.37	106.3		
8/8/2018	9*		18.82	8	258.9	9.37	106.2		
8/8/2018	10		18.1	8.03	266.1	9.8	109.5	9.49	
8/8/2018	12		17.65	8.01	270.1	9.86	109.1		
8/8/2018	15		17.58	7.95	271.6	9.57	105.7		
8/8/2018	18		17.5	7.94	272.2	9.63	106.3		
8/8/2018	18.5		17.53	7.94	272.1	9.55	105.4		
8/29/2018	0.5	11:20	20.97	8.49	214.2	9.53	113.2		3.6
8/29/2018	1		20.55	8.51	214.8	9.68	114.1		
8/29/2018	2		20.42	8.54	215.1	9.82	115.4		
8/29/2018	3		20.42	8.51	215.3	9.71	114.1		
8/29/2018	4		20.31	8.26	210.5	8.84	103.6		
8/29/2018	5		19.91	8.24	221.7	8.75	101.8	7.64	
8/29/2018	6		19.64	8.24	221.8	8.75	101.2		
8/29/2018	7		19.18	8.23	226.3	8.78	100.6		
8/29/2018	8		18.67	8.23	231.6	8.92	101.2		
8/29/2018	9		17.71	8.16	248.2	8.85	98.4		
8/29/2018	9*		17.7	8.15	247.4	8.92	99.2		
8/29/2018	10		17.26	8.16	250.5	9.18	101.2	7.99	
8/29/2018	12		15.55	8.09	271.7	9.54	101.4		
8/29/2018	15		14.99	8.03	278.2	9.55	100.3		
8/29/2018	18		14.99	8.01	278.3	9.49	99.7		
8/29/2018	18.5		14.99	8.01	278.2	9.49	99.6		
9/13/2018	0.5	9:45	19	8.47	224.6	9.49	108.1		3.8

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
9/13/2018	1		19	8.47	224.6	9.5	108.2		
9/13/2018	2		18.97	8.48	224.3	9.55	108.7		
9/13/2018	3		18.96	8.48	224.7	9.55	108.7		
9/13/2018	4		18.95	8.47	224.5	9.51	108.2		
9/13/2018	5		18.93	8.47	224.5	9.46	107.7	7.38	
9/13/2018	6		18.91	8.46	224.9	9.4	106.8		
9/13/2018	7		18.81	8.42	225.7	9.22	104.6		
9/13/2018	8		18.2	8.38	230.7	9.48	106.1		
9/13/2018	9		17.22	8.28	239.1	9.38	103		
9/13/2018	9*		17.36	8.28	237.3	9.38	103.3		
9/13/2018	10		15.8	8.17	249.6	9.43	100.5	8.77	
9/13/2018	12		15.24	8.13	256.2	9.48	99.8		
9/13/2018	15		14.95	8.07	254.8	9.43	98.7		
9/13/2018	18		14.89	8.05	255.1	9.47	99		
9/13/2018	18.5		14.89	8.05	255.1	9.49	99.2		
9/26/2018	0.5	11:50	17.49	8.46	233.5	9.5	103.7		4.4
9/26/2018	1		17.4	8.47	232.9	9.47	103.2		
9/26/2018	2		17.35	8.47	232.8	9.55	104		
9/26/2018	3		17.33	8.48	232.8	9.56	104.1		
9/26/2018	4		17.27	8.47	232.9	9.59	104.3		
9/26/2018	5		17.26	8.45	233	9.51	103.3	8.83	
9/26/2018	6		17.22	8.45	233.2	9.41	102.2		
9/26/2018	7		17.15	8.43	233.3	9.41	102		
9/26/2018	8		16.94	8.42	232.7	9.47	102.3		
9/26/2018	9		16.46	8.41	235.7	9.69	103.6		
9/26/2018	9*		16.47	8.41	235.3	9.68	103.6		
9/26/2018	10		15.5	8.32	242	9.77	102.3	8.79	
9/26/2018	12		14.15	8.28	249.2	10.15	103.3		
9/26/2018	15		13.9	8.22	250.5	10.15	102.7		
9/26/2018	18		13.88	8.21	250.4	10.19	103.1		
9/26/2018	18.5		13.89	8.21	250.4	10.17	102.9		
10/17/2018	0.5	11:30	12.72	8.38	245.2	10.69	105		4.0
10/17/2018	1		12.72	8.38	245.5	10.68	104.9		
10/17/2018	2		12.66	8.39	245.2	10.77	105.5		
10/17/2018	3		12.62	8.38	245.3	10.69	104.7		
10/17/2018	4		12.59	8.38	245.5	10.71	104.8		
10/17/2018	5		12.55	8.37	245.1	10.68	104.4	10.5	
10/17/2018	6		12.33	8.31	242.5	10.42	101.4		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
10/17/2018	7		11.82	8.21	238.9	10.27	98.8		
10/17/2018	8		11.57	8.17	236.8	10.24	97.9		
10/17/2018	9		11.03	8.12	231.4	10.39	98.2		
10/17/2018	9*		11.22	8.12	232.5	10.35	98.2		
10/17/2018	10		10.94	8.1	230.4	10.4	98.1	10.6	
10/17/2018	12		10.58	8.06	226.6	10.49	98.1		
10/17/2018	15		10.51	8.05	225.8	10.53	98.3		
10/17/2018	18		10.49	8.04	226.1	10.49	97.9		
10/17/2018	18.5		10.48	8.04	225.7	10.52	98.1		

*QA/QC measurement for Hydrolab
**Secchi disk depths average of 3 measurements

Table A-9. Station LL4 *In Situ* Water Quality Data, 2018

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
5/17/2018	0.5	11:23	13.84	7.67	66.2	11.81	120.8		2.1
5/17/2018	1		13.84	7.61	65.9	11.82	120.9		
5/17/2018	2		13.84	7.62	65.9	11.82	121		
5/17/2018	3		13.84	7.62	65.9	11.87	121.4		
5/17/2018	4		13.84	7.6	66.1	11.89	121.7		
5/17/2018	4*		13.84	7.59	65.7	11.92	121.9		
5/17/2018	5		13.84	7.6	66	11.85	121.2		
5/17/2018	6		13.84	7.6	66	11.86	121.3		
5/17/2018	7		13.84	7.58	65.7	11.9	121.7		
5/17/2018	8		13.84	7.59	65.7	11.88	121.5		
6/7/2018	0.5	10:39	16.3	7.78	115.1	9.65	104.2		4.3
6/7/2018	1		15.99	7.8	114.6	9.72	104.2		
6/7/2018	2		15.91	7.78	114.9	9.71	103.9		
6/7/2018	3		15.89	7.78	114.5	9.74	104.1		
6/7/2018	4		15.81	7.72	115	9.59	102.4		
6/7/2018	4*		15.82	7.72	114.5	9.56	102.1		
6/7/2018	5		15.77	7.71	115.5	9.56	102		
6/7/2018	6		15.76	7.71	116.1	9.53	101.7		
6/7/2018	7		15.75	7.72	116.3	9.58	102.2		
6/7/2018	8		15.75	7.71	116.1	9.56	102		
6/20/2018	0.5	11:10	18.19	8.2	148.2	10.48	116.9		4.1
6/20/2018	1		16.74	7.96	155	10.43	112.8		
6/20/2018	2		16.02	7.87	154.4	10.39	110.7		
6/20/2018	3		15.92	7.86	154.2	10.34	109.9		
6/20/2018	4		15.9	7.85	154.8	10.36	110.1		
6/20/2018	4*		15.94	7.84	154.7	10.34	110		
6/20/2018	5		15.83	7.88	156.4	10.36	110		
6/20/2018	6		15.76	7.84	157.5	10.34	109.6		
6/20/2018	7		15.72	7.83	157.6	10.29	108.9		
6/20/2018	8		15.68	7.79	157.6	10.25	108.4		
7/11/2018	0.5	10:50	22.35	8.61	159.3	10.05	121.5		4.1
7/11/2018	1		22.13	8.57	160	10.04	120.9		
7/11/2018	2		22.15	8.46	166.6	9.81	118.1		
7/11/2018	3		21.3	8.36	178.1	9.75	115.5		
7/11/2018	4		19.83	8.22	197.9	9.5	109.3		
7/11/2018	4*		19.67	8.16	199.8	9.51	109.1		
7/11/2018	5		18	8.13	214.7	9.43	104.5		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
7/11/2018	6		17.96	8.11	214.4	9.4	104.1		
7/11/2018	7		17.92	8.1	214.8	9.39	103.9		
7/11/2018	8		17.89	8.09	214.6	9.37	103.7		
7/24/2018	0.5	10:55	24.3	8.67	166.2	10.04	126.2		5.0
7/24/2018	1		24.17	8.67	166.6	10.06	126.1		
7/24/2018	2		24.03	8.71	165.8	10.3	128.9		
7/24/2018	3		23.79	8.6	173.3	10.17	126.6		
7/24/2018	4		21.41	8.4	212.4	10.21	121.5		
7/24/2018	4*		21.48	8.39	212.5	10.14	120.8		
7/24/2018	5		17.92	8.08	251.1	9.68	107.4		
7/24/2018	6		17.6	8.06	253.6	9.63	106.2		
7/24/2018	7		17.56	8.1	254.5	9.73	107.2		
7/24/2018	8		17.53	8.06	254.6	9.74	107.2		
8/8/2018	0.5	12:25	25.32	8.54	183.7	10.1	129.6		4.8
8/8/2018	1		24.99	8.52	182	10.05	128.4		
8/8/2018	2		24.54	8.51	182.5	10.22	129.4		
8/8/2018	3		24.46	8.5	182.9	10.1	127.7		
8/8/2018	4		24.15	8.43	187.2	9.89	124.3		
8/8/2018	4*		24.07	8.42	189.6	9.97	125.2		
8/8/2018	5		20.77	8.22	233.8	10.32	121.6		
8/8/2018	6		17.42	7.97	272.4	10.27	113.1		
8/8/2018	7		17.2	7.9	273.6	10.19	111.7		
8/8/2018	8		17.19	7.92	274	10.2	111.8		
8/29/2018	0.5	12:10	20.99	8.43	212	9.88	117.4		3.2
8/29/2018	1		20.92	8.49	211.9	9.92	117.7		
8/29/2018	2		20.64	8.51	211.9	9.97	117.7		
8/29/2018	3		20.53	8.52	211.9	10.07	118.6		
8/29/2018	4		19.87	8.53	216.7	10.3	119.7		
8/29/2018	4*		19.86	8.51	216.6	10.24	119		
8/29/2018	5		17.23	8.3	254	10.2	112.4		
8/29/2018	6		14.86	8.03	284.5	9.73	101.9		
8/29/2018	7		14.7	8.01	285.6	9.8	102.3		
8/29/2018	8		14.72	8	285.3	9.83	102.6		
9/13/2018	0.5	10:35	18.48	8.58	223.5	10.34	116.5		3.0
9/13/2018	1		18.49	8.59	222.4	10.34	115.6		
9/13/2018	2		18.35	8.6	221.8	10.51	118.2		
9/13/2018	3		18.31	8.61	221.2	10.56	118.6		
9/13/2018	4		17.23	8.5	233.3	10.56	116		

