RECLAMATION
Managing Water in the West

2015 Annual Report for Activities under the Endangered Species Act Biological Opinion

(For the period October 31, 2014 to December 31, 2015)

Lewiston Orchards Project, Lewiston Idaho
Submitted to the National Marine Fisheries Service
Boise, Idaho

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Snake River Area Office
Boise, Idaho

August 2016

U.S. DEPARTMENT OF THE INTERIOR

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Front cover photograph – Sweetwater Creek looking upstream from the Sweetwater Diversion on the Lewiston Orchards Project

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Acronyms and Abbreviations

2010 Opinion	National Marine Fisheries Service 2010 Biological Opinion
cfs	cubic feet per second
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily significant units
IDEQ	Idaho Department of Environmental Quality
LOID	Lewiston Orchards Irrigation District
LOP	Lewiston Orchards Project
NMFS	National Oceanic and Atmospheric Administration National Marine Fisheries Service
Reclamation	U.S. Bureau of Reclamation
RPM	Reasonable and prudent measures
Tribe	Nez Perce Tribe
USGS	U.S. Geological Survey

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1. INTRODUCTION

On April 15, 2010, the National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS) issued a 2010 Biological Opinion (2010 Opinion) under the Endangered Species Act (ESA) to the U.S. Bureau of Reclamation (Reclamation) for the operation and maintenance of the Lewiston Orchards Project (LOP). This report is submitted to comply with Reasonable and Prudent Measure (RPM) 6, requiring Reclamation to report to the NMFS annually on activities related to implementing the 2010 Opinion (Reclamation 2010a).

This 2010 Opinion requires that Reclamation provide minimum flows below the diversion dams as described in the proposed action. Reclamation may be required to provide additional flows from June through mid-September, based upon combined storage as of June 1 in Soldiers Meadow Reservoir and Reservoir A.

As a result of court-sponsored mediation in January 2011, Reclamation agreed to provide 90 acre-feet of LOP water annually to supplement instream flows in both Sweetwater and Webb Creek. The 90 acre-feet is timed to be released during normal operation periods in accordance with the direction of the Nez Perce Tribe (Tribe).

This annual report covers the LOP operation and maintenance activities from October 31, 2014 to December 31, 2015 for published streamflows, irrigation operations, and fisheries monitoring. The Lewiston Orchard Irrigation District (LOID) operated the surface water collection system from February 2, 2015 until October 31, 2015.

To enhance the project's ability to consistently meet minimum flow requirements, Reclamation and the LOID continue to operate and maintain water measurement and gate automation equipment at the headgates to Sweetwater Canal and Webb Creek Diversion Dam. The gate automation equipment continually self-adjusts to maintain minimum streamflow past the diversion dam. Gate automation greatly improves LOP's ability to maintain flow targets and minimize daily variability related to operations.

No injuries or mortalities of ESA-listed steelhead, associated with operations, were observed during the 2014 reporting period.

2. RPM 1: Flow Management

2.1 Minimum Bypass Streamflow Requirements in Sweetwater and Webb Creeks

2.1.1 Background

RPM 1 of the 2010 Opinion, require LOP operations to bypass flows in Sweetwater and Webb Creek based on the life stage of steelhead. The minimum daily bypass flows for Sweetwater and Webb creeks are shown in Table 1.

Table 1. Instream flow minimum releases (cfs) for Sweetwater and Webb Creeks at their respective diversion dam sites (NMFS 2010).

Life Stage	Spawning			Juvenile Rearing							
Month	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep 1-15	Sep 16-30	Oct	Nov Dec Jan
Sweetwater Creek	7.8/I[b]	7.8/I	7.8	3.0	2.5	2.5	2.5	2.5	2.5	2.5	I[a]
Webb Creek	4.0/I[b]	4.0/I	4.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	I[a]

a During November, December, and January, all inflow (I) at Sweetwater and Webb Creeks Diversion Dams will be bypassed.

b During February and March, either the specified streamflow will be provided or all inflow (I) to the Sweetwater and Webb Creek Diversion Dams will be bypassed, whichever is less.

The instream flow regime in Table 1 addresses all months of the year; these flows will be used to support spawning conditions during February through April and juvenile rearing conditions from May through January. The LOP will not operate the Sweetwater and Webb Creek Diversion Dams during November, December, and January; therefore, all instream flow reaching the dams will be bypassed during those months. During February and March, if the inflows to either Sweetwater or Webb Creek Diversion Dams are below the specified minimum flow, the LOID will bypass all inflow (I) to that diversion dam until it reaches the specified targets before beginning any diversions. In October the specified minimum flows will be passed when the diversion dams are in operation. When the diversion dams are turned off for the season, all inflow will be bypassed. For Webb Creek, the “I” flow is composed of all runoff from the watershed upstream of the diversion and below Soldiers Meadow Dam. For Sweetwater Creek, the “I” flow is composed of all runoff from the watershed upstream of the dam, except for any diversions occurring at the West Fork diversion which are being conveyed to Lake Waha (NMFS 2010).

In addition, Reclamation may supply additional flows into Sweetwater and Webb Creek for June through mid-September, based on the combined storage in Soldiers Meadow Reservoir and Reservoir A, as assessed on June 1. The additional increments allocated for Sweetwater and Webb Creek, and the storage conditions under which they would occur, are shown in Table 2. There were no incremental flows added because the combined reservoir storage was below 3,800 acre-feet on June 1 in 2015.

Table 2. Increments of additional juvenile rearing flow as a function of combined storage for June 1 through September 15 (NMFS 2010).

Combined Storage (acre-feet)	<3,800	3,900	4,000	4,100	4,200	>4,250
Sweetwater Creek (cfs)	+0	+0.5	+0.9	+1.0	+1.0	+1.0
Webb Creek (cfs)	+0	+0	+0	+0.3	+0.8	+1.0
Total Flow (cfs)	3.50	4.00	4.40	4.80	5.30	5.50

In 2015, the Tribe negotiated an additional 90 acre-feet of water to be supplied at their discretion in Sweetwater and Webb Creek to assist in juvenile rearing flows. Table 3 shows the total flows and timing required in Sweetwater and Webb Creek including the minimum flows, the additional incremental flows, and the negotiated 90 acre-feet flows for 2015.

Table 3. Total flows required in Sweetwater and Webb Creeks with the additional volume and mediated flows.

Life Stage	Spawning			Juvenile Rearing										
Month	Feb	Mar	Apr	May	Jun	Jul 1-15	Jul 15-18	Jul 18-31	Aug	Sep 1-11	Sep 12-15	Sep 16-30	Oct	Nov, Dec, Jan
Sweetwater Creek Base ByPass Flows	7.8*	7.8*	7.8	3.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	Bypass
Incremental Add-In	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	
Tribal Negotiated 90 AF 2011-2013 (1/28/11)	0.0	0.0	0.0	0.0	0.3	0.5	0.5	0.5	0.5	0.3	0.3	0.0	0.0	
Total Sweetwater Creek ByPass Flows	**7.8**	**7.8**	**7.8**	**3.0**	**3.8**	**4.0**	**4.0**	**4.0**	**4.0**	**3.8**	**3.8**	**2.5**	**2.5**	
Webb Creek Base ByPass Flows	4.0*	4.0*	4.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	Bypass
Incremental Add-In	0	0	0	0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	0	
Total Webb Creek ByPass Flows	**4.0**	**4.0**	**4.0**	**1.5**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**1.0**	**1.0**	

The proposed action states that Reclamation will monitor daily mean streamflows whenever the LOID is diverting water. Currently, 1-hour averages are posted for Sweetwater and Webb Creek onto Reclamation's public Hydromet page. The 2010 Opinion describes the minimum flows as a mean daily average, with criteria that flows be adjusted when they fall more than 20 percent below the target as monitored on an hourly basis.

In past water years, Reclamation and LOID installed gate automation and water measurement equipment at the Sweetwater Diversion Dam and Webb Creek Diversion Dam to improve the ability to measure and maintain the target minimum streamflows. Although the gate automation equipment substantially improved the project's ability to meet instream flow requirements, occasional operational problems occur with the mechanical and electrical equipment. Operation or technical limitations may occur when equipment malfunctions or debris catches at the structures or around the gates. Debris can physically prevent the gate from adjusting and/or cause inaccurate measurement due to backwatering near the gaging equipment that sends information to the gate controls.

2.1.2 Data Collection

The streamflow data are collected at 1-hour intervals below the weirs at Sweetwater and Webb Creek Diversion Dams. The automated data loggers record the bypass streamflow released over the compound weirs installed on the top of the diversion dams and the 4-foot weir located in the sluiceways. The data logger is located on the diversion dam. Reclamation posts data from these measurement points at http://www.pn.usbr.gov/hydromet.

All data collected during the irrigation season is provisional and could contain recording errors. The U.S. Geological Survey (USGS) and Reclamation reconcile the data at the end of irrigation season and post the data on the Hydromet at the end of the calendar year. The reconciled data is the official record.

2.2 Sweetwater Creek

2.2.1 Bypass Streamflow Results for Spring Spawning Period March 1 through May 31

It is important to note that the minimum flows are provided under the terms of the 2010 Opinion, which describes the minimum flows as a mean daily average, with criteria that flows be adjusted when they fall more than 20 percent below the target. This criteria recognizes that some fluctuations are expected while meeting the target minimum flows. As seen in Figure 1, there was a large spike in late March and early April due to high runoff. There were also some low natural flows recorded in early March where the flows dropped below the target bypass flow rate. Other flow fluctuations can be seen in Appendix A. This appendix notes the target bypass flow rates and the corresponding hourly rate in Sweetwater Creek.

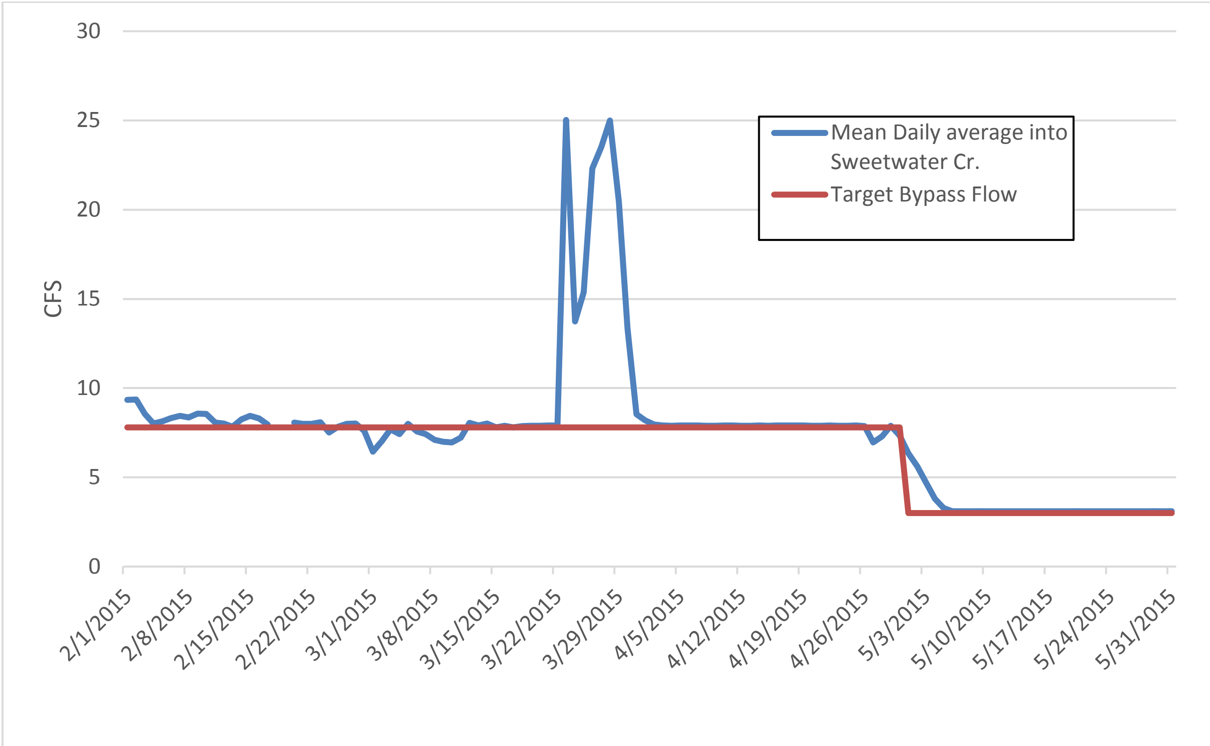


Figure 1. Mean daily streamflow (cfs) measured past the Sweetwater Diversion Dam and bypass flow targets for the first half of the irrigation season (March 1 through May 31, 2015).

2.2.2 Bypass Streamflow Results for Juvenile Rearing Period June 1 through October 31

Minimum streamflows for juvenile rearing in Sweetwater Creek are 2.5 cfs. Additional juvenile rearing flows are made available based on combined reservoir volumes of Soldiers Meadows and Reservoir A as of June 1 (Table 2). On June 1 the combined storage of Soldiers Meadows and Reservoir A were less than 3,800 acre-feet thus establishing no additional juvenile rearing flows, in Sweetwater Creek between June 1 and October 31. The additional 90 acre-feet of water was released into Sweetwater Creek according to Tribal direction from June through September. The minimum flows and mediated flows for 2015 are summarized in Table 3. The combined flows resulted in minimum flow targets for June at 2.8 cfs; July through August at 3.0 cfs; September 1 to 15 at 2.8 cfs; September 16 through end of irrigation season at 2.5 cfs.

Figure 2 compares mean daily streamflow to the target bypass flow for juvenile rearing. Around June 2, 2015 there was a rain event that caused a spike in the hydrograph. Surface water diversions from Sweetwater Diversion Dam were turned off October 30, 2015.

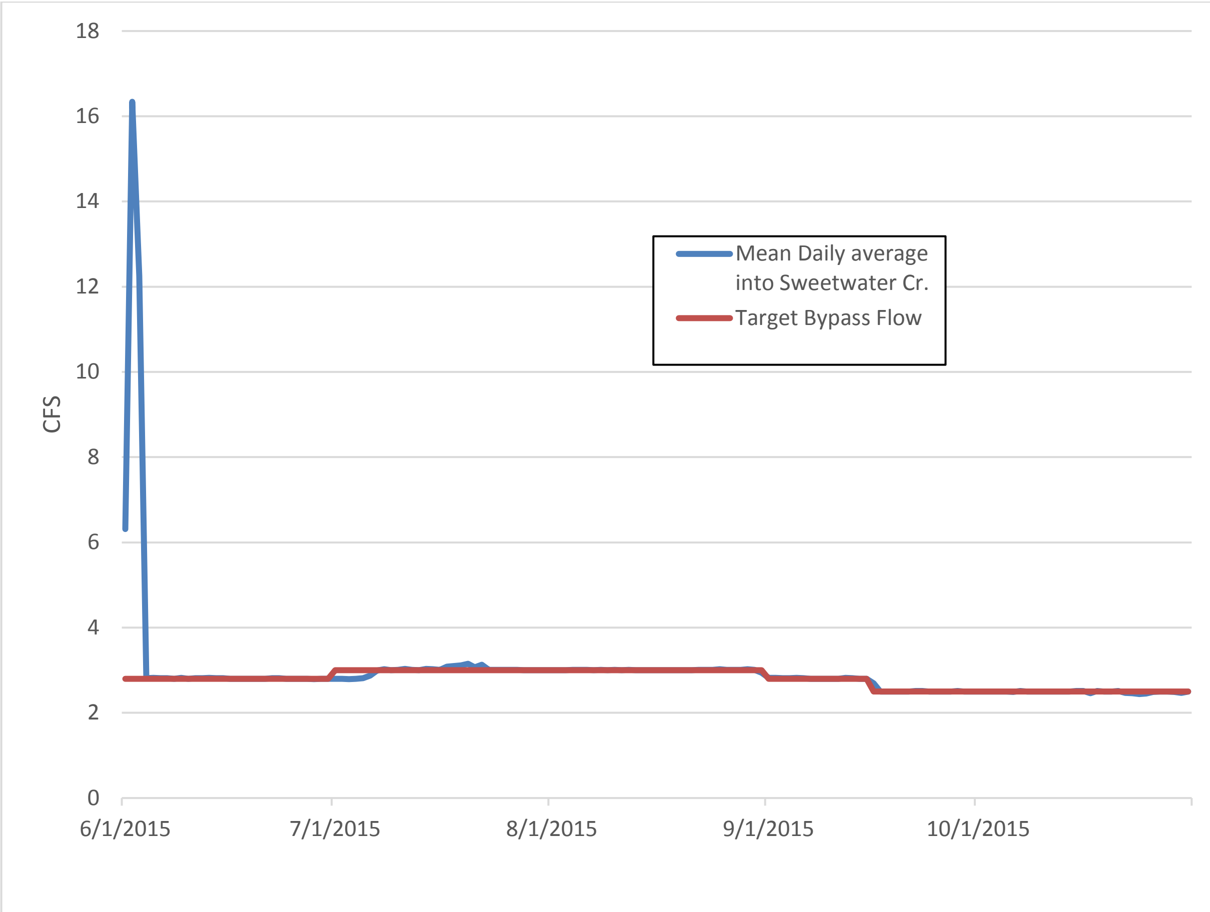


Figure 2. Mean daily streamflow (cfs) measured past the Sweetwater Diversion Dam for the second half of the irrigation season (June 1 to October 31, 2015).

2.3 Webb Creek

2.3.1 Minimum Bypass Streamflow Requirements in Webb Creek

The Webb Creek diversion was operated from February 11, 2015, until October 31, 2015. Measured streamflows, in relation to the bypass flow targets, are shown in Figure 3.

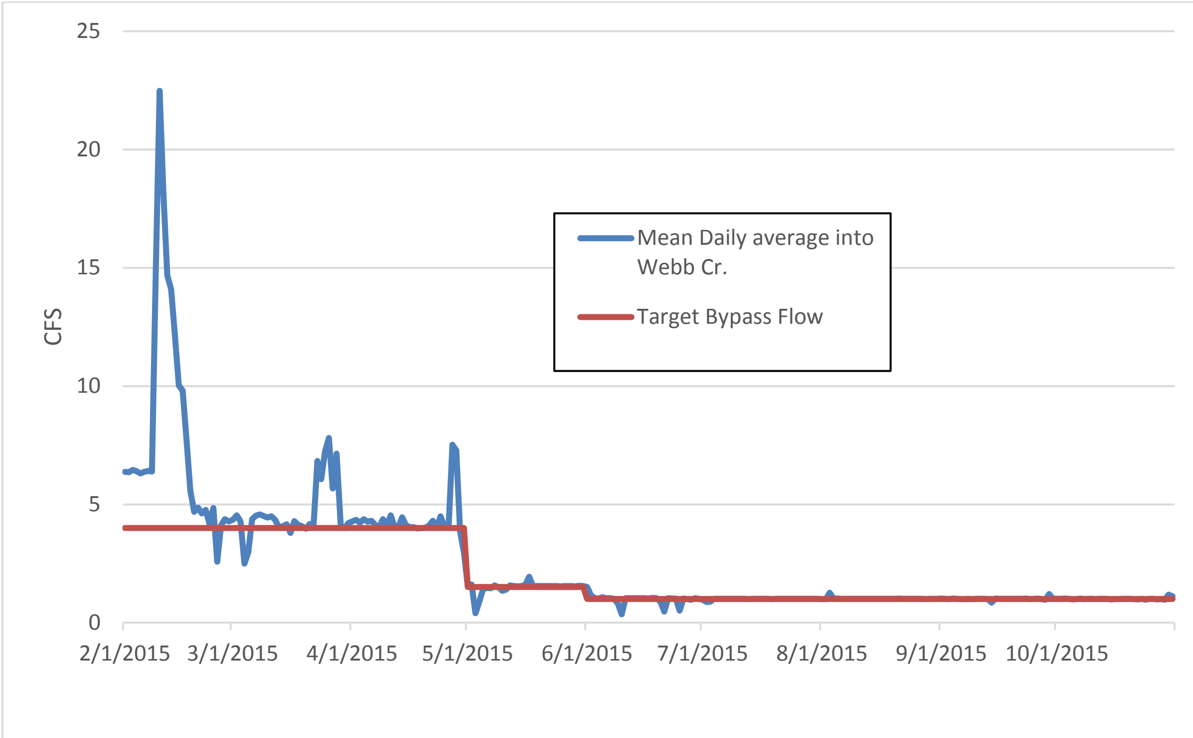


Figure 3. Mean daily streamflow (cfs) measured past the Webb Creek Diversion Dam for the 2015 irrigation season.

Minimum flow targets for 2015 resulted in 4.0 cfs in February, March, and April; 1.5 cfs in May; 1.0 cfs June 1 through the remaining irrigation season. No tribal negotiated flows were designated for Webb Creek in 2015.

Other flow fluctuations can be seen in Appendix A. This appendix notes the target bypass flow rates and the corresponding hourly rate in Webb Creek.

2.4 Ramping Rates

Ramping flows were incorporated into the proposed action and described in Reclamation's *Biological Assessment for the Operation of the Lewiston Orchards Project* (Reclamation 2009, pages 4 through 11). Ramping will occur during the start of the irrigation period; the down-ramping from spawning flows to juvenile rearing flows on May 1; the end of the irrigation season; and any other time during the irrigation season for scheduled operation or maintenance purposes. The following ramping rates were identified to simulate natural conditions of the stream as much as possible. When the streamflow is high (>70 cfs), the maximum gate adjustment will take 10 cfs from the stream per day. When the streamflow is moderate (20 to

70 cfs), the maximum gate adjustment will take 5 cfs from the stream per day. When the streamflow is <20 cfs, the maximum gate adjustment will take 1 cfs from the stream per day.

There is some confusion regarding ramping related to the daily fluctuations of streamflow in Sweetwater and Webb Creeks when gate changes are not being made at the facilities. Ramping is a requirement directly associated with gate changes (see excerpt from 2009 BA below). Other fluctuations in streamflow occur naturally from climatic and precipitation conditions and these fluctuations in streamflow would be natural hydrologic conditions in the stream.

> *Proposed Action (Reclamation 2009, pages 4 through 11)*
>
> "Ramping of stream flows is intended to make gradual changes during gate operations that avoid stranding fish in dewatered or pooled areas when stream flows are reduced (diversion gates opened) or flushing fish downstream when increasing stream flows (diversion gates closed). These gradual alterations in stream flow are intended to allow fish that are rearing in the streams sufficient time to adjust to changes in stream habitat. Stream flow ramping will be implemented at the Sweetwater and Webb diversion headgates during the following periods: initial opening of the headgates at the start of the irrigation season; down-ramping from spawning flows to juvenile rearing flows on May 1; during the end of the irrigation season when the headgates are closed; and any other time that the headgates are opened or closed during the irrigation season for operation or maintenance purposes."

In 2015, there are instances where streamflows fluctuate but are not associated with gate changes, and therefore, are not subject to ramping criteria. Some instances occur naturally as the system fluctuates during spring runoff and hydrologic events; other instances are caused by mechanical failures and are noted in Appendix A.

2.5 Gravel Management Activities

Maintenance of the Sweetwater Creek Diversion Dam requires periodic removal of sediment that accumulates behind the dam, typically conducted every 4 to 6 years. Sediment was removed from the Sweetwater diversion dam pool during 2011 and was reported in the *2011 Annual Report* (Reclamation 2012). Sediment was again removed from the pool upstream of the Sweetwater Diversion Dam in 2015.

3. RPM 2: Connectivity Monitoring

On July 14, 2010, Reclamation submitted its connectivity monitoring plan to NMFS as required by Term and Condition 2 of the 2010 Opinion (Reclamation 2010b). Measurements in Sweetwater Creek were discontinued after 2012 with no connectivity issues identified. To better understand channel connectivity conditions in Webb Creek, walk-through surveys were conducted in 2012 and 2013 on the lower 3.3 km of Webb Creek between the upper University of Idaho (UI) sampling site (UWU) and the mouth. The connectivity survey on Webb Creek was reported in Reclamation's 2012 and 2013 Annual Reports submitted in the springs of 2013 and 2014, respectively. No additional connectivity monitoring is planned for the duration of the 2010 Opinion.

4. RPM 3: Streamflow Monitoring

Streamflows are measured at both the mouth of Sweetwater and Webb Creek via USGS stream flow gages. Gage number 13342340 is the mouth of Sweetwater and gage number 13342295 is the mouth of Webb Creek. These gages are monitored to validate fluctuations and/or erroneous readings caused by malfunctions at the diversion sites.

Mean daily streamflow ranged from 4.08 to 26.5 cfs at the mouth of Sweetwater Creek, and from 0.745 to 13.9 cfs at the mouth of Webb Creek during water year 2015. Hydrographs from these sites show that peak flows occurred during February, and low flows occurred from July through September (Table 4; Figures 4 and 5).

Table 4. Mean monthly streamflow (cfs) measured from daily average data at the USGS monitoring gages at the mouth of Sweetwater and Webb creeks during water year 2015.

Sweetwater Creek at Mouth		Webb Creek at Mouth	
Month	Mean	Month	Mean
Oct-14	5.59	Oct-14	1.22
Nov-14	6.89	Nov-14	3.12
Dec-14	15.5	Dec-14	8.01
Jan-15	26.2	Jan-15	13.9
Feb-15	26.5	Feb-15	13.1
Mar-15	25.4	Mar-15	8.04
Apr-15	24.5	Apr-15	7.43
May-15	12.6	May-15	2.53
Jun-15	5.99	Jun-15	1.39
Jul-15	3.94	Jul-15	0.802
Aug-15	4.08	Aug-15	0.745
Sep-15	4.46	Sep-15	0.825

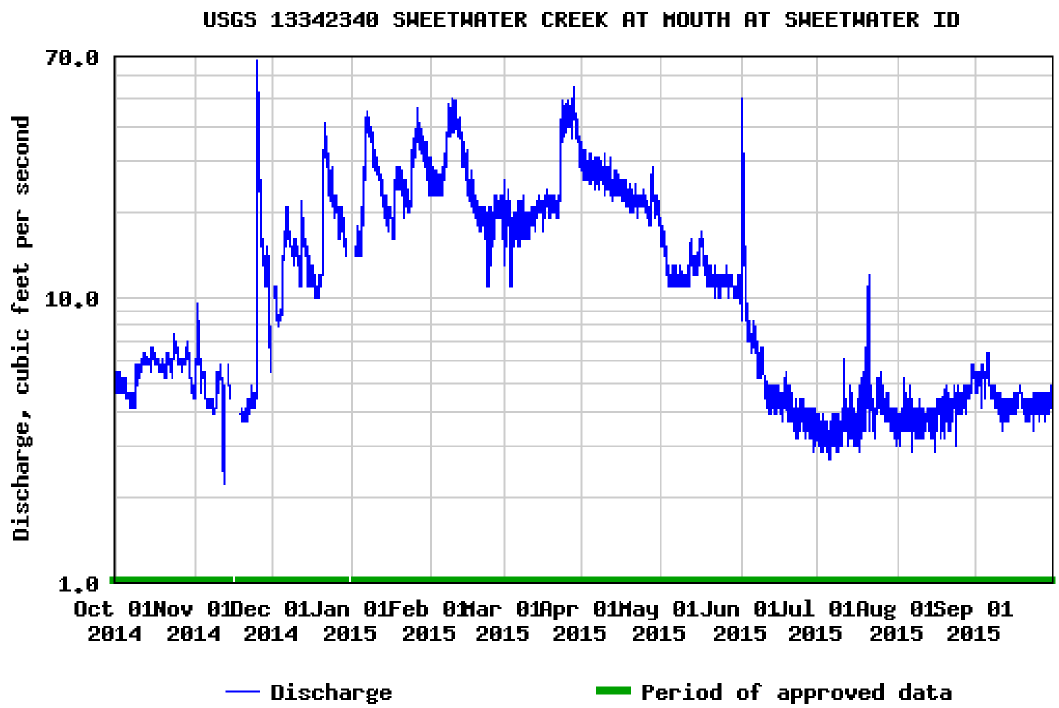


Figure 4. **Mean daily streamflows (cfs) measured near the mouth of Sweetwater Creek (USGS gage 13342340) during water year 2015.**

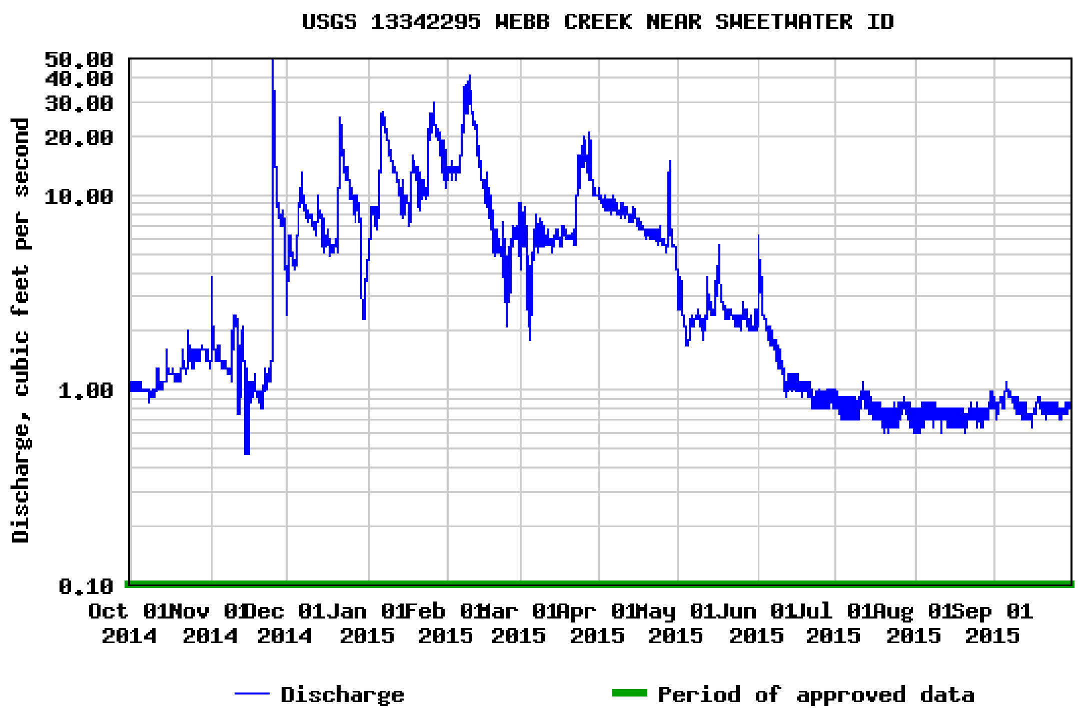


Figure 5. **Mean daily streamflow (cfs) measured near the mouth of Webb Creek (USGS gage 13342295) during water year 2015.**

Both graphs show the large variability in streamflows, even when LOID is not operating the diversion structures. The spring runoff and corresponding peak occurs in early March followed by the descending arm of the hydrograph in May. Flows continue on a downward trend through October.

5. RPM 4: Monitoring Critical Uncertainties

RPM 4 requires Reclamation to monitor listed steelhead in areas of the Lapwai Basin impacted by the project, and also requires Reclamation to address several critical uncertainties in relation to the project effects and the listed steelhead. As a result, Reclamation has collected information to address the critical uncertainties either directly, or through partnerships with the State of Idaho, the Tribe, and/or the UI.

Reclamation completed the monitoring plan for steelhead densities and critical uncertainties on January 27, 2011 (Reclamation 2011). This steelhead monitoring project was started under RPM 3 of the 2006 Opinion and continues as RPM 4 in the 2010 Opinion. The RPM required Reclamation to monitor steelhead densities in the action area and to answer critical uncertainties regarding the effects of the action.

Reclamation had a multi-year agreement (Agreement Number R12AC11005) with the UI to research and monitor the effects of streamflow on the growth and survival of juvenile steelhead and address several of the critical uncertainties identified in the Opinion. That agreement ended May 31, 2015. A new agreement (Agreement Number R14AC00042) with the UI, which goes through May 31, 2019, has been put in place to continue the steelhead density monitoring described in the monitoring plan for steelhead densities and critical uncertainties. The data collected during 2015 is summarized in an annual report (Appendix B; Kennedy et al. 2015). During these surveys, a total of 1,153 steelhead were captured during electroshocking. Total incidental mortality rate among all sites and visits during the 2015 sampling season was 0.9 percent.

PIT tag reading stations are being used to record the movement of tagged individuals. All systems use multiple antenna arrays (2 or 3) to determine direction of movement and detection efficiency. During 2015, PIT tag interrogation stations were operating at Lapwai, Sweetwater, Mission, and Webb. Webb Creek lost power on May 2, 2015, and it was restored on May 4, 2015. Mission Creek also experienced short periods of downtime in the fall of 2015 due to issues with the MUX unit. The other stations did not experience any considerable downtime in 2015.

5.1 *O. mykiss* Density Monitoring

Monitoring of juvenile *O. mykiss* densities was scaled back starting in 2014 as the objectives transitioned from monitoring critical uncertainties to long-term density monitoring. Due to low steelhead abundance, poor access, inadequate reach representation, and other physical issues resulting in little or poor-quality data, monitoring was discontinued at two of the original six sites where sampling started in 2008. Reclamation and the UI exchanged these two original long-term density monitoring sites with two of the sites developed by the UI in 2010. During a conference call on March 25, 2014, NMFS, UI, and Reclamation agreed on the six long-term monitoring sites that will be used until 2020.

Four of the original six sites remain, which include: ULU, UMU, UWM and LSX (Figure 6). The other two original sites, LLL and USM were replaced by sites that have been monitored by the UI since 2010. The LLL site experiences annual channel shifts due to spring high flows. This leads to shifts in steelhead densities that are linked more towards inter-annual changes in structural habitat conditions rather than temperature and flow conditions. Sampling at LLL is further complicated by the presence of spawning Coho in the fall. The USM site was inundated behind a beaver dam in the spring of 2010. Portions of the pool above the beaver dam were filled in with gravel in the spring of 2011, further complicating the site and reducing the viability of this site for meaningful long-term monitoring. The beaver dam no longer exists; however, due to the extreme habitat changes that have occurred since the original sampling in 2008, the UI and Reclamation have determined this site will no longer provide relevant, statistically viable data for inclusion into the overall monitoring framework.

Reclamation replaced LLL and USM with MLX and USU, respectively. MLX is more stable from year to year than LLL and has a lower likelihood of being influenced by spawning Coho. USU is also more stable than USM and is more representative of the available habitat within Sweetwater Creek. Even though LLL and USM were part of the original six sampling sites, habitat modifications described above limit the number of years of data that would be comparable to future sampling. Long-term density monitoring at MLX and USU will provide more meaningful data with regards to the critical uncertainties identified in Term and Condition #4 and will provide statistically valid data, allowing for long-term trend analysis. The density monitoring from 2014 through 2020 includes three sites located in Webb and Sweetwater Creeks (USU, UWM, LSX) that are influenced by the LOP water operations and three sites (MLX, UMU, ULU) that are not influenced by the project.

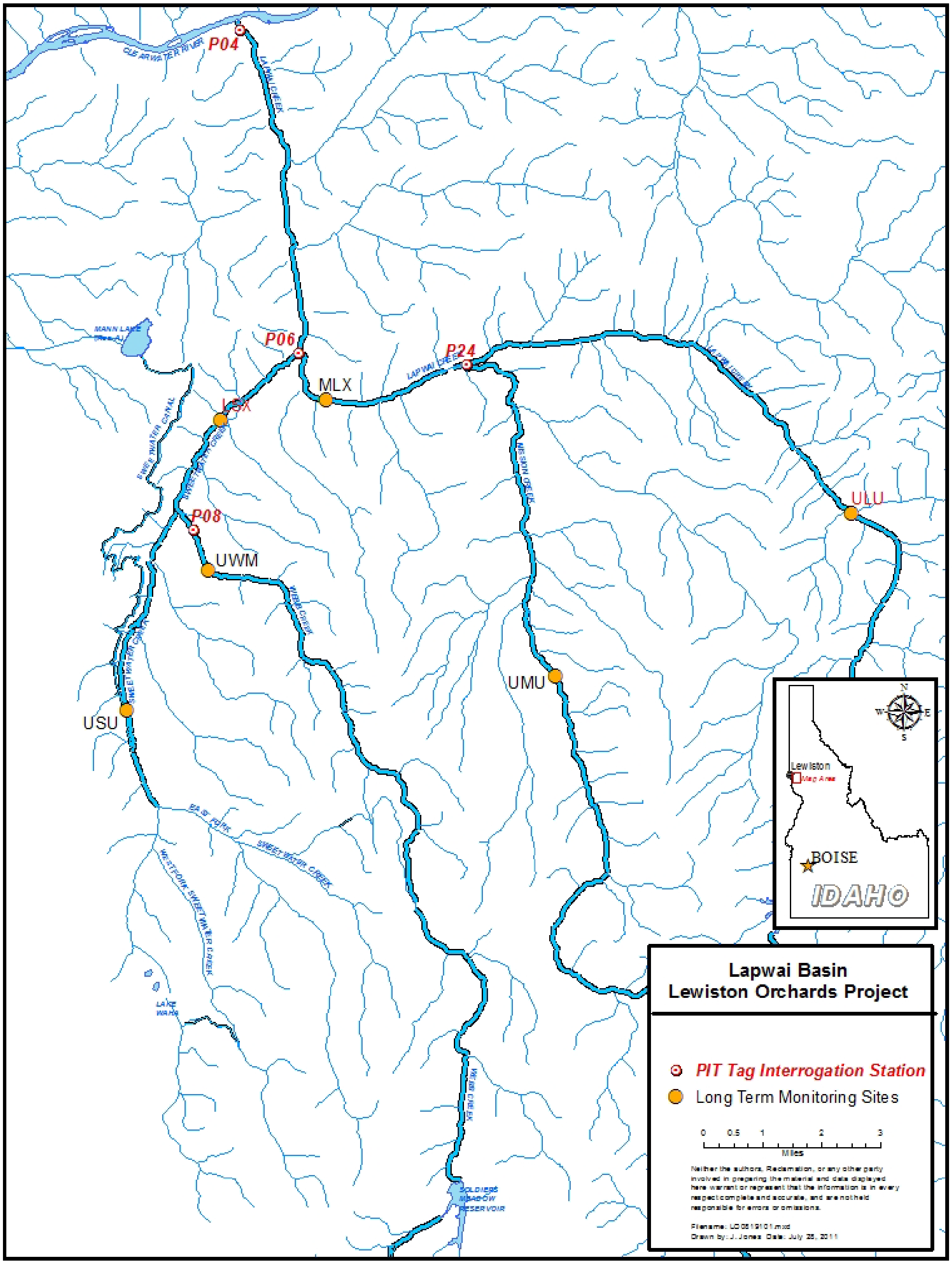


Figure 6. Map of the Lapwai Basin showing the six long-term monitoring sites.

Densities are based on abundance values estimated through 3-pass depletion in stream reaches 100 m in length. Reach-scale area is calculated from several measurements of reach width made within the study area at each sampling event. Stream area generally decreases from July to September, though this change has little influence on density estimates compared to change in fish abundance. The total densities estimated during August for young of year (0+) combined with older fish (1+) are shown in Figure 7 for 2010 through 2015.

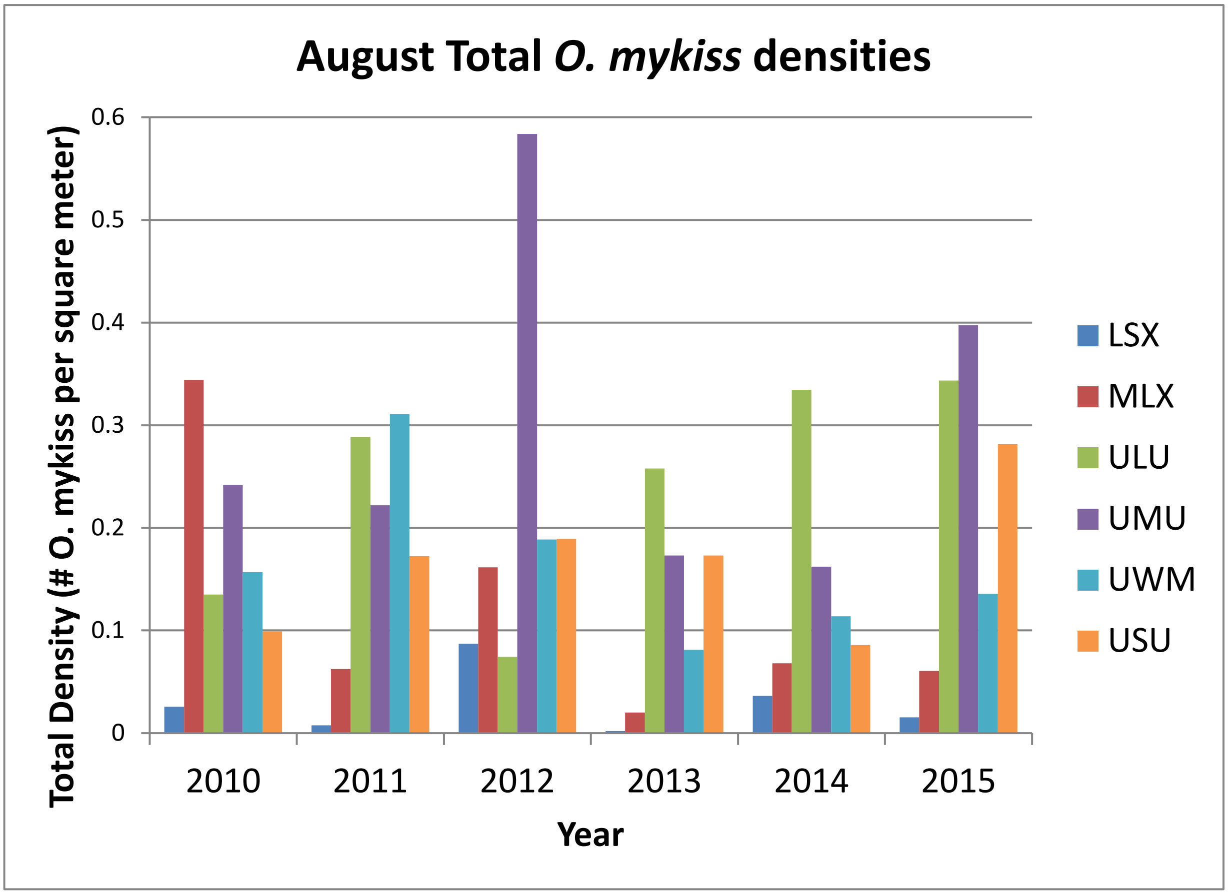


Figure 7. Total *O. mykiss* densities at 6 monitoring sites during August 2010 through 2015. Site codes are: LSX (lower Sweetwater), MLX (Lapwai below Mission), ULU (upper Lapwai), UMU (upper Mission), UWM (upper Webb), and USU (upper Sweetwater).

5.2 *O. mykiss* Adult Returns

In 2012, Reclamation entered into agreements with LOID and the Tribe to operate, maintain, and manage four PIT tag arrays in the Lapwai Basin to collect fish-movement data within the basin. The operation and maintenance of the four arrays provide tributary-scale data for populations in the Snake River evolutionarily significant units (ESUs); including the Lower Clearwater population. Data collected about escapement into this basin would be very informative in relation to the status of listed *O. mykiss* in the Snake River ESUs as well as the role and potential of Lapwai Creek at the spawning aggregate, local population, and larger ESU-level scales.

The 2015 adult PIT tag detections at the four Lapwai Basin instream arrays are summarized in an annual report to Reclamation from the Nez Perce Tribe Department of Fisheries Resource Management (Appendix C).

5.3 Water Quality and Temperature Monitoring

5.3.1 Introduction

The year 2015 was the 7th year for temperature monitoring in the Sweetwater and Webb Creek Drainages of the Lapwai Watershed. Temperature monitoring will continue to track and develop the understanding of temperature shifts, or lack thereof, as a result of discharge changes in the watersheds. In the 6 years preceding, no discernable temperature trend could be established due to changes in operations. The most pronounced changes noted in these years were water year changes driven by climactic variables such as day time temperature or annual precipitation.

Temperature is a water quality factor integral to the life cycle of fish and other aquatic species. Different temperature regimes also result in different aquatic community compositions. Water temperature dictates whether a warm, cool, or cold water aquatic community is present. The temperature of stream water usually varies on seasonal and daily time scales, and differs by location according to climate, elevation, extent of streamside vegetation, and the relative importance of groundwater inputs. Other factors affecting stream temperatures include solar radiation, cloud cover, evaporation, humidity, air temperature, wind, inflow of tributaries, and width-to-depth ratio. Anthropogenic factors include riparian zone alteration, channel alteration, and flow alteration.

Diurnal temperature fluctuations are common in small streams, especially if stream-side shade is lacking, due to day versus night changes in air temperature and absorption of solar radiation during the day. Aquatic species are restricted in distribution to a certain temperature range, and many respond more to the magnitude of temperature variation and amount of time spent at a particular temperature rather than an average value. Although species have adapted to cooler and warmer extremes of most natural waters, few cold water taxa are able to tolerate very high temperatures. Reduced oxygen solubility at high water temperatures can compound the stress on fish caused by marginal dissolved oxygen concentrations. Indirect effects of elevated stream temperatures could include reduced growth and feeding, greater susceptibility to disease, and increased metabolic costs. However, most stream environments often have cold water refugia (such as areas with groundwater or spring inflows) that biota may utilize to reduce some of these effects.

