AVISTA CORPORATION

2011
LONG LAKE HED TAILRACE
DISSOLVED OXYGEN
MONITORING REPORT

WASHINGTON 401 CERTIFICATION, SECTION 5.6(B)

Spokane River Hydroelectric Project
FERC Project No. 2545

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List of Acronyms and Abbreviations

% saturation	percent of saturation
°C	degrees Celsius
7Q10	7-day average flow with a 10-year return period
Avista	Avista Corporation
AC	alternating current
BAR	barometric pressure
cfs	cubic feet per second
DO	dissolved oxygen
DO TMDL	Spokane River and Lake Spokane Dissolved Oxygen Total Maximum Daily Load
DQO	data quality objective(s)
Ecology	Washington State Department of Ecology
FERC	Federal Energy Regulatory Commission
ft amsl	feet above mean sea level
Golder	Golder Associates Inc.
HED	hydroelectric development
m	meter(s)
mg/L	milligrams per liter
mm Hg	millimeters mercury (pressure)
MOA	Memorandum of Agreement
MQO	measurement quality objective
MS5	Hydrolab® MS5 Multiprobe®
LLFB	monitoring station at Long Lake forebay
LLGEN	monitoring station at Long Lake HED Unit 4 generation plume
LLTR	monitoring station at Long Lake tailrace
LLTRSP1	monitoring station across the river from LLTR
LLGEN_Spot	monitoring station between Long lake powerhouse and LLTR
PDT	Pacific Daylight Time
REMI	Reservoir Environmental Management, Inc.
RFP	request for proposal
RMSE	root mean squared error
TDG	total dissolved gas, as pressure
TDG%	total dissolved gas, as percent of saturation
WQC	Amended section 401 water quality certification

1.0 INTRODUCTION

Results of previous water quality monitoring indicate that Long Lake Hydroelectric Development (HED) at certain times of the year discharges water that does not meet the applicable dissolved oxygen (DO) water quality standards. To address this issue, Avista Corporation (Avista) proposed to conduct a feasibility study to identify potential mechanisms to improve DO levels at the discharge of Long Lake HED, evaluate which alternatives are reasonable and feasible, and implement selected alternative(s) to improve DO of Long Lake HED discharges. Avista initiated this process with the Long Lake HED Phase I Aeration Study (HDR 2006). Avista issued a request for proposal (RFP) for conducting the Phase II Feasibility and Implementation Plan, and selected HDR as the contractor for this work in 2010.

On October 14, 2008, Avista signed a Memorandum of Agreement (MOA) with the Spokane Tribe, which also addresses low DO (and other water quality issues) on their reservation. This MOA commits Avista to "work collaboratively [with the Spokane Tribe] to develop and carry out feasibility studies and implementation actions pertaining to the goal of meeting the DO, TDG [(total dissolved gas)], and Temperature requirements at the Reservation boundary."

Condition 5.6(B) of the Washington section 401 water quality certification (Ecology 2010) requires that Avista "*submit to Ecology a Detailed Phase II Feasibility and Implementation Plan based on the Long Lake HED DO Aeration Study within one year of license issuance (by June 17, 2010), choosing one or several options to implement. The plan shall contain:*

- *Anticipated compliance schedule for conducting preliminary and final implementation plans.*
- *A monitoring plan to evaluate compliance (including avoidance of super-saturation) and coordinate results with the DO TMDL efforts.*"

The Detailed Dissolved Oxygen Phase II Feasibility and Implementation Plan was approved by Washington State Department of Ecology (Ecology) on June 11, 2010 (Avista 2010). The Federal Energy Regulatory Commission (FERC) (2010) modified and approved the Feasibility and Implementation Plan on December 9, 2010. Shortly thereafter DO enhancement testing and monitoring was conducted (HDR and REMI 2010). This is the first annual report required under the FERC approved Feasibility and Implementation Plan.

2.0 LONG LAKE HED

2.1 Objectives

The objectives of this DO monitoring plan are:

1. Improve the understanding of the seasonal timing and magnitude of DO levels in the Long Lake HED tailrace, particularly as they relate to the applicable water quality standards.
2. Obtain data for aeration feasibility studies for the Long Lake dam, powerhouse, and tailrace.
3. Document the effectiveness of meeting the DO water quality standards through measure(s) implemented to increase DO levels of Long Lake HED discharges.
4. Document gas super-saturation caused by measure(s) implemented to increase DO levels of Long Lake HED discharges.
5. Coordinate results with DO TMDL efforts .

2.2 Monitoring Period

The 2011 monitoring period for this study was from July 1 through October 31. High flows resulted in continued use of the Long Lake Dam spillways until July 16. Aeration valves were installed on Turbine Units 3 and 4 on August 3, 2011. Avista aerated using the Unit 4 valves on August 24, August 25, and September 2 through September 14, and Unit 3 valves from September 15 through October 19.

2.3 Methods

Water quality parameters that were recorded include DO concentration (mg/L), TDG (mm Hg), and water temperature (°C). Water depth (meters) was also recorded and used in conjunction with water temperature to evaluate whether and when the water quality monitoring instruments were out of the water and when they were above the minimum TDG compensation depth.

2.3.1 Equipment and Calibration

Hydrolab® MS5 Multiprobe® (MS5) instruments with TDG, optical DO, temperature, and depth sensors were used. Each MS5 deployed for extended periods[1] was connected to an external alternating current (AC) power source after the first download to reduce potential issues associated with low or no power supply.

Solinst® barologgers were used to determine local barometric pressure. The barologger was deployed at the Long Lake pumphouse. As an additional quality assurance measure, resulting site-specific barometric pressures were compared to corresponding values for the Spokane International Airport. Spokane International Airport station sea-level daily ranges for barometric pressure were downloaded

[1] AC power was not connected to MS5s used during spot measurements.

from www.wunderground.com and adjusted by subtracting 37.05 mm Hg to account for the altitude of the Long Lake HED tailrace (1,365 ft amsl).

A MS5 equipped with a short power/data cable and a laptop computer were used as a portable DO meter to obtain spot measurements at long-term and short-term DO monitoring stations.

All instruments used were factory calibrated before the 2011 monitoring season. Monitoring equipment was calibrated according to the manufacturer's instructions prior to deployment and on periodic site visits. Pre-deployment field verification included synchronizing the clocks, comparing the MS5s' TDG pressure value with the silastic membrane removed to the ambient barometric pressure, confirming the patency of the MS5's TDG silastic membrane, and testing the barologgers to confirm that the recorded values were similar and comparable to the Spokane International Airport.

During service periods, each MS5 was retrieved and the pull time recorded. Each service session included verification of logging status and downloading the data to a portable field computer. The Solinst® barologger also was downloaded during these service periods. Patency of the original TDG membrane was confirmed by observing a rapid increase in TDG pressure while pressurizing the sensor with soda water. The manufacturer's instructions were implemented to calibrate depth, and DO sensors and verify the temperature sensor.

2.3.2 Station Facilities

Permanent water quality monitoring facilities are constructed at three locations associated with Long Lake HED: 1) 0.6 mile downstream of the Long Lake Dam referred to as LLTR, 2) in the Long Lake HED forebay referred to as LLFB, and 3) in the Long Lake HED Unit 4 generation plume referred to as LLGEN (Table 2-1; Figure 2-1). For this study, MS5 long-term deployments were done in LLTR and LLFB.

The permanent stations consisted of a length of 4-inch-diameter pipe stilling-well (standpipe), which was sealed at the pipe's submerged end to prevent the MS5 from falling out of the pipe. Each standpipe had ½-inch-diameter perforations along its sides and a hole at the bottom to provide water exchange between the interior and exterior of the pipe and limit accumulation of sediment and debris in the bottom of the pipe. The top end of the LLTR standpipe was protected by a threaded PVC cap with a bolt and lock on it to provide security. Armored flex conduit was used to protect data power cables.