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
9/13/2018	4*		17.05	8.48	235.7	10.56	115.5		
9/13/2018	5		14.57	8.05	257.5	9.4	97.6		
9/13/2018	6		14.35	8.02	257	9.55	98.7		
9/13/2018	7		14.34	8.04	256.9	9.58	99		
9/13/2018	8		14.32	8.03	256.5	9.6	99.1		
9/26/2018	0.5	12:35	17.21	8.38	231.1	10.19	110.7		5.6
9/26/2018	1		16.95	8.4	230.8	10.21	110.3		
9/26/2018	2		16.81	8.42	230.5	10.27	110.6		
9/26/2018	3		16.47	8.41	231.3	10.24	109.5		
9/26/2018	4		15.45	8.36	237.7	10.59	110.8		
9/26/2018	4*		15.42	8.35	237.8	10.59	110.8		
9/26/2018	5		13.48	8.05	250.8	10.06	100.9		
9/26/2018	6		13.35	8.06	250.7	10.24	102.4		
9/26/2018	7		13.32	8.05	250.6	10.31	103		
9/26/2018	8		13.3	8.05	250.6	10.32	103.1		
10/17/2018	0.5	12:20	10.52	7.77	219.9	10.65	99.4		6.1
10/17/2018	1		10.29	7.79	219.6	10.73	99.7		
10/17/2018	2		10.2	7.81	219.7	10.77	99.7		
10/17/2018	3		10.13	7.81	220	10.78	99.7		
10/17/2018	4		10.08	7.87	220.8	10.91	100.8		
10/17/2018	4*		10.09	7.85	219.9	10.93	101		
10/17/2018	5		10.07	7.87	220.3	10.9	100.7		
10/17/2018	6		10.07	7.89	220.6	10.92	100.9		
10/17/2018	7		10.07	7.92	221.3	11.05	102.1		
10/17/2018	8		10.05	7.92	221.3	10.98	101.4		

*QA/QC measurement for Hydrolab
**Secchi disk depths average of 3 measurements

Table A-10. Station LL5 *In Situ* Water Quality Data, 2018

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
5/17/2018	0.5	11:53	13.64	7.63	66.4	11.89	121.1		1.9
5/17/2018	1		13.67	7.64	66.5	11.9	121.3		
5/17/2018	2		13.66	7.64	66.6	11.9	121.2		
5/17/2018	3		13.67	7.63	66.7	11.9	121.3		
5/17/2018	4		13.67	7.63	66.4	11.99	122.2		
5/17/2018	5		13.68	7.63	66.6	11.91	121.4		
6/7/2018	0.5	11:03	16.03	7.75	118.6	9.67	103.7		3.9
6/7/2018	1		16.01	7.74	118.4	9.69	103.9		
6/7/2018	2		16.02	7.73	118.2	9.64	103.4		
6/7/2018	3		16.03	7.73	118.6	9.64	103.5		
6/7/2018	4		16	7.72	118.7	9.68	103.8		
6/7/2018	5		16.01	7.73	118.4	9.7	104		
6/20/2018	0.5	11:40	16.13	7.77	159.6	9.53	101.8		5.2
6/20/2018	1		15.95	7.81	159.5	9.39	99.7		
6/20/2018	2		15.85	7.79	159.5	9.5	100.8		
6/20/2018	3		15.79	7.79	159.7	9.49	100.6		
6/20/2018	4		15.73	7.78	159.5	9.53	100.9		
6/20/2018	5		15.72	7.78	159.3	9.56	101.2		
7/11/2018	0.5	11:15	17.09	7.97	219.5	8.99	97.8		5.6
7/11/2018	1		16.97	7.95	219.7	9	97.7		
7/11/2018	2		16.9	7.92	219.8	8.95	97		
7/11/2018	3		16.88	7.91	220	9.07	98.2		
7/11/2018	4		16.8	7.91	220.2	9.09	98.3		
7/11/2018	5		16.8	7.91	220.1	9.12	98.6		
7/24/2018	0.5	11:15	21.4	8.43	209.6	9.71	115.6		5.6
7/24/2018	1		19.16	8.19	236.8	9.51	108.3		
7/24/2018	2		17.4	8.05	262.5	9.34	102.5		
7/24/2018	3		17.34	8.02	262.7	9.24	101.3		
7/24/2018	4		17.32	8.01	262.8	9.16	100.3		
7/24/2018	5		17.28	8	262.6	9.12	99.9		
8/8/2018	0.5	12:50	24.33	8.57	194.6	10.2	128.7		5.7
8/8/2018	1		22.7	8.43	207.9	10.21	124.9		
8/8/2018	2		17.06	7.94	277.7	9.86	107.8		
8/8/2018	3		16.79	7.89	280.6	9.73	105.8		
8/8/2018	4		16.6	7.86	281.3	9.55	103.4		
8/8/2018	5		16.52	7.84	281.2	9.5	102.7		
8/29/2018	0.5	12:35	19.17	8.59	222.5	11	126.1		3.7

Date	Depth (m)	Time	Temperature (°C)	pH	Cond (µS/cm)	DO (mg/l)	DO Sat. (%)	Winkler DO (mg/L)	Secchi Disk Depth (m)**
8/29/2018	1		15.46	8.12	273.6	9.98	105.9		
8/29/2018	2		14.42	7.96	289.8	9.86	102.3		
8/29/2018	3		14.39	7.95	289.9	9.8	101.6		
8/29/2018	4		14.36	7.92	289.9	9.81	101.8		
8/29/2018	5		14.36	7.94	289.7	9.81	101.6		
9/13/2018	0.5	10:55	13.98	8.07	259.1	9.78	100.2		5.6
9/13/2018	1		13.94	8.08	258.8	9.77	100		
9/13/2018	2		13.87	8.07	258	9.67	98.9		
9/13/2018	3		13.74	8.06	258.9	9.6	97.9		
9/13/2018	4		13.7	8.04	259.1	9.58	97.6		
9/13/2018	5		13.7	8.03	259	9.58	97.5		
9/26/2018	0.5	12:55	13.26	8	253.4	9.69	96.7		6.0
9/26/2018	1		13.01	7.99	251.9	9.66	95.8		
9/26/2018	2		13.01	7.99	251.8	9.62	95.4		
9/26/2018	3		12.89	7.97	252.1	9.7	96		
9/26/2018	4		12.85	7.96	252.1	9.7	95.8		
9/26/2018	5		12.85	7.96	252	9.7	95.9		
10/17/2018	0.5	12:45	10.31	7.81	215.9	10.33	95.9		5.9
10/17/2018	1		10.2	7.77	216	10.35	95.8		
10/17/2018	2		10.2	7.78	215.6	10.36	96		
10/17/2018	3		10.16	7.75	215.5	10.37	96		
10/17/2018	4		10.12	7.79	215.4	10.43	96.4		
10/17/2018	5		10.1	7.79	215.5	10.47	96.8		

*QA/QC measurement for Hydrolab
**Secchi disk depths average of 3 measurements

APPENDIX II – Lake Spokane Zooplankton Data

(See Excel Spreadsheet of Laboratory Data)

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APPENDIX III – IEH Analytical Laboratory Chain of Custody's

(See PDF)

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IEH Analytical Laboratories
)27 Aurora Ave N • Seattle • WA • 981(
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