Water quality criteria for temperature primarily focus on time of year and consider maximum temperature thresholds (either instantaneous or averaged) above which the water body is considered impaired. Alterations to the thermal regime of a water body may influence incubation time and growth rates of anadromous fish and other aquatic organisms in either a positive or negative manner. The Lewiston Orchards impoundments and diversions themselves do not act as heat sources, but rather they act to change the temperature regime within the drainages.

5.3.2 Monitoring

In 2008, Reclamation, as required by Term and Condition 4 of the 2010 Opinion, established 17 monitoring stations throughout the Sweetwater, Webb, and lower portions of Lapwai Creek drainages. Water temperature monitoring has been conducted at most of these locations since that time. An additional temperature logger was installed at the Webb Canal Hydromet station in spring of 2014.

The current temperature monitoring in the LOP includes data loggers or Hydromet stations deployed at 13 of the monitoring locations to assess the changes in temperature that occur as water moves from the impoundments and springs in the headwaters to the lower reaches of Sweetwater Creek and into Lapwai Creek. In 2014, Reclamation had data loggers deployed at the following locations:

- Lapwai Creek (four loggers deployed) – downstream from the confluence of Sweetwater Creek, upstream from the confluence of Sweetwater Creek, near the confluence of Tom Beal Creek, and near mouth of Lapwai Creek
- Webb Creek (four loggers deployed, one Hydromet location) – Soldiers Meadow's outflow (logger and Hydromet), Webb Creek Diversion pool, near Webb Creek mouth, and the Webb Creek Canal Hydromet station (logger, Hydromet only collects flow).
- Lower Sweetwater Creek (three loggers deployed) – upstream from confluence of Webb Creek, downstream from confluence of Webb Creek, near Sweetwater Creek mouth
- Upper Sweetwater Creek (three loggers deployed) – East Fork Sweetwater Creek, West Fork Sweetwater Creek, and below the Sweetwater Creek Diversion Dam

The data loggers collect water temperature (degrees Celsius) data every 15 to 60 minutes. Reclamation or LOID staff downloads the data from the monitoring loggers every few months. Occasionally loggers are lost, dewatered or buried due to flow events, channel reconfiguration, or vandalism. Periodic downloads minimizes data lost due to these events. The data loggers used by Reclamation arrive from the factory pre-calibrated.

5.3.2.1 Temperature Data Summary

Below is a summary of stream temperatures at the Reclamation and LOID-maintained locations throughout the three watersheds from January through December of 2015. Missing dates are noted for each location. Summary statistics for the available site data are presented below.

Webb Creek

Reclamation collected temperature data from the Webb Creek system at four locations. The first of these was just below the outfall from Soldiers Meadows Reservoir (Figure 8). Hydromet collects temperature data at 15-minute intervals at this location. Data is available year round at this location. In the available data, set Webb Creek never exceeds 19°C daily average nor does it exceed the 22°C instantaneous maximum water quality criteria. In comparison with the Environmental Protection Agency (EPA) suggested temperature guidance of 16°C Seven Day Average Daily Maximum (7DADM), the outflow from the reservoir approaches 16°C on August 16, and remains elevated through to August 30. The maximum 7DADM (16.74°C) was reached on August 21. This maximum is consistent with data collected throughout the study and seems to be representative of the reservoir discharge.

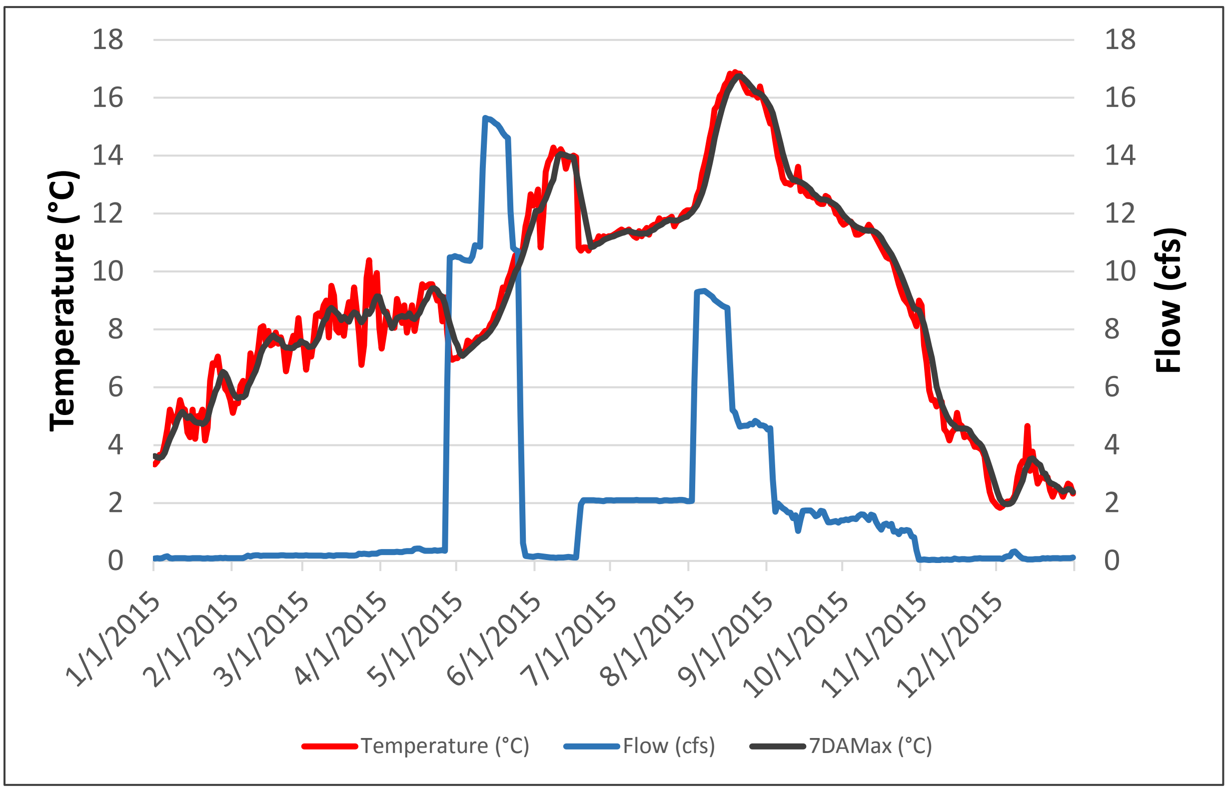


Figure 8. Maximum daily stream temperature (ºC) and mean daily flow (cfs) measured near the outflow from Soldiers Meadow Reservoir during 2015.

Daily average temperature variations during reservoir operations portion of the data set show daily variation was below 1°C (Figure 9). This is likely due to the modulating effect from the reservoir discharge, and likely corresponded to the temperature of the hypolimnion of the reservoir.

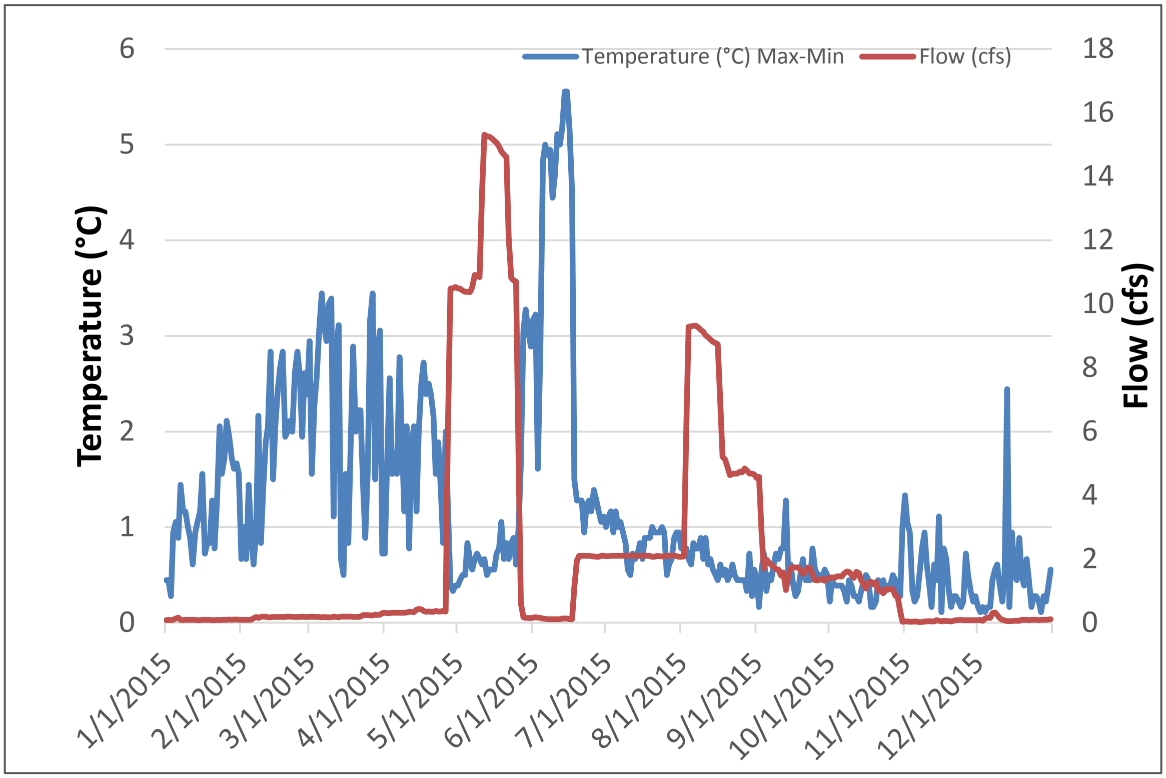


Figure 9. Daily stream temperature variation (ºC) measured near the outflow from Soldiers Meadow Reservoir (daily maximum – daily minimum).

The second Reclamation data collection location was from the pool above the Webb Creek diversion. Equipment malfunction at this site caused data to not be available after June 26, 2015. Where data is available this site showed similar trends to past years with temperatures between that of the outflow from Soldiers Meadow Reservoir and the mouth of Webb Creek. Full temperature analyses at this site are not possible for 2015 due to the missing data during peak summer temperatures (Figure 10).

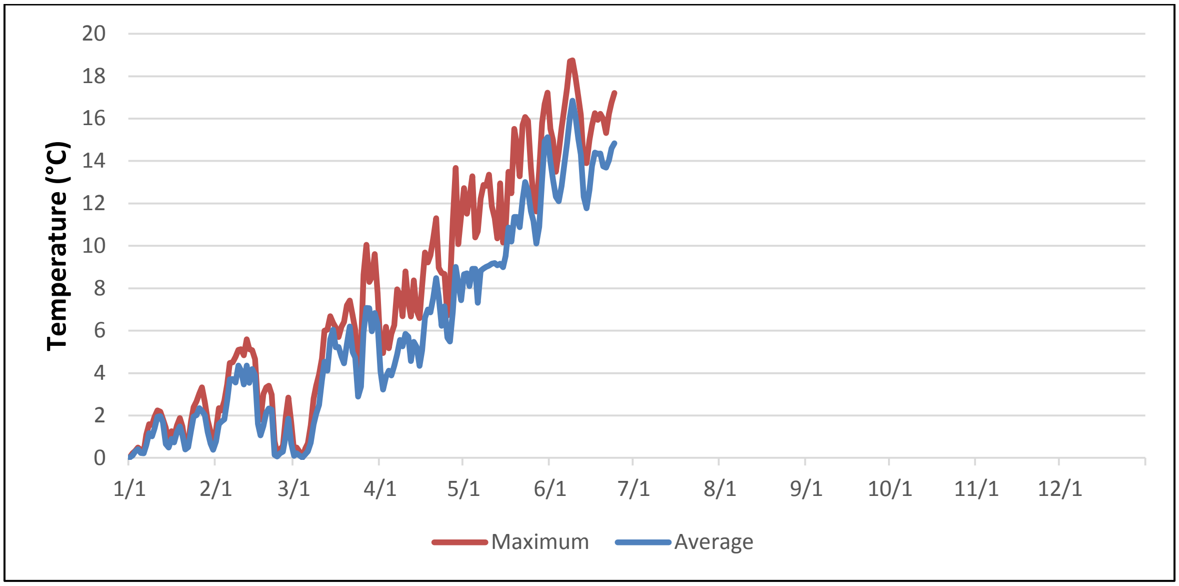
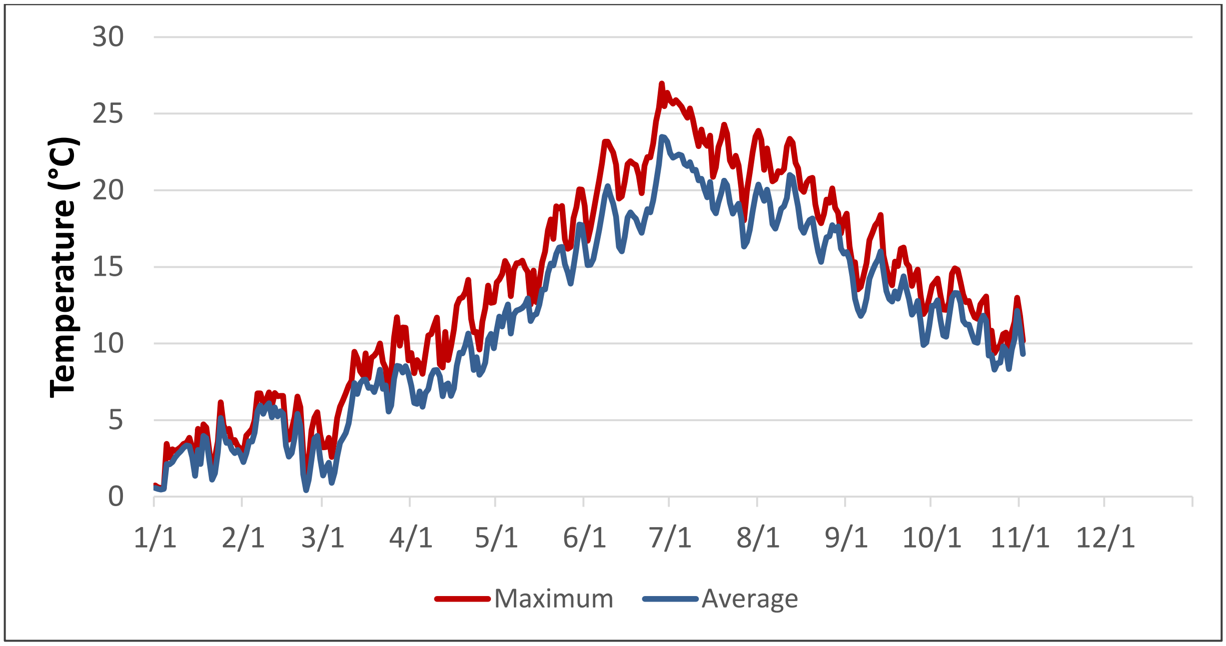


Figure 10. Maximum and average daily stream temperature (ºC) measured upstream from the Webb Creek Diversion.

Reclamation collected data at a third location on Webb Creek at the mouth of the system (Figure 11). Seasonally, the Webb Creek system at the mouth reaches wintertime minimums in late February, and is often less than 0.1°C. The system gradually warms through the spring to early summer with summer time average temperatures of approximately 17.465°C. Since 2010, summertime maximum temperatures have averaged 20.27°C and reach the warmest temperature of approximately 22 to 27°C typically in early to mid-July. Daily average temperature exceeded 22°C for 8 days from June 22 through July 5, 2015.



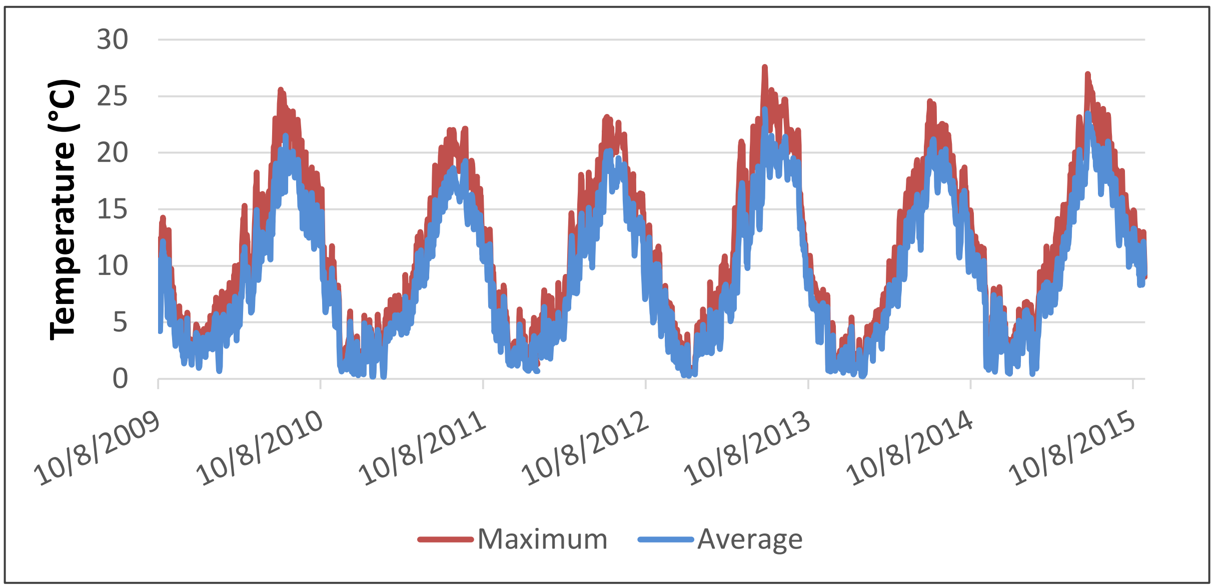


Figure 11. Maximum and average daily stream temperature (ºC) measured near the mouth of Webb Creek.

In addition, daily average variation at the Webb Mouth site was very high (Figure 12). Daily average temperature variation ranged from near 1°C in the winter up to nearly 8°C in July. This data also illustrate the annual difference between years. The data set suggest that 2010 and 2013 were much warmer than the remainder of the years. These high daily variations are indicative of thermal loading from atmospheric sources.

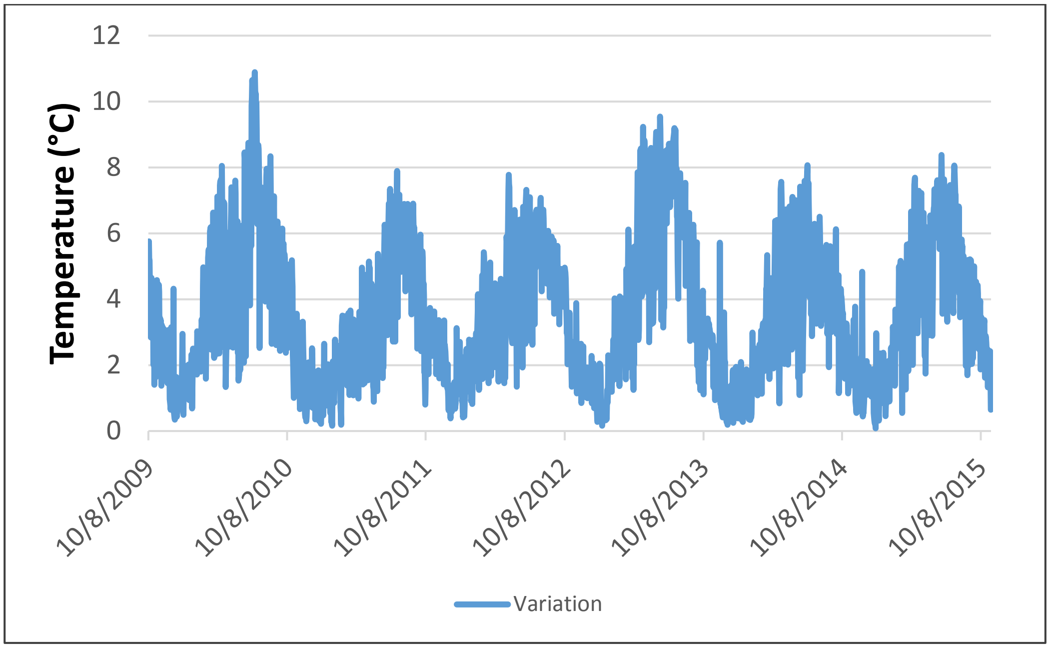


Figure 12. Maximum – minimum daily stream temperature variation (ºC) measured near the mouth of Webb Creek.

Beginning in June of 2014 Reclamation began collecting water temperature at the Hydromet location on the Webb Creek canal. Water temperature does not change noticeably between the diversion temperature monitoring and the canal monitoring location. On average the canal is only 0.17°C warmer than the temperatures measured at the diversion.

5.3.2.2 Sweetwater Creek

Reclamation collected temperature data in seven locations in the Sweetwater Creek system.

The first data collection location in the Sweetwater drainage is in the headwaters at the mouth of the West Fork Sweetwater Creek. Typically, the West Fork has winter maximums ranging from 1 to 8°C trending upward through the spring to warm summer maximums averaging near 14°C (Figure 13). During 2015, maximum stream temperatures peaked at 18.37°C in late June. This site did not exceed state water quality standards for cold-water aquatic life. Daily variation in stream temperature in 2015 was similar to past years with a maximum variation around 8ºC (Figure 14).

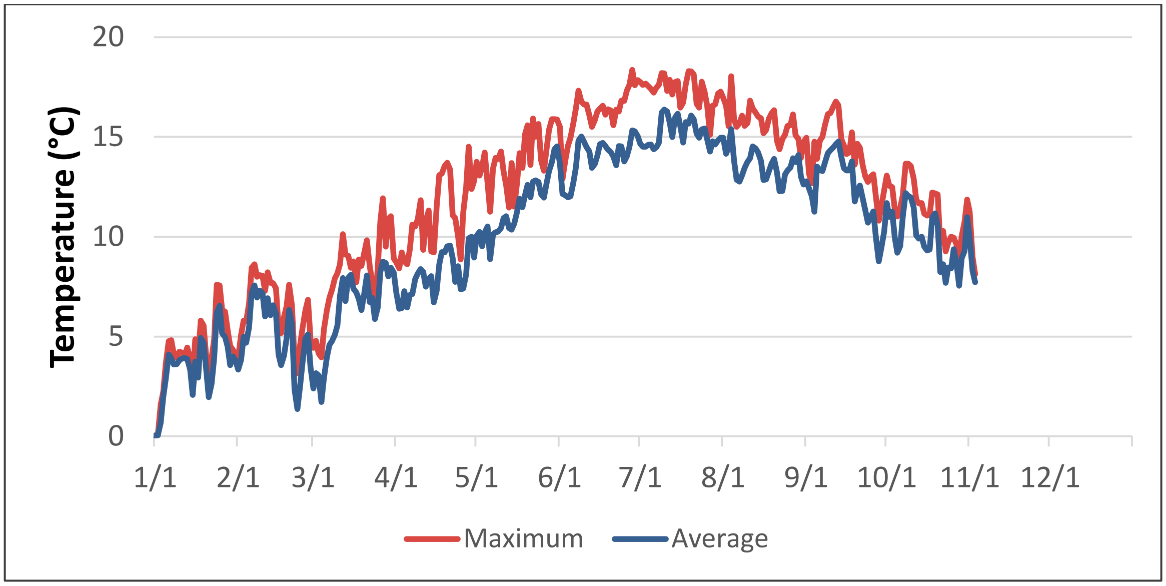
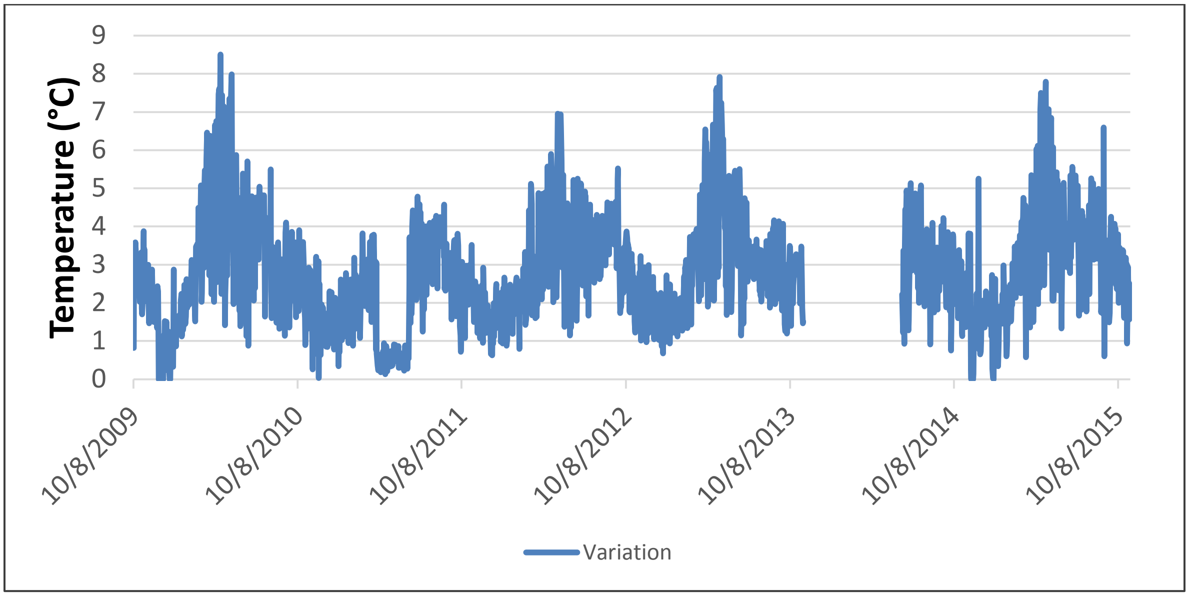


Figure 13. Maximum and average daily stream temperature (ºC) measured near the mouth of the West Fork of Sweetwater Creek. Note the drop in daily variation when the logger was buried in sediment during high flows in 2011.



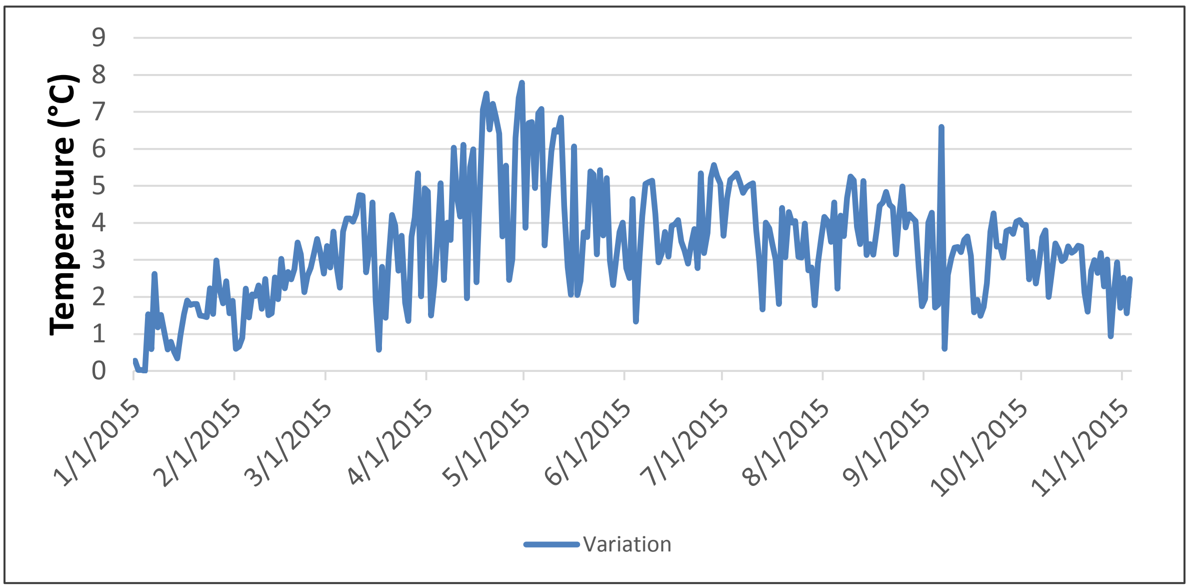
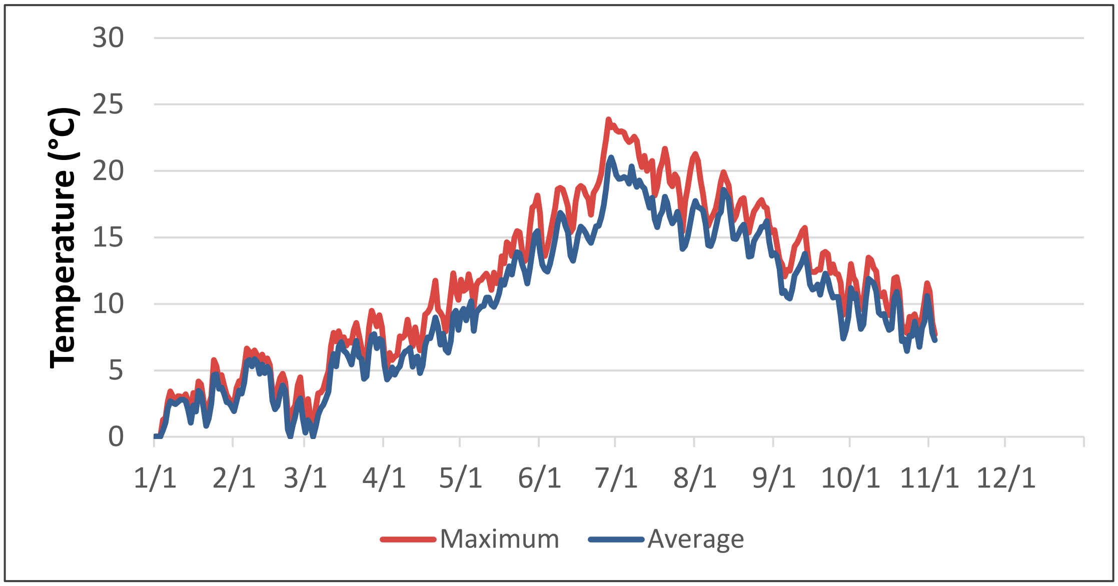


Figure 14. Daily stream temperature variation (ºC) measured near the mouth of the West Fork of Sweetwater Creek.

In the East Fork of Sweetwater Creek (East Fork), the other tributary stream, the only data gap is from a logger that was lost during 2011 high flows and was replaced in July of that year. Summer maximum temperatures normally occur in August. The stream has warmed slightly over the past 2 years of data collection similar to what has been shown in the West Fork data set.

The East Fork exhibits cold winter maximums averaging less than 1 to 2°C trending upward through the spring to warm summer maximums near 22°C (Figure 15). In some cases, flows diminish to the point the logger records ambient air temperatures. Daily temperature variation during the summer averaged approximately 4°C. This site also rarely exceeds state water quality standards for cold-water aquatic life when the system carries sufficient flow to record temperature. The peak daily maximum temperature in 2014 was 20.75°C.



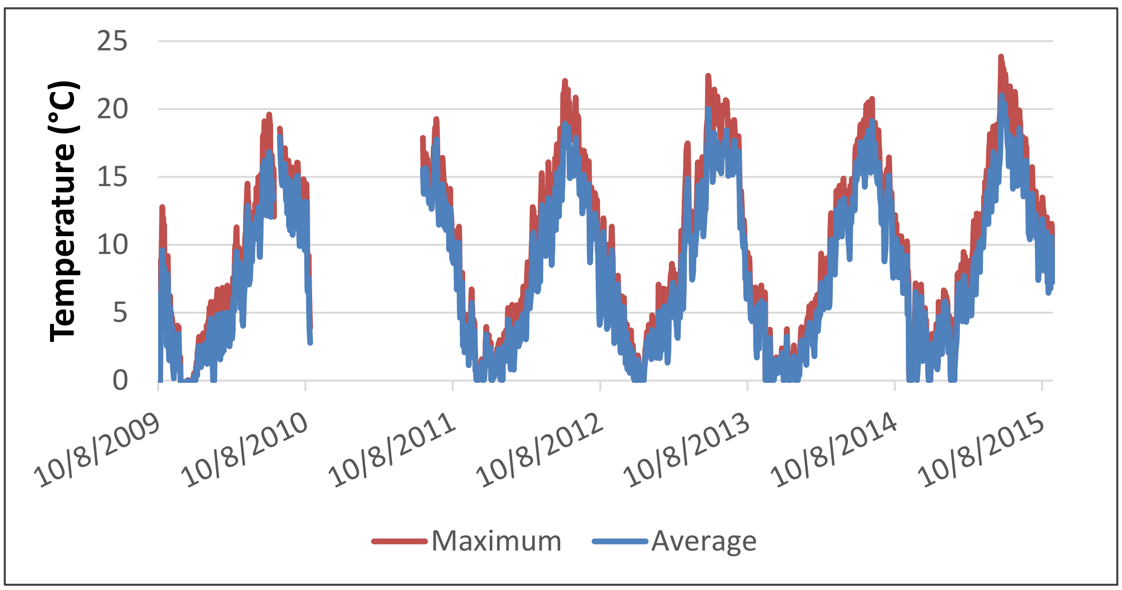


Figure 15. Maximum and average daily stream temperature (ºC) measured near the mouth of the East Fork of Sweetwater Creek.

The East Fork exhibits a slightly different temperature regime in comparison with the West Fork. It is slightly warmer in the summer and much cooler during the winter (Figure 16). Some of these differences can be explained by the operation of the Lake Waha pumps, which cools the West Fork during the late summer. In addition, the East Fork carries water delivered from the Webb Creek system during reservoir operations. The influence of the 21 Ranch Springs (Big Springs) a natural spring system that is linked to Lake Waha, may also explain some of the seasonal difference between the West Fork and East Forks. Spring-fed systems are warmer during the winter due to the relatively constant temperature discharged. The East Fork is also a smaller system than the West Fork, which can result in lower wintertime temperatures and greater day-to-day temperature variation due to a lower thermal mass in the system.

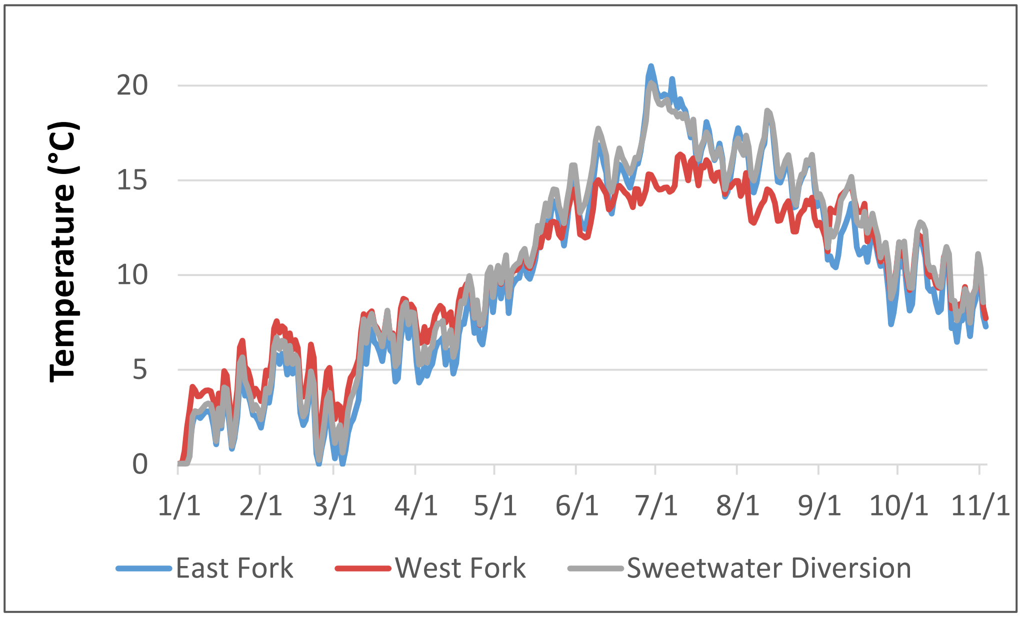
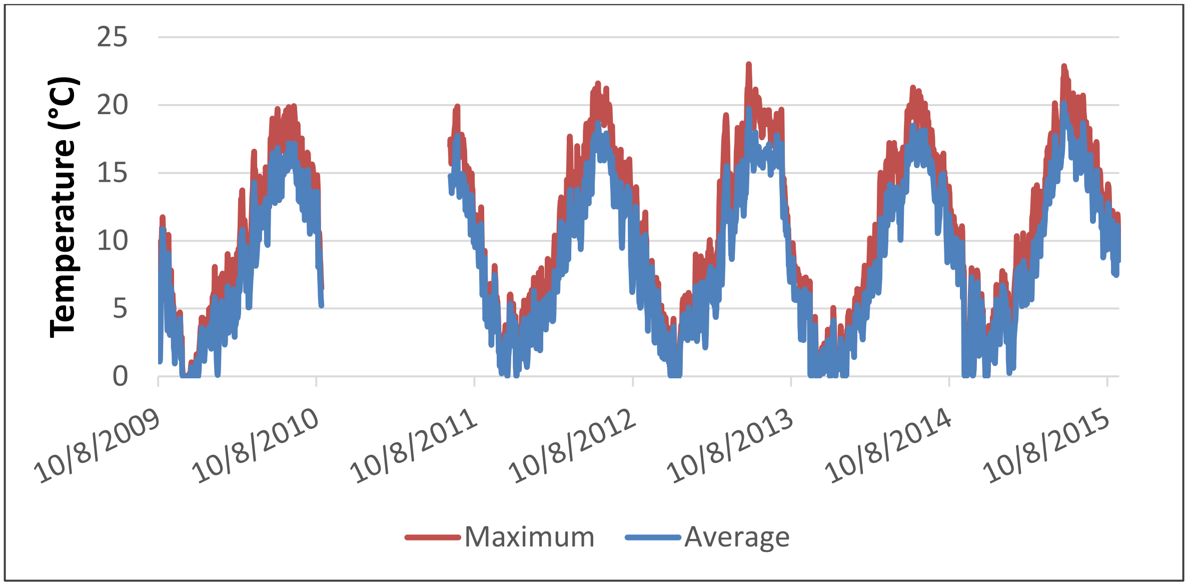


Figure 16. Mean daily stream temperature (°C) measured near the mouth of the East Fork of Sweetwater Creek, at the mouth of the West Fork of Sweetwater Creek, and below the Sweetwater Creek Diversion.

Due to the influence of 21 Ranch Springs (Big Springs) on the West Fork, some modulation of the daily temperature variation would be expected, especially in the winter time. However, this does not seem to be the case. Temperature variation between the two systems seems similar with no discernable trends or differences.

The next downstream logger placement was in Sweetwater Creek just downstream from the Sweetwater Creek Diversion Dam (Figure 17). This logger has been lost due to high spring flows and replaced several times. This location was selected to measure the temperature changes associated with project inputs on Sweetwater Creek from diversions from Webb Creek below Soldiers Meadows Reservoir, and to measure the temperature changes associated with project withdrawals as well as any temperature amelioration that occurs because of discharge from 21 Ranch Springs (Big Springs).



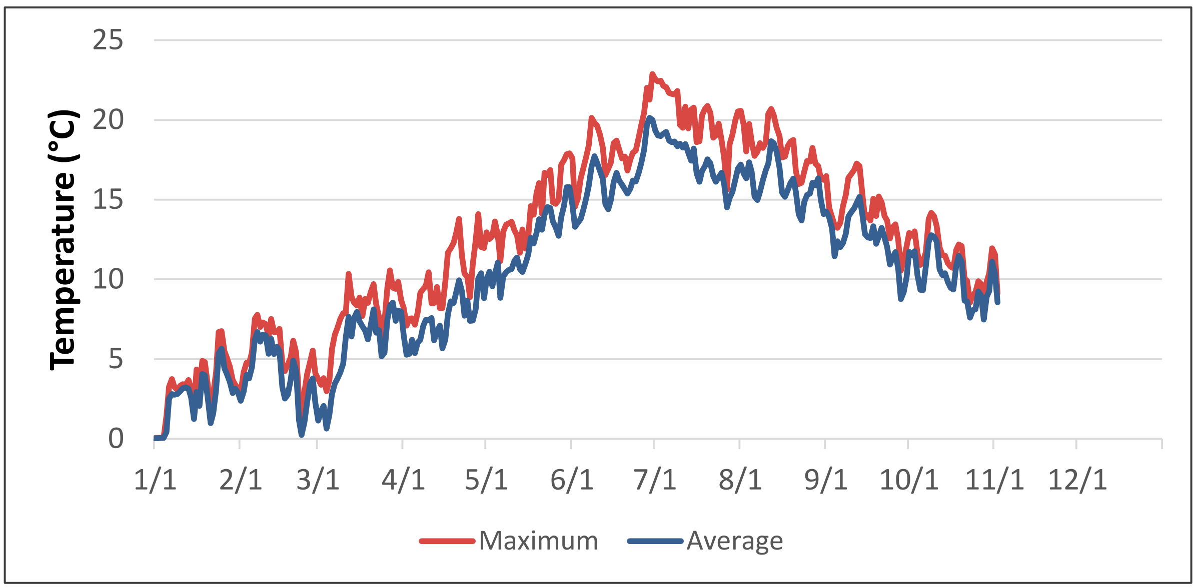


Figure 17. Maximum and average daily stream temperature (ºC) measured near the Sweetwater Creek Diversion.

This location is situated below 21 Ranch Springs (Big Springs), which is linked to Lake Waha. There is a slight warming occurring in the winter that is likely to be the result of Big Springs' temperature amelioration. The year 2015 appears to be warmer than the proceeding years, with periods of temperatures exceeding state water quality standards for both daily average and daily maximum in 2015 for 8 days (June 28 through July 5).

Summer time maximum temperatures near the Sweetwater Creek Diversion average 18.35ºC, 20.21ºC, and 18.21°C in June, July, and August, respectively. This maximum temperature is slightly warmer than the upstream reaches.

The next data logger on Sweetwater Creek system is upstream from the confluence with Webb Creek (Figure 18). In past years, this logger has recorded some of the highest temps in the whole Sweetwater Creek basin, as reported in Reclamation's 2009 BA for the LOP. These high temperatures are likely due to lack of shade, channel alteration and water withdrawals. Inflows downstream of this point help to improve (or offset) some high temperatures.

The warmest temperatures of the data set occurred in 2015. Stream temperatures exceeded 24°C in late June. At this location, stream temperatures were above the state water quality standards for 8 days each in 2012 and 2013, for only 2 days in 2014 and for 18 days in 2015.

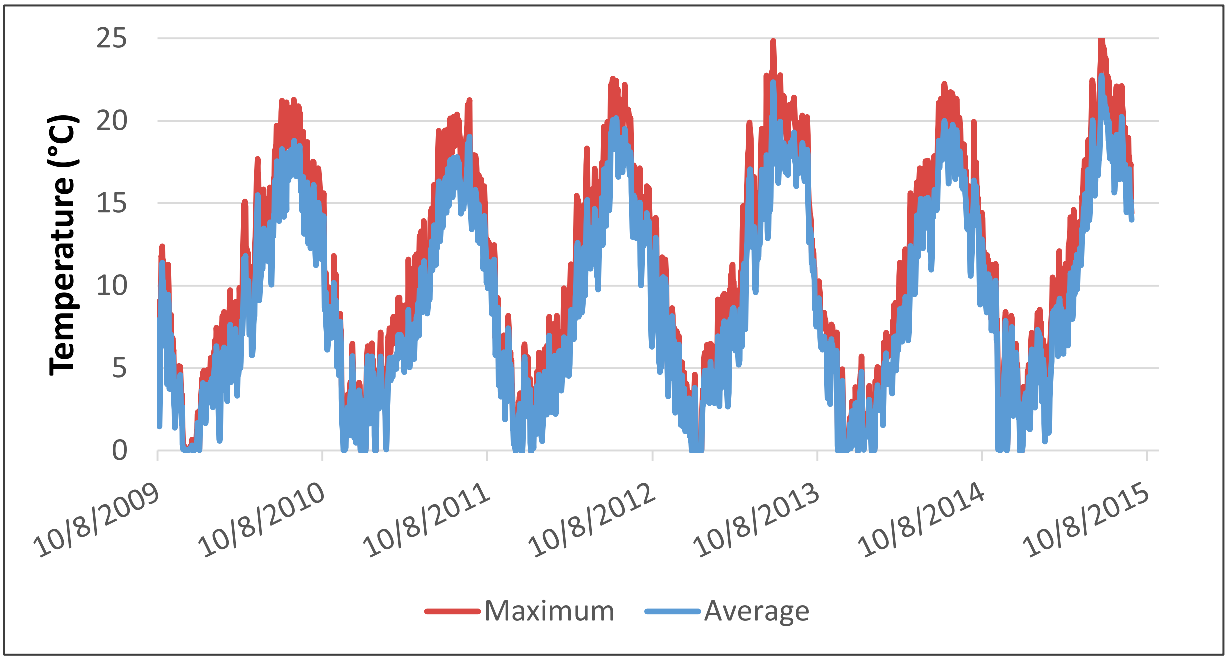


Figure 18. Mean and maximum daily stream temperature (°C) measured upstream from the Webb Creek confluence with Sweetwater Creek.

