Water Quality Monitoring Report

Hells Canyon Recreation Area – Water Quality Monitoring Project
EPSCoR – MURI Program

Summer 2016

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Executive Summary

The purpose of this research project is to begin building a database of real-time water quality data over both temporal and seasonal time to predict climate change effects on water quality in the Hells Canyon National Recreation Area (HCNRA). The HCNRA is located in a section of the Snake River where access is limited; therefore, there is very little water quality data on this reach. The overall goal of this project is to further our understanding of past and present human impacts on an area that is presently managed to maximize its wildlife, cultural heritage, recreational, and economic values. It is our hope that results from this project will inform future management decisions in the face of climate change, economic pressures, and increasing recreational usage.

This project is a continuation of summer 2015 MURI research. The project consisted of collecting water quality data from the same or nearby sites as the previous year. Water quality parameters included pH, dissolved oxygen (DO), temperature, specific conductance, and turbidity, using Hydrolab water quality multi-probe Sondes. For the 2016 project, ammonium and nitrate were added to the suite of parameters measured. This report includes summarized data from a six-day monitoring trip (Aug 4-9) through the HCNRA which ranges from Hells Canyon Dam to Cache Bar. Readings for temperature ranged from 70 °F – 73.8 °F, dissolved oxygen ranged from 6.9 mg/L – 8.46 mg/L, nitrate ranged from 1.59 mg/l-N to 2.26 mg/l-N and pH ranged from 8.1 – 8.5. Additional data from several short-term "test" sites around the Lewis-Clark Valley is also included.

Background

Hells Canyon, North America's deepest river gorge, encompasses a vast and remote region with dramatic changes in elevation, terrain, climate and vegetation. Carved by the Snake River, Hells Canyon is more than a mile below Oregon's west rim, and 8,000 feet below Idaho's Seven Devils Mountains. The deepest section of the canyon is 7,913 feet near Granite Creek in the upper section near the dam. The Snake River is designated a Wild and Scenic River. The 31.5-mile section of the river between Hells Canyon Dam and Upper Pittsburg Landing is designated Wild and the 36-mile section of river downstream from Upper Pittsburg Landing to mile 180.2 (eight miles below the confluence of the Salmon River) is designated Scenic. The HCNR Area straddles both sides of the Snake River in Oregon and Idaho and includes the Wallowa-Whitman National Forest, lands from the Payette National Forest, Nez Perce National Forest, and Bureau of Land Management.

This part of the Snake River section is also unusual in that jet boats have been used in the canyon for many years and Congress included specific language in the HCNRA Act which allows their continued use. Trip permits are required seven days a week during the primary season, Friday before Memorial Day through September 10. There are three private permit launches each day. Permits are issued through a lottery in March of each year or cancelled permits can be obtained as available once the lottery reservations have been allocated. Self-issue river permits are required for the entire river corridor outside of the primary season, but do not require an advance reservation. A permit for this trip was obtained when a cancelled permit became available.

There is little existing water quality data for the HCNRA; likely due to the lack of accessibility. A Total Maximum Daily Load (TMDL) was developed for this section, but it is based on limited temperature and dissolved oxygen data. No water quality data has been collected with the type of equipment we are using, therefore, a sampling and deployment methodology has also been developed for this project. This new methodology was based on similar sampling by the Utah Department of Environmental Quality, the Portneuf River Monitoring Project, and EPA Guidelines for Quality Assurance Plans.