2.3.3 Spot Measurements

Spot measurements of DO, TDG, and water temperature were made at each of the DO monitoring stations being serviced during the site visits, which were done at approximately 2- to 3-week intervals. Spot measurements also were taken across the river from LLTR, at LLTRSP1, (Table 2-1) to assess mixing downstream of the HED.

2.3.4 Data Collection and Processing

Parameters monitored at 15-minute log intervals with the instruments described above included:

- Barometric pressure (mm Hg)
- Air Temperature (°C)
- Depth (m)
- TDG (mm Hg)
- Dissolved Oxygen (mg/L)
- Water Temperature (°C)

In addition, TDG percent of saturation (TDG%) was computed based on measurements as:

- TDG% = TDG in mm Hg / Barometric pressure in mm Hg x 100
  - DO percent saturation (DO%) was computed using equations in the National Park Service's DO Calculator (Thoma and Mailick n.d.)

Data downloaded to the laptop computer were transferred to an office server and were checked for errors using Microsoft Excel®. Erroneous data were identified, assigned data quality codes, and removed from the final data set.

Long Lake HED operational logs were provided by Avista for the period of July 1 through October 31, 2011. These logs provide the HED's hourly discharges as generation and spill along with total discharge. In addition, Avista identified aeration operations during the monitoring period.

2.3.5 Monitoring Difficulties

Monitoring difficulties during the 2011 DO monitoring season are described below.

The LLTR standpipe was found broken on arrival at the site on July 14. Review of depth data suggests it likely broke on July 5, and that it likely was being held above its typical elevation since the beginning of the 2011 DO monitoring study on July 1. A new standpipe was installed on August 1.

On July 14, all of the data on the LLFB continuous MS5 could not be downloaded, even though it had been programmed correctly. The MS5 was retrieved and sent to Hach, who also could not recover the data. This resulted in a data gap from July 3 17:15 PDT to July 14 17:00 PDT.

2.4 Results

Results of 2011 DO monitoring season data collection activities are presented below. MS5s and baraloggers were set up to record data for nearly 11,800 15-minute periods (referred to as "continuous" data in this report) from July 1 through October 31 (Table 2-2). The barologger deployed at LLTR provided a complete data set for local barometric pressure. DO data were successfully obtained for nearly 100 percent of the LLTR continuous monitoring periods and 91 percent of the LLFB continuous monitoring periods. Spot measurements were collected on July 1, July 14, August 1, August 18, August 30, September 14, October 1, October 21, and October 31, when long-term deployment and/or instrument downloads were conducted (Table 2-3). Results of continuous measurements are displayed in Figures 2-2 through 2-5. Comparison of LLTRSP1 spot measurements and corresponding LLTR data are discussed below to indicate the extent of mixing across the river at the designated long-term water quality monitoring station (i.e., LLTR).

2.4.1 Discharge

Combined Long Lake HED generation, spill discharge, and seepage for the July 1 to October 31 monitoring period ranged from approximately 200 to 16,200 cfs (Table 2-4). Long Lake HED generation was at full capacity for the entire period from July 1 to July 16. Maximum hourly discharge at LL HED ranged from 4,600 cfs to 6,700 cfs during August through October.

2.4.2 Water Temperature

Water temperature in the forebay (LLFB) increased from approximately 15°C at the beginning of July to approximately 23°C in mid-August (Figure 2-2). Tailrace (LLTR) water temperature increased from approximately 15°C at the beginning of July to nearly 20°C in mid-August (Figure 2-3). From late July through mid-October, temperature was more variable at LLFB than LLTR. During generation periods, corresponding measurements for LLFB and LLTR were within 4°C of one another, and powerhouse discharge temperatures (LLTR) were generally cooler than the centerline of the intake (i.e., LLFB) (Figure 2-4).

Temperature spot measurements at LLTRSP1 were within 0.3°C of the corresponding LLTR values. Only one of the eight sets of temperature data varied by greater than 0.2°C.

2.4.3 Barometric Pressure

Site-specific barometric pressures ranged from 712 to 735 mm Hg based on the Solonist® barologger deployed at LLTR (Table 2-2).

2.4.4 Dissolved Oxygen

Measured DO concentrations were 5.9 to 10.7 mg/L for LLFB and 1.3 to 11.4 mg/L for LLTR (Table 2-2). Greatest DO concentrations occurred near the beginning of the monitoring period when temperature was near its lowest causing potential solubility for oxygen to be greatest and spill occurred at the dam (Figures 2-2 and 2-3). DO generally decreased through July and August reaching approximately 8 mg/L at LLTR in late August. Figure 2-5 displays DO and TDG% as aeration was iteratively increased in early to mid-September.

DO concentration spot measurements at LLTRSP1 were within 0.5 mg/L of the corresponding LLTR values. Six of the eight sets of DO concentration data varied by 0.2 mg/L or less. The two remaining sets of values had DO concentrations that differed by approximately 0.4 mg/L. One of these occurred when powerhouse aeration operations were being adjusted and the other was within 15 minutes of increasing powerhouse discharge by more than 10 percent.

Long Lake HED discharges, monitored at LLTR, were less than the 8.0-mg/L DO criterion 15.8 percent of the time during the DO monitoring season (Table 2-5). Table 2-5 also includes a summary of corresponding DO values for LLFB[2] for comparative purposes. LLTR DO remained greater than 8.0 mg/L throughout the entire period that Long Lake Dam's spillways were used. LLTR DO was less than 8 mg/L for 19.2 percent of the measurements during powerhouse discharge without spill, although approximately half of these low DO concentrations were within 0.2 mg/L of 8 mg/ L (i.e. 7.8 to 8.0 mg/L) (Figure 2-6). Additional information on the HED's operations, use of spillgates, aeration operation, and the corresponding frequency of LLTR DO values less than 8 mg/L are presented in Table 2-6.

Calculated DO% saturation values were 66 to 128 percent for LLFB and 13 to 121 percent for LLTR (Table 2-2). The DO% saturation at LLTR ranged from 105 to 121 percent during periods of generation with spill, from 28 to 107 percent during periods of generation without spill, and from 13 to 96 percent during periods of non-generation (Figure 2-7).

2.4.5 Total Dissolved Gas

The range of TDG% computed was 95 to 116 percent of saturation for LLFB and 92 to 119 percent of saturation for LLTR (Table 2-2).[3] TDG% of Long Lake HED discharges, monitored at LLTR, were only greater than 110 percent of saturation criterion for five (0.1%) of 6,676 measurements taken after spill was terminated (Table 2-7, Figure 2-6). All five of these elevated TDG% values occurred on September 14 (Figure 2-5). TDG% was also greater than the 110 percent of saturation criterion during early July when spill occurred at Long Lake Dam, although these elevated values were not associated with aeration operations (Table 2-7). TDG% associated with spill is discussed in the 2011 Long Lake TDG Monitoring Report (Golder 2011).

TDG% spot measurements at LLTRSP1 were within 7 percent of saturation of the corresponding LLTR TDG% values. Four of the six sets of TDG% data varied by 2 percent of saturation or less. TDG% for the two sides of the river differed by 4 percent of saturation within 15 minutes of the powerhouse discharge increasing by more than 10 percent. The maximum TDG% difference, 7 percent of saturation, occurred when powerhouse aeration operations were being adjusted.

[2] The DO criterion of 8 mg/L is not directly applicable to LLFB.