Some heat gain appears to be occurring between these two sites. Water temperature change in August and September, from the upper location to the lower location averages approximately 1.27°C gain, while in November through February; there is an average change of approximately 0.28°C from the upstream location to the downstream location (Figure 19).

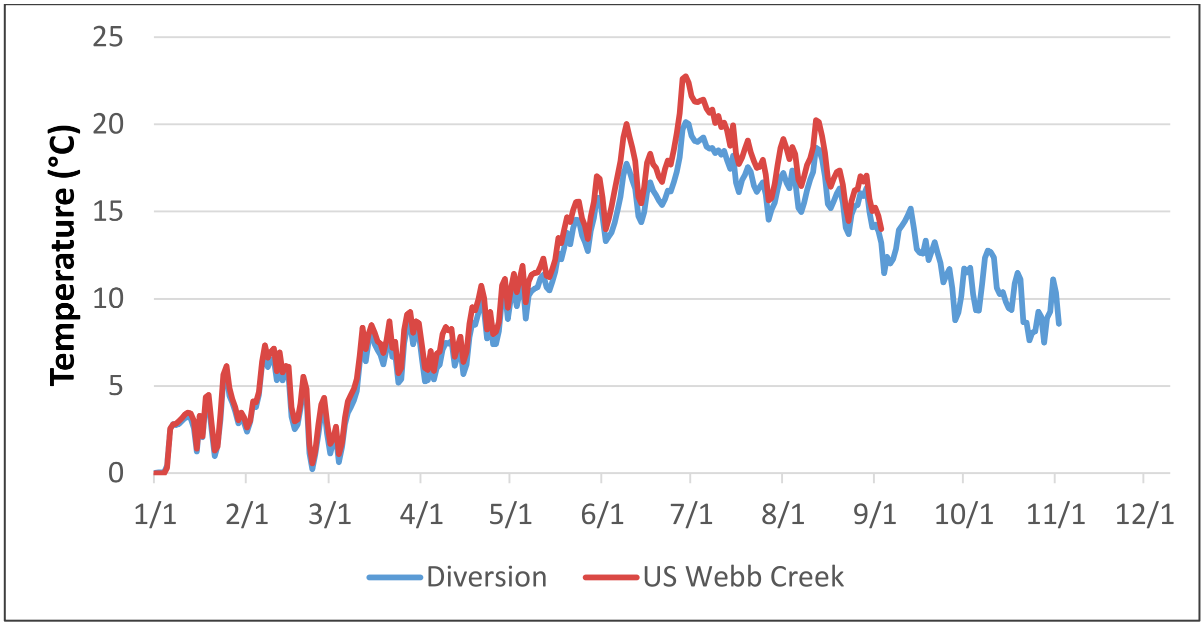


Figure 19. Mean daily stream temperature (°C) measured upstream from the Webb Creek confluence with Sweetwater Creek compared to mean daily temperatures just downstream of the Sweetwater Creek Diversion.

The third logger location on the mainstem Sweetwater Creek system was just below the confluence with Webb Creek (Figure 20). The data from this location provides an understanding of how Sweetwater Creek thermal regime is changed by the addition of Webb Creek water.

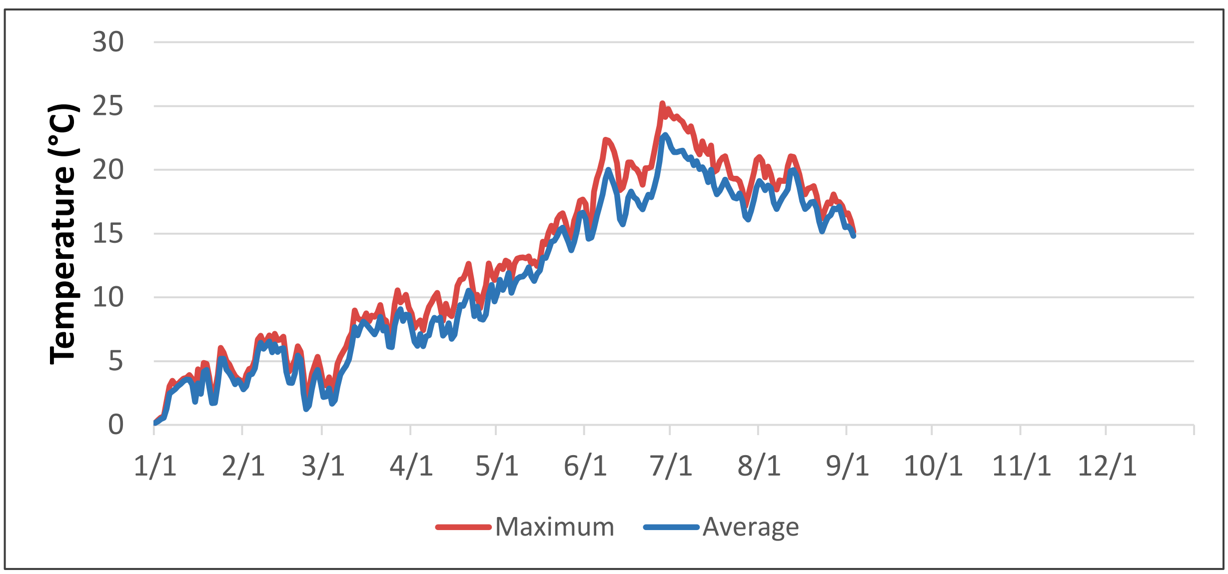


Figure 20. Maximum and average daily stream temperature (°C) measured downstream from the Webb Creek confluence with Sweetwater Creek.

Some heat gain occurs between these two sites. Heat gain is more pronounced in the summer, from the upper location to the lower location, and average approximately 1°C. While in November through February, the downstream location average 0.5°C warmer than the upstream location (Figure 21). This slight warming is likely due to the effect of the smaller warmer tributary, Webb Creek, entering the Sweetwater system.

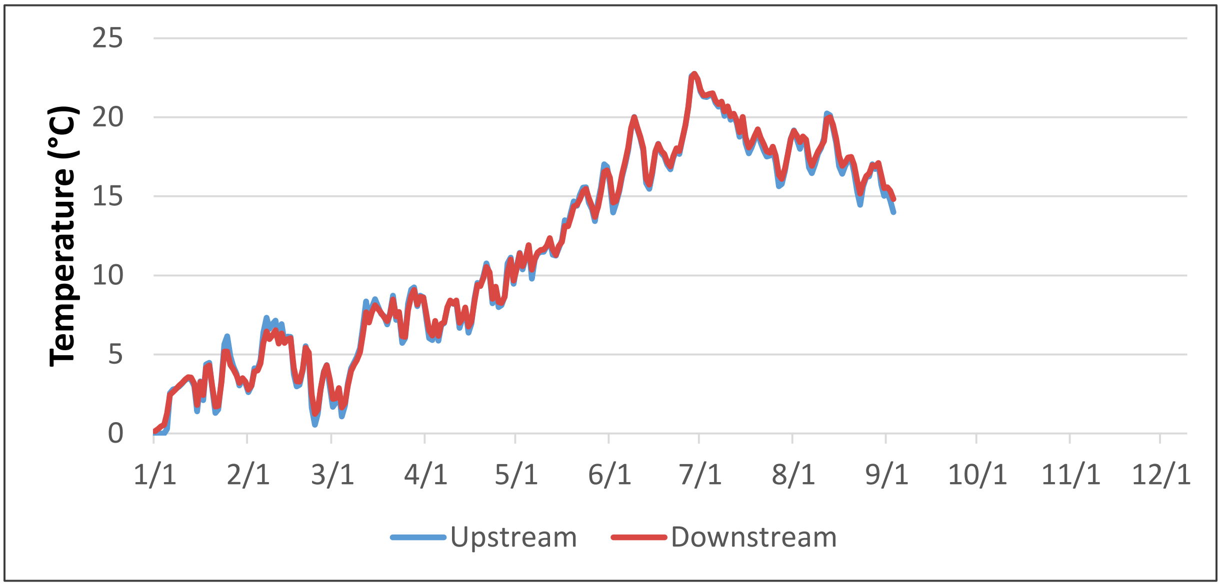


Figure 21. Mean daily stream temperature (°C) measured upstream from the Webb Creek confluence with Sweetwater Creek compared to mean daily temperatures just downstream of the Webb Creek confluence.

In recent years this difference has become statistically significant. An analysis of variance indicates that the variance between the two locations is significantly different ($p \approx 0.0004$), while the slope and intercept of the regression analysis (as shown in Figure 22) remain nearly 1 and 0, respectively. The average annual temperature downstream from Webb Creek is 10.09°C, while the average annual temperature from the upstream location is 9.92°C.

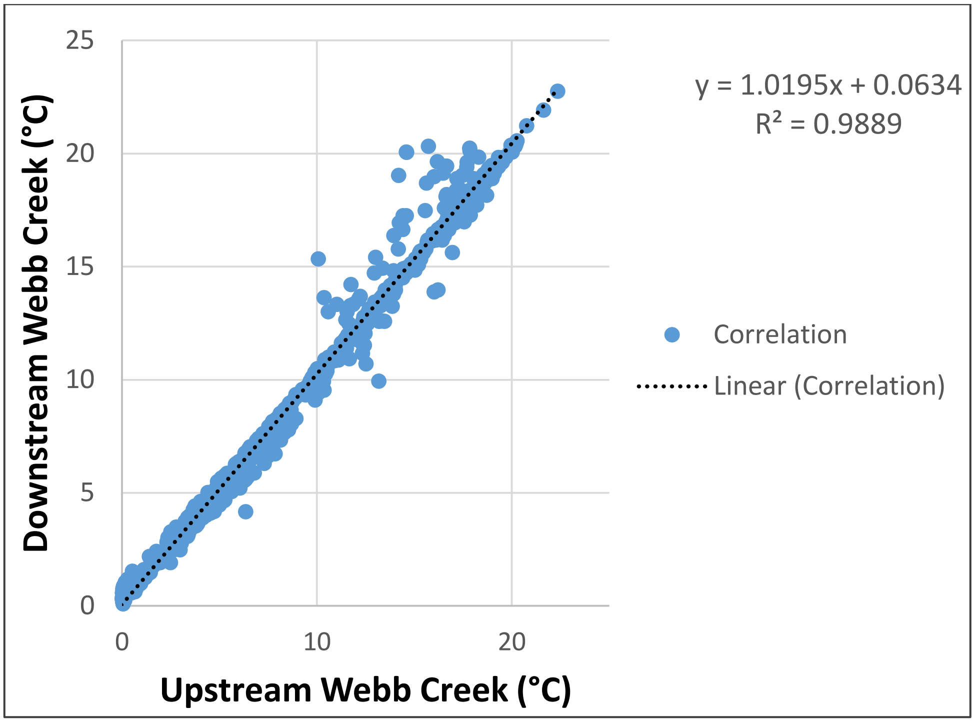


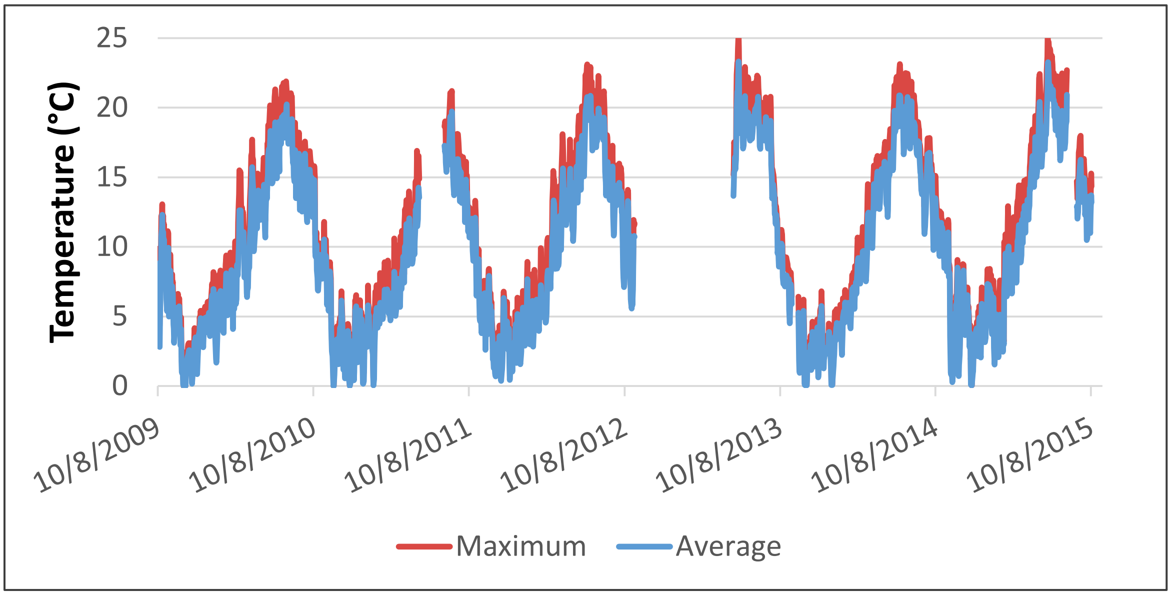
Figure 22. Correlation of mean daily stream temperature (°C) measured upstream and downstream from the Webb Creek confluence with Sweetwater Creek.

The final logger location on the mainstem Sweetwater Creek system was at the mouth of Sweetwater Creek before it meets with Lapwai Creek Figure 23). The data from this location provides an understanding of how Sweetwater Creek thermal regime is changed by the addition of Webb Creek water, and shows the potential differences between the Sweetwater system and the Lapwai system. The logger was found removed from the water and temperature readings are not available from August 14 to September 3, 2015.

At this site the winter daily maximum temperatures range from 0 to 6°C. As the spring progresses, the system warms to approximately 16°C by early May 31. This annual progression is similar to that seen in Sweetwater Creek upstream from the Webb Creek confluence. Typically, average daily stream temperature reaches its warmest in July, but generally only remains above 19°C for a few days each year. The 2013 daily average temperatures were the warmest in July and remained above 19°C for approximately 32 days. In 2014, there were 28 days with average temperatures over 19°C while 2015 had at least 33 in the usable dataset. Typical daily maximum temperature during this warm period can reach 21 to 22°C. Daily maximum temperatures reached 25°C in 2013, 23.1°C in 2014, and 25.8°C in 2015.

The difference between the average daily temperatures recorded downstream from the Webb Creek confluence and the mouth of Sweetwater Creek site in the winter time, January and February, the temperature differences from the Webb Creek confluence to the mouth of

Sweetwater Creek averaged 0.83°C (Figure 23 and Figure 24). This may be indicative of a spring source located between the two sampling locations or that the reach is gaining water from hyporheic flows. The May through June temperature difference was approximately 0.40°C warmer at the mouth than downstream from Webb Creek.



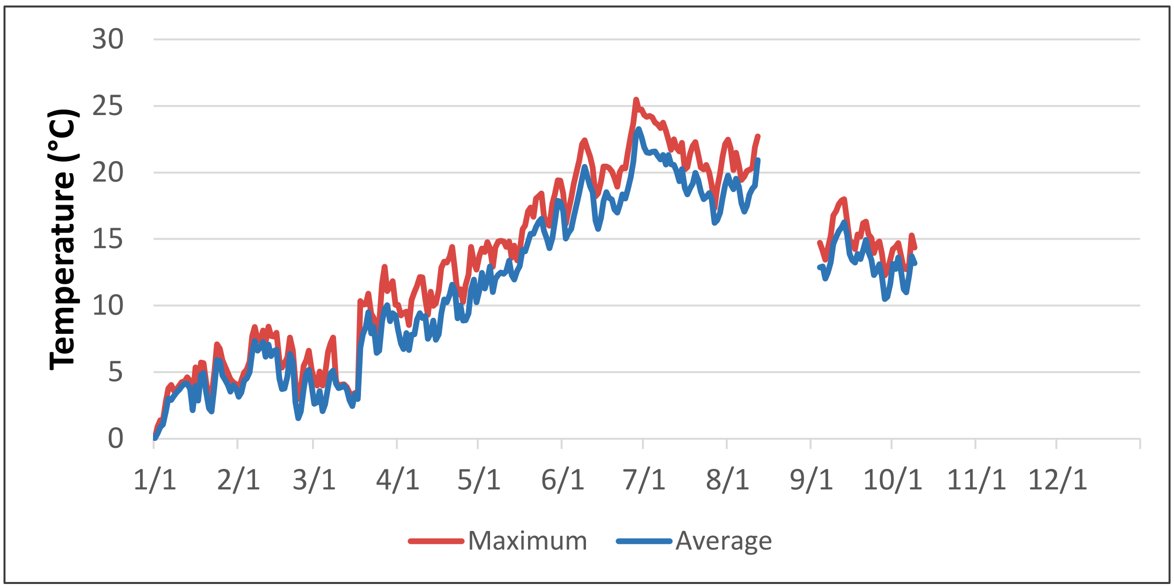


Figure 23. Maximum and average daily stream temperature (°C) measured near the Sweetwater Creek mouth.

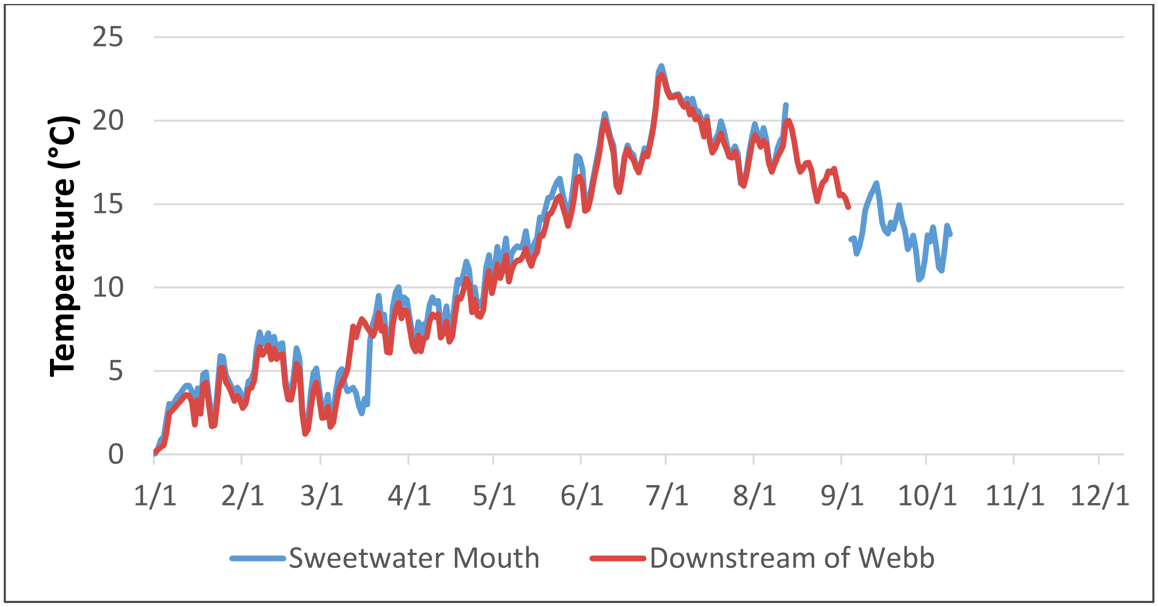


Figure 24. Mean daily stream temperature (°C) measured upstream from the Webb Creek confluence with Sweetwater Creek compared to mean daily temperatures measured near the mouth of Sweetwater Creek.

In the previous three years, the summertime difference between the daily maximum temperatures recorded at the Webb Creek Mouth location and the Sweetwater Creek mouth location averaged 1.35°C, indicating that Webb Creek was much warmer than Sweetwater Creek (Figure 25). The wintertime difference between the two systems is the opposite of summer with Webb Creek averaging 0.95°C cooler than Sweetwater. The difference between the two systems in the summer is the result of the cooling effects of Big Springs and the larger volume and width to depth ratios in Sweetwater Creek. During the winter, Big Springs actually exerts a warming influence and the smaller volume of water in Webb Creek cools off more easily than Sweetwater Creek. Additionally, it appears that all monitoring locations are responding with similar between-day temperature changes as seen in the temperature peaks in July. These changes are of similar magnitude at all Sweetwater Creek locations. This gives a clear indication that the locations are responding to solar loading similarly and that groundwater and other factors such as shade are similar between the monitoring locations in the two watersheds.

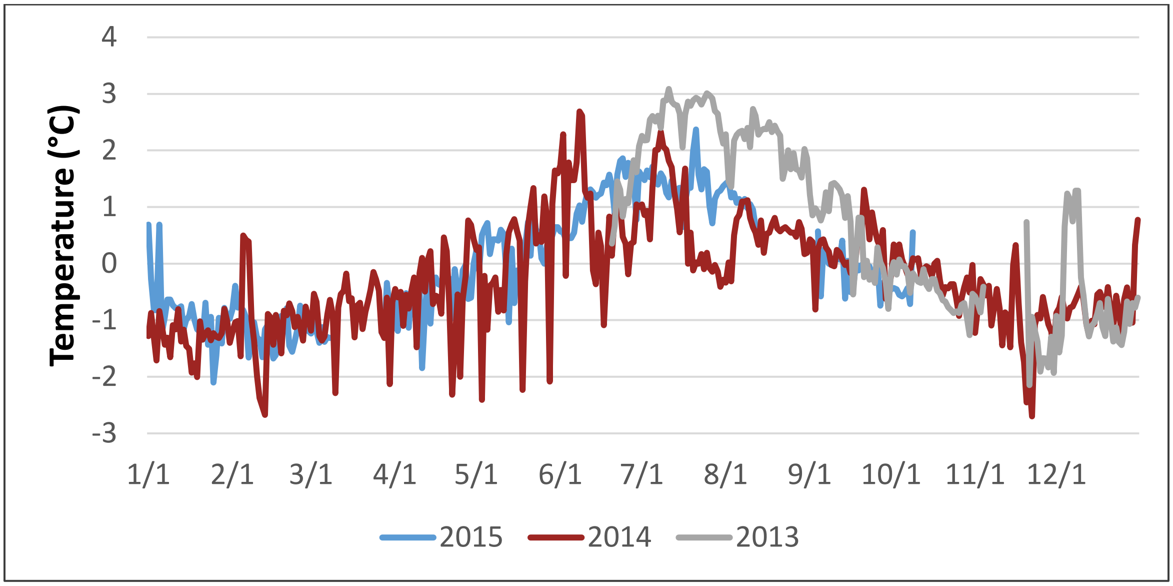


Figure 25. Daily maximum stream temperature (°C) measured near the mouth of Webb Creek compared to daily maximum temperatures measured near the mouth of Sweetwater Creek.

Lapwai Creek

Reclamation also collected temperature data at four locations in Lapwai Creek. The first of these was just above the Sweetwater Creek confluence (Figure 26 and Figure 27). Typically, this segment begins to warm steadily throughout the late winter and reaches the warmest period in early August. In this data set Lapwai Creek above Sweetwater Creek often exceeds the State of Idaho water quality standard 19°C daily average, and can exceed 22°C instantaneous maximum standard for several weeks each year. Daily maximum temperatures in 2015 exceeded 22°C for 71 days in 2015. Daily variation during this period was also very high and averaged approximately 6.89°C in 2015. This high daily variation is likely due to a general lack of shade throughout the upper reaches of Lapwai Creek, and is similar to the high variation seen in Webb Creek that is likely due to low shade coupled with low flow volume in that system. In comparison with the temperature regime seen in Sweetwater Creek, this Lapwai site is approximately 1.53°C warmer on average. This relationship is consistent through the period of record. The high correlation between the two temperature data sets indicates that water temperatures in the two streams are likely influenced by similar environmental variables.

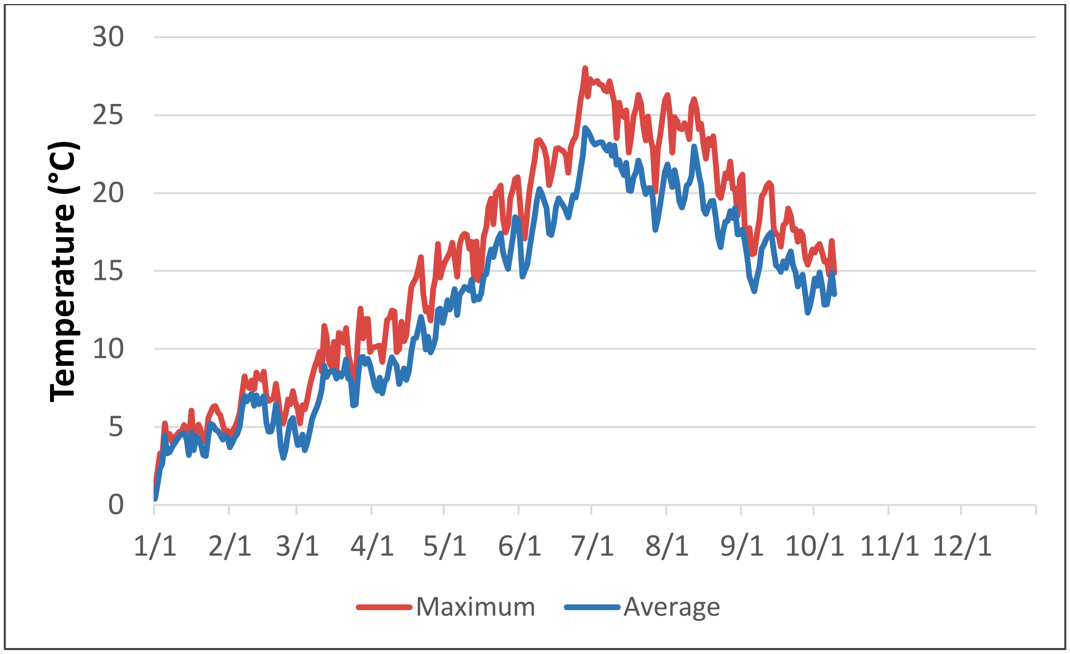


Figure 26. Maximum and average daily stream temperature (°C) of Lapwai Creek measured upstream from the Sweetwater Creek Lapwai Creek Confluence.

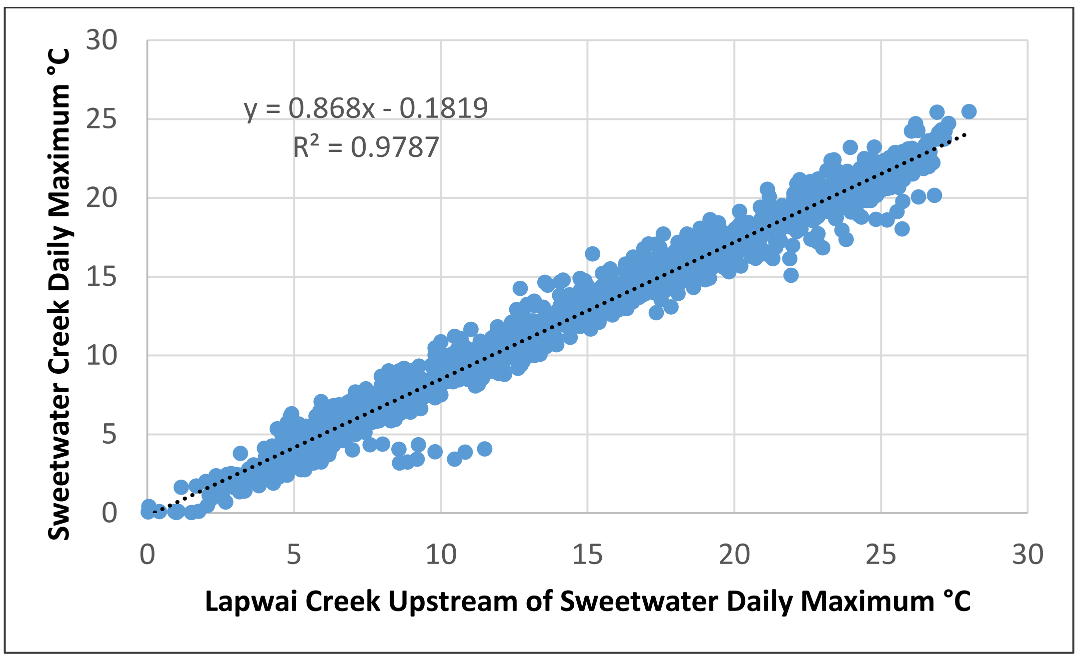


Figure 27. Maximum daily stream temperature (°C) relationship between Lapwai Creek and the maximum daily stream temperature of Sweetwater Creek mouth during 2009 to 2014.

The second Reclamation data collection location on Lapwai Creek was downstream from the Sweetwater Creek confluence, which allows for comparison with the effects from Sweetwater Creek (Figure 28). In this data set, Lapwai Creek below Sweetwater Creek exceeds 19°C daily average and the 22°C instantaneous maximum for several days each year. In summer of 2015, the downstream location was 1.15°C cooler on average than the upstream location. The following graphs show the slow increase in temperatures from downstream from the confluence of Sweetwater Creek to the mouth of Lapwai Creek (Figure 28 through 32).

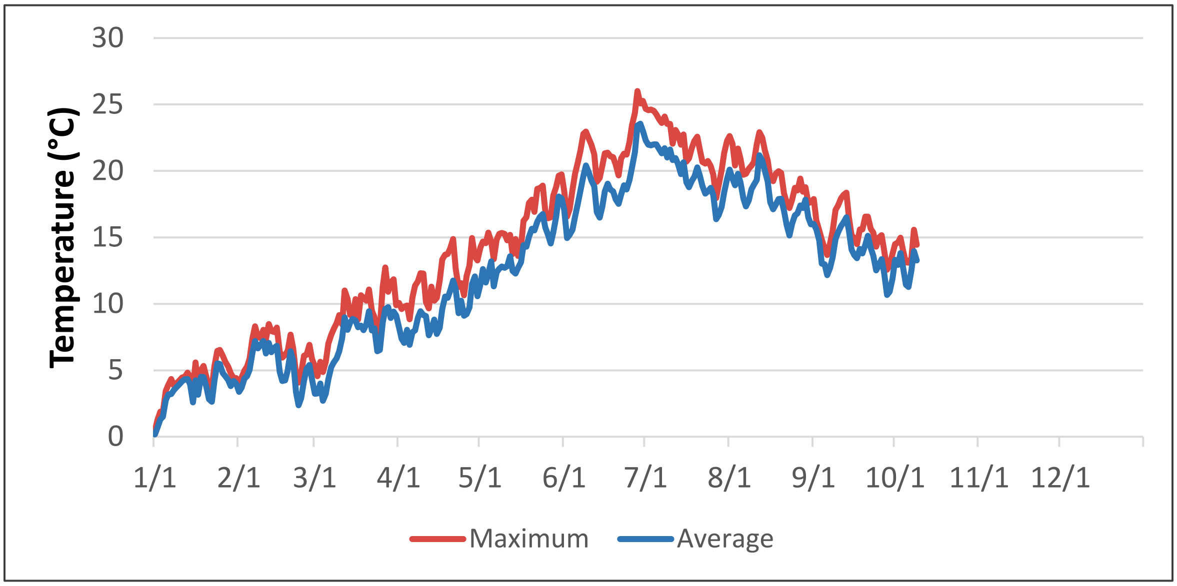


Figure 28. Maximum and average daily stream temperature (°C) of Lapwai Creek measured upstream from the Sweetwater Creek Lapwai Creek.

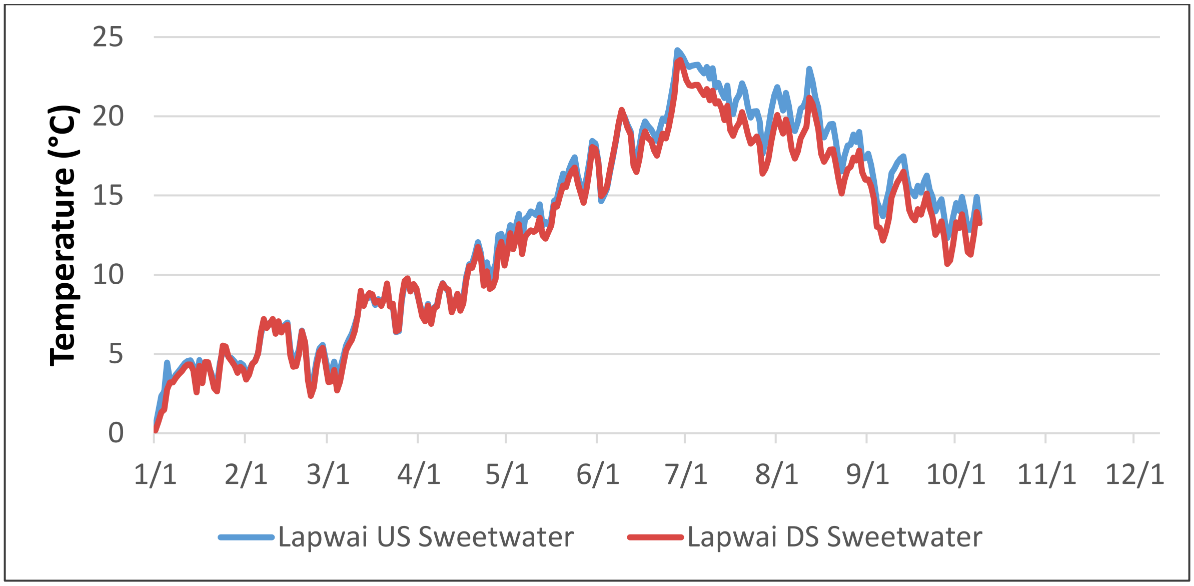


Figure 29. Mean daily stream temperature (°C) of Lapwai Creek measured upstream and downstream from the Sweetwater Creek Lapwai Creek confluence.

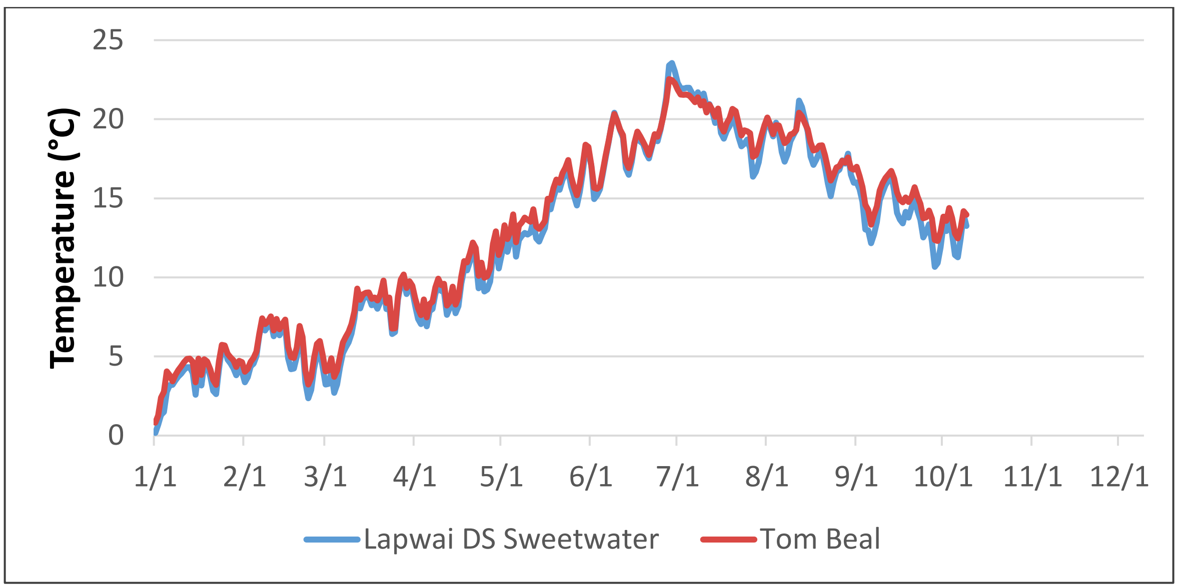


Figure 30. Mean daily stream temperature (°C) of Lapwai Creek measured downstream from the Sweetwater Creek Lapwai Creek confluence and near the Tom Beal Creek confluence.

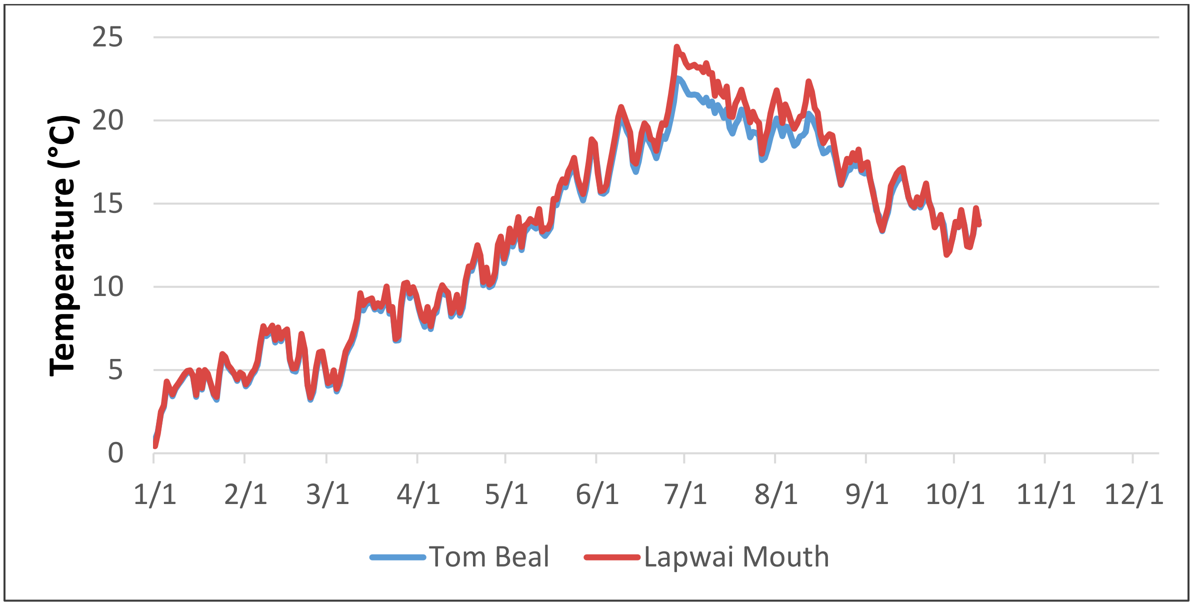


Figure 31. Mean daily stream temperature (°C) of Lapwai Creek measured near the Tom Beal Creek confluence and the mouth of Lapwai Creek.

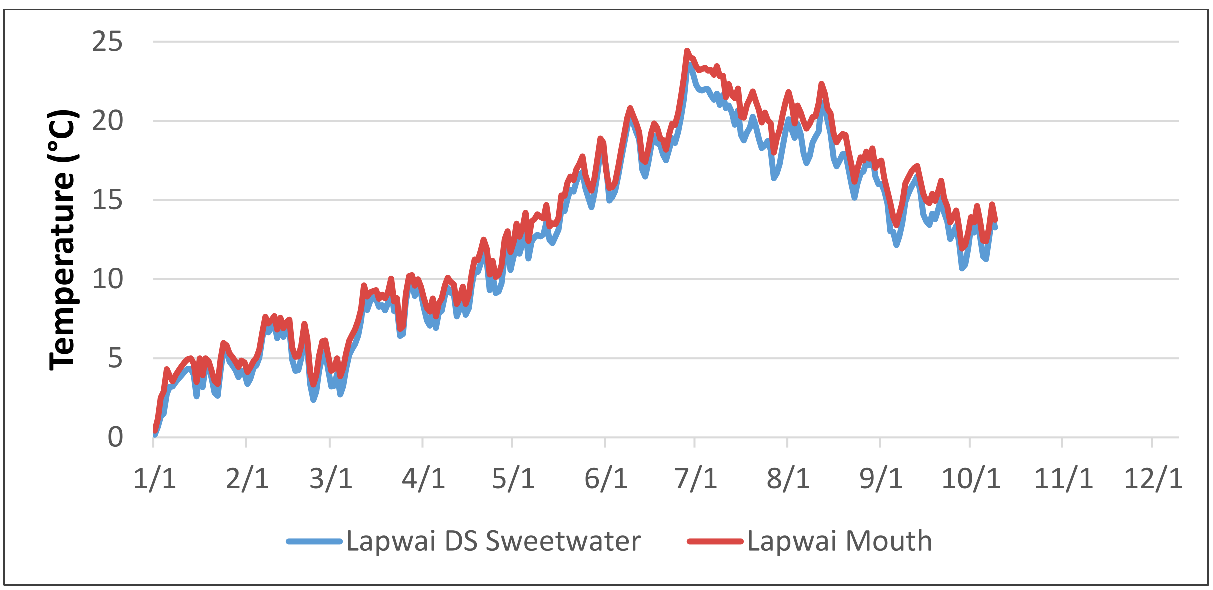


Figure 32. Mean daily stream temperature (°C) of Lapwai Creek measured downstream from the Sweetwater Creek Lapwai Creek confluence and the mouth of Lapwai Creek.

Temperature increases per km of steam channel throughout the basin ranged from 0.01 to 0.6°C (Table 5). The highest rates of temperature change were documented at the highest (Soldiers Meadows outflow to Webb Diversion) and lowest site Tom Beal Road to Lapwai mouth. Sweetwater Creek downstream of Webb to Sweetwater mouth had the lowest rate of temperature increase documented. These differences identified in the rate of temperature change in different sections of the drainage are likely caused by differences in riparian vegetation and groundwater influence as well as the total volume of water and width-to-depth ratios.

Table 5. Rates of temperature increase over distance between temperature monitoring locations in the Lapwai Drainage on June 24, 2015.

From	To	Distance km	Temperature Change/km
Soldiers outflow	Webb Diversion	9.23	0.60
Webb Diversion	Webb Mouth	14.80	0.33
SW Diversion	US Webb	4.24	0.53
DS Webb	SW Mouth	5.93	0.01
DS SW	Tom Beal	5.57	0.17
Tom Beal Road	Lapwai Mouth	3.21	0.60

5.4 Water Quality

Water samples were analyzed for 13 parameters listed in Table 6. In addition, field measurements such as temperature, pH, conductivity and dissolved oxygen were taken with a hand held YSI 54A or Hach Hydrolab DS5X multi-meter. Laboratory analysis was conducted according to approved methods listed in the Standard Methods for the Examination of Water and Wastewater 20th Ed., EPA methods, and the Quality Assurance Plan for Reclamation's Pacific Northwest Laboratory.

Table 6. Analytical procedures and methods.

Parameter	Unit Measurement	Method Number
Temperature	C	EPA 170.1
Dissolved Oxygen	mg/L	EPA 360.1
Turbidity	NTU	EPA 180.1
Total Suspended Solids	mg/L	SM 2540 D
Volatile Solids	mg/L	SM 2540 C
Nitrate+Nitrite as N	mg/L	EPA 353.2
Total Kjeldahl Nitrogen as N	mg/L	EPA 351.2
Total Ammonia as N	mg/L	SM 4500-NH_3 D
Ammonia, Dissolved as N	mg/L	SM 4500-NH_3 G
Ortho-Phosphate	mg/L	SM 4500-P F
Total Phosphorus	mg/L	SM 4500-P F
Chlorophyll-a	mg/m^3	10200 H
Pheophytin a	mg/m^3	10200 H

Primary water quality problems, identified by the Idaho Department of Environmental Quality (IDEQ), in the Lower Lapwai, Sweetwater, and Webb Creek drainages include water temperature, sediment, bacteria, nutrients, low dissolved oxygen, pesticides, organic enrichment, and unknown pollutants.

Sweetwater Creek from its source to Webb Creek (Assessment Units ID17060306CL006_02, 03, and 04) confluence was assessed by IDEQ as not meeting Cold Water Aquatic Life beneficial use in all three Assessment Units and Primary Contact Recreation beneficial use in Assessment Units _03 and _04. Causes of the impairments are attributed to flow regime alterations, habitat alterations, sediment, and water temperature in all Assessment Units. Assessment Units _03 and _04 also have fecal coliform as a cause of impairment. In addition, all Assessment Units have "Unknown" as a causal impairment, and noted that pesticides, nutrients, and low dissolved oxygen (DO) due to suspected organic enrichment may be the causal factors (IDEQ 2014).

- Webb Creek from its source to Sweetwater Creek (Assessment Unit ID17060306CL007_02) confluence was assessed as not meeting Cold Water Aquatic Life and Primary Contact Recreation beneficial uses by IDEQ. Causes of the impairments are the same as those described previously for Sweetwater Creek Assessment Units _3 and _4.

- Sweetwater Creek (Assessment Unit ID17060306CL005_4) from Webb Creek confluence to Lapwai Creek confluence was assessed by IDEQ as fully supporting Cold Water Aquatic Life and Secondary Contact Recreation beneficial uses.

