Evaluate the Life History of Native Salmonids in the Malheur Subbasin

Burns Paiute Tribe, Natural Resources Department, Fisheries Program

Project 1997-019-00, Contract # 67693

For work completed 01/15-12/15

FY2015 Annual Report

Prepared for

Bonneville Power Administration

Northwest Power and Conservation Council

Background and Context for FY2015 Annual Report

In FY2015 the Burns Paiute Tribe Natural Resources Department Fisheries Program (BPT) completed multiple complementary statements of work via funding through Bonneville Power Administration (BPA) Project 1997-019-00 and two additional federal contracts. In this Annual Report, we summarize data collection completed under all contracts in the 2015 field season, since these were all related to the goals and objectives of 1997-019-00. All goals and objectives for Project 1997-019-00 were approved by the Northwest Power and Conservation Council (NPCC) during the 2011-2012 Categorical Review of Resident Fish Projects for FY2013-FY2017.

Primarily, the BPT Fisheries Program seeks to protect, restore and enhance native fish species assemblages in the Malheur River with an emphasis on ESA-listed bull trout as a focal species. During the approved five year period for Project 1997-019-00, the Fisheries Program has focused on the removal of nonnative brook trout. Brook trout have been identified as the primary limiting factor to bull trout recovery in the Upper Malheur River in both the 2002 and 2015 ESA Recovery Plans for this species. In order to accomplish the goal of suppression on the appropriate geographic and temporal scales, BPT conducts extensive coordination with state and federal land management agencies in efforts to implement multi-jurisdictional actions.

Coordination efforts were central to the FY2015 SOW and comprise the majority of in kind contributions to 1997-019-00. In January 2013, at the Malheur River Bull Trout Meeting hosted annually by BPT, an interagency Malheur River Bull Trout Technical Advisory Committee (TAC) was formed. This group met monthly throughout 2015, to prioritize bull trout recovery actions in the Upper Malheur River Watershed and to identify strategies toward implementation of these actions, relying upon leverage of respective authorities and jurisdictions to design landscape scale actions. The 2015 the TAC consisted of BPT, U.S. Forest Service (USFS), Oregon Department of Fish and Wildlife, U.S. Fish and Wildlife Service (USFWS), U.S. Bureau of Reclamation (USBR), and the U.S. Bureau of Land Management. The TAC continues to meet at minimum quarterly, with the purpose of advancing bull trout recovery actions in the Upper Malheur and North Fork Malheur River watersheds.

The TAC is integral in long-term implementation of bull trout recovery actions, and in maximizing benefit to bull trout by encouraging the simultaneous implementation of both fisheries and land management actions. Most notably in 2015, the TAC begun drafting the "Malheur River Bull Trout Conservation Implementation Plan" scheduled for preliminary release in the fall of 2016. This planning process began after the Annual Bull Trout Meeting in Burns on March 17th-18th.

Other changes in 2015 include a ramping of youth education and outreach efforts within the Burns Paiute Tribal community. Through a pilot program funded by BPA, the Fisheries Program hosted a multi-day youth trip from August 18th to August 21st. During this trip, youth, elders and staff visited the Columbia River Estuary, Portland (including the Oregon Museum of Science and Industry and the Oregon Zoo), and Bonneville Dam and Hatchery. Youth ages middle and high school participated on this trip, with the purpose of learning about the effects of dams on fishery resources, with special emphasis on the historic path of salmon through the Columbia and Snake Rivers and into the Malheur River. Day trips were also implemented throughout the summer to generate interest in local fishing areas and primarily included elementary school youth. Additionally, on July 13th the Fisheries Program participated in the local 4-H camp in Logan Valley by hosting electrofishing and macroinvertebrate capture and identification activities. The Fisheries Program plans to continue this type of outreach, in conjunction with the TAC, to contribute to nation building activities within this community.

The BPA Statement of Work (SOW) for FY2015 included the third year of continuous electrofishing removal of brook trout in Lake Creek (Chapter 1); continuous temperature monitoring on the Logan Valley Wildlife Mitigation Property (Chapter 2), and interagency coordination to develop a long-term brook trout removal strategy for Malheur River headwaters. USFWS Tribal Wildlife Grant funding was utilized to collect baseline data on amphibians (Chapter 3) and macroinvertebrates (Chapter 4) in anticipation of the possible transition from mechanical removal of brook trout to piscicide treatment. USBR Native Affairs funding was utilized to further advance the use of eDNA to reliably detect brook trout presence (Chapter 5).