[3] Minimum depth for the LLFB continuous MS5 was 10 meters, indicating that the MS5s remained below the compensation depth. However, LLTR had depths of less than 1 meter, which was less than the compensation depth. Following replacement of the stilling well on July 13, the LLTR MS5 remained deeper than the compensation depth.

3.0 DISCUSSION

Dissolved oxygen levels were monitored from July 1, 2011 through October 31, 2011. Due to widely varying runoff conditions, Avista operated the HED at varying capacities throughout this period with spill occurring until mid-July (Figure 2-3). Aeration operations were conducted between August 24 and October 19 using either Unit 3 or 4 (Table 2-6, Figure 2-5). The various generating and aeration conditions along with comparisons of DO during generation, as measured at LLTR, to the 8-mg/L criterion are summarized below and in Table 2-6.

- July 1 through July 23 at 6:45 PDT: Avista generated continuously, with and without spill. DO remained greater than the 8-mg/L criterion.
- July 23 to September 2: Avista used Units 2, 3 and/or 4 at varying capacities, and did not aerate (with two brief exceptions). DO was less than the 8-mg/L criterion approximately 17 percent of the time, although 60 percent of these low values were within the 0.2-mg/L measurement accuracy of the criterion.
- September 2 through 14: Avista continued using Units 2, 3 and/or 4, but aerated each day using Unit 4 (with one exception). DO was less than the 8-mg/L criterion approximately 70 percent of the time, although 58 percent of these low values were within the 0.2-mg/L measurement accuracy of the criterion.
- September 15 through October 19: Avista continued using Units 2, 3 and/or 4, but aerated each day using Unit 3. DO was less than the 8-mg/L criterion approximately 18 percent of the time, although 44 percent of these low values were within the 0.2-mg/L measurement accuracy of the criterion.
- October 20 through October 31: Avista continued using Units 2, 3 and/or 4, but did not aerate. DO was less than the 8-mg/L criterion approximately 3 percent of the time, although 46 percent of these low values were within the 0.2-mg/L measurement accuracy of the criterion.

Results of this study demonstrate progress toward meeting the DO criterion of 8 mg/L through aeration at Turbine Units 3 and 4. Although the DO criterion was not met for all powerhouse discharge periods, powerhouse discharges satisfied the DO criterion approximately 84 percent of the time (Table 2-5), and were within measurement accuracy (i.e., 7.8 mg/L or more) 91 percent of the time when spill was not occurring (Figure 2-6). Aeration operations typically maintained TDG% less than the 110 percent of saturation criterion (Figure 2-6). Avista's continued refinement of aeration settings is expected to provide additional improvements in DO while limiting adverse TDG% conditions.

Comparison of corresponding water temperature, DO, and TDG% values for both sides of the river indicates the river is generally well mixed by the time water is 0.6 mile downstream of the Long lake Dam, at the designated long-term monitoring station, LLTR. As expected, exceptions to this occurred shortly after significant changes in powerhouse discharge and while aeration operations were being adjusted.

4.0 REFERENCES

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TABLES

Table 2-1: Long Lake HED DO Monitoring Stations

Station Code	Description	Latitude / Longitude (NAD83)	Monitoring Type
LLFB	Long Lake Forebay between Unit 3 and 4 intakes near centerline of intake (elevation 1499 feet)	47°37'48" / 117°31'47"	Long-term
LLGEN	Long Lake HED Unit 4 generation plume	47°37'48" / 117°31'47"	None
LLTR	On left downstream bank, at a water pumphouse approximately 0.6 mile downstream from Long Lake dam	47°37'48"/ 117°31'47"	Long-term
LLTRSP1	On right downstream bank, across river from LLTR station	47° 50'19" / 117° 51'02"	Spot

Table 2-2: Summary of Continuous Water Quality Monitoring Results

	LLFB			LLTR		
	Minimum	**Maximum**	**Count**	**Minimum**	**Maximum**	**Count**
Date/Time (PDT)	7/1/2011 0:00	10/31/2011 23:45	11,808	7/1/2011 0:00	10/31/2011 23:45	11,808
Water Temperature (°C)	11.96	22.97	10,703	11.76	19.56	11,786
Dissolved Oxygen (mg/L)	5.9	10.7	10,705	1.3	11.4	11,787
BAR (mm Hg)	used LLTR BAR			712	735	11,785
TDG (mm Hg)	688	836	10,696	666	858	11,767
TDG (% saturation)[1]	95.1	116.1	10,681	91.7	119.0	11,748
DO (% saturation)[1]	65.7	128.5	10,688	13.4	120.6	11,765

Notes:

1. TDG (% saturation) and DO (% saturation) calculated using site-specific barometric pressure data collected at LLTR and corrected for altitude.

Table 2-3: LLTRSP1 Spot Measurement Results

Date Time (PDT)	Water Temperature (°C)	Dissolved Oxygen (mg/L)	TDG (mm Hg)	LLTR BAR (mm Hg)	TDG (% saturation)[1]	DO (% saturation)[1]
7/1/2011 13:45	15.7	11.5	864	727	118.9	121.2
7/14/2011 13:30	17.9	9.8	795	720	110.4	109.1
8/1/2011 9:00	17.8	8.5	752	724	103.9	94.1
8/18/2011 13:30	18.5	8.1	753	725	103.9	91.4
8/30/2011 15:00	18.7	8.5	743	716	103.8	96.7
9/14/2011 15:15	18.3	8.7	750	720	104.2	97.7
10/1/2011 12:45	16.2	9.0	769	719	107.0	97.1
10/21/2011 11:15	13.2	9.0	705	--	--	--
11/2/2011 15:00	10.0	9.5	707	--	--	--

Notes:
1. TDG (% saturation) and DO (% saturation) calculated using site-specific barometric pressure data collected at LLTR and corrected for altitude.

Table 2-4: Monthly Outflow from Long Lake HED

Month-Year	Minimum Hourly Outflow (cfs)	Maximum Hourly Outflow (cfs)	Average Hourly Outflow (cfs)
July 2011	210	16,230	7,872
August 2011	180	6,700	2,610
September 2011	180	4,680	2,164
October 2011	180	4,640	2,536

Table 2-5: Summary of DO Less than 8 mg/L, DO Criterion Lower Limit, During Generation

	LLFB[1]			LLTR		
Operations	**Total Number**	**Number <8 mg/L DO**	**Frequency <8 mg/L DO**	**Total Number**	**Number <8 mg/L DO**	**Frequency <8 mg/L DO**
Generation Without Spill	6,683	977	14.6%	6,709	1,290	19.2%
Generation With Spill	414	0	0.0%	1,472	0	0.0%
All Generation	7,097	977	13.8%	8,181	1,290	15.8%

Notes:
[1] DO criterion of 8 mg/L is not directly applicable to LLFB.

Table 2-6: Summary of Exceedances of DO Criterion at LLTR, During Generation

Operations, Spill, and Aeration Characteristics				LLTR		
Period	**Operations**	**Spill**	**Aeration**	**Total Number**	**Number <8 mg/L DO**	**Frequency <8 mg/L DO**
7/1 00:00 to 7/16 08:45	All 4 Units Full Capacity, continuous generation throughout the day	Yes	No	1,472	0	0.0%
7/16 09:00 to 7/18 23:45	All 4 Units Full Capacity, continuous generation throughout the day	No	No	252	0	0.0%
7/19 00:00 to 7/23 06:45	# Units Varies, Capacity Varies, continuous generation throughout the day	No	No	412	0	0.0%
7/23 07:00 to 9/2 11:45	# Units Varies, Capacity Varies[1]	No	Brief period of aeration on Aug 24 and 25	2,522	436	17.3%
9/2 12:00 to 9/14 22:45	# Units Varies (but Unit 1 not used), Capacity Varies[1]	No	Unit 4 during generation, except Unit 3 used on Sept 7	637	447 [2]	70.2% [2]
9/14 23:00 to 10/19 23:45	# Units Varies (but Unit 1 not used), Capacity Varies[1]	No	Unit 3 during generation	2,104	385	18.3%
10/20 00:00 to 10/31 23:45	# Units Varies (but Unit 1 not used), Capacity Varies[1]	No	No	782	22	2.8%

Notes:
[1] Periods of non-generation occur during each day.
[2] Of the 637 measurements, 150 (23.5%) were less than 7.8 mg/L.