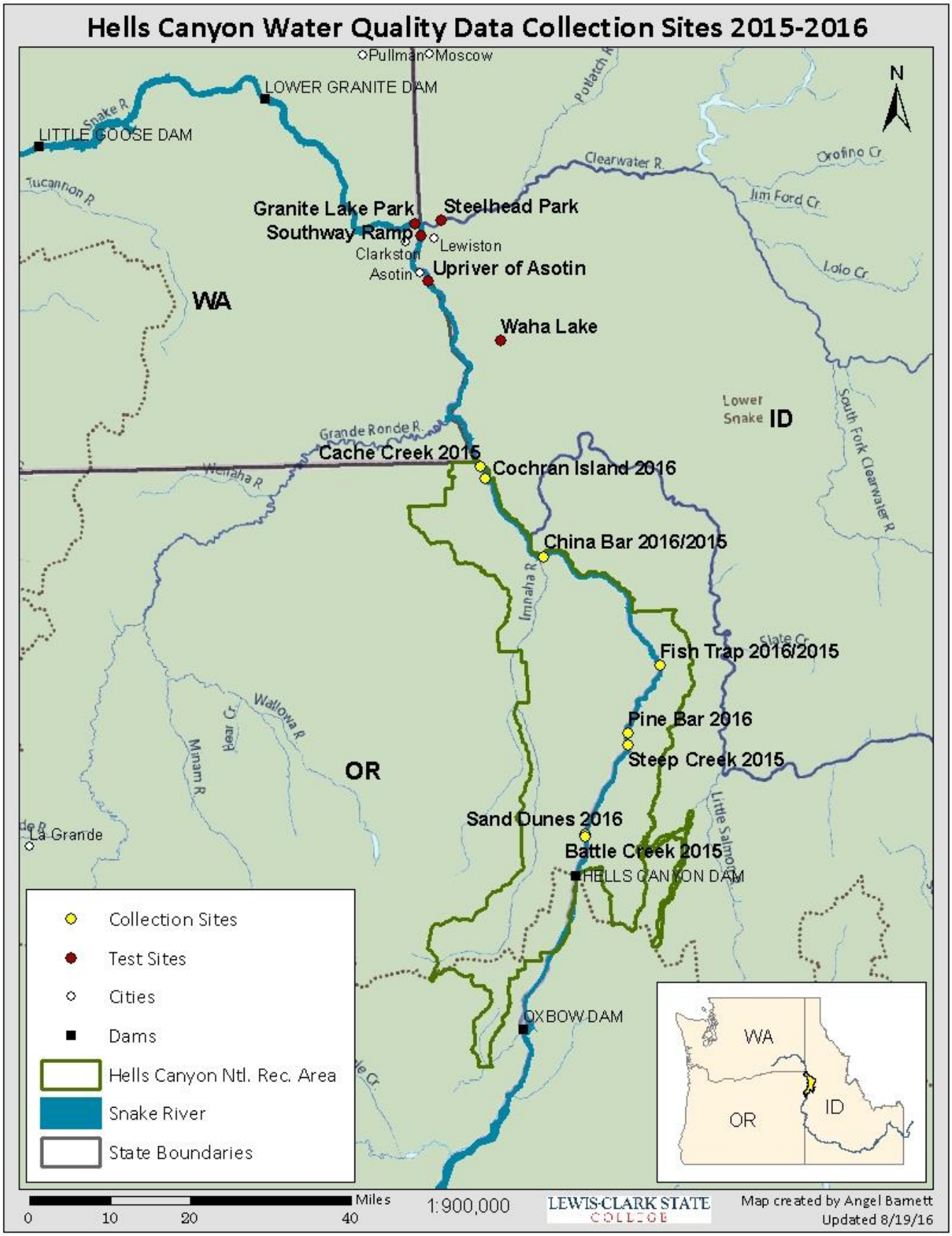

Figure 1. Monitoring and test sites.

Project Description

Two Hydrolab multiprobe Sondes were used on this research project. LCSC owns both a DS5 (measures pH, temperature, specific conductance, ammonium, nitrate) and MS5 (measures pH, temperature, specific Conductance, Turbidity, Dissolved Oxygen). The Standard Operating Procedure (SOP) developed during the summer 2015 MURI research project (see LCSC STANDARD OPERATING PROCEDURE FOR CALIBRATION, MAINTENANCE, AND USE OF HYDROLAB SONDES, Revision 2, March 22, 2016) was modified and improved based on the 2015 experience.

To test the calibrated sensors and usability of the SOP, real-time readings were collected through attended monitoring at local water bodies. These readings are called "tests" throughout the report. These test sites were chosen because they are easily accessible, provide data from specific water bodies, and have good stream flow. These test sites will be used for future testing of the equipment and and for future local sampling locations that are easily monitored. The test sites include the Waha Lake dock, Steelhead Park ramp (Clearwater R.), Southway Park ramp (Snake R.), Granite Lake Park dock (confluence of Clearwater R. and Snake R.), and from a boat about three miles upriver from the city of Asotin (Snake R. before urban development). The Sonde parameters were calibrated before the deployments and then checked after returning. Data for the test sites can be found in "Test Sites" in the Results Section.