 TET013-59

REPORT TO:
Client: Avista Utilities and Tetra Tech, Inc.
Address:
Contact: Chris Moan and Shannon Brattebo
Email: chris.moan@avistacorp.com; shannon.brattebo@tetratech.com
Phone: 509-232-4312 Fax

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Avista Utilities
Addres 1411 E. Mission Ave. MSC-1
Spokane, WA 99202
Contac Chris Moan
Email: chris.moan@avistacorp.com
Phone: 509-495-4084 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project: Lake Spokane 2018

Reporting/Invoicing Format
☐ Fax ☒ Email ☒ Mail

QC Data Reported
☒ Yes ☐ No

Sample Disposal
☐ Hold ☐ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Da
☐ 3 Business Da ☒ Standard
Specific Date:
*Advanced notice required for Rush

LAB USE ONLY
Case File Number

SAMPLING Date (mm-dd-)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	Winkler DO	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
* 5-16	910	SW	LL0 - 5m # 170	1	X						
"	915	SW	LL0 - 15m # 320	1	X						
5-16	1015	SW	LL1 - 5m # 190	1	X						
"	1020	SW	LL1 - 21m # 93	1	X						
5-16	1055	SW	LL1a - 5m # 107	1	X						
"	1100	SW	LL1a - 21m # 180	1	X						
5-16	1150	SW	LL2 - 5m # 138	1	X						
"	1155	SW	LL2 - 21m # 258	1	X						
5-16	1250	SW	LL2a - 5m # 95	1	X						
"	1255	SW	LL2a - 15m # 286	1	X						
5-17	920	SW	LL2b - 5m # 159	1	X						
"	925	SW	LL2b - 10m # 179	1	X						
5-17	955	SW	LL3 - 5m # 140a	1	X						
"	1000	SW	LL3 - 10m # 136	1	X						
5-17	1035	SW	LL3a - 5m # 96	1	X						
"	1040	SW	LL3a - 10m # 182	1	X						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments: *Sample LL0-5m #170 broke in shipping -BCS

	Date	Time
Sampled By: [signature]	5/17/18	13:00
Received By		
Relinquished to IAL By (Signature)		

Shipped By
Shipping Reference

Received at IAL By: [signature] Date 05/18/18 Time 1000

(15) samples 12.2°C

IEH Analytical Laboratories
327 Aurora Ave N • Seattle • WA • 981
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

 TET013-61

REPORT TO:
Client: Avista Utilities and Tetra Tech, Inc.
Address:
Contact: Chris Moan and Shannon Brattebo
Email: chris.moan@avistacorp.com; shannon.brattebo@tetratech.com
Phone: 509-232-4312 Fax

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Avista Utilities
Address: 1411 E. Mission Ave. MSC-1
Spokane, WA 99202
Contact: Chris Moan
Email: chris.moan@avistacorp.com
Phone: 509-495-4084 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project: Lake Spokane 2018

Reporting/Invoicing Format
☐ Fax ☒ Email ☒ Mail

QC Data Reported
☒ Yes ☐ No

Sample Disposal
☐ Hold ☐ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☒ Standard
Specific Date:
*Advanced notice required for Rush

Date (mm-dd-)	Time	Matrix**	Sample Description (This Will Appear On The Report)	Number of Containers		Winkler DO	Field pH (If applicable)	Field Temp (If applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
6/6/18	915	SW	LL0 - 5m # 21	1		X						
"	920	SW	LL0 - 25m # 12	1		X						
"	1020	SW	LL1 - 5m # 16	1		X						
"	1025	SW	LL1 - 21m # 18	1		X						
"	1055	SW	LL1a - 5m # 136	1		X						
"	1100	SW	LL1a - 21m # 320	1		X						
"	1140	SW	LL2 - 5m # 14	1		X						
"	1145	SW	LL2 - 15m # 8	1		X						
"	1215	SW	LL2a - 5m # 7	1		X						
"	1220	SW	LL2a - 15m # 51	1		X						
6/7/18	840	SW	LL2b - 5m # #53	1		X						
"	845	SW	LL2b - 10m # #63	1		X						
"	~~[illegible]~~ 915	SW	LL3 - 5m # #~~[illegible]~~64	1		X						
"	~~[illegible]~~ 920	SW	LL3 - 10m # #~~[illegible]~~13	1		X						
"	~~[illegible]~~ 945	SW	LL3a - 5m # #20	1		X						
"	950	SW	LL3a - 10m # #10	1		X						

Analysis Requested / **LAB USE ONLY** — Case File Number

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments: #18 broke in shipping -BLS

Sampled By	Date	Time
Chris Moan	6/7/18	13:00
Received By	Date	Time
Relinquished to IAL By (Signature)	Date	Time

Shipped By	Shipping Reference

Received at IAL By	Date	Time
[signature]	06/08/18	1000

(16) samples 12°C

IEH Analytical Laboratories
?27 Aurora Ave N • Seattle • WA • 981?
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

Page 1 of 1 TET013-63

REPORT TO:
Client: Avista Utilities and Tetra Tech, Inc.
Address:
Contact: Chris Moan and Shannon Brattebo
Email: chris.moan@avistacorp.com; shannon.brattebo@tetratech.com
Phone: 509-232-4312 Fax

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Avista Utilities
Addres 1411 E. Mission Ave. MSC-1
Spokane, WA 99202
Contac Chris Moan
Email: chris.moan@avistacorp.com
Phone: 509-495-4084 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project: Lake Spokane 2018

Reporting/Invoicing Format
☐ Fax ☒ Email ☒ Mail

QC Data Reported
☒ Yes ☐ No

Sample Disposal
☐ Hold ☐ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Da
☐ 3 Business Da ☒ Standard
Specific Date:
*Advanced notice required for Rush

Date (mm-dd-)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers		Winkler DO											Field pH (if applicable)	Field Temp (if applied)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
6/19/18	900	SW	LL0 - 5m # ~~20~~ 210 (BLS)	1		X																
"	905	SW	LL0 - 15m # 159A	1		X																
"	955	SW	LL1 - 5m # 93	1		X																
"	1000	SW	LL1 - ~~30~~ 21m # 307	1		X																
"	1050	SW	LL1a - 5m # 112	1		X																
"	1055	SW	LL1a - 21m # 336	1		X																
"	1120	SW	LL2 - 5m # ~~210~~ 179 (BLS)	1		X																
"	1125	SW	LL2 - 15m # 95	1		X																
"	1205	SW	LL2a - 5m # 140	1		X																
"	1210	SW	LL2a - 15m # 305	1		X																
6/20/18	850	SW	LL2b - 5m # 105	1		X																
"	855	SW	LL2b - 10m # 144	1		X																
"	925	SW	LL3 - 5m # 95	1		X																
"	930	SW	LL3 - 10m # 188	1		X																
"	1005	SW	LL3a - 5m # 182	1		X																
"	1010	SW	LL3a - 10m # 286	1		X																

*LL2 5m I did not write down bottle # before packing it up. I think its #210 whatever # is left

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments: contacted client to confirm bottle #s for LL0-5m + LL2-5m -BLS

Sampled By	Date	Time
Chris Moan	6/20/18	13:30
Received By	**Date**	**Time**
Relinquished to IAL By (Signature)	**Date**	**Time**

Shipped By	Shipping Reference

Received at IAL By	Date	Time
[signature]	06/21/18	1000

(16) samples 12°C

IEH Analytical Laboratories
327 Aurora Ave N • Seattle • WA • 9810
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

TET013-65

REPORT TO:
Client: Avista Utilities and Tetra Tech, Inc.
Address:
Contact: Chris Moan and Shannon Brattebo
Email: chris.moan@avistacorp.com; shannon.brattebo@tetratech.com
Phone: 509-232-4312 Fax

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Avista Utilities
Address: 1411 E. Mission Ave. MSC-1
Spokane, WA 99202
Contact: Chris Moan
Email: chris.moan@avistacorp.com
Phone: 509-495-4084 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project: Lake Spokane 2018

Reporting/Invoicing Format
☐ Fax ☒ Email ☒ Mail

QC Data Reported
☒ Yes ☐ No

Sample Disposal
☐ Hold ☐ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Days
☐ 3 Business Days ☒ Standard
Specific Date:
*Advanced notice required for Rush

LAB USE ONLY
Case File Number
MAR
7/12/18
mg/L

Date (mm-dd-)	Time	Matrix**	Sample Description (This Will Appear On The Report)	Number of Containers	Winkler DO												Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
7/10	910	SW	LL0 - 5m # 101	1	X																10.47	
"	915	SW	LL0 - 15m # 157A	1	X																8.02	
7/10	1010	SW	LL1 - 5m # 291	1	X																9.98	
"	1015	SW	LL1 - 21m # 212	1	X																8.26	
7/10	1058	SW	LL1a - 5m # 8	1	X																10.01	
"	1105	SW	LL1a - 21m # 21	1	X																8.34	
7/10	1140	SW	LL2 - 5m # 320	1	X																10.90	
"	1145	SW	LL2 - 15m # 63	1	X																8.36	
7/10	1225	SW	LL2a - 5m # 84	1	X																9.86	
"	1230	SW	LL2a - 15m # 49	1	X																9.16	
7/11	845	SW	LL2b - 5m # 286	1	X																9.79	
"	850	SW	LL2b - 10m # 48	1	X																8.98	
7/11	920	SW	LL3 - 5m # 7	1	X																10.38	
"	925	SW	LL3 - 10m # 136	1	X																9.52	
7/11	1000	SW	LL3a - 5m # 307	1	X																10.45	
"	1005	SW	LL3a - 10m # 88	1	X																8.54	