5.4.1 Results

Dissolved Oxygen

Water temperature is inversely related to dissolved oxygen. Therefore, warmer temperatures result in lower dissolved oxygen levels. The water quality standard for dissolved oxygen in the State of Idaho is a lowest 1-day minimum of 6.0 milligrams per liter (mg/L). The mean and median DO levels for all years sampled (2010 to 2012 and 2015) were well above the 6 mg/L threshold except for deeper lake profile sites at Soldiers Meadow Reservoir (Figure 33). Only two sites, at or near the confluence of Webb and Sweetwater creeks went below the 6 mg/L DO threshold (Figure 34)

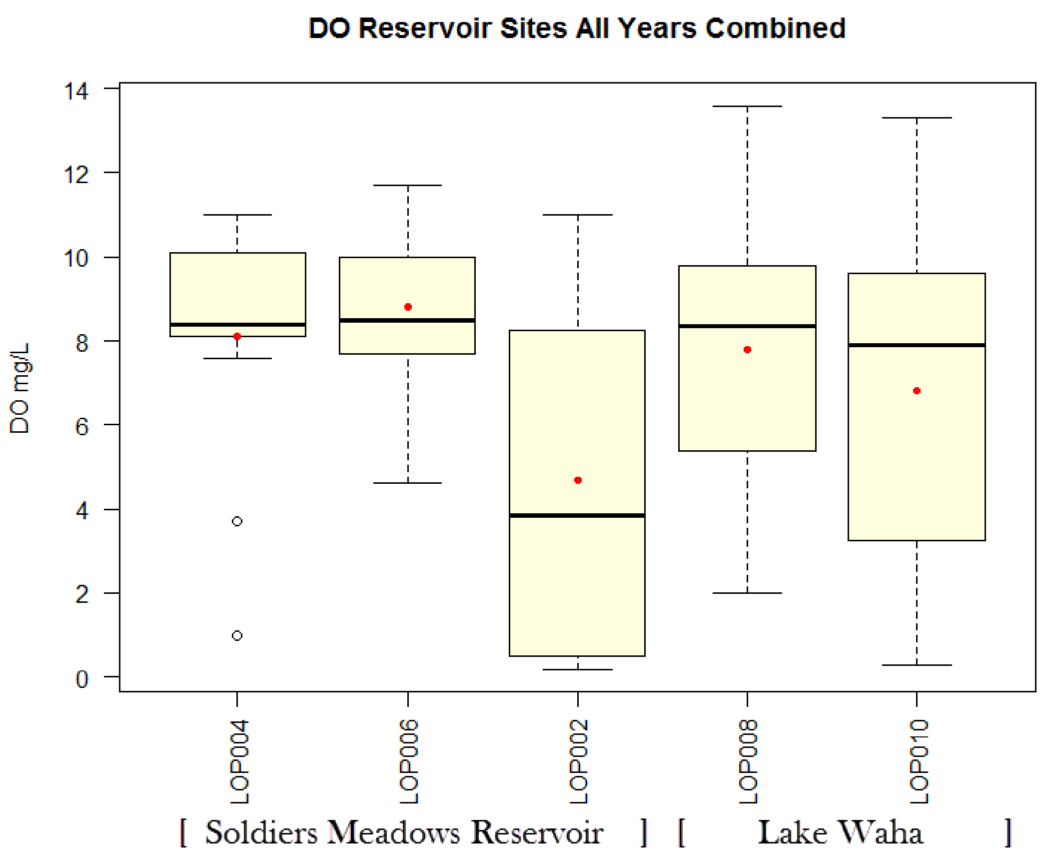


Figure 33. Box and whisker plots of dissolved oxygen concentrations at Soldiers Meadow Reservoir and Lake Waha.

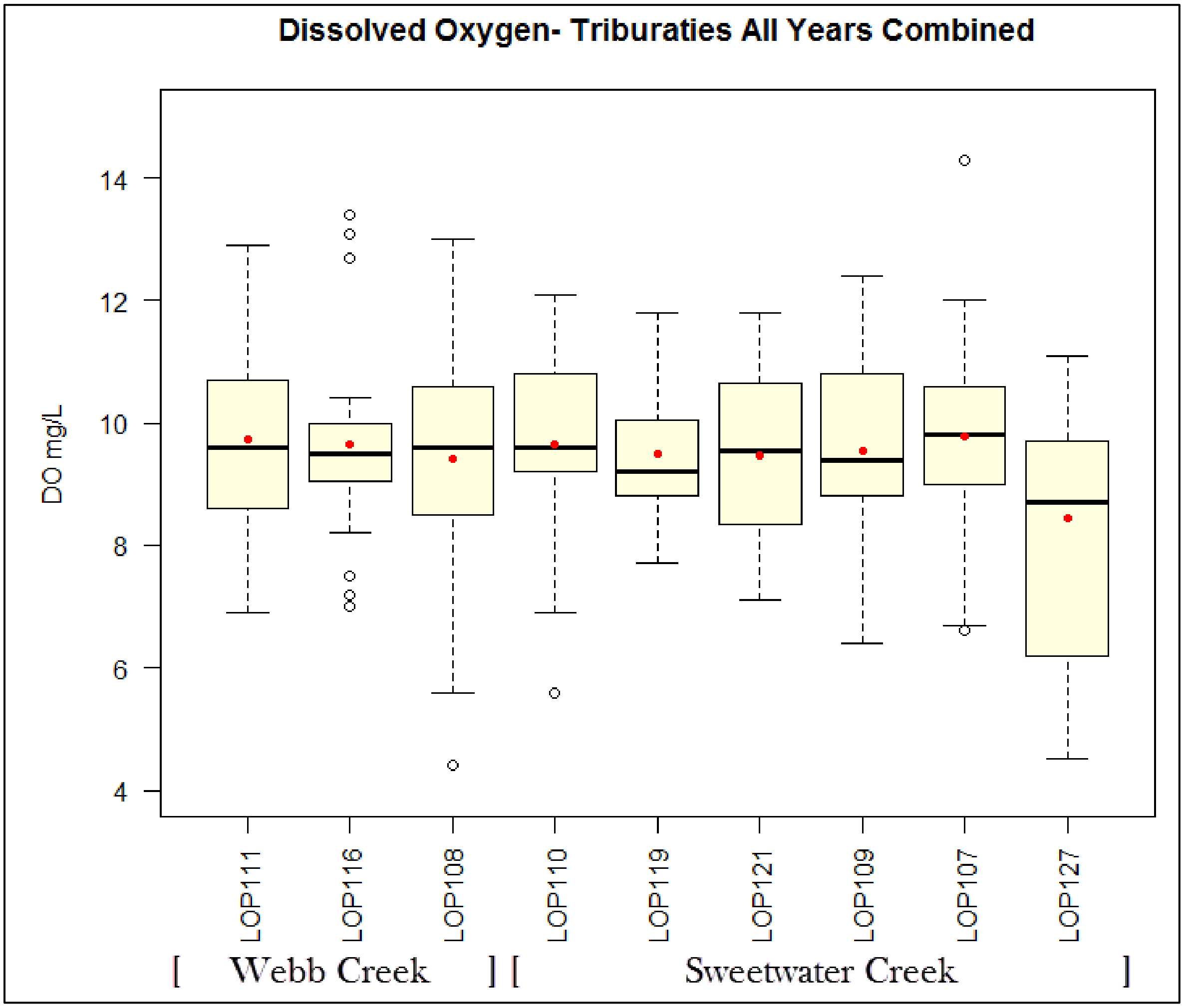


Figure 34. Box and whisker plots of dissolved oxygen concentrations at Webb and Sweetwater creeks.

As seen in Figure 35, the mean and median DO concentrations vary between wet (sampled in 2011) and dry (sampled in 2015) years among Webb and Sweetwater creeks. The mean and median 2015 DO concentrations in Webb and Sweetwater creeks are above 6 mg/L, but two sites at or near the confluence of Webb and Sweetwater creeks approach and dip below the 6 mg/L DO threshold.

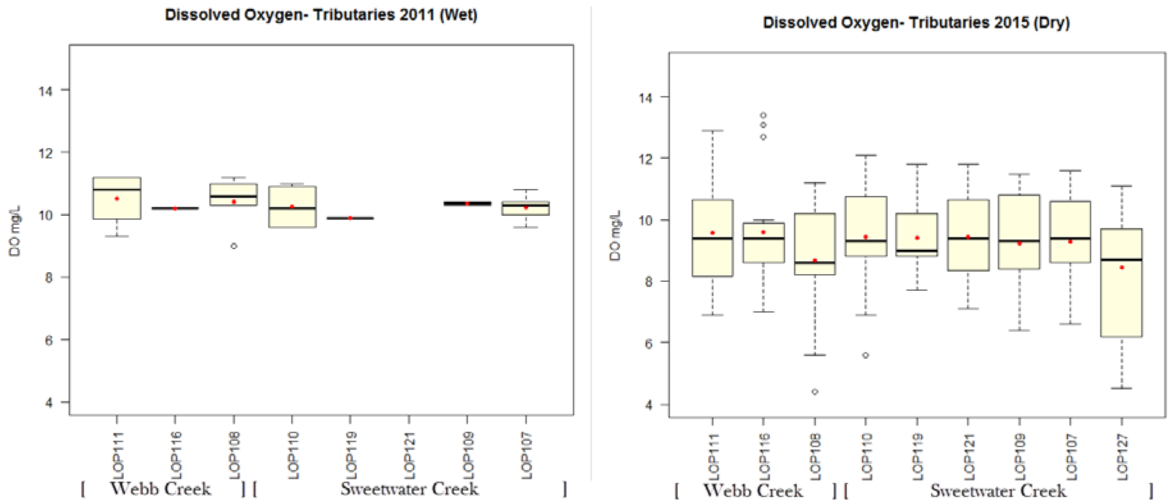


Figure 35. Box and whisker plots of dissolved oxygen concentrations at Webb and Sweetwater creeks for 2011 wet and 2015 dry years.

Turbidity

Turbidity is a measure of the amount of light scattered by particles in the water. Subjectively, it can be visually observed by how cloudy the water is. The Idaho water quality standard for turbidity in regards to cold water aquatic life, is no more than 50 NTU (nephelometric turbidity units) above background, instantaneous measurement, or no more than 25 NTU over background for more than 10 consecutive days.

Soldiers Meadow Reservoir and Lake Waha median turbidity for all the years sampled ranged between 7 and 14 NTUs with no recorded data greater than 30 NTU (Figure 36). Webb and Sweetwater creeks' turbidities for all the years sampled were more variable, however, the median NTUs ranged between 5 and 15 and no samples exceeded 50 NTUs.

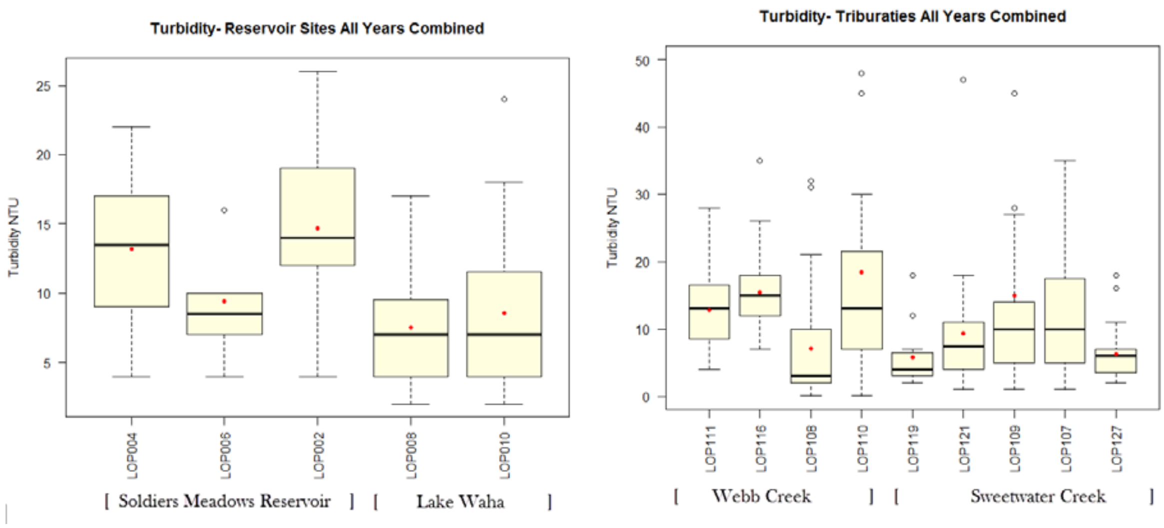


Figure 36. Box and whisker plots of turbidity at Soldiers Meadow Reservoir, Lake Waha, Webb and Sweetwater creeks.

Median turbidity for Webb and Sweetwater creeks in a wet year (2011) ranged from 10 to 17 NTUs and on a dry year (2015) ranged from 5 to 15 NTUs (Figure 37). Dry year turbidity data has several outliers, indicating that sediment is likely mobilized quickly during a storm event. In general, all the collected data (combined years, wet and dry years) indicate low turbidity throughout this watershed as indicated by the low median values.

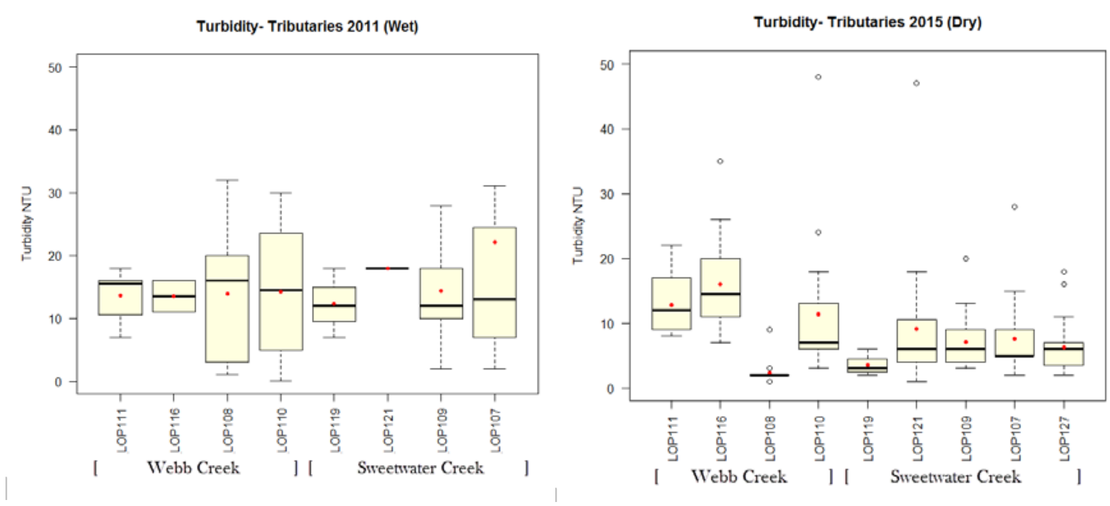


Figure 37. Box and whisker plots of turbidity at Webb and Sweetwater creeks for 2011 wet and 2015 dry years.

Total Suspended Solids

Total Suspended Solids (TSS), is a measure of the amount of suspended material in the water by weight. TSS is related to turbidity, and the strong correlation between these two parameters can often be seen. There are currently no water quality standards for TSS in Idaho that are applied to the beneficial uses. However, it is still an important water quality measurement. The more suspended solids in a water body, the less light can penetrate. This has a negative effect on photosynthesis decreasing the dissolved oxygen levels. In addition, as suspended solids settle out, available habitat for macro invertebrates and fish can be reduced.

Median TSS concentrations in Soldiers Meadow Reservoir and Lake Waha for all years sampled ranged between 5 and 7 mg/L and did not exceed 25 mg/L (Figure 38). TSS concentrations varied more in the Webb and Sweetwater creeks and have median concentrations ranging between 5 and 15 mg/L and rarely exceeded 60 mg/L.

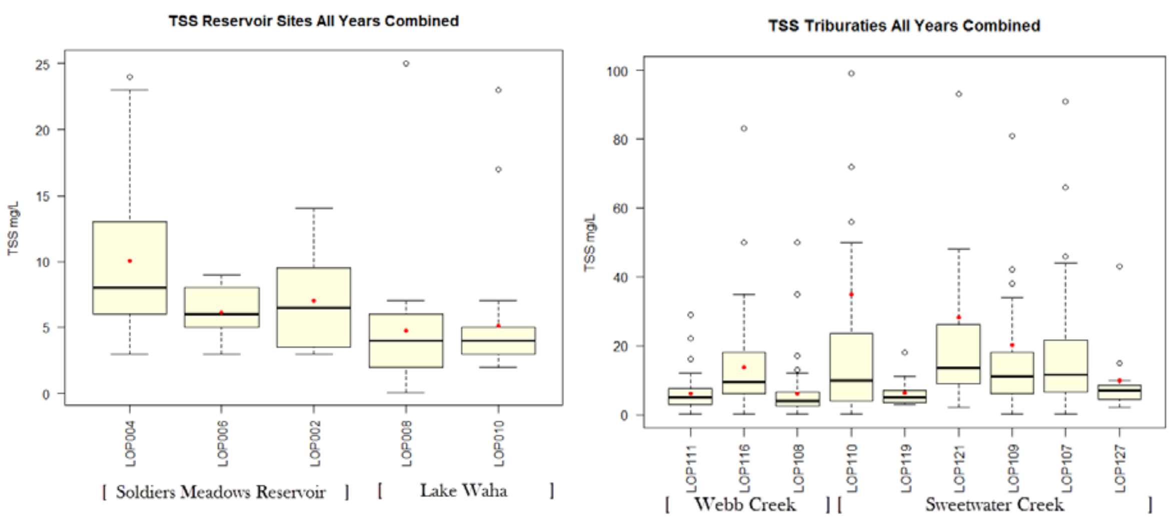


Figure 38. Box and whisker plots of total suspended solids at Soldiers Meadow Reservoir, Lake Waha, Webb and Sweetwater creeks.

There is little difference between TSS concentrations between 2011 (wet) and 2015 (dry) years. Median concentrations for both years ranged between 5 to 10 mg/L. There were several isolated instances of higher dry year TSS concentrations as indicated by the outliers in Figure 39.

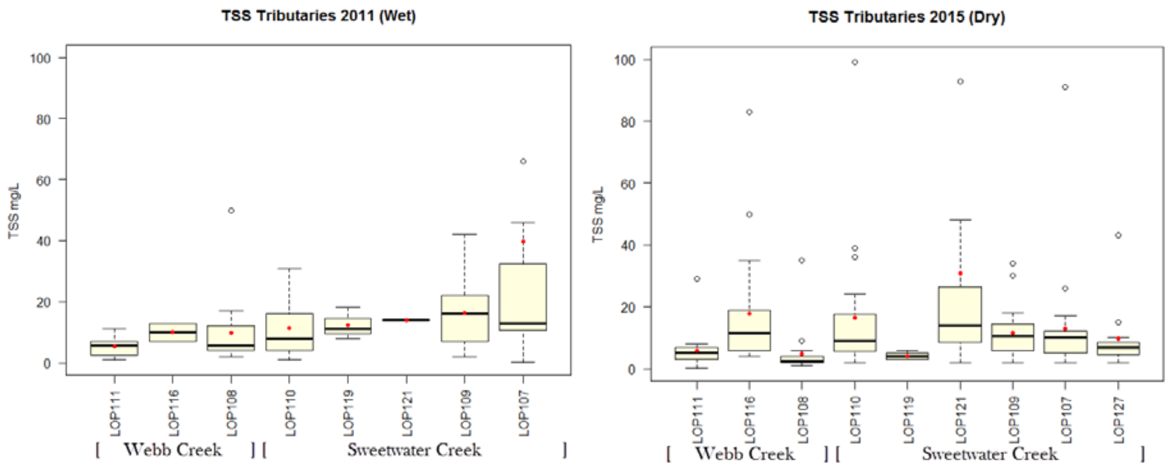


Figure 39. Box and whisker plots of total suspended solids and Webb and Sweetwater creeks for 2011 wet and 2015 dry years.

Total Volatile Solids

Total Volatile Solids (TVS), is a measure of the amount of organic material in the water by weight. Coupled with TSS, TVS gives an indication of the mineral content of a sample. High TSS and low TVS indicate a large mineralized fraction. TVS should be higher within a water body with high primary productivity. In streams and rivers the TVS should make up a smaller percentage during runoff events.

Median TVS concentrations for both reservoirs and tributaries for all years sampled were low; less than 2 mg/L for Soldiers Meadow Reservoir and Lake Waha and less than 3 mg/L for Webb and Sweetwater creeks (Figure 40).

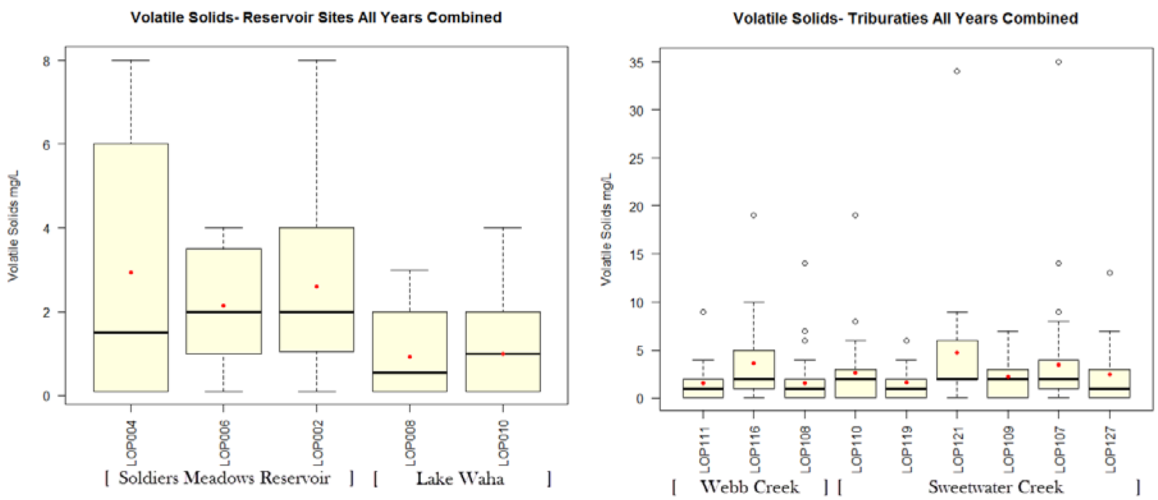


Figure 40. Box and whisker plots of total volatile solids at Soldiers Meadow Reservoir, Lake Waha, Webb and Sweetwater creeks.

TVS concentrations do not vary much between wet (2011) and dry years in Webb and Sweetwater creeks (Figure 41). Median concentrations for both years are less than 5 mg/L and the maximum is less than 10 mg/L.

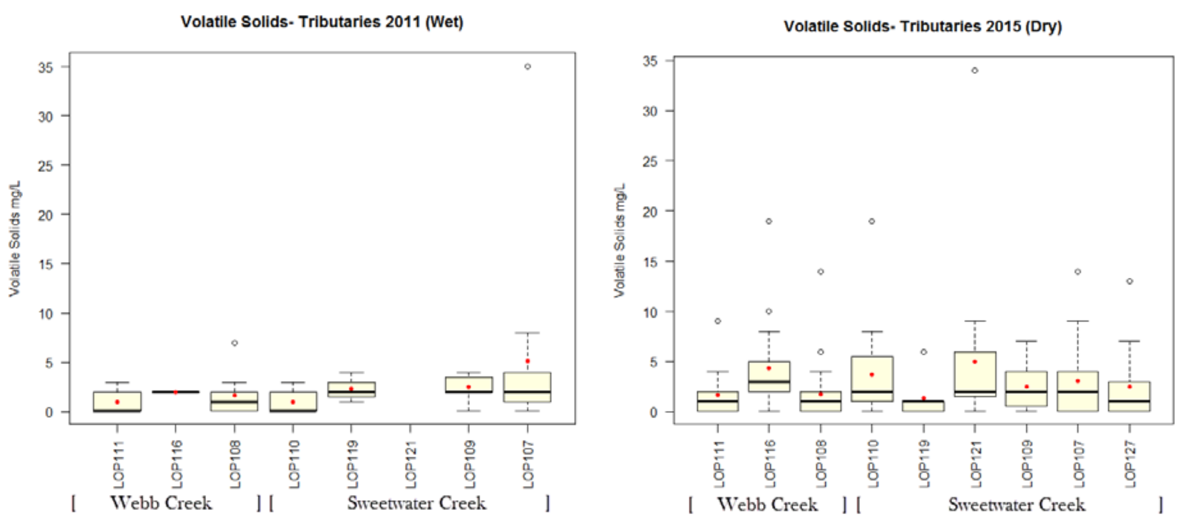


Figure 41. Box and whisker plots of total volatile solids at Webb and Sweetwater creeks for 2011 wet and 2015 dry years.

Nutrients

Reclamation analyzes samples for five nutrients: Nitrate (NO_3) + Nitrite (NO_2), Total Kjeldahl Nitrogen (TKN), Ammonia (NH_4), Orthophosphate (PO_4) and Total phosphorus as P. Sources of these nutrients found in waterways can include agricultural practices, urban development, and regional geology.

The Water Quality Standards for Surface Waters of the State of Idaho (IDAPA.01.02) does not include water quality standards for the nutrients (except total ammonia, which does have a standard due to its potential for toxicity at higher temperature and pH) monitored during this study. However, they are still an important part of determining water quality within a water body and the system. An increase in the nutrient levels could lead to an increase in plant and algae growth. Increased algal production can lead to positive water quality conditions such as an increase in secondary production, but it can also lead to nighttime oxygen depletion and other detrimental water quality impacts.

Nitrate plus Nitrite

Nitrate plus Nitrite (NO_3 + NO_2) is bioavailable, inorganic form of nitrogen that is essential for plant growth. Typically NO_3 + NO_2 concentrations decrease during periods of intense plant growth. Median NO_3 + NO_2 concentrations were low for all years sampled for both the reservoirs and tributaries. Maximum NO_3 + NO_2 concentration for Soldiers Meadow Reservoir and Lake Waha is less than 0.25 mg/L and for Webb and Sweetwater creeks 3 mg/L (Figure 42).

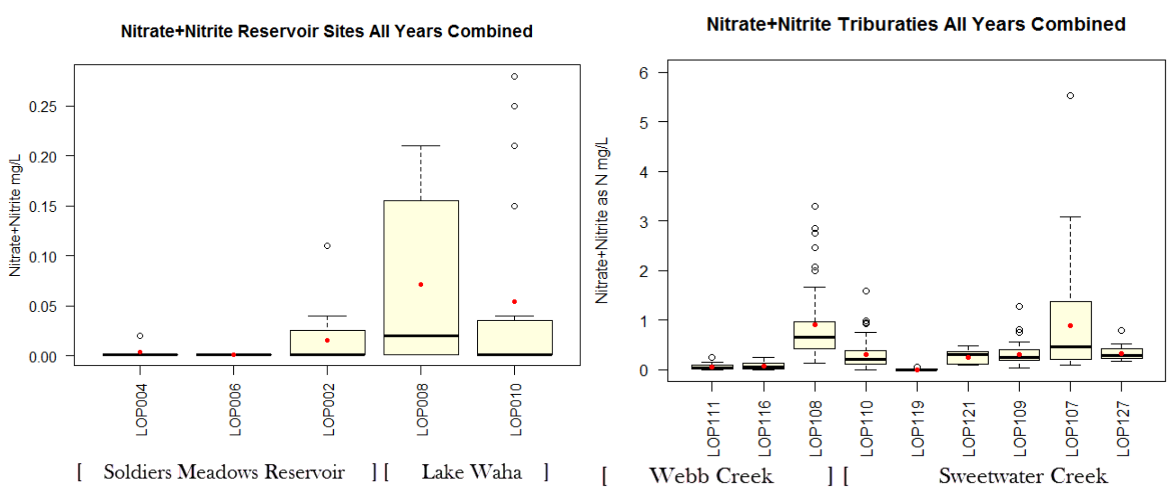


Figure 42. Box and whisker plots of NO_3 + NO_2 concentrations at Soldiers Meadow Reservoir, Lake Waha, Webb and Sweetwater creeks.

Webb and Sweetwater creeks $NO_3 + NO_2$ concentrations in a wet year (2011) are higher at three sites compared to the corresponding sites during a dry (2015) year (Figure 43). Overall, $NO_3 + NO_2$ concentrations are low; median concentrations are less than 2 mg/L in the wet year and less than 1 mg/L for the dry year.

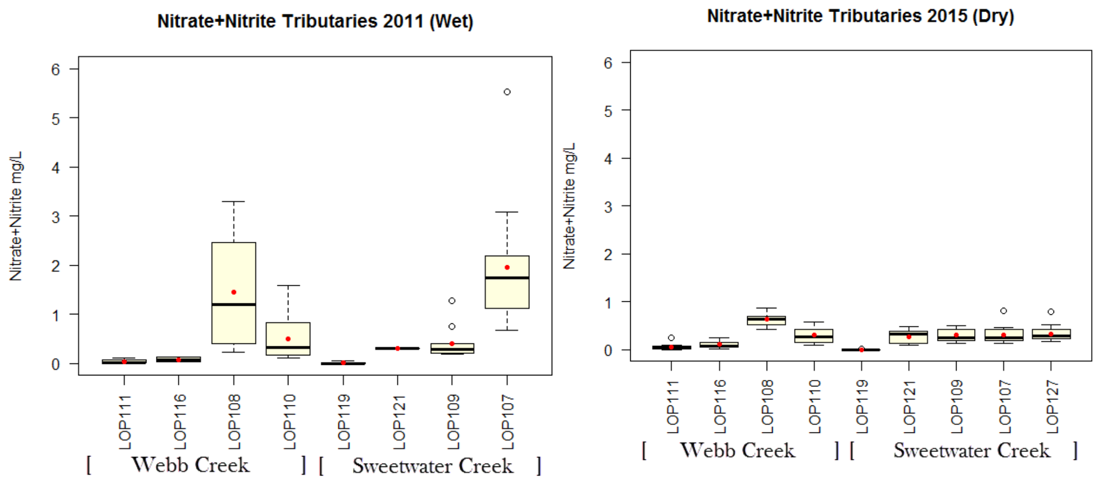


Figure 43. Box and whisker plots of $NO_3 + NO_2$ concentrations at Webb and Sweetwater creeks for 2011 wet and 2015 dry years.

Total Kjeldahl Nitrogen

TKN is the organic form of nitrogen, and is typically found in greater concentrations in areas that are experiencing decaying of organic matter. Similar to the corresponding $NO_3 + NO_2$ concentrations above, TKN concentrations for both reservoirs and tributaries for all years sampled are low, less than 2 mg/L (Figure 44).

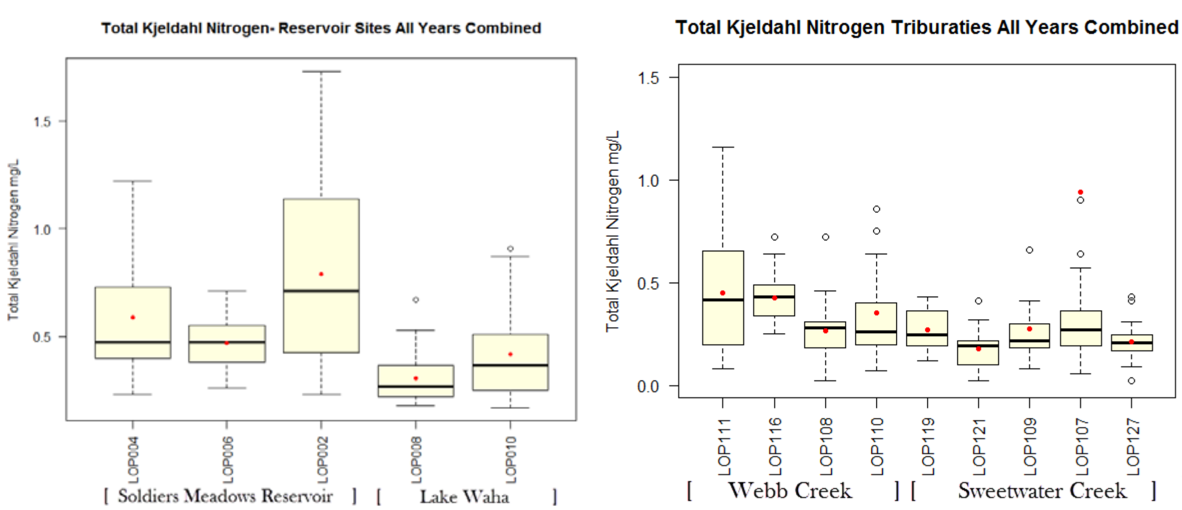


Figure 44. Box and whisker plots of TKN concentrations at Soldiers Meadow Reservoir, Lake Waha, Webb and Sweetwater creeks.

Webb and Soldiers Meadow creeks TKN concentrations in a wet year (2011) are similar to the corresponding sites during a dry (2015) year except for two dry year sites in Webb Creek, which are slightly higher (Figure 45). Overall, TKN concentrations are low; median concentrations are less than 0.5 mg/L in the wet year and less than 1 mg/L for the dry year.

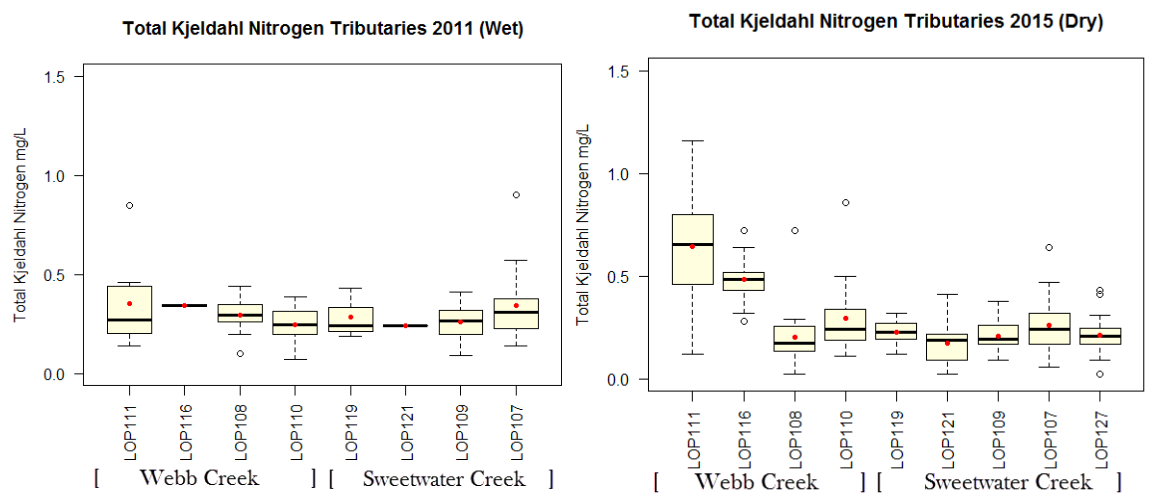


Figure 45. Box and whisker plots of TKN concentrations at Webb and Sweetwater creeks for 2011 wet and 2015 dry years.

Ammonia

Ammonia is the only nutrient that has a water quality standard for acute and chronic toxicity levels. The acute toxicity criterion is dependent on pH. It requires a 1-hour average concentration not to exceed 0.88mg/L (pH=9) to 5.62mg/L (pH=8). The water samples collected show only an instantaneous level of chemical and not an average over time; however, given the range of values, it is unlikely that acute toxicity would be exceeded.

Reservoir dissolved ammonia concentrations from all years sampled are very low; highest concentration measured at 0.57 mg/L, and the median concentrations less than 0.15 mg/L (Figure 46). Tributaries ammonia concentrations measured in 2015 (dry year) were also very low; however, site LOP111 was much higher than the other sites with a median concentration of 0.19 mg/L and a maximum concentration of 0.38 mg/L. The higher ammonium concentration can be attributed to Soldiers Meadow Reservoir outflow. Overall, ammonia concentrations in both the reservoirs and tributaries are very low.

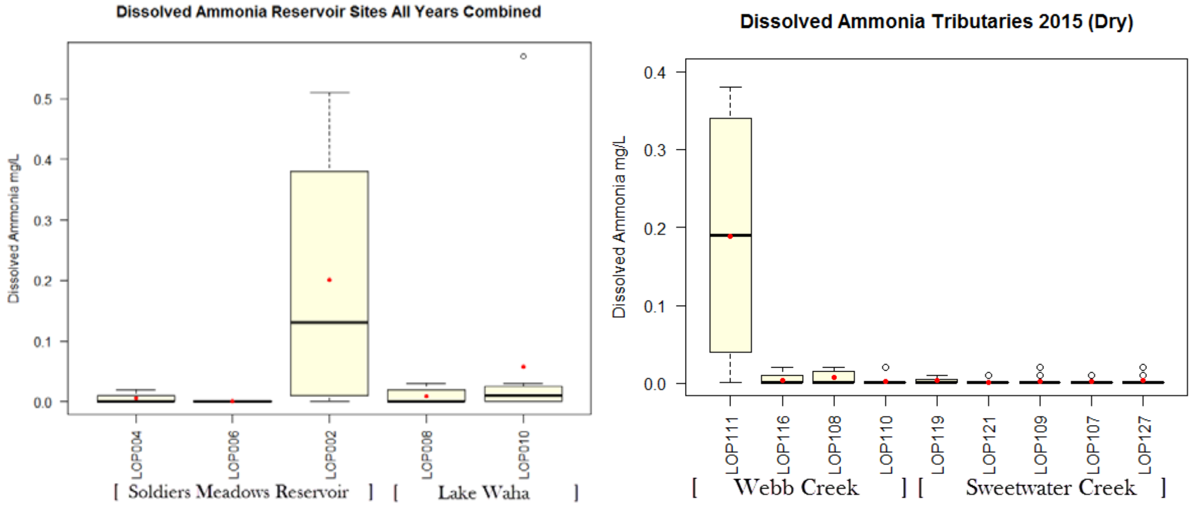


Figure 46. Box and whisker plots of Ammonia concentrations at Soldiers Meadow Reservoir, Lake Waha, Webb and Sweetwater creeks.

Ortho-phosphorus

Ortho-phosphorus (OP) is the bioavailable form of phosphorous, and thus is an important water quality parameter. OP concentration were very low in the reservoirs and tributaries for all years sampled (Figure 47). The maximum OP concentrations occurred in Lake Waha at 0.12 mg/L.

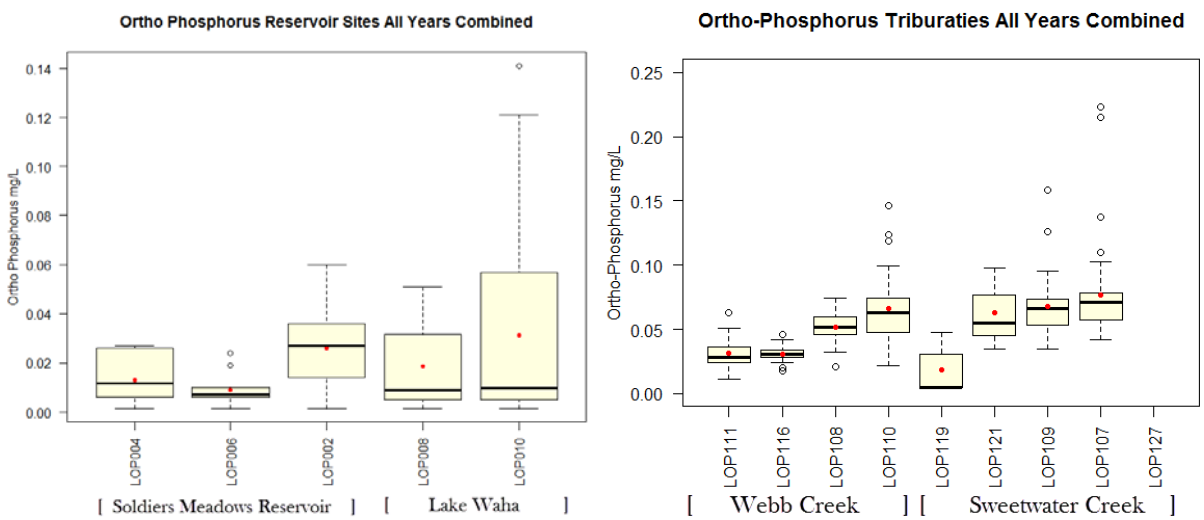


Figure 47. Box and whisker plots of Ortho-phosphorus concentrations at Soldiers Meadow Reservoir, Lake Waha, Webb and Sweetwater creeks.

Total Phosphorus

TP values include both particulate P and dissolved OP. TP values follow similar trends as TSS and turbidity, as often sediment carries undissolved P. Similar to OP samples, TP concentrations in the reservoirs and tributaries for all years sampled were very low, less than 0.25 mg/L (Figure 48).

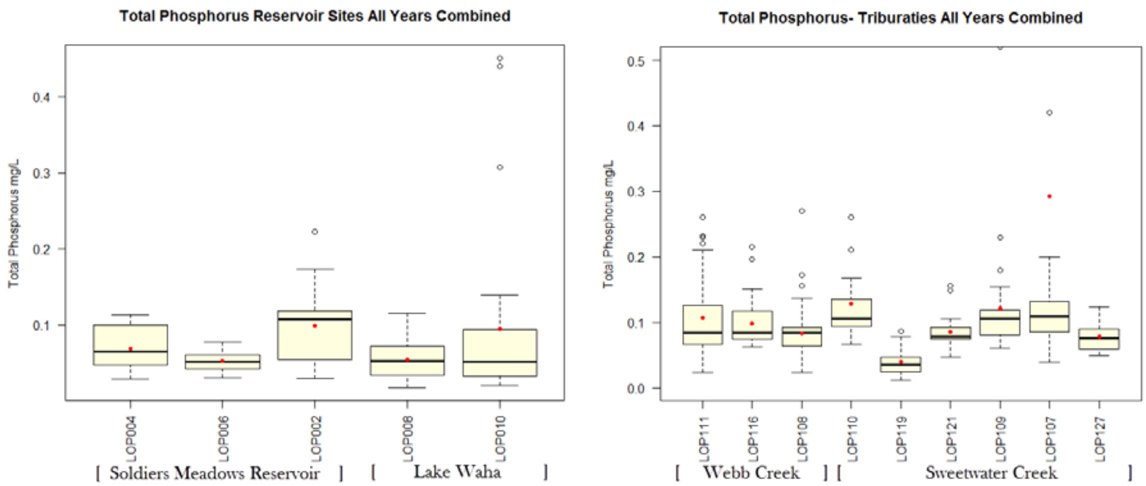


Figure 48. Box and whisker plots of total phosphorus concentrations at Soldiers Meadow Reservoir, Lake Waha, Webb and Sweetwater creeks.

Webb and Soldiers Meadow creeks TP concentrations in a wet year (2011) are similar to the corresponding sites during a dry (2015) year (Figure 49). Overall, TP concentrations are very low; median concentrations are less than 0.2 mg/L for both wet and dry years.

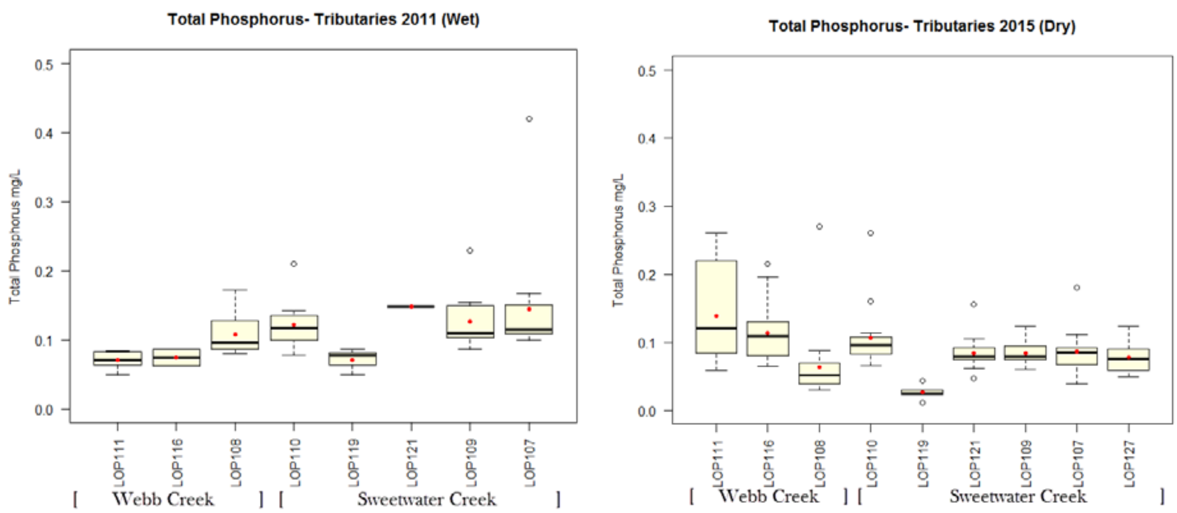


Figure 49. Box and whisker plots of total phosphorus concentrations at Webb and Sweetwater creeks for 2011 wet and 2015 dry years.

Chlorophyll-a

Chlorophyll-a is a useful water quality parameter as it can be an indicator of the overall health of a system. High concentrations of chlorophyll-a can indicate excessive nutrient loads, while often a system that has little chlorophyll-a may not have enough nutrients to support a healthy, diverse community. Typically, the greatest concentrations are found in the summer months.

Chlorophyll-a concentrations tended to be higher in reservoirs than tributaries (Figure 50). Median Chlorophyll-a concentrations for all years sampled was less than 12 mg/L for Soldiers Meadow Reservoir and Lake Waha and less than 5 mg/L for Webb and Sweetwater creeks. The site on Sweetwater Creek (LOP109) where the pump from Lake Waha releases water, had a median of 10 mg/L, which was over twice the concentration of other Sweetwater or Webb creek values. At the next site downstream from this, West Fork Sweetwater Mouth (LOP121), Chlorophyll-a concentrations had returned to lower levels.