The six-day monitoring trip in the HCNRA took place from August 4 through August 9, 2016. Data was collected in-situ using both the DS5 and MS5 through unattended monitoring in which the Sondes are programmed to collect and store data at specified times. The Sondes were deployed at five locations with data collection times set for 15 minute intervals over an 11-hour period at each site. Results from the monitoring trip can be found under "Six-day monitoring trip" in the **Results** section. Additionally, results from the 2015 Hells Canyon monitoring trip are included for comparison. Please note there was no nitrate or nitrite analysis for 2015. Additional water samples were collected during the trip for mercury analysis. Results from those water samples are not yet available and are not included in this report.

The deployment strategy for the unattended monitoring during the six-day monitoring trip required a configuration that allowed the Sonde sensors to remain floating at a constant depth of one meter in the river channel over widely fluctuating river levels. Sonde deployment includes a buoy, anchor, cables, and rope as shown in Figure 2 below. A picture of what it looks like deployed (from Pine Bar camp) is shown in Figure 3. The deployment accessories are shown in Figure 4.

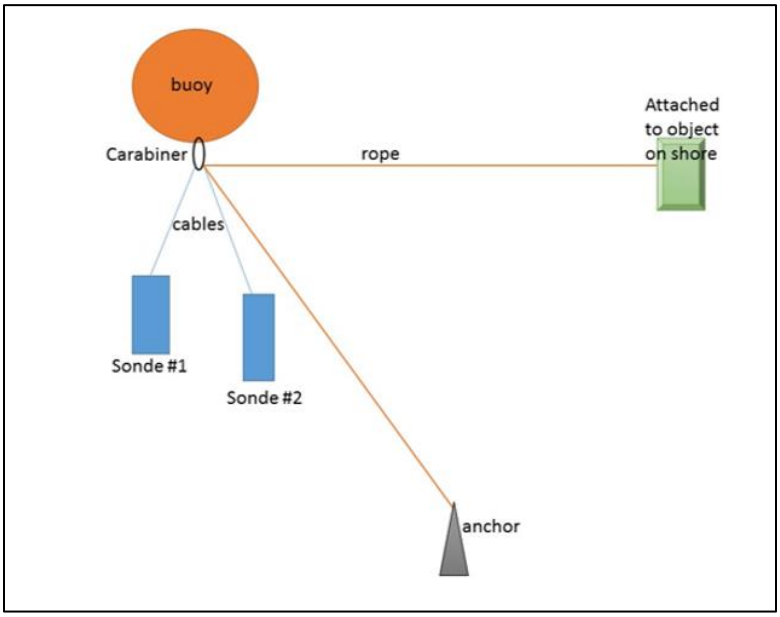

Figure 2. Deployment diagram

Figure 3. Sonde deployment at Pine Bar

Figure 4. Deployment accessories

Results

Test Sites

Real-time readings using the DS5 and MS5 were collected through short-term, attended monitoring at the Waha Lake dock, Steelhead Park ramp, Southway Park ramp, Granite Lake Park dock, and from a boat upriver of Asotin. The MS5 sensors include pH, dissolved oxygen (LDO), temperature, specific conductance (SpCond), and turbidity. The DS5 sensors include pH, temperature, and specific conductance. The purpose of the "test" sites is to test the calibration of the sensors and the usability of the SOP. Additionally, these sites may be used for future monitoring sites. Unfortunately, the nitrate and ammonium sensors were not available during these monitoring excursions.

Sonde sensors were calibrated prior to deployment and then checked upon return. Following are the results from each of the test sites. Grayed out cells in the tables indicate unreliable readings.

Waha Lake

Real-time readings were collected at Waha Lake on 6/27/16 between 5:00pm and 6:00pm with an air temp of ~91.1°F. The results of the deployment are shown in Table 1 below.