Unforeseen and uncontrollable events that occurred during 2015 and which affected Fisheries Program operations in FY2015:

- A major wildfire (Canyon Creek Complex) precluded completion of many contracts and 1997-019-00 Work Elements from mid-August until snowfall, either due directly to fire activity or area closures post-fire.
- Most unfortunately, sometime during the night of April 21st, 2015, the Burns Paiute Tribe IT department burned at a total loss due to an electrical fire.

One additional federal contract with a data collection component were held by the Fisheries Program to support the FY2015 SOW for 197-019-00, but these factors affected its completion:

- Collaborative Forest Landscape Restoration Plan (CFLR) funds were awarded to the USFS Malheur National Forest (MNF) and subsequently awarded as a subcontract to the Fisheries Program. Funds were intended to support documentation of fish presence and distribution in the Little Malheur River, a tributary to the North Fork Malheur River. This project will be completed in FY2016. Completion was not possible in FY2015 due to the Canyon Creek Complex Fire.

One additional federal contract regularly held by the Fisheries Program was not implemented in FY2015 due to both an administrative lapse in renewal of this contract and to a lack of environmental conditions triggering its implementation. The BPT has a multiple year agreement with the USBR to conduct bull trout trap and haul in the tailrace of Agency Valley Dam (Beulah Reservoir) during spring spill events. There was no spill over the dam in 2015; therefore, these trap and haul activities were not conducted had a replacement contract been in place. The purpose of this contract is to capture entrained bull trout via angling for release in the North Fork Malheur upstream of Beulah Reservoir. The last time this contract was triggered by environmental conditions was in 2011.

The Fisheries Program staff in FY2015 consisted of Erica Maltz (Fisheries Program Manager), Brandon Haslick (Fisheries and Wildlife Biologist), Kristopher Crowley (Fish Biologist) and Franki Gould (seasonal Fisheries and Wildlife Technician).

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FY 2015 Annual Report
BPA Project #199701900
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Chapter 1: Selective Removal of Brook Trout (*Salvelinus fontinalis*) in Lake Creek, Upper Malheur River, Oregon

Kristopher Crowley, Fish Biologist
Burns Paiute Tribe Natural Resources Department, Fisheries Program

1.1 Introduction

Brook trout (*Salvelinus fontinalis*) have been introduced throughout the western United States. Although many of the introductions were originally intended to provide sport fishing opportunities, brook trout have been implicated in declines of native aquatic biota (Adams 1999). Due to an apparent increased dispersal ability in the downstream direction, the stocking of mountain lakes with brook trout can be especially detrimental (Adams, 1999; Paul and Post, 2001). Though the mechanism(s) through which brook trout affect native species may be variable, predation, resource competition and hybridization are commonly cited factors (Dunham et al. 2002; Gunckel 2001; Ratliff and Howell 1992). In response to the identification of brook trout as a limiting factor to the recovery of ESA-listed bull trout (*Salvelinus confluentus*) in the Malheur River basin (USFWS 2002), the Burns Paiute Tribe Natural Resources Department (BPT) began brook trout suppression efforts in 2010 (Poole and Harper 2011).

Nonnative brook trout exist in high numbers in the Upper Malheur River basin. In the 1930's brook trout were introduced to High Lake (Bowers et al. 1993), a naturally fishless lake which serves as the headwater source of Lake Creek. Brook trout have also likely been introduced through several authorized and unauthorized stockings in the Upper Malheur basin over the last century. The reproductive success of brook trout in High Lake and tributaries of the Upper Malheur River has led to its dispersal into the majority of known suitable habitat (estimated 80-100 river miles). Three genetically distinct population segments have been documented in the Malheur basin and gene flow between them has been documented (DeHaan et al. 2010). Tribal biologists have located hot spots with high brook trout densities via annual electrofishing surveys in the basin (Schwabe et al. 2000; Schwabe et al. 2001; Fenn 2004; BPT, unpublished data) and brook trout spawning has been observed in most tributaries known to harbor these fish (Ray Perkins, Pers. Comm.). This apparent prolific dispersal and reproduction has resulted in competition between brook trout and native fish species as well as hybridization between brook and ESA-listed bull trout.

The presence of brook trout poses serious threats to the long term viability of bull trout due to the ability to outcompete and hybridize with native species. Resource competition and high rates of introgressive hybridization between the two species has been documented in the Upper Malheur (Gunckel 2001; DeHaan et al. 2010). Brook trout encroachment, along with 2-2 other environmental and anthropogenic factors, have imperiled bull trout in the Upper Malheur and led to the population being classified as having a high risk of extinction (Buchanan et al. 1997).