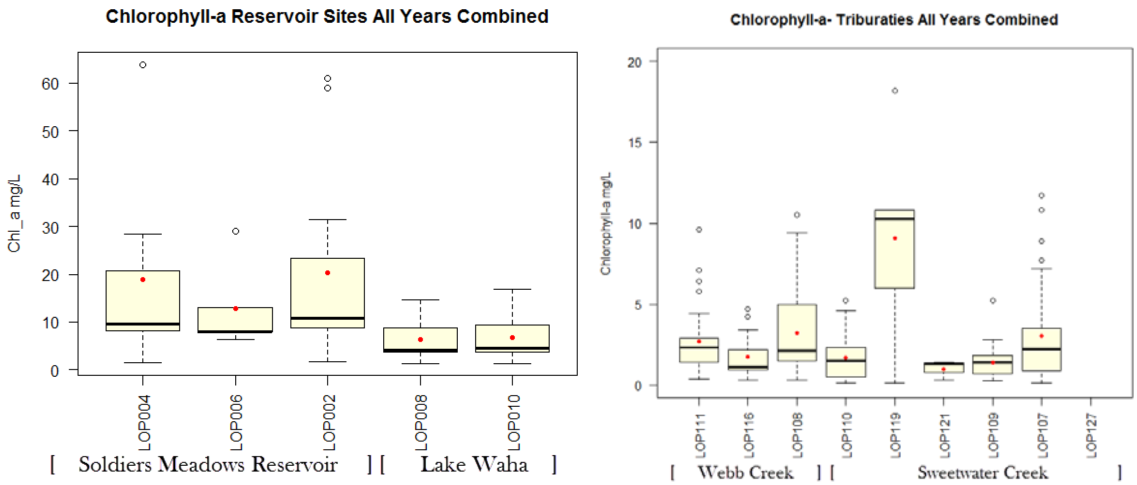


Figure 50. Box and whisker plots of Chlorophyll-a concentrations at Soldiers Meadow Reservoir, Lake Waha, Webb and Sweetwater creeks.

Summary

Based on the available data it appears that the water chemistry in the LOP exhibits trends one might expect in a healthy system. For instance, nutrient concentrations were low at all collection sites, and there was not much differentiation between the parameter concentrations collected during a wet or dry year. There were single collection points that had greater concentrations of certain parameters, but these were consistent with runoff events or other unusual occurrences, and the majority of the data points were within a range of values that could be expected.

The addition of water quality information from a dry year (2015) addresses the unknown water quality of releases from Soldiers Meadows Reservoir at extremely low reservoir volumes. Potentially high tributary turbidity levels were the main concern identified in the Opinion. Turbidity levels at the outlet of Soldiers Meadows Reservoir were within the range of other sites within the basin. The highest turbidity readings measured were at sites lower in the basin during high flow events. Additionally, in comparing turbidity during the “wet”-2011 year to the “dry”-2015 year, site LOP111 (Soldiers Meadow outflow) turbidity measurements are very similar between years, suggesting there are no significant impacts on turbidity from draw down at Soldiers Meadow during dry years.

Water quality concerns for the 2010 Opinion have been fully investigated and no additional water quality sampling is required at the LOP. Water temperature and flow monitoring will continue through the term of the Opinion.

6. RPM 5: Optimal Streamflow Allocation

Reclamation's proposed action and streamflow allocations are based on the best available scientific data and were developed cooperatively with NMFS and the Tribe. Term and Condition 5 of the 2010 Opinion requires Reclamation to submit a completed study and report to NMFS, related to optimizing streamflow allocations between Sweetwater and Webb creeks. After discussions with the Tribe, Reclamation submitted the *Lewiston Orchards Project Sweetwater and Webb Creek Flow Allocation Analysis Report* to NMFS on July 7, 2015. This report is attached as Appendix D.

7. Literature Cited

Parenthetical Reference	Bibliographic Citation
IDEQ	Idaho Department of Environmental Quality. 2014. *Idaho's 2012 Integrated Report*. Boise, Idaho.
Kennedy et al. 2015	Kennedy, B.P., K.M. Myrvold, R. Hartson, and E. Benson. 2015. *Lewiston Orchards Project: Sweetwater Basin flow fish study*. Progress report prepared by the University of Idaho, Moscow, Idaho. Submitted to the Bureau of Reclamation, Snake River Area Office, Boise, Idaho.
NMFS 2010	NMFS 2010 National Marine Fisheries Service. 2010. *Endangered Species Act Section 7 Formal Consultation 2010 Opinion and Magnusen-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the Operation and Maintenance of the Lewiston Orchard Project.* NMFS Consultation number 2009/06062. Submitted to the U.S. Bureau of Reclamation, Boise, Idaho.
Reclamation 2009	U.S. Bureau of Reclamation. 2009. *Biological Assessment for Operation of the Lewiston Orchards Project, Idaho*. Snake River Area Office. Boise, Idaho. October.
Reclamation 2010a	U.S. Bureau of Reclamation. 2010a. *Lewiston Orchard Project 2009 Annual Report for activities under the Endangered Species Act 2010 Opinion*. Submitted to the National Marine Fisheries Service, Boise, Idaho.

Parenthetical Reference	Bibliographic Citation
Reclamation 2010b	U.S. Bureau of Reclamation. 2010b. *Lewiston Orchards Project Connectivity Monitoring Plan*. Submitted to the National Marine Fisheries Service, Boise, Idaho.
Reclamation 2011	U.S. Bureau of Reclamation. 2011. *Monitoring Plan for Steelhead Densities and Critical Uncertainties for the Lewiston Orchards Project 2010 Opinion*. Submitted to the National Marine Fisheries Service, Boise, Idaho.
Reclamation 2012	U.S. Bureau of Reclamation. 2012. *2011 Annual Report on Monitoring and Implementation Activities Associated with the USFWS 2005 Biological Opinion for Operation and Maintenance of the Bureau of Reclamation Lewiston Orchards Project.* Snake River Area Office, Boise, Idaho.

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APPENDICES

APPENDIX A

SWEETWATER AND WEBB CREEK FLOW TABLES

(This is an excel data file for data sharing and is included as a CD at the back of this report)

APPENDIX B

UNIVERSITY OF IDAHO 2015 REPORT
"THE ECOLOGY OF *ONCORHYNCHUS MYKISS* IN THE LAPWAI BASIN: DENSITY AND GROWTH MONITORING

The ecology of *Oncorhynchus mykiss* in the Lapwai Basin: Density and growth monitoring

Continuation of the Lewiston Orchards Project:
Sweetwater Basin Fish & Flow Study

Period of Study: July 1, 2014 – May 31, 2019

Progress report (July 2015 – December 2015) prepared for:

Bureau of Reclamation

USBR Snake River Area Office

Boise, Idaho

Prepared by:

Brian P. Kennedy

with

Natasha Wingerter, Ph.D.; Jeff Caisman, M.S. student; and Knut Marius Myrvold, post-doctoral researcher

Department of Fish and Wildlife Resources and Water Resources Graduate Program

College of Natural Resources

University of Idaho

LAPWAI ACTIVITIES REPORT 2014

Introduction and Background

The Bureau of Reclamation owns a series of water storage reservoirs, diversion dams and canals that provide irrigation water to the Lewiston Orchards area of Lewiston, Idaho. The Lewiston Orchards Project (LOP) is operated by the Lewiston Orchards Irrigation District (LOID), which distributes the water to agricultural, urban and suburban users. The Lewiston Orchards Project is contained entirely within the Lapwai Creek watershed. In order to maintain minimum water supplies to these users during long dry summer growing seasons, operations of the water diversions capture much of the water that would naturally be feeding Webb and Sweetwater Creeks, which together comprise approximately half of the area of the Lapwai basin.

Lapwai Creek contributes to one of the 6 major population groups (MPG), the Clearwater River, of the Snake River *Distinct Population Segment* (DPS) of federally endangered steelhead, *Oncorhynchus mykiss*. Within the Clearwater MPG, Lapwai provides a portion of the spawning and rearing habitat within one of 5 functional populations of interest (the Clearwater River – Lower Mainstem population). The LOP withdraws water from these creeks, some of which are designated as critical habitat for this subpopulation. Importantly, the major temporal impact that water withdrawals have are during the summer months when juvenile fish are trying to gain mass before smolting (migrating to the ocean) and diversion operations can have measureable impacts on in-stream flows. Decreased flows during spring may also impact spawning of adult A-run *O. mykiss* in the basin (NOAA 2006). Temporally, impacts during the other times of year are expected to be less severe. Spatially, the Lapwai basin likely represents habitat that could have supported approximately 1-2% of the population of the Clearwater-Lower Mainstream (CRLMA) population of the Snake River DPS (289 watersheds and 26 independent populations).

On April 15, 2010, the Bureau of Reclamation received the Biological Opinion prepared by National Ocean and Atmospheric Administration Fisheries (NOAA) pursuant to the Section 7(a)(2) of the Endangered Species Act (ESA) on the effects of the operation and maintenance of the Lewiston Orchards Project (Project). In this Opinion, NOAA concludes that the proposed action is not likely to jeopardize the continued existence of ESA listed species or adversely modify critical habitat. Reclamation and NOAA have cooperatively proposed a monitoring plan that includes annual monitoring activities and critical uncertainties relevant to this project (Reclamation 2011). This monitoring plan identifies the University of Idaho as an independent scientific entity who has been working on questions related to steelhead growth and survival since 2007 and identifies a more focused monitoring plan that seeks to identify annual and spatial trends in abundance and growth of juvenile steelhead in sites for which long term data now exist. Reclamation will continue these research activities to complete investigation into these critical uncertainties through 2019. This Interagency Agreement implements specific tasks from this monitoring plan using the University of Idaho as an independent research institution. The University of Idaho has been working on several of the tasks listed below since 2007, and this agreement will complete this research effort aimed at providing specific information on the impacts of the Lewiston Orchards Project operations on listed *O. mykiss* in the Lapwai Basin and understanding the status and role of the Lapwai Basin in relation to the Snake River ESU and Lower Clearwater Local Population.

Understanding the effects of hydrologic changes on fish populations requires an integrative approach that addresses 1) how the growth potential of individual fish is affected, 2) how changes in growth and growth potential influence survival of individuals and, ultimately, how processes for the individual scale up to population level dynamics, and 3) how population dynamics are influenced by altered connections among subpopulations. These changes can be a direct result of hydrologic change (Lopes et al. 2004) or an indirect effect through altered temperatures, productivity or trophic relationships (Almodovar and Nicola 1999, Horne et al. 2004, Hartson and Kennedy 2014, Myrvold and Kennedy 2014). Our monitoring efforts will continue to address how environmental conditions in the Lapwai system influence density, growth, and survival of juvenile *O. mykiss* and are designed to identify mechanistic relationships between fish performance and habitat. Herein, we report on the data collection and results from our seventh field season in the Lapwai basin.

Six of the possible 16 sites monitored in 2010 - 2013 were selected for continued abundance measurements of *O. mykiss* in 2014 - 2019 in order to quantify spatial and temporal variation among sites. The 16 original sites were intended to identify variables related to growth and production representing the elevation, geologic and ecological gradients across the Lapwai Basin. The six continued-monitoring sites were selected such that all sites provide enough production for a robust statistical design, and such that both impacted and "unimpacted" sites in the basin are represented. Unimpacted in this context is meant to simply refer to those sites that are not directly affected by BOR projects; impacts from land use, roads and other local disturbances are realized and documented.

As outlined in the monitoring plan for this project, beginning in 2014, the University of Idaho has begun (and will continue) ongoing research on the following tasks, in accordance with the timeline detailed in Table 1:

Task 1.1: Capture, PIT tag, and collect data on juvenile *O. mykiss* (i.e., length, weight, condition factor) at six established monitoring sites during the juvenile growing season (July - September) 2014 - 2019.

Task 1.2: Cooperatively collect and edit stream temperature data with Reclamation, Snake River Area Office and LOID efforts.

Task 1.3: Use data collected in task 1.1 to compare observed juvenile *O. mykiss* densities across years sampled at six established monitoring sites from 2008 through 2013 (and more sites if available, i.e. between 2010 and 2013).

Table 1. Reporting timeline (timeline of research activities in agreement).

Task	Deliverable	Draft due	Final due
1	Annual reports that include: data summary, *O. mykiss* density and growth estimates (with confidence intervals) and other data collected during the previous year	Feb 1, 2015 for 2014; and each year thereafter.	Mar 1, 2015 for 2014; and each year thereafter to 2019.
2	Synthesis of density trends based upon annual monitoring activities	Sept 30, 2019	Dec 31, 2019
3	Final Financial and Performance Reports	Feb 1, 2015 for 2014; and each year thereafter.	Mar 1, 2015 for 2014; and each year thereafter to 2019.

Methods

Study sites

In the first year of the study (2008) we established six study sites at which to obtain consistent information on productivity, fish population metrics, and mark-recapture information throughout the growing seasons. In the second year of the study, 2009, we continued sampling at five of these sites and moved one site (lower Lapwai) upstream approximately 4 km in an effort to sample more representative *O. mykiss* rearing habitat (Hartson and Kennedy, 2014). In 2010 and 2011 we continued to sample the same six sites as in 2009, and sampled ten additional sites (Fig. 1) despite our funding obligations only requiring monitoring at the original six sites. We learned from our 2008-09 field seasons that the survival and emigration models were data intensive and ideally were based upon more individually-tagged fish than we were sampling.

We developed a new naming scheme for our sites in 2010 (Table 2) in which the six sites from 2009 were renamed to fit the new naming scheme. Lower Lapwai is now lower Lapwai lower (LLL), lower Sweetwater is now lower Sweetwater (LSX), upper Sweetwater is now upper Sweetwater middle (USM), lower Webb is now upper Webb middle (UWM), upper Lapwai is now upper Lapwai upper (ULU) and upper Mission is now upper Mission upper (UMU). Each site is approximately 100 m in length. We added two sites to each of the tributaries (Sweetwater, Webb, Mission, and Lapwai), one on Lapwai below the Mission confluence (MLX), and one site on Lapwai below the Sweetwater confluence (LLU). In sum, nine of the 16 sites are considered within the project affected area, however, all sites represent some level of anthropogenic alteration, as even those outside of the affected area exhibit some hydrographic (e.g. irrigation withdrawal) and some geomorphic (e.g. leveeing) alteration.

In 2012 and 2013 we scaled back our sampling efforts in response to reduced field support. We sampled nine of the 16 sites that were sampled in 2010 and 2011; five are considered within the project affected area (LLU, LSX, USM, USU, and UWM), while four are not within the project affected area (MLX, ULU, UMM, and UMU). The nine sites we sampled spanned the environmental conditions in the basin, and the temporal detail was similar to previous years.

As the density and growth monitoring phase of the project began in 2014, we scaled back our sampling efforts to focus on six of the 16 sites that were sampled in 2010 and 2011: LSX, USU, UWM, MLX, ULU, and UMU (Table 2; Fig. 1). Sites were sampled three times over the field season. These six sites reflect the variety of environmental conditions within the basin, represent all four main tributaries, and four of them have been sampled consistently since the beginning of our fieldwork in the Lapwai basin in 2008. Half of the sites fall within the project affected area (LSX, USU, and UWM); the other half do not (MLX, ULU, and UMU).

Study design

Task 1.1: Density Monitoring

We visited each site once every five weeks between late July and early October 2015, resulting in three visits to each site despite our funding obligations only requiring two monitoring visits at each site; three visits allowed us to estimate growth rates over two periods. The dates for the visits are shown in Table 2. At each visit we collected data on: 1) the fish community and individual steelhead in particular, 2) the energy resources in the streams, and 3) a suite of physical environment factors.

Benthic invertebrate samples were collected using a Surber sampler (250 um mesh) at the six sites on all visits of the field season (dates shown in Table 2) as a measure of energy resources available in the streams. Due to the time consuming nature of processing invertebrate samples, we have not yet processed or analyzed the benthic samples from 2015.

In order to estimate habitat availability for juvenile *O. mykiss*, we measured physical habitat variables at each site during summer base flows (August 25-September 1), the period when impacts of water withdrawal were expected to be greatest. We established transects perpendicular to the channel five meters apart throughout the entire electrofishing reach, with the first transect 2.5 m above the lower end of the reach. We quantitatively measured wetted channel width and counted the number of large woody debris pieces (LWD; debris > 100 mm diameter and 1 m long) within 30 cm of each transect. Each transect was then split into five sections of equal width. We measured velocity using a Marsh McBirney flow meter (cm sec^{-1}), depth (using a wading rod), substrate size (D50), and visually estimated whether there was overhanging cover with live vegetation 2 m or less above the water surface, or undercut banks in each of the five sections of each transect.

Fish were captured during three-pass depletion electrofishing surveys (described below); non-salmonids were identified to species (except for sculpin, which were identified to family), counted, and batch-weighed in order to determine average individual weight for each taxa and each pass.

Task 1.2: Data Collection

We employed a combination of direct counting and mark-recapture techniques to estimate *O. mykiss* abundance and density. Direct counts were made by conducted three-pass depletion electrofishing surveys. For depletion estimates of population size we used R-gui and based our calculations on the methods of Carle and Strub (1978). Combined with estimates of stream area taken following each electrofishing effort, we used these population estimates to calculate densities of *O. mykiss*. Steelhead were scanned for a PIT (passive integrated transponder) tag, and, if not present, fish ≥ 65 mm (fork length) were equipped with one. For both first-time captures and recaptures, lengths and weights were recorded; recaptures were noted.

PIT tags are small glass encapsulated tags that are inserted into the body cavity of the fish; each tag has an individual identification code, making it possible to follow individuals through time in their natural environment. Additionally, PIT tags are used to monitor salmon and steelhead throughout the Columbia Basin, allowing fish that migrate out of our study area to be detected during outmigration and allowing us to make inferences about the migration behavior and success of juvenile fish tagged in the study area.

Fish recaptured over time were used to assess growth during various seasonal and environmental conditions as well as survival. We estimated age-specific cohort growth by measuring the change in average size of all individuals of each age class (subyearling and yearling) present at a site. Individual growth estimates were made by comparing recorded length and weight data over time for fish that were recaptured. We also used length and weight data to calculate the Fulton condition factor of *O. mykiss* individuals using the following equation:

$$K = (W(g)/L(mm)^3)*100{,}000$$

Individual *O. mykiss* were assigned to age classes (subyearling or yearling) using cut-off lengths based on body length histograms. Age class data are critical in order to establish environmental or annual effects on age classes within sites and to compare biomass across sites.

Task 1.3: Data summary and comparison across years of consistent sampling

We estimated *O. mykiss* density for each date we visited each site as described above. We compared densities across years over the maximum time record possible; four of the sites visited in 2015 have been monitored since 2008 (LSX, UWM, ULU, and UMU), while the other two have been monitored since 2010 (USU and MLX).

Results from reporting period (July 2015 – December 2015)

We have reported annually on the previous year's activities, and we refer to these reports for results from 2008 through 2014. Data from 2015 are presented here, and include demographic estimates (body size histograms, abundance, density, cohort growth, and condition factor) and their derivatives for juvenile *O. mykiss* and long-term *O. mykiss* density trends.

Tasks 1.1 and 1.2: Density monitoring and data collection of juvenile O. mykiss

We PIT tagged a total of 970 individual *O. mykiss* in the watershed and had 321 recapture events (any rehandled previously tagged fish – including multiple recaptures of some individuals) in 2015.

Histograms of abundance and size distributions describe the dominant patterns throughout the six study reaches (Figs. 2 – 7). In general, two size/age classes were distinguishable (i.e., sites tended to have bimodal size distributions), one composed of subyearling (0+) individuals that emerged in spring 2015 and a second composed of yearling or older fish (1+) that emerged in previous springs. During the first visit, yearling fish were usually more abundant or equal to subyearling fish (with the exception of ULU). By the second visit in late August/early September, when we were able to more effectively collect subyearlings with our sampling gear, subyearlings were relatively more abundant than they had been earlier in the season, and that pattern continued for the third and final visit of the sampling season in October. Subyearling body size at lower elevation sites (LSX and MLX) was larger on a given date compared to sites at higher elevations (USU, UWM, ULU, and UMU).

Notable abundance patterns this year included the high abundance of both subyearlings and yearlings at ULU and UMU relative to all other sites, and the high subyearling to yearling ratios observed at the sites lower in the watershed (LSX and MLX) compared to all other sites (Tables 3 – 5). In 2015, total densities of juvenile *O. mykiss* did not display the same temporal pattern across the six sampled sites. Over the course of the summer sampling season, total density increased slightly at ULU, changed little with a slight decrease at two sites (LSX and UWM), and decreased at three site (USU, MLX, and UMU) (Fig. 8). Subyearling densities displayed the same temporal pattern as total densities with the exception of ULU which decreased and UMU which increased (Fig. 9), suggesting that the relatively lower total densities early in the summer may have been due to our inability to sample small subyearlings during that time. Subyearling densities appear to display consistent spatial variation as LSX and MLX consistently had lower subyearling densities than high in the watershed). The highest densities of both age classes were consistently observed at ULU and UMU (Figs. 9 – 10). Yearling densities were relatively constant over the summer at LSX and UWM, and decreased at USU, MLX, ULU, and UMU (Fig. 10). Yearling densities were lowest at lower elevation sites (LSX and MLX), and there was little difference in density between those two sites.

We calculated cohort growth rates for juvenile *O. mykiss* over two five-week growth periods (first period = late July to late August/early September; second period = late August/early September to early October) at each site. Subyearling cohort growth rates were uniformly positive except UMU, where growth was near zero (Fig. 11). Yearling cohort growth rates were more variable, with most sites showing positive cohort growth during the first growth period (with the exceptions of USU, where growth was negative, and UMU, where growth was near zero) and positive cohort growth during the second growth period (with the exceptions of ULU and UMU, where growth was negative) (Fig. 12).

Condition factor for both subyearling and yearling fish (averaged across all individuals within an age class and site) tended to decline over the sampling season and reached a minimum at the end of the sampling season, though the pattern was variable at some sites (e.g. LSX) (Figs. 13-14). Subyearling fish had higher condition factors than yearling fish, particularly by the end of the sampling season. For both subyearling and yearling fish, condition factors at sites lower in the watershed were not substantially different from sites higher in the watershed. In general, there also did not appear to be significant differences in condition factor based on hydrologic alteration; however yearling fish at project affected sites tended to have slightly higher condition factors than yearling fish caught at control sites.

The overall mortality rate of *O. mykiss* that we handled over the course of the field season was 0.90% (Table 6), comparable to that of previous years. The majority of those mortalities (four out of seven) occurred during the first visit to the sites, when high temperatures and high fish density led to low oxygen conditions in a bucket being used to transport fish. Of the mortalities, two were yearling fish.

Task 1.3: Compare observed juvenile O. mykiss *densities across years*

Subyearling *O. mykiss* densities in 2015 fell within the range of variation we have observed in the Lapwai watershed since 2008 (Fig. 16). In previous years, subyearling densities have tended to peak in mid-summer before decreasing (though not all sites have followed this pattern in all years – notably, subyearling density increased throughout the entire field season at ULU in 2009 and 2013). In 2015 this pattern occurred at some sites (USU and UMU). We did not observe this pattern across all sites in 2015, when densities decreased throughout the field season at three sites (UWM, MLX, and ULU), and were constant at one site (LSX). Since 2008, ULU or UMU has generally been the site with the highest subyearling densities (with the exception of 2010, when subyearling densities at MLX were the highest). This pattern held true for 2015, when the highest subyearling densities during each visit were observed at ULU or UMU. Each year, the highest densities are typically observed at a control site (MLX, ULU, and UMU are all control sites); however, subyearling densities at the other control sites generally overlap with subyearling densities observed at project affected sites. As in previous years, this pattern occurred in 2015, with high densities observed at ULU but densities at other sites similar and overlapping.

Yearling *O. mykiss* densities in 2015 also fell within the range of variation we have observed in the Lapwai watershed since 2008 (Fig. 17). In previous years, yearling densities have tended to decrease throughout the field season at sites where densities are high, and to stay constantly low at sites with fewer fish (though not all sites have followed this pattern in all years; for example, densities increased throughout the season at USU in 2010). We observed this pattern at high density sites in 2015 (i.e., at USU, ULU, and UMU, where yearling densities were relatively high, density decreased over the field season), but also at relatively low density sites (LSX, UWM, and MLX). In the early years of the study (2008-2009), the highest yearling densities were observed at ULU and UMU, while other sites had low densities. Over the next four years (2010-2013), yearling densities continued to be low at LSX, but other sites were more variable, with no site consistently having the highest densities. In 2014 and 2015, we observed a repeat of the earlier pattern, with the highest yearling densities observed at ULU and UMU during each visit.

Additional Outreach and Educational Activities

In addition to the field density monitoring program, the following products of the Sweetwater – Lewiston Orchards juvenile steelhead project have been accomplished during this reporting period.

- We have published one manuscript to an international journal (Ecosphere, 2015) recently (Myrvold and Kennedy), and another was submitted for revisions at the Canadian Journal of Fisheries and Aquatic Sciences (see below for complete list of published manuscripts).
- One student, Jeff Caisman, funded by both this agreement and the previous agreement (#R12AC11005) completed his entitled, "Partial migration in Steelhead (*Oncorhynchus mykiss*): Identifying factors that influence migratory behavior and population connectivity across a watershed"
- Two manuscripts have been prepared for publication from Jeff Caisman's thesis entitled, "Variability of life history expression in *Oncorhynchus mykiss*: Causes of partial migration," and "Effects of barriers on movement, gene flow, and life history expression of *Oncorhynchus mykiss* in Lapwai Creek, Idaho" respectively.
- We have worked on the preparation and submission of at least one other manuscripts (Taylor, Myrvold and Kennedy 2015) for journal review.
- Talks were given at the national AFS meeting in Portland as well as internationally in Spain for a population dynamics of freshwater salmonids symposium (see below for complete list of conference proceedings).
- We initiated and finalized preparations and equipment inventory and maintenance for 2016 field season.

At the end of the summer of 2014, Ph.D. student Natasha Wingerter joined the Kennedy lab. She continued her involvement with the project throughout 2015. She helped supervise and support field sampling efforts during the summer. She is also working on processing macroinvertebrate and diet samples in the lab, and is continuing to analyze the data gathered from those samples. Natasha plans to present her findings at the Society of Freshwater Science's national meeting in May 2016.

The following are manuscripts and presentations from 2015 that were enabled by this funding:

Manuscripts

*Myrvold, K.M. and **Kennedy, B.P.** (2015) Metabolic constraints and physical habitat characteristics explain the spatial variation in the strength of self-thinning in a stream salmonid. *Ecology and Evolution, In press*.

*Myrvold, K.M. and **Kennedy, B.P.** (2015) Age-specific density dependence and its impact on individual growth rates for a stream salmonid. *Ecosphere, 6(12): NA.*

*Myrvold, K.M. and **Kennedy, B.P.** (2015) Variation in juvenile steelhead densities in relation to instream habitat and watershed characteristics. *Transactions of the American Fisheries Society. In press*.

*Hartson, R.B. and **Kennedy, B.P.** (2015) Competitive release modifies the impacts of hydrologic alteration for a partially migratory stream predator. Ecology of Freshwater Fish. 24(2): 276-292. **(*Included in application packet*)**

*Myrvold, K.M. and **Kennedy, B.P.** (2015) Interactions between body mass and water temperatures cause energetic bottlenecks in juvenile steelhead. Ecology of Freshwater Fish. DOI 10.1111/eff.12151.

Conference proceedings and presentations

August 2015. *American Fisheries Society Annual Symposium, Portland, OR, USA.* Densities of juvenile steelhead in relation to instream habitat and watershed characteristics. K.M. Myrvold*, and B.P. Kennedy.

August 2015. *American Fisheries Society Annual Symposium, Portland, OR, USA.* Variability of life history expression in Oncorhynchus mykiss: causes and consequences of partial migration. J. Caisman*, and B.P. Kennedy.

May 2015. *Advances in the Population Ecology of Stream Salmonids International Symposium. Gerona, Spain.* Interactions of climate and density on survival and movements of juvenile steelhead: Results from a 7-year study. B.P. Kennedy, K.M. Myrvold, J. Caisman, R. Hartson and E. Benson.

May 2015. *Advances in the Population Ecology of Stream Salmonids International Symposium. Gerona, Spain.* Local habitat conditions explain the variation in self thinning slopes in steelhead parr. K.M. Myrvold*, and B.P. Kennedy.

February 2014. *Annual meeting for the Idaho Chapter; American Fisheries Society, Idaho Falls, ID, US.* Effects of Anthropogenic Barriers on Movement, Gene Flow Potential, and Life-History Expression of *Oncorynchus mykiss* in Lapwai Creek, Idaho. J. Caisman*, B.P. Kennedy, M.W. Ackerman, C.J. Smith and J. Stedman.

Current and Future Efforts

We are currently in the process of analyzing the following data:

- Fish community structure: spatiotemporal variation in composition, densities and the effects on *O. mykiss*
- Diet (stomach samples) and available food resources (drift and Surber samples)
- Validation of age and analysis of maternal origin (of mortalities)
- Assessing site fidelity of PIT tagged juvenile *O. mykiss*
- Identifying drivers of population densities and the effects on growth rates and movement
- Relationships between habitat conditions and steelhead densities and individual performance.

Future efforts will consist of completing the analyses listed above, as well as continuing to work on the scientific manuscripts currently in preparation. Project members also plan to attend professional meetings throughout the coming year, where they will present the findings of this project.

Tables

Table 2. Names, three-letter codes, and dates for sites sampled in Lapwai watershed from late July to early October, 2015. Sampling effort in 2015 was reduced relative to previous years; gray rows indicate sites that were not sampled in 2015. Each site in white was sampled three times throughout the field season; sites were sampled five times throughout the season in previous years, except in 2008, when they were sampled four times.

Site name	Site code	Date of first visit	Date of second visit	Date of third visit
Lower Lapwai lower	LLL	Not sampled	Not sampled	Not sampled
Lower Lapwai upper	LLU	Not sampled	Not sampled	Not sampled
Lower Sweetwater	LSX	7/24/2015	8/29/2015	9/30/2015
Middle Lapwai	MLX	7/29/2015	8/26/2015	10/04/2015
Upper Lapwai lower	ULL	Not sampled	Not sampled	Not sampled
Upper Lapwai middle	ULM	Not sampled	Not sampled	Not sampled
Upper Lapwai upper	ULU	7/28/2015	8/25/2015	10/03/2015
Upper Mission lower	UML	Not sampled	Not sampled	Not sampled
Upper Mission middle	UMM	Not sampled	Not sampled	Not sampled
Upper Mission upper	UMU	7/22/2015	9/01/2015	10/6/2015
Upper Sweetwater lower	USL	Not sampled	Not sampled	Not sampled
Upper Sweetwater middle	USM	Not sampled	Not sampled	Not sampled
Upper Sweetwater upper	USU	7/23/2015	8/27/2015	9/29/2015
Upper Webb lower	UWL	Not sampled	Not sampled	Not sampled
Upper Webb middle	UWM	7/27/2015	8/31/2015	10/01/2015
Upper Webb upper	UWU	Not sampled	Not sampled	Not sampled

Table 3. Number, population size estimated using methods of Carle and Strub (1978), and density (number m^{-2}) of *O. mykiss* captured via electrofishing at six sites in Lapwai watershed (four of which have been sampled since 2008: LSX, UWM, ULU, UMU) in **late July**, 2015 (first visit to each site). Each site was approximately 100 meters in length. Original name refers to the site name used in calendar years 2008 and 2009 and associated Activities Reports, and new name refers to the site name used in calendar years 2010-2015.

Original name (2008-2009)	**New name (2010-2015)**	**Number *O. mykiss* captured**	**Population estimate (standard error)**	**Density (number m^{-2})**
Lower Sweetwater	Lower Sweetwater (LSX)	21	28(9.613)	0.049
(not sampled)	Upper Sweetwater upper (USU)	79	88(6.018)	0.273
Lower Webb	Upper Webb middle (UWM)	39	46(6.53)	0.140
(Not sampled)	Middle Lapwai (MLX)	39	50(11.012)	0.154
Upper Lapwai	Upper Lapwai upper (ULU)	193	201(4.226)	0.494
Upper Mission	Upper Mission upper (UMU)	75	79(3.33)	0.247

Table 4. Number, population size estimated using methods of Carle and Strub (1978), and density (number m^{-2}) of *O. mykiss* captured via electrofishing at six sites in Lapwai watershed (four of which have been sampled since 2008: LSX, UWM, ULU, UMU) in **late August**, 2015 (second visit to each site). Each site was approximately 100 meters in length. Original name refers to the site name used in calendar years 2008 and 2009 and associated Activities Reports, and new name refers to the site name used in calendar years 2010-2015.

Original name (2008-2009)	**New name (2010-2015)**	**Number *O. mykiss* captured**	**Population estimate (standard error)**	**Density (number m^{-2})**
Lower Sweetwater	Lower Sweetwater (LSX)	8	8(0.290)	0.015
(not sampled)	Upper Sweetwater upper (USU)	59	98(33.885)	0.281
Lower Webb	Upper Webb middle (UWM)	38	46(7.642)	0.136
(Not sampled)	Middle Lapwai (MLX)	17	17(1.028)	0.061
Upper Lapwai	Upper Lapwai upper (ULU)	125	136(6.021)	0.344
Upper Mission	Upper Mission upper (UMU)	132	143(5.878)	0.397

Table 5. Number, population size estimated using methods of Carle and Strub (1978), and density (number m^{-2}) of *O. mykiss* captured via electrofishing at six sites in Lapwai watershed (four of which have been sampled since 2008: LSX, UWM, ULU, UMU) in **early October**, 2015 (third visit to each site). Each site was approximately 100 meters in length. Original name refers to the site name used in calendar years 2008 and 2009 and associated Activities Reports, and new name refers to the site name used in calendar years 2010-15.

Original name (2008-2009)	**New name (2010-2015)**	**Number *O. mykiss* captured**	**Population estimate (standard error)**	**Density (number m^{-2})**
Lower Sweetwater	Lower Sweetwater (LSX)	16	18(3.694)	0.034
(not sampled)	Upper Sweetwater upper (USU)	57	61(3.564)	0.175
Lower Webb	Upper Webb middle (UWM)	27	32(5.807)	0.098
(Not sampled)	Middle Lapwai (MLX)	12	12(2.646)	0.036
Upper Lapwai	Upper Lapwai upper (ULU)	117	133(8.462)	0.366
Upper Mission	Upper Mission upper (UMU)	97	104(4.579)	0.306

Table 6. Number of *O. mykiss* mortalities during electrofishing and fish handling/processing at six sites in Lapwai watershed (four of which have been sampled since 2008: LSX, UWM, ULU, UMU); includes fish <65 mm fork length. Sites were sampled three times each between late July and early October, 2015. Total number of *O. mykiss* captured on a given visit is shown in parentheses; an addition 7 mortalities occurred while working in the watershed; total mortality rate among all sites and visits during the sampling season was 0.90%.

Site code	**First visit**	**Second visit**	**Third visit**
LSX	1(21)	0(8)	0(16)
USU	1(79)	0(59)	0(57)
UWM	0(39)	0(38)	0(27)
MLX	0(39)	0(17)	0(12)
ULU	2(193)	1(125)	1(117)
UMU	0(75)	1(132)	0(97)

Figures

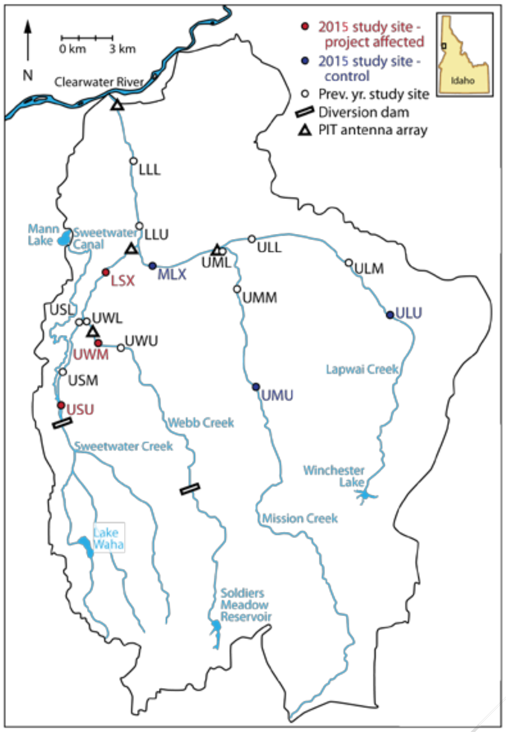

Figure 1. Study site locations in 2015 (and previous years). Red circles denote project affected sites visited in 2015, blue circles denote control sites visited in 2015, and sites visited only in previous years are represented by white circles. Diversion dams and PIT antenna arrays are also noted.

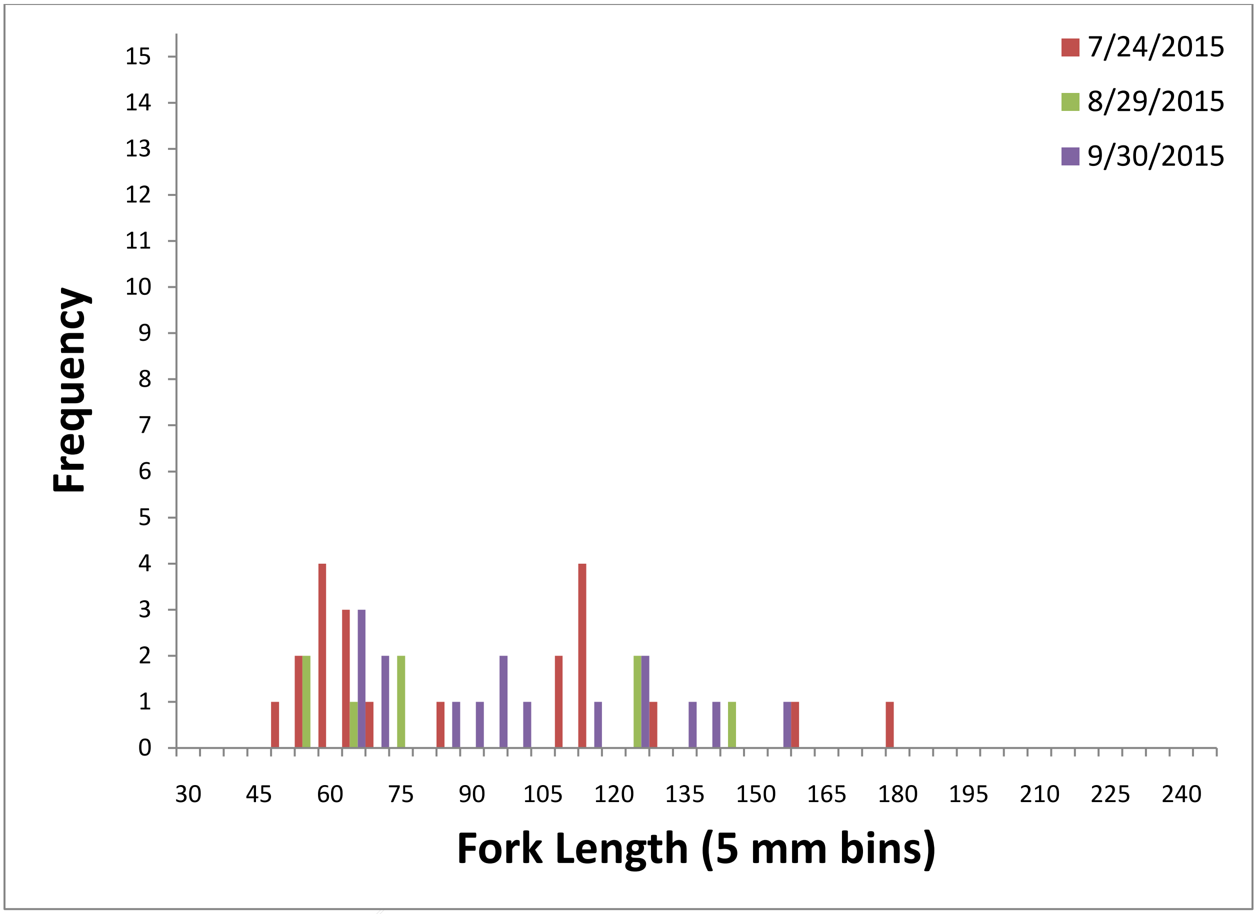

Figure 2. Histogram of juvenile *O. mykiss* fork length (mm) throughout 2015 at the lower Sweetwater site (LSX).

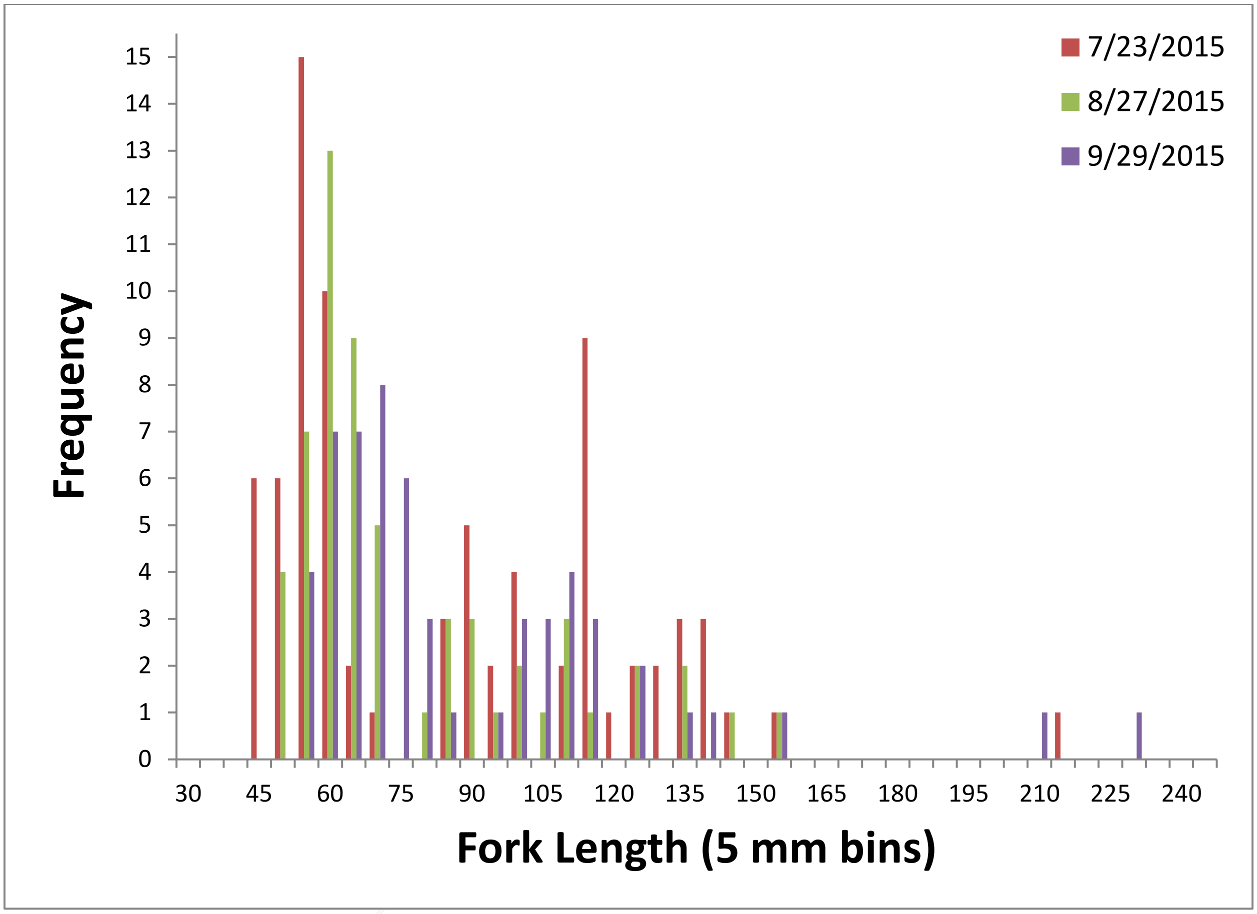

Figure 3. Histogram of juvenile *O. mykiss* fork length (mm) throughout 2015 at the upper Sweetwater upper site (USU).