Table 2-7: Summary of TDG% Greater than 110%, TDG Criterion Upper Limit, During Generation

	LLFB			LLTR		
Operations	**Total Number**	**Number >110% TDG**	**Frequency >110% TDG**	**Total Number**	**Number >110% TDG**	**Frequency >110% TDG**
Generation Without Spill	6,660	272	4.1%	6,676	5	0.1%
Generation With Spill [1,2]	413	413	100.0%	1,467	1,457	99.3%
All Generation	7,073	685	9.7%	8,143	1,462	18.0%

Notes:
[1] 110% TDG criterion is not applicable when discharge exceeds the 7-day average flow with a 10-year return period, which is referred to as the 7Q10.
[2] TDG exceedances during spill are discussed in 2011 Long Lake Total Dissolved Gas Monitoring Report (Golder 2011).

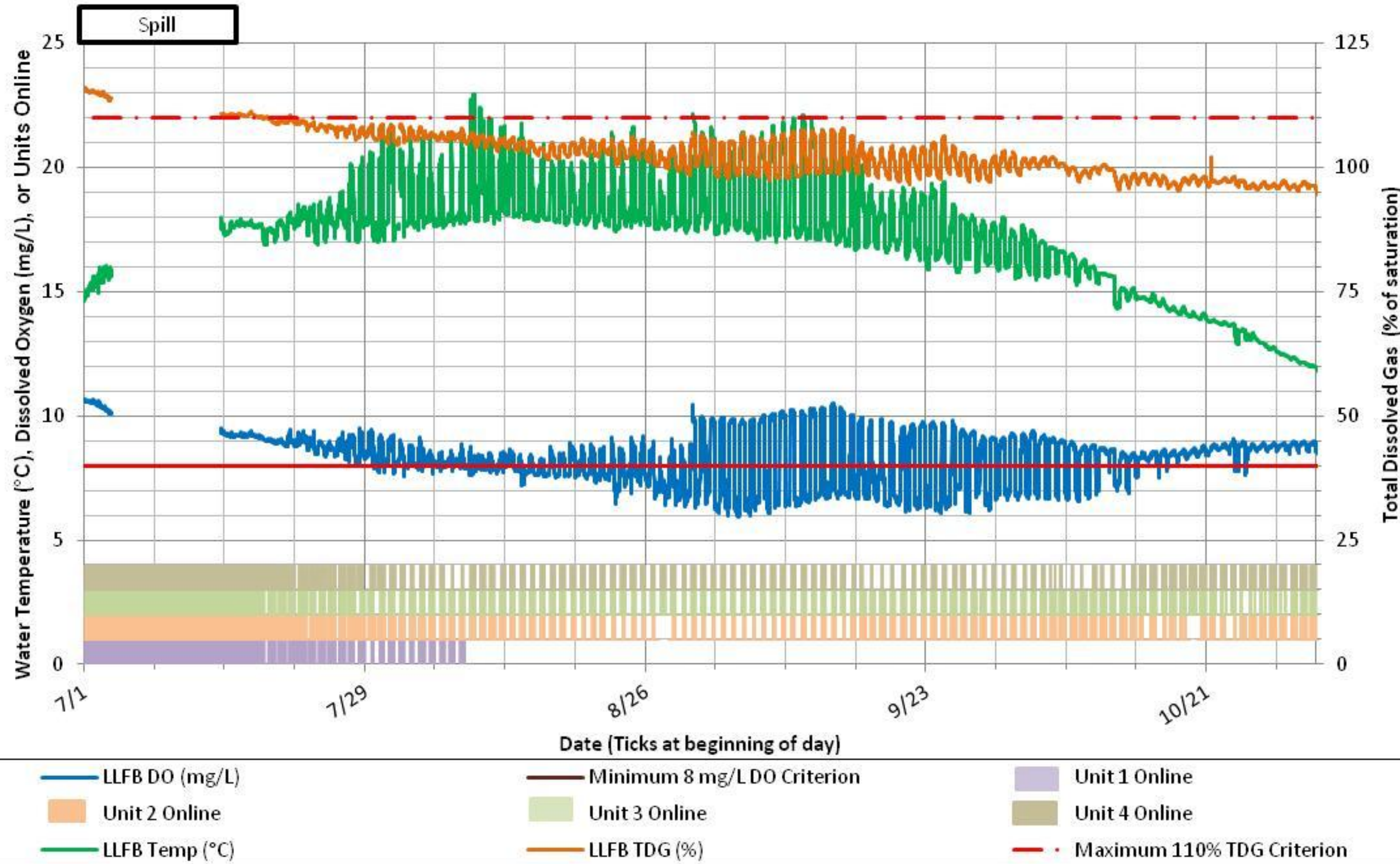
FIGURES

DRAFT

Source: Avista

Figure 2-1: Long Lake HED Permanent Water Quality Monitoring Station Locations

Note: LLTRSP1 temporary water quality monitoring station was across the river from the Tailrace Pumphouse (LLTR).



