AVISTA CORPORATION

LAKE SPOKANE DISSOLVED OXYGEN WATER QUALITY ATTAINMENT PLAN TEN YEAR REPORT

WASHINGTON 401 CERTIFICATION
FERC LICENSE APPENDIX B, SECTION 5.6

SPOKANE RIVER HYDROELECTRIC PROJECT
FERC PROJECT NO. 2545

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AVISTA

and

FOUR PEAKS ENVIRONMENTAL
Science & Data Solutions

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Abbreviations

Abbreviation	Definition
401 Certification	water quality certification
AHOD	areal hypolimnetic oxygen demand
Avista	Avista Corporation
CE-QUAL-W2 model	Lake Spokane CE-QUAL-W2 hydrodynamic and water quality model
DIN	dissolved inorganic nitrogen
DNR	Washington State Department of Natural Resources
DO	dissolved oxygen
DO TMDL	Spokane River and Lake Spokane Dissolved Oxygen Total Maximum Daily Load
Ecology	Washington Department of Ecology
EPA	U.S. Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
HED	hydroelectric development
Project	Spokane River Hydroelectric Project
QAPP	Quality Assurance Project Plan
SCC	Spokane Community College
SCCD	Stevens County Conservation District
SRP	soluble reactive phosphorus
TN	total nitrogen
TP	total phosphorous
WDFW	Washington Department of Fish and Wildlife
WQAP	Water Quality Attainment Plan

1 Introduction

1.1 Spokane River Hydroelectric Project

The Spokane River Hydroelectric Project (Project) consists of five hydroelectric developments (HEDs). Long Lake HED, the most downstream of the five, creates Lake Spokane (Figure 1.1). Avista Corporation (Avista) received a new, 50-year license from the Federal Energy Regulatory Commission (FERC) on June 18, 2009 (FERC 2009) for the Project. The license incorporates a water quality certification (401 Certification) issued by the Washington Department of Ecology (Ecology) under Section 401 of the Clean Water Act (Ecology 2009). The 401 Certification requires that Project operations do not affect Washington State ambient water quality standards for the Spokane River and Lake Spokane. This Water Quality Attainment Plan Ten-Year Report has been developed per the requirements in the 401 Certification to demonstrate progress towards meeting water quality standards, specifically for dissolved oxygen (DO), in Lake Spokane.

1.2 Spokane River Dissolved Oxygen Issues

Ecology determined that the 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 (DO TMDL) Water Quality Improvement Report (Ecology 2010b,c).

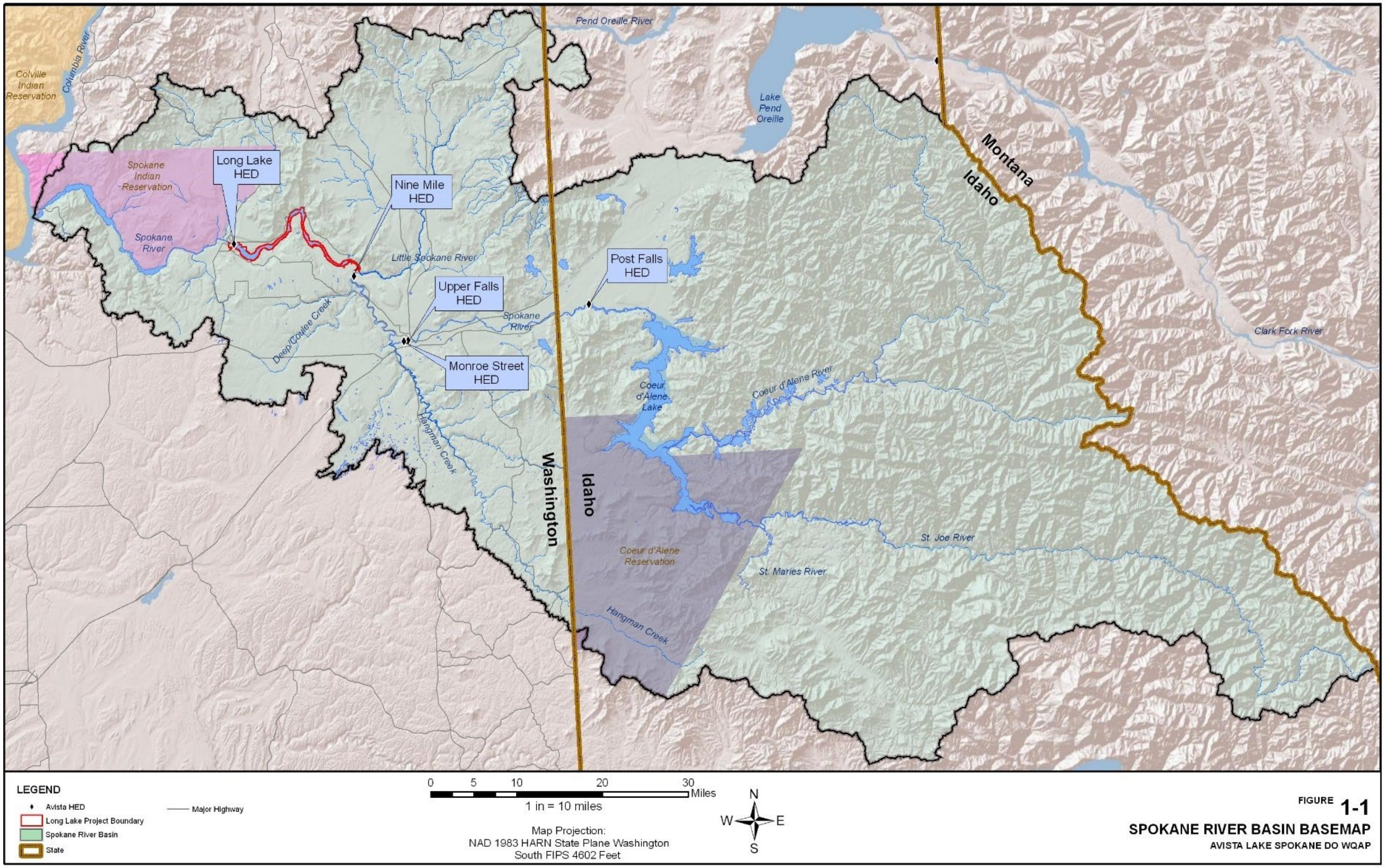
Avista does not discharge nutrients into either the Spokane River or Lake Spokane; however, the Long Lake HED impoundment creating Lake Spokane increases the residence time for water flowing down the Spokane River, and thereby influences nutrient assimilation and DO levels. Reduced DO levels are largely 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 wastewater treatment facilities and industrial facilities, and from non-point sources, such as tributaries, groundwater, and stormwater runoff, relating largely to land-use practices.

The DO TMDL recognized the effects of point and non-sources, and the potential impacts the Long Lake HED could have on the DO resources of Lake Spokane. The DO TMDL included a modeling analysis to determine Avista's proportional level of responsibility for improving DO within Lake Spokane (Ecology 2010b,c). These conditions formed the basis for Avista's DO Water Quality Attainment Plan (WQAP) compliance schedule approved by Ecology.

1.3 Dissolved Oxygen Water Quality Attainment Plan

Avista committed to a DO WQAP (Avista 2012) to address Avista's proportional level of responsibility identified in the DO TMDL and to comply with Section 5.6.C of the 401 Certification. The DO WQAP was approved by Ecology and filed with FERC on October 8, 2012. Avista began implementing the DO WQAP upon receiving FERC's December 19, 2012 approval.

The DO WQAP 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 10-year compliance period identified in the DO WQAP (Figure 1.2).



Note: Figure adapted from DO Water Quality Attainment Plan (Avista 2012).

Figure 1.1. Spokane River Hydroelectric Project map

		2012				2013				2014				2015				2016				2017				2018				2019				2020				2021				2022			
	Activity	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	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		x																																										
	Receive approval from Ecology*			x																																									
	Submit DO WQAP to FERC*			x																																									
	Receive approval from FERC*				x																																								
Carp Reduction	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			x	x			x	x			x	x			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			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			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			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]		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			x	x			x	x			x	x			x	x			x	x					
	Site Specific Nutrient Reduction Analysis[6]																																												
	CE-QUAL Modeling[7]																																								x	x	x	x	x
Compliance Reporting	DO WQAP Annual Summary Report*									x				x				x								x				x								x							
	Five, Eight, and Ten-Year Reports*																					x												x								x			

Notes:
*Benchmarks
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. CE-QUAL-W2 modeling efforts presently ongoing and differ from schedule originally proposed in the DO WQAP.

Figure 1.2. Revised implementation schedule from the Dissolved Oxygen Water Quality Attainment Plan

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 implementation 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; lawn area reduction; 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 (TP) in Lake Spokane (Avista 2014). However, Avista has continued, as appropriate, to implement winter drawdowns, diver aquatic weed removal, herbicide applications at public and community lake access sites, and education/outreach to control invasive/noxious aquatic weeds within Lake Spokane.

Avista included a recommendation in its 2014 Annual Report to implement a pilot study using 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 (Avista 2015a). Ecology approved the 2014 Annual Report and the recommendation to move forward with the carp removal pilot study. Avista has been working with the Washington Department of Fish and Wildlife (WDFW) to plan and implement the carp removal since 2017.

1.4 Organization of this Report

As required by the DO WQAP, this report assesses Avista's progress towards addressing its proportional responsibility to improve DO in Lake Spokane. This includes assessing the progress made towards improving Lake Spokane's water quality through the implementation of the selected reasonable and feasible measures. This report is structured to be consistent with the requirements in the DO WQAP as follows:

- Section 2 presents the 2021 annual climate and flow data, implementation activities, effectiveness of the implementation activities, and proposed actions for 2022.
- Section 3 presents a 10-year implementation summary of the baseline monitoring phosphorus removal and outreach activities.
- Section 4 provides an evaluation of DO improvements, both from the context of Avista's actions and load reductions that have occurred in the Spokane River watershed. Section 4 also presents a synthesis of the DO drivers in Lake Spokane based on the monitoring and evaluation activities completed by Avista in the past 10 years.
- Section 5 provides next steps that Avista will undertake prior to Fall 2022.

Finally, Avista is presently utilizing the Lake Spokane CE-QUAL-W2 hydrodynamic and water quality model (CE-QUAL-W2 model), which was originally proposed for development and application within the first 8 years of the DO WQAP. However, modeling was delayed based on Ecology's determination that water quality improvements, as identified in the DO TMDL, need to occur in the upstream watershed prior to running the model. The modeling efforts will be described in a subsequent report (Sections 2 and 5).

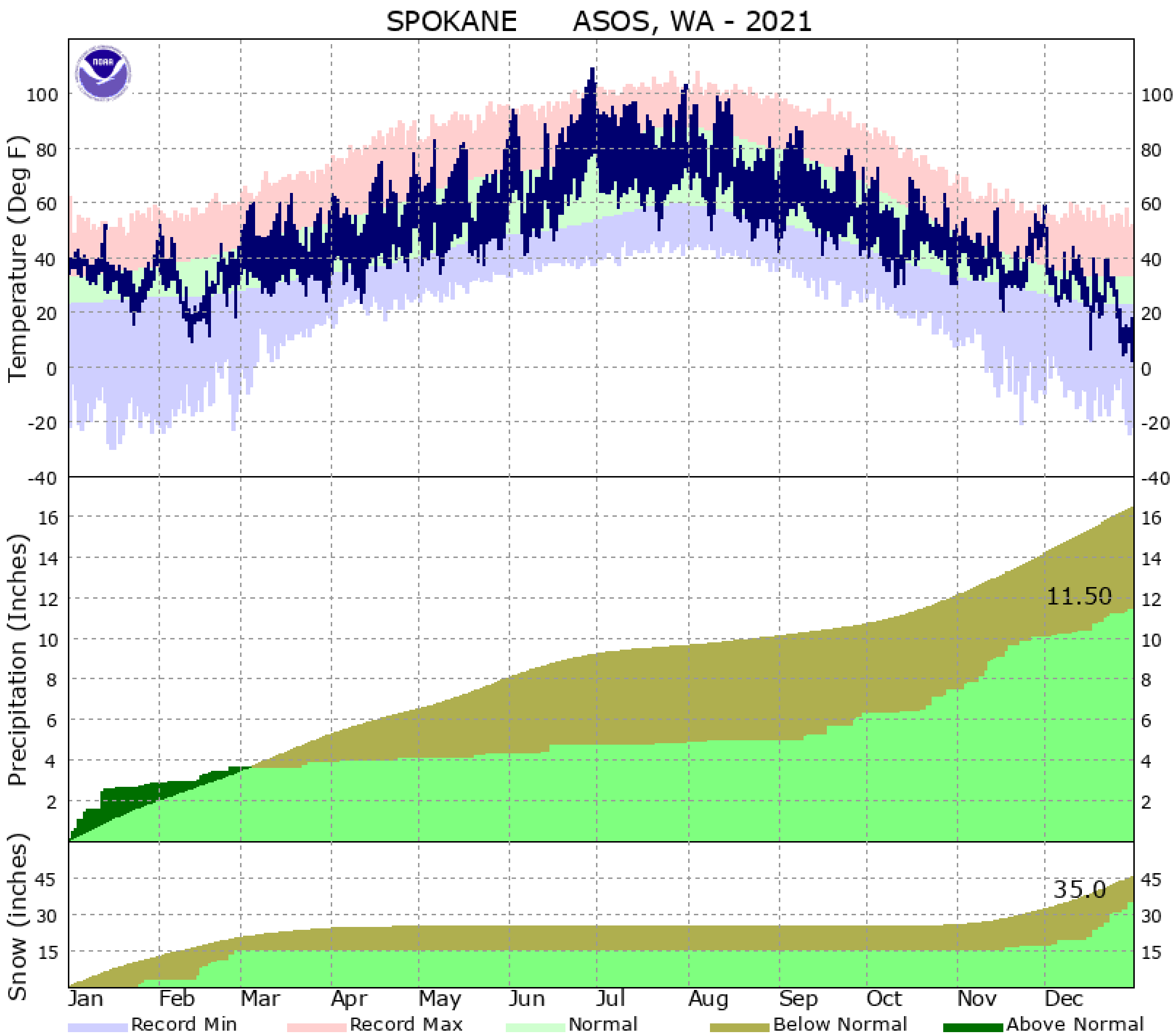
2 Annual Activities: 2021

Baseline monitoring was not conducted in 2021 in Lake Spokane. A description of the general climatic and hydrologic conditions, residence time, and algae bloom occurrences are discussed in Section 2.1.

2.1 Baseline Conditions

2.1.1 Climatic Conditions

Air temperatures in the Spokane region were within NOAA 30-year climate normals but had periods of extremes greatly above and below the normals (Figure 2.1) (NOAA 2021). Warmer than normal temperatures occurred periodically throughout the year with a particularly extreme heat wave occurring during June and July that recorded the highest temperature ever measured in Spokane at 109°F (42.7°C). Warmer than normal temperatures also occurred periodically through the year with at or near record maximums during January, August, and November. Periods of colder than normal temperatures also occurred, with most of mid-February and late December below normal.

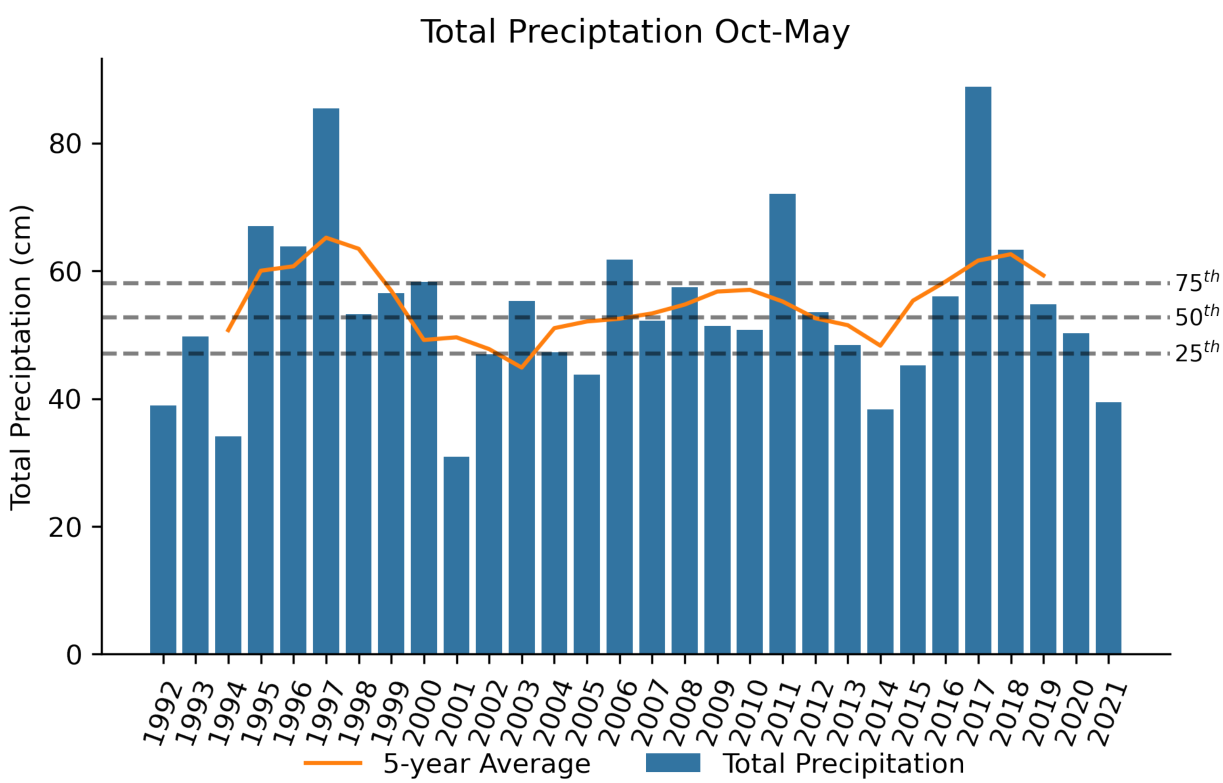


Source: NOAA 2021

Figure 2.1. Air temperature and precipitation at the Spokane International Airport for 2021

Precipitation was below NOAA 30-year normals in 2021 (Figure 2.1). The year began with higher-than-normal rainfall but lower-than-normal snowfall. There was very little precipitation between February and October, with a cumulative precipitation of approximately 2 inches. The low precipitation during 2021 led to cumulative precipitation consistently below normal levels. July and onwards the cumulative precipitation was consistently 4-5 inches below normal. At years end, the cumulative precipitation was 11.5 inches, approximately 5 inches below normal.

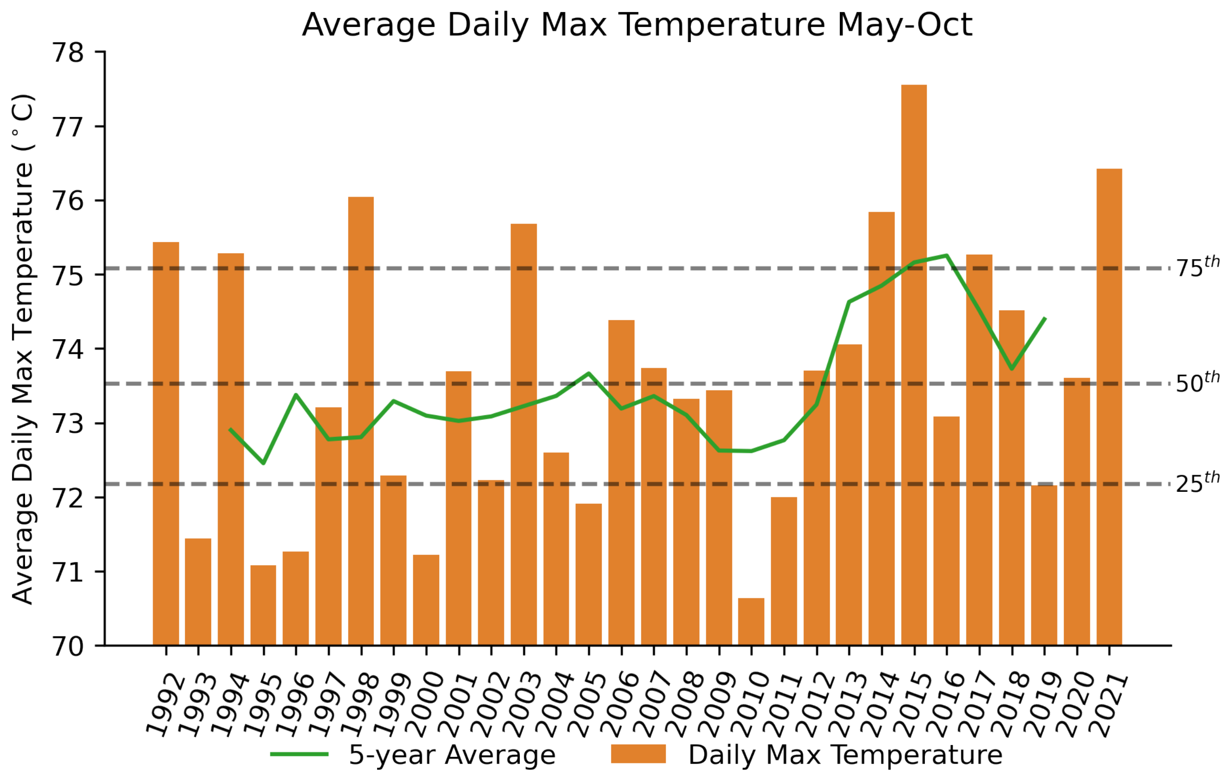
Wet season (fall through spring) precipitation and May through October temperature can both have a substantial influence on the primary productivity and oxygen demand of lakes and reservoirs in the Pacific Northwest by mobilizing nutrients and determining the strength of thermal stratification. The 2021 fall to spring (October 2020-May 2021) total precipitation measured at Spokane International Airport was within the lower 20th percentile of the past 30 years of wet season total precipitation (Figure 2.2). The 2021 average daily maximum temperature during the growing season was the second highest average daily maximum temperature after 2014 in the past 30-year period (Figure 2.3). Together, 2021 was a year of climatic extremes with low precipitation and high atmospheric heat flux.



Data source: NCEI 2022

Note: Dashed lines represent percentiles of total precipitation. The 5-year average is centered on each year with 3-year averages at the endpoints.

Figure 2.2. October through May total precipitation at Spokane International Airport over the past 30 Years



Data source: NCEI 2022

Note: Dashed lines represent percentiles of average daily maximum temperatures. The 5-year average is centered on each year with 3-year averages at the endpoints.

Figure 2.3. Growing season daily maximum air temperature at Spokane International Airport over the past 30 Years

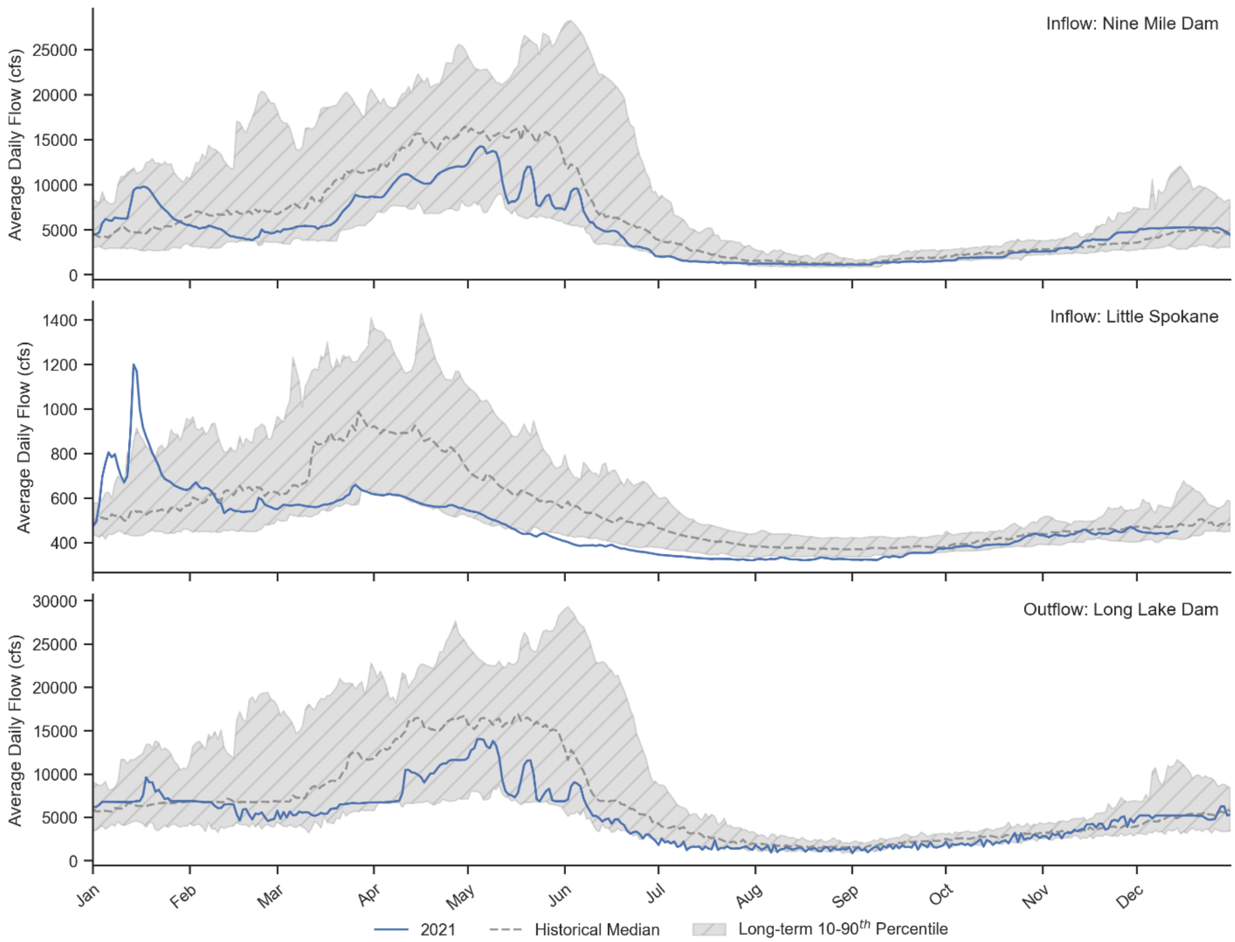
2.1.2 Hydrological Conditions

Figure 2.4 shows average daily inflows and outflows at Lake Spokane during 2021 with comparison to the 30-year median and 10-90th percentiles. Lake Spokane inflows are represented by the outflow at Nine Mile Dam and the flow at the USGS station in the Little Spokane River (Gage #12431500).

Inflows from Nine Mile Dam and outflows from Long Lake Dam are usually very similar, with only slight differences between inflow and outflow during annual drawdown in the early part of the year. Annual drawdown started at the end of December 2020 and lasted until about the end of March 2021.

Overall, 2021 inflows and outflows were well below median flows of the past 30 years for most of the year (Figure 2.4). Flows during January were well above the 30-year median, particularly at the Little Spokane USGS station, which was well above the 90th percentile for January. The elevated flow is due to the above normal rainfall, but below normal snowfall during the early months of year (Figure 2.1). The increased rainfall instead of snow during the winter resulted in less snow and ice pack for the spring freshet. Less snowpack and below normal precipitation resulted in spring flows that were well below the historical median and at times at the 10th percentile. Peak flows occurred in early May at approximately 14,000 cfs at Nine Mile and Long Lake Dams. Subsequent smaller peaks occurring from May to early June are linked to upstream operations. Lower than normal precipitation through the remainder of the year resulted in flows below the historical median and at times at or below the 10th percentile. The Little Spokane River was more sensitive to the extremes with times above and below the 10-90th percentile range.

Low flows through the summer (June-October) resulted in long residence times compared to years with higher flows. Whole lake reservoir residence time during 2021 was approximately 50 days with the transition/riverine and lacustrine zone residence times of 7.7 days and 42.3 days, respectively. These residence times are the second highest residence times since 2010, after 2015.



Notes: Long-term flow records at Nine Mile Dam and Long Lake Dam were measured by Avista and are a combination of spill and turbine outflow (1992-2021). Long-term flow records for the Little Spokane (1998-2021) were obtained from USGS (Gage #12431500).

Figure 2.4. 2021 Inflows and outflow to Lake Spokane compared to long-term record

2.1.3 Algal Bloom Occurrence

Algae bloom occurrences and intensity have greatly decreased since the late 1970s, following the reduction of nutrient inputs to Lake Spokane. Algae blooms are still observed in Lake Spokane, typically during August and September.

Cyanobacteria (blue-green algae) blooms were minimal in Lake Spokane during the summer of 2021(personal com. Galen Buterbaugh to Meghan Lunney, January 20, 2022). According to Mr. Galen Buterbaugh, retired US Fish and Wildlife Service Fishery Biologist who serves as the Lake Spokane Association Technical Advisor, cyanobacteria occurrence was very limited with a number of light blooms in isolated areas. These minor blooms disappeared within 24 hours and occurred in areas within the upper portion of the lake. According to the Washington State Toxic Algae website one sample was collected during 2021 (August 25) in an area just downstream of Sportsman's Paradise. The sample was analyzed for cyanotoxin analysis. Results indicate anatoxin-a, cylindrospermopsin, and saxitoxin were all below their respective maximum detection levels. Microcystin levels were below the Washington Department of Health recreational guidance value of 6 µg/L (WSDOH 2008).

We expect the frequency and duration of blooms to remain improved, with intensity and occurrence being a function of annual residence time and climatic conditions.

2.2 Monitoring and Modeling Activities for 2021

DO WQAP-related water quality monitoring was not performed during 2021.

Avista initiated the development of CE-QUAL-W2 modeling for Lake Spokane following discussions with Ecology. The modeling work was originally contemplated to commence in 2016 in the DO WQAP. Ecology advised deferring the modeling until additional upstream actions were completed before Avista pursue the water quality modeling efforts for Lake Spokane. These actions are ongoing. Ecology is collecting data to assess the efficacy of these actions as part of its 10-year review for the DO TMDL, which will not be completed before Avista's current compliance schedule concludes in fall 2022.

To provide a meaningful evaluation of the actions implemented to date, appropriately prioritize actions that are likely to yield the greatest water quality improvements in Lake Spokane, and better understand the DO and temperature conditions in the lake and their effects on useable fish habitat, Avista proposed to pursue the modeling efforts discussed in the DO WQAP. To this end, Avista submitted a modeling memorandum to Ecology (Gong and Mugunthan 2021) that outlined the modeling objectives, calibration, and model application steps. Ecology accepted this memorandum in lieu of a detailed modeling Quality Assurance Project Plan (QAPP) and recommended that Avista continue to engage Ecology throughout this process (personal com. Jordan Bauer to Meghan Lunney, December 17, 2021). The model domain will be limited to Spokane River between Nine Mile Dam and Long Lake Dam. It will build off the Spokane River DO TMDL model and, as such, maintain a similar segmentation and structure within Lake Spokane, except for updates pertinent to more recent bathymetry and boundary conditions reflecting the simulation periods.

Avista is presently developing and calibrating this model for current conditions to better reflect natural variability over a multi-year time period (2010-2017) and expects to have a calibrated model by Spring 2022. Once model development is completed, Avista will apply the model to better understand the factors that affect DO within Lake Spokane; assess improvements in Lake Spokane relative to the DO objectives set in Table 7 of the DO TMDL (Ecology 2010b and 2010c) and Washington water quality standards; assess the DO improvements from the phosphorus reduction activities completed under the DO WQAP; and assess other potential reasonable actions that could further improve DO within Lake Spokane. Avista expects to document the findings from these evaluations in support of a new compliance schedule request to Ecology (Section 5).

2.3 2021 Implementation of Reasonable and Feasible Actions for Phosphorus Reduction

The DO WQAP states that Avista will work towards meeting its proportional level of responsibility, outlined in the DO TMDL, by implementing Ecology-approved reasonable and feasible water quality improvement measures (Figure 1.2), with the goal of improving water quality in Lake Spokane. All implemented actions since 2012 are summarized in Section 3.3. Actions undertaken in 2021 are summarized below. Additional activities conducted during 2021 include significant dialogue with Ecology regarding the implementation completed from 2012 through 2020, along with the structure, objectives, and milestones of implementation measures for the next Lake Spokane DO WQAP. Proposed phosphorus reduction actions for 2022 are discussed in Section 5.2.

2.3.1 Reducing Carp Populations

Based on the results of the Lake Spokane Carp Population Abundance and Distribution Study (Golder 2015) and pilot testing in 2016, Avista has worked with WDFW to remove carp (Cyprinus carpio) from Lake Spokane from 2017 through 2021. The 2021 removal effort was done in cooperation with WDFW and completed under a Scientific Collection Permit issued by WDFW. During the 2021 carp removal activities, WDFW continued to include efforts to remove Northern Pike (Esox lucius), a non-native and highly invasive predator, considered a serious threat to native and other preferred fish species. The removal efforts benefit the fishery by removing invasive species that compete with warm-water trophy fish.

Carp removal efforts occurred during 4-week-long sampling events from April 10 through June 10 and focused on sampling carp during their spring spawning behavior. Removal efforts were focused on the upper portion of Lake Spokane between McLellan Slough and the Nine Mile Recreation Area, consistent with past carp removal locations (Section 3.3.1.1). Multifilament gillnets (60 m long by 3 m high) were deployed at the same four study areas as were surveyed in previous years: McLellan Slough, Felton Slough, Sportsman's Paradise, and Nine Mile Flats. Nets were also set in areas that met depth and habitat characteristics preferred by carp that were outside the four study areas, including Willow Bay and Sunset Bay. In total, 953 carp were collected along with 1,569 other fish considered by-catch (Table 2.1).

Table 2.1. Species, total number caught, and total number removed (per species) during the spring 2021 carp removal effort

Species	Total Caught	Total Removed
Common carp	953	951
Black crappie	50	0
Brown bullhead	43	2
Largemouth bass	66	15
Largescale sucker	515	90
Longnose sucker	1	0
Mountain whitefish	1	1
Northern pike	80	80
Northern pikeminnow	89	36
Peamouth	1	0
Rainbow trout (hatchery)	95	72
Rainbow trout (wild)	13	9
Smallmouth bass	94	13
Tench	349	310
Walleye	165	96
Yellow perch	7	2
Total	2,522	1,677

All carp were weighed, measured, and checked for sex and maturity. Carp ranged in length from 16.2 to 32.4 inches and averaged 26.9 inches. The average carp weight was 10.8 lbs with the range of weights being 2.8 to 25.9 lbs. All removed carp were placed into a refuse bin and transported to the Greater Wenatchee Regional Landfill for disposal.

The 951 carp removed in 2021 totaled approximately 10,301 lbs of biomass being completely removed from the watershed. Using an average TP content of 1.7% of biomass which was determined from 2014 to 2018 laboratory analysis, removal was calculated to be 56.2 lbs of TP in 2021.

2.3.2 Acquiring, Restoring, and/or Enhancing Wetlands

Wetland acquisition, restoration, and enhancement was identified in the DO WQAP as a reasonable and feasible measure. In 2021, Avista has continued management and restoration activities at the Sacheen Springs and Hangman Creek wetlands. Details on these sites and previous actions are summarized in Section 3.3.3.

2.3.2.1 Sacheen Springs Wetlands

During 2021, Avista continued management and restoration activities at Sacheen Springs including (a) understory thinning of approximately 0.5 acres of the mature upland forest to remove ladder fuels and promote forest health; (b) development of a 1.2-mile primitive trail along the interface of the wetland and mature upland forest; and (c) herbicide application to control terrestrial invasive weeds on 0.5 miles of two-track access road.