Recovery criteria for the Malheur Recovery Unit cite stable or increasing abundance trends in bull trout populations and the reestablishment of connectivity between the isolated populations of the North Fork and Upper Malheur as actions necessary to achieve delisting (USFWS 2002). It has also been deemed necessary to achieve a reduction or elimination of threats from brook trout interaction in the Upper Malheur prior to restoration of passage (USFWS 2002). Full recovery of Malheur River bull trout is therefore contingent upon minimizing the threats posed by brook trout interactions in the basin.

In 2010, the BPT began implementation of a mechanical removal project aimed at eliminating brook trout from High Lake and associated headwater portions of its outlet stream, Lake Creek. High Lake and Upper Lake Creek are high elevation sites in the Malheur National Forest of eastern Oregon. Once naturally devoid of fish, this area now hosts populations of brook trout which may serve as a source population for the Upper Malheur watershed. Suppression efforts continued in 2015 with increased emphasis on reaching sites directly below Lake Creek Falls, a natural barrier that serves as the upstream extent of all native fish in the stream. In no year since the beginning of the study has the falls been reached due to time constraints associated with the start of spawning by bull trout.

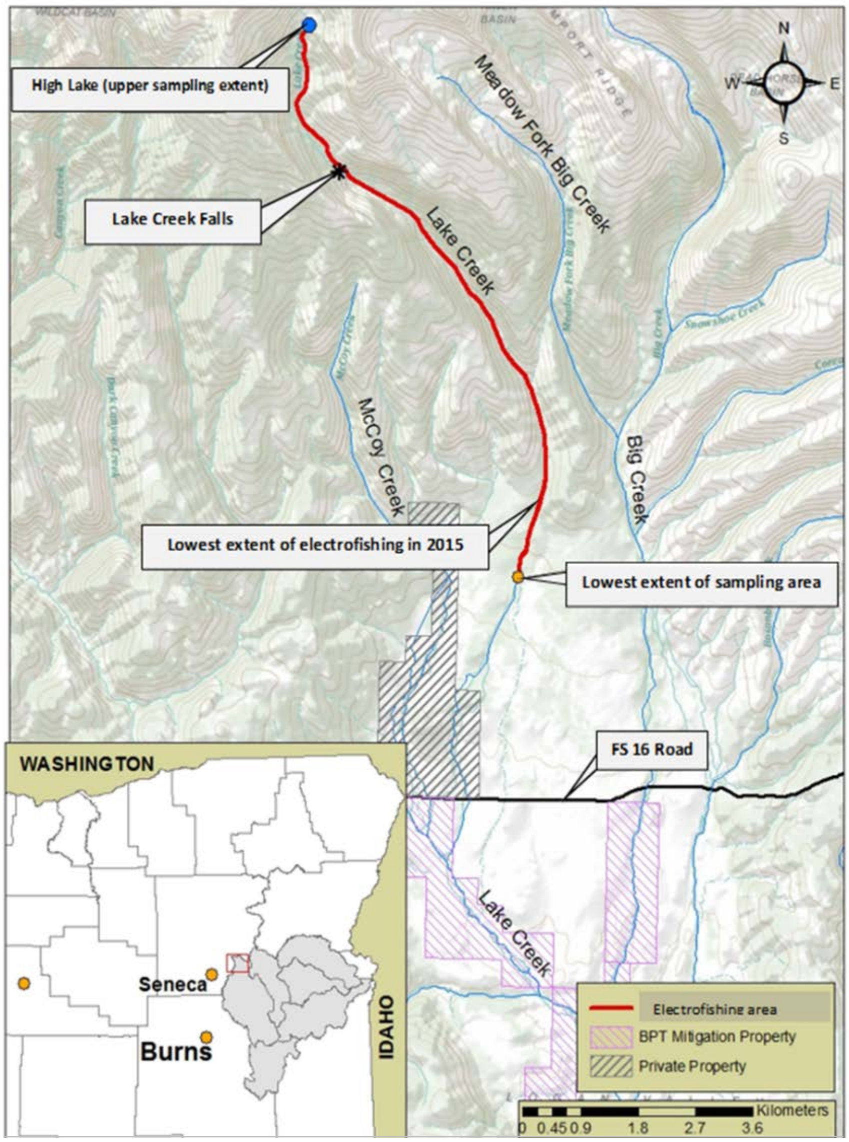

Figure 1-1. Lake Creek Study Area

1.1.1 Study Area

The study area (Figure 1-1) is located on the southern flank of the Strawberry Mountains in eastern Oregon. A major headwater tributary to the Upper Malheur River, Lake Creek flows approximately 20 kilometers from its source at High Lake to its confluence with Big Creek, where the two form the Upper Malheur River. Lake Creek Falls is located near river kilometer (RK) 17 and presents a complete barrier to upstream fish passage. Brook trout are the only fish species present above Lake Creek Falls. Below the falls, Lake Creek is characterized by moderate gradients (2-5%) and channel widths of 2-5 meters. Fish species present beside bull and brook trout include sculpin (*Cottus sp.*), redband trout (*Oncorhynchus mykiss gairdneri*), and brook trout/bull trout hybrids (Fenn 2005).