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments: Sample #21 had a small air bubble
MAR 7/12/18

Sampled By	Date	Time
Chris Moan	7/11/18	13:30
Received By	Date	Time
Relinquished to IAL By (Signature)	Date	Time

Shipped By	Shipping Reference	
Received at IAL By	Date	Time
[signature]	07/12/18	1100

(16) samples

IEH Analytical Laboratories
?27 Aurora Ave N • Seattle • WA • 981(
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

TET013-66

REPORT TO:
Client: Avista Utilities and Tetra Tech, Inc.
Address:
Contact: Chris Moan and Shannon Brattebo
Email: chris.moan@avistacorp.com; shannon.brattebo@tetratech.com
Phone: 509-232-4312 Fax

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Avista Utilities
Addres 1411 E. Mission Ave. MSC-1
Spokane, WA 99202
Contac Chris Moan
Email: chris.moan@avistacorp.com
Phone: 509-495-4084 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project: Lake Spokane 2018

Reporting/Invoicing Format
☐ Fax ☒ Email ☒ Mail

QC Data Reported
☒ Yes ☐ No

Sample Disposal
☐ Hold ☐ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Da
☐ 3 Business Da ☒ Standard

Specific Date:

*Advanced notice required for Rush

LAB USE ONLY
Case File Number

Date (mm-dd-	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers		Winkler DO										Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
7/23	905	SW	LL0 - 5m # #50	1		X															
"	910	SW	LL0 - 15m # 179	1		X															
7/23	1010	SW	LL1 - 5m # 64	1		X															
"	1015	SW	LL1 - 21m # 107	1		X															
7/23	1100	SW	LL1a - 5m # 118	1		X															
"	1105	SW	LL1a - 21m # 20	1		X															
7/23	1145	SW	LL2 - 5m # 112	1		X															
"	1150	SW	LL2 - 15m # 144	1		X															
7/23	~~8~~1225	SW	LL2a - 5m # 140	1		X															
"	1230	SW	LL2a - 15m # 210	1		X															
7/24	835	SW	LL2b - 5m # 53	1		X															
"	840	SW	LL2b - 10m # 10	1		X															
7/24	915	SW	LL3 - 5m # 336	1		X															
"	920	SW	LL3 - 10m # 182	1		X															
7/24	945	SW	LL3a - 5m # 305	1		X															
"	950	SW	LL3a - 10m # 75	1		X															

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments: #50 and #112 arrived broken -BLS

Sampled By	Date	Time
Chris Moan	7/24/18	13:30
Received By	**Date**	**Time**
Relinquished to IAL By (Signature	**Date**	**Time**

Shipped By	Shipping Reference	
Received at IAL By	**Date**	**Time**
[signature]	07/25/18	1000

IEH Analytical Laboratories
)27 Aurora Ave N • Seattle • WA • 981(
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

TET013-68

REPORT TO:
Client: Avista Utilities and Tetra Tech, Inc.
Address:
Contact: Chris Moan and Shannon Brattebo
Email: chris.moan@avistacorp.com; shannon.brattebo@tetratech.com
Phone: 509-232-4312 Fax

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Avista Utilities
Addres 1411 E. Mission Ave. MSC-1
Spokane, WA 99202
Contac Chris Moan
Email: chris.moan@avistacorp.com
Phone: 509-495-4084 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project: Lake Spokane 2018

Reporting/Invoicing Format
☐ Fax ☒ Email ☒ Mail

QC Data Reported
☒ Yes ☐ No

Sample Disposal
☐ Hold ☐ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Da
☐ 3 Business Da ☒ Standard

Specific Date:

*Advanced notice required for Rush

LAB USE ONLY
Case File Number

SAMPLING Date (mm-dd-	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	Winkler DO	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
8/7	920	SW	LL0 - 5m # 221	1	X						
"	925	SW	LL0 - 33m # 182	1	X						
8/7	1015	SW	LL1 - 5m # #104	1	X						
"	1020	SW	LL1 - 21m # #144	1	X						
8/7	1100	SW	LL1a - 5m # #20	1	X						
"	1105	SW	LL1a - 29m # #179	1	X						
8/7	1135	SW	LL2 - 5m # #138	1	X						
"	1140	SW	LL2 - 15m # #212	1	X						
8/7	1210	SW	LL2a - 5m # #107	1	X						
"	1215	SW	LL2a - 15m # #118	1	X						
8/8	1025	SW	LL2b - 5m # #292a	1	X						
"	1030	SW	LL2b - 10m # #180	1	X						
8/8	1055	SW	LL3 - 5m # #291	1	X						
"	1100	SW	LL3 - 10m # #258	1	X						
8/8	1130	SW	LL3a - 5m # #5	1	X						
"	1135	SW	LL3a - 10m # #1	1	X						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Chris Moan	8/8/18	14:30
Received By	**Date**	**Time**
Relinquished to IAL By (Signature)	**Date**	**Time**

Shipped By	Shipping Reference	
Received at IAL By	**Date**	**Time**
[signature]	08/09/18	0930

(16) samples 14°C

IEH Analytical Laboratories
)27 Aurora Ave N • Seattle • WA • 981(
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form TET013-70

REPORT TO:
Client: Avista Utilities and Tetra Tech, Inc.
Address:
Contact: Chris Moan and Shannon Brattebo
Email: chris.moan@avistacorp.com; shannon.brattebo@tetratech.com
Phone: 509-232-4312 Fax

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Avista Utilities
Addres 1411 E. Mission Ave. MSC-1
Spokane, WA 99202
Contac Chris Moan
Email: chris.moan@avistacorp.com
Phone: 509-495-4084 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project: Lake Spokane 2018

Reporting/Invoicing Format
☐ Fax ☒ Email ☒ Mail

QC Data Reported
☒ Yes ☐ No

Sample Disposal
☐ Hold ☐ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Da
☐ 3 Business Da ☒ Standard
Specific Date:
*Advanced notice required for Rush

LAB USE ONLY
Case File Number

SAMPLING Date (mm-dd-	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers		Winkler DO										Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
8/28	915	SW	LL0 - 5m # 7	1		X															
"	920	SW	LL0 - 42m # 88	1		X															
8/28	1035	SW	LL1 - 5m # 53	1		X															
"	1040	SW	LL1 - 21m # 336	1		X															
8/28	1115	SW	LL1a - 5m # 96	1		X															
"	1120	SW	LL1a - 21m # 46	1		X															
8/28	1155	SW	LL2 - 5m # 159	1		X															
"	1200	SW	LL2 - ~~8~~ 15m # 120	1		X															
8/28	1250	SW	LL2a - 5m # 19	1		X															
"	1255	SW	LL2a - 15m # 23	1		X															
8/29	1015	SW	LL2b - 5m # 41	1		X															
"	1020	SW	LL2b - 10m # 245	1		X															
8/29	1050	SW	LL3 - 5m # 85	1		X															
"	1055	SW	LL3 - 10m # 193	1		X															
8/29	1120	SW	LL3a - 5m # 16	1		X															
"	1125	SW	LL3a - 10m # 35	1		X															

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
[signature]	8/29/18	1530
Received By	Date	Time
Relinquished to IAL By (Signature)	Date	Time

Shipped By	Shipping Reference

Received at IAL By	Date	Time
[signature]	08/30/18	1000

(16) samples 11°C

TET013-73

IEH Analytical Laboratories
327 Aurora Ave N • Seattle • WA • 9810
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: Avista Utilities and Tetra Tech, Inc.
Address:
Contact: Chris Moan and Shannon Brattebo
Email: chris.moan@avistacorp.com; shannon.brattebo@tetratech.com
Phone: 509-232-4312 Fax

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Avista Utilities
Addres 1411 E. Mission Ave. MSC-1
Spokane, WA 99202
Contac Chris Moan
Email: chris.moan@avistacorp.com
Phone: 509-495-4084 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project: Lake Spokane 2018

Reporting/Invoicing Format
☐ Fax ☒ Email ☒ Mail

QC Data Reported
☒ Yes ☐ No

Sample Disposal
☐ Hold ☐ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Da
☐ 3 Business Da ☒ Standard
Specific Date:
*Advanced notice required for Rush

LAB USE ONLY
Case File Number

SAMPLING Date (mm-dd-	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	Winkler DO											Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
9/12	1135	SW	LL0 - 39m # 19	1	X																
"	1140	SW	LL0 - 27m # 336	1	X																
9/12	1235	SW	LL1 - 5m # 159	1	X																
"	1240	SW	LL1 - 21m # 23	1	X																
9/12	1325	SW	LL1a - 5m # 95	1	X																
"	1330	SW	LL1a - 21m # 53	1	X																
9/12	1405	SW	LL2 - 5m # 85	1	X																
"	1410	SW	LL2 - 15m # 193	1	X																
9/12	1445	SW	LL2a - 5m # 5	1	X																
"	1450	SW	LL2a - 15m # 16	1	X																
9/13	835	SW	LL2b - 5m # 120	1	X																
"	840	SW	LL2b - 10m # 245	1	X																
9/13	910	SW	LL3 - 5m # 7	1	X																
"	915	SW	LL3 - 10m # 46	1	X																
9/13	945	SW	LL3a - 5m # 188	1	X																
"	950	SW	LL3a - 10m # 41	1	X																