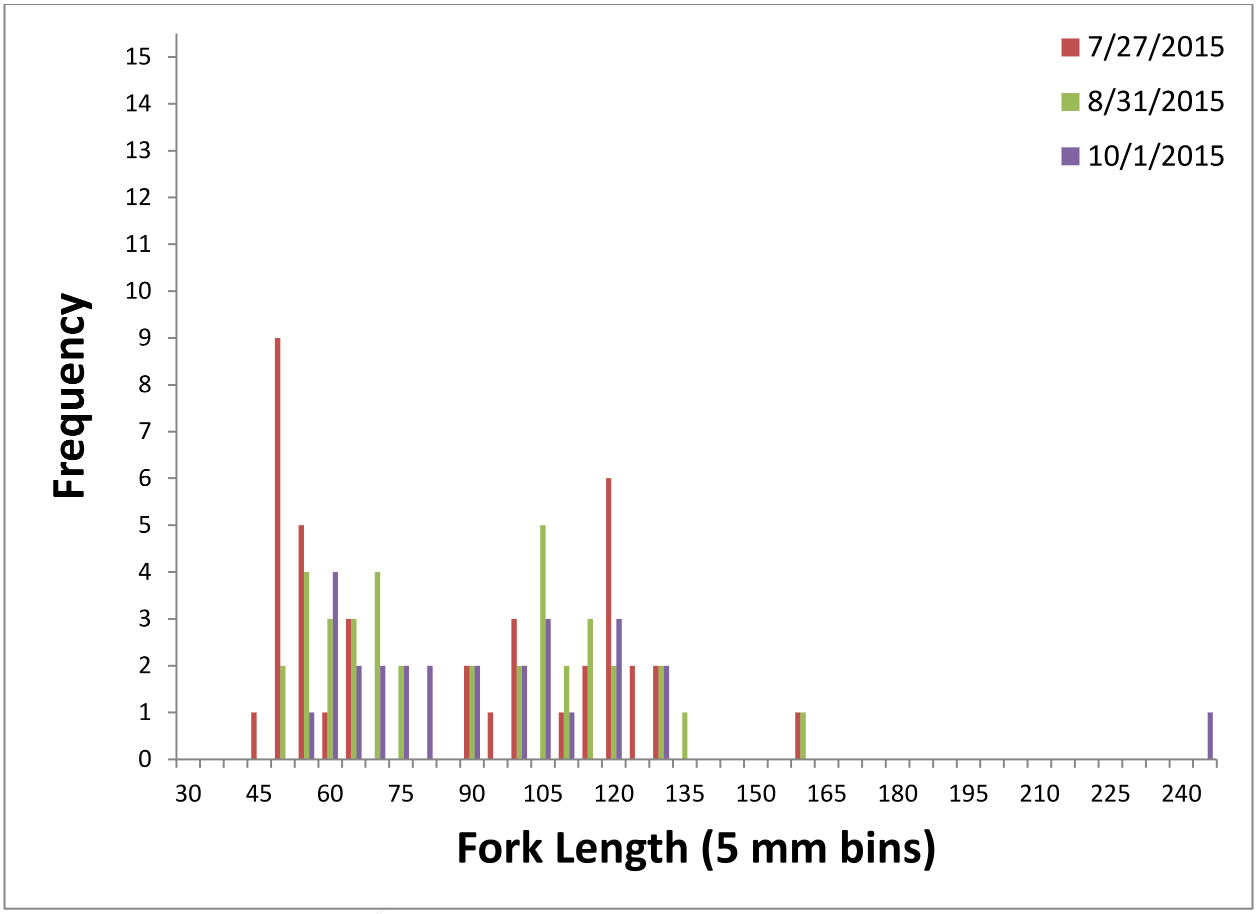

Figure 4. Histogram of juvenile *O. mykiss* fork length (mm) throughout 2015 at the upper Webb middle site (UWM).

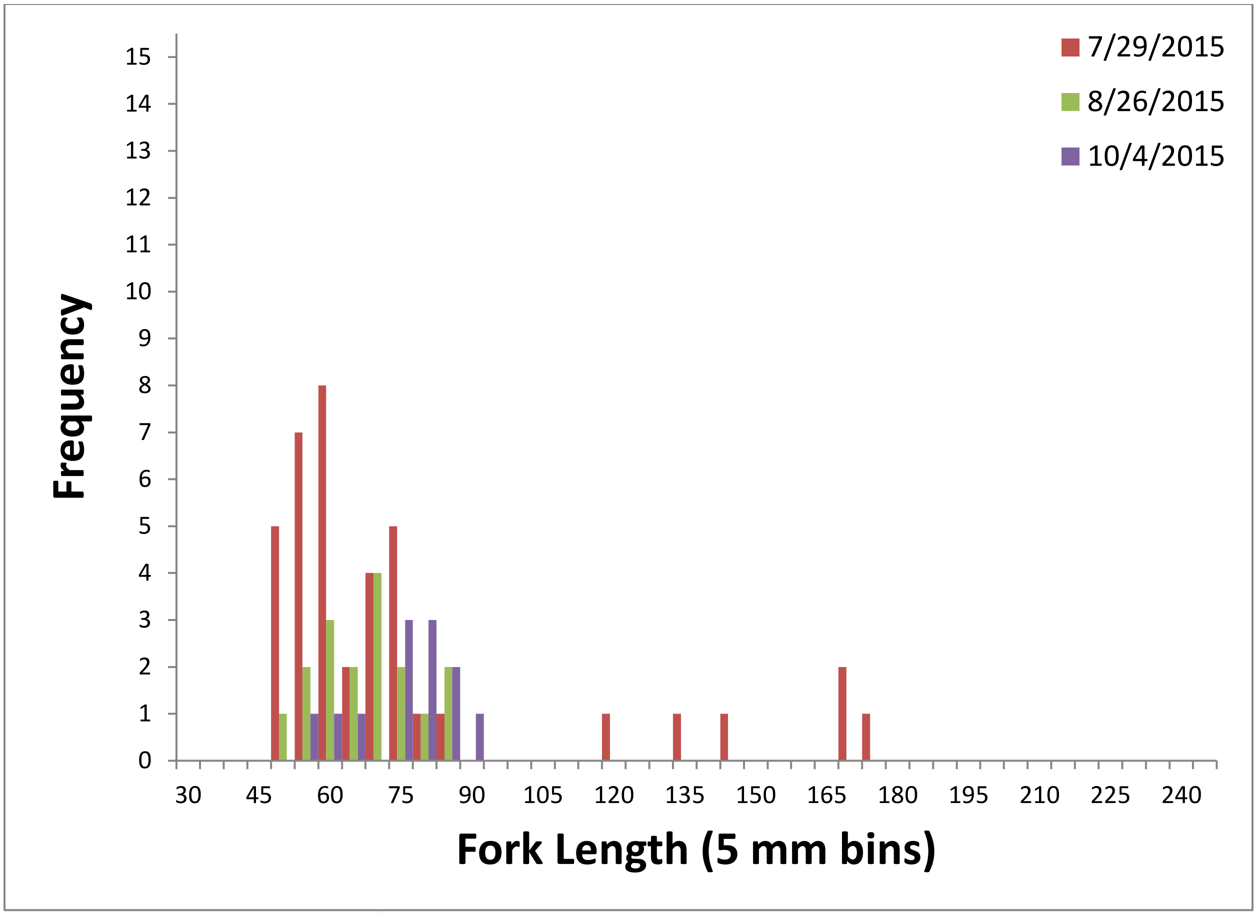

Figure 5. Histogram of juvenile *O. mykiss* fork length (mm) throughout 2015 at the middle Lapwai site (MLX).

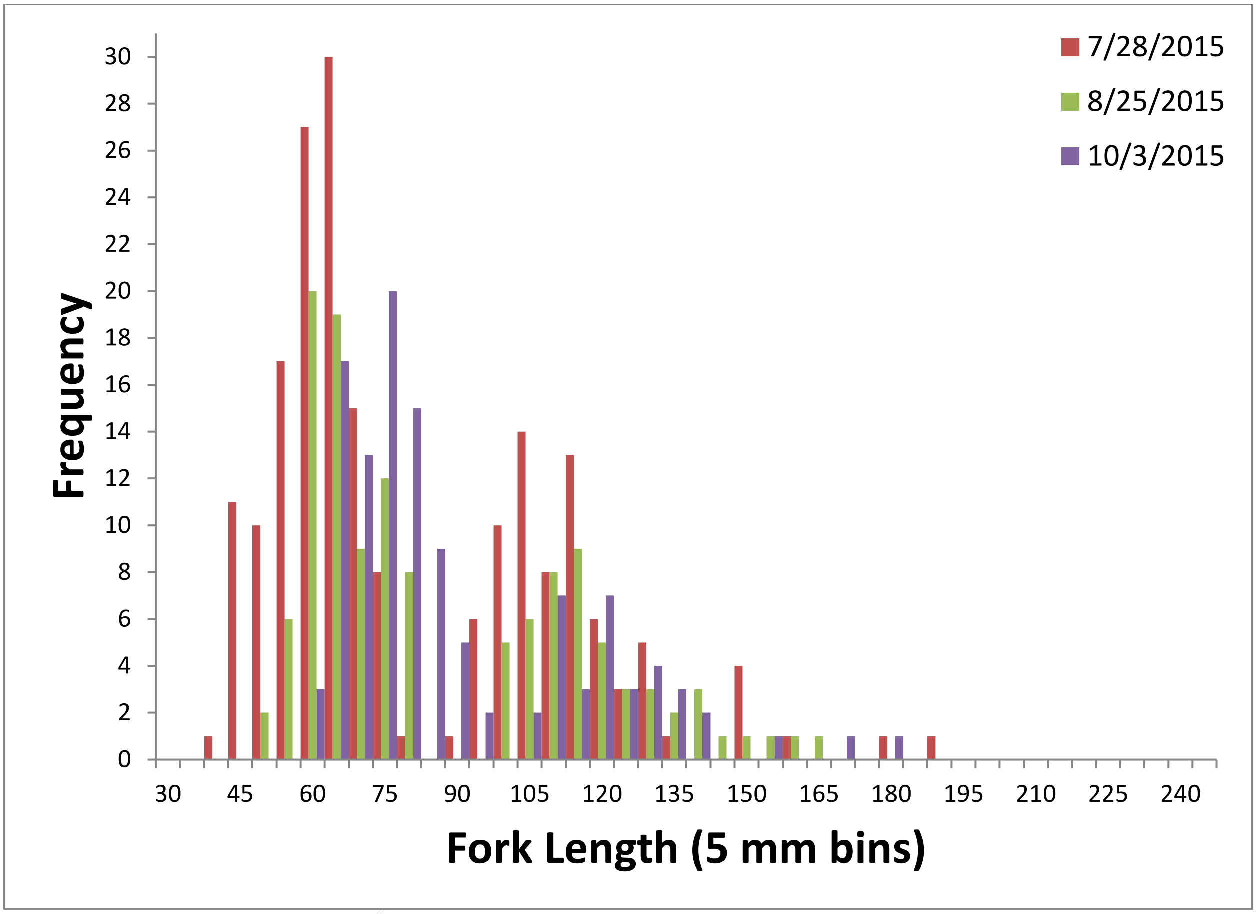

Figure 6. Histogram of juvenile *O. mykiss* fork length (mm) throughout 2015 at the upper Lapwai upper site (ULU). Note that y-axis scale is different from other histograms.

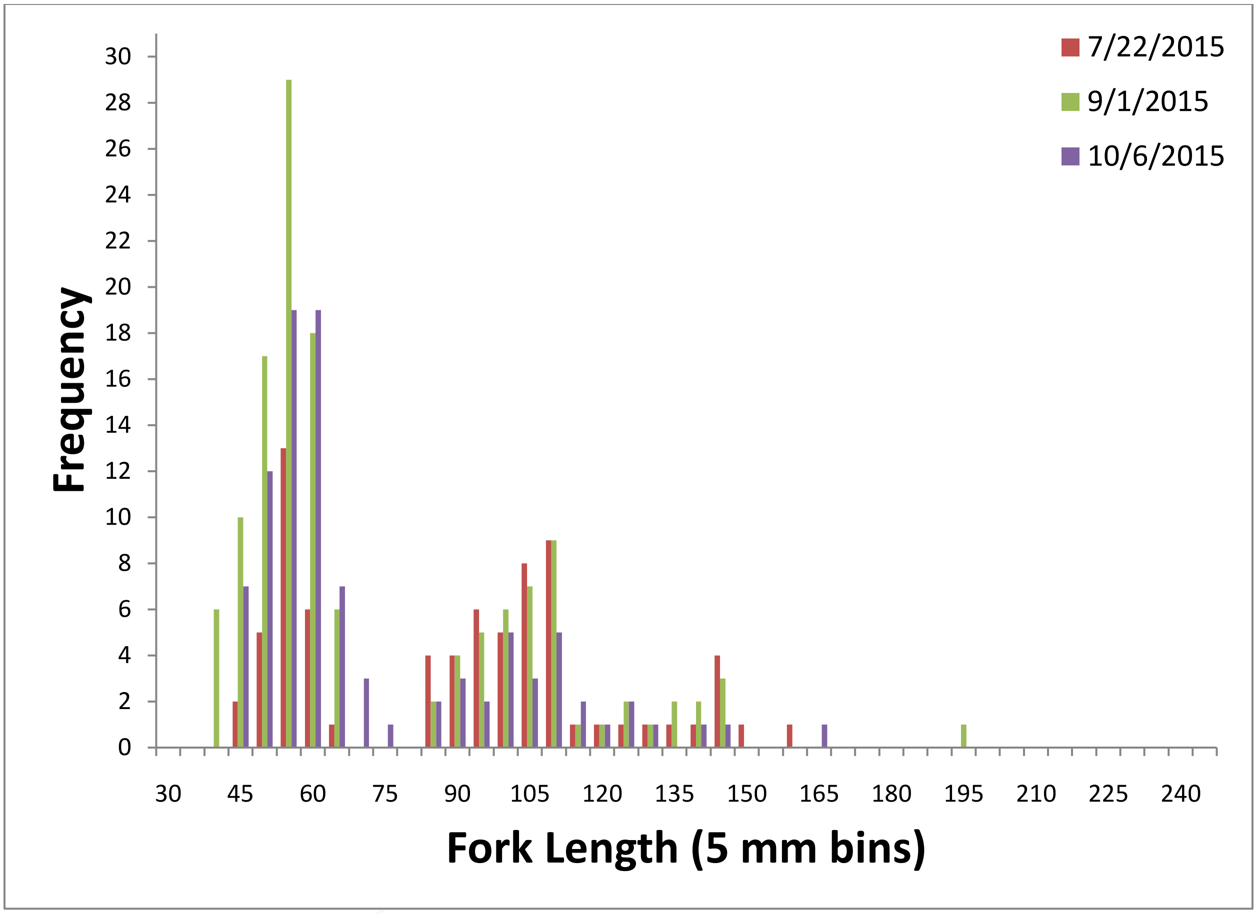

Figure 7. Histogram of juvenile *O. mykiss* fork length (mm) throughout 2015 at the upper Mission upper site (UMU). Note that y-axis scale is different from other histograms.

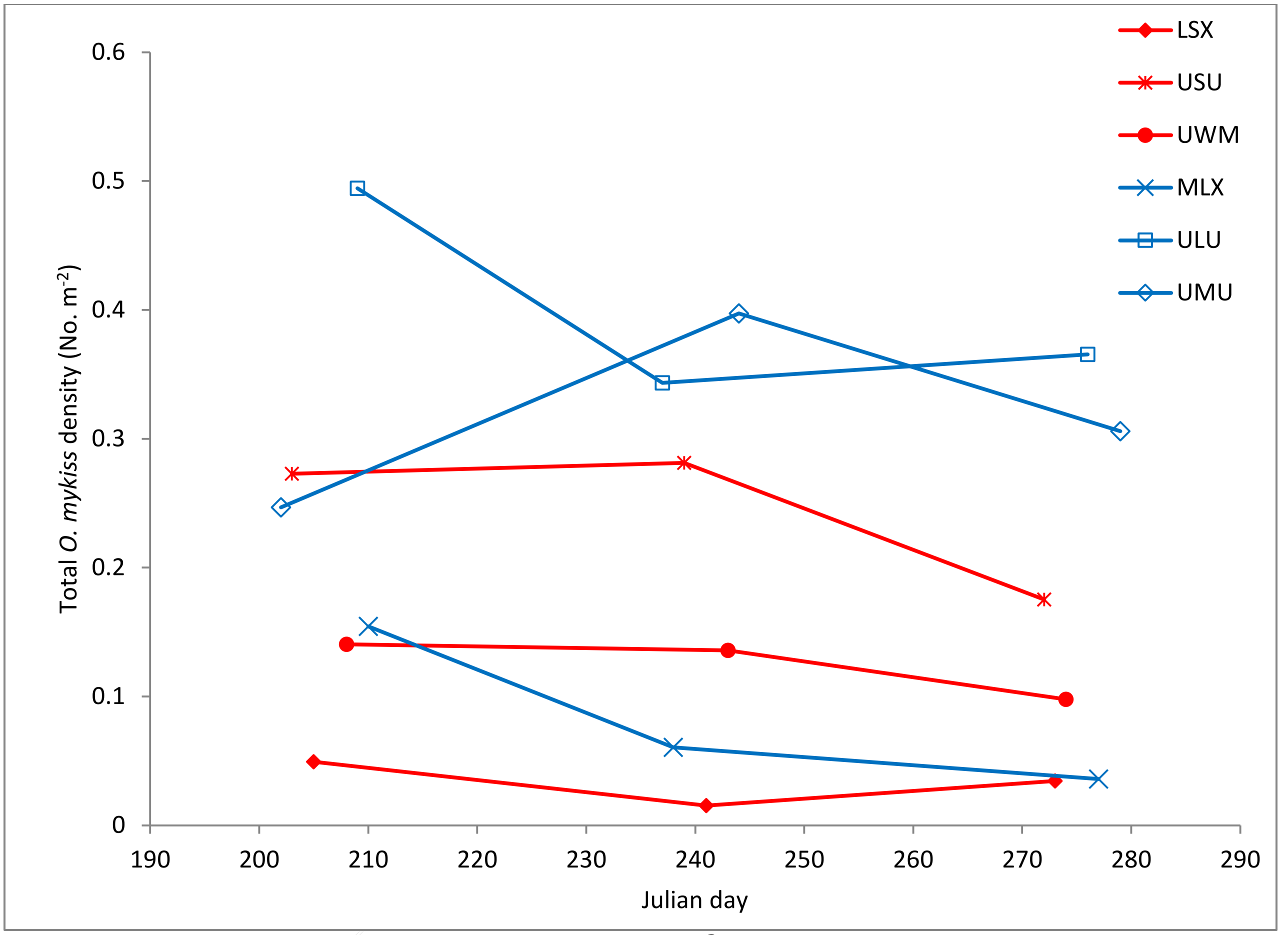

Figure 8. Density of juvenile *O. mykiss* (individuals m^{-2}) at six study sites in Lapwai watershed (four of which have been sampled since 2008: LSX, UWM, ULU, UMU) from late July to early October, 2015. Sites on Webb and Sweetwater Creeks are in the project affected area (indicated by red color). Site names follow new naming scheme.

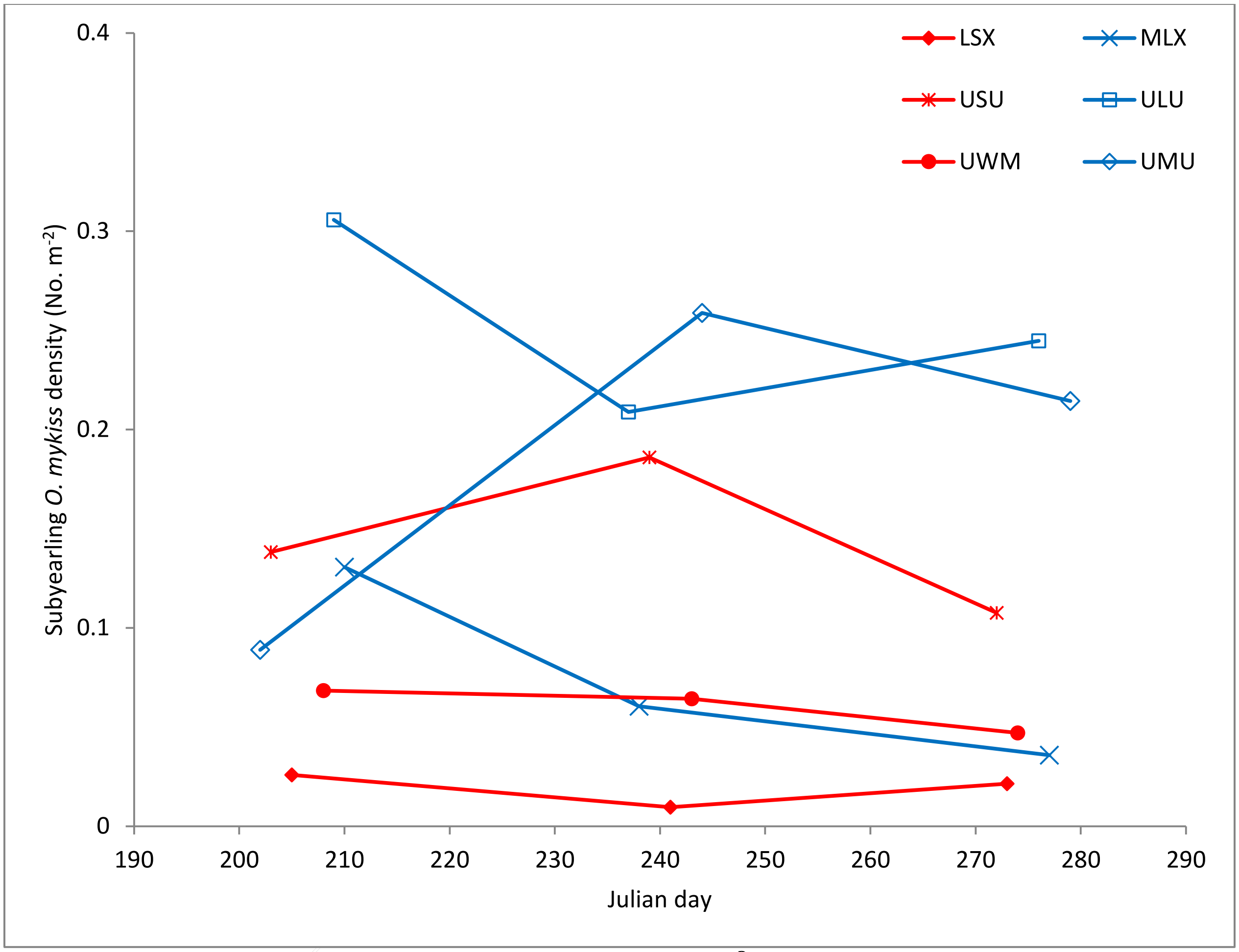

Figure 9. Density of subyearling *O. mykiss* (individuals m^{-2}) at six study sites in Lapwai watershed (four of which have been sampled since 2008: LSX, UWM, ULU, UMU) from late July to early October, 2015. Sites on Webb and Sweetwater Creeks are in the project affected area (indicated by red color). Site names follow new naming scheme.

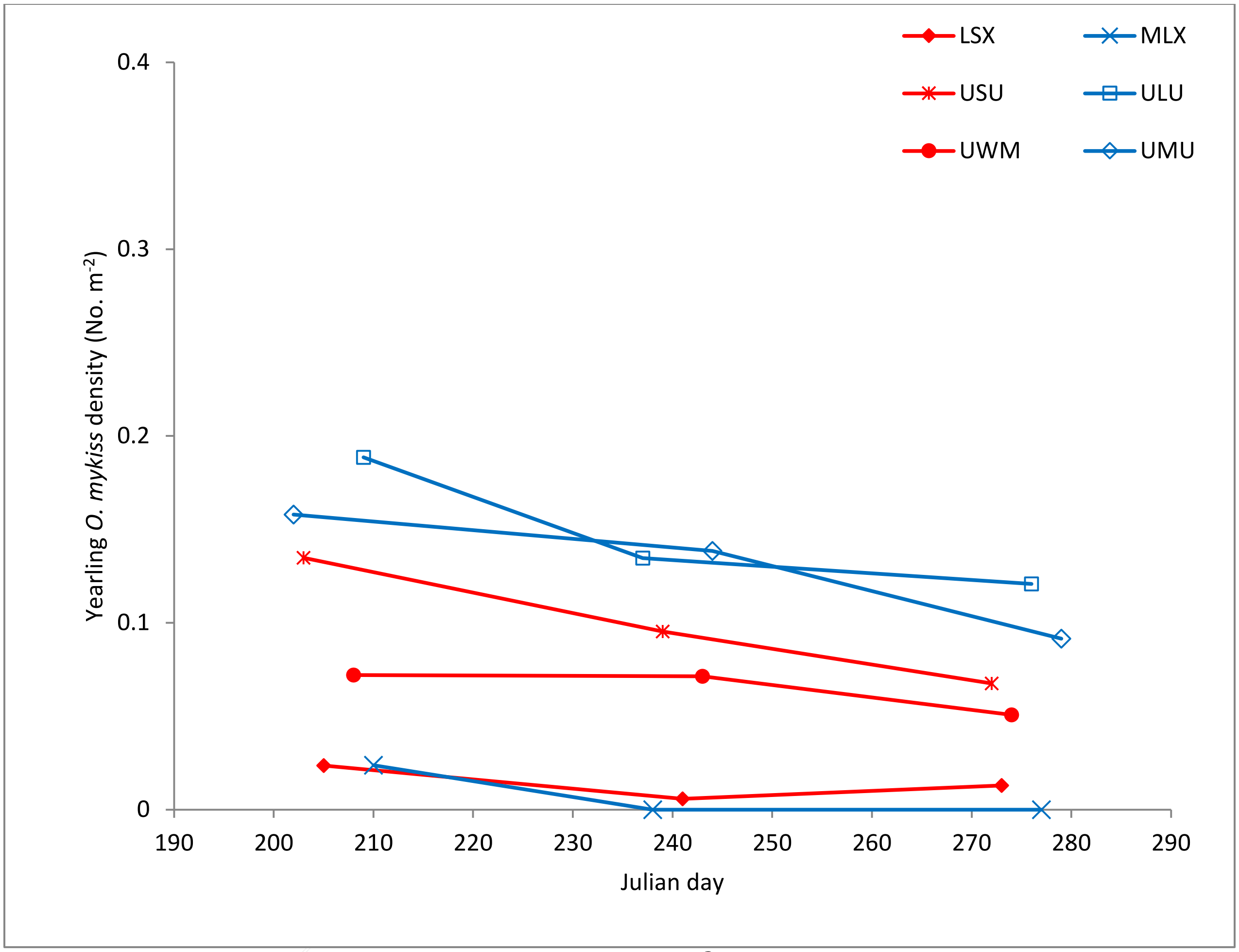

Figure 10. Density of yearling *O. mykiss* (individuals m^{-2}) at six study sites in Lapwai watershed (four of which have been sampled since 2008: LSX, UWM, ULU, UMU) from late July to early October, 2015. Sites on Webb and Sweetwater Creeks are in the project affected area (indicated by red color). Site names follow new naming scheme.

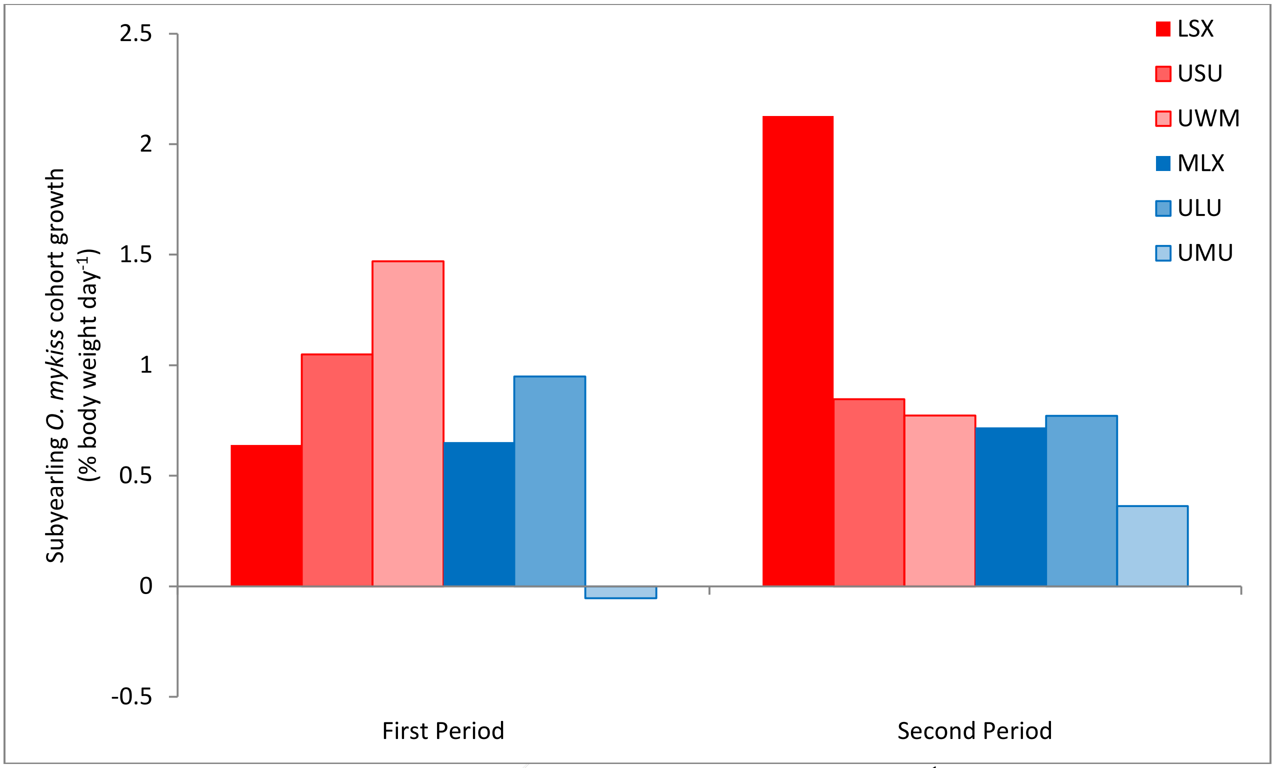

Figure 11. Cohort growth of subyearling *O. mykiss* (% body weight day^{-1}) at six study sites in Lapwai watershed (four of which have been sampled since 2008: LSX, UWM, ULU, UMU) from late July to early October, 2015. Sites on Webb and Sweetwater Creeks are in the project affected area (indicated by red color). Site names follow new naming scheme.

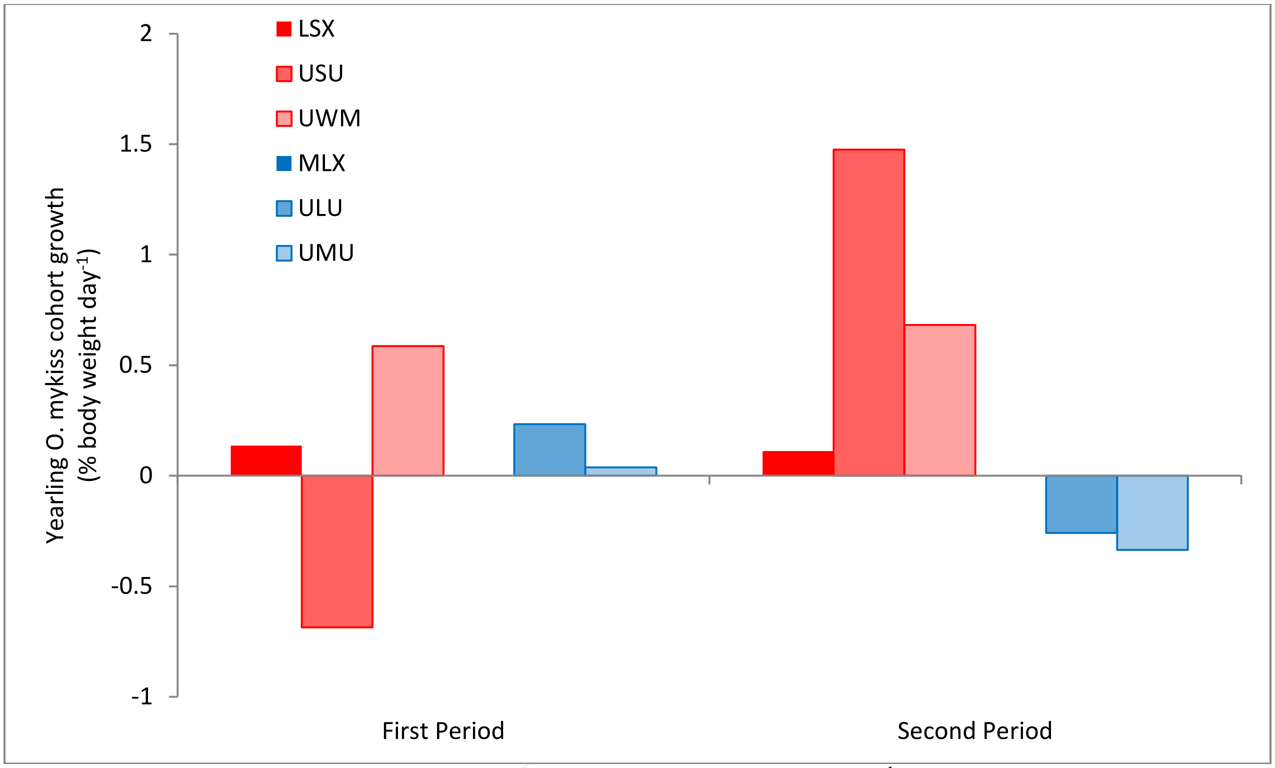

Figure 12. Cohort growth of yearling *O. mykiss* (% body weight day^{-1}) at six study sites in Lapwai watershed (four of which have been sampled since 2008: LSX, UWM, ULU, UMU) from late July to early October, 2015. Sites on Webb and Sweetwater Creeks are in the project affected area (indicated by red color). Site names follow new naming scheme. Note that y-axis scale is different from subyearling figure.

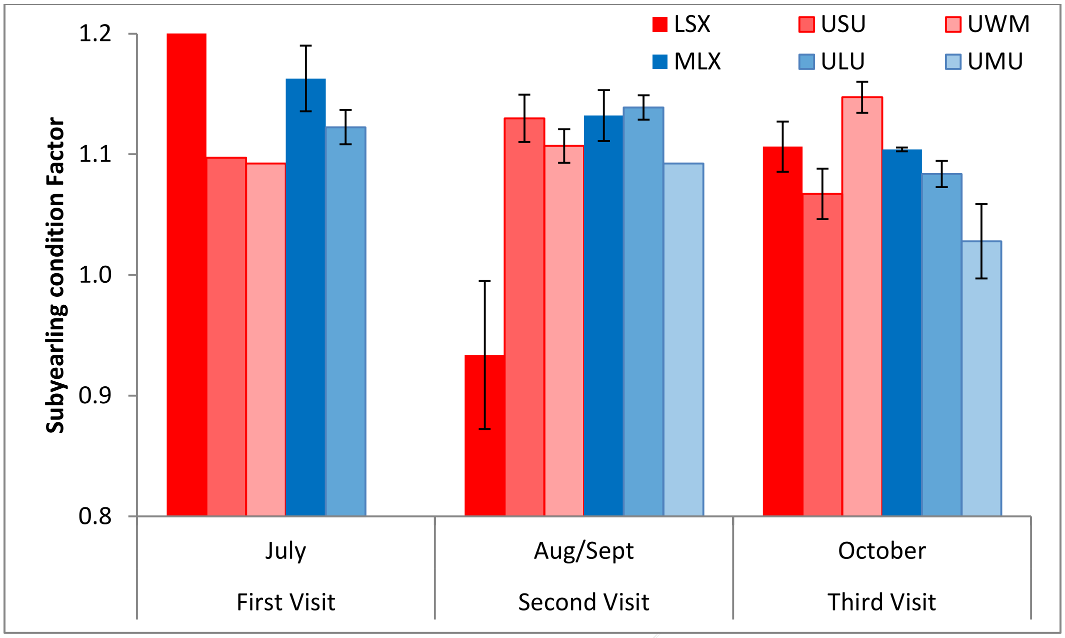

Figure 13. Condition factor of subyearling *O. mykiss* ≥ 65 mm fork length at six study sites in Lapwai watershed (four of which have been sampled since 2008: LSX, UWM, ULU, UMU) from late July to early October, 2015. Sites on Webb and Sweetwater Creeks are in the project affected area (indicated by red color). Error bars indicate +/- 1 standard error. Site names follow new naming scheme.

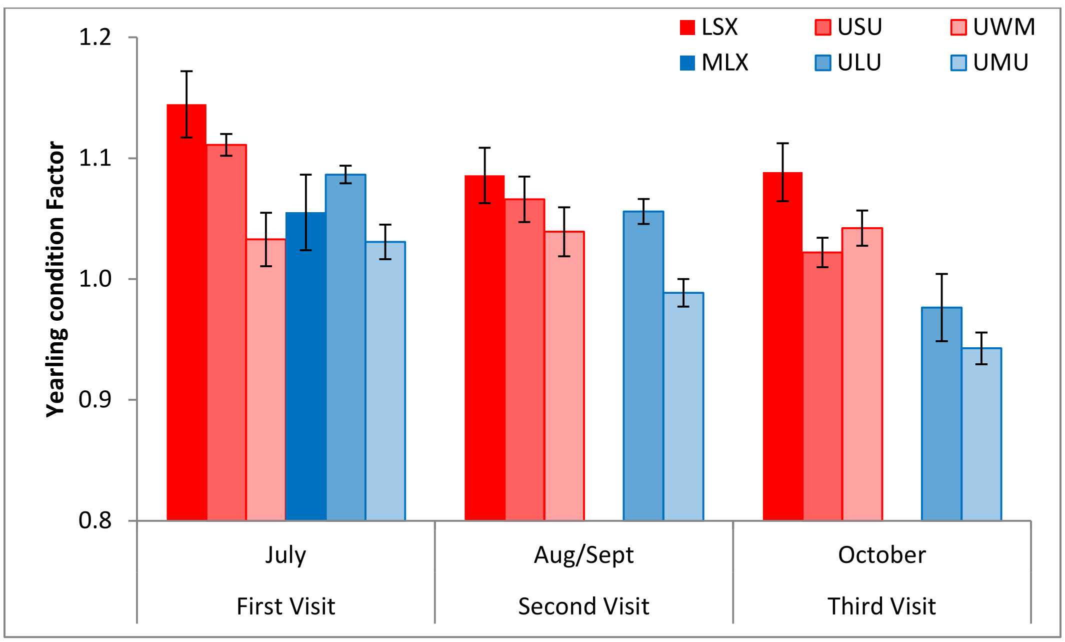

Figure 14. Condition factor of yearling *O. mykiss* at six study sites in Lapwai watershed (four of which have been sampled since 2008: LSX, UWM, ULU, UMU) from late July to early October, 2015. Sites on Webb and Sweetwater Creeks are in the project affected area (indicated by red color). Error bars indicate +/- 1 standard error. Site names follow new naming scheme.

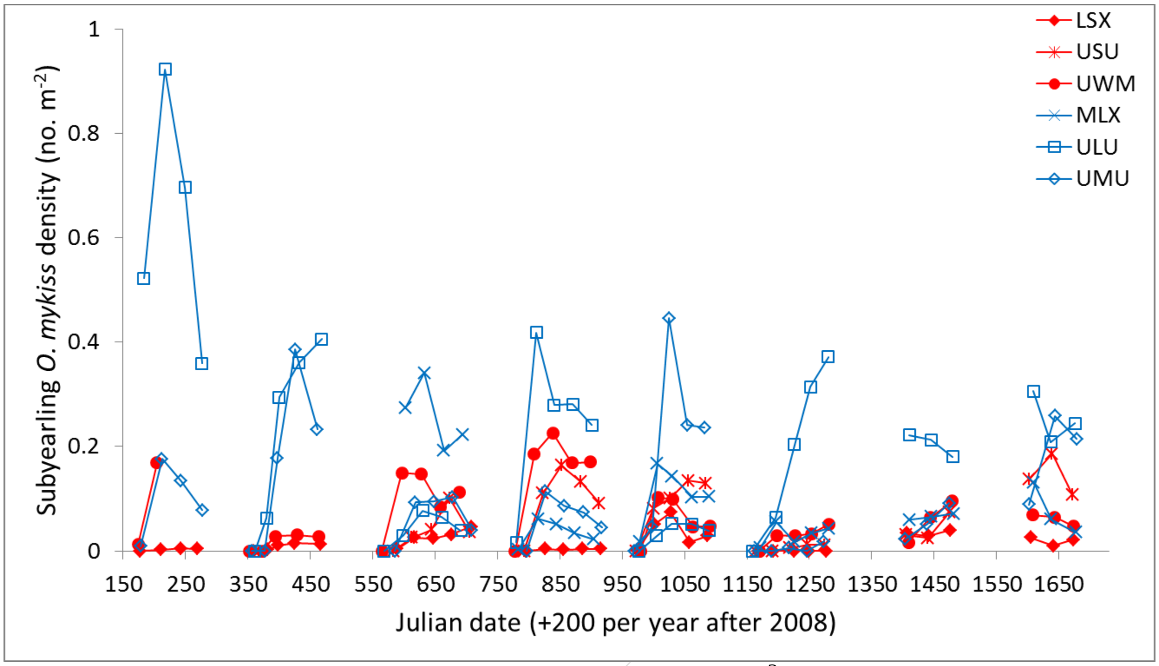

Figure 16. Density of subyearling *O. mykiss* (individuals m^{-2}) at six study sites in Lapwai watershed between 2008 and 2015 (note: USU and MLX were not sampled until 2010). Sites on Webb and Sweetwater Creeks are in the project affected area (indicated by red color). Site names follow new naming scheme.

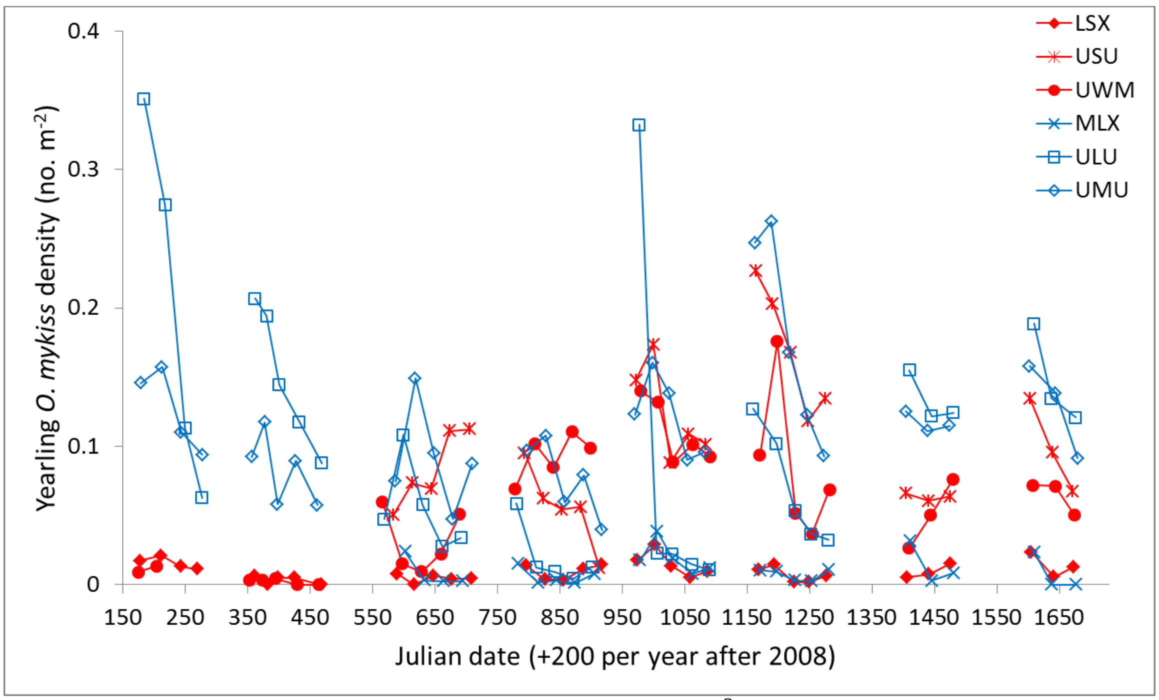

Figure 17. Density of yearling *O. mykiss* (individuals m^{-2}) at six study sites in Lapwai watershed between 2008 and 2015 (note: USU and MLX were not sampled until 2010). Sites on Webb and Sweetwater Creeks are in the project affected area (indicated by red color). Site names follow new naming scheme. Note that y-axis scale is different from subyearling figure.

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APPENDIX C

NEZ PERCE TRIBE 2015 LAPWAI CREEK PIT TAG DETECTION SUMMARY

NEZ PERCE TRIBE
Department of Fisheries Resources Management

Administration • Enforcement • Harvest • Production • Research • Resident Fish • Watershed

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Date: February 25, 2016

To: Jay Hesse, NPT Research Division Director
Jim Taylor, BOR Supervisor Environmental Compliance Group

From: Rick Orme, NPT ISEMP Project Leader
Cameron M. Albee, NPT ISEMP Biologist

Subject: 2015 Lapwai Creek PIT Tag Detection Summary

The Nez Perce Tribe and Bureau of Reclamation entered into a Memorandum of Agreement (MOA) in 2012 to monitor adult steelhead escapement into Lapwai Creek via Passive Integrated Transponder (PIT) tag arrays (Reclamation Agreement NO: R12MA11706). This summary report provides preliminary results for the period of July 1, 2014 through July 1, 2015. Final results are pending the completion of a multi-entity collaborative report for Snake River Basin In-stream PIT Tag Detection System (IPTDS). The data summarized here and in the final report is the product of multiple projects and agencies and is generated from the PIT tagging and biological sampling of a known proportion of adult steelhead and Chinook salmon as they migrate through the Lower Granite Dam (LGR) fish ladder and the subsequent detection of those PIT tagged adults at the Lapwai Creek IPTDS. The Integrated Status and Effectiveness Monitoring Project (ISEMP; BPA Project 2003-017-00) spearhead PIT tagging of adults at LGR, have been integral in the development and maintenance of IPTDS infrastructure throughout the Snake River, and developed the Bayesian patchwork occupancy model to estimate population-level estimates of abundance. Idaho Steelhead Monitoring and Evaluation Studies (ISMES; BPA Project 1990-055-00) and the Idaho Natural Production Monitoring and Evaluation Program (NPM; BPA Project 1991-073-00) coordinate biological sampling of adults at LGR and provide length, age, and passage timing data. The Snake River Genetic Stock Identification (BPA Project 2010-026-00) provides SNP genotype data for population-level genetic diversity and structure analysis. Trapping at LGR is coordinated by National Marine Fisheries Service (NMFS; BPA Project 2005-002-00; Harmon 2003; Ogden 2010, 2011). The Bureau of Reclamation and Lewiston Orchards Irrigation District support the maintenance of PIT tag arrays in Lapwai, Mission, Sweetwater, and Webb creeks.