2.3.2.2 Hangman Creek Wetlands Supporting Watershed Activity

During 2021, Avista and the Coeur d'Alene Tribe continued management and restoration activities at Hangman Creek including (a) planting 1,600 seedlings; (b) applying noxious weed herbicide treatments; (c) constructing fence enclosures to protect seedlings; and (d) monitoring survival of the seedlings planted as well as wetland functionality. The activities in Hangman Creek were not included as a reasonable and feasible measure to improve DO in Lake Spokane in the DO WQAP; rather, they were undertaken to support watershed activity under Appendix D of the license.

2.3.3 Vegetative Shoreline Buffer on Avista Lake Spokane Property

Section 3.3.2.1 provides a summary of the shoreline phosphorus reduction efforts that occurred in the past. In 2021, Avista continued the maintenance and enhancement of 350 acres of vegetative shoreline buffer located within 200 feet of the Lake Spokane shoreline in Spokane, Stevens, and Lincoln counties at the downstream end of the reservoir. Avista conducted vegetation monitoring of the tree and shrub seedlings planted during 2020 along the shoreline of Lake Spokane at four of Avista's recreation sites. Vegetation survival monitoring consisted of counting live seedlings within the 2020 planting areas. The data will be used to evaluate survival and what areas may need further planting. Once mature, the trees and shrubs will form canopy cover along the lake and provide shade, reduce water temperature, encourage fish habitat, and help stabilize the shoreline.

2.3.4 Lawn Area Reduction and Native Vegetation Buffers

Avista completed the second year of vegetation monitoring at the Wright Project, under the U.S. Army Corp of Engineers' permits for the project. Avista conducted vegetation monitoring during July 2021 and worked with the landowner to complete the annual report. See Section 3.3.2.3 for more details on the Wright Project and previous lawn area reduction and native vegetation buffer efforts.

2.3.5 Education and Outreach

In 2021, a majority of Avista's education and outreach activities were temporarily placed on hold in response to the COVID pandemic. Avista continues to explore virtual education and outreach venues such as participating with the Lake Spokane Association to periodically feature articles and post information on the association's Facebook website regarding best management practices for shoreline homeowners to protect water quality. See Section 3.3.2.4 for a summary of previous education and outreach efforts.

3 10-Year Implementation Summary of Reasonable and Feasible Actions

This section provides a summary of the data collected by Avista and the phosphorus removal actions implemented by Avista in accordance with the Lake Spokane DO WQAP. Most of monitoring activities were completed within the first 8 years. The Lake Spokane DO WQAP Eight-Year Report ("8-year report") provided a detailed presentation and analysis of most of these data (Avista 2020). The sections below are intended to be a high-level summary of the in-lake monitoring data and build on the analyses presented in the 8-year report, to support the discussion of DO drivers in Section 4.

3.1 Baseline Water Quality Monitoring

Figure 3.1 shows flow and water quality monitoring locations in the watershed. Avista's baseline monitoring locations LL0 through LL5 are shown in Figure 3.1 and cover the riverine (first 2 river miles below Nine Mile Dam which includes Station LL5), transition (the next 9 miles and includes stations LL4 and LL3), and lacustrine (the 13-mile stretch extending down to Long Lake Dam, and includes stations LL2, LL1, and LL0) zones of Lake Spokane.

Legend
Lake Spokane
Lake Spokane Monitoring Locations (Avista)
Lake Spokane Supplemental Monitoring Locations
Flow (USGS; Avista)
Temperature and Water Quality (Ecology)
Meteorology (NOAA)
N
0 1 2 4 Miles

Figure 3.1. Baseline monitoring locations and other flow and water quality data locations in the vicinity of Lake Spokane

Table 3.1 provides a summary of the flow and water quality monitoring data available for Lake Spokane. In addition, flow data are also available from the USGS gage on the Little Spokane River to provide information on tributary inflow into Lake Spokane. Ecology's long-term stations below Nine Mile Dam (54A090) and the mouth of the Little Spokane River (55B070) provide monthly incoming nutrient concentrations (Figure 3.1).

Table 3.1. Summary of flow and water quality data available for Lake Spokane

Data	Data Source	Site ID	Site Name	Period of Record	Temporal Frequency
Flow	Avista	--	Nine Mile Dam	1986 to current	Daily
Temperature and Water Quality	Ecology	54A090	Spokane River at Nine Mile Bridge	1970 to current	Monthly
Flow	Avista	--	Long Lake Dam	1986 to current	Daily
Flow	USGS	12431500	Little Spokane River near Dartford, WA	1997 to current	Every 15 minutes
Temperature and Water Quality	Ecology	55B070	Little Spokane River near Mouth	1970 to current	Monthly
Temperature and Water Quality	Ecology	54A120	Spokane River at Riverside	1970 to current	Monthly
Temperature and Water Quality	Avista	LL5 to LL0	LL5 to LL0	2010 to 2018, May through October	Twice a month

Avista's monitoring was conducted under Ecology's QAPP for Lake Spokane (Ecology 2010a) and Avista's addendum to this QAPP (Avista 2012), which was approved by Ecology in May 2012. At the six baseline monitoring locations (LL5 to LL0) Avista monitored nutrients, chlorophyll-a, and field (in-situ) water quality parameters (DO, temperature, pH, and specific conductance). Nutrients and chlorophyll-a data were collected bi-monthly from mid-May to mid-October of 2010-2017, with 2010-2011 using composite samples and 2012-2017 using grab samples encompassing the euphotic/epilimnion (typically the top 9 m), interflow/metalimnion (typically 10 to 18 m), and hypolimnion (below 18 m). Field parameters were collected at the same frequency through a downward cast of a field probe to record in-situ depth profiles from the surface to the bottom, at intervals of 1 m within the top 10 m and 3 m thereafter extending to the bottom. At the riverine and transition zones (Stations LL5 through LL3), water is not deep enough for a fully formed hypolimnion, as seen in the lacustrine zone (Stations LL2 through LL0). Thus, the samples at LL5 through LL3 represent the euphotic and interflow zones only. Results of the monitoring are summarized in Avista's 2013 through 2017 Annual Summary Reports and the data uploaded into Ecology's Environmental Information Management database (Avista 2014, 2015a, 2016a, 2018).

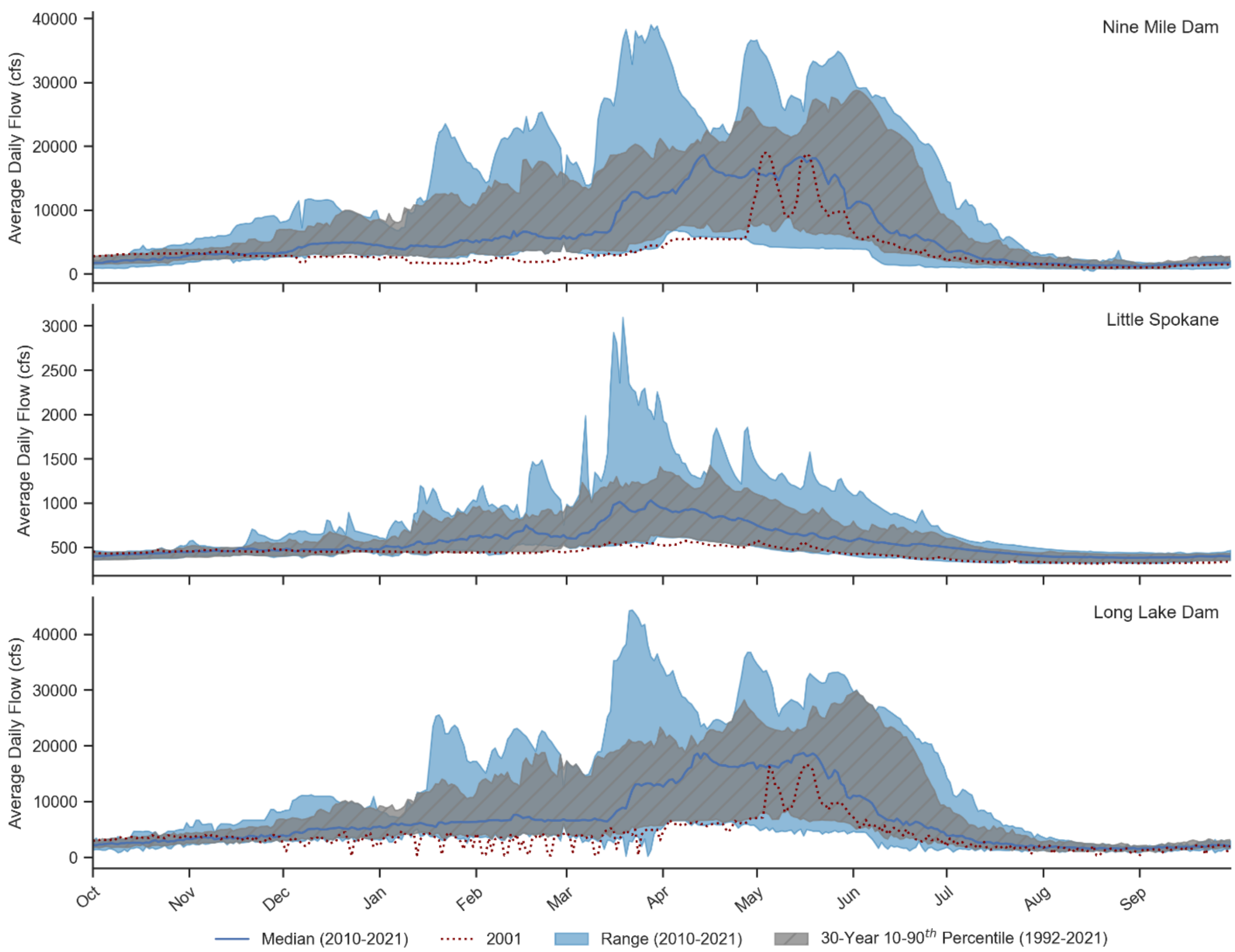
In 2018, monitoring was modified to only include in-situ DO, temperature, conductivity, and pH at the six established stations along with four supplemental monitoring locations, May through October (Figure 3.1). Additionally, zooplankton samples were collected at all ten monitoring locations. The narrow scope of the 2018 monitoring allowed Avista to focus on more detailed analyses of the 2010 through 2018 water quality monitoring data to explore the relationship between rainbow trout (*Oncorhynchus mykiss*) habitat utilization in Lake Spokane and the multitude of water quality attribute information available. Results of this monitoring are summarized in Avista's 2018 Annual Summary Report, and the data was uploaded into Ecology's Environmental Information Management database (Avista 2019b).

In 2020, Avista performed continuous temperature and DO monitoring at three near-shore, shallow locations over the summer months to characterize the diurnal fluctuations of temperature and DO in the epilimnion and its association with primary productivity. Temperature and DO measurements were recorded every 15 minutes, at varying depths of the epilimnion from June through September using recorders affixed to floating buoys. Results of the monitoring are summarized in Appendix A of Lake Spokane Annual Summary, 2020 Water Quality Monitoring Results, and the data was uploaded into Ecology's Environmental Information Management database (Avista and Tetra Tech 2021).

3.1.1 Results

3.1.1.1 Flows

Figure 3.2 provides a comparison of the past 10-year flow record, covering the compliance schedule period (from 2010-2021), relative to the past 30 years. Table 3.2 provides a summary of the 25th percentile, median, and 75th percentile flows for the last 30-year period of record. The flow summary shows that in the past 10 years there have been extreme flow years (high and low) relative to the longer-term 10th and 90th percentile flows.



Notes: Water year is defined as the October through September range and labeled as the in-coming year (e.g., WY 2021 is October 2020-September 2021). Flows at Nine Mile Dam and Long Lake Dam were measured by Avista and are a combination of spill and turbine outflow. Little Spokane flow was from USGS Gage #12431500.

Figure 3.2. Summary of inflows and outflows at Lake Spokane based on flow record

Table 3.2. Summary statistics for growing season and water year outflows at Long Lake Dam from 1992 to 2021

Percentile	Growing Season (June-October) Flow (cfs)	Water Year (October – September) Flow (cfs)
25th	2,497	5,554
Median (50th)	3,489	6,623
75th	4,130	8,663

To support the evaluation of flow on DO drivers (Section 4), the years were categorized as high, low, and normal flow years based on the growing season (June-October), average flows (Figure 3.3), and the water year average flows (October of prior year to September of current year, which reflects the precipitation and runoff for each water year; Figure 3.4) using the 30-year record of the total discharge (spill and turbine flows) at Long Lake Dam. In each case, years with period-average flows between lower and upper quartiles (i.e., 25th and 75th percentiles) in Figures 3.3 and 3.4 were classified as normal, years with period-average flows above the upper quartile were classified as high, and years with period-average flows below the lower quartile were classified as low. Table 3.3 provides a summary of the water year and growing season flow classifications. The 2001 low-flow year used in the TMDL is also shown for reference (and shaded in blue). While on a water year basis 2001 had lower average flows, on a growing season basis 2015 and 2021 flows were both lower on average. As discussed subsequently in Section 4.2.1, the growing season flows are more critical in determining the time available for assimilating incoming phosphorus as well as in determining the strength of thermal stratification, and hence, the associated effects on the hypolimnetic DO from both processes.

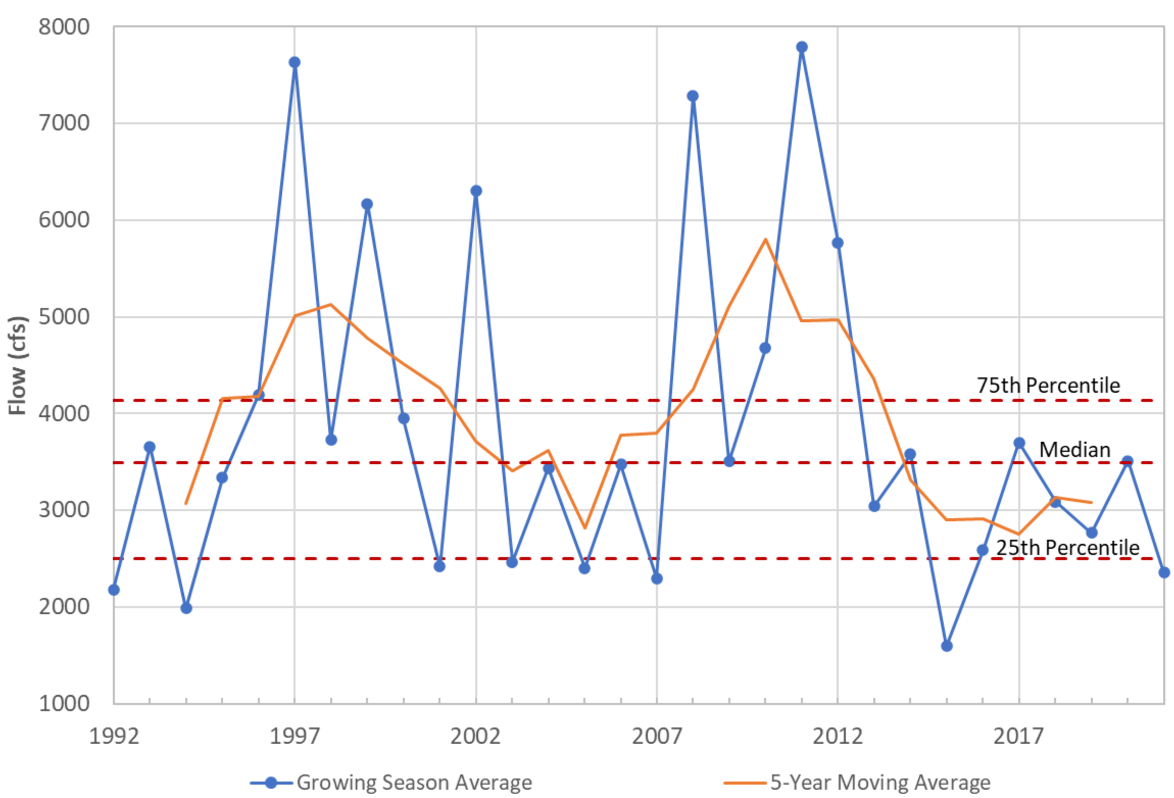
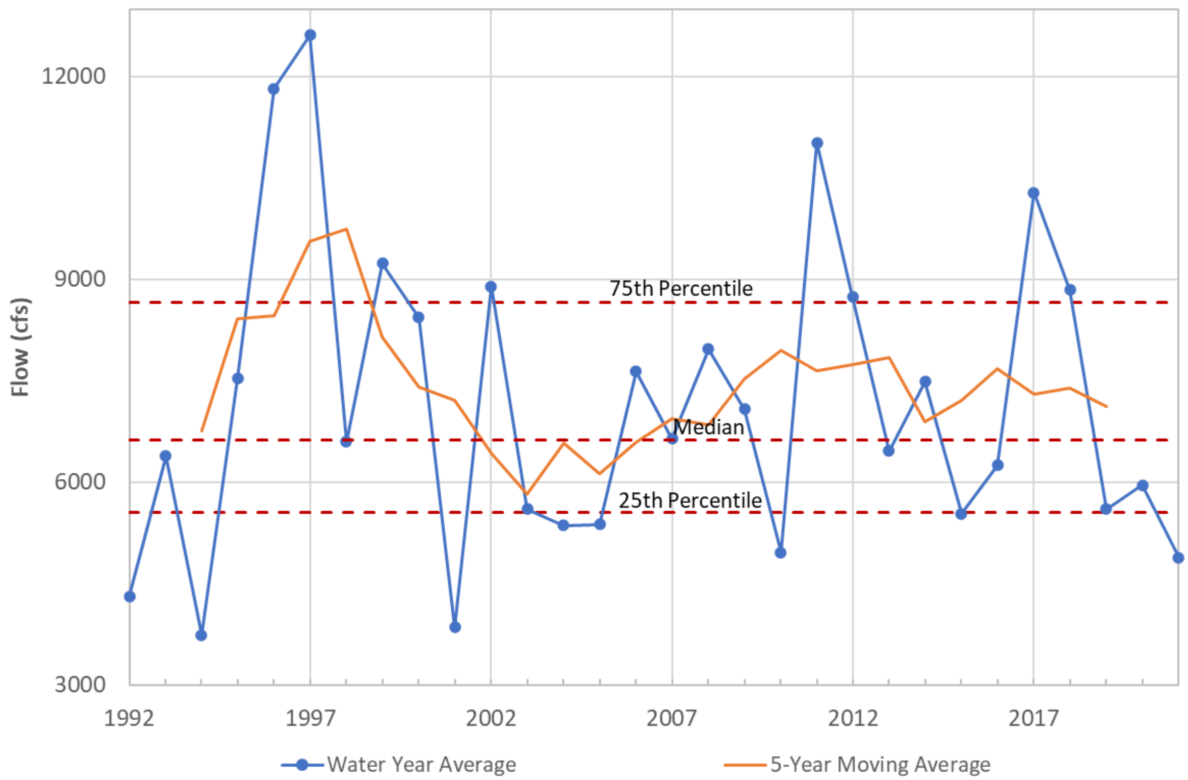


Figure 3.3. Growing Season (June-October) average daily flow from 1992-2021 at Long Lake Dam



Notes: Water year is defined as the October through September range and labeled as the in-coming year (e.g., WY 2021 is October 2020-September 2021).

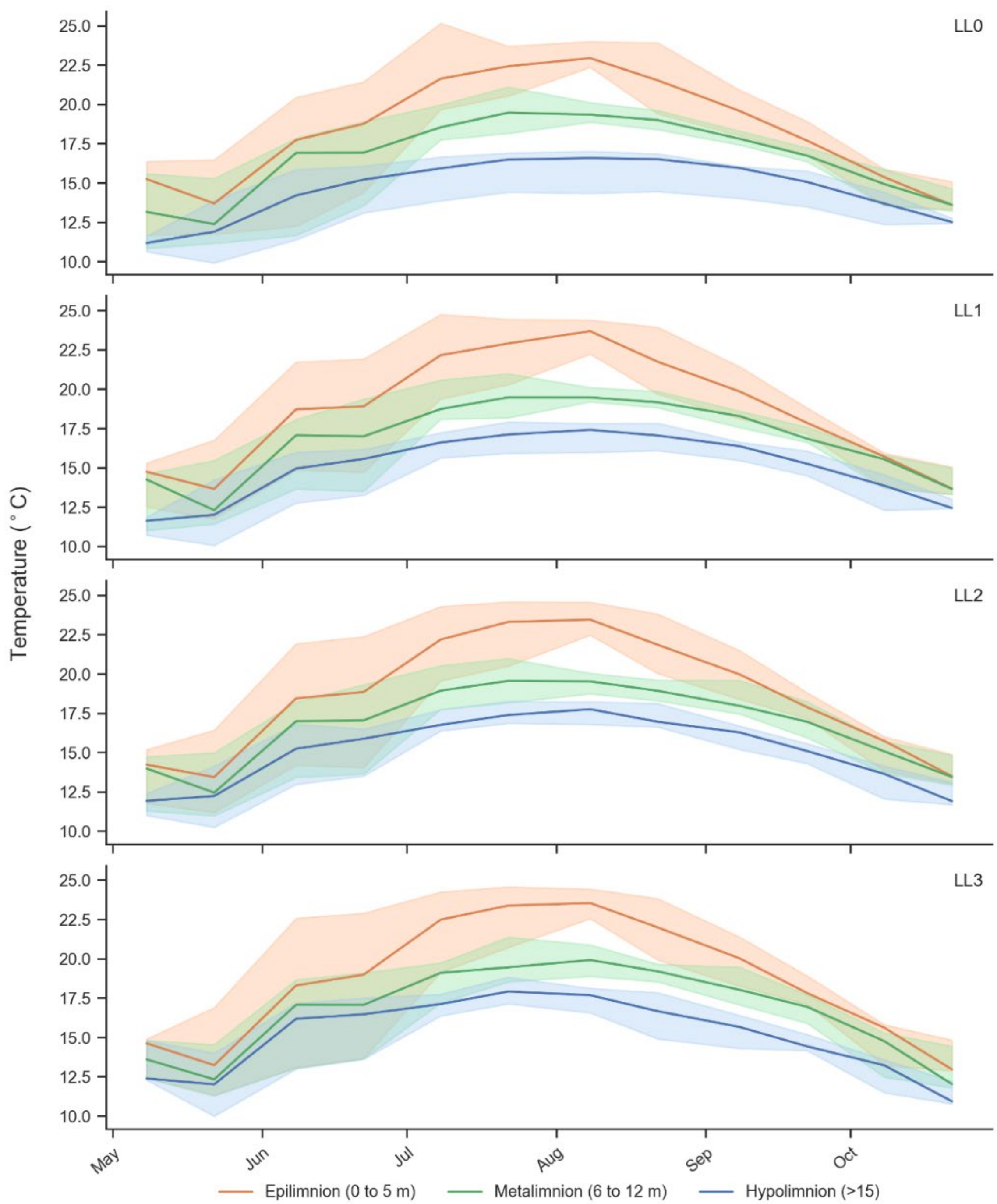
Figure 3.4. Water year (October-September) average daily flow from 1992 to 2021 at Long Lake Dam

Table 3.3. Growing season flow categorization for the years spanning the compliance schedule

Year	Growing Season (June-October)		Water Year (October-September)	
	Average Flow (cfs)	Category	Average Flow (cfs)	Category
2001	2,416	LOW	3,857	LOW
2010	4,677	HIGH	4,962	LOW
2011	7,791	HIGH	11,026	HIGH
2012	5,768	HIGH	8,737	HIGH
2013	3,039	NORMAL	6,461	NORMAL
2014	3,580	NORMAL	7,491	NORMAL
2015	1,596	LOW	5,539	LOW
2016	2,588	NORMAL	6,255	NORMAL
2017	3,701	NORMAL	10,289	HIGH
2018	3,086	NORMAL	8,847	HIGH
2019	2,768	NORMAL	5,601	NORMAL
2020	3,508	NORMAL	5,960	NORMAL
2021	2,352	LOW	4,888	LOW

3.1.1.2 Temperature

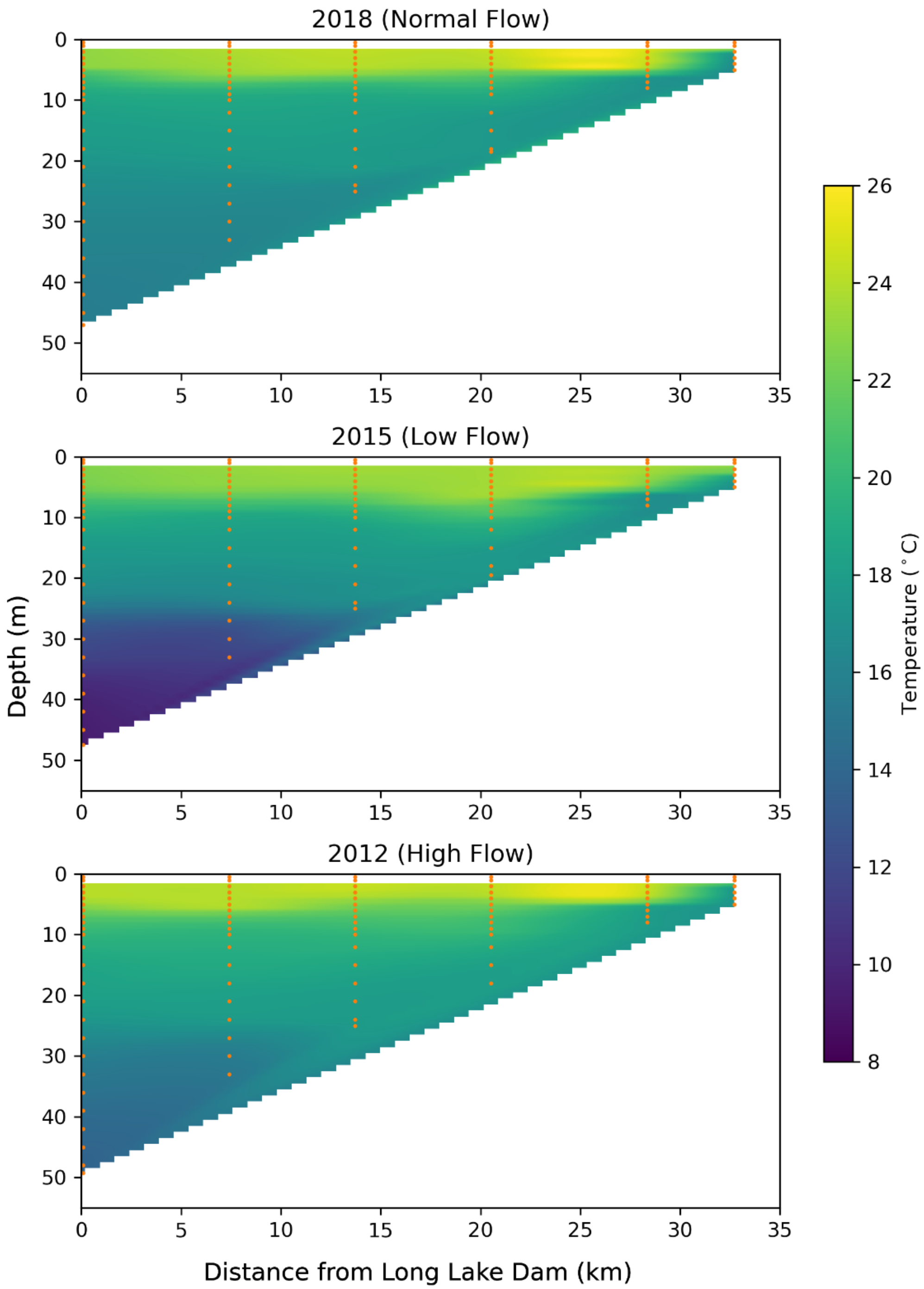
Bi-monthly temperature data are summarized by the limnetic zones in Figure 3.5. The figure shows that in all years of data Lake Spokane stratifies thermally. The strength of the stratification is weaker upstream at LL3 relative to downstream at LL0 particularly in early through mid-summer (average difference from May-Aug at LL3 is approximately 3.5°C versus 4.4°C at LL0).



Notes: Figure shows volume-weighted average of temperature profile data from 2010-2018, with the solid lines representing the median over the years and the shaded areas representing the range for each limnetic zone.

Figure 3.5. Median and range of water temperature by limnetic zone

Typical mid-summer (early August) stratification in Lake Spokane is shown in Figure 3.6 for representative normal (2018), low (2015), and high (2012) flow years. The figure shows that in low flow years the thermal stratification is stronger, which is evident from the cooler bottom water temperatures in 2015 (darker bottom color in the low flow panel compared to the normal and high flow panels in Figure 3.6). Cooler upstream water plunging to the interflow zone is also apparent in the low flow year.



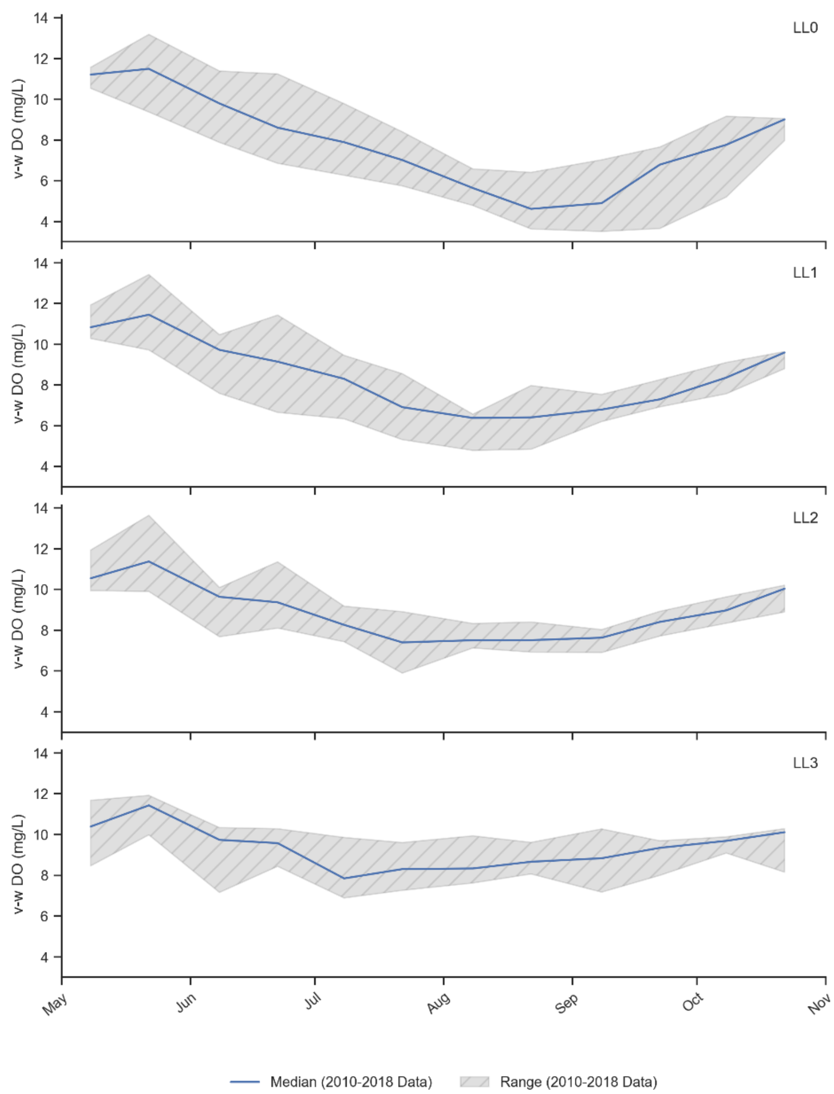
Notes: Depth profiles of temperature were interpolated between the six monitoring locations. The monitoring locations are represented by orange dots on the figure.

Figure 3.6. Mid-summer (early August) longitudinal sections of temperature for low, normal, and high flow years

3.1.1.3 Dissolved Oxygen

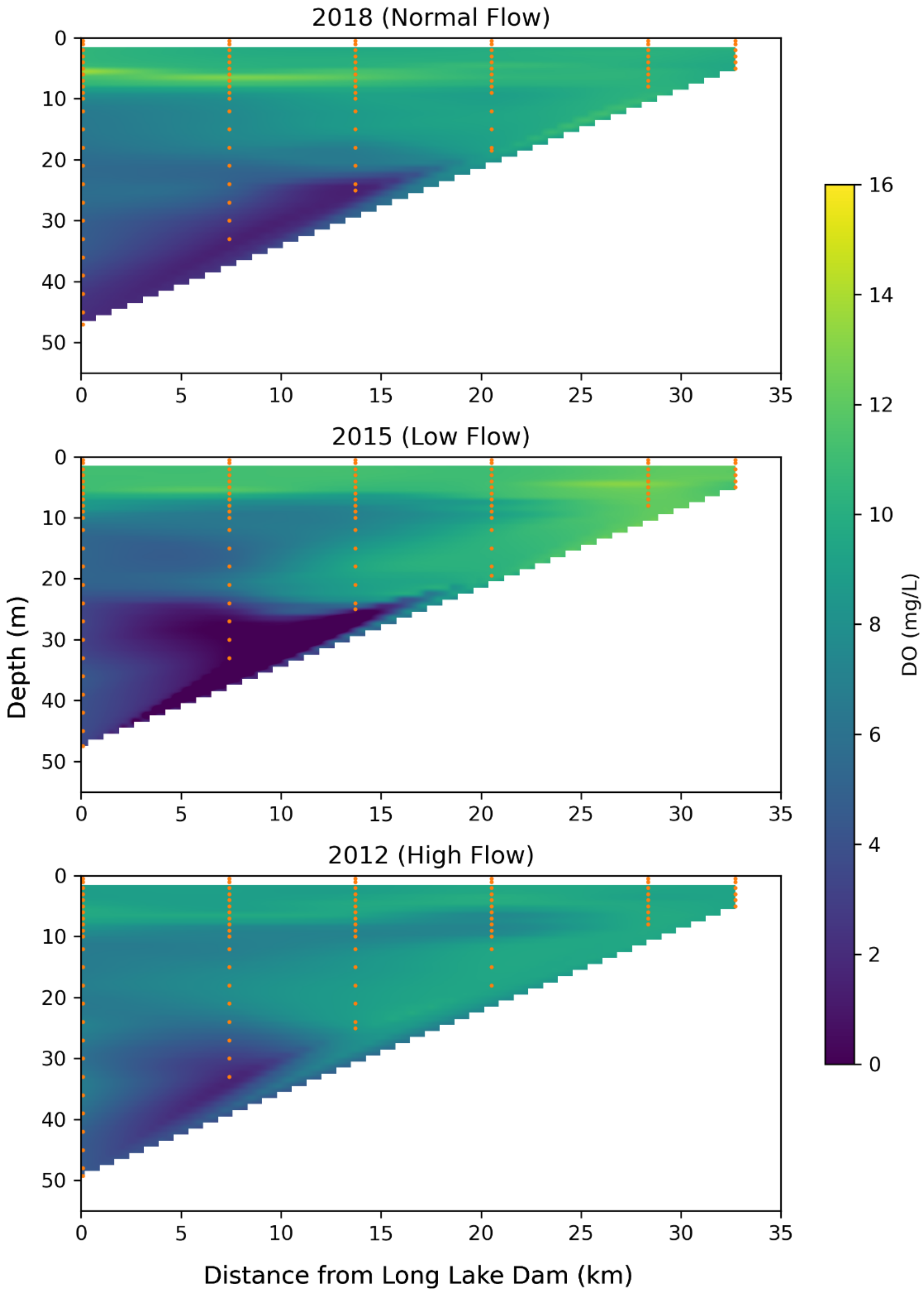
A summary of the longitudinal profiles of volume-weighted DO at 8 m and below is shown in Figure 3.7. This depth range was selected because this was also used to assess Avista's proportional contribution to DO in the DO TMDL (Ecology 2010b,c). The maximum depth of measurement for Stations LL4 and LL5 are 9 m and 7 m, respectively, and are considered riverine without a prominent hypolimnion. In addition, these locations also do not exhibit low DO. Therefore, they are not included in Figure 3.7, which is designed to provide DO conditions at 8 m and below.