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments: 336, 159, 23, 193, and 120 broke during transit

Sampled By	Date	Time
Chris Moan	9/13/18	13:00
Received By	Date	Time
Relinquished to IAL By (Signature)	Date	Time

Shipped By	Shipping Reference

Received at IAL By	Date	Time
Ben Shaw (signature)	09/14/18	1000

(11) samples

IEH Analytical Laboratories
)27 Aurora Ave N • Seattle • WA • 981(
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

TET013-74

REPORT TO:	INVOICE TO: (IF DIFFERENT FROM REPORT)	PROJECT INFORMATION
Client: Avista Utilities and Tetra Tech, Inc.	Client: Avista Utilities	
Address:	Addres 1411 E. Mission Ave. MSC-1	Quote No.:
	Spokane, WA 99202	Client PO:
Contact: Chris Moan and Shannon Brattebo	Contac Chris Moan	Client Project: Lake Spokane 2018
Email: chris.moan@avistacorp.com; shannon.brattebo@tetratech.com	Email: chris.moan@avistacorp.com	
Phone: 509-232-4312 Fax	Phone: 509-495-4084 Fax:	

Reporting/Invoicing Format: ☐ Fax ☒ Email ☒ Mail

Turn Around Time (TAT)*: ☐ Next Day ☐ 2 Business Da ☐ 3 Business Da ☒ Standard

Specific Date:

*Advanced notice required for Rush

QC Data Reported: ☒ Yes ☐ No

Sample Disposal: ☐ Hold ☐ Dispose ☐ Return

LAB USE ONLY — Case File Number

Date (mm-dd-	Time	Matrix**	Sample Description (This Will Appear On The Report)	Number of Containers	Winkler DO	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
9/25	905	SW	LL0 - 5m # 11	1	X						
"	910	SW	LL0 - 15m # 12	1	X						
9/25	1005	SW	LL1 - 5m # 15	1	X						
"	1010	SW	LL1 - 21m # 10	1	X						
9/25	1045	SW	LL1a - 5m # 5	1	X						
"	1050	SW	LL1a - 21m # 212	1	X						
9/25	1125	SW	LL2 - 5m # 64	1	X						
"	1130	SW	LL2 - 15m # 182	1	X						
9/25	1158	SW	LL2a - 5m # 20	1	X						
"	1205	SW	LL2a - 15m # 107	1	X						
9/26	1042	SW	LL2b - 5m # 116	1	X						
"	1050	SW	LL2b - 10m # 286	1	X						
9/26	1115	SW	LL3 - 5m # 210	1	X						
"	1120	SW	LL3 - 10m # 118	1	X						
9/26	1150	SW	LL3a - 5m # 23	1	X						
"	1155	SW	LL3a - 10m # 88	1	X						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Chris Moan	9/26/18	15:00
Received By	Date	Time
Relinquished to IAL By (Signature)	Date	Time

Shipped By	Shipping Reference

Received at IAL By	Date	Time
[signature]	09/27/18	1000

(16) samples

8°C

IEH Analytical Laboratories
?27 Aurora Ave N • Seattle • WA • 981?
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form TET013-76

REPORT TO:
Client: Avista Utilities and Tetra Tech, Inc.
Address:
Contact: Chris Moan and Shannon Brattebo
Email: chris.moan@avistacorp.com; shannon.brattebo@tetratech.com
Phone: 509-232-4312 Fax

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Avista Utilities
Addres 1411 E. Mission Ave. MSC-1
Spokane, WA 99202
Contac Chris Moan
Email: chris.moan@avistacorp.com
Phone: 509-495-4084 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project: Lake Spokane 2018

Reporting/Invoicing Format
☐ Fax ☒ Email ☒ Mail

QC Data Reported
☒ Yes ☐ No

Sample Disposal
☐ Hold ☐ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Da
☐ 3 Business Da ☒ Standard
Specific Date:
*Advanced notice required for Rush

LAB USE ONLY
Case File Number

Date (mm-dd-	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	Winkler DO	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
10/16	900	SW	LL0 - 5m # 46	1	X						
"	905	SW	LL0 - 15m # 53	1	X						
10/16	1014	SW	LL1 - 5m # 107	1	X						
"	1020	SW	LL1 - 21m # 210	1	X						
10/16	1040	SW	LL1a - 5m # 144	1	X						
"	1045	SW	LL1a - 21m # 291	1	X						
10/16	1120	SW	LL2 - 5m # 182	1	X						
"	1125	SW	LL2 - 15m # 212	1	X						
10/16	1200	SW	LL2a - 5m # 88	1	X						
"	1205	SW	LL2a - 15m # 85	1	X						
10/17	1030	SW	LL2b - 5m # 95	1	X						
"	1035	SW	LL2b - 10m # 286	1	X						
* 10/17	1055	SW	LL3 - 5m # 13	1	X						
"	1100	SW	LL3 - 10m # 179	1	X						
10/17	1130	SW	LL3a - 5m # 188	1	X						
"	1135	SW	LL3a - 10m # 118	1	X						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments: *Bottle #13 broke in transit - BLS

Sampled By	Date	Time
Chris Moan	10/17/18	14:30
Received By	Date	Time
Relinquished to IAL By (Signature)	Date	Time

Shipped By

Shipping Reference

Received at IAL By	Date	Time
[signature]	10/18/18	1000

(15) samples 6°C

APPENDIX B

Total Phosphorus Lab Analysis – Lake Spokane 2018 Carp

September 05, 2018 Service Request No:K1806683

Chris Moan
Avista Corporation
1411 E. Mission
PO Box 3727 MSC-1
Spokane, WA 99220

Laboratory Results for: Carp Analysis

Dear Chris,

Enclosed are the results of the sample(s) submitted to our laboratory July 17, 2018
For your reference, these analyses have been assigned our service request number **K1806683.**

Analyses were performed according to our laboratory's NELAP-approved quality assurance program. The test results meet requirements of the current NELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP-accredited analytes, refer to the certifications section at www.alsglobal.com. All results are intended to be considered in their entirety, and ALS Group USA Corp. dba ALS Environmental (ALS) is not responsible for use of less than the complete report. Results apply only to the items submitted to the laboratory for analysis and individual items (samples) analyzed, as listed in the report.

Please contact me if you have any questions. My extension is 3275. You may also contact me via email at Chris.Leaf@ALSGlobal.com.

Respectfully submitted,

ALS Group USA, Corp. dba ALS Environmental

for Chris Leaf
Project Manager

ADDRESS 1317 S. 13th Avenue, Kelso, WA 98626
PHONE +1 360 577 7222 | FAX +1 360 636 1068
ALS Group USA, Corp.
dba ALS Environmental

Narrative Documents

ALS Environmental—Kelso Laboratory
1317 South 13th Avenue, Kelso, WA 98626
Phone (360) 577-7222 Fax (360) 425-9096
www.alsglobal.com

ALS Environmental

Client: Avista Corporation **Service Request:** K1806683
Project: Carp Analysis Fish **Date Received:** 07/17/2018
Sample Matrix: Tissue

CASE NARRATIVE

All analyses were performed consistent with the quality assurance program of ALS Environmental. This report contains analytical results for samples designated for Tier II data deliverables. When appropriate to the method, method blank results have been reported with each analytical test. Surrogate recoveries have been reported for all applicable organic analyses. Additional quality control analyses reported herein include: Laboratory Duplicate (DUP), Matrix Spike (MS), Matrix/Duplicate Matrix Spike (MS/DMS), Laboratory Control Sample (LCS), and Laboratory/Duplicate Laboratory Control Sample (LCS/DLCS).

Sample Receipt:

Five fish tissue samples were received for analysis at ALS Environmental on 07/17/2018. The samples were received in good condition and consistent with the accompanying chain of custody form. The samples were stored frozen at -20ºC upon receipt at the laboratory.

Metals:

No significant anomalies were noted with this analysis.