Table 1. Waha Lake Real-Time Readings					
	Temp °F	SpCond µS/cm	pH	Turbidity NTU	LDO mg/l
DS5	67.5	0.0675	9.05	n/a	n/a
MS5	68.0	0.0687	9.64	Not Stable	12.20

Notes: MS5 turbidity doesn't stabilize, it fluctuates from 12 NTU to 220 NTU; pH readings are slightly different for each Sonde

Steelhead Park

Real-time readings were collected from the Clearwater River on 7/7/16 between 1:00pm and 1:30pm with an air temp of ~81.0°F. The results of the deployment are shown in Table 2 below.

Figure 5. Steelhead Park

Table 2. Steelhead Park Real-Time Readings					
	Temp °F	SpCond µS/cm	pH	Turbidity NTU	LDO mg/l
DS5	54.7	0.0304	7.51	n/a	n/a
MS5	55.0	0.0311	7.70	0.3	11.51

Southway Park

Real-time readings were collected from the Snake River on 7/7/16 between 2:00pm and 2:30pm with an air temp of ~86.0°F. The results of the deployment are shown in Table 3 below.

Figure 6. Southway Park

Table 3. Southway Park Real-Time Readings					
	Temp °F	SpCond µS/cm	pH	Turbidity NTU	LDO mg/l

DS5	69.4	0.1859	7.98	n/a	n/a
MS5	69.7	0.1911	7.87	3.3	8.68

Granite Lake Park

Real-time readings were collected from the Snake River after the confluence of the Clearwater on 7/7/16 between 3:00pm and 3:30pm with an air temp of ~85.3°F. The results of the deployment are shown in Table 4 below.

Figure 7. Granite Lake Park

Table 4. Granite Lake Park Real-Time Readings					
	Temp °F	SpCond µS/cm	pH	Turbidity NTU	LDO mg/l
DS5	59.5	0.0904	7.51	n/a	n/a
MS5	60.2	0.0945	7.74	3.8	9.90

Upriver of Asotin

Real-time readings were collected by boat from the Snake River on 7/14/16 between 7:15pm and 7:45pm with an air temp of ~78.7°F. The results of the deployment are shown in Table 5 below.

Table 5. Upriver of Asotin Real-Time Readings					
	Temp °F	SpCond µS/cm	pH	Turbidity NTU	LDO mg/l
DS5	69.2	.2028	8.03	n/a	n/a
MS5	69.5	.2056	8.18	5.4	9.83

Six-day monitoring trip

Five sites were monitored over a six-day field excursion of the HCNRA using both the DS5 and MS5 over the period of August 4, 2016 through August 9, 2016. Monitoring was conducted as close as possible to previous sampling locations so results can be compared to the previous year. The sites included Sand Dunes, Pine Bar, Fish Trap, China Bar, and, new this year, Cochran Island. River miles from "The Boater's Guide for the Wild and Scenic Snake River" are shown for relative distances between monitoring sites. For reference, Hells Canyon Dam is located at river mile 247.0 and is where the rafts were launched for the monitoring trip. All 2016 results are averaged 11 hour overnight deployments (8:00pm to 7:00am) at each of the sampling sites. Readings were collected at 15 minute intervals. Summarized results for each of the field sites are shown below along with results from the 2015 summer trip for comparison. Grayed out cells in the tables indicate unreliable readings.

Sand Dunes

Table 6 summarizes data from the 2016 Sand Dunes deployment, river mile 241.8.

Figure 8. Sand Dunes site

Table 6. Sand Dunes 2016 Summary Data										
	Start Date	Temp °C	Temp °F	SpCond µS/cm	pH Units	LDO% Sat	LDO mg/l	Turbidity NTU	NH4+ mg/l-N	NO3- mg/l-N
DS5	8/4/16	21.18	70.13	318.58	7.94	n/a	n/a	n/a	0.33	1.59
MS5	8/4/16	21.31	70.35	327.02	8.10	80.8	6.95	0.00	n/a	n/a

For comparison, Table 7 summarizes data from the 2015 Battle Creek deployment, river mile 242.1. Overnight readings were collected in 10-minute increments over a 12 hour period.

Table 7. Battle Creek 2015 Summary Data							
	Start Date	Temp °C	Temp °F	SpCond µS/cm	pH	LDO mg/L	Turbidity NTU
DS5	7/27/15	21.80	71.24	364.57	8.54	n/a	n/a
MS5	7/27/15	21.91	71.44	373.88	8.34	7.08	37.83

Pine Bar

Table 8 summarizes data from the 2016 Pine Bar deployment, river mile 227.5.