Figure 3.7 shows the DO demand is greatest near Long Lake Dam and highest demands occur in the mid to late summer. DO levels remain relatively high in the upper sections of Lake Spokane (LL2 and LL3). These observations are also evident in the longitudinal sections of DO (Figure 3.8) for representative normal, low, and high flows years. A more detailed evaluation of these DO patterns relative to long-term improvements and 2001 ambient DO levels is presented in Section 4.



Notes: Figure shows data from 2010-2018, with the solid lines representing the median over the years and the shaded areas representing the range over the years.

Figure 3.7. Median and range of volume-weighted dissolved oxygen below 8 meters, 2010-2018



Notes: Depth profiles of DO were interpolated between the six monitoring locations. The monitoring locations are represented by orange dots on the figure.

Figure 3.8. Mid-summer (early August) longitudinal sections of dissolved oxygen for low, normal, and high flow years

3.1.1.4 Nutrients

3.1.1.4.1 Incoming Nutrients

Changes in incoming nutrients over time were analyzed in the 8-year report (Avista 2020). This analysis was extended through 2021 (Figure 3.9), and a closer evaluation of the post-2000 period was also undertaken (Figure 3.10). The incoming concentrations for both figures were generated using the flow weighted average concentration from the Ecology station at Little Spokane River near Mouth (55B070) paired with flow data from the USGS station at Little Spokane River near Dartford (12431500) and water quality data from the Ecology station at Spokane River at Nine Mile Bridge (54A090), paired with flow data from Avista's discharge data at Nine Mile Dam. Concentrations from Ecology's Spokane River at Riverside station are also shown to provide an indication of conditions upstream of Nine Mile Dam.

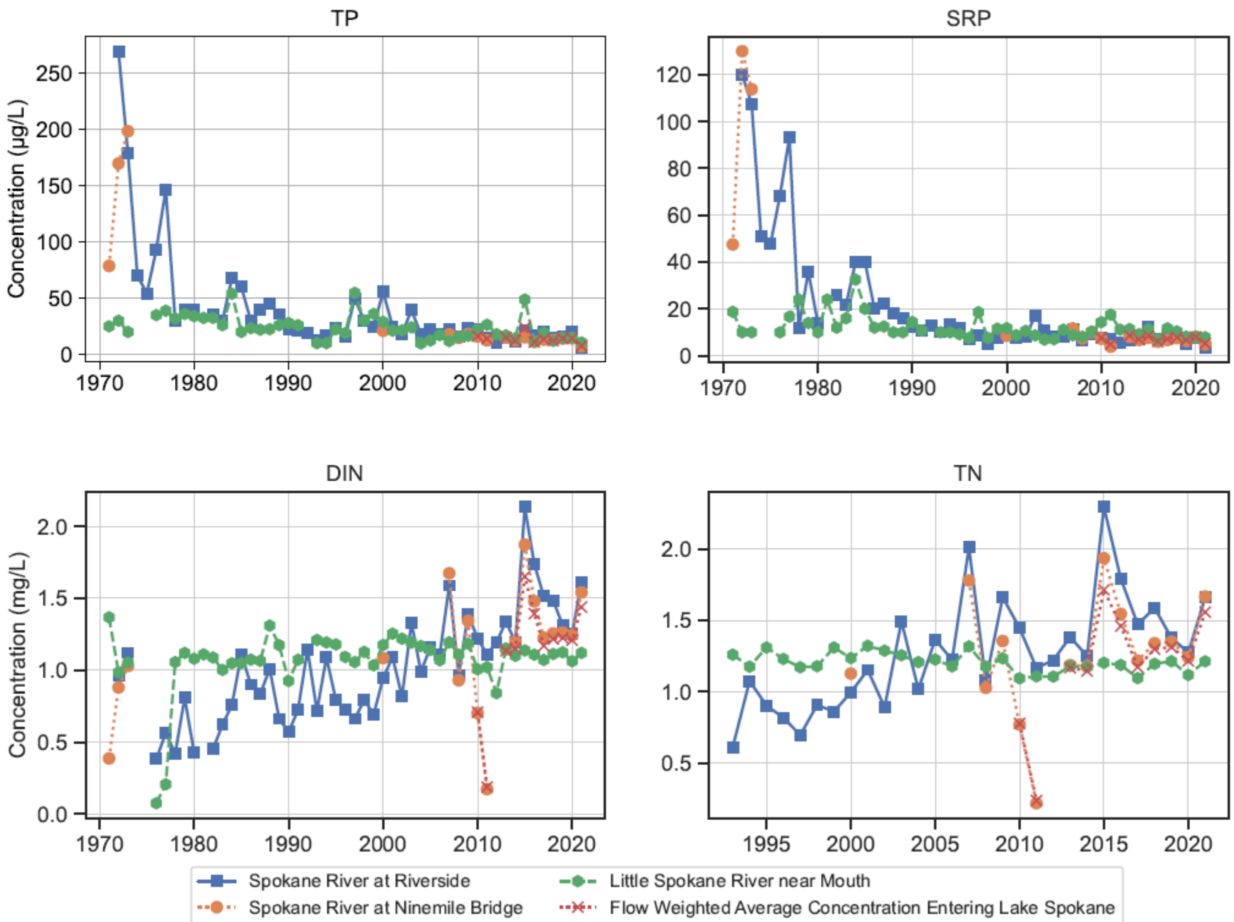


Figure 3.9. Historical growing season (June-October) average inflow nutrient concentrations to Lake Spokane, 1971-2021

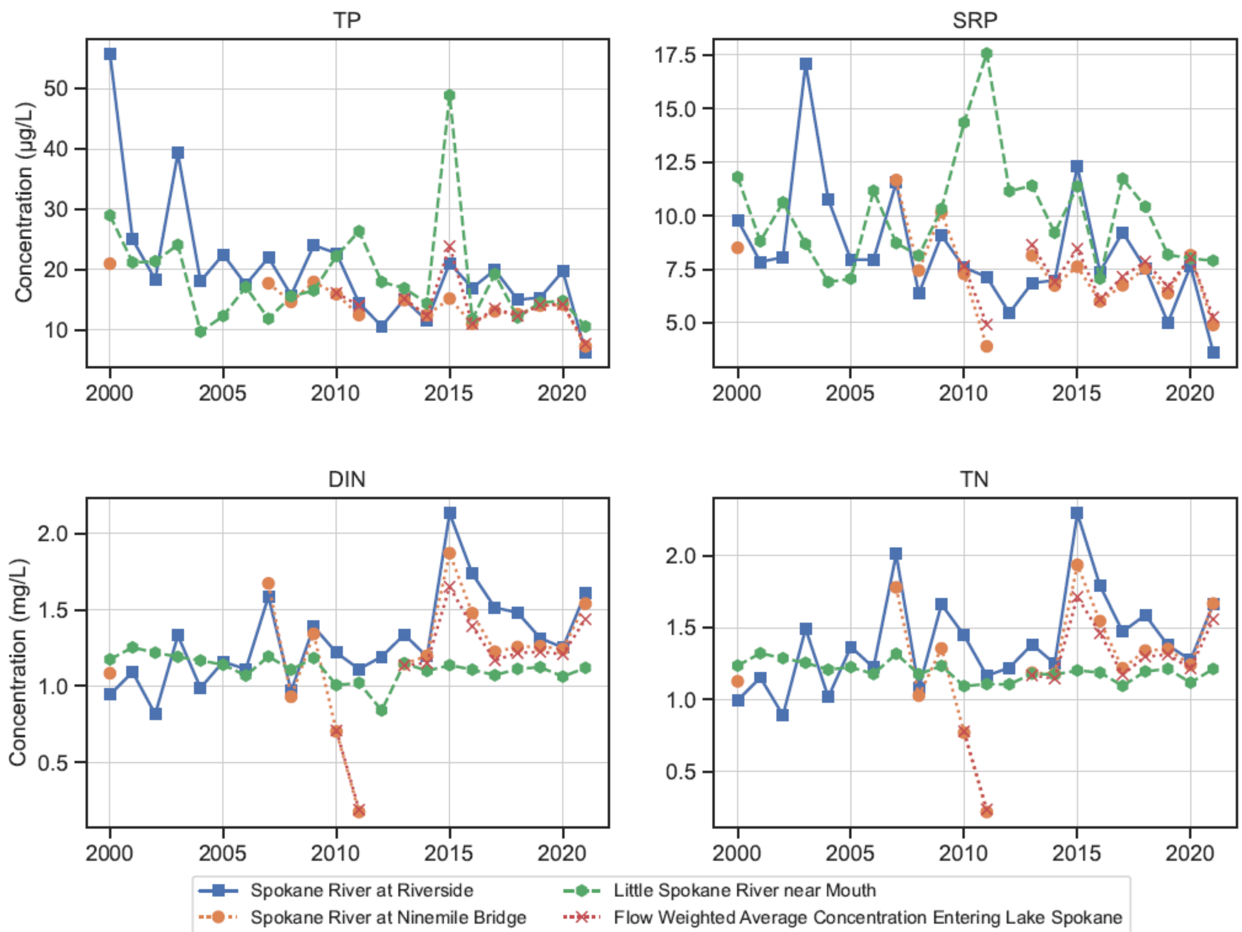


Figure 3.10. Growing season (June-October) average inflow nutrient concentrations to Lake Spokane since 2000

Figure 3.9 shows that incoming TP concentrations to Lake Spokane have shown a dramatic decline following the phosphorus reductions from point sources in the late 1970s and early 1980s. Most of the declines result from source reductions in the Spokane River, which is evident from the proportional declines in TP at Riverside. While the orthophosphate and TP levels within the Little Spokane River also show a decline, these are much smaller in magnitude. Figure 3.10 also shows that historically about 50% of the incoming phosphorus was bioavailable. Recent data continues to show approximately the same ratio of bioavailable to TP entering Lake Spokane (Section 4.2.4), even though the magnitudes of both have declined precipitously over time (Figure 3.10). The incoming TP in the Spokane River in the post-2010 period has remained low, approximately between 10 to 20 µg/L, with 2021 data showing an average growing season TP value of 7.3 µg/L.

Dissolved inorganic nitrogen (DIN) and total nitrogen (TN) are also shown in Figures 3.9 and 3.10. Considering how close the magnitudes of DIN and TN are, it is apparent that a majority of the incoming nitrogen is in the dissolved inorganic (i.e., bioavailable) form. DIN and TN levels in the Spokane River show an increasing trend over time, but these levels have remained stable in the Little Spokane River. The increasing trend in DIN in the Spokane River suggests that the reduction in TP is limiting biological growth and therefore uptake of DIN. The DIN and TN levels entering Lake Spokane from the Little

Spokane River have not changed appreciably over time indicating that the in-stream nutrient assimilation of either nitrogen or phosphorus has not changed appreciably.

3.1.1.4.2 Nutrients within Lake Spokane

Figure 3.11 shows a longitudinal profile of nutrients, chlorophyll-a, and DO within Lake Spokane. Rather than pair them by the typical limnetic zones used for the temperature longitudinal sections in Figure 3.5, this figure shows data grouped by the level of light penetration (top 10 m – euphotic zone) and plunging of cooler upstream waters to form the interflow (10–20 m – interflow zone). Moreover, the depth intervals at which nutrient and chlorophyll-a data were collected are not as finely resolved as DO and temperature—most sampling events collected one to two samples in the euphotic zone, one in the interflow zone, and one to two samples in the hypolimnion. The depth groupings affect the volume-weighting used for zones with multiple samples. The values shown in Figure 3.11 are the median of the volume-weighted averages from June-October of each year from 2010-2017, the period over which nutrients and chlorophyll-a data were collected.

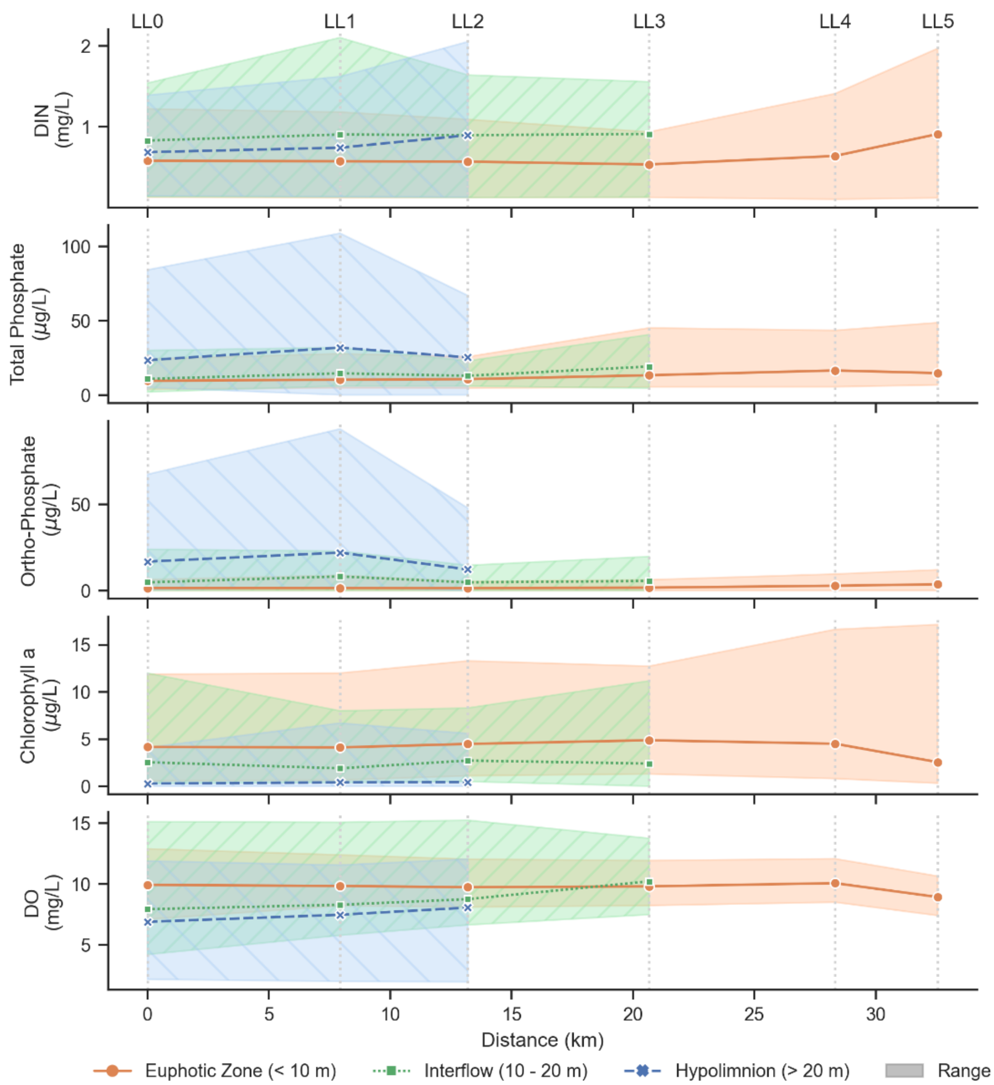


Figure 3.11. Median and range of volume-weighted nutrients and dissolved oxygen by limnetic zone at Lake Spokane monitoring stations 2010-2017

Declining nutrient levels in the photic zone from upstream (LL5) to downstream (LL2-LL0) indicate progressive assimilation (i.e., uptake of phosphorus by phytoplankton). This is also evident in the generally higher range in photic zone chlorophyll-a in the riverine/transition areas of Lake Spokane (LL5 to LL3). The DO levels remain high (at or above saturation) in the euphotic zone, but it is interesting that the interflow zone shows a greater range of DO indicating that in some years there is production within the interflow zone that likely carries more nutrients (particularly in the lacustrine sections; see soluble reactive phosphorus [SRP] and DIN panels) and does not mix as well with the upper or lower layers, resulting in higher levels of supersaturation. The layers below 20 m, predominantly in the lacustrine areas of Lake Spokane (LL2 to LL0), are nutrient-enriched and light-poor resulting in very low levels of assimilation. The higher organic matter levels in the hypolimnion also result in substantially greater oxygen demand that cannot be fully met from atmospheric exchange or interflow due to limited diffusion of DO below the thermocline.

3.1.1.4.3 Phosphorus Mass Budgets

TP mass budgets were calculated for Lake Spokane by evaluating the TP loads entering Lake Spokane from the Spokane River and the Little Spokane River, and those leaving Long Lake Dam (Figure 3.12). The TP loads from the Little Spokane River entering Lake Spokane were calculated from water quality data at Ecology station at Little Spokane River near Mouth (55B070) paired with flow data at USGS station at Little Spokane River near Dartford (12431500). The TP loads from the Spokane River entering Lake Spokane were calculated from water quality data from Ecology's station at Nine Mile Bridge (54A090) paired with Avista's discharge data at Nine Mile Dam. In 2011 and 2012, water quality data at Ecology station at Little Spokane River near Mouth were not available. This data gap was filled by using TP loads calculated from volume weighted TP concentration at LL5 in Lake Spokane (approximately 2 miles below the confluence of Little Spokane River) paired with the total flow from Little Spokane River and Nine Mile Dam.

TP loads leaving Lake Spokane were calculated from water quality data at LL0 in Lake Spokane (approximately 0.4 miles above the Long Lake Dam) paired with flow data from Avista operation records at Long Lake Dam. Nutrient data at LL0 were measured at multiple depths, therefore, the surface data (at 0.5 m depth) were paired with spill flows, whenever spill flows were non-zero, and data at 15 m depth (which is near intake depth of ~10 to 15 m or ~30 to 45 feet) were paired with the turbine flows. Figure 3.12 shows that in most years when flows are high the inflow and outflow TP loads are close to each other, suggesting little retention within Lake Spokane during high flows. During the summer months, the inflow loads are consistently higher than the outflow loads in nearly all the years.

Figure 3.13 shows a summary of the TP loads entering and leaving Lake Spokane in the Jun – Oct period of each year, with the difference in outgoing and incoming loads representing the phosphorus retention during the growing season. The figure shows that TP retention in a low flow year (2015) is higher, and in high flow years (2010, 2011 and 2012) the retention is lower compared to normal flow years. This highlights the importance of growing residence time in assimilating incoming phosphorus (discussed further in Section 4.2.1).

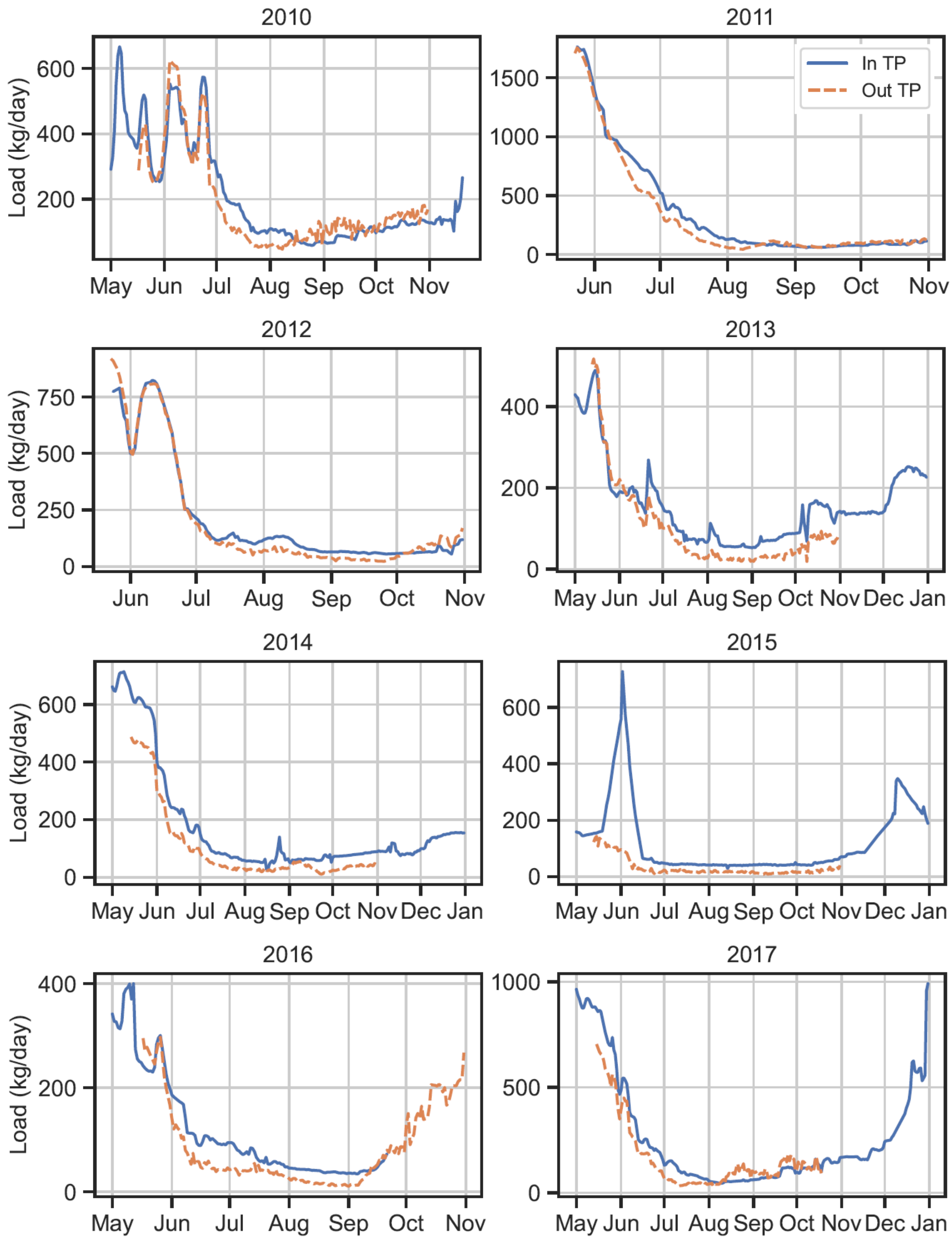


Figure 3.12. Total phosphorous inflow and outflow loads to Lake Spokane between May through December 2010-2017

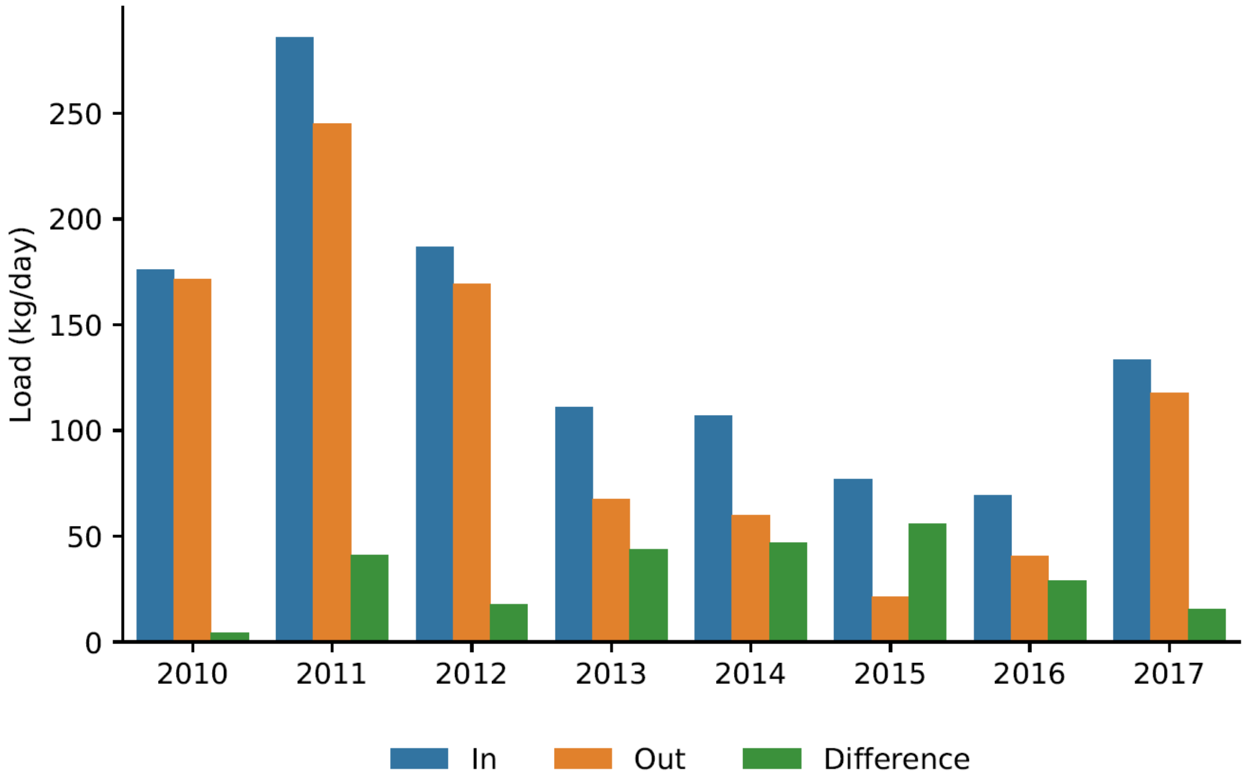


Figure 3.13. Growing season (June-October) total phosphorous inflow, outflow and difference (retention) in Lake Spokane, 2010-2017

3.2 Fish Habitat Studies

3.2.1 Rainbow Trout Habitat Assessment

Avista completed a fish population and habitat assessment in Lake Spokane in 2017 and 2018 and reported the findings in the 8-year report (Avista 2020). These studies were conducted in coordination with WDFW, and were aimed at determining fish health, fish use of the lake habitat, and correlation between fish use and ambient water quality (primarily DO and temperature).

Avista initiated a multi-year fish growth and mortality study in 2017 to understand the health of hatchery stocked rainbow trout (*Oncorhynchus mykiss*) within Lake Spokane (Section 3.2.3 discussing the annual rainbow trout stocking program within Lake Spokane). In 2017, Avista Floy-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 was calculated from lengths of tagged fish that were collected approximately a year later.

Avista also conducted an acoustic tracking study in 2017 and 2018. The 2017 study tracked 20 acoustically tagged hatchery-derived rainbow trout (14.5 – 17.5 inches in length) from July through November. The 2018 study tracked 5 additional acoustically-tagged rainbow trout from April through November. Tracking was conducted with a Lotek Wireless ® directional hydrophone with a 180-degree baffle. The tags transmitted ID, water temperature, and depth data.

The studies above concluded the following:

- Of the (small) subset of Floy-tagged hatchery rainbow trout recovered a year after release from Lake Spokane, the growth rate was estimated to be 0.52 mm/d, and the average length was approximately 15 inches.
- Acoustically tagged rainbow trout were observed to use warmer near-surface (0 – 2 m) habitat even during periods when cooler waters with DO in excess of 95% saturation was available at depth (2 – 10 m)[1].
- Early in the year (April-May), the highest densities of acoustically-tagged rainbow trout were recorded in the lacustrine section of Lake Spokane, but by early to mid-summer the highest fish densities were recorded in the upper lacustrine and transition sections of Lake Spokane (State Park's Riverside boat launch to Sportsman Paradise area) primarily in the epilimnion.

The growth rate of 0.52 mm/d equates to about 7.5 inches approximately a year after release. This is within the growth range of 5 to 10 inches after the first year for hatchery spawned rainbow trout released in the wild by WDFW (Wydoski and Whitney 2003).

3.2.2 Fish Habitat Drivers

Avista's preliminary evaluation of DO and temperature implications on fish habitat in the 8-year report indicated that in spring and early summer, temperature was generally more restrictive than DO, with DO becoming progressively more restrictive in mid-summer particularly in lacustrine zones. These analyses were expanded in the context of available habitat in the section below based on the recent guidance issued by the U.S. Environmental Protection Agency (EPA) on considering cold water habitat in lakes during the development of lake nutrient criteria (EPA 2021).

To reconcile the effects of warm temperature and low DO on fish habitat in stratified lakes, the EPA has suggested a minimum thickness of 0.3 m as the minimum refugia to consider a waterbody to be habitable for cool and cold water fish (EPA 2021). The EPA guidance document suggested an illustrative temperature threshold of 18 C for cold water species, and a 7-day average of daily minimum DO threshold of 5 mg/L. For temperature the Washington State Water Quality Standard for Lake Spokane of 1-day maximum temperature of 20°C was used rather than EPA's guidance of 18°C. A DO threshold of 5 mg/L was used for this analysis with the recognition that it is not a 7-day average. This is because the available DO and temperature data are both point measurements performed twice monthly from May-October rendering the calculation of a 7-day average of the daily minimum as infeasible from these discrete measurements. Moreover, Washington's freshwater aquatic life DO criteria are based on the daily minimum DO, rather than using a 7-day average of the daily minimum DO, and the diurnal fluctuations in the hypolimnetic DO are minimal. So, the use of the discrete data for this analysis is appropriate.

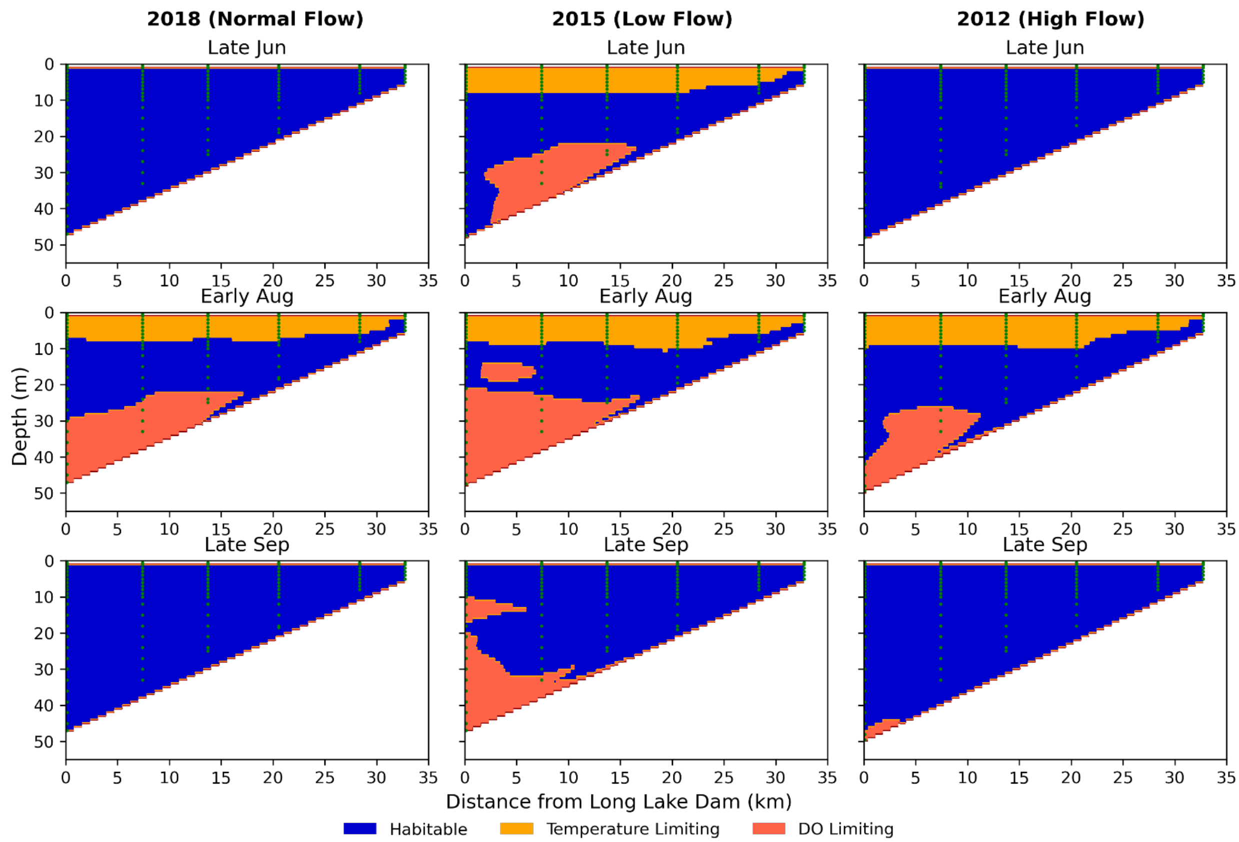
Figure 3.14a shows representative longitudinal sections from normal (2018), low (2015), and high (2012) flow years for early and mid-summer (top and middle panels) and early fall (bottom panel). These figures were constructed for each profile sampling event by interpolating the vertical profiles of

[1] Over the periods when the acoustic tagging study was conducted, the average DO saturation from 2 – 10 m between LL0 – LL3 was 105% and 108% for 2017 and 2018, respectively.

temperature and DO between successive sampling locations from upstream (LL5) to downstream (LL0), and identifying the areas that met one or both criteria. A full presentation of these habitable longitudinal sections is provided in Appendix A for all temperature and DO sampling events. Figure 3.14a shows that in early summer, regardless of the flow year a large habitable zone exists throughout the lake. The habitable zone shrinks mid-summer in most years. Conditions in early fall resemble those of early summer with a substantially large habitable zone in the mid depths of the lake. Figure 3.14a (and the figures in Appendix A) shows that conditions in the lower sections from LL1 to LL0, (closest to Long Lake Dam) remain almost entirely habitable in early summer in most years (late June and early July) while upper layers become progressively limited for temperature over this period, particularly in low flow years. In mid-to late-summer, the deeper portions of the lacustrine area of the lake become DO limited, with the severity and extent dependent on the flow conditions and the strength of thermal stratification (Section 4.2). A substantial habitable zone that meets both the temperature and DO thresholds was available even in 2015. These findings suggest that conditions in Lake Spokane are generally habitable in spring and summer, with downstream lacustrine sections of the lake becoming progressively more limited for both DO and temperature in mid- to late summer. This is consistent with the 2017-2018 rainbow trout habitat study where the density of fish progressively shifted from downstream to upstream from spring through fall (Avista 2020). It is also interesting that tagged acoustic rainbow trout tended to prefer warmer surface waters more than the interflow zone (based on their use of the upper habitat), even though the interflow zone provided better temperature and a habitable zone (based on the EPA thresholds for DO) year-round. In summary, the temperature and DO data show that while both factors affect the refuge available for fish, these effects are staggered in time and space such that there is seldom a period where the lake is completely uninhabitable even for a critical low flow year such as 2015.