Approved by ____________ Date 09/05/2018

SAMPLE DETECTION SUMMARY

CLIENT ID: 612/3020	Lab ID: K1806683-001					
Analyte	**Results**	**Flag**	**MDL**	**MRL**	**Units**	**Method**
Phosphorus	16300		20	40	mg/Kg	6010C
Total Solids	33.4				Percent	Freeze Dry

CLIENT ID: 692/4440	Lab ID: K1806683-002					
Analyte	**Results**	**Flag**	**MDL**	**MRL**	**Units**	**Method**
Phosphorus	22100		20	40	mg/Kg	6010C
Total Solids	27.6				Percent	Freeze Dry

CLIENT ID: 644/4140	Lab ID: K1806683-003					
Analyte	**Results**	**Flag**	**MDL**	**MRL**	**Units**	**Method**
Phosphorus	14200		20	40	mg/Kg	6010C
Total Solids	32.6				Percent	Freeze Dry

CLIENT ID: 602/2910	Lab ID: K1806683-004					
Analyte	**Results**	**Flag**	**MDL**	**MRL**	**Units**	**Method**
Phosphorus	13200		20	40	mg/Kg	6010C
Total Solids	36.3				Percent	Freeze Dry

CLIENT ID: 611/3610	Lab ID: K1806683-005					
Analyte	**Results**	**Flag**	**MDL**	**MRL**	**Units**	**Method**
Phosphorus	14700		20	40	mg/Kg	6010C
Total Solids	34.3				Percent	Freeze Dry

Sample Receipt Information

ALS Environmental—Kelso Laboratory
1317 South 13th Avenue, Kelso, WA 98626
Phone (360) 577-7222 Fax (360) 425-9096
www.alsglobal.com

Client: Avista Corporation **Service Request:** K1806683
Project: Carp Analysis

SAMPLE CROSS-REFERENCE

SAMPLE #	CLIENT SAMPLE ID	DATE	TIME
K1806683-001	612/3020	6/14/2018	
K1806683-002	692/4440	6/14/2018	
K1806683-003	644/4140	6/14/2018	
K1806683-004	602/2910	6/14/2018	
K1806683-005	611/3610		
K1806683-006	Rinsate Blank	8/28/2018	0835
K1806683-007	Homog. Blank	8/28/2018	1018
K1806683-008	Homog. Blank	8/28/2018	1130

ALS Environmental

90961

CHAIN OF CUSTODY

90961

1317 South 13th Ave, Kelso, WA 98626 Phone (360) 577-7222 / 800-695-7222 / FAX (360) 636-1068
www.alsglobal.com

001

SR# K1806083

COC Set____of____

COC#____________

Page 1 of 1

Project Name:
Project Number:
Project Manager:
Company: Avista
Address: 1411 E Mission Ave
Phone #: 509-495-4084
email: Chris.moran@avistacorp.com
Sampler Signature: [signature]
Sampler Printed Name: Chris Moran

CLIENT SAMPLE ID	LABID	SAMPLING Date	SAMPLING Time	Matrix	NUMBER OF CONTAINERS	180D 6010C / Metals T	999D Frz Dry / Frz Dry	999D Homogen / Homogen	1	2	3	4	5	Remarks
1. 612/3020		6/14/18												
2. 692/4440		6/14/18												
3. 644/4140		6/14/18												
4. 602/2910		6/14/18												
5. 611/3610														
6.														
7.														
8.														
9.														
10.														

Report Requirements

___ I. Routine Report: Method Blank, Surrogate, as required

___ II. Report Dup., MS, MSD as required

___ III. CLP Like Summary (no raw data)

___ IV. Data Validation Report

___ V. EDD

Invoice Information

P.O.#____________

Bill To:____________

Turnaround Requirements

____ 24 hr. ____48 hr.
____ 5 Day
____ Standard

Requested Report Date

Circle which metals are to be analyzed

Total Metals: Al As Sb Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn Hg

Dissolved Metals: Al As Sb Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn Hg

Special Instructions/Comments:

*Indicate State Hydrocarbon Procedure: AK CA WI Northwest Other____(Circle One)

	Relinquished By:	Received By:	Relinquished By:	Received By:	Relinquished By:	Received By:
Signature	[signature]	K Moran				
Printed Name	Chris Moran	ALS				
Firm	Avista	7-17-18 0920				
Date/Time	7/16/18 9:30					

ALS

PC Cr ✓

Cooler Receipt and Preservation Form

Client Avista Service Request K18 00683

Received: 7-17-18 Opened: 7-17-18 By: Km Unloaded: 7-17-18 By: Km

1. Samples were received via? USPS **(Fed Ex)** UPS DHL PDX Courier Hand Delivered
2. Samples were received in: (circle) **(Cooler)** Box Envelope Other ______ NA
3. Were custody seals on coolers? NA Y **(N)** If yes, how many and where? ______
   If present, were custody seals intact? Y **(N)** If present, were they signed and dated? Y N

Raw Cooler Temp	Corrected. Cooler Temp	Raw Temp Blank	Corrected Temp Blank	Corr. Factor	Thermometer ID	Cooler/COC ID NA	Tracking Number NA	Filed
4.2	4.2	N/A	N/A	0	356	90961	7818 7052 4790	

4. Packing material: Inserts Baggies Bubble Wrap **(Gel Packs)** Wet Ice Dry Ice Sleeves lg. Black Bags
5. Were custody papers properly filled out (ink, signed, etc.)? NA **(Y)** N
6. Were samples received in good condition (temperature, unbroken)? *Indicate in the table below.* NA **(Y)** N
   If applicable, tissue samples were received: Frozen **(Partially Thawed)** Thawed
7. Were all sample labels complete (i.e analysis, preservation, etc.)? NA **(Y)** N
8. Did all sample labels and tags agree with custody papers? *Indicate major discrepancies in the table on page 2.* NA **(Y)** N
9. Were appropriate bottles/containers and volumes received for the tests indicated? **(NA)** Y N
10. Were the pH-preserved bottles (*see SMO GEN SOP*) received at the appropriate pH? *Indicate in the table below* **(NA)** Y N
11. Were VOA vials received without headspace? *Indicate in the table below.* **(NA)** Y N
12. Was Cl2/Res negative? **(NA)** Y N

Sample ID on Bottle	Sample ID on COC	Identified by:

Sample ID	Bottle Count Bottle Type	Out of Temp	Head-space	Broke	pH	Reagent	Volume added	Reagent Lot Number	Initials	Time

Notes, Discrepancies, & Resolutions: Rec'd 5 whole Fish; COC doesn't indicate what analysis is being requested

7/25/16

Page ____ ***of*** ____

Miscellaneous Forms

ALS Environmental—Kelso Laboratory
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Phone (360) 577-7222 Fax (360) 425-9096
www.alsglobal.com

Inorganic Data Qualifiers

*	The result is an outlier. See case narrative.
#	The control limit criteria is not applicable. See case narrative.
B	The analyte was found in the associated method blank at a level that is significant relative to the sample result as defined by the DOD or NELAC standards.
E	The result is an estimate amount because the value exceeded the instrument calibration range.
J	The result is an estimated value.
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.2 definition* : Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
i	The MRL/MDL or LOQ/LOD is elevated due to a matrix interference.
X	See case narrative.
Q	See case narrative. One or more quality control criteria was outside the limits.
H	The holding time for this test is immediately following sample collection. The samples were analyzed as soon as possible after receipt by the laboratory.

Metals Data Qualifiers

#	The control limit criteria is not applicable. See case narrative.
J	The result is an estimated value.
E	The percent difference for the serial dilution was greater than 10%, indicating a possible matrix interference in the sample.
M	The duplicate injection precision was not met.
N	The Matrix Spike sample recovery is not within control limits. See case narrative.
S	The reported value was determined by the Method of Standard Additions (MSA).
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.2 definition* : Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
W	The post-digestion spike for furnace AA analysis is out of control limits, while sample absorbance is less than 50% of spike absorbance.
i	The MRL/MDL or LOQ/LOD is elevated due to a matrix interference.
X	See case narrative.
+	The correlation coefficient for the MSA is less than 0.995.
Q	See case narrative. One or more quality control criteria was outside the limits.

Organic Data Qualifiers

*	The result is an outlier. See case narrative.
#	The control limit criteria is not applicable. See case narrative.
A	A tentatively identified compound, a suspected aldol-condensation product.
B	The analyte was found in the associated method blank at a level that is significant relative to the sample result as defined by the DOD or NELAC standards.
C	The analyte was qualitatively confirmed using GC/MS techniques, pattern recognition, or by comparing to historical data.
D	The reported result is from a dilution.
E	The result is an estimated value.
J	The result is an estimated value.
N	The result is presumptive. The analyte was tentatively identified, but a confirmation analysis was not performed.
P	The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.2 definition* : Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
i	The MRL/MDL or LOQ/LOD is elevated due to a chromatographic interference.
X	See case narrative.
Q	See case narrative. One or more quality control criteria was outside the limits.

Additional Petroleum Hydrocarbon Specific Qualifiers

F	The chromatographic fingerprint of the sample matches the elution pattern of the calibration standard.
L	The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of lighter molecular weight constituents than the calibration standard.
H	The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of heavier molecular weight constituents than the calibration standard.
O	The chromatographic fingerprint of the sample resembles an oil, but does not match the calibration standard.
Y	The chromatographic fingerprint of the sample resembles a petroleum product eluting in approximately the correct carbon range, but the elution pattern does not match the calibration standard.
Z	The chromatographic fingerprint does not resemble a petroleum product.