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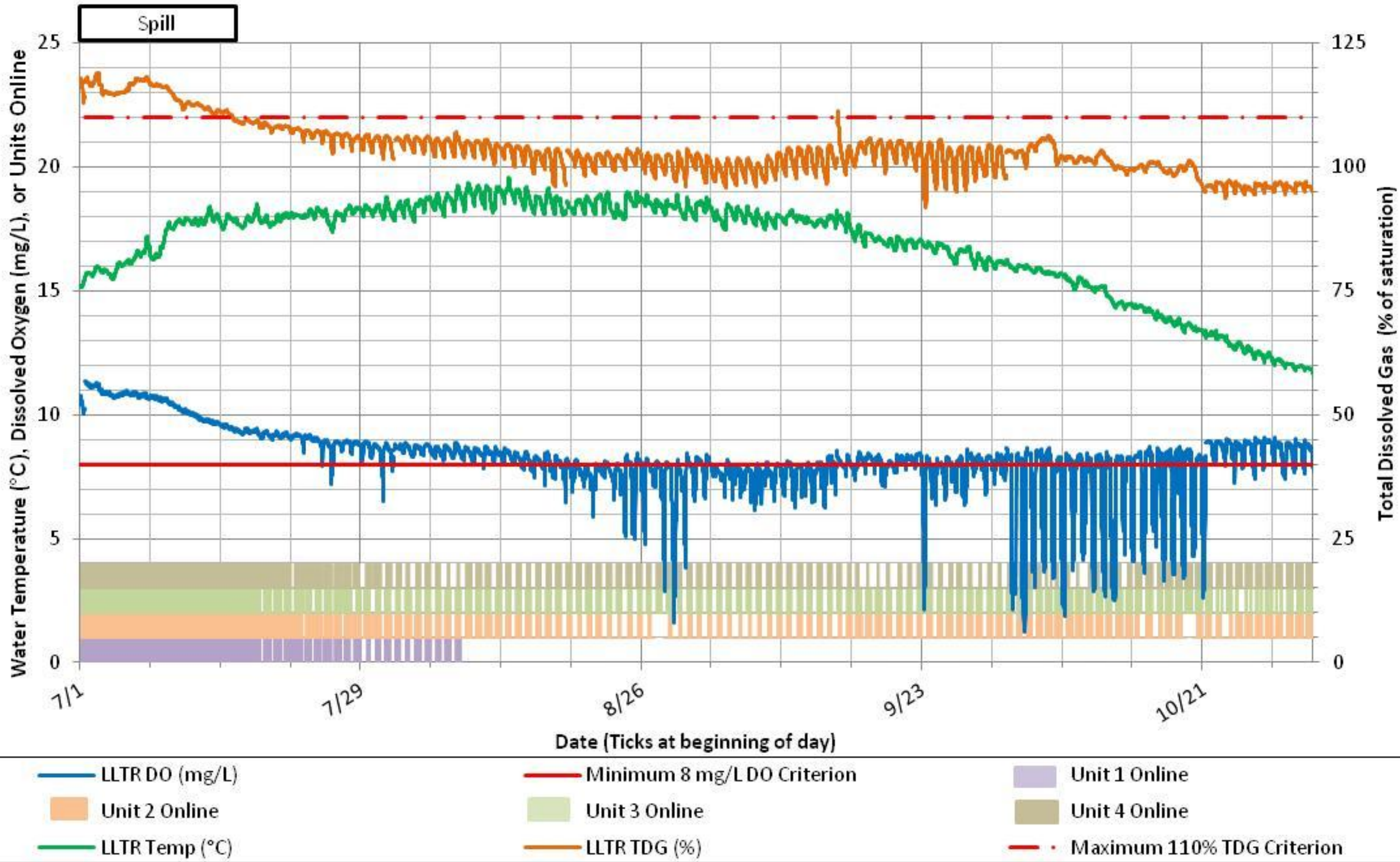
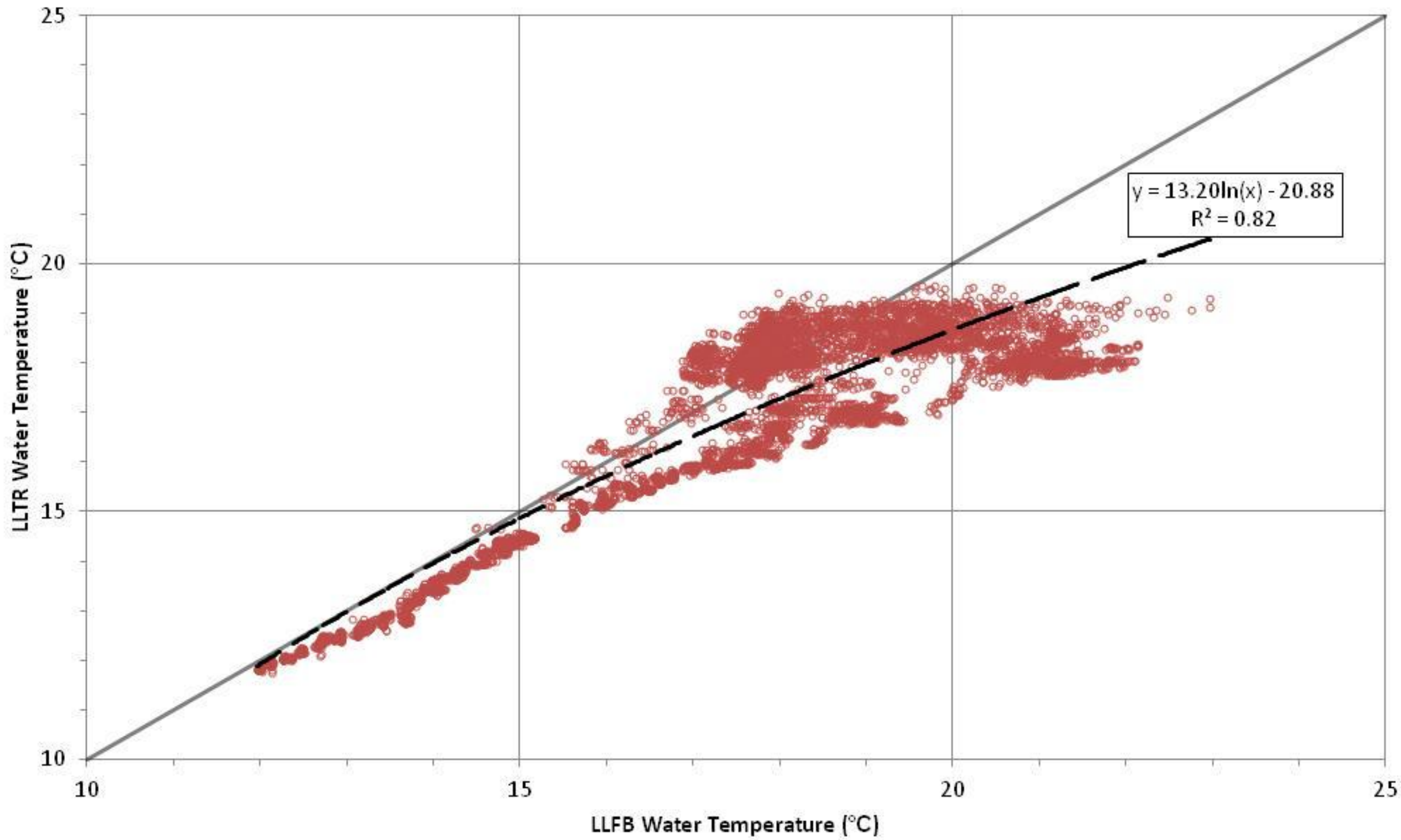
Title	LLFB Water Temperature, Dissolved Oxygen, TDG%, and Operations		
Project Name	LL DO Monitoring	Project No.	073-93081-02.500
Client Name	Avista	Date	February 16, 2012