Figure 9. Pine Bar site.

Table 8. Pine Bar 2016 Summary Data										
	Start Date	Temp °C	Temp °F	SpCond µS/cm	pH Units	LDO% Sat	LDO mg/l	Turbidity NTU	NH4+ mg/l-N	NO3- mg/l-N
DS5	8/5/16	21.48	70.66	316.64	8.01	n/a	n/a	n/a	0.38	1.60
MS5	8/5/16	21.61	70.90	325.27	8.17	94.7	8.09	0.00	n/a	n/a

For comparison, Table 9 summarizes data from the 2015 Steep Creek deployment, river mile 229.2. Overnight readings were collected in 10-minute increments over a 12 hour period.

Table 9. Steep Creek 2015 Summary Data							
	Start Date	Temp °C	Temp °F	SpCond µS/cm	pH	LDO mg/L	Turbidity NTU
DS5	7/28/15	21.92	71.46	362.52	8.59	n/a	n/a
MS5	7/28/15	22.02	71.64	372.00	8.38	7.82	38.23

Fish Trap

The table below summarizes data from the 2016 Fish Trap deployment, river mile 216.3. Picture was not taken at this deployment.

Table 10. Fish Trap 2016 Summary Data										
	Start Date	Temp °C	Temp °F	SpCond µS/cm	pH Units	LDO% Sat	LDO mg/l	Turbidity NTU	NH4+ mg/l-N	NO3- mg/l-N
DS5	8/6/16	21.43	70.58	318.40	7.98	n/a	n/a	n/a	0.42	2.26
MS5	8/6/16	21.57	70.82	326.76	8.16	94.5	8.09	0.00	n/a	n/a

For comparison, the table below summarizes data from the 2015 Fish Trap deployment. Overnight readings were collected in 10-minute increments over an 11 hour period.

Table 11. Fish Trap 2015 Summary Data							
	Start Date	Temp °C	Temp °F	SpCond µS/cm	pH	LDO mg/L	Turbidity NTU
DS5	7/29/15	22.28	72.10	364.56	8.53	n/a	n/a
MS5	7/29/15	22.39	72.30	373.78	8.33	7.32	38.48

China Bar

Table 12 summarizes data from the 2016 China Bar deployment, river mile 192.2.

Figure 10. China Bar site.

Table 12. China Bar 2016 Summary Data										
	Start Date	Temp °C	Temp °F	SpCond µS/cm	pH Units	LDO% Sat	LDO mg/l	Turbidity NTU	NH4+ mg/l-N	NO3- mg/l-N
DS5	8/7/16	21.38	70.49	318.71	8.05	n/a	n/a	n/a	0.46	2.00
MS5	8/7/16	21.51	70.73	325.00	8.24	97.8	8.38	0.00	n/a	n/a

For comparison, Table 13 summarizes data from the 2015 China Bar deployment. Overnight readings were collected in 10-minute increments over an 11 hour period.

Table 13. China Bar 2015 Summary Data							
	Start Date	Temp °C	Temp °F	SpCond µS/cm	pH	LDO mg/L	Turbidity NTU
DS5	7/30/15	22.96	73.33	365.05	8.62	n/a	n/a
MS5	7/30/15	23.07	73.53	374.73	7.81	7.81	38.33

Cochran Island

Table 14 summarizes data from the 2016 Cochran Island deployment, river mile 176.2.

Figure 11. Cochran Island site. Note deployment in white square.

Table 14. Cochran Island 2016 Summary Data										
	Start Date	Temp °C	Temp °F	SpCond µS/cm	pH Units	LDO% Sat	LDO mg/l	Turbidity NTU	NH4+ mg/l-N	NO3- mg/l-N
DS5	8/8/16	21.46	70.63	261.89	8.12	n/a	n/a	n/a	0.39	1.56
MS5	8/8/16	21.59	70.86	267.58	8.30	98.8	8.46	0.00	n/a	n/a

For comparison, Table 15 summarizes data from the 2015 Cache Creek Ranch deployment, river mile 177.0. Daytime readings were collected in 10-minute increments over a 1 hour period.