ALS Group USA Corp. dba ALS Environmental (ALS) - Kelso
State Certifications, Accreditations, and Licenses

Agency	Web Site	Number
Alaska DEH	http://dec.alaska.gov/eh/lab/cs/csapproval.htm	UST-040
Arizona DHS	http://www.azdhs.gov/lab/license/env.htm	AZ0339
Arkansas - DEQ	http://www.adeq.state.ar.us/techsvs/labcert.htm	88-0637
California DHS (ELAP)	http://www.cdph.ca.gov/certlic/labs/Pages/ELAP.aspx	2795
DOD ELAP	http://www.denix.osd.mil/edqw/Accreditation/AccreditedLabs.cfm	L16-58-R4
Florida DOH	http://www.doh.state.fl.us/lab/EnvLabCert/WaterCert.htm	E87412
Hawaii DOH	http://health.hawaii.gov/	-
ISO 17025	http://www.pjlabs.com/	L16-57
Louisiana DEQ	http://www.deq.louisiana.gov/page/la-lab-accreditation	03016
Maine DHS	http://www.maine.gov/dhhs/	WA01276
Minnesota DOH	http://www.health.state.mn.us/accreditation	053-999-457
Nevada DEP	http://ndep.nv.gov/bsdw/labservice.htm	WA01276
New Jersey DEP	http://www.nj.gov/dep/enforcement/oqa.html	WA005
New York - DOH	https://www.wadsworth.org/regulatory/elap	12060
North Carolina DEQ	https://deq.nc.gov/about/divisions/water-resources/water-resources-data/water-sciences-home-page/laboratory-certification-branch/non-field-lab-certification	605
Oklahoma DEQ	http://www.deq.state.ok.us/CSDnew/labcert.htm	9801
Oregon – DEQ (NELAP)	http://public.health.oregon.gov/LaboratoryServices/EnvironmentalLaboratoryAccreditation/Pages/index.aspx	WA100010
South Carolina DHEC	http://www.scdhec.gov/environment/EnvironmentalLabCertification/	61002
Texas CEQ	http://www.tceq.texas.gov/field/qa/env_lab_accreditation.html	T104704427
Washington DOE	http://www.ecy.wa.gov/programs/eap/labs/lab-accreditation.html	C544
Wyoming (EPA Region 8)	https://www.epa.gov/region8-waterops/epa-region-8-certified-drinking-water-	-
Kelso Laboratory Website	www.alsglobal.com	NA

Analyses were performed according to our laboratory's NELAP-approved quality assurance program. A complete listing of specific NELAP-certified analytes, can be found in the certification section at www.ALSGlobal.com or at the accreditation bodies web site.
Please refer to the certification and/or accreditation body's web site if samples are submitted for compliance purposes. The states highlighted above, require the analysis be listed on the state certification if used for compliance purposes and if the method/anlayte is offered by that state.

Acronyms

ASTM	American Society for Testing and Materials
A2LA	American Association for Laboratory Accreditation
CARB	California Air Resources Board
CAS Number	Chemical Abstract Service registry Number
CFC	Chlorofluorocarbon
CFU	Colony-Forming Unit
DEC	Department of Environmental Conservation
DEQ	Department of Environmental Quality
DHS	Department of Health Services
DOE	Department of Ecology
DOH	Department of Health
EPA	U. S. Environmental Protection Agency
ELAP	Environmental Laboratory Accreditation Program
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
LOD	Limit of Detection
LOQ	Limit of Quantitation
LUFT	Leaking Underground Fuel Tank
M	Modified
MCL	Maximum Contaminant Level is the highest permissible concentration of a substance allowed in drinking water as established by the USEPA.
MDL	Method Detection Limit
MPN	Most Probable Number
MRL	Method Reporting Limit
NA	Not Applicable
NC	Not Calculated
NCASI	National Council of the Paper Industry for Air and Stream Improvement
ND	Not Detected
NIOSH	National Institute for Occupational Safety and Health
PQL	Practical Quantitation Limit
RCRA	Resource Conservation and Recovery Act
SIM	Selected Ion Monitoring
TPH	Total Petroleum Hydrocarbons
tr	Trace level is the concentration of an analyte that is less than the PQL but greater than or equal to the MDL.

Analyst Summary report

Client: Avista Corporation
Project: Carp Analysis
Service Request: K1806683

Sample Name: 612/3020
Lab Code: K1806683-001
Sample Matrix: Fish Tissue
Date Collected: 06/14/18
Date Received: 07/17/18

Analysis Method	Extracted/Digested By	Analyzed By
6010C	CLUKKEN	EMCALLISTER
Freeze Dry		GBEATLEY

Sample Name: 692/4440
Lab Code: K1806683-002
Sample Matrix: Fish Tissue
Date Collected: 06/14/18
Date Received: 07/17/18

Analysis Method	Extracted/Digested By	Analyzed By
6010C	CLUKKEN	EMCALLISTER
Freeze Dry		GBEATLEY

Sample Name: 644/4140
Lab Code: K1806683-003
Sample Matrix: Fish Tissue
Date Collected: 06/14/18
Date Received: 07/17/18

Analysis Method	Extracted/Digested By	Analyzed By
6010C	CLUKKEN	EMCALLISTER
Freeze Dry		GBEATLEY

Sample Name: 602/2910
Lab Code: K1806683-004
Sample Matrix: Fish Tissue
Date Collected: 06/14/18
Date Received: 07/17/18

Analysis Method	Extracted/Digested By	Analyzed By
6010C	CLUKKEN	EMCALLISTER
Freeze Dry		GBEATLEY

Analyst Summary report

Client:	Avista Corporation	**Service Request:**	K1806683
Project:	Carp Analysis		

Sample Name:	611/3610	**Date Collected:**	NA
Lab Code:	K1806683-005	**Date Received:**	07/17/18
Sample Matrix:	Fish Tissue		

Analysis Method	**Extracted/Digested By**	**Analyzed By**
6010C	CLUKKEN	EMCALLISTER
Freeze Dry		GBEATLEY

Sample Results

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Metals

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Client:	Avista Corporation		**Service Request:**	K1806683
Project:	Carp Analysis		**Date Collected:**	06/14/18
Sample Matrix:	Fish Tissue		**Date Received:**	07/17/18 09:20
Sample Name:	612/3020		**Basis:**	Wet
Lab Code:	K1806683-001			

Inorganic Parameters

Analyte Name	Analysis Method	Result	Units	MRL	MDL	Dil.	Date Analyzed	Q
Total Solids	Freeze Dry	**33.4**	Percent	-	-	1	08/29/18 14:15	

Client: Avista Corporation
Project: Carp Analysis
Sample Matrix: Fish Tissue

Service Request: K1806683
Date Collected: 06/14/18
Date Received: 07/17/18 09:20

Sample Name: 612/3020
Lab Code: K1806683-001

Basis: Dry

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
Phosphorus	6010C	**16300**	mg/Kg	40	20	10	09/04/18 14:00	08/30/18	

Client:	Avista Corporation		**Service Request:**	K1806683
Project:	Carp Analysis		**Date Collected:**	06/14/18
Sample Matrix:	Fish Tissue		**Date Received:**	07/17/18 09:20
Sample Name:	692/4440		**Basis:**	Wet
Lab Code:	K1806683-002			

Inorganic Parameters

Analyte Name	Analysis Method	Result	Units	MRL	MDL	Dil.	Date Analyzed	Q
Total Solids	Freeze Dry	**27.6**	Percent	-	-	1	08/29/18 14:15	

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dba ALS Environmental

Analytical Report

Client:	Avista Corporation	**Service Request:**	K1806683
Project:	Carp Analysis	**Date Collected:**	06/14/18
Sample Matrix:	Fish Tissue	**Date Received:**	07/17/18 09:20
Sample Name:	692/4440	**Basis:**	Dry
Lab Code:	K1806683-002		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
Phosphorus	6010C	**22100**	mg/Kg	40	20	10	09/04/18 14:10	08/30/18	

Client:	Avista Corporation	**Service Request:**	K1806683
Project:	Carp Analysis	**Date Collected:**	06/14/18
Sample Matrix:	Fish Tissue	**Date Received:**	07/17/18 09:20
Sample Name:	644/4140	**Basis:**	Wet
Lab Code:	K1806683-003		

Inorganic Parameters

Analyte Name	Analysis Method	Result	Units	MRL	MDL	Dil.	Date Analyzed	Q
Total Solids	Freeze Dry	**32.6**	Percent	-	-	1	08/29/18 14:15	

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dba ALS Environmental

Analytical Report

Client:	Avista Corporation	**Service Request:**	K1806683
Project:	Carp Analysis	**Date Collected:**	06/14/18
Sample Matrix:	Fish Tissue	**Date Received:**	07/17/18 09:20
Sample Name:	644/4140	**Basis:**	Dry
Lab Code:	K1806683-003		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
Phosphorus	6010C	**14200**	mg/Kg	40	20	10	09/04/18 14:27	08/30/18	

ALS Group USA, Corp.
dba ALS Environmental

Analytical Report

Client: Avista Corporation
Project: Carp Analysis
Sample Matrix: Fish Tissue

Service Request: K1806683
Date Collected: 06/14/18
Date Received: 07/17/18 09:20

Sample Name: 602/2910
Lab Code: K1806683-004

Basis: Wet

Inorganic Parameters

Analyte Name	Analysis Method	Result	Units	MRL	MDL	Dil.	Date Analyzed	Q
Total Solids	Freeze Dry	**36.3**	Percent	-	-	1	08/29/18 14:15	

ALS Group USA, Corp.
dba ALS Environmental

Analytical Report

Client:	Avista Corporation	**Service Request:**	K1806683
Project:	Carp Analysis	**Date Collected:**	06/14/18
Sample Matrix:	Fish Tissue	**Date Received:**	07/17/18 09:20
Sample Name:	602/2910	**Basis:**	Dry
Lab Code:	K1806683-004		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
Phosphorus	6010C	**13200**	mg/Kg	40	20	10	09/04/18 14:29	08/30/18	