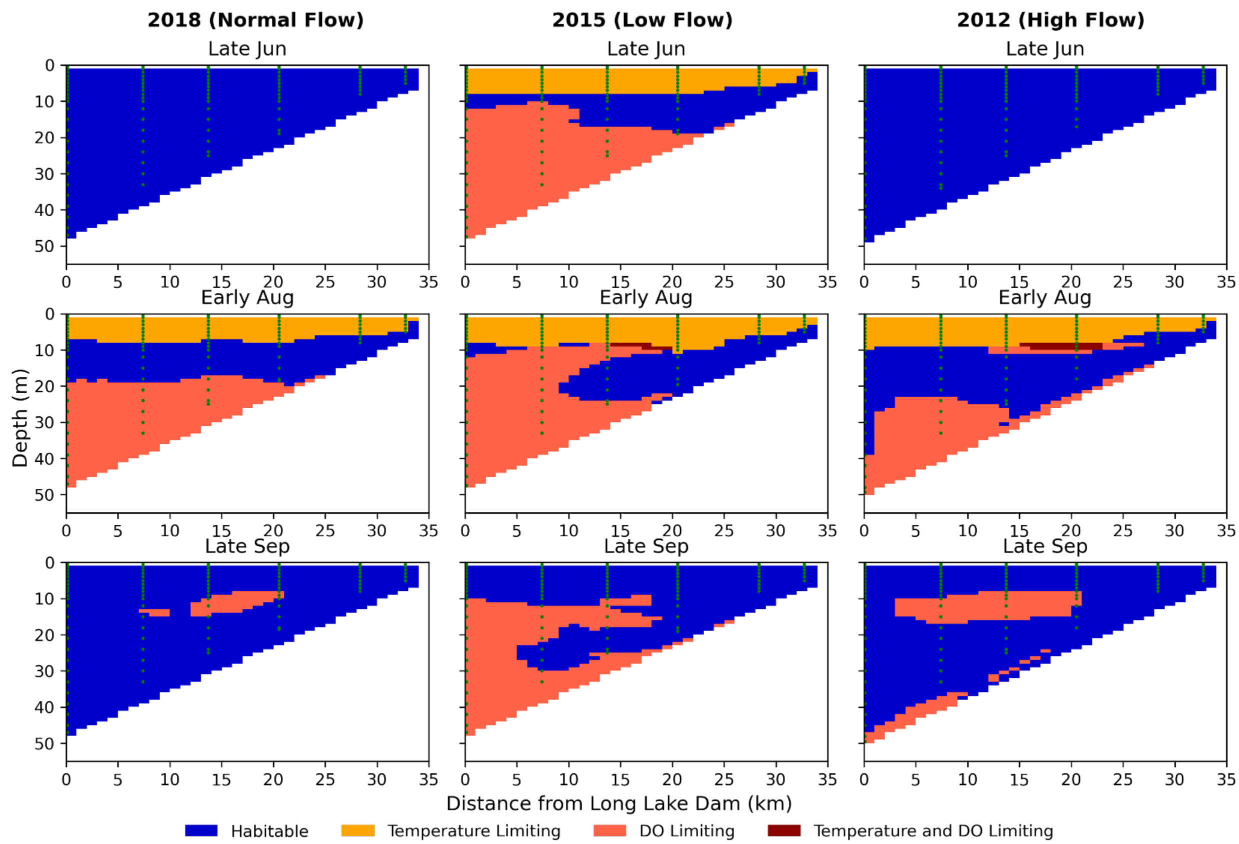
Ecology noted in its comments on the draft version of this report (Appendix C) that the DO threshold of 5 mg/L from EPA guidance is different from DO targets for Lake Spokane, which are provided in Table 7 of the DO TMDL. We note here that Table 7 targets are based on the volume weighted DO levels 8 m and below that were simulated in the CE-QUAL-W2 model run for the 2001 “No Sources” scenario minus 0.2 mg/L. The DO target based on Table 7 varies spatially and over the growing period and is always higher than the 5 mg/L EPA guidance value. Therefore, it represents a more stringent evaluation of the habitable zone. The modeling efforts that are currently being undertaken by Avista are extending this analysis for the 2010-2018 period and would provide a year-specific DO target following the approach adopted in the TMDL (see Sections 2.2 and 5.3), but these simulations have not yet been finalized and were therefore not available at the time this report was compiled. Nonetheless, to address Ecology’s comment, an alternative analysis of habitable zone using values presented in Table 7 of the DO TMDL (i.e., vol. weighted DO for 8-m and below from the “No Sources” simulation minus 0.2 mg/L) was used as the DO target instead of EPA guidance value of 5 mg/L. The result of this analysis is presented in Figure 3.14b (and the figures in Appendix B). The temperature criterion of 20°C remained the same as the analysis presented for Figure 3.14a.

The general findings are similar when using either the EPA-based or TMDL-based DO targets: conditions in Lake Spokane are generally habitable in spring and fall, with conditions in summer being the most critical. However, the alternative habitable zones shown in Figure 3.14b are at times smaller than the habitable zones shown in Figure 3.14a using EPA-based DO criteria, most notably in mid-summer (early August). In particular, in 2015, a low flow year, the higher DO threshold from Table 7 results in sections of the lake where the habitable conditions are diminished from top to bottom in mid-summer, with small portions of the water column being limiting for both. Nonetheless, there are still large areas within the lacustrine sections that meet both the temperature and the higher DO targets based on Table 7, indicating areas of refuge are still available within Lake Spokane even during critical mid-summer conditions. Furthermore, as discussed in the next section, the 2016 creel survey indicated healthy age 1+ triploid rainbow trout, suggesting that fish stocked in prior years survived through the 2015 summer (see Section 3.2.3).



Note: Habitable areas have temperature < 20°C and DO > 5 mg/L; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < 5 mg/L.

Figure 3.14a. Habitable areas for cold water fish in Lake Spokane for representative normal, low, and high flow years



Notes:
1. Habitable areas have temperature < 20°C and DO > spatially- and temporally-variable DO targets; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < spatially- and temporally-variable DO targets.
2. Spatially- and temporally-variable DO targets are 0.2 mg/L below the modeled No Source condition DO concentrations for 2001 conditions as presented in the DO TMDL Table 7.

Figure 3.15b. Habitable areas for cold water fish in Lake Spokane for representative normal, low, and high flow years

3.2.3 Rainbow Trout Stocking

Avista began implementing 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 6 inches in length) in the lake every spring. To evaluate how the fish stocking program affects the lake's recreational fishery, Avista conducted biennial creel surveys during the fishing season (March–November) in 2016, 2018, and 2020, in accordance with its Revised Lake Spokane Fishery Enhancement and Creel Survey Plan (Avista 2013) (Revised Plan). Data from the 2016 survey indicated harvested rainbow trout ranged in length from 10 to 18 inches, with 40% being 15 to 16 inches (Pinnacle 2017). The 2018 survey results indicated that the largest proportion of rainbow trout harvested were 13 and 14 inches long (Avista 2019a). Prior to rainbow trout stocking in 2014, rainbow trout were not targeted or caught by anglers as reported in the 2011 baseline study (Landau 2012). The 2018 survey results indicate that groups that targeted specific species of fish sought bass or rainbow trout and that their catching success improved by 5% from 2016 to 2018 (Avista 2019a). Avista will conduct another creel survey in 2022, in accordance with the Revised Creel Survey Plan. Avista and WDFW will complete a comprehensive evaluation of the rainbow trout stocking efforts in 2023.

Avista monitors recreation activities and visitor use at Lake Spokane to help guide management decisions and assess visitor experiences. In 2014, visitors were asked to rate their satisfaction with the number of sites and recreation facilities and experiences at Lake Spokane. Overall, 83% of visitors were “satisfied” or “very satisfied” with their outdoor experience. The most popular recreation activity on Lake Spokane is swimming, followed by boating, fishing, water-skiing, tubing or wake boarding, and canoeing and kayaking (Avista 2015b). In 2020, visitor use at Lake Spokane increased dramatically with some sites experiencing over 40% increases in recreation visits (Pinnacle 2021).

3.3 Implementation of Reasonable and Feasible Phosphorus Reduction Measures

In accordance with the DO WQAP and its Revised Implementation Schedule (Figure 1.2), 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. The following section highlights measures Avista has implemented, or assisted in the implementation of, to reduce phosphorus loading and improve DO concentrations in Lake Spokane. Table 3.4 summarizes the years’ phosphorus reduction measures undertaken by Avista.

Table 3.4. Summary of reasonable and feasible phosphorus reduction measures

Measures	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
In-Lake Measures										
Carp Population Reductions		o	o			x	x	x	x	x
Aquatic Weed Management		o								
Floating Wetland							o	o	o	
Lake Shoreline and Riparian Restoration										
Vegetative Shoreline Buffer		x	x	x	x	x	x	x	x	x
Riparian Zone Grazing Land Conservation						x	x	x	x	x
Bulkhead Removals, Lawn Area Reduction, and Native Vegetation Buffers	x							x	x	x
Watershed										
Sacheen Springs			x	x	x	x	x	x	x	x

Note: o –Study; x – Implementation

3.3.1 In-Lake Actions

3.3.1.1 Reducing Carp Populations

To investigate whether removing common 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 used to complete different components of the Phase I and II analyses, including Golder Associates, 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 2015a).

Results of the Phase I and Phase II analyses indicated 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 resuspended 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 using a combination of passive netting and electrofishing to identify the most effective way to remove carp from Lake Spokane. Netting was found to be the more successful of the two methods and was the method used exclusively in the 2018-2021 carp reduction program (Avista 2019b, 2020; Avista and Tetra Tech 2021).

Based on the results of the Lake Spokane Carp Population Abundance and Distribution Study and pilot testing in 2017, Avista worked with WDFW to remove carp from Lake Spokane from 2017 through 2021. Removal efforts primarily focused on four areas of the upper portion of Lake Spokane between McLellan Slough and Nine Mile Recreation area: McLellan Slough, Felton Slough, Sportsman's Paradise, and Nine Mile Flats (Figure 3.15). During 2020 and 2021, nets were also set at additional areas that met depth and habitat requirements to hold carp, including Willow Bay and Sunset Bay. All carp were weighed, measured, and checked for sex and maturity. All removed carp were placed into a refuse bin and transported to the Greater Wenatchee Regional Landfill for disposal.

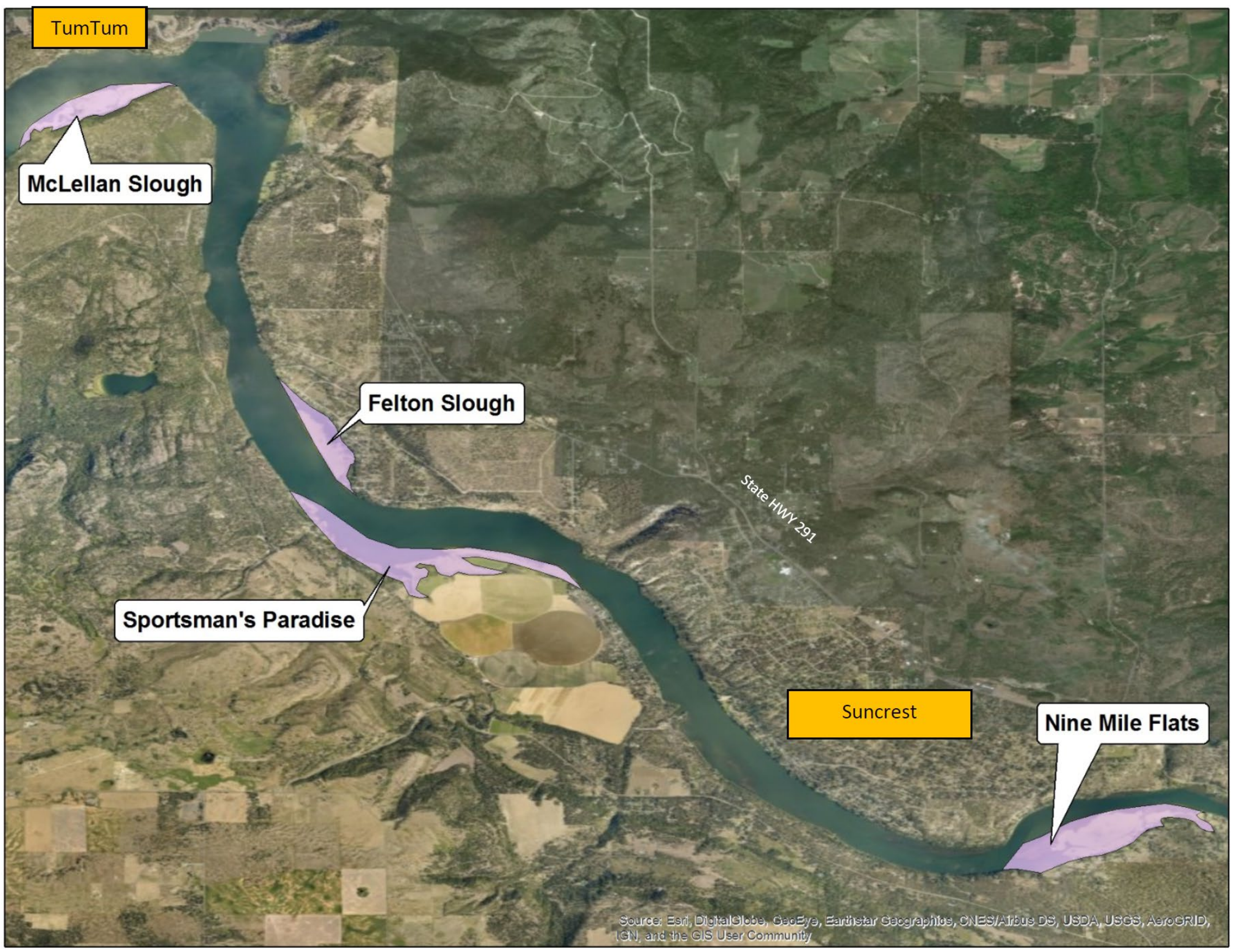


Image Source: Avista (2020).
Figure 3.16. Lake Spokane carp removal locations

Table 3.5 summarizes the number and total weight of carp collected by year and provides an estimate of total phosphate removal based on whole-body TP analysis conducted in 2014, 2017, and 2018. Between 2017-2021, a total of 22.4 tons of carp have been removed from Lake Spokane by Avista's carp reduction program. Table 3.5 shows that 1.7% of the carp biomass is phosphorus. 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 3.5. Total number and weight of carp removed from Lake Spokane, 2017-2021

	2017	2018	2019	2020	2021
Total Carp Collected	1,219	557	577	1227	951
Carp Weight Removed (lbs)	10,310	5,183	5,432	13,580	10,301
Average Total Solids (% wet wt)[1]	32%				
Average TP (% dry wt)[1]	1.7%				
TP Removed (lbs)	56	28	30	74	56

Note: 1. Average of 2014-2018 laboratory measurements

3.3.1.2 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). To evaluate harvesting aquatic plants as a viable method of reducing phosphorus in the lake, Avista completed a Phase I Analysis, which assessed whether harvesting would be a reasonable and feasible activity to perform in Lake Spokane, refined TP concentrations of relevant weed species in Lake Spokane, and 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 DO WQAP 2013 Annual Summary Report (Avista 2014). 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 has continued to implement winter drawdowns, herbicide applications at public and community lake access sites, diver aquatic weed removal, and education/outreach to control invasive/noxious aquatic weeds within the lake. Avista has, and will continue to, reassess opportunities to harvest aquatic plants to control phosphorus.

3.3.1.3 Floating Wetlands

In 2017, 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. This project is supported by an Ecology grant awarded to the SCCD, with the purpose to evaluate a floating wetlands' potential for TP removal and wave attenuation, water quality education for both SCC students and boaters, as well as to gain information on plant species growth and fish habitat. The floating wetland structures were launched, monitored, and removed in coordination with SCCD and SCC during the summers of 2018, 2019, and 2020 (Figure 3.16). Throughout the summer seasons, SCC students and Avista monitored the site for plant survivability, limited water quality parameters, presence of invasive plants, wildlife activity, fish habitat, and shoreline wave impacts.

Figure 3.17. Floating wetland structures on Lake Spokane installed in 2019

3.3.2 Lake Shoreline and Riparian Restoration

Lawn area reduction, reduced fertilizer use, bulkhead removal, and installation of natural vegetative buffers along residential properties are intended to help reduce non-point source phosphorus loading into Lake Spokane. Since 2012 Avista has pursued several avenues in restoring and maintaining riparian zones, improving land use, and educating best management practices. These actions are summarized below.

3.3.2.1 Vegetative Shoreline Buffer

Avista owns approximately 350 acres of land 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 2016b). For the most part this land is contiguous along the north and south shorelines and is managed primarily as Conservation Land. Avista has maintained a 200-foot buffer along the lake's shoreline on these properties, creating a sediment-filtering effect.

To enhance the vegetative buffer, reduce erosion, and provide shade, Avista began a tree planting program in 2013, planting trees and shrubs along Avista-owned shoreline on a 2-year cycle. Since 2013 more than 14,000 seedlings, bushes, and tress have been planted. The potential phosphorus loads that have been avoided by maintaining a 200-foot vegetative buffer along the shoreline have not been identified.

3.3.2.2 Grazing Land Conversion

As early as 2009, Avista identified 215 acres of Lake Spokane property that the Washington State Department of Natural Resources (DNR) leased for cattle grazing. Avista and the Washington State Parks and Recreation Commission pursued a lease for the 215 acres of land from DNR with the intent of changing the land use. Following a robust, multiyear negotiation, DNR leased the property to the Washington State Parks and Recreation Commission starting in 2017 for public recreation, eliminating livestock grazing on this Lake Spokane shoreline property.

Phosphorus load reduction estimates for converting grazing land use to conservation are identified in the DO WQAP. Avista and Ecology discussed quantification of phosphorus removal from the conversion of land use, however, were unable to reach consensus on phosphorus reduction amounts due to the complexities associated with incorporating land and soil types.

3.3.2.3 Lawn Area Reduction and Bulkhead Removal

Lawn area reduction, reduced fertilizer use, bulkhead removal, and installation of natural vegetative buffers along residential properties are intended to help reduce non-point source phosphorus loading into Lake Spokane. Since 2012, Avista has partnered with local and state agencies and homeowners to identify, encourage, and implement projects to convert bulkheads or lawns to more naturalized shorelines. Additionally, Avista participated with others to support passage of a Washington law, 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 has been an important tool in reducing phosphorus loads to the lake (Section 3.3.2.4).

In 2012, a 90-foot bulkhead was replaced with a natural shoreline (Staggs Project). Avista and SCCD worked from 2013 to 2017 to secure permits and plans for a native shoreline installation project on

Avista-owned property on Lake Spokane, which was not able to be completed. In 2019, another 90-foot bulkhead was replaced with a bioengineered vegetative wall and buffer (Wright Project). Avista has worked with multiple landowners interested in these projects but ultimately, with the associated costs and permitting, many choose other, cheaper ways of improving their waterfront property.

3.3.2.4 Education and Outreach

Avista has targeted education and outreach to raise awareness of non-point sources entering the lake and how shoreline best management practices can have a positive impact on water quality.

Avista has been actively involved, educating the public since 2013 in best shoreline management practices by creating public education documents, regularly managing a booth and presenting at the Northern Idaho/Eastern Washington Annual Lakes Conference, and educating Lake Spokane High School students through SCCD Best Management Implementation Project, funded by an Ecology grant. Additionally, Avista features articles in the Lake Spokane Association (LSA) Spokane River Newsletter and the LSA Facebook page in addition to other venues such as the Spokane Indian Baseball team newsletter, *Protecting the health of our waterways* (myavista.com).

Avista also worked with WDFW and Ecology in 2019 to produce two educational videos focused on natural shorelines and how to properly install a bottom barrier to control nuisance aquatic weeds. The two videos are available for viewing at Shoreline Health (myavista.com). Avista additionally participated in a video produced by WDFW regarding carp removal in Lake Spokane, available for viewing at Carp and Pike Removal on Lake Spokane, Washington - YouTube.

3.3.3 Watershed Actions

Wetland acquisition, restoration, and enhancement was identified in the DO WQAP as a reasonable and feasible measure. Wetlands can increase the deposition of sediments and their attached phosphorus along with increasing the uptake and retention of phosphorus by emergent wetland plant species. In 2012, Avista pursued acquisition or permanent protection of a 43-acre wetland area downstream of Nine Mile Dam, in the vicinity of the Spokane River and the Little Spokane River confluence. Due to landowner complications Avista was unable to acquire this property but since 2012, Avista has purchased and enhanced over 1,600 acres of wetlands and associated uplands within the Spokane River drainage. Avista is in the third stage of implementing a Five-Year Wetland Plan with the Coeur d'Alene Tribe for Hangman Creek, Alder Creek, and Benewah Creek properties within the Coeur d'Alene Reservation.

The potential phosphorus load reduction from wetland acquisition, restoration, and/or enhancement is described in the DO WQAP. Avista and Ecology discussed quantification of phosphorus removal from its wetland acquisition and implementation activities over the last few years, however, were unable to reach consensus on phosphorus reduction amounts due to the complexities associated with incorporating the property's distance from Lake Spokane, land and soil types, types of wetland enhancement/restoration activities, etc.

3.3.3.1 Sacheen Springs Wetlands

In 2013, Avista acquired the 109-acre Sacheen Springs property, located on the west branch of the Little Spokane River. This property contains over one-half mile of frontage along the West Branch of the Little Spokane River and consists of a highly valuable wetland complex with approximately 51 acres of emergent, scrub-shrub, and forested wetlands and 58 acres of mature upland forest. Avista completed a site-specific wetland management plan and implemented it upon Ecology and FERC's approval in 2014. The property was protected in perpetuity when it was put into a conservation easement with the Inland Northwest Land Conservancy in 2018.

Herbicide application to control terrestrial invasive weeds was completed in 2014, 2015, and 2016 to improve the overall biodiversity and function of the wetland property. Since 2014 Avista has continued to maintain and monitor Sacheen Springs by: (a) completing the Sacheen Springs Wetland Five-Year Monitoring Report 2014-2018 (Anderson 2019); (b) continuing herbicide treatment to invasive weeds; (c) constructing a new gate with a wing fence across the road along the Avista property boundary; (d) removing 600-feet of old three-strand barbed wire fence along the property boundary; (e) finalizing a conservation easement on the property with the Inland Northwest Land Conservancy in August 2019; (f) thinning the understory of approximately 0.5 acres of the mature upland forest to remove ladder fuels and promote forest health; and (g) developing a primitive trail along the interface of the wetland and mature upland forest.

3.3.3.2 Hangman Creek Wetlands Supporting Watershed Activity

The following activities were conducted to support watershed activity but not as part of the DO WQAP reasonable and feasible measures. Avista and the Coeur d'Alene Tribe have acquired approximately 1,519 acres on upper Hangman Creek since 2011, within the southern portion of the Coeur d'Alene Tribe Reservation in Idaho, approximately 10 miles east of the Washington-Idaho Stateline. The Hangman Creek wetland complex contains over 15,000 linear feet of Hangman Creek, flowing north and west through the complex then continuing along its northwest course for approximately 63 miles until it meets with the Spokane River just west of the City of Spokane.

Prior to the tribe's acquisition of the Hangman Creek wetland complex, portions of the land were in agricultural use, and streams had been straightened to maximize farming yields. Avista and the Coeur d'Alene Tribe implement the Coeur d'Alene Reservation Hangman Creek Site Management Plan (Avista and the Coeur d'Alene Tribe 2020), which focuses on establishing long-term, self-sustaining native emergent, scrub-shrub and/or forested wetlands, riparian habitat, and associated uplands, through preservation, restoration, and enhancement activities.

Since 2013, approximately 20,578 native tree and shrub species have been planted on this wetland complex. Other wetland management activities included noxious weed herbicide treatments, construction of fence enclosures to protect seedlings, and monitoring survival of the seedlings planted as well as wetland functionality.

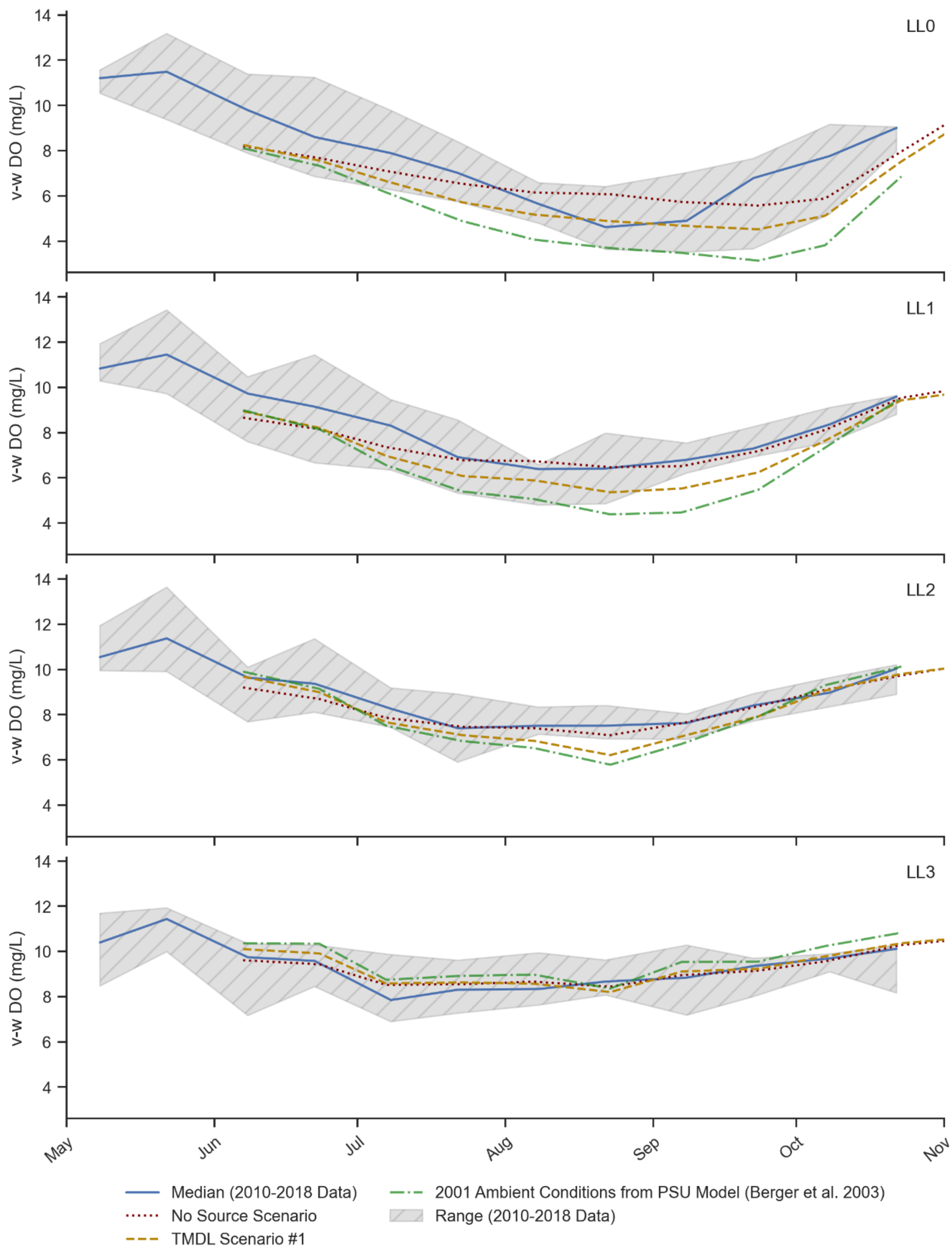
4 Synthesis of Dissolved Oxygen Drivers in Lake Spokane

Avista's in-lake and watershed actions are evaluated in the context of DO changes in the Lake. The 8-year report provided various detailed analyses of the changes in DO drivers within Lake Spokane (Avista 2020). These factors are summarized here and further evaluated to refine the conceptual model of DO drivers.

4.1 Dissolved Oxygen Improvements in Lake Spokane

Avista's in-lake and watershed actions in reducing phosphorus began in 2012 and continued through 2021 (Section 3.3). The most significant in-lake actions that are likely to have an immediate reduction in phosphorus occurred in 2017-2021 (carp removal and riparian zone grazing and land conservation). Watershed management actions (acquisition of Sacheen Springs) began in 2014 and continue to present. However, it is difficult to separate out the effect of removal actions from the ambient phosphorus levels entering the lake. To provide a more accurate quantification of these actions on the lake's DO, a more rigorous mechanistic evaluation will be required (Section 5).

To better understand the overall DO conditions in the lake relative to the improvements anticipated in the DO TMDL, the longitudinal DO changes (8 m and below) observed from 2010-2018 were compared to the corresponding DO levels predicted in the 2001 DO calibration run performed by Portland State University (Berger et al. 2003; Figure 4.1). The 2001 DO run shows the ambient DO conditions in the lake based on the nutrient loads as they existed at that time. The corresponding 2001 target DO levels from the TMDL Scenario #1 and No Sources Scenario (Ecology 2010b,c; Figure 4.1), which are simulated based on the 2001 hydrological and meteorological conditions, are also shown for reference. It is important to recognize that TMDL Scenario #1 and No Sources Scenario targets will be different for each year from 2010-2018 and must be estimated through mechanistic simulations of the TMDL Scenario #1 and No Source Scenario loads, with the corresponding hydrological and meteorological conditions for that year (Avista is presently undertaking a modeling effort that would complete these simulations; Section 5). Nonetheless, the 2010-2018 median and range of ambient DO levels in the lake provide useful comparisons to the anticipated improvements targeted in the TMDL because, as discussed in Section 3.3.1, the range of flows represented in the 2010-2018 period includes a year (2015) with flows even lower than the 2001 low flow for the June-October critical period.



Notes: Median (blue line) and range (gray shaded area) of DO were calculated from 2010-2018 data. No Source and TMDL #1 Scenarios are from Table 7 of Ecology 2010c. 2001 Calibration run (green line) is from Berger et al. 2003.

Figure 4.1. Comparison of minimum volume-weighted dissolved oxygen for the June-October period for years with and without Avista's phosphorus removal actions

The following observations (moving from upstream to downstream) can be deciphered from Figure 4.1:

- At the transition zone from riverine to lacustrine (LL3), the 2001 model simulation showed that the ambient conditions were higher than both the corresponding TMDL Scenario #1 and the No Sources Scenario simulations. Furthermore, the 2001 No Sources Scenario is lower than the TMDL Scenario #1 throughout the June-October critical period. This higher DO in the transition zone is indicative of the higher assimilation of the incoming phosphorus from primary production in the upper riverine zone with concomitantly supersaturated DO levels that plunge into the metalimnion (typically depths below 10 m) as it enters the transition zone resulting in an overall higher DO. Because the incoming TP loading decreases progressively from the 2001 calibration run to the TMDL Scenario # 1 and the No Sources Scenario, the least amount of primary production in the riverine zone occurs in the No Sources Scenario with correspondingly lower DO supersaturation. The ambient conditions for the 2010-2018 period reflect load reductions from ongoing watershed and point sources actions upstream. This is evident in the median DO levels, which are well below the 2001 ambient condition predicted in the DO model. The lower median DO levels indicate lower primary production in the riverine section (a reflection of the change towards oligo-mesotrophic conditions relative to the meso-eutrophic conditions of the past; Section 4.2).
- In the lacustrine zones of Lake Spokane (LL2 through LL0), the 2001 model simulated DO levels are consistently lower than the corresponding TMDL Scenario #1 and No Source Scenario, with the differences getting larger over the summer months and diminishing in early fall when turnover resulted in meeting the DO demand. The median 2010-2018 ambient DO data show that conditions in the lake are consistently better relative to 2001 ambient conditions. In all locations the median DO levels are higher than the 2001 conditions throughout the June-October period, with even the lower bound of the DO range (reflective of 2015 conditions) plotting above the 2001 ambient condition simulation from mid-summer onwards. This shows the overall improvements in the DO levels in the lake.

The discussion above shows that, while it was difficult to isolate the effects of Avista's actions, the DO levels in the lake have nonetheless shown considerable improvements from the past. A more detailed consideration of the monitoring data collected in the DO WQAP is presented in Section 4.2 to improve the conceptual understanding of the factors that drive DO levels. In Section 5, a more detailed mechanistic evaluation of Avista's actions is proposed as a next step to identify actions that would have the greatest DO impact in the lake.

4.2 Primary Factors Affecting Dissolved Oxygen

4.2.1 Flow

Flow is a fundamental driver of water quality. During the growing season (June-October; Section 3) the reservoir volume is relatively constant because the water surface elevation does not change appreciably. Thus, flow is the primary determinant of both whole lake and euphotic residence times.[2] Residence time in turn affects how much of the incoming nutrients are assimilated within the lake through primary production and how much of the associated detrital organic matter generated within the lake reaches the bottom waters and influences DO. Residence time (along with the withdrawal depth) also affects the strength of thermal stratification, which in turn affects mixing between the oxygen-rich surface waters and oxygen-poor bottom waters.

Figure 4.2 shows a comparison of the growing season residence times within Lake Spokane for the whole lake (all 24 miles), lacustrine (bottom 13 miles) and the riverine/transition zones (upper 11 miles), for the entire water column, as well as only for the top 11 m. The figure shows that the lacustrine zone, despite covering approximately 55% of the length, does not differ appreciably from the whole lake residence time because of the volume of water stored within this zone. The residence times in the top 11 m for both the lacustrine zone and the whole lake makes up a portion of the residence time over the entire water column (55% and 60% respectively), whereas in the transition/riverine zone, there is not an appreciable difference between the two (top 11 m represents about 90% of the residence time relative to the entire water column) because of the relatively shallow nature of the latter. Finally, the residence times show that in most of the years, the incoming dissolved phosphorus loads flush through the transition zone in approximately 5 days, whereas phytoplankton have nearly 3 times as long within the euphotic zone of the lacustrine sections of the lake to assimilate the incoming phosphorus. In addition, phytoplankton produced within the riverine/transition sections are more likely to get transported and settle within the lacustrine zone because of the longer time (and hence lower velocities) that would allow for settling.

The implications of the growing season residence times on the hypolimnetic (bottom 15 m) DO were presented in the 8-year report (repeated as Figure 4.2 herein). When the residence times are viewed in light of the flow categorizations presented in Section 3.1.1. (Table 3.2), it is evident that low flow years such as 2015 have a large impact on the minimum DO by exacerbating the assimilation time for nutrients within the lake. Conversely, high flow years (2011-2012) have higher minimum DO and correspondingly lower residence times. The normal years are clustered within a relatively narrow band both in terms of residence time (~30-40 days) as well as minimum DO (~5.7- 6.3 mg/L). 2010 is classified as a low flow year based on Water Year, but as a high flow year relative to growing season. This indicates that in some years other factors such as temperature (Section 4.2.5) may have been more influential. Finally, Figure 4.2 also illustrates that for the same range of residence times (30 to 40 days), the range of minimum DO observed in the 1970s and 1980s was significantly wider (~1 to 5 mg/L or a net range of 4 mg/L) than the post-2010 period (which shows a range 5.7 – 6.3 mg/L, or a net range of <1 mg/L). This suggests that for a similar residence time for assimilating the incoming phosphorus, the higher levels of incoming phosphorus in 1970s and 1980s likely had a much more profound effect on DO than the low levels of incoming phosphorus in the post-2010 period.

[2] Residence time = volume/flow. For this discussion, the top 11 m was assumed to be the euphotic zone. Lake Spokane's average Secchi Depth of about 5 m translates to a euphotic depth of about 13 m. Ecology's QAPP for Lake Spokane (Ecology, 2010a) considers the euphotic zone as the top 10 m which is comparable.