FIGURE 2-2



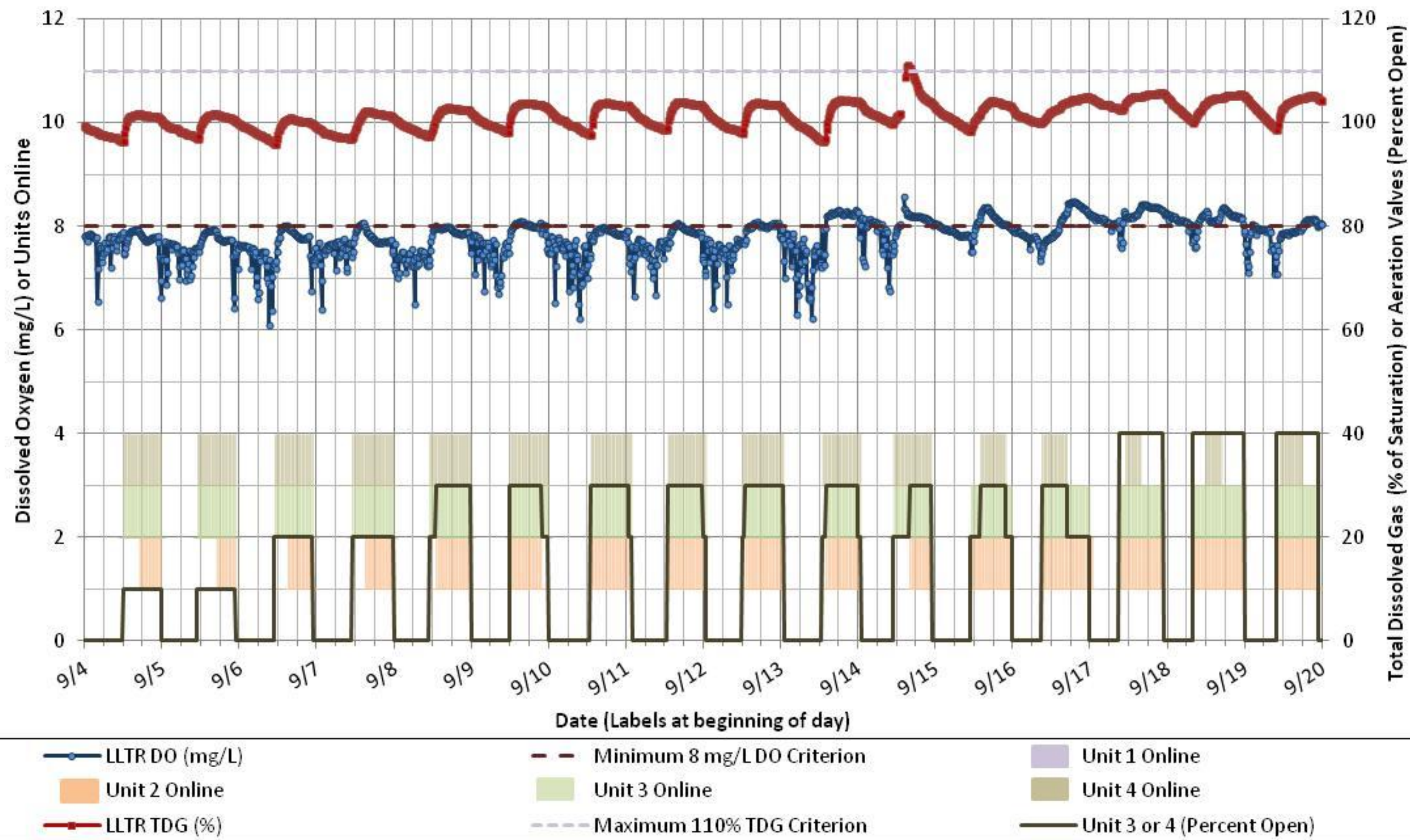
Golder Associates	Title	LLTR Water Temperature, Dissolved Oxygen, TDG%, and Operations	
	Project Name: LL DO Monitoring	Project No. 073-93081-02.500	FIGURE 2-3
	Client Name: Avista	Date: February 16, 2012	



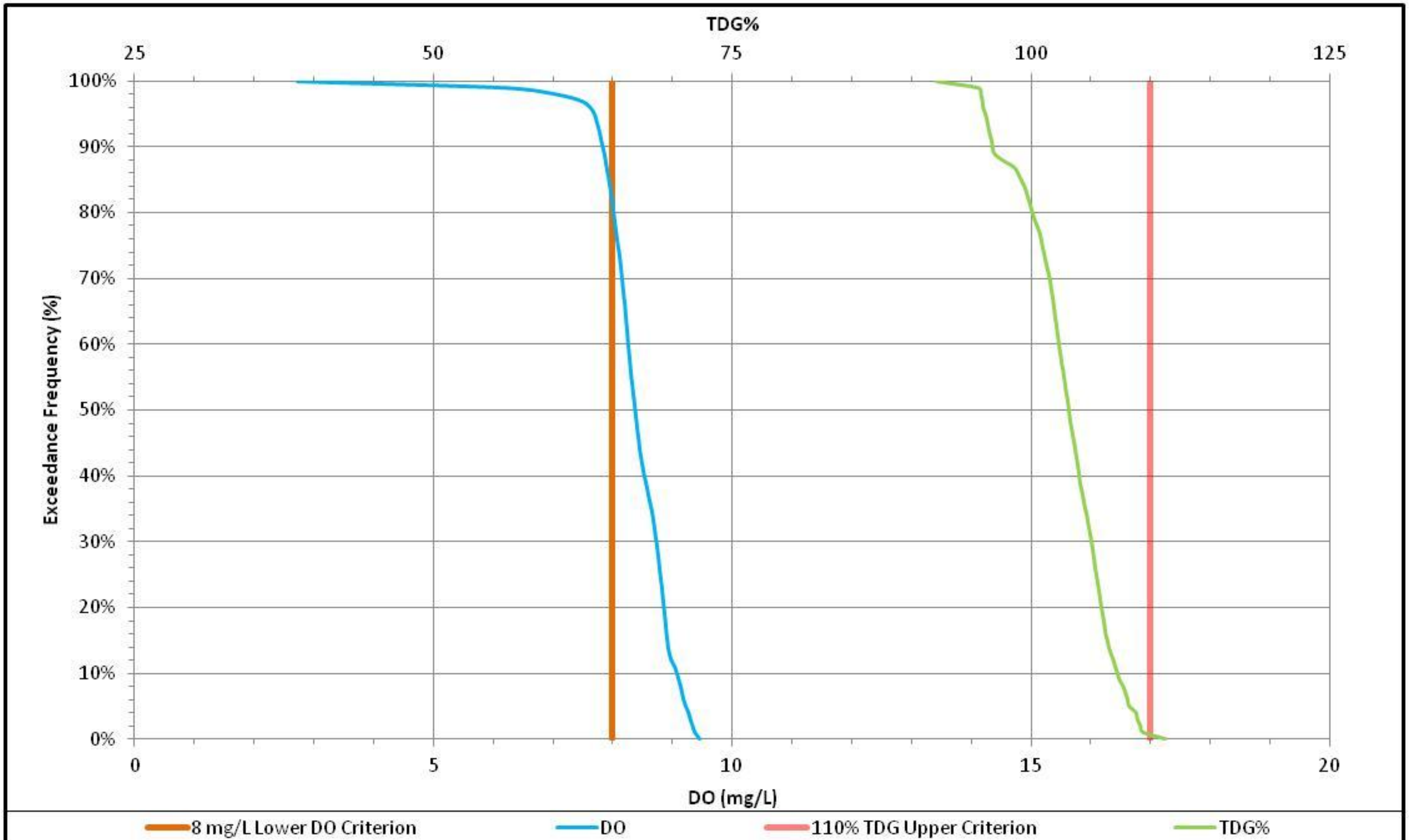
Title	Water Temperature Comparison for LLTR and LLFB During Generation		
Project Name	LL DO Monitoring	Project No.	073-93081-02.500
Client Name	Avista	Date	February 16, 2012

Golder Associates

FIGURE 2-4



Golder Associates	Title: LLTR Dissolved Oxygen Concentration and TDG% Along with Operations, September 4-19		
	Project Name: LL DO Monitoring	Project No.: 073-93081-02.500	FIGURE 2-5
	Client Name: Avista	Date: February 16, 2012	



Golder Associates	Title: LLTR DO and TDG% Exceedance Frequency During Generation Without Spill		
	Project Name: LL DO Monitoring	Project No. 073-93081-02.500	FIGURE 2-6
	Client Name: Avista	Date: February 16, 2012	

Golder Associates	Title: LLTR Dissolved Oxygen Concentration and Percent of Saturation along with Operations		
	Project Name: LL DO Monitoring	Project No. 073-93081-02.500	FIGURE 2-7
	Client Name: Avista	Date: February 16, 2012	

APPENDIX A
DATA QUALITY ANALYSIS

DATA QUALITY SUMMARY

Data quality objectives (DQOs) and Measurement Quality Objectives (MQOs) are the quantitative and qualitative terms used to specify how good the data need to be to meet the project's specific monitoring objectives. DQOs for measurement data, also referred to as data quality indicators, include measurement range, accuracy, precision, representativeness, completeness, and comparability. The range, accuracy, and resolution for each measured parameter are provided in Table A-1.