ALS Group USA, Corp.
dba ALS Environmental

Analytical Report

Client:	Avista Corporation	**Service Request:**	K1806683
Project:	Carp Analysis	**Date Collected:**	NA
Sample Matrix:	Fish Tissue	**Date Received:**	07/17/18 09:20
Sample Name:	611/3610	**Basis:**	Wet
Lab Code:	K1806683-005		

Inorganic Parameters

Analyte Name	Analysis Method	Result	Units	MRL	MDL	Dil.	Date Analyzed	Q
Total Solids	Freeze Dry	**34.3**	Percent	-	-	1	08/29/18 14:15	

Client:	Avista Corporation	**Service Request:**	K1806683
Project:	Carp Analysis	**Date Collected:**	NA
Sample Matrix:	Fish Tissue	**Date Received:**	07/17/18 09:20
Sample Name:	611/3610	**Basis:**	Dry
Lab Code:	K1806683-005		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
Phosphorus	6010C	**14700**	mg/Kg	40	20	10	09/04/18 14:32	08/30/18	

QC Summary Forms

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Metals

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ALS Group USA, Corp.
dba ALS Environmental

Analytical Report

Client:	Avista Corporation	**Service Request:**	K1806683
Project:	Carp Analysis	**Date Collected:**	NA
Sample Matrix:	Fish Tissue	**Date Received:**	NA
Sample Name:	Method Blank	**Basis:**	Dry
Lab Code:	KQ1812044-02		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
Phosphorus	6010C	ND U	mg/Kg	4.0	2.0	1	09/04/18 13:49	08/30/18	

QA/QC Report

Client:	Avista Corporation	**Service Request:**	K1806683
Project:	Carp Analysis	**Date Collected:**	06/14/18
Sample Matrix:	Fish Tissue	**Date Received:**	07/17/18
		Date Analyzed:	09/4/18
		Date Extracted:	08/30/18

Matrix Spike Summary
Total Metals

Sample Name:	612/3020	**Units:**	mg/Kg
Lab Code:	K1806683-001	**Basis:**	Dry
Analysis Method:	6010C		
Prep Method:	PSEP Metals		

Matrix Spike
KQ1812044-06

Analyte Name	Sample Result	Result	Spike Amount	% Rec	% Rec Limits
Phosphorus	16300	15900	997	-34 #	75-125

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

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dba ALS Environmental

QA/QC Report

Client:	Avista Corporation	**Service Request:**	K1806683
Project	Carp Analysis	**Date Collected:**	06/14/18
Sample Matrix:	Fish Tissue	**Date Received:**	07/17/18
		Date Analyzed:	08/29/18

Replicate Sample Summary
Inorganic Parameters

Sample Name:	612/3020	**Units:**	Percent
Lab Code:	K1806683-001	**Basis:**	Wet

Analyte Name	Analysis Method	MRL	MDL	Sample Result	Duplicate Sample K1806683-001DUP Result	Average	RPD	RPD Limit
Total Solids	Freeze Dry	-	-	33.4	33.0	33.2	1	20

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

QA/QC Report

Client:	Avista Corporation	**Service Request:**	K1806683
Project	Carp Analysis	**Date Collected:**	06/14/18
Sample Matrix:	Fish Tissue	**Date Received:**	07/17/18
		Date Analyzed:	09/04/18

Replicate Sample Summary
Total Metals

Sample Name:	612/3020	**Units:**	mg/Kg
Lab Code:	K1806683-001	**Basis:**	Dry

Analyte Name	Analysis Method	MRL	MDL	Sample Result	Duplicate Sample KQ1812044-05 Result	Average	RPD	RPD Limit
Phosphorus	6010C	40	20	16300	19300	17800	17	20

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

Client: Avista Corporation
Project: Carp Analysis
Sample Matrix: Fish Tissue

Service Request: K1806683
Date Analyzed: 09/04/18

Lab Control Sample Summary
Total Metals

Units: mg/Kg
Basis: Dry

Lab Control Sample
KQ1812044-01

Analyte Name	Analytical Method	Result	Spike Amount	% Rec	% Rec Limits
Phosphorus	6010C	942	1000	94	80-120

APPENDIX C

Agency Consultation

1411 East Mission Avenue
PO Box 3727
Spokane, WA 99220-3727

February 1, 2019

Patrick McGuire, Water Quality Program
Washington Department of Ecology
Eastern Regional Office
4601 N Monroe Street
Spokane, WA 99205-1295

Subject: Lake Spokane Dissolved Oxygen Water Quality Attainment Plan, 2018 Annual Summary Report

Dear Pat:

I have enclosed the Lake Spokane Dissolved Oxygen Water Quality Attainment 2018 Annual Summary Report (Annual Report) for your review and approval. The Annual Report was completed in accordance with the Lake Spokane Dissolved Oxygen Water Quality Attainment Plan (DO WQAP), required by the Spokane River Hydroelectric Project License (License) Appendix B, Section 5.6.C of the Washington Department of Ecology (Ecology) Section 401 Water Quality Certification.

The Annual Report provides a summary of the 2018 baseline monitoring, implementation activities, effectiveness of the implementation activities, and proposed actions for the upcoming year.

As we discussed in our January 28 meeting, Avista has collected baseline nutrient monitoring for the past nine years. Over this timeframe we have covered the full spectrum of flows that are likely to exist in the Spokane River under current license conditions. Avista would like to shift focus in 2019 from baseline monitoring to analysis of all collected data. Possible products of analysis are data gaps, correlations between habitat and water quality parameters, and investigating ways to use the data to determine lake health. Along with analysis of the data, further focus can be placed on quantification of phosphorus reductions as a result of implementation activities.

Avista will also continue to implement the carp removal project in Lake Spokane in 2019. Our primary focus will be during the spring spawning season (May/June). We will continue to coordinate our effort with the Washington Department of Fish and Wildlife (WDFW) and keep Ecology updated as we implement this project.

We would appreciate your review of the Annual Report by **March 8, 2019**. This will allow us time to incorporate your comments and recommendations, if you have any, and submit it to the Federal Energy Regulatory Commission by **April 1, 2019**.

Please feel free to call me at (509) 495-4651 if you have any questions about the Annual Report.

Sincerely,

Monica Ott
Water Quality Specialist
Enclosure (1)

cc: Chad Atkins, Ecology
Karl Rains, Ecology
Chad Brown, Ecology
Cathrene Glick, Ecology
Meghan Lunney, Avista
Chris Moan, Avista

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
4601 N Monroe Street • Spokane, WA 99205-1295 • 509-329-3400

March 14, 2019

Monica Ott
Water Quality Specialist
Avista Corporation
1411 East Mission Avenue, MSC-1
Spokane, WA 99220-3727

RE: Request for Ecology Review and Comments – *Lake Spokane Dissolved Oxygen Water Quality Attainment Plan, 2018 Annual Summary Report*
Spokane River Hydroelectric Project, No. P-2545

Dear Monica Ott:

The Department of Ecology (Ecology) has reviewed the *Lake Spokane Dissolved Oxygen Water Quality Attainment Plan, 2018 Annual Summary Report* sent to Ecology on February 1, 2019. The Annual Summary Report is a requirement of Section 5.6.C, Appendix B of the 401 Certification.

Ecology approves the report and has no comments.

For potential monitoring events in the future, Ecology would like to have a discussion with Avista about the following:

1. In conjunction with temperature monitoring, do a 24-hour (diel) monitoring in the epilimnion at least once per month from June through September in order to track the daily variability in dissolved oxygen concentrations. This data would also be a benefit for fish habitat assessment.
2. Resumption of phytoplankton and nutrient monitoring when the City of Spokane tertiary treatment comes online.

Please contact me at (509) 329-3567 or pmcg461@ecy.wa.gov if you have any questions.

Sincerely,

Pat McGuire

Patrick McGuire
Eastern Region Hydropower Projects 401 Certification Manager
Water Quality Program

PDM:red
cc: Meghan Lunney, Avista

ECOLOGY COMMENTS AND AVISTA RESPONSES

On March 14, 2019, Ecology provided an approval letter of the Lake Spokane Dissolved Oxygen Water Quality Attainment Plan 2018 Annual Summary Report (dated February 1, 2019). Although Ecology had no comments, they expressed an interest in continuing a discussion regarding future monitoring efforts. Ecology's discussion points, and Avista's responses to them, are provided as follows.

Ecology Discussion Point 1:

In conjunction with temperature monitoring, do a 24-hour (diel) monitoring in the epilimnion at least once per month from June through September in order to track the daily variability in dissolved oxygen concentrations. This data would also be a benefit for fish habitat assessment.

Avista Response

Avista conducted overnight monitoring of tagged rainbow trout during the 2018 component of the fish habitat assessment, recording temperature values from seven different fish at varying depths. The results of this monitoring are presented in Table 3, page 20.

Avista agrees that additional monitoring, such as a 24-hour (diel) monitoring effort in the epilimnion, should be geared towards supporting the fish habitat assessment and will plan on discussing these monitoring opportunities with Ecology during 2019.

Ecology Discussion Point 2:

Resumption of phytoplankton and nutrient monitoring when the City of Spokane tertiary treatment comes online.

Avista Response

Avista looks forward to discussing the timeline when the City of Spokane tertiary treatment comes online and how that timing coincides with Ecology's two-year data gathering for the 10-year assessment of the Spokane River and Lake Spokane DO TMDL.