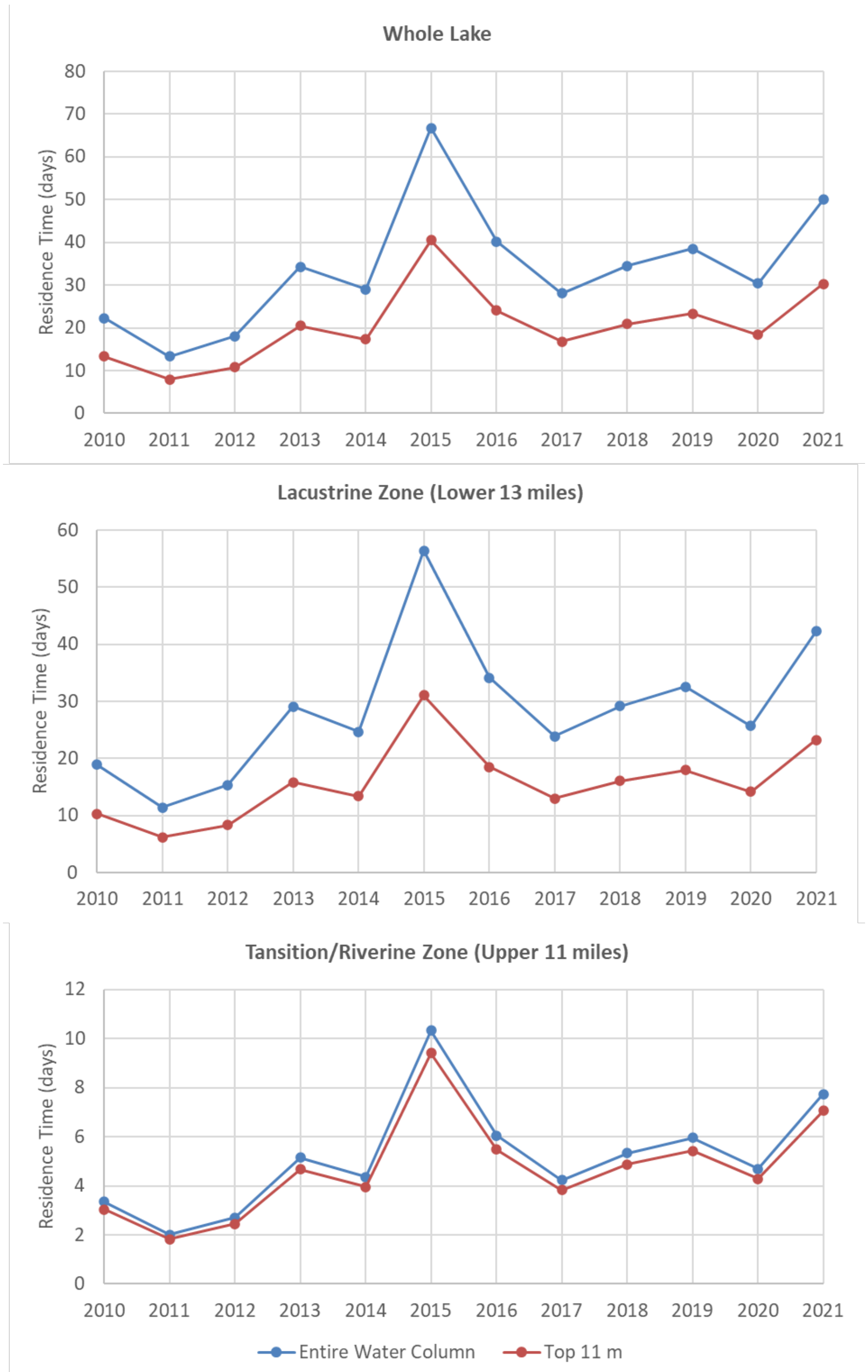
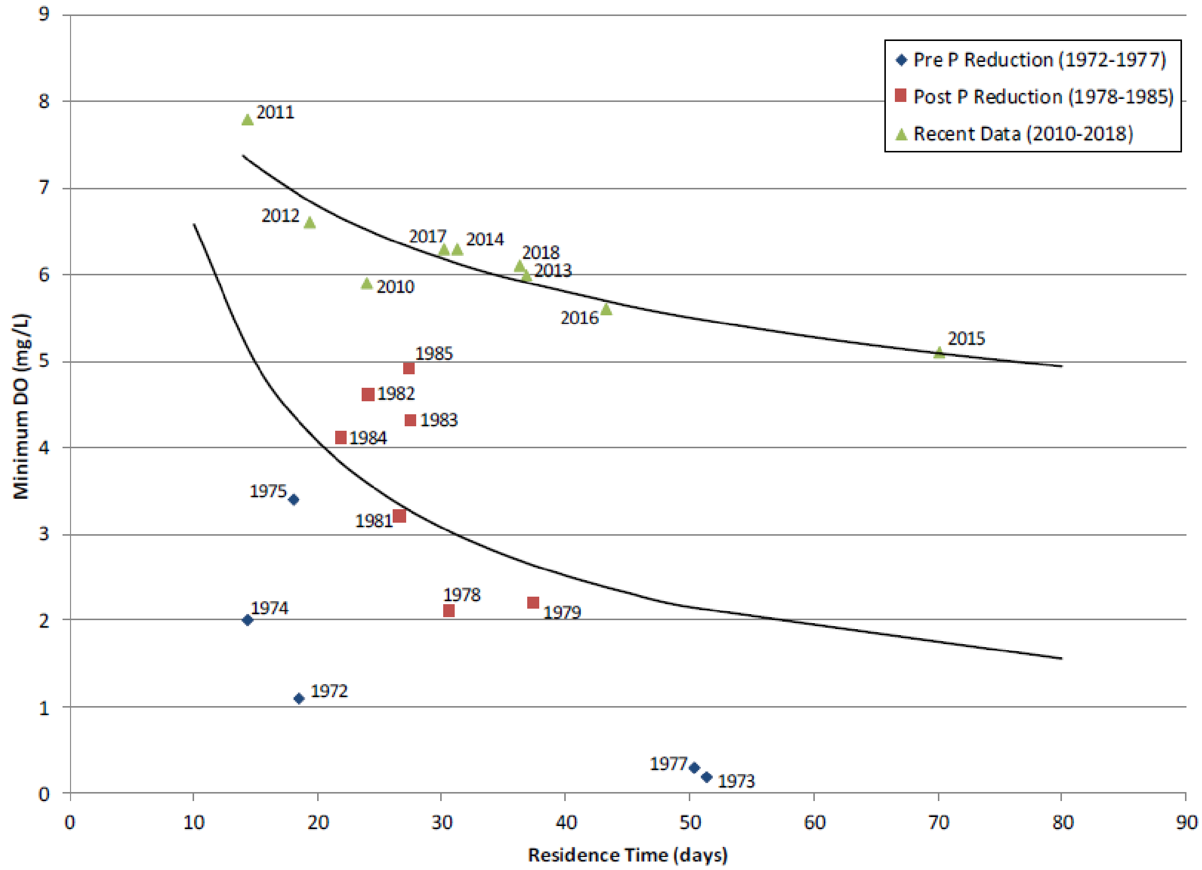


Figure 4.2. Comparison of growing season (June-October) residence times in whole lake, lacustrine, and transition/riverine zones in Lake Spokane from 2010-2021

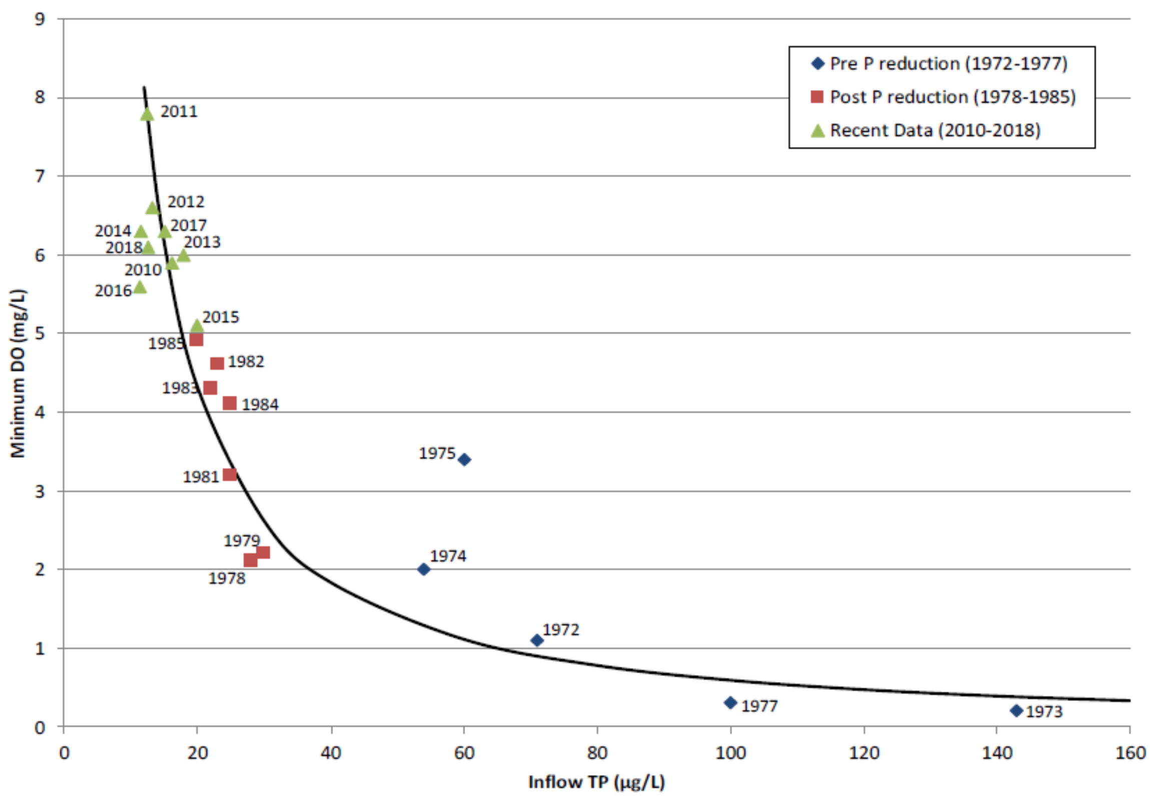


Note: This figure was presented as Figure 13 in the 8-year report (Avista 2020).

Figure 4.3. Relationship between June-October residence time and minimum volume-weighted hypolimnetic (below 15 m) dissolved oxygen

4.2.2 Incoming Phosphorus

The 8-year report undertook a detailed analysis of the implications of the changes in incoming phosphorus loads to Lake Spokane. The analysis indicated that historical (pre-TMDL) reductions had a substantial impact on the volume-weighted DO in the growing season (Figure 4.4). This conclusion was based on the fact that the post-2010 incoming phosphorus levels are already low (between 10–20 µg/L), and the residence time also has a significant influence on the minimum DO relative to the actual incoming phosphorus concentration (Figure 4.4). There is a noticeable reduction in incoming TP in 2021 which also coincides with phosphorus treatment upgrades coming online in (June) 2021. The average June-October incoming TP at Nine Mile Bridge from 2010-2020 was 14 ug/L (standard deviation 1.5 ug/L); and in 2021 it was 7.3 µg/L.



Note: This figure was presented as Figure 12 in the 8-year report (Avista 2020).

Figure 4.4. Correlation between average June-October incoming total phosphorous concentrations to Lake Spokane and the minimum volume-weighted hypolimnetic dissolved oxygen

The analysis in the 8-year report was further expanded to consider the effects of flow and the assimilation that occurs both upstream and within Lake Spokane. For these analyses, the volume-weighted DO averages were calculated for 8 m and lower (Table 7 of the DO TMDL [Ecology 2010b,c]). Therefore, these are slightly different from the hypolimnetic (15 m or lower) volume-weighted average DO concentrations presented in the 8-year report (Figures 4.5 and 4.6). Table 4.1 shows the data used for the additional analyses.

Table 4.1. Summary of June-October average observed and derived data used in the analysis of dissolved oxygen drivers

Year	Average Flow at Long Lake Dam[1] (cfs)	Flow Classification[2]	Whole Lake Residence Time[3] (days)	Vol. Wt. Incoming TP[4] (µg/L)	Vol. Wt. Incoming SRP[4] (µg/L)	Proportion of Incoming Bioavailable Phosphorus (%)	Max. Surface to Bottom Temperature Difference[5] (°C)	Minimum DO[6] (mg/L)	Lake-wide Average Chlorophyll-a[7]	Lake-wide TP Retention[8] (%)	Observed AHOD ($g/m^2/d$)	Estimated AHOD[9] ($g/m^2/d$)	Predicted Chlorophyll-a[10] (ug/L)
2010	4,676.8	HIGH	22.2	17.7	9.4	53%	6.5	5.9	4.5	3%	0.54	0.34	6.5
2011	7,791.0	HIGH	13.4	14.1	8.4	59%	5.5	7.4	3.0	14%	0.67	0.31	5.4
2012	5,768.3	HIGH	18.0	13.6	3.5	25%	7.1	6.5	4.4	9%	0.85	0.30	5.3
2013	3,039.0	NORMAL	34.2	15.2	8.9	58%	7.6	5.9	3.8	39%	0.58	0.32	5.8
2014	3,580.4	NORMAL	29.1	12.5	7.3	58%	7.4	6.1	4.5	44%	0.71	0.29	4.9
2015	1,596.2	LOW	66.7	16.7	7.7	46%	11.3	5.3	5.2	72%	0.56	0.33	6.2
2016	2,587.6	NORMAL	40.2	11.3	6.2	55%	6.4	5.8	3.9	42%	0.48	0.27	4.5
2017	3,701.4	NORMAL	28.1	14.1	7.9	56%	7.0	6.3	4.1	12%	0.66	0.30	5.4
2018	3,085.5	NORMAL	34.5	12.7	7.9	62%	6.5	6.1			0.74	0.29	5.0
2019	2,767.6	NORMAL	38.5	14.0	6.7	48%						0.30	5.4
2020	3,508.1	NORMAL	30.4	13.9	7.6	55%						0.30	5.4
2021	2,351.6	LOW	50.0	8.6	3.9	45%						0.24	3.6

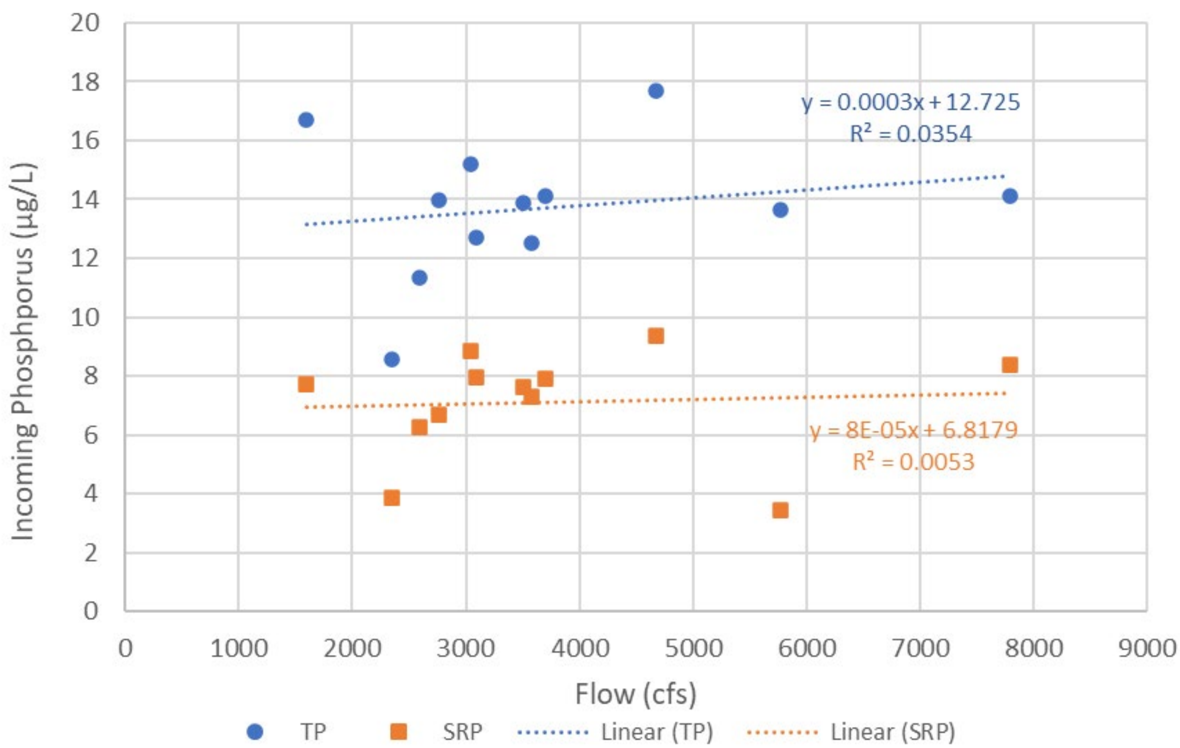
Notes:

1. Combined spill and generation discharge at Long Lake Dam.
2. Normal flows are in the inter-quartile range of the June-October flows from 1992 to 2021, high flows are above the upper quartile, and low flows are below the lower quartile (Section 3.3).
3. Computed as reservoir volume derived from 2019 bathymetry data divided by the total discharge at Long Lake Dam.
4. Flow weighted by Nine Mile and Little Spokane River inflows; for 2010-2011, Ecology data were not available below Nine Mile Dam; therefore, the volume-weighted average concentration at LL5 and combined discharge of Spokane River below Nine Mile Dam and Little Spokane River were used.
5. Surface = average of top 5 m (epilimnion); bottom = 15 and lower (hypolimnion). Differences are based on paired data.
6. Volume weighted by paired depth profile data 8 m and below (consistent with the approach used for Table 7 of the DO TMDL) and computing the minimum over all sampling events between June-October.
7. Euphotic zone (0 to 10 m) average computed as by volume-weighting by depth first, and volume-weighting by location next (LL0 to LL5), and then averaging over June-October.
8. June-October retention expressed as percentage (Figure 3.14).
9. From Section 2.2.2, Page 31 of the 8-Year Report (Avista 2020).
10. Based on phosphorus loading-chlorophyll-a relationship from Bartsch and Garkstatter (1978) as reported in Chapra (1997).

4.2.3 Correlation with Flow

Figure 4.5 shows the correlation between the flows and incoming phosphorus in Lake Spokane. The analysis uses the total discharge at Long Lake Dam to maintain consistency with Table 4.1, rather than using the inflows (sum of the Little Spokane River and discharge from Nine Mike Dam). As is evident from Figure 3.2, Lake Spokane June-October discharge is dominated by Nine Mile Dam outflow, and there isn't an appreciable difference in the flow patterns between Nine Mile Dam and Long Lake Dam outflows because of the steady water levels maintained in Lake Spokane over this period.

Figure 4.5 illustrates that the steady incoming total and soluble reactive phosphorus concentrations in summer months (see also Figure 3.10), are not strongly correlated with the flows. This suggests runoff-based sources from the watershed are not dominant over this period. Rather, the phosphorus is more likely dominated by point sources and low-flow non-point sources (such as groundwater).



Note: Flow and concentration data shown are from 2010-2021. Incoming concentrations are flow-weighted averages from Ecology's long-term stations at Little Spokane River and Ninemile Dam. Flows represent discharge at Long Lake Dam.

Figure 4.5. Correlation between June-October average flow at Long Lake Dam and incoming phosphorus to Lake Spokane

4.2.4 Bioavailability

From 2010-2018, the SRP was approximately 50% of incoming TP, but varied from 25% (in 2012) to 62% (in 2018). Except for 2012, bioavailability in the other years was notably similar (range of 46 to 62%). There was no apparent correlation between flow and incoming proportion of SRP (R^2 = 0.03) even after excluding 2012 data (R^2 = 0.17). This indicates that during the June-October period, approximately half the incoming TP to Lake Spokane in the summer is bioavailable regardless of flow. Secondly, the minimum volume weighted DO shows no apparent correlation regardless of the incoming form of phosphorus (R^2 = 0.01 for SRP and R^2 = 0.06 for TP; Figure 4.6). When viewed in light of the strong correlation between summer residence times and minimum DO (Figure 4.3; the log-linear fit has an R^2 of 0.8), in-lake conditions may likely be more important in determining minimum DO compared with external phosphorus loading during June-October period.

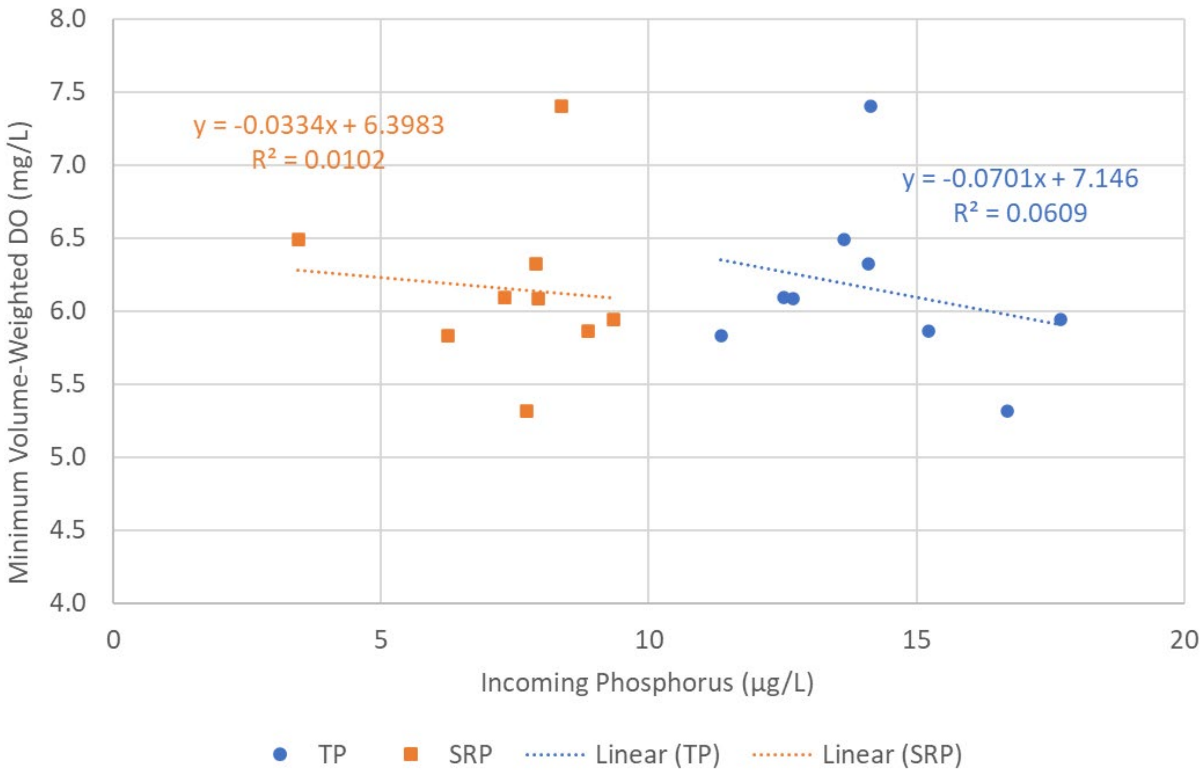


Figure 4.6. Correlation between minimum volume-weighted hypolimnetic dissolved oxygen (below 8 m) and forms of incoming phosphorus for the post-2010 period

4.2.5 Winter Runoff

A related analysis to the incoming summer phosphorus is the amount of organic matter brought in during high flows in winter, which may be deposited within the lake and cause a hypolimnetic oxygen demand in the growing season. Figure 4.7 illustrates the correlation between November (from prior year) – May (of current year) flows versus the Jun-Oct volume-weighted minimum hypolimnetic DO in Lake Spokane. The winter flows are used rather than incoming total suspended solids because the latter are available at the Ecology stations in the winter months only from 2018 onwards and only limited data are available from 2010-2017 when the majority of the growing season DO data were collected. Figure 4.7 shows a weak correlation with winter flows suggesting that winter organic matter loading may have an influence in the subsequent growing season. In contrast, there is a strong correlation (R^2 = 0.86) between the incoming flow and the volume-weighted DO in the summer (orange dots and corresponding trend line in Figure 4.7), indicating the importance of growing season flows as a major driver of growing season volume-weighted hypolimnetic DO.

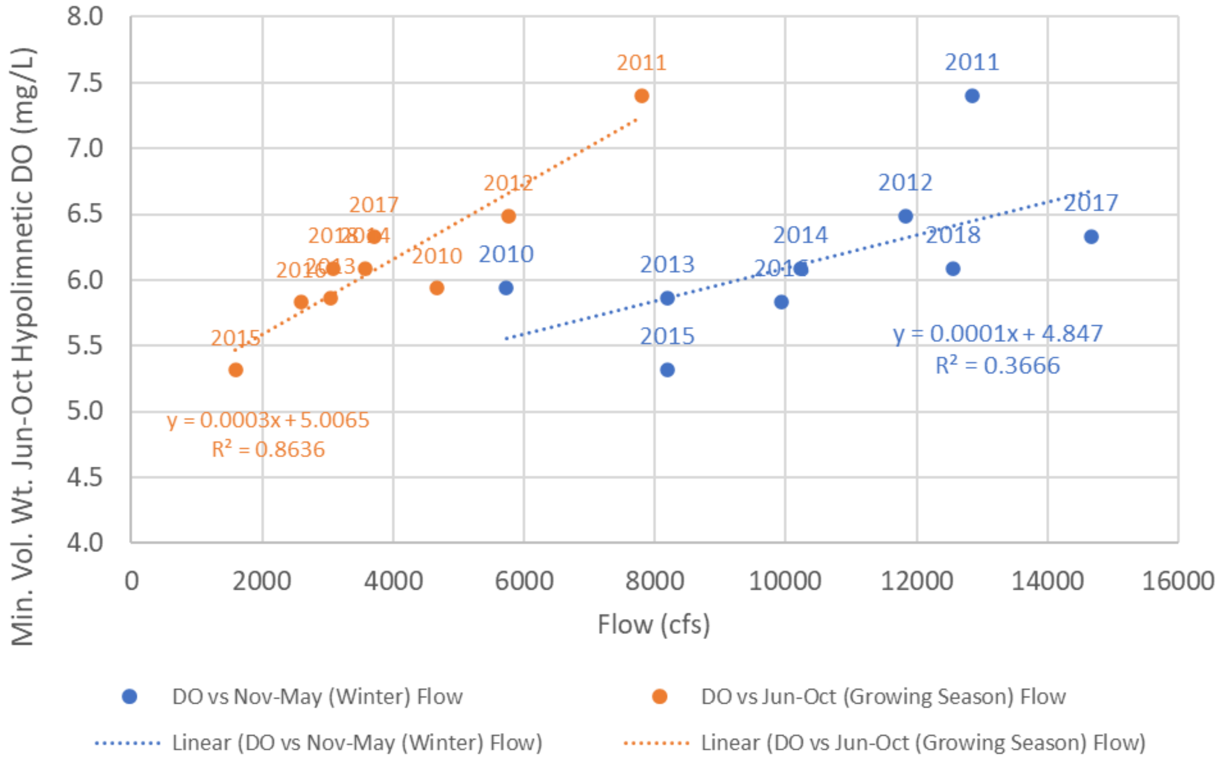


Figure 4.7. Correlation between June-October minimum volume-weighted hypolimnetic dissolved oxygen (below 8 m) and winter (November – May) flows for the post-2010 period.

4.2.6 Stratification

The influence of thermal stratification was evaluated for correlation between the maximum difference in the paired, volume-weighted epilimnion (0 to 5 m) and hypolimnion (15 m and lower) temperatures for the lacustrine portion of the lake and the minimum volume-weighted DO for the June-October period (Figure 4.8). The maximum temperature difference provides an indication of how strong the temperature stratification was for the year. A strong thermal stratification will limit mixing between the oxygen rich epilimnion and the oxygen poor hypolimnion to a greater extent. Figure 4.8 shows that there is a moderate correlation between stratification and minimum volume-weighted DO. Thermal stratification in a storage reservoir is driven primarily by the morphometry, flows (and hence residence time), and atmospheric heat exchange. A cursory comparison to the residence time suggests that strength of thermal stratification in Lake Spokane does indeed exhibit a moderately strong correlation (Figure 4.9). In particular, in years with a strong flow signature (high [2011] or low [2015]) a proportional (weak [2011] or strong [2015]) response in stratification is evident.

The similarity in the correlations between temperature and DO to residence time indicates the importance of physical drivers (flow, morphometry, and atmospheric heat flux) and internal factors (stratification and associated limited mixing that exacerbates the oxygen demand from benthic respiration).

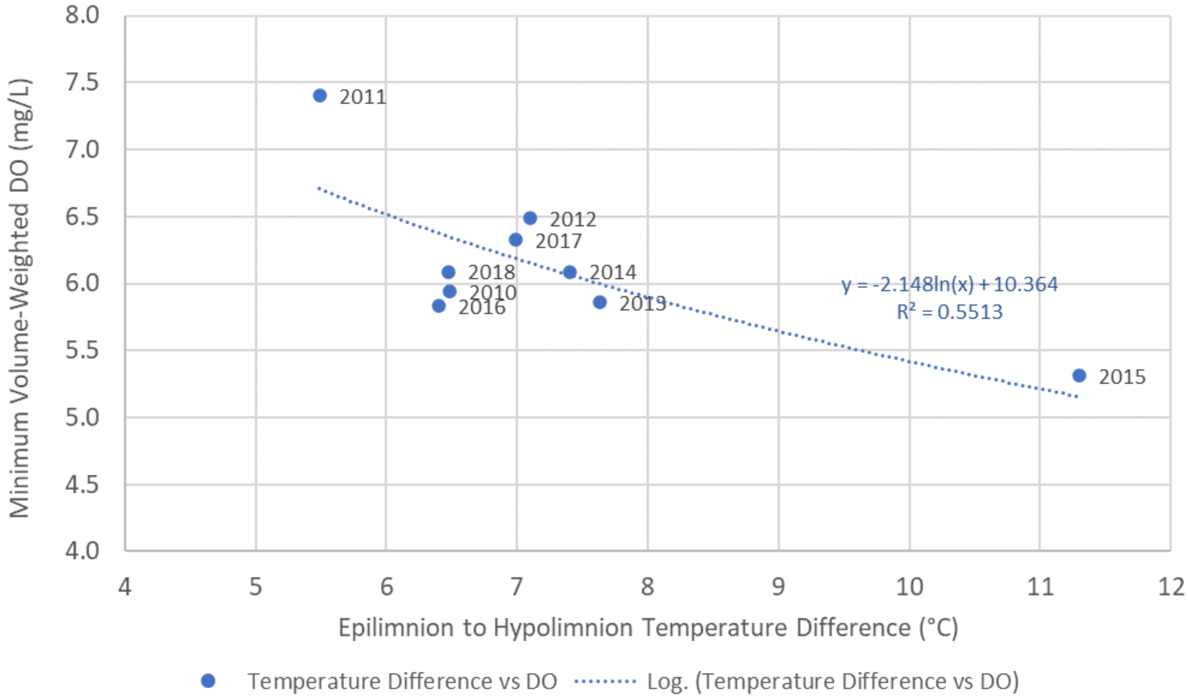


Figure 4.8. Relationship between stratification and minimum volume-weighted dissolved oxygen (below 8 m)

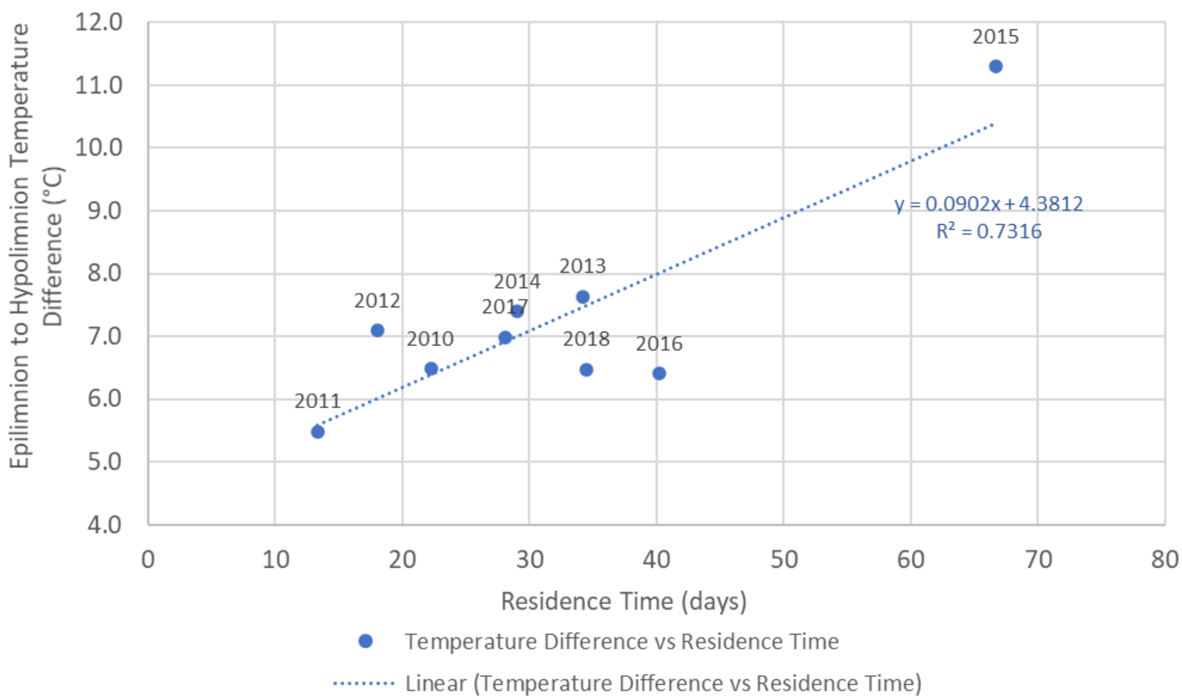


Figure 4.9. Relationship between residence time and thermal stratification

4.2.7 Hypolimnetic Oxygen Demand

The 8-year report presented an analysis of the areal hypolimnetic oxygen demand (AHOD) as a metric to evaluate improvements within Lake Spokane. AHOD evaluates the oxygen depletion within the hypolimnion, which is a result of both water column (from settling detrital organic matter) and sediment oxygen demand (from freshly settled as well as historically deposited organic matter). The range of AHOD within Lake Spokane from 2010-2017 is 0.54 – 0.85 g $m^{-2}d^{-1}$ and an average AHOD of 0.63 g $m^{-2}d^{-1}$ (Avista 2020). The range of AHOD for mesotrophic lakes is estimated to be 0.25 – 0.55 g $m^{-2}d^{-1}$ (Wetzel 2001). This suggests that Lake Spokane is likely meso-eutrophic.

The 8-year report also presented a detailed trophic state analysis of Lake Spokane based on other water quality parameters including TP, chlorophyll-a, and Secchi depth and concluded that the lacustrine portion of Lake Spokane is oligotrophic, which is a different conclusion from the trophic status derived from AHOD. In general, oligotrophic lakes will have a lower AHOD than eutrophic lakes because in-lake productivity is lower in oligotrophic lakes which in turn does not exert a large hypolimnetic oxygen demand from (internally produced) detrital organic matter relative to eutrophic lakes. The water-column based conclusion on trophic status (TP, chlorophyll-a, and Secchi depth) indicates a move towards oligotrophy (lower productivity) in Lake Spokane. However, this is not yet apparent in the hypolimnetic oxygen demand within Lake Spokane. This suggests that the hypolimnetic oxygen demand within Lake Spokane is likely dominated by sediment oxygen demand from organic matter deposited from the past or from external organic matter brought in from the watershed rather than internally produced (autochthonous) organic matter from the same growing season. In other words, further reductions in incoming phosphorus to Lake Spokane are unlikely to result in an immediate improvement in DO in the lake’s hypolimnion. This was also supported in the earlier analysis which showed little correlation between incoming TP and hypolimnetic DO in the growing season (Figure 4.6), and modest correlations between winter flows and growing season hypolimnetic DO (Figure 4.7).

4.3 Summary of Dissolved Oxygen Drivers

Based on the synthesis of the data collected under the DO WQAP and past studies discussed above, an updated conceptual model of DO drivers in Lake Spokane is presented in Figure 4.10. The conceptual model of DO drivers in Lake Spokane can be summarized as follows:

- The lacustrine portion of Lake Spokane (the lower 13 miles) has a 5 to 6 times longer residence time compared to the riverine/transition zone (the upper 11 miles).
- The lacustrine and the lower portions of the transition zone stratify in the summer months. The inflows to Lake Spokane are generally cooler than the upper portions of the transition and lacustrine zones. The inflow plunges to form an interflow zone that approximately coincides with the metalimnion of the lacustrine portions of the reservoir.
- Biological uptake of the incoming TP occurs in the riverine and transition zones of Lake Spokane (upper 11 miles), with primary productivity generally declining in the mid-portions of the lacustrine zones (LL2 and LL1) due to phosphorus limiting conditions.
- Primary productivity increases near Long Lake Dam (LL0). The majority of the primary production occurs in the lower portions of the photic zone (at a depth of approximately 5 - 10 m)., which not only has nutrients from the interflow, but may also have hypolimnetic nutrients diffusing up across the thermocline.