Table 15. Cache Creek 2015 Summary Data							
	Start Date	Temp °C	Temp °F	SpCond µS/cm	pH	LDO mg/L	Turbidity NTU
DS5	7/31/15	23.13	73.63	312.14	8.59	n/a	n/a
MS5	7/31/15	23.22	73.80	320.43	8.37	8.24	38.63

Discussion

Deployment of Sondes using the rigging developed for this project worked well. The configuration allowed the Sondes to float approximately 1 meter from the surface and at least one meter from the bottom over large fluctuations in river levels. River flows during the monitoring trip ranged from 21,000 to 12,700 cubic feet per second. For perspective, river heights at these flows fluctuate about 2.5 feet.

The Snake River TMDL (2004) states: "To address elevated temperatures occurring during salmonid spawning periods below Hells Canyon Dam, a temperature load allocation in the form of a required temperature change at Hells Canyon Dam was identified such that the temperature of water released from Hells Canyon Dam is less than or equal to the water temperature at M 345, or the maximum weekly maximum temperature target of 13 °C (55.4 °F) for salmonid spawning, plus no greater than 0.14°C."

Temperature levels from both the 2015 and 2016 monitoring trips exceeded salmonid spawning temperatures of 13 °C. Measurements were made during the first week of August and spawning generally occurs October through April for fall Chinook and November through March for Mountain Whitefish.

The lowest dissolved oxygen levels were 6.95 mg/L measured at Sand Dunes, which was the monitoring site closest to Hells Canyon Dam. Other sites further downstream were closer to 8 mg/L. The highest level was 8.46 mg/L at Cochran Island. All readings are overnight averages at one meter depths. For salmon and trout eggs, dissolved oxygen levels below 11 mg/L will delay their hatching, and below 8 mg/L will impair their growth and lower their survival rates. When dissolved oxygen falls below 6 mg/L, the vast majority of trout and salmon eggs will die. (http://www.fondriest.com/environmental-measurements/parameters/water-quality/dissolved-oxygen/#9)

Data Limitations

Turbidity was not recorded by the MS5 at any of the deployment sites. It is programmed to display on the log file with all other parameters, but instead of recording a reading it just shows "0." When connected to the hand-held Surveyor (a portable instrument that reads real-time data from the sensors) the turbidity sensor seems to work fine, with readings fluctuating when sediment is stirred around the sensors. Consequently, no turbidity readings were collected.

It should be noted that the DS5 ammonium sensor fluctuated further from the known standard value over time and the ammonium results may not be reliable. When first checked with the 50mg/l standard, it read near 70 mg/l. When checked again two days later it read near 90 mg/l. Before another deployment, the ammonium sensor will have to pass quality assurance tests as defined in the SOP.

Improvements

As the equipment is getting used more, it became apparent a better and safer system for transporting equipment was needed. After researching options for a case, it was decided that the Pelican shown below was the best option because of its long term durability, waterproof interior, handles, wheels, and customizable foam. Below is a picture of the Pelican case after the foam was cut to fit each individual piece of equipment.

Figure 12. Pelican equipment transportation case.

Additional improvements include refining the calibration SOPs, updating and simplifying data log sheets, and multiple improvements to recordkeeping that allow multiple students to use the equipment and record data independently and consistently ensuring a wider range of usage in a variety of settings.

Appendix A – Project Logs

Project Log: project prep monitoring prep pre-deployment

- 6/14- Review of SOP
- 6/15- Calibration of both MS5 and DS5 sensors (calibration reports filled out); Waiting for new ammonium and nitrate sensors for the DS5

  -Edit calibration reports
- 6/20- Jenni changes Surveyor battery (internal 2032 cu)
- 6/22- Edit/Revise SOP; MS5 and DS5 sensors are checked with known standards; MS5 is slightly off on turbidity and specific conductance
- 6/27- Recalibrate specific conductance and turbidity on MS5

  -Gather field supplies and deploy both Sondes at Waha Lake dock to collect real-time readings via attended monitoring; GPS waypoint of deployment taken; Deployment results are shown in Table 1

  -After deployment it is determined that the date and time need reset for the Sondes before creating log files, MS5 turbidity needs checked due to unstable readings, and pH reads slightly different for each Sonde