Adult Detections

Adult PIT tag detections at in-stream PIT tag arrays within Lapwai Creek were summarized for detections occurring July 1, 2014 through June 30, 2015. First and last adult salmonid detections in Lapwai Creek ranged from October 2014 through June 2015 (Table 1.) Adult detections were from steelhead, hatchery Fall Chinook, Coho salmon, and a Northern Pike Minnow (Table 2).

Table 1. First and last PIT tag observation date by species from in-stream arrays within Lapwai Creek during the period of July 1, 2014 through June 30, 2015.

Species	First Observation Date	Last Observation Date
Coho	10/12/2014	12/21/2014
Fall Chinook	11/27/2014	12/04/2014
Steelhead	12/21/2014	6/4/2015

A total of 134 unique PIT tagged adults were detected between the Lapwai (LAP), Mission (MIS), Sweetwater (SWT), and Webb (WEB) creek in-stream arrays (Table 2). Both hatchery and wild/natural adults were detected within Lapwai Creek from 13 different release locations (Table 2). Of these, 85 were steelhead, 2 Fall Chinook, 36 Coho, and one Northern Pike Minnow (Table 2). Based on the timing of detections at Lapwai Creek arrays, it was determined that 1 unique adult steelhead and 9 unique juvenile of unknown species and origin were detected but listed as orphans (no other information within the PTAGIS data base) (Table 2).

Table 2. Number of unique PIT tagged adults detected at Lapwai Creek in-stream arrays between July 1, 2014 through June 30, 2015 by species and rear type (Wild, Hatchery, Unknown) and by release site.

Release Site	Steelhead Wild	Steelhead Hatchery	Steelhead Unknown	Fall Chinook Hatchery	Fall Chinook Unknown	Coho Hatchery	Coho Unknown	Northern Pike Minnow	Unknown	Total
BCCAP				1						1
BONAFF			5		1					6
COLR3			1				1			2
KOOS						1				1
LAPC	2					34				36
LGRLDR	52	4								56
LGRRBR	4									4
LGRRRR	5									5
MISSC	2									2
ORPHAN									10	10
PRDLD1	7									7
SNAKE3								1		1
SWEETC	1									1
WEBBC	2									2
Total	75	4	6	1	1	35	1	1	10	134

Steelhead Detections

A total of 56 adult steelhead that were PIT tagged as adults at Lower Granite Dam (LGRLDR) were detected within Lapwai Creek for spawn year 2015 (Table 2). Of these, 52 were wild/natural and 4 hatchery (Table 2). In general, PIT tags from Lower Granite Dam (LGRLDR) are a representative sample of wild/natural steelhead adults passing Lower Granite Dam and therefore can be used to assess the wild/natural run of steelhead into Lapwai Creek that includes arrival timing at Lower Granite Dam, arrival timing into Lapwai Creek, residency time, and dip-in behavior.

Based on the LGRLDR adult PIT tags, the wild/natural adult steelhead that entered Lapwai creek arrived at Lower Granite Dam beginning in late-June 2014 through April of 2015 (Figure 1). Forty-six percent of Lapwai Creek steelhead crossed Lower Granite Dam in October, 2014 with approximately ten percent crossing Lower Granite Dam in the spring of 2015 (Figure 1). Arrival into Lapwai Creek began in December 2014 with the majority of the adults entering Lapwai Creek during February 2015 (Figure 1). In January, large discharge events attracted only a few adult steelhead into Lapwai Creek (Figure 2). Arrival of the majority of steelhead adults into Lapwai Creek coincided with an increase in stream discharge during early February (Figure 2). Detections during mid-March, April, and throughout May at the Lapwai Creek array were dominated by downstream passages indicating post spawn adults (Figure 2). Post spawn adult steelhead were observed passing the Lapwai Creek array from mid-March through the end of April (Figure 3). Both dip-ins and post spawn adults were observed at the Mission Creek array (Figure 4). The Sweetwater Creek array had both post spawn adult steelhead and dip-ins (Figure 5). Four PIT tagged wild/natural adult steelhead were observed crossing the Webb Creek array with one showing dip-in behavior.

The detection probability for all PIT tagged adult steelhead moving upstream at the Lapwai Creek was 1.0 and Mission creek arrays was 0.896 respectively. The detection probability for PIT tagged adult steelhead at the Sweetwater and Webb creek arrays was calculated to be 1.0. However, the operational status and operational time periods for the Sweetwater and Webb creek arrays were not assessed. It was assumed that the Sweetwater and Webb creek arrays operated normally and continuously over the entire time period of assessment. A violation of this assumption would result in an underestimate of PIT tagged adults entering Sweetwater and Webb creeks. The detection probability of downstream passages was not calculated but likely less than 1.0, therefore the number of dip-ins and post spawn adults may be underestimated. However, the available data suggest that 50 PIT tagged steelhead adults from the tagging effort at Lower Granite Dam entered and remained in Lapwai Creek for a preliminary estimated abundance of 375 wild/natural adults based on a 7.5 expansion factor (Table 3). The preliminary estimated abundance within Mission Creek was 83 wild/natural adults, 105 wild/natural adults within Sweetwater Creek, and 23 wild/natural adults within Webb Creek.

Table 3. The number of wild/natural Lower Granite Dam PIT tagged adult steelhead by array site detected moving upstream, the number leaving the site prior to spawning, the final number remaining upstream to spawn, and the approximate abundance by stream (7.5 expansion factor (1 / 0.133)).

Site	Upstream	Dip-ins	Final Upstream	Approximate abundance
Lapwai Creek	52	2	50	375
Mission Creek	12	1	11	83
Sweetwater	16	2	14	105
Webb Creek	4	1	3	23

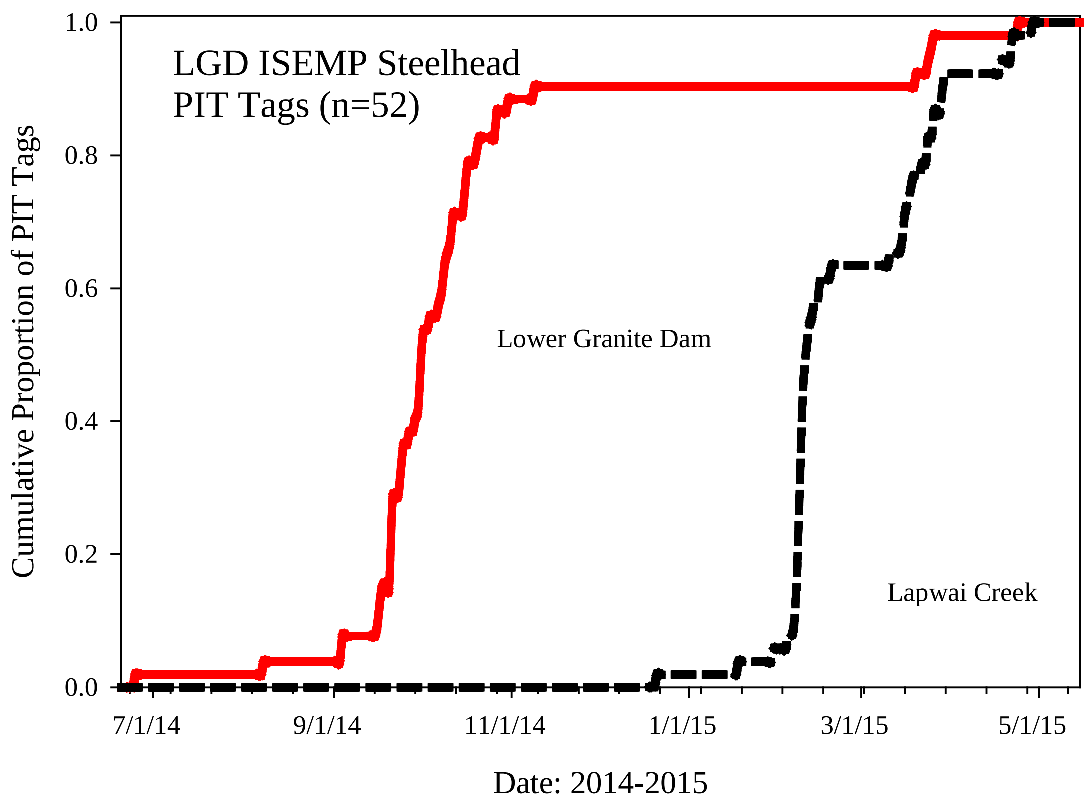

Figure 1. The cumulative proportion of Lower Granite Dam PIT tagged wild/natural adult steelhead by arrival date at the Lapwai Creek in-stream PIT tag array (dashed black line) and the date tagged and released at Lower Granite Dam (solid red line).

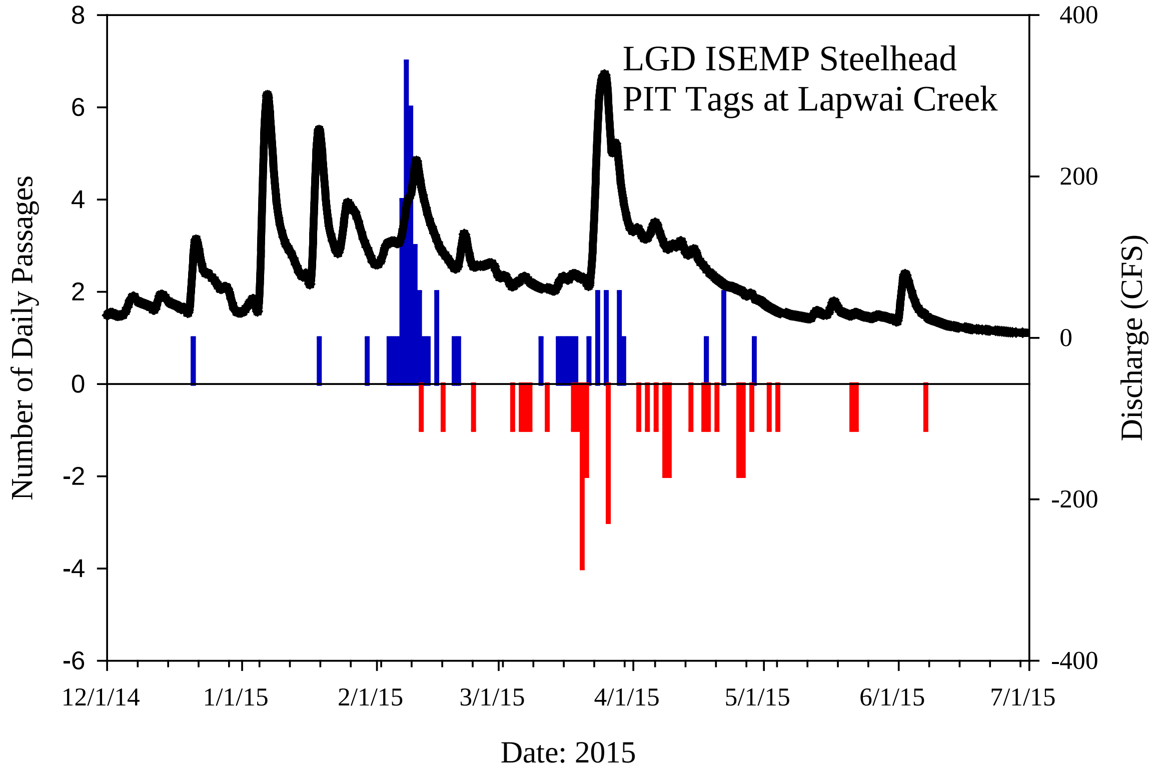

Figure 2. The number of observed upstream (positive blue bars) and downstream (negative red bars) daily passages of Lower Granite Dam PIT tagged wild/natural adult steelhead at the Lapwai Creek in-stream PIT tag array. Also shown is the Lapwai Creek discharge (cubic feet per second) (solid black line)(UGGS gaging station 13342450).

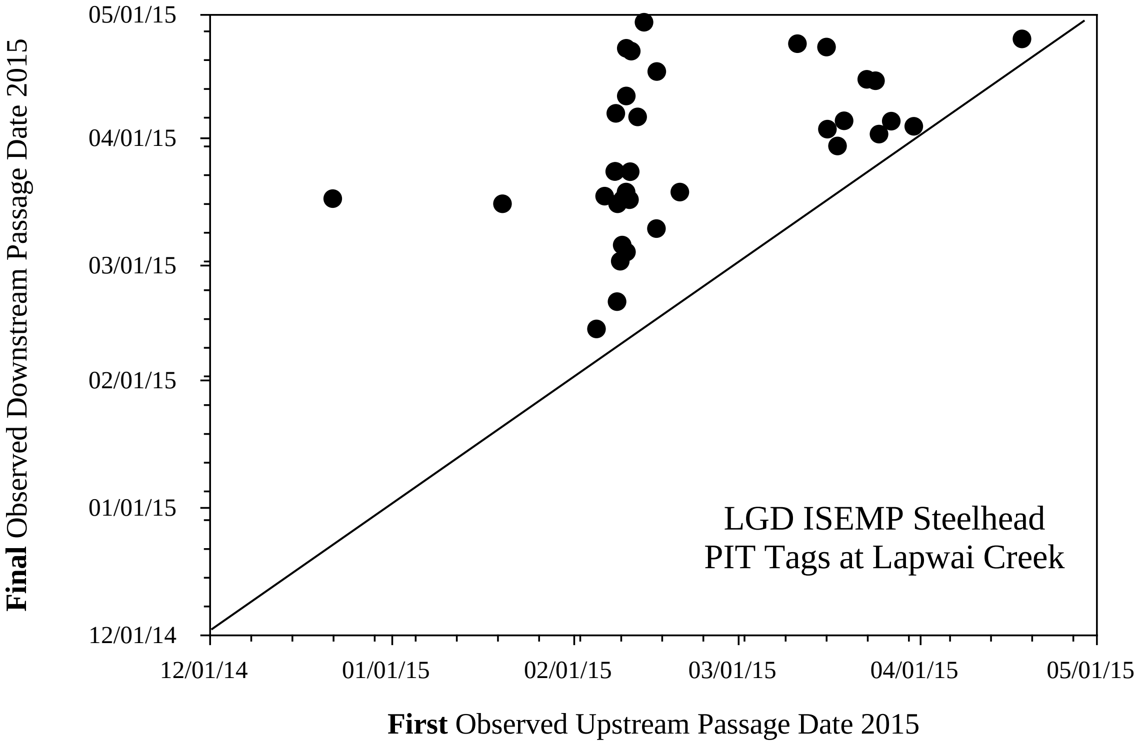

Figure 3. The first observed upstream passage (x-axis) and the final observed downstream passage (y-axis) of Lower Granite Dam PIT tagged wild/natural adult steelhead at the Lapwai Creek in-stream PIT tag array showing post spawn adults (above 1:1 line) and dip-ins (on or near the 1:1 line).

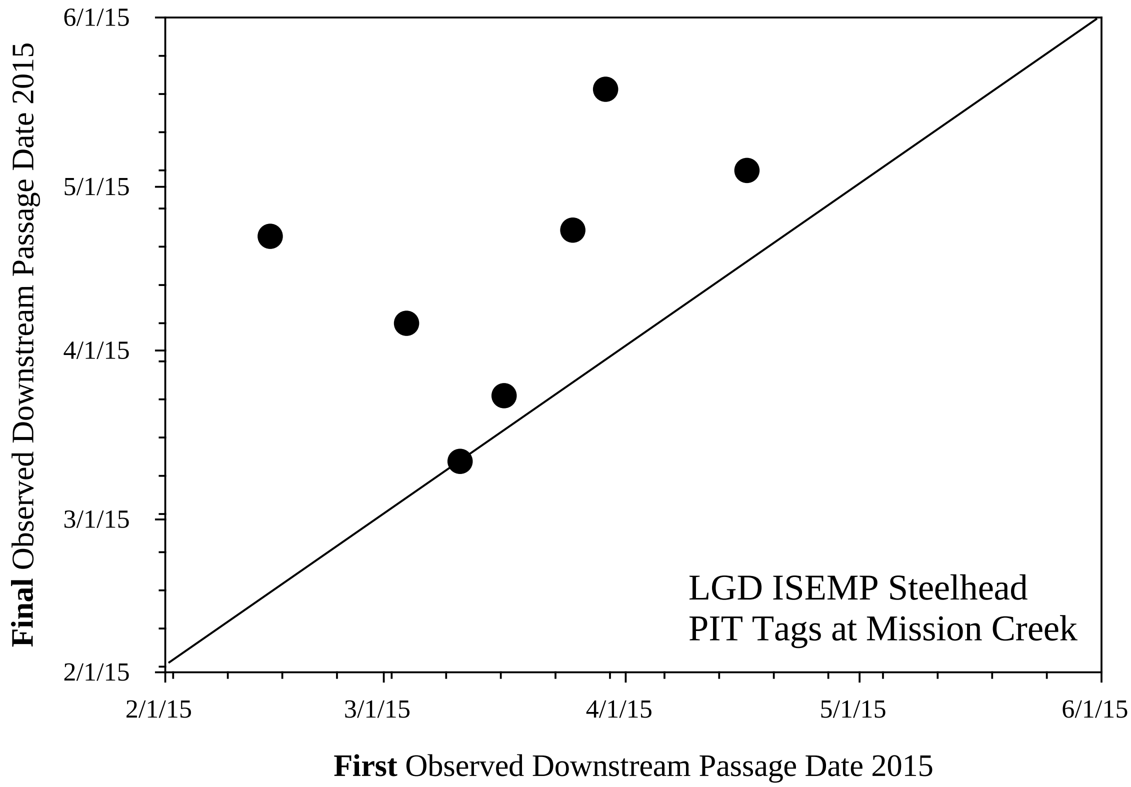

Figure 4. The first observed upstream passage (x-axis) and the final observed downstream passage (y-axis) of Lower Granite Dam PIT tagged wild/natural adult steelhead at the Mission Creek in-stream PIT tag array showing post spawn adults (above 1:1 line) and dip-ins (on or near the 1:1 line).

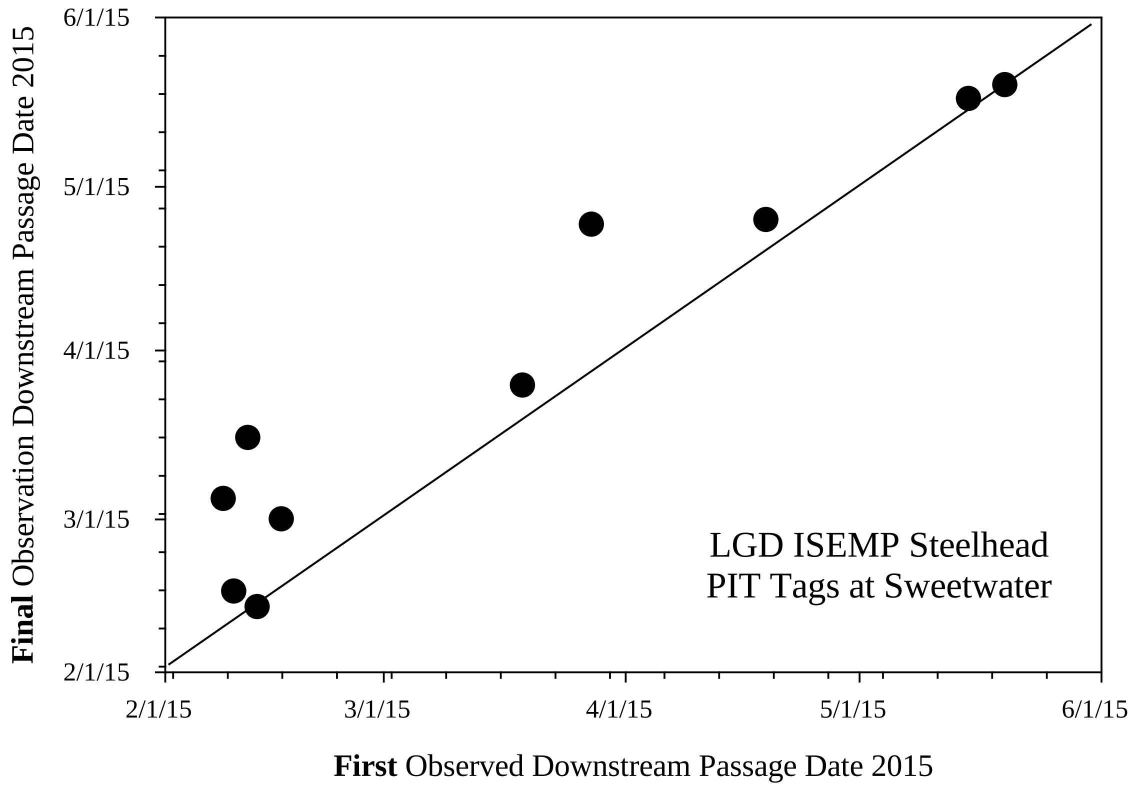

Figure 5. The first observed upstream passage (x-axis) and the final observed downstream passage (y-axis) of Lower Granite Dam PIT tagged wild/natural adult steelhead at the Sweetwater Creek in-stream PIT tag array showing post spawn adults (above 1:1 line) and dip-ins (on or near the 1:1 line).

Array Maintenance

The Lapwai Creek PIT tag array (LAP) operated continuously without disruption during the period of July 2014 through June of 2015. The Mission Creek array had zero downtime during the same time period.

APPENDIX D

LEWISTON ORCHARDS PROJECT
SWEETWATER AND WEBB CREEK
FLOW ALLOCATION ANALYSIS REPORT – JUNE 2015

RECLAMATION
Managing Water in the West

Lewiston Orchards Project Sweetwater and Webb Creek Flow Allocation Analysis Report

Lewiston, Idaho

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Snake River Area Office
Boise, Idaho

June 2015

U.S. DEPARTMENT OF THE INTERIOR

PROTECTING AMERICA'S GREAT OUTDOORS AND POWERING OUR FUTURE

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

MISSION OF THE BUREAU OF RECLAMATION

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Front cover photograph – Sweetwater Creek looking upstream from the Sweetwater Diversion on the Lewiston Orchards Project

RECLAMATION
Managing Water in the West

Lewiston Orchards Project Sweetwater and Webb Creek Flow Allocation Analysis Report

Lewiston, Idaho

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Snake River Area Office
Boise, Idaho

June 2015

Acronyms and Abbreviations

2010 Opinion	National Marine Fisheries Service 2010 Biological Opinion
BA	Biological Assessment
cfs	cubic feet per second
EFH	essential fish habitat
ESA	Endangered Species Act
ITS	Incidental Take Statement
LOID	Lewiston Orchards Irrigation District
LOP or Project	Lewiston Orchards Project
NMFS	National Oceanic and Atmospheric Administration National Marine Fisheries Service (also known as NOAA Fisheries)
NPT	Nez Perce Tribe
Reclamation	U.S. Bureau of Reclamation
RPM	Reasonable and prudent measures
UI	University of Idaho
USGS	U.S. Geological Survey
WUA	wetted usable area

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1. INTRODUCTION

The Bureau of Reclamation (Reclamation) initiated formal consultation with the National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS) under Section 7 (a)(2) of the Endangered Species Act (ESA) for the Lewiston Orchards Project (LOP or Project) to address impacts on ESA-listed species. The consultation was also a result of the remand and settlement agreement under Nez Perce Tribe v. NOAA Fisheries & Bureau of Reclamation (NPT et al. 2004).

In October 2009, Reclamation submitted a biological assessment (BA) to NMFS that described the future operation and routine maintenance of the Project. The BA included potential effects of the proposed action on threatened Snake River basin steelhead and its associated critical habitat, as well as on essential fish habitat (EFH) for Chinook and coho salmon.

On April 15, 2010, NMFS issued a biological opinion (2010 Opinion) to Reclamation for the operation and maintenance of the LOP in which it was determined that Reclamation's proposed action would not result in jeopardy, but would adversely affect the Snake River basin steelhead. The Opinion included an Incidental Take Statement (ITS) with Reasonable and Prudent Measures (RPM) and associated Terms and Conditions. The species considered in the Opinion were the Snake River basin steelhead, Snake River spring/summer Chinook salmon, Snake River fall Chinook salmon, and Snake River sockeye salmon. The remaining species do not consistently occur in Sweetwater, Webb, or Lapwai creeks, and the effects of the action are negligible outside the Captain John Creek and Lapwai Creek drainages.

RPM 5 of the ITS indicated "Reclamation shall determine the optimal flow allocation between Webb and Sweetwater creeks to maximize aggregate steelhead production, and adjust flows accordingly and in a manner consistent with [the] Opinion, as mutually agreed by LOlD, the Nez Perce Tribe, Reclamation, and NMFS. A completed study and report shall be submitted to NMFS no later than 4 years after the signing of this Opinion." The flow allocation identified in the proposed action and analyzed in the Opinion was determined with the best available scientific information at the time and represented the optimal allocation.

Following issuance of the 2010 Opinion, Reclamation issued a decision document which identified Reclamation's intended actions to carry out the activities identified in the Opinion and ITS. Reclamation also identified an approach to addressing the ITS requirements, including RPM's and Terms and Conditions set forth in the Opinion. As a result of the Opinion, Reclamation and University of Idaho (UI) research personnel conducted several years of monitoring, data collection, and detailed analysis starting in 2010. Research results were made available to Reclamation, and subsequent data analysis was completed in late 2014. Reclamation evaluated these results and made the best management decisions that the information allowed. This report includes a summary of the research and monitoring results including Reclamation's recommendations for flow allocation.

This completed report is based on the analysis and will be provided to NMFS consistent with the 2010 Opinion and the NMFS extension letter dated October 9, 2014. Reclamation conferred with other agencies (Nez Perce Tribe [NPT], Lewiston Orchards Irrigation District [LOID], NMFS) prior to making adjustments to the proposed action. The resulting decision, however, is based on the scientific data and the potential to maximize aggregate steelhead production within the Lapwai system.

2. BACKGROUND

LOP is an authorized water supply project located along the Clearwater River in northern Idaho (Figure 1) and is operated and maintained by the LOID. Project facilities and features were constructed by private interests from 1906 through 1934 to provide irrigation water supply to orchards near Lewiston, Idaho. As the facilities gradually fell into disrepair, LOID requested federal assistance to improve the Project. Under the Reclamation Project Act of July 31, 1946, Reclamation was authorized to construct and operate the Project, "...for the purposes of irrigating lands and the purposes thereto."

Project facilities are located in three basins, including some on the Nez Perce Reservation. These facilities include three small storage reservoirs (Soldiers Meadow, Lake Waha, and Reservoir A), four diversion structures (located on Captain John Creek, West Fork Sweetwater Creek, Webb Creek, and Sweetwater Creek), feeder canals and pipelines, and a domestic water system which is no longer used. All operation and maintenance activities for the Project facilities were transferred to the LOID according to the 1947 repayment contract. A complete description of Project facilities and their current operation may be found in Reclamation's 2009 *Biological Assessment for the Operation of the Lewiston Orchards Project, Idaho* (Reclamation 2009a).

The Project collects system drainage and alters the stream hydrology in Webb Creek, Sweetwater Creek, and Lapwai Creek. These streams run through the Nez Perce Reservation and are part of the treaty fisheries areas of the NPT. Snake River salmon and steelhead are a significant Tribal cultural resource and are important trust assets promised to the Tribe by the federal government. The Lapwai Creek drainage has historically been important to the Tribe and Sweetwater Creek was traditionally used for cultural and spiritual activities.

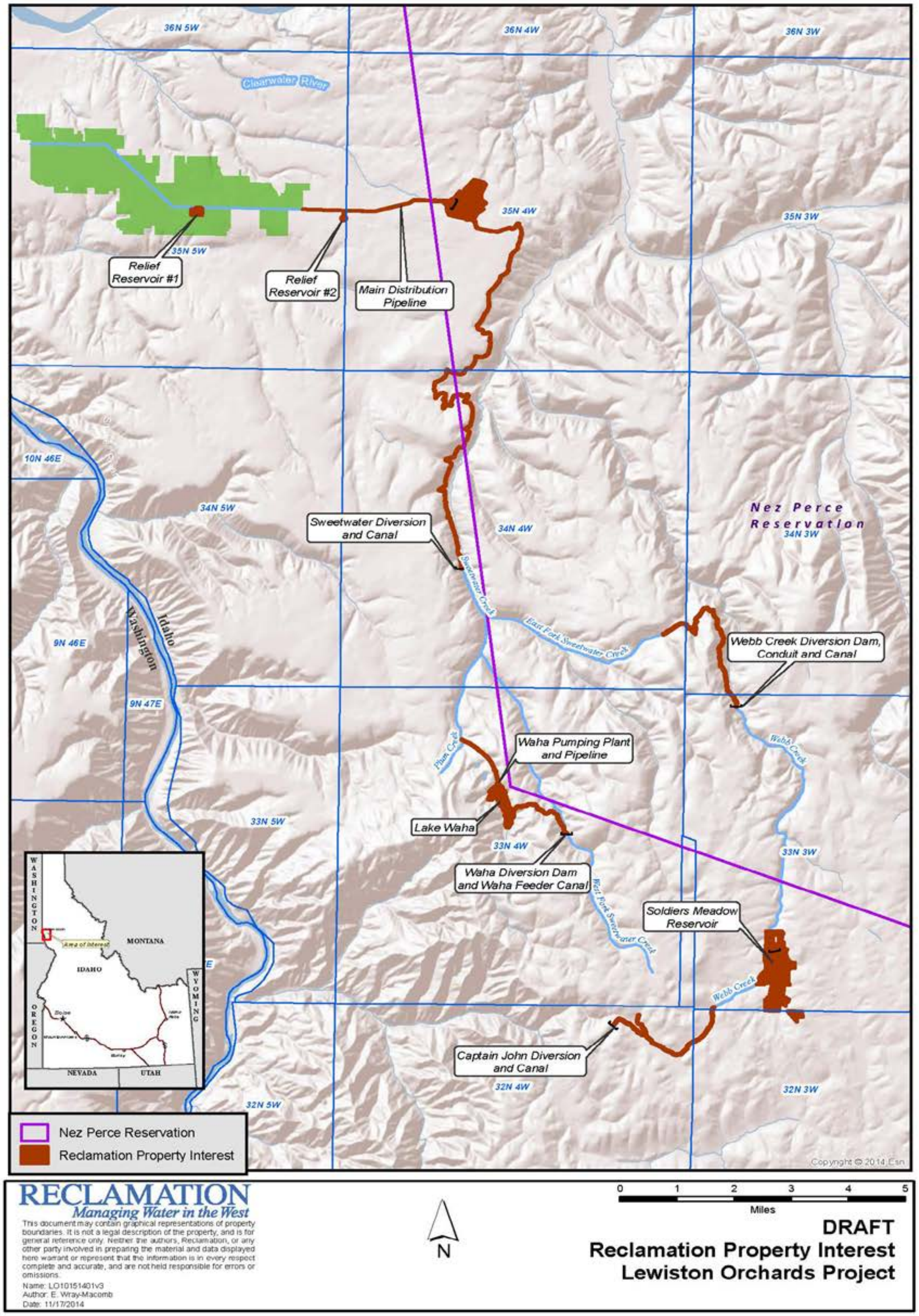

Figure 1. Location map of Lewiston Orchards Project and respective facilities.

3. PROJECT OVERVIEW AND OPERATIONS DESCRIPTION

The Project provides irrigation and domestic water supply to approximately 18,000 patrons in a 3,729-acre service area southeast of Lewiston, Idaho. This water supply is provided by storage and conveyance facilities developed in the Captain John Creek, Sweetwater Creek (including Webb Creek, the largest tributary of Sweetwater Creek), and Lindsay Creek basin.

When originally developed in 1906, the service area of the Project consisted primarily of fruit orchards. Presently, with residential areas expanding, more than 76 percent of the land within the LOID boundary is in ownership parcels of less than 2 acres, with parcels averaging 0.55 acre in size. The remaining 24 percent of the land in the District is in ownerships averaging less than 5 acres. Subdividing has occurred with the issuance of the Opinion and is expected to continue.

As noted earlier, authorized project facilities are located in the Captain John Creek, Sweetwater Creek, and Lindsay Creek basins and include:

- Four diversion structures located on Captain John Creek, West Fork Sweetwater Creek, Webb Creek, and Sweetwater Creek.
- Feeder canals and pipelines.
- Three storage reservoirs (Soldiers Meadow, Reservoir A, and Lake Waha).
- A domestic water system including a water filtration plant which is no longer in use. The domestic water supply which initially was provided by surface water resources now comes entirely from groundwater resources developed by LOID.
- A system for distribution of irrigation water.

The Captain John Creek basin is involved only via a small diversion dam in its headwaters, from which water is diverted each spring to the Sweetwater basin. With the exception of the Captain John Creek diversion, water supply for the Project is collected from the Sweetwater Creek basin (including Sweetwater Creek and its main tributary, Webb Creek), where Soldiers Meadow Reservoir, Lake Waha, and the diversion dams are located. From the Sweetwater Basin, water is diverted to Reservoir A in the Lindsay Creek basin.

System configuration within each basin is described below.

- **Captain John Creek Basin**: The Captain John diversion is located in a small basin at the headwaters of Captain John Creek. Water from this diversion is conveyed via canal and excavated channel to the watershed of Webb Creek, where it is stored in Soldiers Meadow Reservoir.

- **Sweetwater Basin – Webb Creek**: Water from the headwaters of Webb Creek (and the Captain John diversion) is stored in Soldiers Meadow Reservoir. From the reservoir, water is released into the natural Webb Creek channel, from which (approximately 6 miles downstream of the dam) it is diverted at the Webb Creek diversion dam and conveyed via the Webb Canal to East Fork Sweetwater Creek, and ultimately to the mainstem of Sweetwater Creek, where it is diverted into the Sweetwater Canal via the Sweetwater diversion dam.
- **Sweetwater Basin – Sweetwater Creek**: Water from West Fork Sweetwater Creek is diverted via West Fork diversion dam and the Waha Feeder Canal into Lake Waha, a natural lake with no natural outlet. Water stored in Lake Waha is pumped from the lake and conveyed to the mainstem of Sweetwater Creek via a pipeline and a tributary of West Fork Sweetwater Creek known as Forsman Draw. On the mainstem of Sweetwater Creek, the Sweetwater diversion dam feeds water to the Sweetwater Canal, which conveys the water supply out of the Sweetwater Creek basin into the Lindsay Creek basin.
- **Lindsay Creek Basin:** Water from the Sweetwater Creek basin (via the Sweetwater Canal) is stored in Reservoir A. From Reservoir A water is supplied directly to the LOID service area via pipeline and the Project distribution system.

System operations have not changed since the issuance of the 2010 Opinion and therefore are incorporated by reference. Detailed descriptions of system operations can be found in Reclamation 2010.

4. CURRENT FLOW ALLOCATION FRAMEWORK

RPM 1 of the 2010 Opinion requires LOP operations to bypass flows in Sweetwater and Webb Creeks. The bypass flows and respective allocations are based on life stage of the steelhead occupying the systems. The minimum daily bypass flows currently utilized for Sweetwater and Webb Creeks are shown in Table 1.

Table 1. Instream flow minimum releases cubic feet per second (cfs) for Sweetwater and Webb Creeks at their respective diversion dam sites (NMFS 2010).

Life Stage	Spawning			Juvenile Rearing							
Month	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept 1-15	Sept 16-30	Oct	Nov Dec Jan
Sweetwater Creek	7.8/I[b]	7.8/I	7.8	3.0	2.5	2.5	2.5	2.5	2.5	2.5	I[a]
Webb Creek	4.0/I[b]	4.0/I	4.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	I[a]

[a] During November, December, and January, all inflow (I) at Sweetwater and Webb Creeks diversion dams will be bypassed.
[b] During February and March, either the specified stream flow will be provided or all inflow (I) to the Sweetwater and Webb Creeks diversion dams will be bypassed, whichever is less.

The instream flow regime in Table 1 addresses all months of the year. These flows are used to support spawning conditions during February through April and juvenile rearing conditions from May through January. The LOP currently does not operate the Sweetwater and Webb diversion dams during November, December, and January; therefore, all instream flow reaching the dams is bypassed during those months. During February and March, if the inflows to either Sweetwater or Webb Creek diversion dams are below the specified minimum flow, the LOID bypasses all inflow (I) to that diversion dam until it reaches the specified targets prior to initiating diversions. In October the specified minimum flows are passed when the diversion dams are in operation. When the diversion dams are turned off for the season, all inflow is bypassed. For Webb Creek, the "I" flow is composed of all runoff from the watershed upstream of the diversion and below Soldiers Meadow Dam. For Sweetwater Creek, the "I" flow is composed of all runoff from the watershed upstream of the dam, except for any diversions occurring at the West Fork diversion which are being conveyed to Lake Waha (NMFS 2010).

In addition, Reclamation supplies additional juvenile rearing flows into Sweetwater and Webb Creek from June through mid-September, based on the combined storage in Soldiers Meadow Reservoir and Reservoir A, as assessed on June 1. The additional increments allocated for Sweetwater and Webb Creek, and the storage conditions under which they would occur, are shown in Table 2.

Table 2. Increments of additional juvenile rearing flow as a function of combined storage for June 1st through September 15th (NMFS 2010).

Combined Storage (af)	<3,800	3,900	4,000	4,100	4,200	>4,250
Sweetwater Creek (cfs)	+0	+0.5	+0.9	+1.0	+1.0	+1.0
Webb Creek (cfs)	+0	+0	+0	+0.3	+0.8	+1.0
Total Flow (cfs)	3.50	4.00	4.40	4.80	5.30	5.50

Additionally, in 2014 the NPT negotiated an additional 90 acre-feet of water to be supplied at their discretion in Sweetwater and Webb Creek to assist in juvenile rearing flows. Table 3 shows the total flows and timing required in Sweetwater and Webb Creeks, including the minimum flows, the additional incremental flows, and the negotiated 90 acre feet flows for 2014.

Table 3. Total flows required in Sweetwater and Webb Creek with the additional volume and mediated flows.

Life Stage	Spawning			Juvenile Rearing										
Month	Feb	Mar	Apr	May	Jun	Jul 1-15	Jul 15-18	Jul 18-31	Aug	Sep 1-11	Sep 12-15	Sep 16-30	Oct	Nov, Dec, Jan
Sweetwater Creek Base ByPass Flows	7.8*	7.8*	7.8	3.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	Bypass
Incremental Add-In	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	
Tribal Negotiated 90 AF 2011-2013 (1/28/11)	0.0	0.0	0.0	0.0	0.3	0.5	0.5	0.5	0.5	0.3	0.3	0.0	0.0	
Total Sweetwater Creek ByPass Flows	**7.8**	**7.8**	**7.8**	**3.0**	**3.8**	**4.0**	**4.0**	**4.0**	**4.0**	**3.8**	**3.8**	**2.5**	**2.5**	
Webb Creek Base ByPass Flows	4.0*	4.0*	4.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	Bypass
Incremental Add-In	0	0	0	0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	0	
Total Webb Creek ByPass Flows	**4.0**	**4.0**	**4.0**	**1.5**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**1.0**	**1.0**	

5. RESEARCH AND MONITORING SUMMARY RESULTS

5.1 Annual Temperature Monitoring

Reclamation has been collecting water temperature data in both Sweetwater Creek and Webb Creek since 2009. Figure 2 displays water temperature in Webb Creek at the mouth of the system for 2014. Seasonally, the Webb Creek system at the mouth reaches wintertime minimums in late February, and is often less than 0.1°C. The system gradually warms through the spring to early summer with a summer time average temperature of approximately 17.4°C. Summertime maximum temperatures average 19.96°C and reach the warmest temperature of approximately 22 to 27°C near the end of August. However, in 2014, summer maximums occurred on and around July 15. As is typically noted, temperatures at the mouth of Webb Creek are warmer in comparison with the temperatures from the pool above the Webb Diversion. The Webb Creek mouth site was approximately 3°C warmer than the Webb Diversion site in 2014.

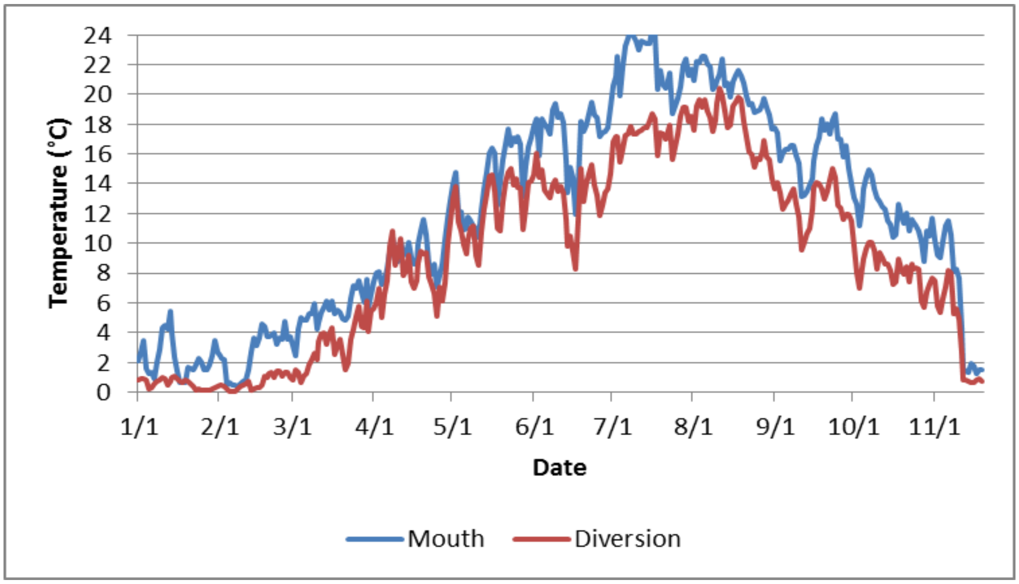

Figure 2. Maximum daily stream temperature (°C) measured near the mouth of Webb Creek and at the Webb Creek Diversion pool.

In addition, daily average variation at the Webb mouth site is typically high (Figure 3). Daily average temperature variation ranges from near 1°C in the winter up to nearly 8°C in July. From the data set it appears that 2010 and 2013 were much warmer than the remainder of the years. These high daily variations are very indicative of thermal loading from atmospheric sources.

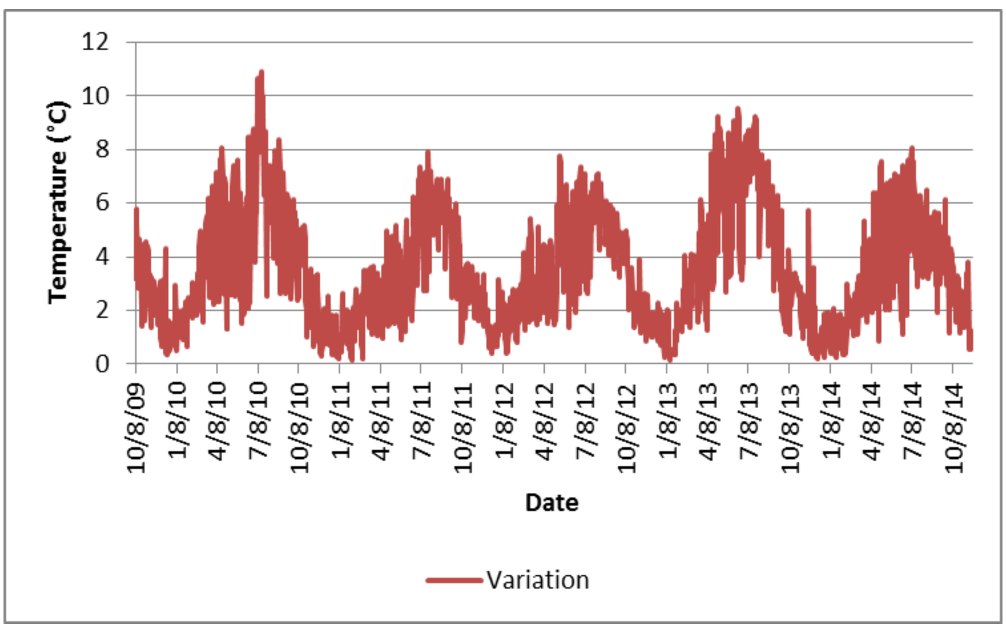

Figure 3. Minimum - maximum daily stream temperature variation (°C) measured near the mouth of Webb Creek from 2009 through 2014.

Temperature data collected from the mainstem Sweetwater Creek system from just below the confluence with Webb Creek is displayed in Figure 4. The data from this location provides an understanding of how Sweetwater Creek thermal regime is changed by the addition of Webb Creek water.