- The lacustrine portion of Lake Spokane is oligotrophic from a nutrients and primary production perspective but is meso-eutrophic based on hypolimnetic oxygen demand.
- The DO changes in Lake Spokane no longer appear to be strongly correlated with incoming phosphorus. Rather, in-lake processes such as residence time, thermal stratification, and hypolimnetic oxygen demand from legacy sediment organic matter appear to have a more significant influence on the DO levels at 8 m and lower (the TMDL target zones for DO improvement).
- Incoming TP loads have shown a considerable decline over time (from 1970s-present). The incoming TP has been low (~10–20 µg/L) in the post-2010 period.

It must be noted that the conceptual model of DO drivers in no way suggests that the incoming phosphorus was not a historical driver of DO conditions in the lake. If the TP levels in the incoming waters were to go up in the June-October period, it would almost certainly have a detrimental effect on the hypolimnetic DO. Rather, the conceptual model tries to make the distinction that the current incoming TP levels are approaching oligotrophic levels, and the internal DO demand from the historically higher organic matter production is potentially a greater contributor to the DO deficit in the bottom waters than current euphotic production during the growing season.

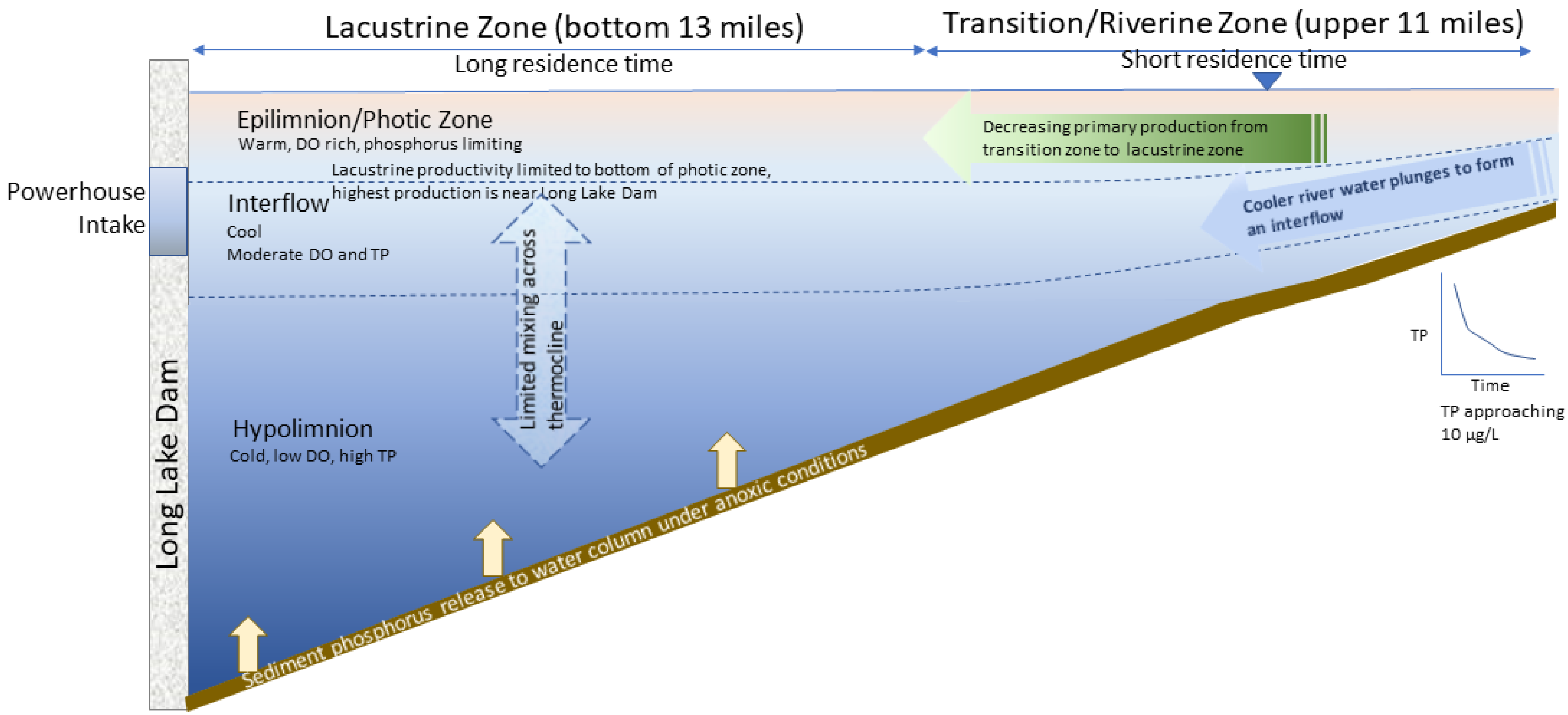


Figure 4.10. Conceptual model of dissolved oxygen drivers in Lake Spokane during summer critical season

5 Implementation Measures for 2022 and Next Steps

5.1 Monitoring and Modeling Activities

Avista is not proposing additional baseline monitoring for 2022.

As discussed in Section 2.2, Avista is conducting mechanistic modeling of Lake Spokane as contemplated in the DO WQAP to further evaluate progress in DO improvements and prioritize actions that are likely to have the greatest benefit. The modeling activities will be documented in a subsequent modeling memorandum or report that will be included with the compliance schedule request (Section 5.3).

5.2 Implementation of Phosphorus Reduction Measures

5.2.1 Reducing Carp Populations

Avista will continue the carp population reduction program in 2022. Similar to the 2020 and 2021 efforts, Avista will partner with WDFW, targeting an approximate 4-week sampling event during spring spawning. After taking measurements, all removed carp will be placed in a refuse bin and transported to a landfill. Additionally, in 2022, the carp population reduction program will be evaluated for continuance or modification. Evaluation may include whether the goals of phosphorus reduction and WDFW's goals for fisheries management are being achieved.

5.2.2 Wetland Actions

Activities that Avista will implement during 2022 at the Sacheen Springs wetland complex include constructing a planked walkway over a 130-foot section of emergent wetland to access the 1.2-mile trail around the forested island, and continuing the forest understory thinning and control of terrestrial weeds along the access road.

Avista and the Coeur d'Alene Tribe will continue to implement the Hangman Creek Site Management Plan which includes annual plantings, monitoring survival of existing plantings and wetland functionality, construction of fence enclosures to protect seedlings, and noxious weed herbicide treatments. Additional wetland property acquisitions will be considered as they become available.

5.2.3 Vegetative Shoreline Buffer

As the tree planting effort is a parallel improvement identified in the Long Lake Dam Reservoir and Tailrace Temperature WQAP (Avista 2011), this program will continue in 2022 with shoreline plantings at three of Avista's recreation sites on Lake Spokane. These plantings are associated with shoreline stabilization project and will include shrubs, trees, and native grasses. Maintenance activities in 2022 will include repairing or removing tree cages that are damaged or no longer needed at previous planting sites and watering new seedlings where necessary and feasible.

5.2.4 Lawn Area Reduction and Native Vegetation Buffers

In 2022, Avista will continue vegetation monitoring at the Wright Bulkhead Removal Project and continue to work with the landowner to complete the annual reporting requirements. Avista is also planning to implement up to three shoreline enhancement projects using bioengineering techniques at heavily used Lake Spokane recreation sites. The anticipated schedule includes design and permitting in 2021 with construction targeted for 2022, pending a successful winter drawdown and permit issuance.

Avista will also continue to evaluate the lawn area reduction and native vegetation buffer program for continuance or modification. Factors that will be taken into consideration for this evaluation include the cost to implement bulkhead removal projects, the permitting difficulties involved, and the level of interest from landowners compared to the long term water quality benefits, both through phosphorus reduction on site as well as education of other landowners through demonstration.

5.2.5 Education and Outreach

Avista will look for opportunities to provide educational materials to the public or participate in virtual conferences, meetings, lake association events, and other public forums.

5.3 Next Steps

Avista has performed a series of baseline monitoring, evaluation, and phosphorus reduction actions under the current DO WQAP. This 10-year report documents these efforts.

The DO and temperature data and habitat studies indicate that a habitable refuge for cold water fish exists in Lake Spokane throughout the critical summer period. The analysis of the monitoring data has also allowed an improved conceptual understanding of DO drivers in Lake Spokane.

The proposed modeling efforts in Section 2.2 and 5.1 will provide a quantitative evaluation of the extent to which Avista has met its proportional level of responsibility for increasing DO, as determined in the DO TMDL. Preliminary modeling results indicate that there may be some years (e.g., 2015) where further increases in DO may be needed to meet Avista's proportional level of responsibility. Therefore, Avista anticipates that a new compliance schedule will be necessary to fully evaluate which actions are likely to have the greatest impact on the lake's DO levels and prioritize those actions for continued implementation. Avista will request a new compliance schedule as outlined under WAC 173-201A-510(5)(g) and in accordance with Section 5.6 of the 401 Certification. Avista expects to use the findings from this 10-year report and the modeling analysis described in Sections 2.2 and 5.1 to support a new compliance schedule request, which is anticipated to be submitted to Ecology by August 2022. The compliance schedule request will propose a plan for monitoring and modeling studies, to better understand the DO response within Lake Spokane; evaluate whether the lake meets the water quality objectives set in the DO TMDL (Table 7) and WA water quality standards; assess the DO improvements from the phosphorus reduction activities completed under the DO WQAP; and assess other potential reasonable actions that could further improve DO within Lake Spokane. This will include an analysis of the engineering and economic feasibility along with the potential downstream effects of such actions. The request for a new compliance schedule will also outline a path towards meeting water quality criteria either through implementation of reasonable and feasible actions or through a regulatory pathway allowed under the Clean Water Act and the Washington State Standards' compliance schedule for dams (WAC-173-201A-510(5)).

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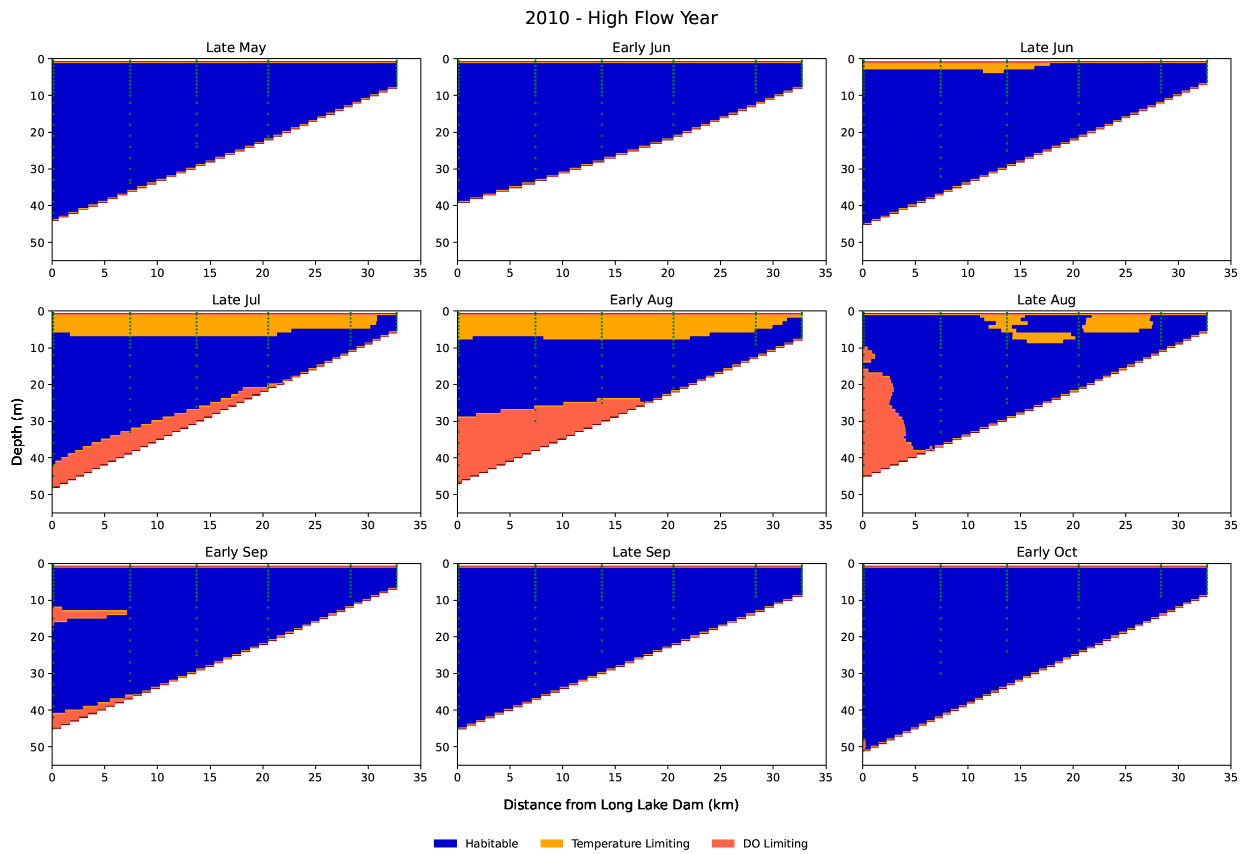
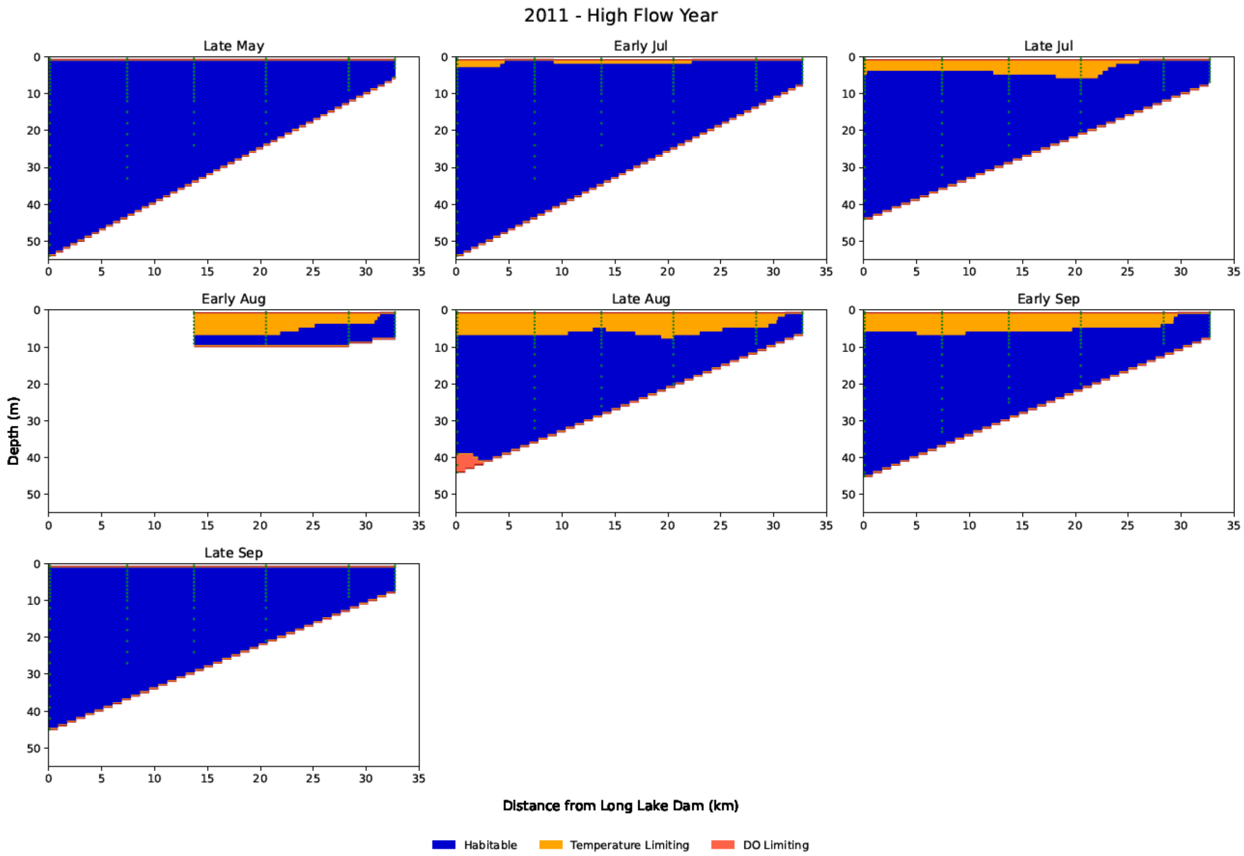
APPENDIX A Longitudinal Sections of Habitable Zones in Lake Spokane Using a Dissolved Oxygen Target Based on U.S. Environmental Protection Agency Guidance



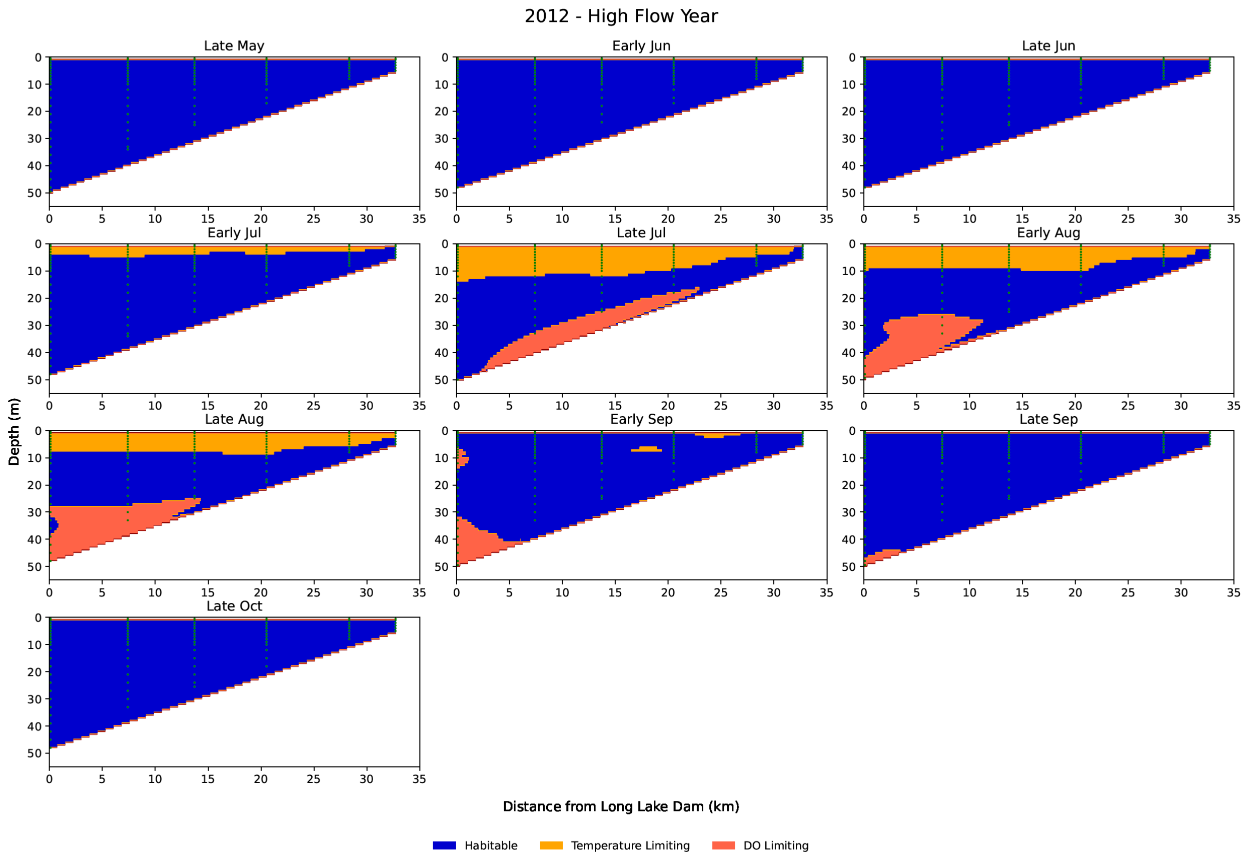
Note: Habitable areas have temperature < 20°C and DO > 5 mg/L; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < 5 mg/L.

Figure A.1. Habitable areas for cold water fish in Lake Spokane in 2010



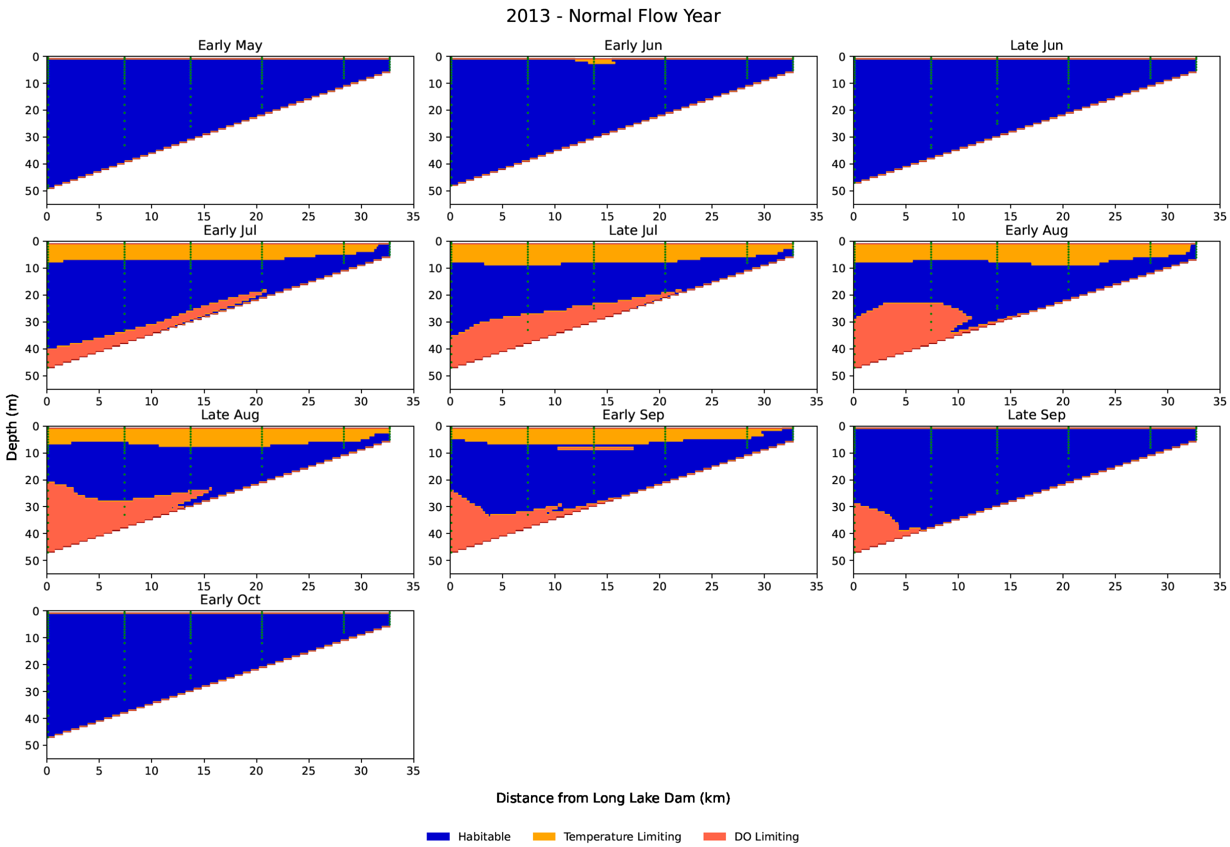
Note: Habitable areas have temperature < 20°C and DO > 5 mg/L; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < 5 mg/L; early August data were not available at all locations.

Figure A.2. Habitable areas for cold water fish in Lake Spokane in 2011



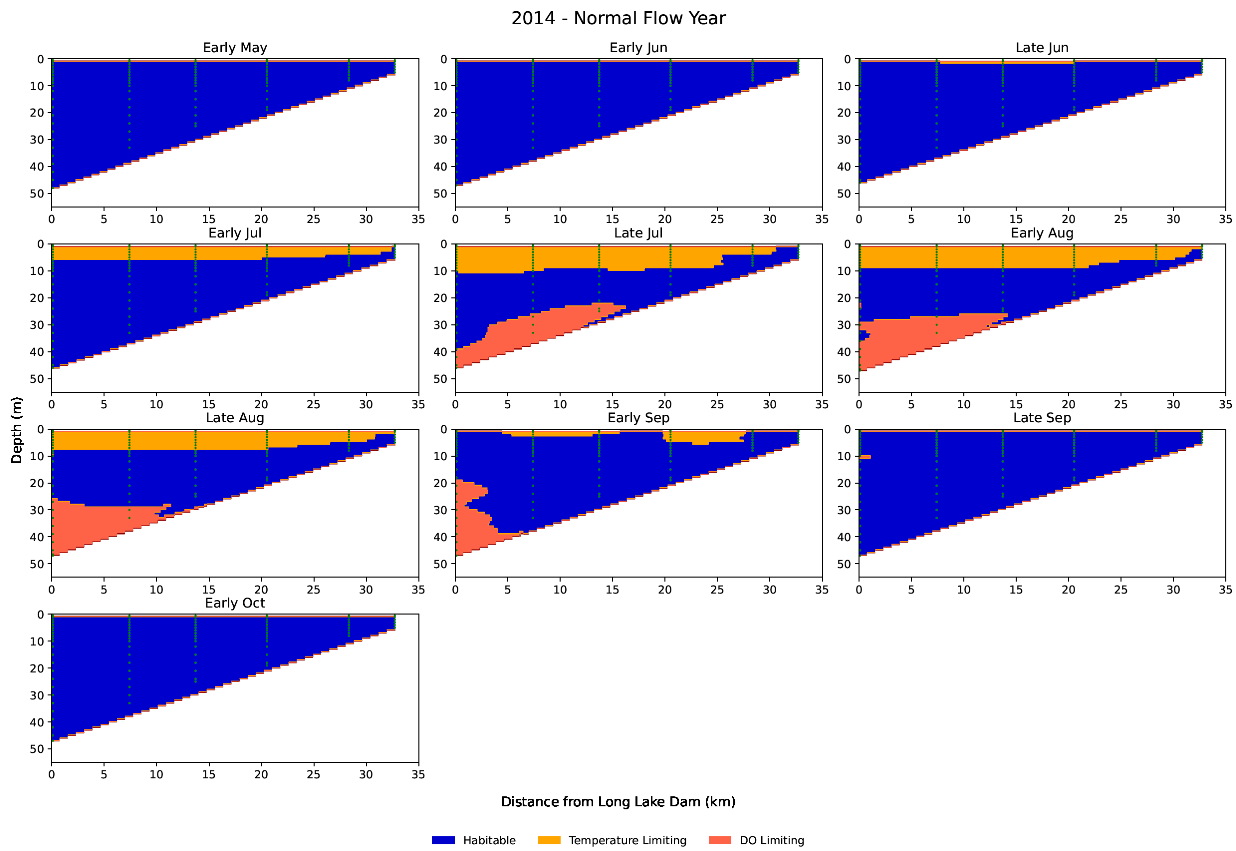
Note: Habitable areas have temperature < 20°C and DO > 5 mg/L; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < 5 mg/L.

Figure A.3. Habitable areas for cold water fish in Lake Spokane in 2012



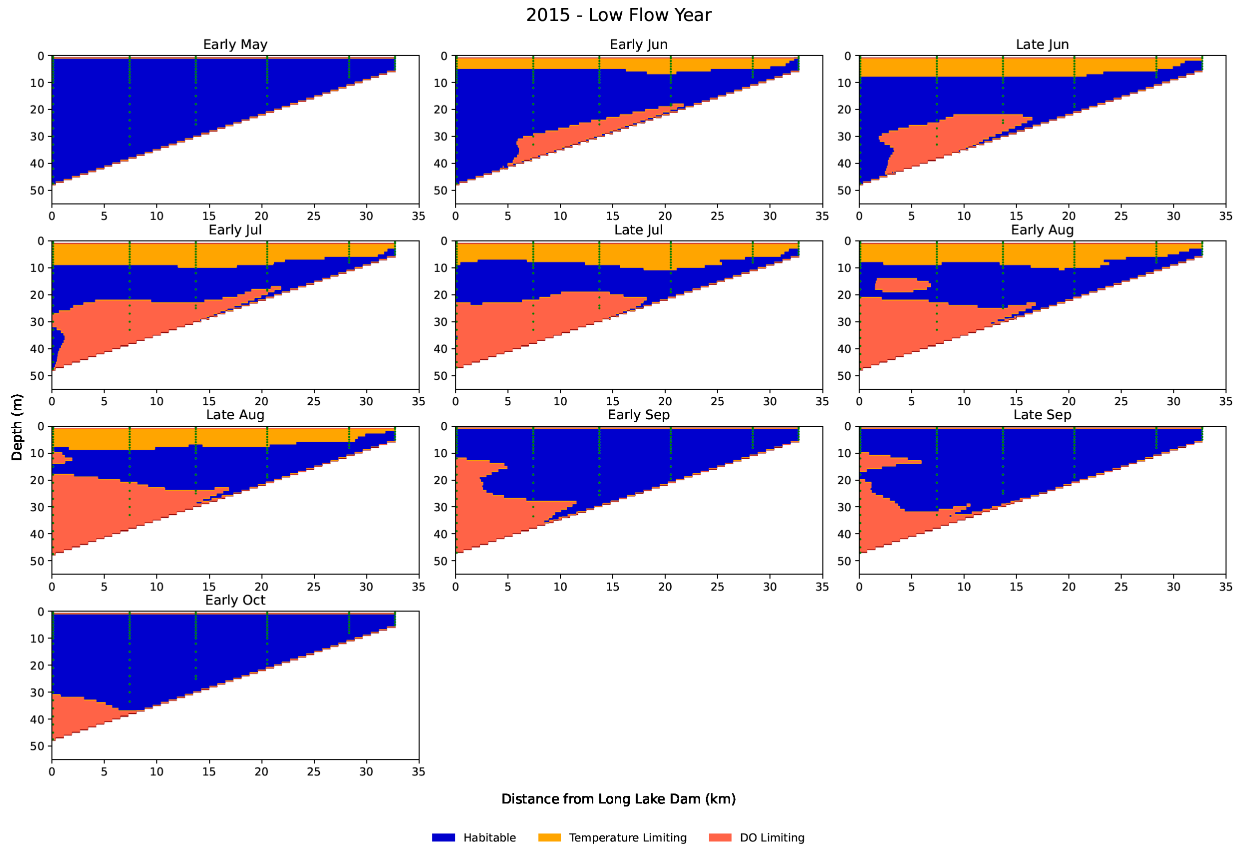
Note: Habitable areas have temperature < 20°C and DO > 5 mg/L; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < 5 mg/L.

Figure A.4. Habitable areas for cold water fish in Lake Spokane in 2013



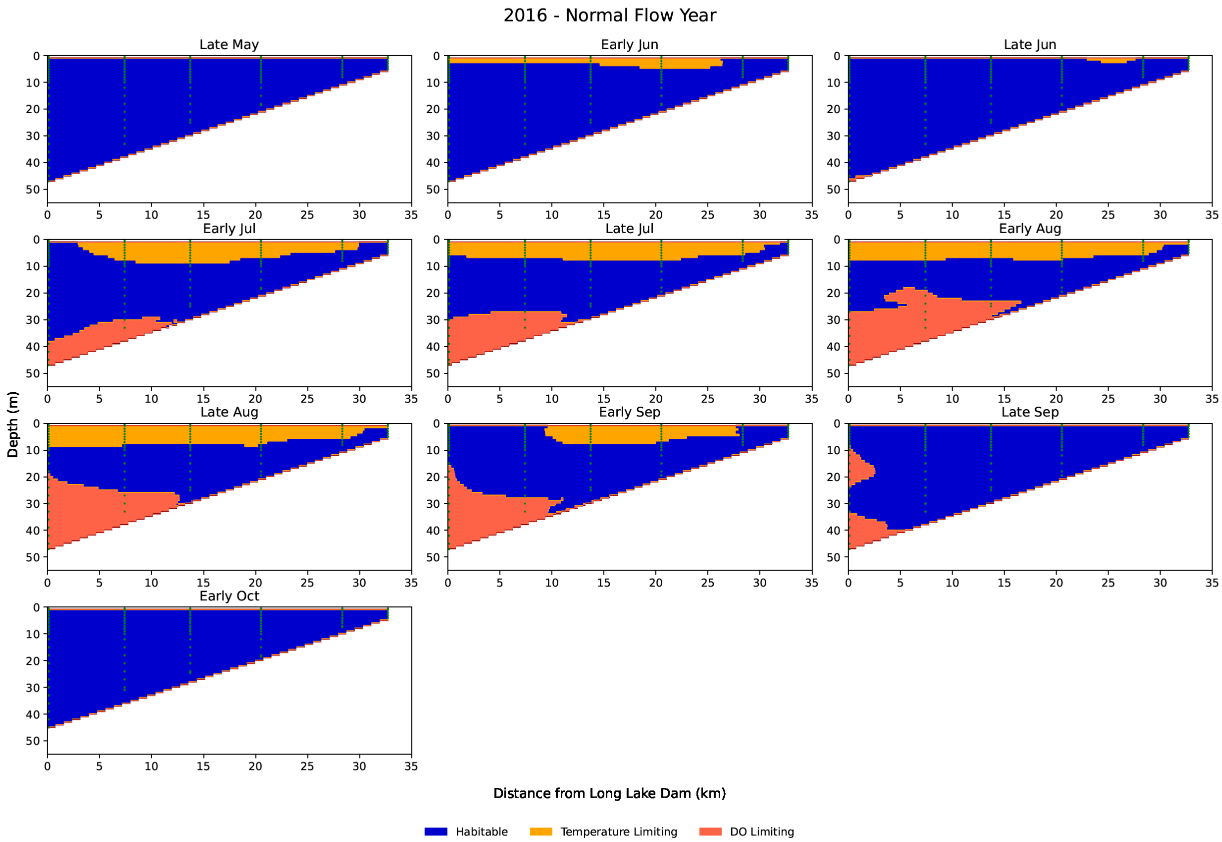
Note: Habitable areas have temperature < 20°C and DO > 5 mg/L; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < 5 mg/L.