  -Collect water sample for later analysis
- 6/28- Recalibrate MS5, paying close attention to Turbidity (calibration report filled out); turbidity may slowly drop due to settling of standard

  -Check DS5 with known standard – acceptable

  -Analyze collected water sample from Waha Lake; turbidity is stable after the recalibration and pH is now acceptable
- 7/7- Deploy Sondes at Steelhead Park ramp (Clearwater R.) to collect real-time readings via attended monitoring; GPS waypoint and pictures taken; Deployment results shown in Table 2

  -It is noted that a rubber o-ring is needed for the DS5 6 pin connector

  - Deploy Sondes at Southway ramp (Snake R.) to collect real-time readings via attended monitoring; GPS waypoint and pictures taken; Deployment results are shown in Table 3

  - Deploy Sondes at Granite Lake Park dock (Snake R. after confluence) to collect real-time readings via attended monitoring; GPS waypoint and pictures taken; Deployment results are shown in Table 4
- 7/11- Replace ammonium and nitrate sensors on DS5

-Call tech support for information on hydrating ammonium and nitrate sensors before calibration; hydrate in water for 24 hours before calibrating

-Replace pH reference electrolyte and salt pellets in both MS5 and DS5

-Research hard case with wheels for equipment

-Replace one of the 3" o-rings on DS5; need to order more

- 7/12- Research standards for ammonium and nitrate sensors; Formula created in gram measurements for mixing standards

  -Formula adjusted after more research and troubleshooting; made nitrate high and low standards

  -Waiting for magnesium acetate to make ammonium standards

  -Calibrate MS5 specific conductance, pH, and turbidity (calibration report filled out); DO doesn't need calibrated because BP is close to what it was during last calibration

- 7/13- Previously made turbidity standard is chunky/stringy, possibly due to the water used to dilute it being DI water instead of filtered water; could also be due to using a clear plastic bottle instead of a brown bottle (standard is light sensitive)

  -New 100NTU standard is made by mixing 0.45µm filtered water with 12.5 ml of the 4000 NTU solution for every 500 ml of solution needed

  -Calibrate DS5; DS5 has inconsistent connection with computer but works with Surveyor; Surveyor doesn't display mV, which is needed to calibrate ammonium and nitrate sensors

  -Turned on audio for DS5 in order to make troubleshooting easier; Inconsistent connection possibly due to low batteries in DS5

  -Compare DS5 and MS5 pH using known standard of 6.4; within ±0.05 units of each other - acceptable

  7/14- Replace batteries in DS5 and MS5

  -Deploy Sondes from a boat upriver of Asotin (Snake R. before urban development) to collect real-time readings via attended monitoring; GPS waypoint taken; Deployment results are shown in Table 5

- 7/19- Meeting with DEQ to discuss possible partnership
- 7/25- Edit/Revise SOP (Revision 2)

  -Custom cut foam for Pelican case to fit equipment

- 7/26- Edit/Revise SOP; Picked up protective sheets to use with SOP in field

  -Find part numbers for o-rings (MS5 cup o-rings, DS5 cup o-rings, 6-pin connector o-ring); order o-rings

- 7/28- Meet with Jay and Jenni to work out anchor/buoy system; Receive custom hardware from the LCSC Physical Plant for the anchor/buoy system

  -Spray glue the foam for the Pelican case

  -Receive magnesium acetate for ammonium standards; Mix ammonium high and low standards

  -Edit/Revise SOP
- 7/29- Edit/Revise SOP
- 8/1- Edit/Revise SOP

  -Revise calibration report templates

  -DS5 has inconsistent connection with computer when trying to calibrate ammonium or nitrate; cannot ensure accuracy of ammonium or nitrate calibration when using Surveyor; sensors not calibrated

  -Discuss with Jenni and Nancy the possibility of collecting water samples for heavy metal analysis
- 8/2- DS5 has consistent connection with computer this time, not sure why

  -All sensors successfully calibrated on DS5 and MS5 (revised calibration reports filled out); DS5 batteries need replaced before next deployment

  -Previously mixed 100 NTU turbidity standard is chunky/stringy again, even after using filtered water and storing in a brown bottle; new 4000 NTU solution is made and used to make a new dilution of 100 NTU solution