Table A-1: Range, Accuracy and Resolution of Parameters Recorded

Instrument and Parameter	Range	Accuracy	Resolution
MS5 Dissolved Oxygen	0 to 30 mg/L	± 0.01 mg/L for 0 to 8 mg/L ± 0.02 mg/L for >8mg/L	0.01 mg/L
MS5 Total Dissolved Gas	400 to 1300 mm Hg	±0.1 % of span	1.0 mm Hg
MS5 Temperature	-5 to 50°C	±0.10°C	0.01°C
MS5 Depth (0-25 meters)	0 to 25 meters	±0.05 meter	0.01 meter
Barologger Relative Barometric Pressure	1.5 meter of water	± 0.1 cm of water	0.002% of full scale
Barologger Temperature	-10 to 40°C	± 0.05°C	0.003°C

Notes: Sources: Hach MS5 User Manual and Solinist Levelogger User Guide [4]

MQOs are the performance or acceptance thresholds or goals for the project's data, based primarily on the data quality indicators precision, bias, and sensitivity. Table A-2 presents MQOs selected during preparation of the Long Lake HED tailrace DO monitoring plan. The meter-specific root mean squared error (RMSE) of the calibration corrections applied after each calibration, and an overall RMSE for all meters compared to MQOs are shown in Table A-3.

Table A-2: Measurement Quality Objectives

Parameter	MQOs
Barometric Pressure	2 mm Hg
Temperature	0.5ºC
Total Pressure	1% (5 to 8 mm Hg)
TDG%	1%
Dissolved Oxygen	0.5 mg/L

[4] Hach Corporation. 2006. Hydrolab DS5X, DS5, and MS5 Water Quality Multiprobes User Manual. February, Edition 3. Catalog Number 003078HY and Solinist. 2010. Levelogger Series (Levelogger Gold, Barologger Gold, Levelogger Junior, LTC Levelogger Junior and Rainlogger) User Guide - Software Version 3.4.0. August 17.

Table A-3: Difference Between RMSE and MQOs by MS5, Part 1: Barometric Pressure, Total Pressure, and Total Dissolved Gas

Meter IDs and Locations	RMSE [1]			MQO			RMSE - MQO		
	BAR[2] (mm Hg)	Total Pressure[3] (%)	TDG[4] (%)	BAR (mm Hg)	Total Pressure (%)	TDG (%)	BAR (mm Hg)	Total Pressure (%)	TDG (%)
48762 (LLFB 7/14-8/30)	1.48	0.21	0.21	2	1	1	-0.52	-0.79	-0.79
48763 (LLFB 7/01-7/14, LLTR 8/30-11/02)	1.18	0.16	0.16	2	1	1	-0.82	-0.84	-0.84
48764	1.58	0.22	0.22	2	1	1	-0.42	-0.78	-0.78
48765	1.00	0.14	0.14	2	1	1	-1.00	-0.86	-0.86
60375 (LLFB 8/30-11/02)	1.94	0.27	0.27	2	1	1	-0.06	-0.73	-0.73
60376 (LLTR 7/01-8/30)	1.10	0.15	0.15	2	1	1	-0.90	-0.85	-0.85
Overall RMSE	1.46	0.20	0.20	2	1	1	-0.54	-0.80	-0.80

Notes:
Shaded values indicate exceedance of MQO.
[1] Pooled RMSE calculated at each station during service period and removal.
[2] Pooled RMSE calculated from BAR record at station during service period and removal as compared to corresponding TDG in air new reading.
[3] Pooled RMSE calculated as the difference in TDG in air new minus the BAR, then divided by the TDG and multiplied by 100.
[4] Pooled RMSE calculated at each station during service period and removal. TDG calculated as TDG in air new divided by the BAR and multiplied by 100.
N/A - Not available, measurement not taken.

Root mean squared error (RMSE) = $\sqrt{\frac{\sum_{i=1}^{n}(x_{1,i} - x_{2,i})^2}{n}}$.

Table A-3 (Continued): Difference Between RMSE and MQOs by MS5, Part 2: Temperature and Dissolved Oxygen

Meter IDs and Locations	RMSE		MQO		RMSE - MQO	
	Temp[1] (°C)	DO[2] (mg/L)	Temp (°C)	DO (mg/L)	Temp[1] (°C)	DO[2] (mg/L)
48762 (LLFB 7/14-8/30)	0.18	0.25	0.5	0.5	-0.32	-0.25
48763 (LLFB 7/01-7/14, LLTR 8/30-11/02)	0.16	0.42	0.5	0.5	-0.34	-0.08
48764	0.19	0.17	0.5	0.5	-0.31	-0.33
48765	0.00	0.71	0.5	0.5	-0.50	0.21
60375 (LLFB 8/30-11/02)	0.12	0.49	0.5	0.5	-0.38	-0.01
60376 (LLTR 7/01-8/30)	0.14	0.12	0.5	0.5	-0.36	-0.38
Overall RMSE	0.16	0.32	0.5	0.5	-0.34	-0.18

Notes:
Shaded values indicate exceedance of MQO.
[1] Pooled RMSE calculated from temperature record at station during service period and removal. Temperature calibration based on the difference between the meter and calibration thermometer in a water bath.
[2] Calculated RMSE as difference of the pre-calibration measurement and 100% saturation. Initial factory calibration included in analysis.
N/A - Not available, measurement not taken

Root mean squared error (RMSE) = $\sqrt{\frac{\sum_{i=1}^{n}(x_{1,i}-x_{2,i})^2}{n}}$.

Measurement Range

The measurement range, range of reliable readings of an instrument or measuring device, specified by the manufacturer is displayed in Table A-1 for each measured parameter. Maintenance of field sampling equipment was conducted in a manner consistent with the corresponding manufacturer's recommendations to provide reliable readings within each instrument's reported measurement range.

Bias

TDG meters, like other field monitoring instruments, are subject to bias due to systematic errors introduced by calibration, equipment hardware or software functioning, or field methods. Bias was generally minimized by following standard protocols for calibration and maintenance, and by following field protocols for stabilization of meter readings. This included using a spreadsheet to ensure correct calculation of BAR from weather station and barologger data.

Precision

Precision refers to the degree of variability in replicate measurements. Instrument precision was evaluated through the calibration and maintenance activities. MQOs for BAR, total pressure, TDG%, and temperature were met for all meters.

The DO MQO was met by all the long-term MS5s deployed at LLTR and LLFB. One of the MS5s used for spot measurements exceeded the DO MQO.

Discharge data were obtained from Avista, which uses a well-established monitoring program. Golder Associates Inc. (Golder) reviewed the variability of discharge data to determine whether it was appropriate based on expected values. All discharge data were deemed acceptable.

Accuracy

Accuracy is a measure of confidence that describes how close a measurement is to its "true" value, or the combination of high precision and low bias. Throughout this seasonal DO monitoring study, the MS5s underwent verification procedures. All differences between DO, TDG pressure, temperature, depth, and barometric pressure were recorded and these differences were discussed in the previous section.

Representativeness

Representativeness qualitatively reflects the extent to which sample data represent a characteristic of actual environmental conditions. For this project, representativeness was addressed through proper design of the sampling program to ensure that the monitoring locations were properly located and sufficient data were collected to characterize DO at that location.

Comparability

Comparability is the degree to which data can be compared directly to previously collected data. Comparability was achieved by consistently monitoring the same downstream long-term monitoring station (LLTR) monitored in the past, monitoring in the LLFB standpipe constructed in 2009, and conducting spot measurements at the same location across the river from LLTR as in past years.

Completeness

Completeness is the comparison between the quantity of data planned to be collected and how much usable data was actually collected, expressed as a percentage (Table A-4). The DO data collection period consisted of approximately 11,800 15-minute periods. Data completeness for all parameters met or exceeded the goal of at least 90 percent for both LLFB and LLTR. Virtually a complete data set was obtained for LLTR.