Figure A.5. Habitable areas for cold water fish in Lake Spokane in 2014



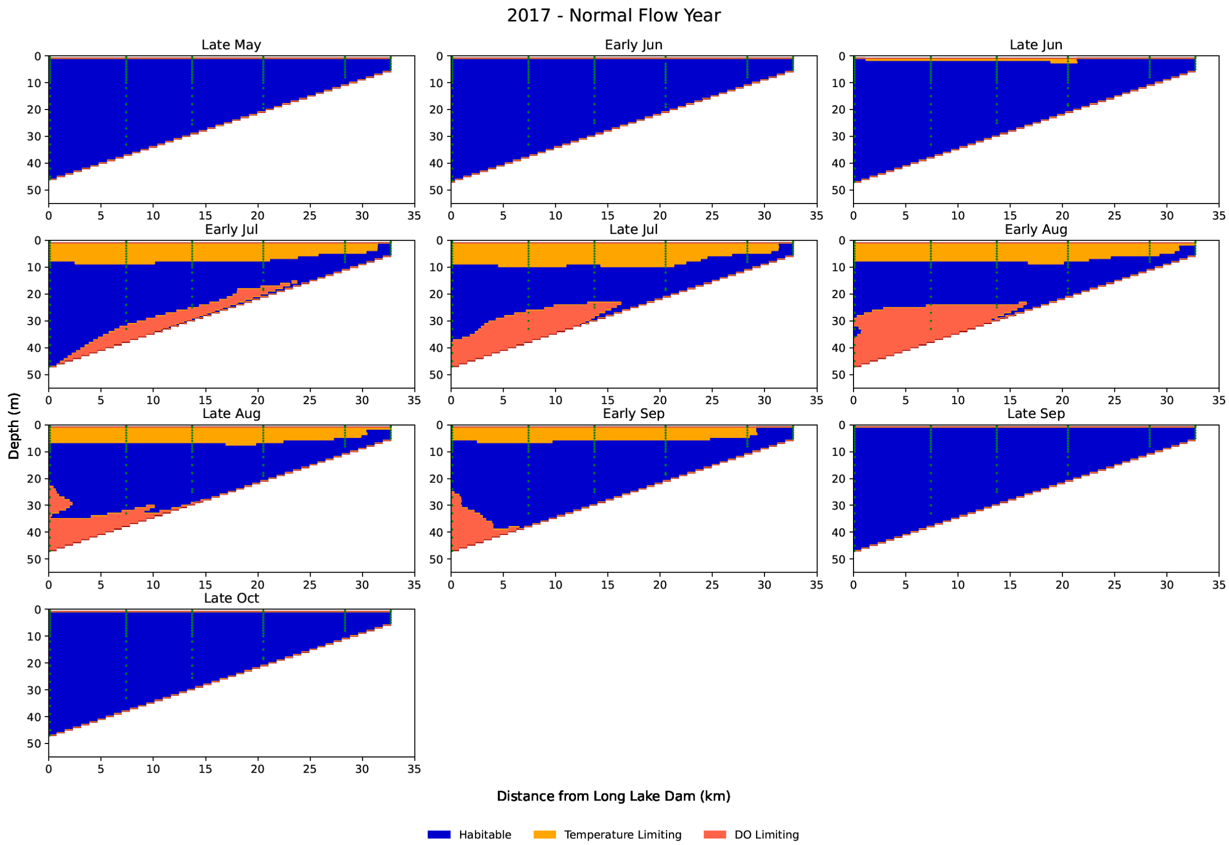
Note: Habitable areas have temperature < 20°C and DO > 5 mg/L; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < 5 mg/L.

Figure A.6. Habitable areas for cold water fish in Lake Spokane in 2015



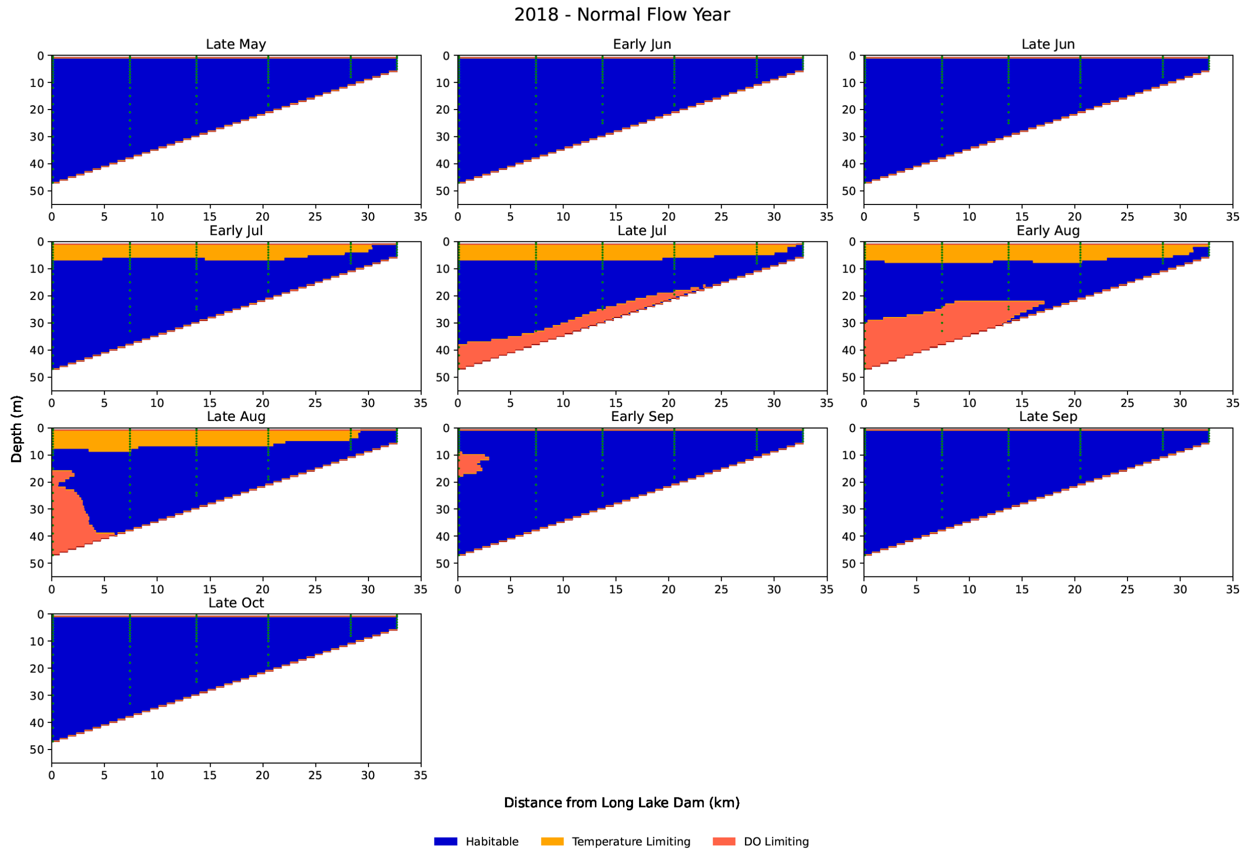
Note: Habitable areas have temperature < 20°C and DO > 5 mg/L; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < 5 mg/L.

Figure A.7. Habitable areas for cold water fish in Lake Spokane in 2016



Note: Habitable areas have temperature < 20°C and DO > 5 mg/L; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < 5 mg/L.

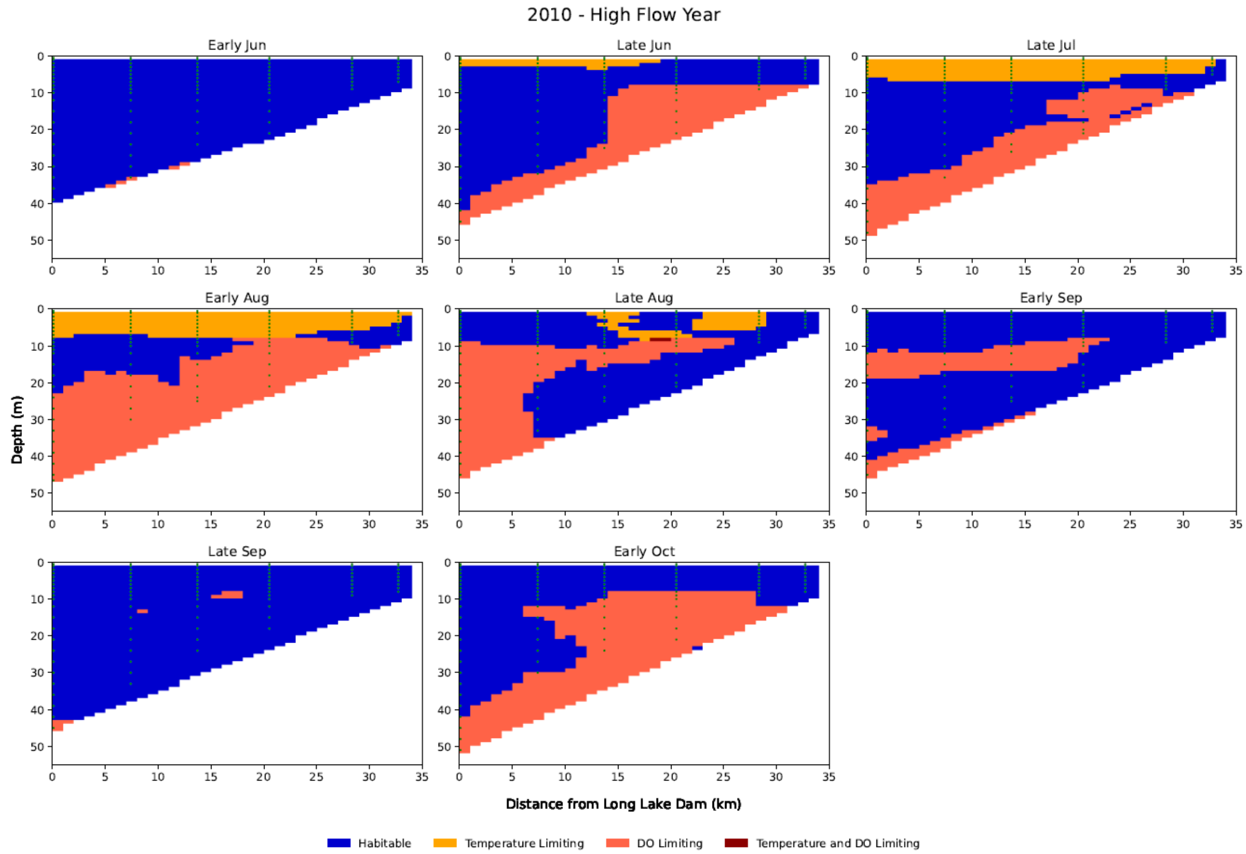
Figure A.8. Habitable areas for cold water fish in Lake Spokane in 2017



Note: Habitable areas have temperature < 20°C and DO > 5 mg/L; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < 5 mg/L.

Figure A.9. Habitable areas for cold water fish in Lake Spokane in 2018

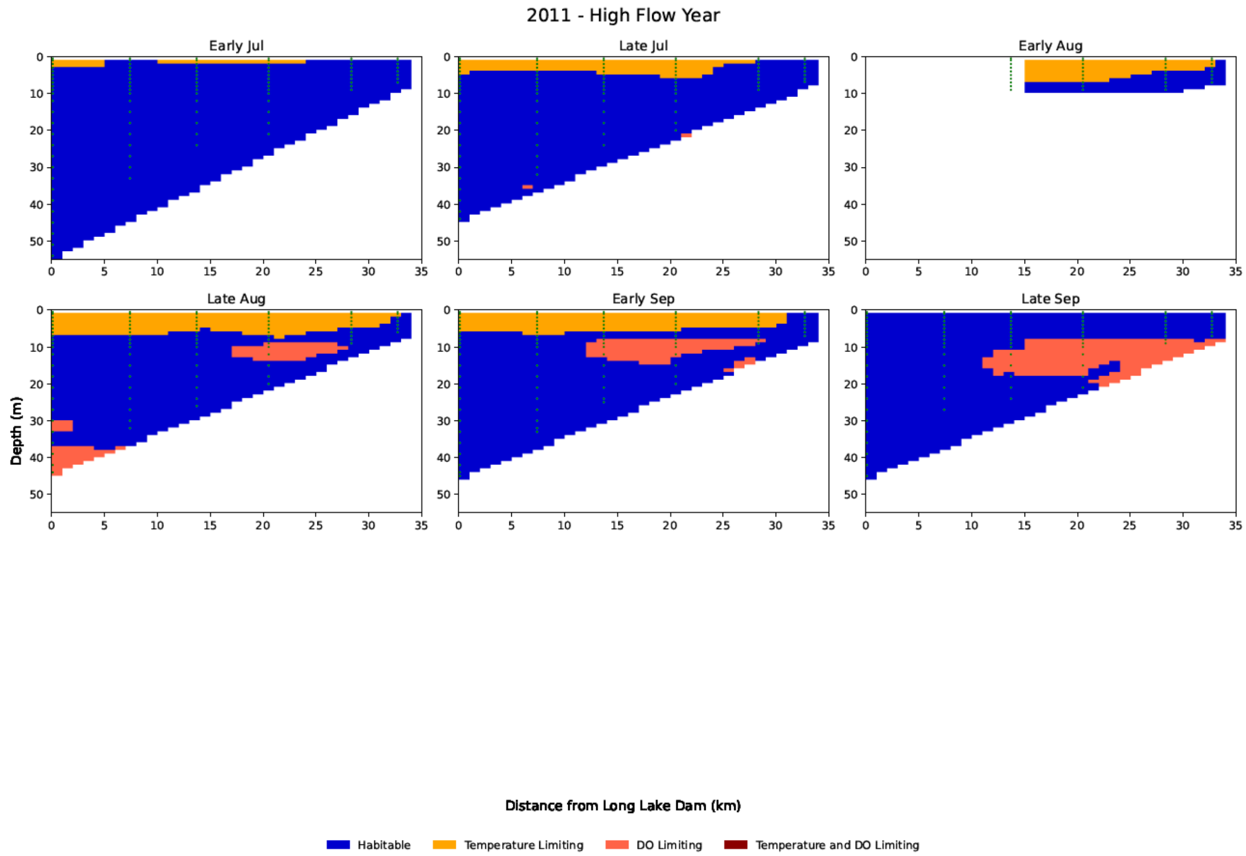
APPENDIX B Longitudinal Sections of Habitable Zones in Lake Spokane Using Dissolved Oxygen Targets Based on Table 7 of the Dissolved Oxygen Total Maximum Daily Load Water Quality Improvement Report



Notes:

1. Habitable areas have temperature < 20°C and DO > spatially- and temporally-variable DO targets; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < spatially- and temporally-variable DO targets.
2. Spatially- and temporally-variable DO targets are 0.2 mg/L below the modeled No Source condition DO concentrations for 2001 conditions as presented in the DO TMDL Table 7.

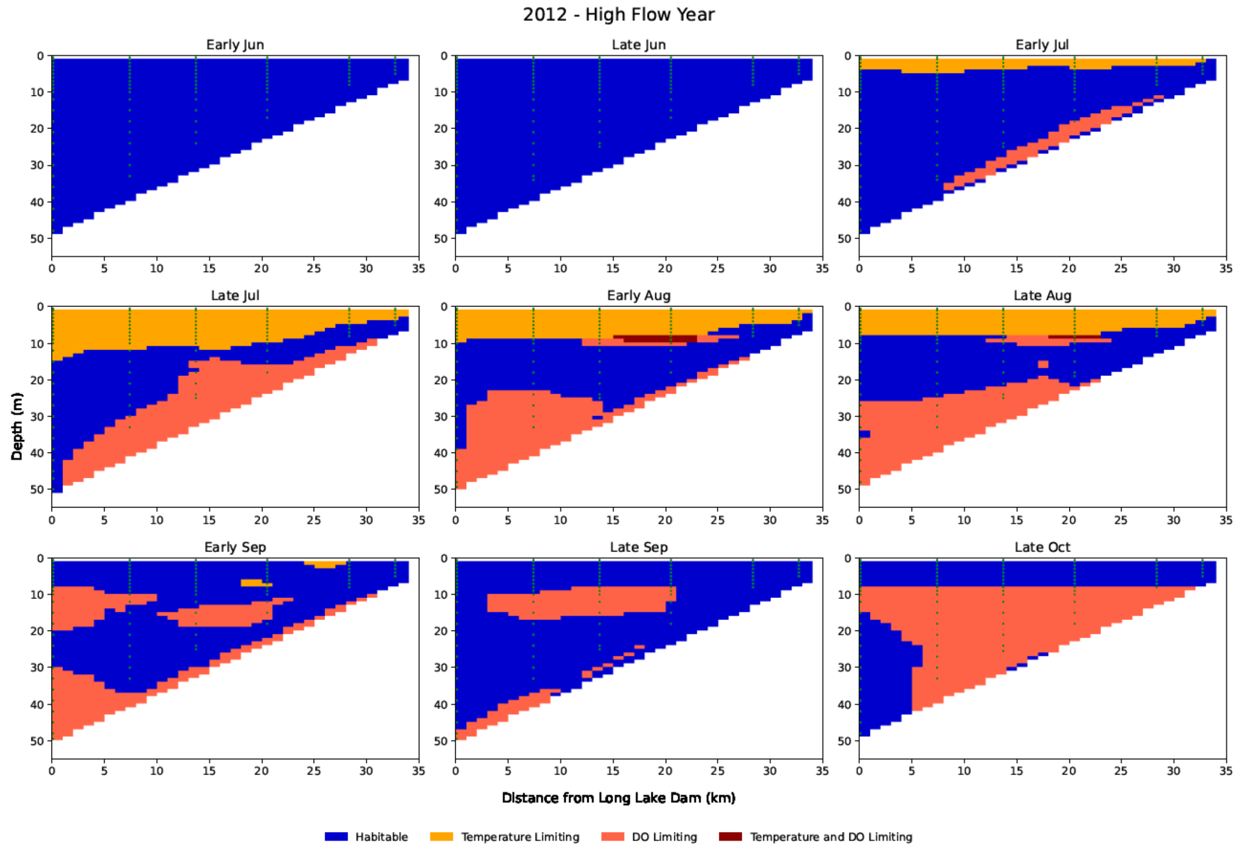
Figure B.1. Habitable areas for cold water fish in Lake Spokane in 2010



Notes:

1. Habitable areas have temperature < 20°C and DO > spatially- and temporally-variable DO targets; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < spatially- and temporally-variable DO targets.
2. Spatially- and temporally-variable DO targets are 0.2 mg/L below the modeled No Source condition DO concentrations for 2001 conditions as presented in the DO TMDL Table 7.

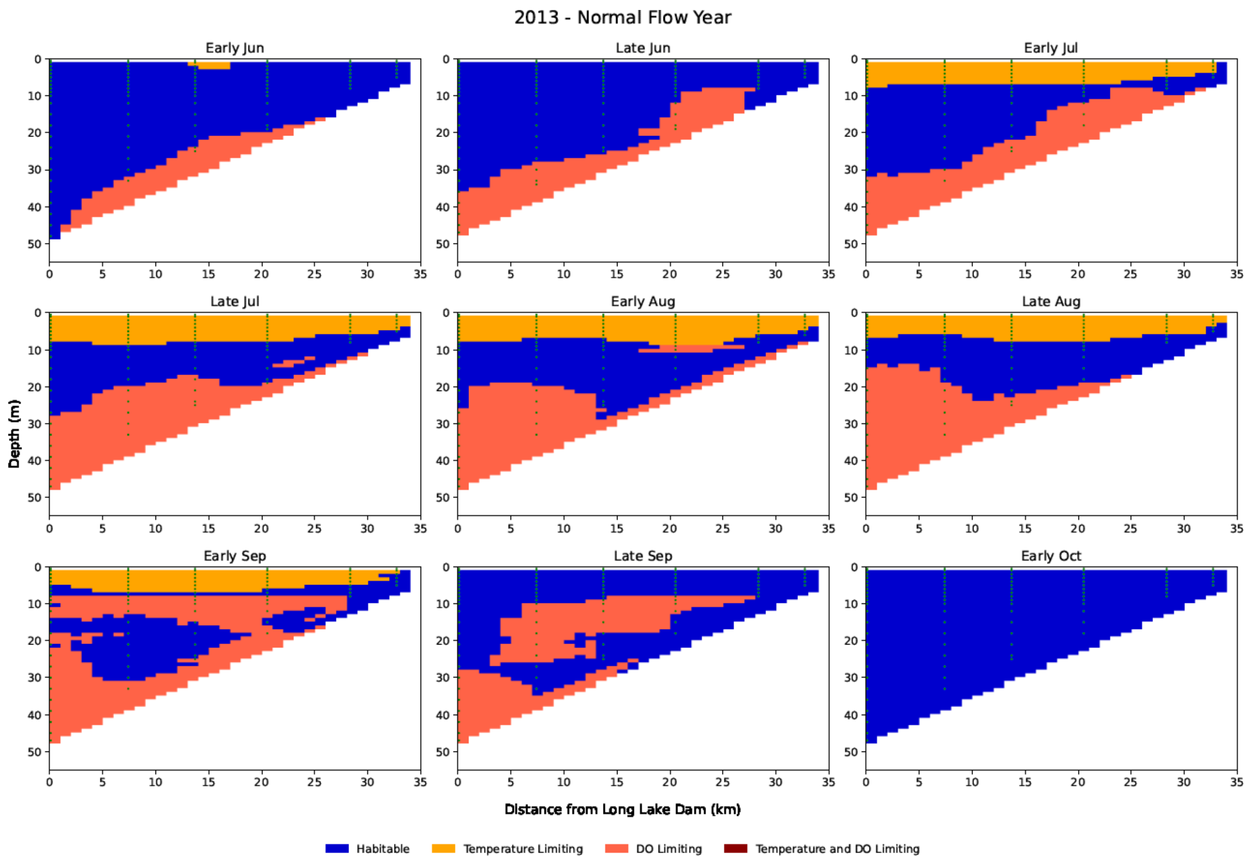
Figure B.2. Habitable areas for cold water fish in Lake Spokane in 2011



Notes:

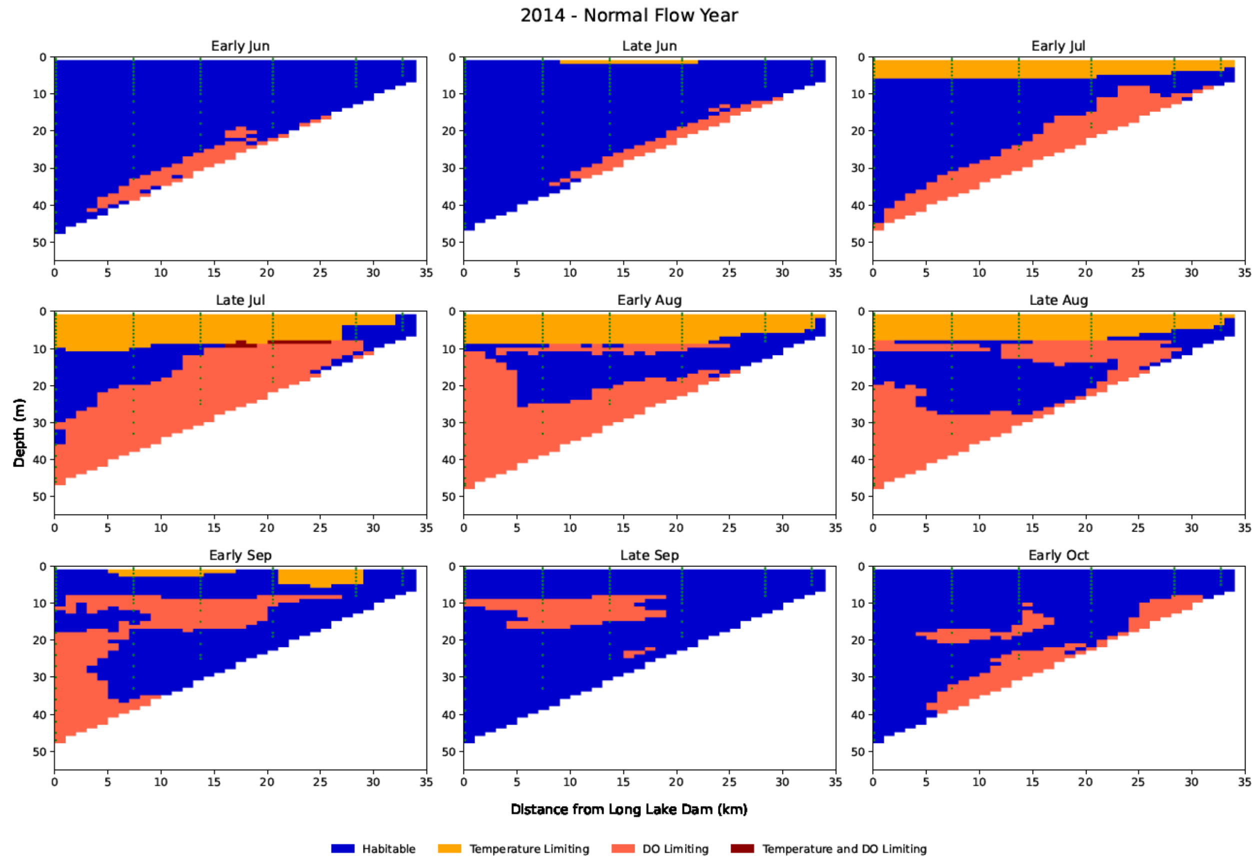
1. Habitable areas have temperature < 20°C and DO > spatially- and temporally-variable DO targets; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < spatially- and temporally-variable DO targets.
2. Spatially- and temporally-variable DO targets are 0.2 mg/L below the modeled No Source condition DO concentrations for 2001 conditions as presented in the DO TMDL Table 7.

Figure B.3. Habitable areas for cold water fish in Lake Spokane in 2012



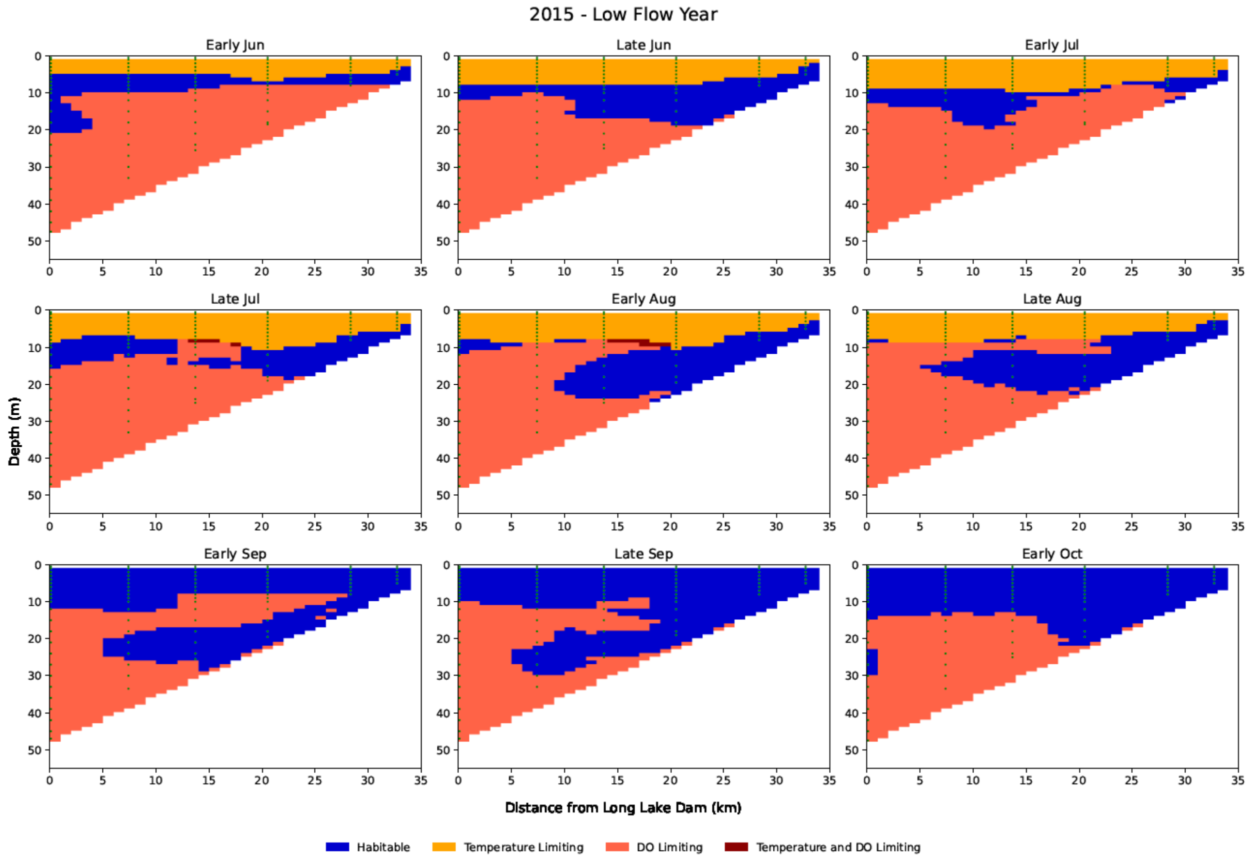
Notes:
1. Habitable areas have temperature < 20°C and DO > spatially- and temporally-variable DO targets; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < spatially- and temporally-variable DO targets.
2. Spatially- and temporally-variable DO targets are 0.2 mg/L below the modeled No Source condition DO concentrations for 2001 conditions as presented in the DO TMDL Table 7.

Figure B.4. Habitable areas for cold water fish in Lake Spokane in 2013



Notes:
1. Habitable areas have temperature < 20°C and DO > spatially- and temporally-variable DO targets; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < spatially- and temporally-variable DO targets.
2. Spatially- and temporally-variable DO targets are 0.2 mg/L below the modeled No Source condition DO concentrations for 2001 conditions as presented in the DO TMDL Table 7.

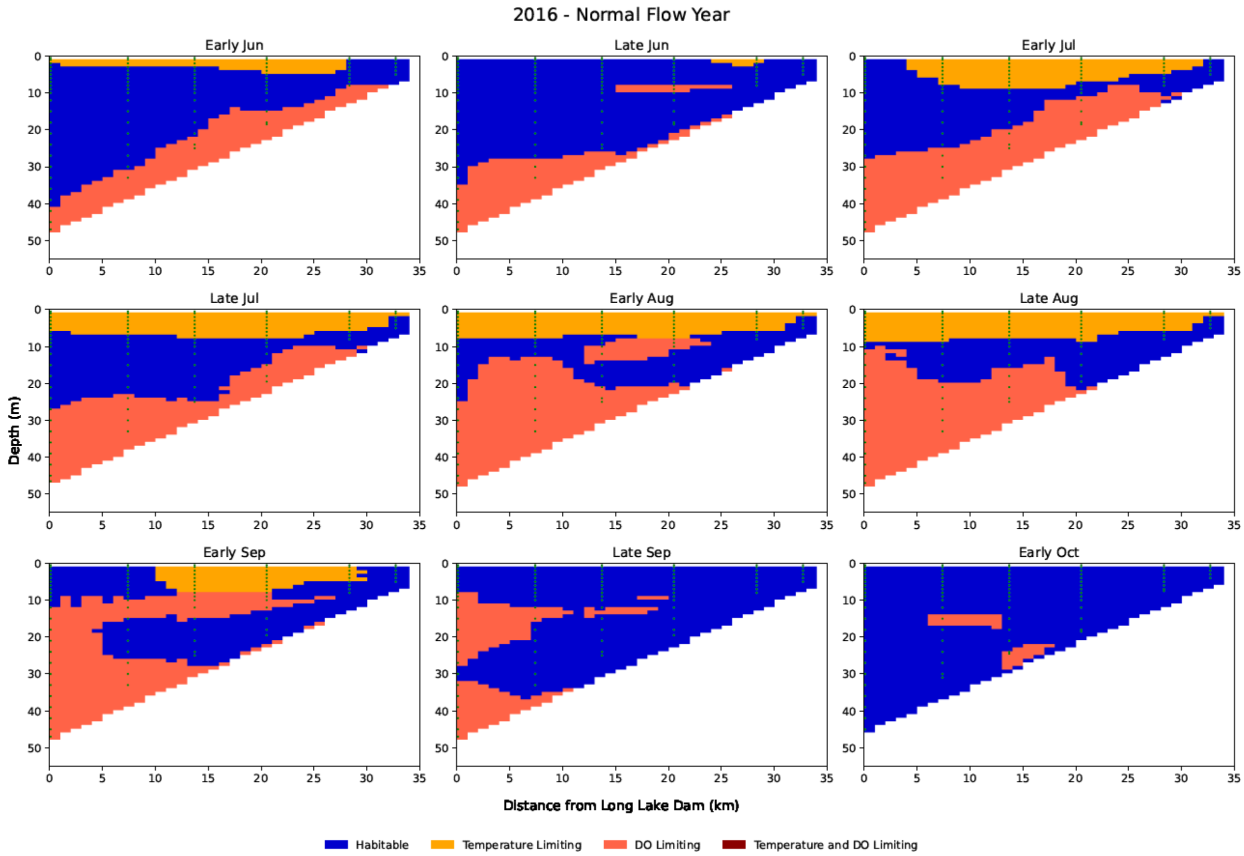
Figure B.5. Habitable areas for cold water fish in Lake Spokane in 2014



Notes:

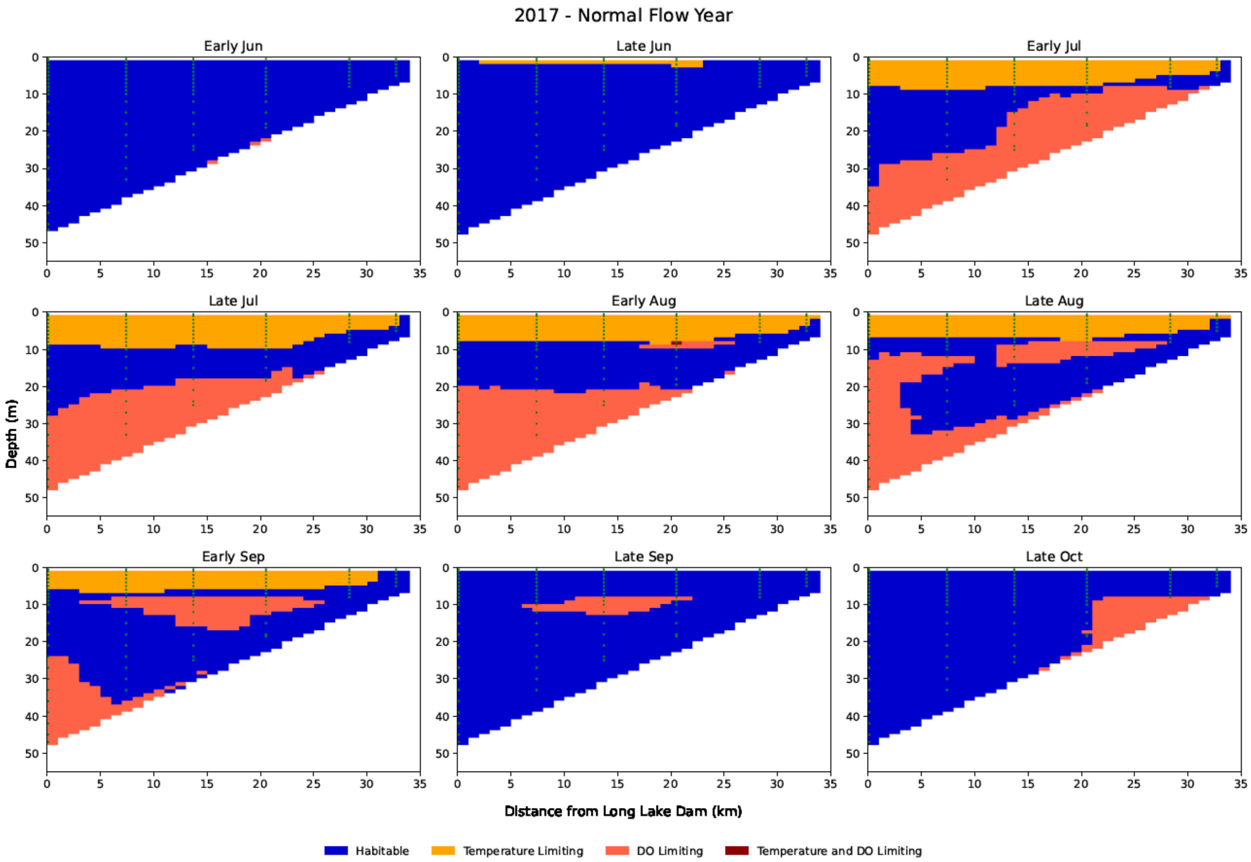
1. Habitable areas have temperature < 20°C and DO > spatially- and temporally-variable DO targets; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < spatially- and temporally-variable DO targets.
2. Spatially- and temporally-variable DO targets are 0.2 mg/L below the modeled No Source condition DO concentrations for 2001 conditions as presented in the DO TMDL Table 7.