  -Receive o-rings; replaced both on MS5 calibration cup, one on DS5 calibration cup, and another on the DS5 6 pin connector

  -Print SOP revision 2; using a binder and protective sheets for field use

  -Discuss with Nancy the process of collecting water samples; gather 6 acidified bottles and concentrated HCl acid for monitoring trip
- 8/3- Prepare for 6 day Hells Canyon monitoring trip; Gather and pack equipment, extra standards, supplies, food, and rafts

6-Day Hells Canyon Monitoring Trip

- 8/4- Travel to Hells Canyon Dam and launch rafts; Camp at Sand Dunes

  -Create log files on Sondes; set to collect readings at 15 minute intervals from 8pm to 7am

-Deploy Sondes at Sand Dunes campsite; it is noted that the Sondes are ~1ft deeper when first deployed due to buoy/anchor system being tied tightly to shore, and then are at regular depth by morning; GPS waypoint and pictures taken; Summary of deployment results are shown in Table 6

- 8/5- Sondes are retrieved after 7am

  -Water sample #1 collected and acidified at Wild Sheep Rapids around 10am, ~0.6 miles downstream of Sand Dunes deployment

  -Camp at Pine Bar

  -Check both Sondes with known standards (reports filled out); MS5 readings acceptable; DS5 ammonium readings not acceptable – previous and following readings will not be reliable; cannot recalibrate in the field

  -Create log files on Sondes; set to collect readings at 15 minute intervals from 8pm to 7am

  -Deploy Sondes at Pine Bar campsite; GPS waypoint and pictures taken; Summary of deployment results are shown in Table 8; it is noted that there was a lightning storm with heavy rain the night of the deployment
- 8/6- Sondes are retrieved after 7am; water sample #2 collected and acidified at Pine Bar ~8am

  -Camp at Fish trap

  -Create log files on Sondes; set to collect readings at 15 minute intervals from 8pm to 7am

  -Deploy Sondes at Fish Trap campsite; GPS waypoint taken; forgot to take picture; Summary of deployment results are shown in Table 10; it is noted that there was a lightning storm with heavy rain the night of the deployment
- 8/7- Sondes are retrieved after 7am; water sample #3 collected and acidified at Fish Trap ~8am

  -'Blank' sample (DI water) is acidified

  -Camp at China Bar

  - Check both Sondes with known standards (reports filled out); turbidity standard got stringy/chunky again and is discarded, may need to order standard from Hach instead of mixing our own in lab; Replace batteries in MS5

  -Download the 3 log files from each Sonde; MS5 turbidity reads 0 on all log files; Turbidity sensor works when connected to Surveyor for attended monitoring of real-time readings, may need to call tech support when back from monitoring trip to find out why it doesn't work with log files

  -Create log files on Sondes; set to collect readings at 15 minute intervals from 8pm to 7am

-Deploy Sondes at China Bar campsite; GPS waypoint and picture taken; Summary of deployment results are shown in Table 12

- 8/8- Sondes are retrieved after 7am; water sample #4 collected and acidified at China Bar ~8am
  -Water sample #5 collected from Mountain Chief Mine Tunnel at river mile 191.9; collected from clear, stagnant puddle in mine that was ~5 inches deep; picture taken
  -Camp at Cochran Island; Water sample #5 is acidified
  -Create log files on Sondes; set to collect readings at 15 minute intervals from 8pm to 7am
  -Deploy Sondes at Cochran Island campsite; GPS waypoint taken and picture taken; Summary of deployment results are shown in Table 14
- 8/9- Sondes are retrieved after 7am; take out rafts at Heller Bar
- 8/10- Collected water samples are taken to the chemistry lab and refrigerated for future analysis
- 8/15- Download raw Sonde data
  -Begin writing 2016 MURI Final Report
- 8/16-Continue working on final report
  -Combine raw data for MS5 and DS5
  -Summarize Sonde data and simplify for report
- 8/17- Continue working on final report
- 8/18- Continue working on final report
  -Create map of data collection sites for 2015 and 2016
- 8/19- Continue working on final report
  -Finish map of data collection sites for 2015 and 2016