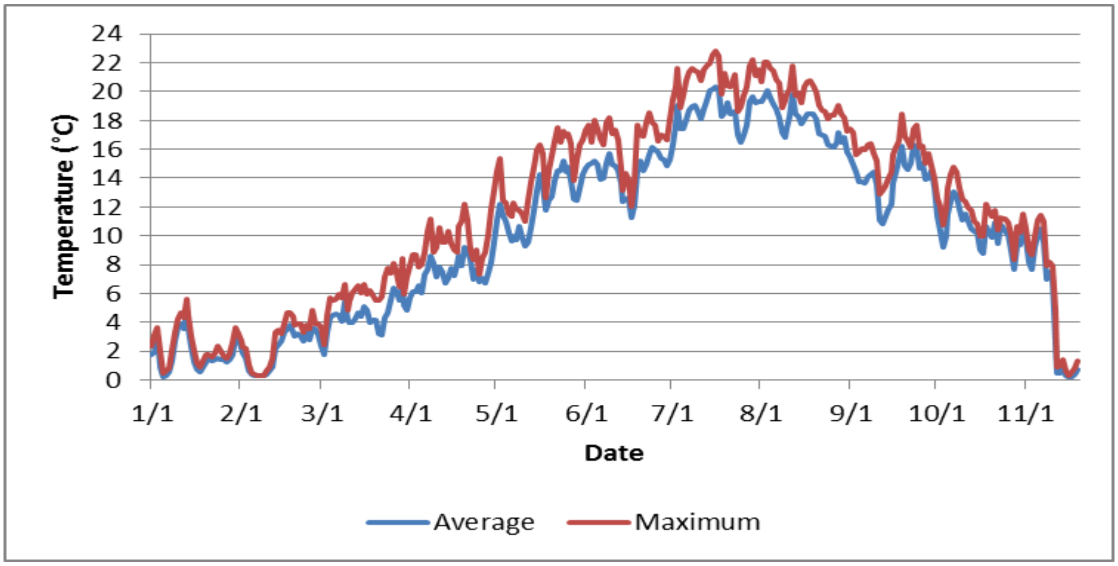

Figure 4. Mean and maximum daily stream temperature (°C) measured downstream from the Webb Creek confluence with Sweetwater Creek.

Some heat gain occurs between these two sites. Heat gain is more pronounced in the summer, as you progress from the upper Sweetwater Creek monitoring sites downstream to the lower temperature monitoring sites. The change averages approximately 1°C. While in November through February, the downstream site averages 0.5°C warmer than the upstream location. This slight warming is likely due to the effect of the smaller, warmer tributary, Webb Creek, entering the Sweetwater system.

In recent years this difference has become statistically significant. An analysis of variance indicates that the variance between the two locations is significantly different ($p \approx 0.0004$), while the slope and intercept of the regression analysis (as shown in Figure 5) remain nearly 1 and 0, respectively. The average annual temperature in Sweetwater Creek, downstream from the confluence with Webb Creek, is 10.09°C, while the average annual temperature from the upstream location is 9.92°C.

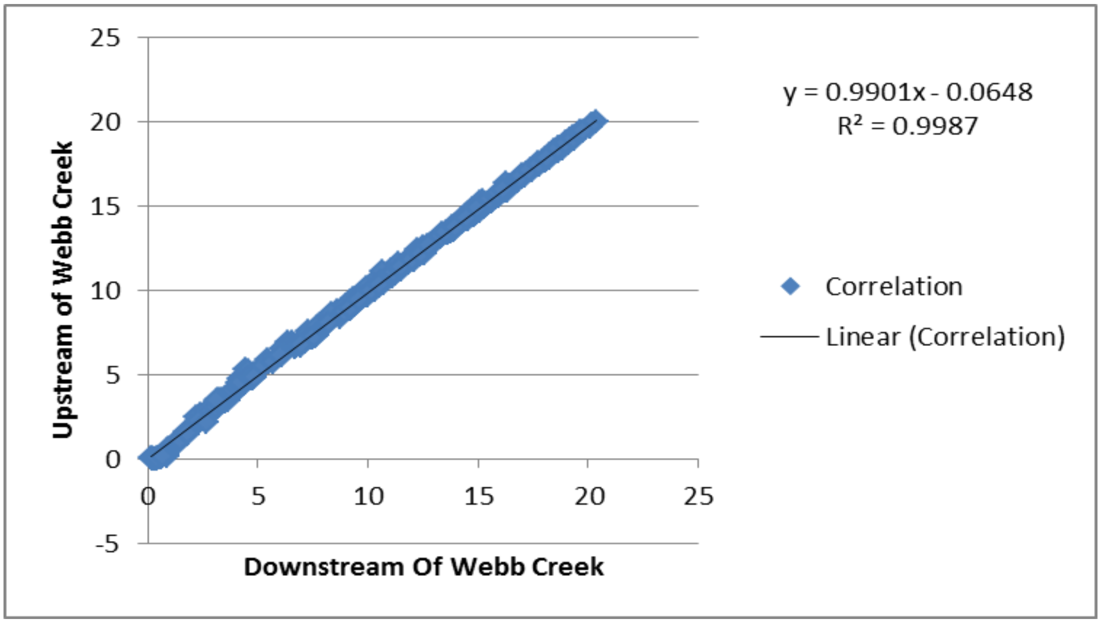

Figure 5. Correlation of mean daily stream temperature (°C) measured upstream and downstream from the Webb Creek confluence with Sweetwater Creek.

Based on temperature data collected from 2009 through 2014, Webb Creek, and Sweetwater Creek below the confluence with Webb Creek, would benefit by an increase in allocations of additional water to Webb Creek. An increase in flow allocation to Webb Creek may aid to reduce daily maximum temperatures during the juvenile rearing period, particularly the late July through August timeframe when thermal loading is at its greatest. Corresponding benefits to the Sweetwater Creek temperature regime during the juvenile rearing period can likewise be anticipated below the confluence of Webb and Sweetwater Creeks.

Flow Allocation Recommendation

Increase flow allocation to Webb Creek from June through September to improve temperature conditions in Webb Creek below the diversion and in Sweetwater Creek downstream of the confluence with Webb Creek.

5.2 Steelhead Bioenergetics

UI research personnel evaluated the relative importance of factors that can cause variation in growth rates in age-0 steelhead within the Lapwai basin. The researchers developed a series of models relating individual growth rate to density, discharge, flow velocity, and maintenance metabolic cost (as incurred by the temperature and the mass of the fish). The random intercept model developed showed a negative relationship between mass and growth rates. The model also showed the fraction of consumed energy allocated towards somatic growth was also negatively related to fish mass.

Among the models relating individual growth rate to density, discharge, flow velocity, and maintenance metabolic cost, the random intercept and slope model of metabolic cost was the single best approximating model. Because metabolic cost was such an important factor governing growth, how it related to temperature and fish mass was further analyzed. As a result of this analysis, the relationship between maintenance metabolic cost and the corresponding absolute ration showed that the consumption rates decreased with fish mass, however the associated ration sizes increased five-fold over the same size interval. The energetic demands incurred by site-specific temperature were overall the highest from mid-June to mid-September, with the difference in energetic demand being greater, later in the season.

The results of this research suggests that larger fish could not consume enough energy past keeping up with their maintenance metabolism, and that temperature appeared to be a more important factor in determining individual growth than were density, flow, and discharge. Therefore the effect of food limitation increased with fish size, primarily due to temperature-induced metabolic cost. System management actions designed to reduce daily maximum temperature, as well as diurnal variability, may serve to reduce this food-limitation effect in juvenile metabolic maintenance.

Flow Allocation Recommendation

Increase flow allocation to Webb Creek from June through September in an effort to reduce summer temperatures in Webb Creek to improve juvenile steelhead metabolic maintenance.

5.3 System Connectivity

Consistent with the 2010 Opinion, connectivity surveys were conducted by the UI in late July of 2011 and 2012 at select fish monitoring sites located in Sweetwater and Webb Creeks. Three sites on Webb Creek and four sites on Sweetwater Creek were surveyed (Figure 6; Table 4). The shallowest depth documented in Sweetwater Creek was 0.135 meters in 2011 at a flow of 4.29 cfs below the Sweetwater Diversion. The shallowest depth documented in Webb Creek during these surveys was 0.076 m in 2011 at a flow of 2.18 cfs below the Webb Diversion.

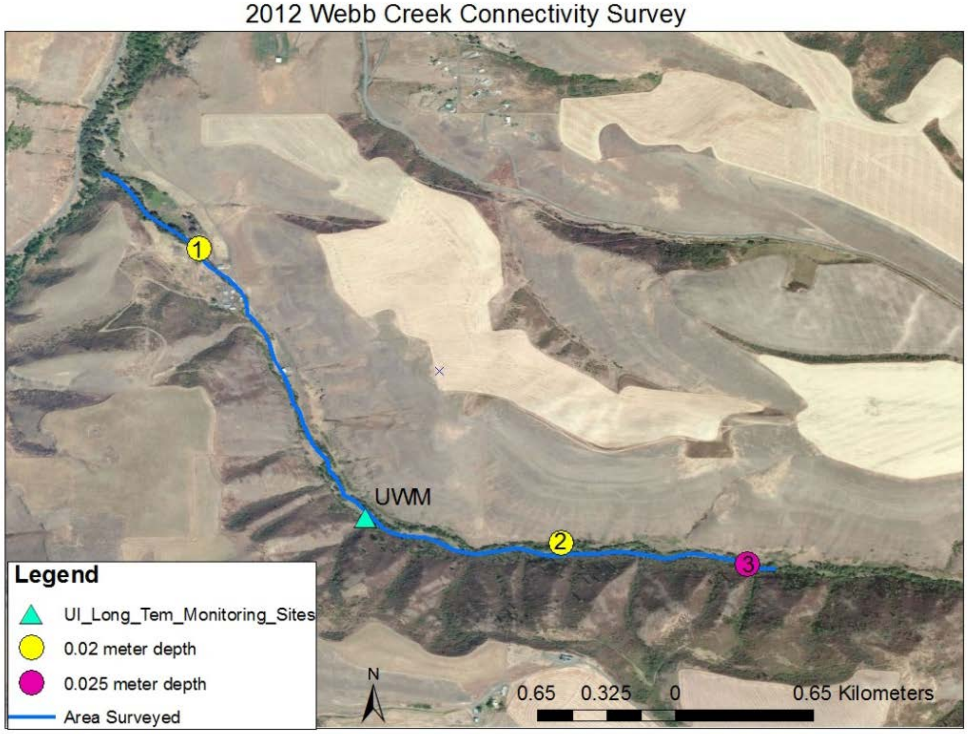

Figure 6. Map of walk through survey conducted on August 16, 2012 and locations of sites where thalweg depth was less than 0.05 meters on lower Webb Creek.

Table 4. Maximum depths in the shallowest cross section at each site surveyed by the University of Idaho in 2011 and 2012.

Stream	Site	Minimum Depth (m)
Sweetwater	LSX	0.135
Sweetwater	USL	0.15
Sweetwater	USM	0.135
Sweetwater	USU	0.15
Webb	UWL	0.11
Webb	UWM	0.076
Webb	UWU	0.12

Throughout the connectivity monitoring period, no connectivity issues were identified in Sweetwater Creek, so monitoring was discontinued following the 2012 effort. However, additional data gathering was necessary to better understand channel connectivity conditions in Webb Creek. Therefore, walk-through surveys were conducted on the lower 3.3 km of Webb Creek between the upper UI sampling site (UWU) and the mouth on August 16, 2012 and 2013. Locations where the thalweg (maximum) depth was less than 0.05 m were identified, photographed, and coordinates recorded using a handheld GPS. No areas of dewatered channel were documented at any of the areas surveyed in 2012 or 2013. Seven locations were identified in Webb Creek with a minimum thalweg depth less than 0.05 m with the shallowest being 0.01 m (Figures 6 and 7). All but one of these sites were located in areas where the channel split into separate flow paths. The individual shallow thalweg depths were limited to relatively short (<5 meter) features. Two of the three locations with thalweg depths less than 0.05 m in 2012 were again identified as issues in 2013. Photos taken at each site show a visible difference in depth between years (Photograph 1 and 2). Channel form had changed at the lower site from 2012, increasing the thalweg depth. A waterfall was also noted as a possible natural migration barrier (Photograph 3).

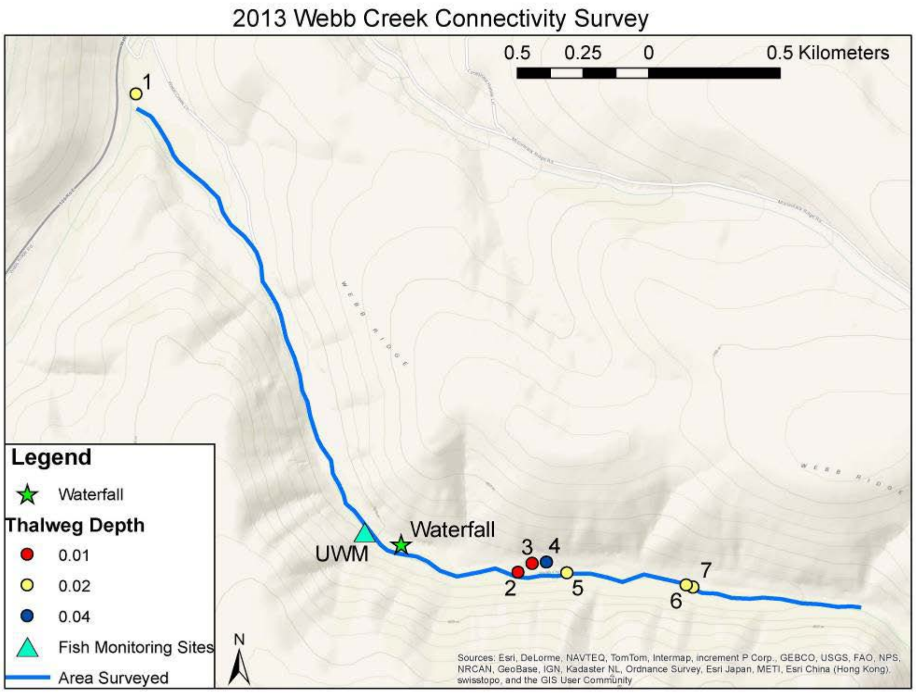

Figure 7. Map of walk through survey conducted on August 16, 2013 and locations of sites where thalweg depth was less than 0.05 meters on lower Webb Creek.

Photograph 1. Location 3 on Figure 6 and location 7 on Figure 7. August 16, 2013 with 1.15 cfs at the Webb Diversion. The stream flows toward the top of the photograph. The channel divides and some of the flow goes through the portion of the photograph circled. A 2-meter-long stadia rod is in right portion of picture for scale. (Reclamation photo taken by A. Prisciandaro).

Photograph 2. Same location as photo 1. August 16, 2012 with 2.58 cfs at the Webb Diversion. (Reclamation photo taken by A. Prisciandaro).

Photograph 3. August 16, 2013 with 1.15 cfs at the Webb Diversion showing a natural waterfall. (Reclamation photo taken by A. Prisciandaro).

No connectivity issues have been identified at Sweetwater at the current minimum flow management strategy, however, marginal connectivity issues for juvenile steelhead appears to exist in Webb Creek. Current connectivity survey data suggests increasing flows to Webb Creek would reduce current connectivity issues, thereby facilitating movement within the system by juvenile steelhead.

Flow Allocation Recommendation

An increase in flow allocation to Webb Creek, during all periods, should facilitate adult and juvenile steelhead movement into and within the system.

5.4 Steelhead Density-Flow Relationship, Metabolic Constraints and Flow-Based Habitat Availability

UI research personnel have been sampling steelhead in the Lapwai basin annually since 2008. Specific methods can be found in (Myrvold 2014). Sampling sites are distributed throughout the Lapwai basin in project-affected streams, as well as reference streams and are shown in Figure 8. Results have identified significant variability in juvenile steelhead densities across sites as well as between years and seasons within individual sites (Figure 9). Young of year (0+) steelhead were usually too small to be captured by the electrofishing gear during spring and early summer sampling events. However, apparent densities of 0+ steelhead typically increased as they attained larger sizes in the summer and then decreased in the fall sampling likely due to mortality and emigration.

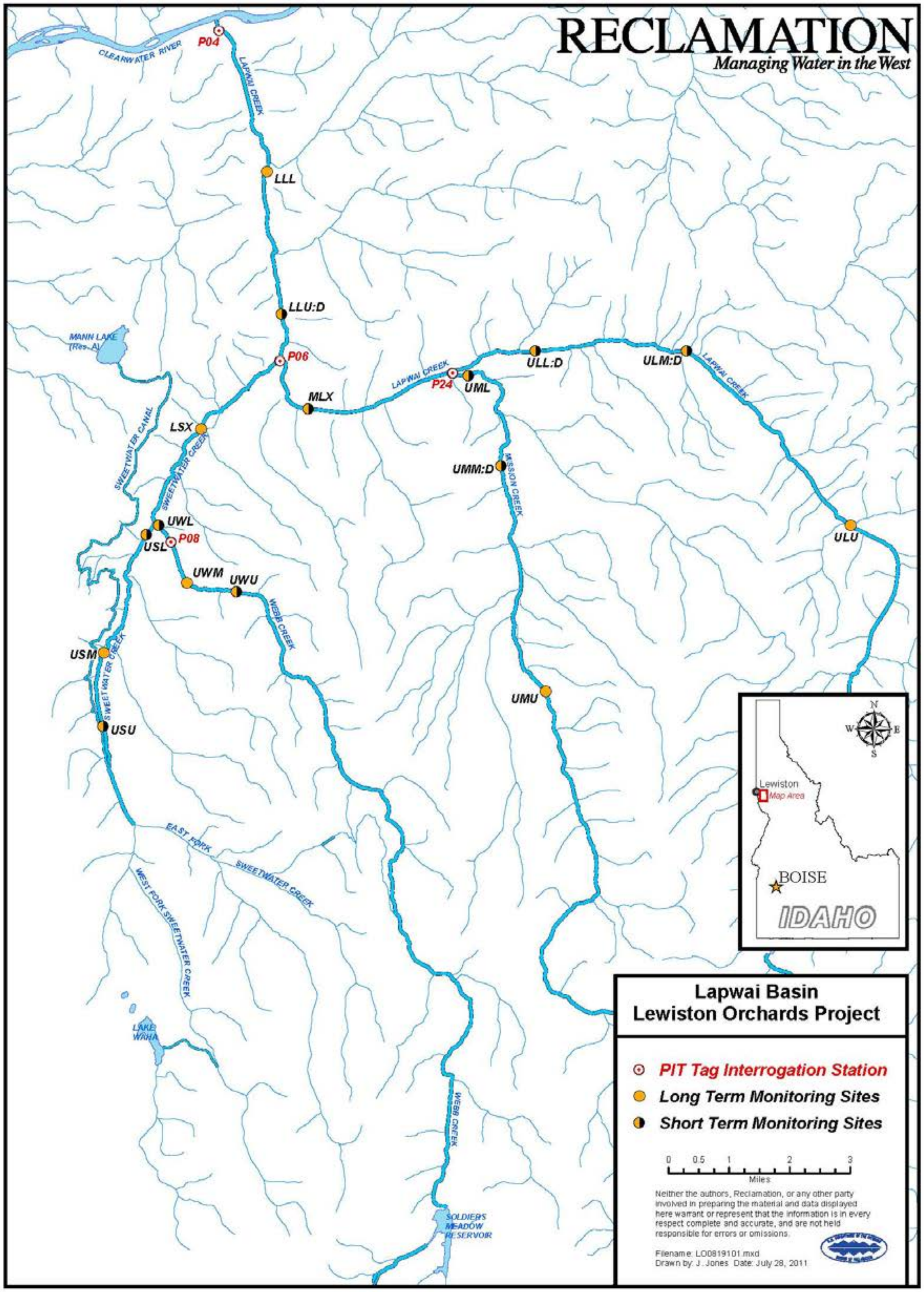

Figure 8. Sampling locations of steelhead monitoring sites in the Lapwai basin.

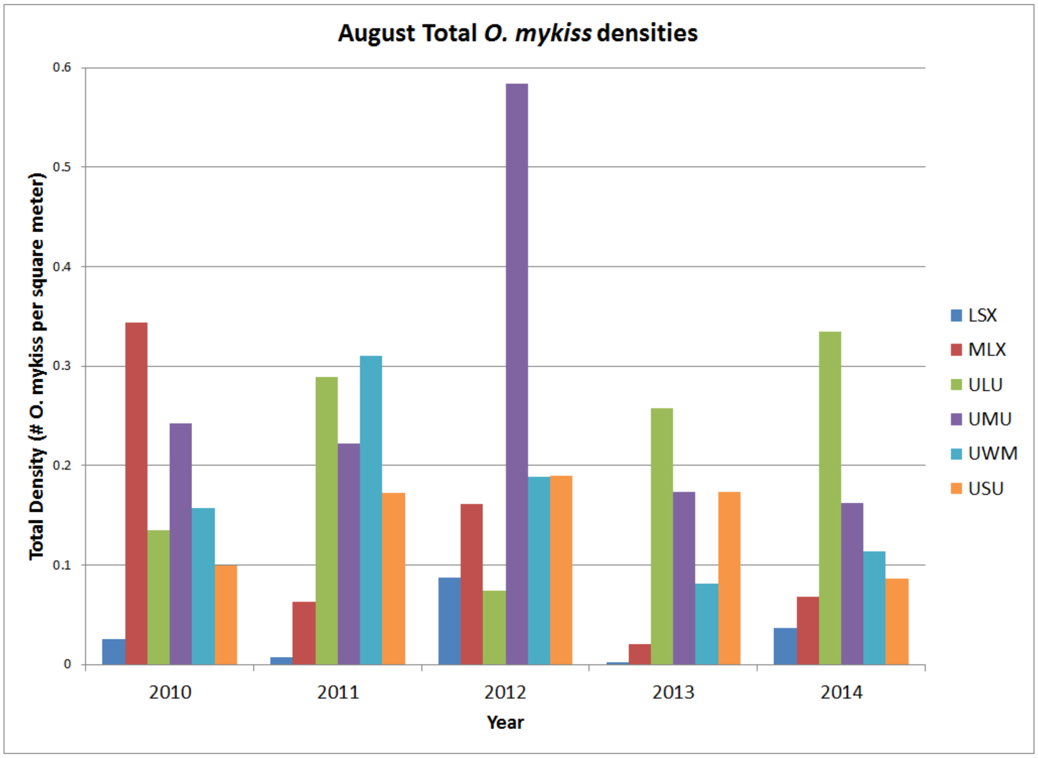

Figure 9. Total *O. mykiss* densities at 6 monitoring sites during August 2010 through 2013. Site codes are: LSX (lower Sweetwater), MLX (Lapwai below Mission), ULU (upper Lapwai), UMU (upper Mission), UWM (upper Webb), USU (upper Sweetwater).

Based on August sampling events, (once 0+ steelhead were large enough for efficient capture at all sites) no consistent pattern was discernable in total densities between sites or between years. Densities of 0+ steelhead were typically higher than 1+ steelhead during August. Across site variation was high from 2010 and 2014 with 4 different sites having the highest August density over the 5-year time frame (Figure 10). Within individual tributaries, higher elevation sites generally had higher densities and lower elevation sites generally had lower densities.

Inter-annual relationships between density and flows were documented in some of the tributaries. In general, densities of steelhead were higher in Webb Creek in years with higher flows (Figure 10; Table 5) with one exception in 2012. Water year 2012 (Figure 11) was characterized by high carryover from 2011, therefore summer base flows were the maximum required by the 2010 Opinion (depicted by the dotted line in Figure 11). Densities in 2012, however, were low in relation to other years with similar summer flows (Figure 12). This could be explained by the lower flows in May and early June prior to the slightly higher summer flow targets identified in 2012. This lower flow may have had negative impacts during the steelhead egg incubation/fry emergence period. The relationship between 0+ steelhead densities in August and September are more strongly related to mean June flows than minimum summer (July through September) flows (Table 5).

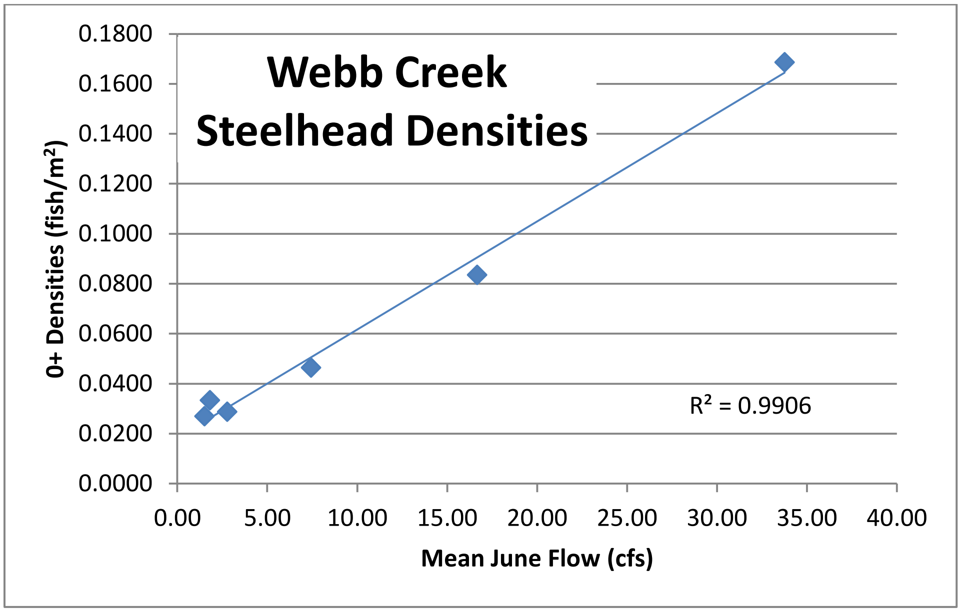

Figure 10. Inter-annual variation in 0+ steelhead densities in Webb Creek in relation to mean June streamflow.

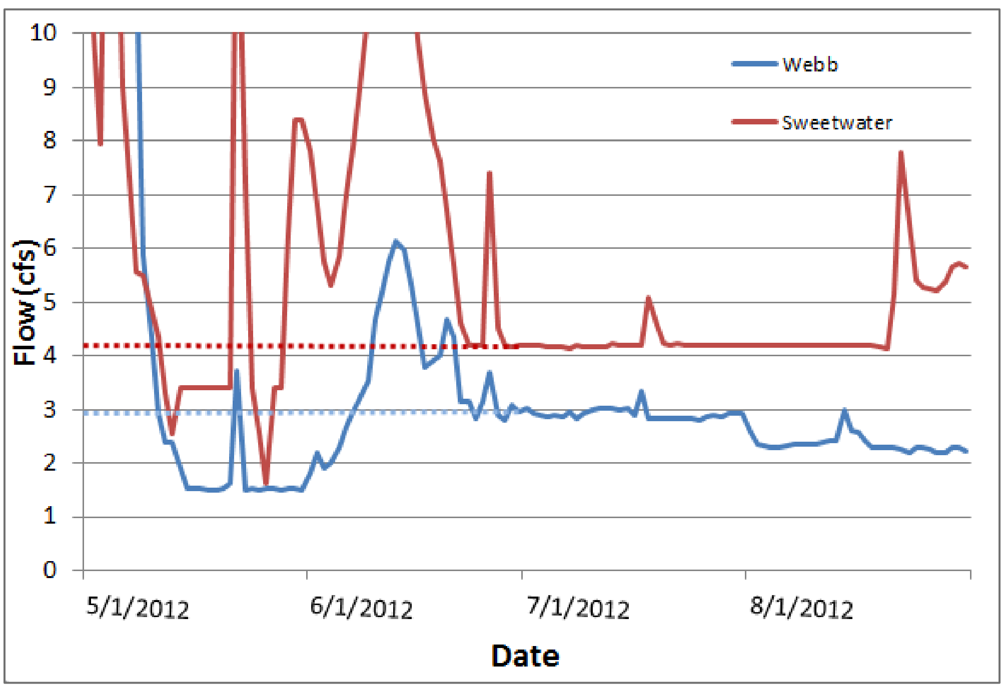

Figure 11. Hydrograph for Sweetwater and Webb Creek from May 1 through August 31, 2012. The dotted lines depict the juvenile rearing bypass flow targets utilized in 2012.

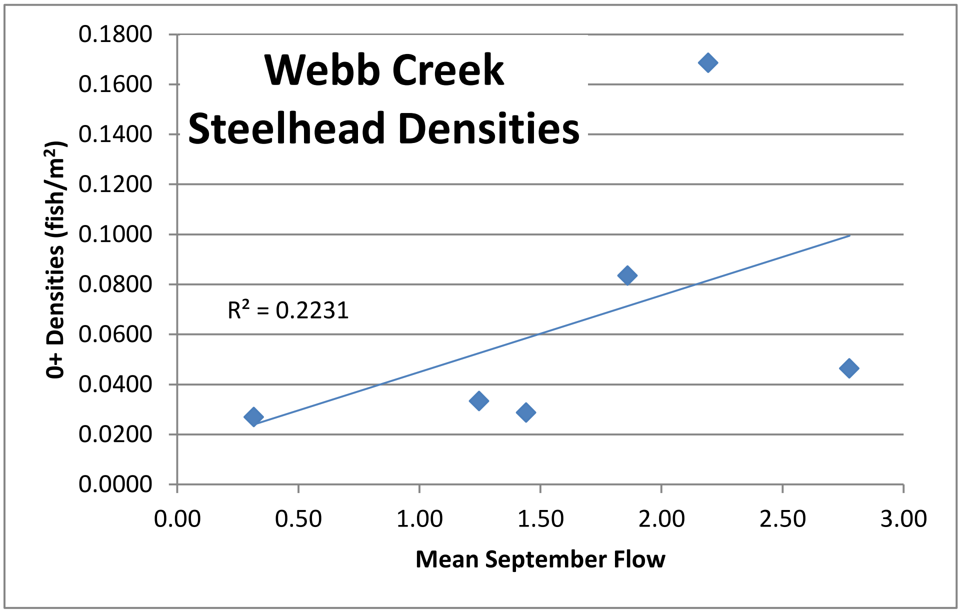

Figure 12. Inter-annual variation in 0+ steelhead densities in Webb Creek in relation to mean September streamflow. Water Year 2012 is identified as the outlier.

Table 5. P-values and correlations for steelhead densities in relation to a variety of flow variables from 2009 through 2014 in Webb Creek site UWM.

P<0.01	P-values				Correlation			
P<0.05	AugDensity.0	AugDensity.1	SeptDensity.0	SeptDensity.1	AugDensity.0	AugDensity.1	SeptDensity.0	SeptDensity.1
Mean.June	0.0007	0.3383	<.0001	0.1623	0.9789	0.4774	0.9953	0.65
Mean.June.1.15	0.0011	0.4295	0.0002	0.2269	0.9727	0.402	0.9881	0.5807
Mean.June.16.31	0.0109	0.1056	0.0068	0.0298	0.9136	0.7214	0.932	0.8554
Max.June	0.0118	0.7552	0.025	0.483	0.9098	0.1647	0.868	0.3603
Max.March1.June.30	0.0746	0.348	0.0297	0.1866	0.7678	0.469	0.8559	0.6228
Mean.July	0.1712	0.0313	0.2316	0.0069	0.6398	0.8519	0.576	0.9314
Mean.August	0.211	0.0879	0.3632	0.0373	0.5969	0.747	0.4562	0.8379
Mean.Sept.15.30	0.141	0.0621	0.2635	0.0406	0.6754	0.789	0.545	0.8306
Mean.Sept	0.1836	0.0872	0.3466	0.0472	0.6261	0.7481	0.4702	0.817
Max.March	0.149	0.1257	0.0923	0.0609	0.6657	0.6945	0.7405	0.7911
Max.April	0.157	0.2932	0.0712	0.1848	0.6561	0.5174	0.7735	0.6248
Min.June	0.2058	0.2681	0.2982	0.2334	-0.6023	-0.5406	-0.5128	-0.5741
Max.May	0.3696	0.7906	0.2761	0.5975	0.4508	0.1406	0.5331	0.2753
Sept/June.Flow	0.0885	0.9864	0.137	0.6365	-0.7461	-0.0091	-0.6803	-0.2474

Sweetwater Creek did not have the same density-flow relationships as observed in Webb Creek; and in some cases displayed opposite correlations than Webb Creek (Table 6). The strongest relationships between flows and densities was at the Upper Sweetwater Creek site (USU) and were observed between Maximum March flows and 0+ steelhead densities as well as mean August flows and 0+ steelhead densities. Even though none of the relationships between flow and 1+ steelhead densities were significant they all showed negative relationships where more water actually led to lower densities. This was the opposite of Webb Creek, where more water in late June through September correlated to significantly higher 1+ steelhead densities.

Table 6. P-values and correlations for steelhead densities in relation to a variety of flow variables from 2010 through 2014 in Sweetwater Creek site USU.

P<0.01	P-values				Correlation			
P<0.05	AugDensity.0	AugDensity.1	SeptDensity.0	SeptDensity.1	AugDensity.0	AugDensity.1	SeptDensity.0	SeptDensity.1
Mean.June	0.4803	0.3737	0.2118	0.6448	0.4209	-0.5158	0.6744	-0.2828
Mean.June.1.15	0.4493	0.379	0.2014	0.6026	0.448	-0.5109	0.6856	-0.3176
Mean.June.16.31	0.6076	0.3696	0.2679	0.8073	0.3134	-0.5195	0.6167	-0.1519
Max.June	0.5527	0.4002	0.2523	0.7433	0.3592	-0.4917	0.6324	-0.203
Max.March1.June.30	0.1642	0.355	0.1144	0.2027	0.7268	-0.533	0.7867	-0.6841
Mean.July	0.1118	0.3559	0.1344	0.1003	0.7901	-0.5322	0.7619	-0.805
Mean.August	0.0131	0.2321	0.0265	0.2237	0.9506	-0.653	0.9206	-0.6618
Mean.Sept.15.30	0.8012	0.5294	0.4546	0.5656	0.1567	-0.3789	0.4433	0.3484
Mean.Sept	0.2746	0.1859	0.0861	0.9443	0.61	-0.7025	0.8242	-0.0437
Max.March	0.0304	0.3975	0.0717	0.2279	0.913	-0.4942	0.8447	-0.6574
Max.April	0.1308	0.4684	0.1744	0.1453	0.7662	-0.4313	0.7152	-0.7488
Min.June	0.2058	0.2681	0.2982	0.2334	-0.6023	-0.5406	-0.5128	-0.5741
Max.May	0.1957	0.4745	0.1842	0.2003	0.6917	-0.426	0.7044	-0.6868
Sept/June.Flow	0.2912	0.2938	0.0891	0.7672	-0.5937	0.5911	-0.8201	0.1839

Additional flows are currently determined based on June 1 reservoir storage. This leads to lower minimum flow requirements during egg incubation and fry emergence period than summer rearing period, in some years. Although it is only a single data point (i.e., 1 out of 6 years), 2012 suggests that raising minimum flows in May/June may be needed to see the full potential of increased summer base flows on steelhead densities. Higher flows in Webb Creek are significantly correlated to higher densities of 0+ and 1+ steelhead and although not significant correlations, all of the flow variables for Sweetwater Creek correlated higher flows to lower densities of 1+ steelhead.

These inter-annual differences in flow in Webb Creek have a better correlation to steelhead densities than inter-annual differences in stream temperature. The only relationship identified between densities in Webb Creek and inter-annual differences in temperature were for May and early June, where higher temperatures in these months lead to lower 0+ steelhead densities later in the year. Densities of juvenile steelhead in Sweetwater Creek were correlated to more temperature variables, but still early season temperature had a higher influence on densities of 0+ and 1+ steelhead later in the summer (Figure 13).

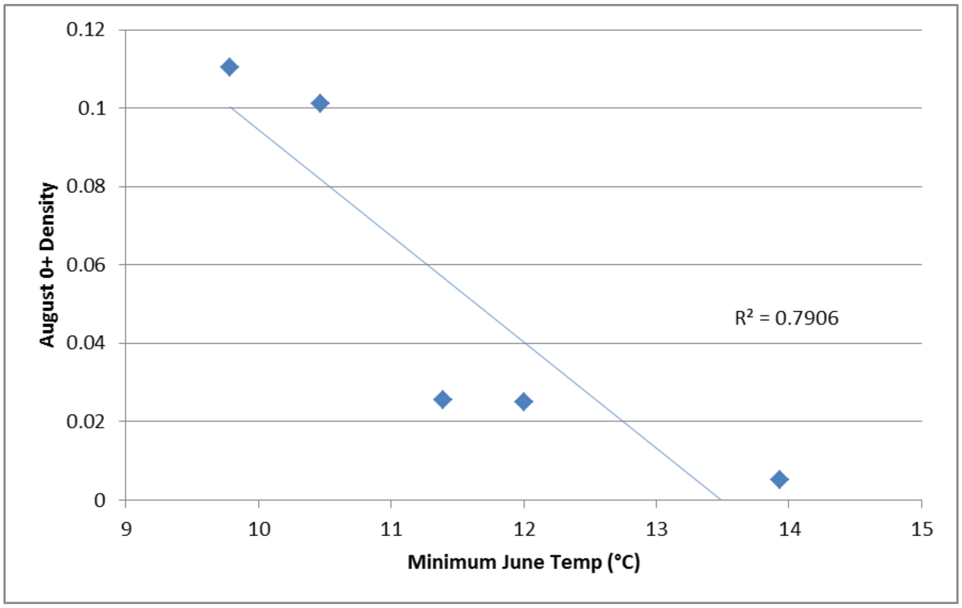

Figure 13. Inter-annual variation in 0+ steelhead densities in Sweetwater Creek in relation to minimum June water temperature.

Growth rates were influenced both by water temperature as well as density of steelhead at individual sites. Lower water temperature allowed for higher growth rates as feeding rates could keep up with increases in metabolism. Some fish at the warmer sites however lost mass during peak summer temperatures because of the increased metabolic costs. Growth rates of 0+ steelhead were depressed with increasing densities of 1+ steelhead, but growth rates of 1+ steelhead were not influenced by densities of 0+ fish.

The *Lewiston Orchards Project Instream Flow Assessment for Sweetwater and Webb Creeks* (Reclamation 2009b) shows that juvenile rearing habitat in Sweetwater Creek at current minimum flows of 2.5cfs would provide approximately 70 percent of the maximum possible wetted usable area (WUA) for juvenile rearing. Current minimum flows of 1cfs at Webb Creek would provide 60 percent WUA. An increase of 1 cfs over current minimum flows would add 5 percent to the WUA of Sweetwater Creek or nearly 20 percent to Webb Creek.

Upstream from the confluence of Webb and Sweetwater Creeks there is a longer distance of usable habitat in Webb Creek than in Sweetwater Creek. Webb Creek provides 11.75 km of habitat from its mouth up to a waterfall barrier that is likely impassable for at least juveniles. Another 3.7 km upstream from this waterfall may be accessible to adults before a higher waterfall likely limits further upstream migration. Sweetwater Creek upstream of the confluence with Webb Creek provides 7.23 km of habitat up to the diversion dam. Even though Sweetwater creek may be wider, it only has 62 percent as much linear distance accessible to juveniles as Webb Creek. Even though Webb Creek is the smaller drainage, the average width at the three UI fish sampling sites is wider (mean=3.7m) than the three sampling sites on Sweetwater Creek above the confluence with Webb (mean=3.1m).

Utilizing Reclamation's PHABSIM data report, at the lowest model-calibration flows (1.2 cfs for Webb and 2.9 cfs for Sweetwater), Webb Creek has a mean width of 1.2 m and Sweetwater Creek has a mean width of 2.9 m, with Webb Creek having 11.75 km of accessible habitat and Sweetwater Creek having 7.23km. At this minimum model-calibration flow, Webb Creek provides 0.135 km2 and Sweetwater Creek provides 0.078 km2 of usable habitat. Therefore Webb Creek provides approximately 1.75 times more habitat than Sweetwater at the same model-calibration flow. An increase from base flow (i.e., 1.2 cfs) of 1 cfs in Webb Creek provides 0.027 km2 of usable habitat and an increase from base flow (i.e., 2.9 cfs) of 1 cfs in Sweetwater Creek provides only 0.0085 km2 of usable habitat. A one cfs increase in each of the streams results in 3.15 times more additional usable area in Webb Creek compared to Sweetwater Creek. Based on the PHABSIM results alone, the 1st three 1cfs increases (1 cfs allocations 1-3) above base flows would each provide more wetted usable area in Webb Creek than just the first 1cfs increase over base flows in Sweetwater Creek. The next 3 cfs available (1 cfs allocations 4-6) would be more beneficial in Sweetwater creek and the last three cfs would go back to Webb Creek (1 cfs allocations 7-9). Flows beyond 9 cfs were not evaluated for the purpose of this report.

Flow Allocation Recommendation

Increase flows in both Sweetwater and Webb Creeks from May through September, as opposed to June through September, to ensure transition between flood releases and managed releases. Avoid the 'dip' in the hydrograph between flood releases and managed releases. Additional water should be allocated to Webb Creek relative to Sweetwater Creek due to the high per cfs gain in habitat in Webb relative to Sweetwater. Model output indicates Webb Creek would benefit most from the first 3 cfs, with the next 3 cfs going to Sweetwater and next 3 cfs back to Webb.

6. CONCLUSION

Flow allocation recommendations identified in this report are based on data collected by Reclamation since 2008 and UI since 2008. Data suggest, prior to making respective flow allocation recommendations, initial diversion operations to provide base-flow requirements need to be managed in conjunction with the final passing of flood/spring runoff flows in such a way so as to avoid the mid May to early June 'dip' in the hydrograph, which occurred in 2012 and as shown in Figure 11. Transitioning to, and not below, juvenile rearing base-flow requirements will reduce potential impacts to incubating and emerging steelhead by reducing the likelihood of stranding and/or desiccating eggs and/or fry, or reducing flows to such a degree so as to adversely impact redds and emerging fry.

Reclamation, through this analysis, does not recommend any changes to the base bypass flows identified in the Opinion and displayed in Table 3. Additionally, Reclamation does not recommend any changes be made to the ramping rates identified in the Opinion. However, based upon final review of current and relevant data, Reclamation recommends changes be made to the current incremental increase and subsequent allocation of flows to Sweetwater and Webb Creeks, based upon the June 1 combined storage of Mann Lake and Soldiers Meadows Reservoirs. The change includes allocating all available incremental increases to Webb Creek (Table 7). This determination is made for current operations under the current LOP system management paradigm. It does not take into account possible future water made available associated with Reclamation's ongoing LOP Water Exchange/Title Transfer Project.

Table 7. Flow allocation recommendations based upon June 1 combined storage at Mann Lake and Soldiers Meadow Reservoirs.

Combined Storage – June 1 (Mann Lake & Soldiers Meadow)	<3,800	3,900	4,000	4,100	4,200	>4,250
Sweetwater Creek Incremental Increase	0.0	0.0	0.0	0.0	0.0	0.0
Webb Creek Incremental Increase	0.0	0.5	0.9	1.3	1.8	2.0

The recommended allocations identified in Table 7 are based on current and relevant data collected within the Lapwai basin during the past 7 years. Data is collected annually within the Lapwai basin by UI, Reclamation, and NPT fisheries personnel. Future recommendations may be made based upon new and relevant data and collaboration with NPT, LOID, and UI fisheries personnel.

7. LITERATURE CITED

Parenthetical Reference	Bibliographic Citation
Myrvold 2014	Myrvold, Knut Marius. 2014. *The Ecology of Juvenile Steelhead (Oncorhynchus Mykiss): Determinants of Population Dynamics and Individual Performance across a Heterogeneous Stream Environment*. Dissertation – College of Graduate Studies, University of Idaho. May 2014.
NMFS 2010	National Marine Fisheries Service. 2010. *Endangered Species Act Section 7 Formal Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the Operation and Maintenance of the Lewiston Orchards Project, Snake River Basin for Steelhead, Snake River spring/summer Chinook Salmon, Snake River Fall Chinook Salmon, and Snake River sockeye Salmon in Sweetwater, Webb, Lapwai, and Captain John Creeks. National Marine Fisheries Service. April 15, 2010.*
NPT et al. 2004	Nez Perce Tribe et al. 2004 *Nez Perce Settlement Agreement Summary.* Nez Perce Tribe. State of Idaho. United States of America. Department of the Interior. May.
Reclamation 2009a	U.S. Bureau of Reclamation. 2009a. *Final Biological Assessment for Operation of the Lewiston Orchards Project, Idaho*. Pacific Northwest Region. Snake River Area. Boise, Idaho. October 2009 Final – Corrected January 2010.
Reclamation 2009b	U.S. Bureau of Reclamation. 2009b. *Lewiston Orchards Project Instream Flow Assessment for Sweetwater and Webb Creek*. Boise, Idaho. May 2009.

Appendix

APPENDIX A

THE ECOLOGY OF JUVENILE STEELHEAD (*ONCORHYNCHUS MYKISS*): DETERMINANTS OF POPULATION DYNAMICS AND INDIVIDUAL PERFORMANCE ACROSS A HETEROGENEOUS STREAM ENVIRONMENT

(This file is included as a CD at the back of this report)