Figure B.6. Habitable areas for cold water fish in Lake Spokane in 2015



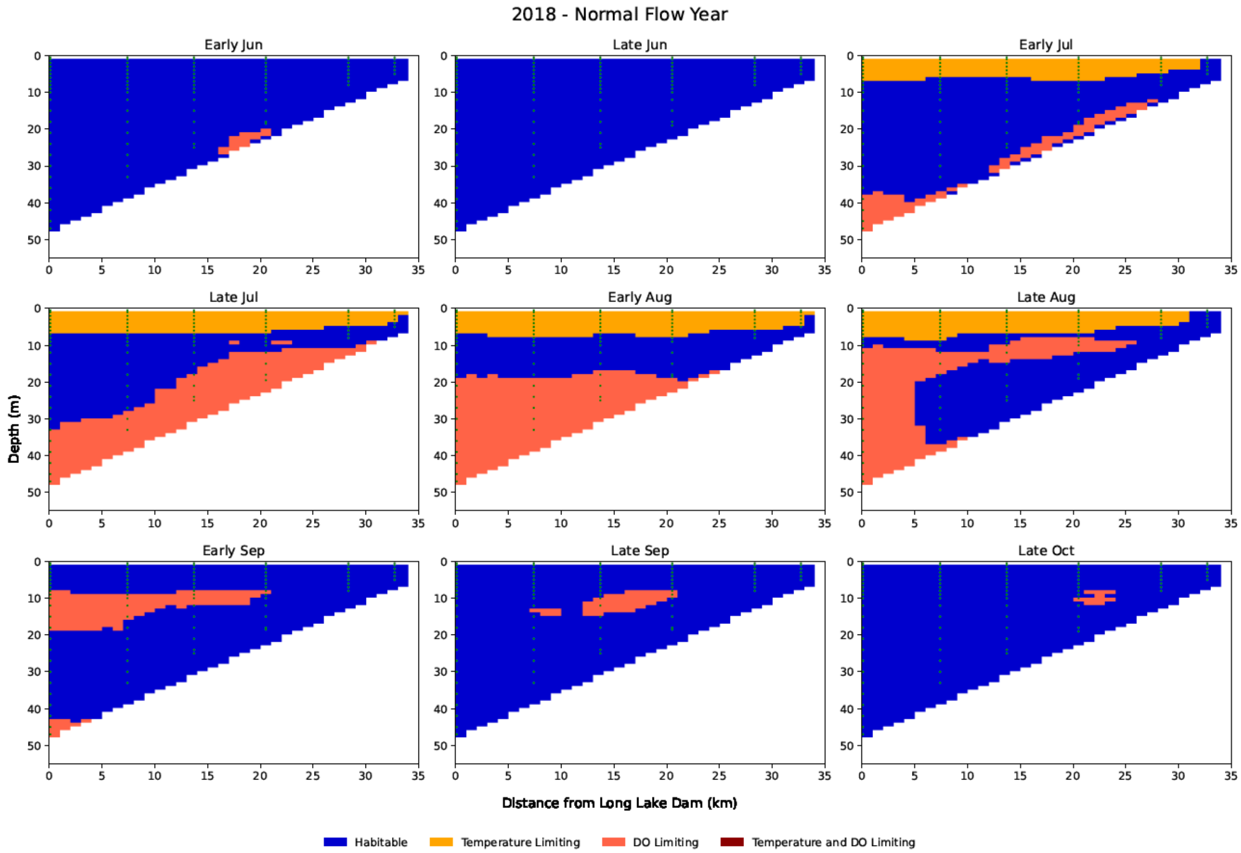
Notes:
1. Habitable areas have temperature < 20°C and DO > spatially- and temporally-variable DO targets; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < spatially- and temporally-variable DO targets.
2. Spatially- and temporally-variable DO targets are 0.2 mg/L below the modeled No Source condition DO concentrations for 2001 conditions as presented in the DO TMDL Table 7.

Figure B.7. Habitable areas for cold water fish in Lake Spokane in 2016



Notes:
1. Habitable areas have temperature < 20°C and DO > spatially- and temporally-variable DO targets; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < spatially- and temporally-variable DO targets.
2. Spatially- and temporally-variable DO targets are 0.2 mg/L below the modeled No Source condition DO concentrations for 2001 conditions as presented in the DO TMDL Table 7.

Figure B.8. Habitable areas for cold water fish in Lake Spokane in 2017



Notes:

1. Habitable areas have temperature < 20°C and DO > spatially- and temporally-variable DO targets; temperature limiting areas have temperature > 20°C; DO limiting areas have DO < spatially- and temporally-variable DO targets.
2. Spatially- and temporally-variable DO targets are 0.2 mg/L below the modeled No Source condition DO concentrations for 2001 conditions as presented in the DO TMDL Table 7.

Figure B.9. Habitable areas for cold water fish in Lake Spokane in 2018

APPENDIX C Agency Consultation

AVISTA

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

February 1, 2022

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

Subject: Spokane River Project License, FERC Project No. 2545, Appendix B Section 5.6.C, Lake Spokane Dissolved Oxygen Water Quality Attainment Plan, Ten Year Report

Dear Jordan:

I have enclosed the Lake Spokane Dissolved Oxygen Water Quality Attainment Plan Ten Year Report (Report) for your review and approval. The 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. Avista appreciates the multiple meetings held during 2021 in which Ecology and Avista discussed the DO WQAP implementation activities, compliance pathways, and next steps.

The enclosed Report assesses the progress made towards improving Lake Spokane's water quality through the implementation of select reasonable and feasible measures and includes monitoring results which address year to year variability and trend analyses. In addition, the Report includes a summary of the 2021 climatic conditions and hydrology, implementation activities, effectiveness of the implementation activities, and proposed actions for 2022.

The Report documents considerable improvements in dissolved oxygen (DO) levels in Lake Spokane. This includes a discussion of DO and temperature data, along with habitat studies, which indicate a habitable refuge for cold water fish exists in Lake Spokane throughout the critical summer period. In addition, a synthesis of the monitoring data provides an improved conceptual understanding of DO drivers in Lake Spokane.

Given the complexities of measuring and achieving Avista's proportional level of DO responsibility as defined by Table 7 of the DO TMDL, and the improved understanding of DO drivers, Avista anticipates submitting a new compliance schedule request to Ecology by August 2022. The request for a new compliance schedule will outline a continued path towards meeting DO water quality criteria either through implementation of reasonable and feasible actions or through an alternative regulatory pathway allowed under WAC-173-201A-510[5].

We would appreciate your review of the Report by **March 8, 2022**. 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, 2022**.

Please feel free to call me at (509) 495-4651 if you have any questions about the Report. We are happy to schedule a meeting with you to discuss the report contents and our next steps at any time.

Sincerely,

Monica Ott

Monica Ott
Water Quality Specialist

Enclosure (1)

cc: Chad Atkins, Ecology
Chad Brown, Ecology
Meghan Lunney, Avista

From:	Bauer, Jordan (ECY)
To:	Lunney, Meghan
Cc:	Ott, Monica; Atkins, Chad (ECY)
Subject:	[External] Ecology DO WQAP Review and Extension Request
Date:	Monday, March 21, 2022 11:34:57 AM

Hi Meghan,

Ecology is still gathering our comments for the Dissolved Oxygen Water Quality Attainment Plan (DO WQAP) 10-year report and requests an extension of our review date from March 8th to March 31st. The reasons for our request are highlighted here:

- We have a number of internal Ecology people across programs needing to complete their review;
- The 10-year report is significant, in that it completes the ten year compliance schedule laid out in the DO WQAP and consistent with WAC 173-201A-510(5) *Compliance schedule for dams*;
- Ecology's compilation of comments will require extra time for review in order to facilitate the transition from this compliance schedule and next steps according to WAC 173-201A-510(5)(g); and,
- It's anticipated Ecology and Avista will need to meet to discuss comments on the DO WQAP.

Please let me know if this request will work for Avista. If you have any questions please contact me.

Thank you,

Jordan Bauer
Hydropower Compliance Coordinator
Washington Department of Ecology – Eastern Region
Water Quality Program
(509)-688-9403

Electronically Filed

March 21, 2022

Ms. Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street N.E.
Washington, DC 20426

Subject: Spokane River Project, FERC Project No. 2545, Appendix B, Section 5.6.C Request for a 60-day Extension of Time to File the Lake Spokane Dissolved Oxygen Water Quality Attainment Plan, Ten Year Report

Dear Secretary Bose:

Ordering Paragraph E of the Federal Energy Regulatory Commission (FERC) Spokane River Hydroelectric Project (FERC Project No. 2545) License incorporated the Washington Department of Ecology (Ecology) Certification Conditions under Section 401 of the Federal Clean Water Act as Appendix B of the License. In accordance with Appendix B, Section 5.6.C of the License, Avista developed the Lake Spokane Dissolved Oxygen Water Quality Attainment Plan (DO WQAP). The DO WQAP was approved by Ecology on September 27, 2012 and by FERC in its December 19, 2012 Order.

In accordance with the DO WQAP, Avista and Ecology have been meeting over the past year discussing the implementation activities, compliance pathways and next steps included in the Lake Spokane Dissolved Oxygen Water Quality Attainment Plan, Ten Year Report (Report). The Report assesses the progress made towards improving Lake Spokane's water quality through the implementation of select reasonable and feasible measures including monitoring results which address year to year variability and trend analyses for a period stretching from 2012 through 2021, along with a proposed approach for future steps. The Report was submitted to Ecology for a 30-day review period on February 1, 2022. On March 21 Ecology requested additional time to review and compile comments on the Report. We have enclosed Ecology's request for your reference.

In order to allow time to address Ecology's comments and/or recommendations Avista is requesting a two-month extension (from April 1 to June 1, 2022) to file the Lake Spokane Dissolved Oxygen Water Quality Attainment Plan, Ten Year Report with FERC.

Please feel free to contact me or Monica Ott if you have any questions or wish to discuss the extension request. I can be reached at (509) 495-4643 and Monica can be reached at (509) 495-4651.

Sincerely,

Meghan Lunney
Spokane River License Manager

Enclosure (1)

cc: Jordan Bauer, Ecology
Chad Brown, Ecology
Chad Atkins, Ecology

From:	Bauer, Jordan (ECY)
To:	Lunney, Meghan
Cc:	Ott, Monica; Atkins, Chad (ECY)
Subject:	[External] Ecology DO WQAP Review and Extension Request
Date:	Monday, March 21, 2022 11:34:56 AM

Hi Meghan,

Ecology is still gathering our comments for the Dissolved Oxygen Water Quality Attainment Plan (DO WQAP) 10-year report and requests an extension of our review date from March 8th to March 31st. The reasons for our request are highlighted here:

- We have a number of internal Ecology people across programs needing to complete their review;
- The 10-year report is significant, in that it completes the ten year compliance schedule laid out in the DO WQAP and consistent with WAC 173-201A-510(5) *Compliance schedule for dams*;
- Ecology's compilation of comments will require extra time for review in order to facilitate the transition from this compliance schedule and next steps according to WAC 173-201A-510(5)(g); and,
- It's anticipated Ecology and Avista will need to meet to discuss comments on the DO WQAP.

Please let me know if this request will work for Avista. If you have any questions please contact me.

Thank you,

Jordan Bauer
Hydropower Compliance Coordinator
Washington Department of Ecology – Eastern Region
Water Quality Program
(509)-688-9403

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Avista Corporation Project No. 2545-158

ORDER GRANTING EXTENSION OF TIME TO FILE DISSOLVED OXYGEN WATER QUALITY ATTAINMENT ANNUAL REPORT

(Issued April 12, 2022)

1. On March 22, 2022, Avista Corporation, licensee for the Spokane River Hydroelectric Project No. 2535, filed a request with the Federal Energy Regulatory Commission (Commission) for a 2-month extension of time to file its ten-year report pursuant to Order Modifying and Approving Water Quality Attainment Plan (WQAP Order).[1] The project is located on the Spokane River in Spokane, Lincoln, and Stevens counties, Washington, and in Kootenai and Benewah counties, Idaho. The project occupies federal and tribal lands, including lands that are part of the Coeur d'Alene Reservation.

2. Appendix (B) of the project license[2] contains the water quality certificate (WQC) issued by the Washington Department of Ecology (Washington Ecology). The licensee developed its Dissolved Oxygen Water Quality Attainment Plan (WQAP) pursuant to section 5.6(C) of the WQC. In accordance with the WQAP, the licensee provides annual reports to document compliance with the dissolved oxygen Total Maximum Daily Load (DO TMDL), as well as prepares five-, eight-, and ten-year reports. The goal for the ten-year report is to address year-over-year variability, analyze trends over time, and assess the progress made towards improving Lake Spokane's water quality through adaptive management and implementation of the selected reasonable and feasible measures.

3. Ordering Paragraph (B) of the December 19, 2012, Order requires the licensee to file the WQAP reports each April 1 for Commission review. The reports must include any comments or recommendations received from the agencies, and the licensee's response to the comments.

4. The licensee is requesting a 2-month extension of time to file its ten-year report pursuant to the WQAP Order. The licensee states that the report was submitted to

[1] 141 FERC ¶ 62,205 (issued December 19, 2012).

[2] 127 FERC ¶ 61,265 (issued June 18, 2009).

Washington Ecology for a 30-day review on February 1, 2022, and that on March 21, 2022, the agency requested additional time to review the report. The additional time will allow Washington Ecology enough time to complete their review of the report as well as allow the licensee an opportunity to respond to the comments prior to filing the report with the Commission.

5. The licensee's request for a 2-month extension of time to file the Dissolved Oxygen Water Quality Attainment Report will accommodate Ecology's request for additional time to review the report as well as allow the licensee adequate time to respond to the comments prior to filing with the Commission. The licensee's request is reasonable and is supported by Washington Ecology, and therefore, should be approved.

The Director orders:

(A) Avista Corporation's request, filed with the Federal Energy Regulatory Commission (Commission) on March 22, 2022, to extend the due date for the Dissolved Oxygen Water Quality Attainment Annual Report, pursuant to the Order Modifying and Approving Water Quality Attainment Plan issued December 19, 2012, for the Spokane River Project No. 2545, is approved. The report is due June 1, 2022.

(B) This order constitutes final agency action. Any party may file a request for rehearing of this order within 30 days from the date of its issuance, as provided in section 313(a) of the Federal Power Act, 16 U.S.C. § 825*l*, and the Commission's regulations at 18 CFR § 385.713 (2021). The filing of a request for hearing does not operate as a stay of the effective date of this order, or of any other date specified in this order. The licensee's failure to file a request for rehearing shall constitute acceptance of this order.

Andrea Claros
Chief, Aquatic Resources Branch
Division of Hydropower Administration
and Compliance

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
4601 N. Monroe Street • Spokane, Washington 99205-1295 • (509) 329-3400

March 22, 2022

Monica Ott
Avista Corp.
1411 East Mission Avenue
PO Box 3727
Spokane, WA 99220

RE: Request for Ecology Review and Comment– Lake Spokane Dissolved Oxygen Water Quality Attainment Plan, Ten Year Report – Spokane River FERC Project No. 2545

Dear Monica Ott:

The Department of Ecology (Ecology) has reviewed Avista's submittal of the "Lake Spokane Dissolved Oxygen Water Quality Attainment Plan, Ten Year Report". This report was received by Ecology on February 1, 2022, via email. The report was submitted in accordance with the Lake Spokane Dissolved Oxygen Water Quality Attainment Plan (DO WQAP), required by Section 5.6 (C) of Ecology's 401 Certification (Certification) and consistent with Spokane River Hydroelectric Project No. 2545 (License) Appendix B. This is the final report of the DO WQAP completed by Avista and previously approved by Ecology on September 27, 2012.

Please find Ecology's comments enclosed for your review. We apologize for our review exceeding your requested deadline and will work with you to address any concerns or questions you may have. We would be happy to schedule a time to meet and discuss comments, if desired. Once updates and comments are completed, please resubmit for final review and approval.

Please contact me at (509) 688-9403 or jordan.bauer@ecy.wa.gov.

Sincerely,

Jordan Bauer
Hydropower Compliance Coordinator
Water Quality Program

JB:red
Enclosure
cc: Meghan Lunney, Avista
Chad Atkins, Ecology
Chad Brown, Ecology

Lake Spokane Dissolved Oxygen Water Quality Attainment Plan, Ten Year Report Comments
Avista requested for review and comment from Washington Department of Ecology (Ecology) on the Spokane River Project Dissolved Oxygen Water Quality Attainment Plan 10-year Report on February 1, 2022.

Brief Description and Need:
The DO WQAP has reached the end of its compliance schedule and the 10-year final report is prepared to evaluate and assess the implementation activities completed and future needs according to WAC 173-201A-510(5), Section 5.6 of the 401 Certification, and the Spokane River DO TMDL.

Ecology Comments on the DO WQAP Ten-Year Report

	Section	Page No.	Comment/Questions
Comment 1	2.1.3	9	Top of page. Ecology also received numerous comments on the light algal bloom activity observed during the 2021 season. Water around the lake appeared to have an overall better transparency during a year in which air temperatures reached record-breaking levels.
Comment 2	2.3.2.2	11	Hangman Creek wetland restoration and acquisition work was conditioned by the Department of Interior pursuant to Section 4(e) of the Federal Power Act, Appendix D of the FERC License. Though we support this work and it has overall benefit to the Spokane River watershed, this work is outside the scope of the WA 401 Certification. If work was completed within the WA state border of the Hangman Creek watershed area we would insist this work be included as part of Avista's DO responsibility. However, stated here, it should not be included as "wetland acquisition, restoration, and enhancement" identified under the DO WQAP. Please revise and indicated activities in the upper Hangman Creek watershed as being a supportive watershed activity under Appendix D of the License. I think its fine to leave it in but it should be clear this wasn't part of the DO WQAP as a reasonable and feasible measure to improve Avista's DO responsibility in Lake Spokane.
Comment 3	3.1.1.3	20	To be consistent with the DO TMDL Table 7, please use a volume-weighted DO at 8 m and below, not 8.5 m.
Comment 4	3.2.1	28	Second bullet at top of page. We suggest refraining from using the word 'sufficient' since we have not defined what a sufficient water column for cold water fish is both biologically and in our state water quality standards. It is likely during the fish migration study that fish had to choose between suboptimal

			temperatures or DO to forage for food and seek favorable refuge. There has been reference to the EPA guidance document (2021) highlighting that a 7-day mean minimum 5 mg/L DO saturation is supportive for cold water fish. However, Ecology recognizes this level of DO to be a recommendation by EPA and not a WA state or site specific protection for our water quality standards. Further, the recommended DO concentration of 5 mg/L for cold water fish assumes there are no early life stages present. This assumption does not align with our state water quality standards and reflects the difference between national guidelines vs state or site specific conditions.
Comment 5	3.2.2	28	Second paragraph. In response to the 5 mg/L DO threshold recommended by EPA and to better align with the Spokane River DO TMDL and Figure 3.14, Avista should tie back in the current Spokane Lake DO water quality criterion determined by depth in Table 7 of the DO TMDL. Though Lake Spokane does not have a singular numeric DO criterion, Table 7 is what Ecology has designated as an in-lake DO criterion over space and time. To better represent Figures 3.14, using the volume-weighted Table 7 DO criterion coupled with the 20 degree temperature criteria would better represent the current habitable water column for the various high, low, and average flow years of 2012, 2015, and 2018, respectively. So for example, during a late June period in the lacustrine zone (between LL1 and LL0) instead of using 5 mg/L DO, a value of approximately 7.8 mg/L DO according to Table 7 water quality standard should be used (including the maximum 0.2 mg/L DO difference). These adjustments should be used throughout each timeframe consistent with Table 7 seasonal periods for Figures 3.14 with updated language for the report section.
Comment 6	3.3	31	Table 3.4. Hangman Creek should be removed from the table for reasons indicated above for section 2.3.2.2. This section (includes 3.3.3) should be revised so it doesn't read like upper Hangman Creek wetlands were part of the DO WQAP reasonable and feasible measures.
Comment 7	4.2.1	44	Figure 4.3. This figure does not include data currently being collected after tertiary treatment has come online in 2021 at point source discharges. It's possible we may see an even higher DO volume-weighted hypolimnetic level above the more recent

			data (2010-2018) near-term. The DO TMDL 10-year assessment data collection and analysis will eventually help better explain this external loading reduction observation and in-lake response.
Comment 3	4.2.2	45	As noted above, update the volume weighted DO water column exclusion depth to 8 m vs 8.5 m to be consistent with value used in the Spokane River DO TMDL.
Comment 8	4.2.4	48	Top of page. It appears reference to Figure 4.8 is incorrect and should be Figure 4.6
Comment 9	4.2.4	48	Top of page. It appears reference to Figure 4.5 is incorrect and should be Figure 4.3? Is the correlation made from 2010-2018 recent data? And does 'minimum DO' refer to hypolimnetic DO? Please clarify statement.
Comment 10	4.2.5	48	During the 10-year report presentation, Pradeep from Four Peaks presented on this section in a slightly different perspective using a figure that was not included in this 10-year report. The figure showed the relationship between growing season hypolimnetic DO and flows related to Figure 4.7 (I believe). Incorporating the figure for discussion provided a different perspective that was not highlighted in the report. Please include this figure and appropriate language for review.
Comment 11	4.2.7	51	Though external P loads during the growing season may not be influencing primary productivity as it once was, it's suspected large amounts of sediments are still being deposited during spring runoff which can carry different sources of sediment P-fractions than those that are generally bioavailable and organically bound during the growing season. The continued sediment accumulation in Lake Spokane may have negative effects nearest the dam with potentially increasing oxygen demand during stratified periods in the hypolimnion. More information may be needed to understand the level of sediment-phosphorus loads accumulating during spring runoff and how it will affect the recycling in the anoxic zone long-term. During stratification oxygen demand may gradually increase over time and result in more primary productivity near the lower portions of the photic zone from nutrients diffusing above the thermocline.

Comment 3	4.3	52	Second bullet from top. As noted above, update the volume weighted DO water column exclusion depth to 8 m vs 8.5 m to be consistent with value used in the Spokane River DO TMDL.
Comment 12	5.3	55	Third paragraph. We recommend including language indicating Avista has not met its proportional level of responsibility determined by the DO TMDL and therefore will develop a new compliance schedule as outlined under WAC 173-201A-510(5)(g) and consistent with Section 5.6 of the 401 Certification. This statement (or similar form of) will tie back the reason a new compliance schedule is being proposed for next steps.

Ott, Monica

From:	Ott, Monica
Sent:	Friday, May 13, 2022 12:00 PM
To:	Bauer, Jordan (ECY)
Cc:	Lunney, Meghan; Atkins, Chad (ECY); Brown, Chad (ECY)
Subject:	RE: [External] RE: Lake Spokane Dissolved Oxygen Water Quality Attainment Plan, Ten Year Report
Attachments:	Avista_Lake Spokane DO WQAP Ten Year Report_Revised_05132022.pdf; Lake Spokane DO WQAP - 10-year Report_20220513_RLSO.docx

Hi Jordan,

We have revised the Lake Spokane Dissolved Oxygen Water Quality Attainment Plan Ten Year Report to address the comments you provided on March 22nd. The revisions include modifications to the main body of the report and Appendix B (Longitudinal Sections of Habitable Zones in Lake Spokane Using Dissolved Oxygen Targets Based on Table 7 of the Dissolved Oxygen Total Maximum Daily Load Water Quality Improvement Report). Avista's responses to Ecology's comments are included in Appendix C (Agency Consultation). To help expedite your review I have included the red-lined version of the report along with a clean copy.

We would greatly appreciate your expedited review of the Report by **May 27th** in order to meet the FERC submittal date of **June 1**.

Please let me know if you have any questions.

-Monica

Monica Ott, Water Quality Specialist
1411 E Mission Ave MSC-1, Spokane, WA, 99202
P 509.495.4651 | **F** 509.495.8469
www.myavista.com

From: Bauer, Jordan (ECY) <jbau461@ECY.WA.GOV>
Sent: Tuesday, March 22, 2022 1:53 PM
To: Ott, Monica <Monica.Ott@avistacorp.com>
Cc: Lunney, Meghan <Meghan.Lunney@avistacorp.com>; Atkins, Chad (ECY) <CATK461@ECY.WA.GOV>; Brown, Chad (ECY) <CHBR461@ECY.WA.GOV>
Subject: [External] RE: Lake Spokane Dissolved Oxygen Water Quality Attainment Plan, Ten Year Report

Hi Monica,

Ecology has reviewed the Ten Year Dissolved Oxygen Water Quality Attainment Plan Report. Please find our cover letter and associated comments for the report attached. If you have any questions please feel free to contact me.

Thanks,

Jordan Bauer
Hydropower Compliance Coordinator
Washington Department of Ecology – Eastern Region
Water Quality Program
(509)-688-9403

From: Ott, Monica <Monica.Ott@avistacorp.com>
Sent: Tuesday, February 1, 2022 4:50 PM
To: Bauer, Jordan (ECY) <jbau461@ECY.WA.GOV>
Cc: Lunney, Meghan <Meghan.Lunney@avistacorp.com>; Atkins, Chad (ECY) <CATK461@ECY.WA.GOV>; Brown, Chad (ECY) <CHBR461@ECY.WA.GOV>
Subject: Lake Spokane Dissolved Oxygen Water Quality Attainment Plan, Ten Year Report

Good afternoon Jordan,

I have attached the Lake Spokane Dissolved Oxygen Water Quality Attainment Plan Ten Year Report (Report) for your review. The Report was completed in accordance with the Lake Spokane Dissolved Oxygen Water Quality Attainment Plan, required by the Spokane River Hydroelectric Project License, Appendix B, Section 5.6.C of the Washington Department of Ecology Section 401 Water Quality Certification. The Report assesses the progress made towards improving Lake Spokane's water quality through the implementation of select reasonable and feasible measures and includes monitoring results which address year to year variability and trend analyses. In addition, the Report includes a summary of the 2021 climatic conditions and hydrology, implementation activities, effectiveness of the implementation activities, and proposed actions for 2022.

We would appreciate your review of the Report by **March 8, 2022**. 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, 2022**.

Although a meeting is currently being scheduled to discuss the Report, I am available at (509) 495-4651 if you have any questions or would like to discuss it prior to meeting. Also, please feel free to forward the Report to other pertinent Ecology staff not included on this email.

-Monica

Monica Ott, Water Quality Specialist
1411 E Mission Ave MSC-1, Spokane, WA, 99202
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AVISTA

On March 22, 2022, Ecology provided a comment letter of the Lake Spokane Dissolved Oxygen Water Quality Attainment Plan, Ten Year Report (Report), dated February 2022. Avista's responses to Ecology's comments are grouped by topic and provided as follows.

Ecology Comment 1: Section 2.1.3, Page 9

Ecology also received numerous comments on the light algal bloom activity observed during the 2021 season. Water around the lake appeared to have an overall better transparency during a year in which air temperatures reached record-breaking levels.

Avista Response

Comment noted.

Ecology Comment 2: Section 2.3.2.2, Page 11

Hangman Creek wetland restoration and acquisition work was conditioned by the Department of Interior pursuant to Section 4(e) of the Federal Power Act, Appendix D of the FERC License. Though we support this work and it has overall benefit to the Spokane River watershed, this work is outside the scope of the WA 401 Certification. If work was completed within the WA state border of the Hangman Creek watershed area we would insist this work be included as part of Avista's DO responsibility. However, stated here, it should not be included as "wetland acquisition, restoration and enhancement" identified under the DO WQAP. Please revise and indicated activities in the upper Hangman Creek watershed as being a supportive watershed activity under Appendix D of the License. I think its fine to leave it in but it should be clear this wasn't part of the DO WQAP as a reasonable and feasible measure to improve Avista's DO responsibility in Lake Spokane.

Avista Response

Avista has revised the text in Section 2.3.2.2 and 3.3.3.2 to clarify that the Hangman Creek activities are to support watershed activity under Appendix D of the license.

Ecology Comment 3: Section 3.1.1.3, Page 20

Section 4.2.2, Page 45

Section 4.3, Page 52

To be consistent with the DO TMDL Table 7, please use a volume-weighted DO at 8m and below, not 8.5m.

Avista Response

Avista has revised the text in Section 3.1.1.3, Section 4.1, Section 4.2.2, and Section 4.3 and all relevant figures to be consistent with the DO TMDL Table 7.

Ecology Comment 4: Section 3.2.1, Page 28

Second bullet at the top of page. We suggest refraining from using the word ‘sufficient’ since we have not defined what a sufficient water column for cold water fish is both biologically and in our state water quality standards. It is likely during the fish migration study that fish had to choose between suboptimal temperatures or DO to forage for food and seek favorable refuge.

There has been reference to the EPA guidance document (2021) highlighting that a 7-day mean minimum 5 mg/L DO saturation is supportive for cold water fish. However, Ecology recognizes this level of DO to be a recommendation by EPA and not a WA state or site specific protection for our water quality standards. Further, the recommended DO concentration of 5 mg/L for cold water fish assumes there are no early life stages present. This assumption does not align with our state water quality standards and reflects the difference between national guidelines vs state or site specific conditions.

Avista Response

Avista has revised the text in Section 3.2.1 from “sufficient DO” to “DO in excess of 95% saturation” for clarification, and added a footnote to indicate the range of DO saturation encountered in the lacustrine portion when the acoustic tagging study was conducted.

EPA’s guidance of 7-day minimum of 5 mg/L is not discussed until Section 3.2.2 and is primarily discussed in the context of providing refuges rather than in the context of meeting current water quality criteria.

Ecology Comment 5: Section 3.2.2, Page 28

Second paragraph. In response to the 5 mg/L DO threshold recommended by EPA and to better align with the Spokane River DO TMDL and Figure 3.14, Avista should tie back in the current Spokane Lake DO water quality criterion determined by depth in Table 7 of the DO TMDL

Though Lake Spokane does not have a singular numeric DO criterion, Table 7 is what Ecology has designated as an in-lake DO criterion over space and time. To better represent Figures 3.14, using the volume weighted Table 7 DO criterion coupled with the 20 degree temperature criteria would better represent the current habitable water column for the various high, low, and average flow years of 2012, 2015, and 2018, respectively. So for example, during a late June period in the lacustrine zone (between LL1 and LL0) instead of using 5 mg/L DO, a value of approximately 7.8 mg/L according to Table 7 water quality standard should be used (including the maximum 0.2 mg/L DO difference).

These adjustments should be used throughout each timeframe consistent with Table 7 seasonal periods for Figures 3.14 with updated language for the report section.

Avista Response

Avista has revised the text in Section 3.2.2 to include a second set of figures using Ecology’s suggested approach.

Ecology Comment 6: Section 3.3, Page 31

Table 3.4 Hangman Creek should be removed from the table for reasons indicated above for section 2.3.2.2. This section (includes 3.3.3) should be revised so it doesn’t read like upper Hangman Creek wetlands were part of the DO WQAP reasonable and feasible measures.

Avista Response

Avista has removed Hangman Creek from Table 3.4 and revised text in Section 3.3.3 to clarify that Hangman Creek activities are not part of the DO WQAP reasonable and feasible measures.

Ecology Comment 7: Section 4.2.1, Page 44

Figure 4.3. This figure does not include data currently being collected after tertiary treatment has come online in 2021 at point source discharges. It's possible we may see an even higher DO volume-weighted hypolimnetic level above the more recent data (2010-2018) near-term. The DO TMDL 10-year assessment data collection and analysis will eventually help better explain this external loading reduction observation and in-lake response.

Avista Response

Comment noted. Avista looks forward to discussing the results of the DO TMDL 10-year assessment data collection and analysis with Ecology when it is complete.

Ecology Comments 8 and 9: Section 4.2.4, Page 48

Top of page. It appears reference to Figure 4.8 is incorrect and should be Figure 4.6.

Top of page. It appears reference to Figure 4.5 is incorrect and should be Figure 4.3? Is the correlation made from 2010-2018 recent data? And does 'minimum DO' refer to hypolimnetic DO? Please clarify statement.

Avista Response

Avista has corrected the reference, modifying the text from Figure 4.8 to Figure 4.6. Additionally, the reference to Figure 4.5 was corrected to Figure 4.3 (the R^2 value was calculated separately and not shown on Figure 4.3). Avista has also revised Section 4.2.4 to clarify that minimum volume-weighted DO refers to hypolimnetic DO below 8 m.

Ecology Comment 10: Section 4.2.5, Page 48

During the 10-year report presentation, Pradeep from Four Peaks presented on this section in a slightly different perspective using a figure that was not included in this 10-year report. The figure showed the relationship between growing season hypolimnetic DO and flows related to Figure 4.7 (I believe). Incorporating the figure for discussion provided a different perspective that was not highlighted in the report. Please include this figure and appropriate language for review.

Avista Response

Avista has revised Figure 4.7 to include the summer flows vs minimum volume weighted DO correlation. The discussion on winter runoff has been expanded to include the growing season flow and DO correlation.

Ecology Comment 11: Section 4.2.7, Page 51

Though external P loads during the growing season may not be influencing primary productivity as it once was, it's suspected large amounts of sediments are still being deposited during spring runoff which can carry different sources of sediment P-fractions than those that are generally bioavailable and organically bound during the growing season.

The continued sediment accumulation in Lake Spokane may have negative effects nearest the dam with potentially increasing oxygen demand during stratified periods in the hypolimnion. More information may be needed to understand the level of sediment-phosphorus loads accumulating during spring runoff and how it will affect the recycling in the anoxic zone long-term.

During stratification oxygen demand may gradually increase over time and result in more primary productivity near the lower portions of the photic zone from nutrients diffusing above the thermocline.

Avista Response

Comment noted. Avista looks forward to continuing the discussion of sediment deposition and its potential impacts to DO.

Ecology Comment 12: Section 5.3, Page 55

Third paragraph. We recommend including language indicating Avista has not met its proportional level of responsivity determined by the DO TMDL and therefore will develop a new compliance schedule as outlined under WAC 173-201A-510(5)(g) and consistent with Section 5.6 of the 401 Certification.

This statement (or similar form of) will tie back the reason a new compliance schedule is being proposed for next steps.

Avista Response

Avista has revised the text in Section 5.3 to address Ecology's comment.

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

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May 24, 2022

Monica Ott
Avista Corp.
1411 East Mission Avenue
PO Box 3727
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RE: Request for Ecology Review and Approval – Lake Spokane Dissolved Oxygen Water Quality Attainment Plan, Ten Year Report – Spokane River FERC Project No. 2545

Dear Monica Ott:

The Department of Ecology (Ecology) has reviewed the revised “Lake Spokane Dissolved Oxygen Water Quality Attainment Plan, Ten Year Report”. This report was revised to incorporate comments by Ecology and resubmitted for review on May 13, 2022, via email. The report was completed in accordance with the Lake Spokane Dissolved Oxygen Water Quality Attainment Plan (DO WQAP), required by Section 5.6 (C) of Ecology’s 401 Certification (Certification) and consistent with Spokane River Hydroelectric Project No. 2545 (License) Appendix B. This is the final report of the submitted DO WQAP implementation schedule completed by Avista and approved by Ecology on September 27, 2012.

Ecology has no further comments and **approves** the “Lake Spokane Dissolved Oxygen Water Quality Attainment Plan, Ten Year Report” as revised. We look forward to the continued modeling check-in meetings and active communication to track the progress and development of the next compliance schedule according to WAC 173-201A-510(5). Ecology will work with Avista to ensure a path towards compliance with their proportional level of responsibility identified in the Spokane DO TMDL and consistent with Section 5.6(C) of the Certification.

Please contact me with any questions at (509) 688-9403 or jbau461@ecy.wa.gov.

Sincerely,

Jordan Bauer
Hydropower Compliance Coordinator
Water Quality Program

JB:red

cc: Meghan Lunney, Avista
Chad Atkins, Ecology