Table A-5 summarizes the number of specific DQCodes applied to LLFB and LLTR data.

Table A-4: Project Completeness

	LLFB		LLTR	
	Count	**Completeness (%)**	**Count**	**Completeness (%)**
Monitoring Period	11,808	--	11,808	--
Water Temperature (°C)	10,703	91%	11,786	100%
Dissolved Oxygen (mg/L)	10,705	91%	11,787	100%
BAR (mm Hg)	used LLTR BAR		11,785	100%
TDG (mm Hg)	10,696	91%	11,767	100%
TDG (% saturation)	10,681	90%	11,748	99%
DO (% saturation)	10,688	91%	11,765	100%

Table A-5: Number of Specific DQCodes During the Monitoring Period

DQ Code	DQ Code Description	LLFB					LLTR						
		Temp (°C)	TDG (mmHg)	Depth (meters)	DO (mg/L)	Batt (volts)	Temp (°C)	TDG (mmHg)	Depth (meters)	DO (mg/L)	Batt (volts)	Level (m H2O)	ATemp (°C)
991	Instrument not deployed at typical long-term depth	25	25	25	25	25	--	--	--	--	--	3	3
992	Out of water/moved for downloading data	--	--	--	--	--	--	--	--	--	--	1	1
993	Out of water for calibration/servicing	28	28	28	28	28	17	17	17	17	17	--	--
995	No instrument deployed	--	--	--	--	--	2	2	2	2	2	--	--
996	No data reported by instrument even though programmed correctly	1,048	1,048	1,048	1,048	1,048	--	--	--	--	--	19	19
997	Suspect not yet equilibrated after deployment	4	11	3	2	2	3	22	--	2	--	--	--
No DQ Code		10,703	10,696	10,704	10,705	10,705	11,786	11,767	11,789	11,787	11,789	11,785	11,785
Monitoring Period		11,808	11,808	11,808	11,808	11,808	11,808	11,808	11,808	11,808	11,808	11,808	11,808

Notes:

-- = not applicable

APPENDIX B
CONSULTATION RECORD

AVISTA

2/17/2012

Marcie Mangold
Department of Ecology
4601 N Monroe Street
Spokane, WA 99205

In accordance with Avista's Federal Energy Regulatory Commission (FERC) June 18, 2009 Spokane River Project (FERC No. 2545) License Avista is submitting the following reports for your review and comment.

Annual Total Dissolved Gas Attainment and Monitoring Report for the Long Lake Development. There are two related components to this report.

A. *Annual Total Dissolved Gas Monitoring Report for 2011, Golder Associates, Dec. 2011.* As required by the Total Dissolved Gas (TDG) Water Quality Attainment Plan (WQAP) and the Washington TDG Monitoring Plan, this report provides the results of monitoring TDG at Long Lake HED and Nine Mile HED during 2011. Avista proposes to continue implementing the same monitoring plan at Long Lake HED in 2012. However, during 2011 the Nine Mile HED was plagued with numerous equipment issues which resulted in lost generation and increased spill. As a result, Avista proposed to delay monitoring until operations at the plant return to normal. Ecology agreed with this proposal and in their correspondence dated February 17, 2012 suspended TDG monitoring until the first season following completion of the Unit 1 and 2 turbine/generator replacement project and the sediment by-pass tube is again fully operational. This correspondence is attached.
B. *Long Lake Dam TDG Abatement Feasibility Phase III, Physical Model Study, 2011 Interim Report. Northwest Hydraulic Consultants, Jan. 2012.* This report documents the progress of building the physical model and hydraulic testing deflectors on the modeled Long Lake Dam spillway. Avista proposes to continue the modeling of the stepped weir alternative identified in the Phase II study during 2012. In addition, a third alternative termed the Noxon Concept (dentated spillway) will be developed including preliminary hydraulic design calculations, civil engineering, drawings, and cost estimates. Once these items are completed, Avista will be able to determine if the design should be modeled. Avista believes this effort could also be completed in 2012.

Annual Long Lake Tailrace Dissolved Oxygen Monitoring Report. This is the first annual report required under the FERC approved Dissolved Oxygen (DO) Feasibility and Implementation Plan. Monitoring DO took place from July 1st through October 31, 2011. The report illustrates the seasonal changes in DO just downstream of the dam during the low flow period of the year. In order to boost DO levels in the river, Avista installed manual aeration equipment on turbine Units 3 and 4. The results of aerating the turbine discharge water with the aeration equipment during generation are included in this report. This was Avista's first effort to implement the system, which had been tested in 2010. The results were encouraging. Avista proposes to automate the components of the system in 2012, which will allow for a more thorough, and effective aeration effort and assessment.

Avista would appreciate your review of the attached reports by March 21, 2012. This 30 day review period should allow Avista enough time to address your comments prior to submitting the reports to

FERC for their review and approval. Please feel free to call me anytime if you have questions or concerns.

Sincerely,

Hank Nelson

Hank Nelson
Environmental Coordinator

Enclosures

CC: Brian Crossley, Spokane Tribe

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

March 21, 2011

Mr. Elvin "Speed" Fitzhugh
Spokane River License Manager
Avista Corporation
1411 East Mission Ave., MSC-1
Spokane, WA 99220-3727

RE: Request for comments – Spokane River Hydroelectric Project No. 2545
Long Lake HED Dissolved Oxygen Monitoring Report
Washington 401 Certification, Section 5.6(B).

Dear Mr. Fitzhugh:

We have reviewed the Long Lake Hydroelectric Development Dissolved Oxygen Monitoring Report that was mailed to the Department of Ecology (Ecology) on February 22, 2012.

We would like to thank Avista for taking the opportunity to discuss the report with us over the phone on March 13, 2012. In reviewing the results of the monitoring report, the aeration of turbine units 3 and 4 have demonstrated progress toward meeting the dissolved oxygen (DO) criterion of 8mg/L, while still maintaining other water quality parameters in or around water quality standards.

While discussing the results with Hank Nelson over the phone on March 13, 2012, he informed us that turbine units 3 and 4 will become automated, and units 1 and 2 will be retrofitted with manual draft tube aeration systems. This will allow for increased flexibility in the system and provide more options for the dam operators.

The performance and success of the draft tube aeration project has proven to be very successful for increasing DO concentrations and we feel that continued monitoring and refinement of aeration settings as you are doing is working well to achieve the best results for all water quality parameters, while maximizing DO concentrations in the tailrace of Long Lake HED. As units 1 and 2 come online and units 3 and 4 become automated, it will be interesting to see if DO concentrations can be improved further.

We are encouraged by the monitoring results and look forward to future results as the other units are automated and brought online.

Thank you for the opportunity to comment and please feel free to contact me at (509) 329-3450 or by email at dman461@ecy.wa.gov if you have any further questions.

Sincerely,

D. Marcie Mangold

D. Marcie Mangold
Water Quality Program

DMM:dw
cc: Brian Crossley, Spokane Tribe of Indians
Hank Nelson, Avista
David Moore, Ecology/WQP

Nelson, Hank

From: Brian Crossley [crossley@spokanetribe.com]
Sent: Wednesday, March 21, 2012 4:23 PM
To: Nelson, Hank
Subject: TDG Long Lake and 9 mile and TDG abatement Phase III

9 mile TDG report- I agree- the data was not collected under "normal" conditions . Are the gates working good this year?

Phase III TDG abatement feasibility - I liked the idea that they constructed multiple level flip-lip that allows Avista some flexibility in managing flows and also that they are constructed across the entire spillway.

I presume the stepped model will be presented after they are done....

I have not read the DO report yet; I will get you comments on that tomorrow if I have any.

Brian