Summer stream temperature regimes in Lake Creek appear suitable for bull trout from Lake Creek Falls downstream to Murray Campground (the lower extent of 2014 sampling; BPT, unpublished data). However, between the campground and USFS Road 16, temperatures increase dramatically and often exceed bull trout thermal tolerances in summer; speculatively creating a thermal barrier to both upstream and downstream migration and isolating bull trout in the upper reaches of Lake Creek (Abel 2010). This may effectively prevent these fish from accessing the higher quality habitat present in tributaries like the nearby Big Creek system for spawning, rearing, and subsisting. Partially due to the lack of an upstream seed source, brook trout exist in much lower densities in the upper Big Creek system. Additionally, the water is generally colder, a supplementary benefit to bull trout able to migrate there.

1.2 Methods

Smith-Root models 12B, LR24 and LR20 backpack electrofishers were used to conduct electrofishing for removal of brook trout in 2015. Electrofisher settings were adjusted based on stream conditions, but were generally set at 500 volts, pulse width of 40 Hz, and frequency of 4ms. In contrast to previous years, electrofishing was not continuous throughout the project area. Sites from 2014 were revisited for removal activities if all of the conditions in Figure 1-2 applied.

1) 2014 captures were greater than 0.1 brook trout/meter.
2) Site’s 3 site average capture rate (one site on both upstream and downstream sides) was greater than 0.1 brook trout/meter.
3) Site’s 5 site average rate (two sites on both upstream and downstream sides) was greater than 0.1 brook trout/meter.
4) Site was sampled in 2014.

Figure 1-2. Criteria for determining whether to revisit a site in 2015.

Per guidance from the Oregon Department of Fish and Wildlife (ODFW) as well as in compliance with the U.S. Fish and Wildlife Service (USFWS) Section 10 Permit, electrofishing should only occur in the Upper Malheur Basin from June 15th to August 15th where native species are present in order to minimize spawning disturbance to redband trout (spring) and bull trout (fall). Sites were approximately 100 meters in length and were based on 2014 waypoints defining the upstream and downstream terminus of reaches. Occasionally sites were combined in the field if circumstances warranted. A site was defined as all wetted channels from the downstream beginning to the upstream terminus. However, sites with high channel complexity such as heavily braided stream areas were sometimes broken into main stem and secondary side channel components. These sites may have been sampled over multiple days if necessary, although for the purpose of analysis they are considered a single site. All sites were sampled with a single continuous upstream pass using the electrofisher to sweep through the entire wetted channel. Extra attention was given to areas where high densities of brook trout generally occur such as deep pools, complex woody habitat, and undercut banks.

All brook trout captured were scanned for PIT tags and measured (length) before being euthanized. Weights were also taken when a scale was available for condition comparisons. Due to new guidance provided via email by USFWS, hybrids were treated similarly to brook trout and were removed from the system. Identification of hybrids were based entirely upon phenotypic features and thus crews were instructed to use extreme cautionary discernment in hybrid identification by releasing suspected hybrids that displayed more of a bull trout phenotype while euthanizing those displaying strong brook trout features. Phenotypic features used are described in DeHaan et al. (2010) and USFWS (2010). In contrast to previous years, native fish were not held in holding buckets until the end of the site. Non target native trout were counted, noted, and immediately released downstream of the electrofisher. Bull trout that were captured were held in a bucket only for immediate data collection such as length and tag identification and then were released likewise downstream of the electrofisher. PIT tags were not implanted into any fish in 2015 in an effort to reduce handling stress on native fish.

Condition factor, also referred to as K Factor ($K=(100{,}000*Weight)/Length^3)$), was calculated for brook trout from 2013-2015 and bull trout from 2013-2014 for use in comparisons of overall body condition as removal has progressed (Ricker 1975). Comparisons of K Factors between years are found in Appendix 1-B.

1.3 Results

In 2015, 98 electrofishing sites were sampled from June 16th to October 28th. Eight sites at the beginning of the study area were removed from sampling in 2015 due to meeting the conditions listed in Figure 1-2. All other sites in the study area were sampled. Total effort electrofishing in Lake Creek totaled 111,886 seconds over approximately 9.8 km of stream. Five species of fish were captured in the electrofishing effort, including brook trout (n=1606 [1527 below the falls]; average length= 134mm), bull trout (n=25; average length= 129mm), bull/brook trout hybrid (n=6; average length= 239mm), redband trout

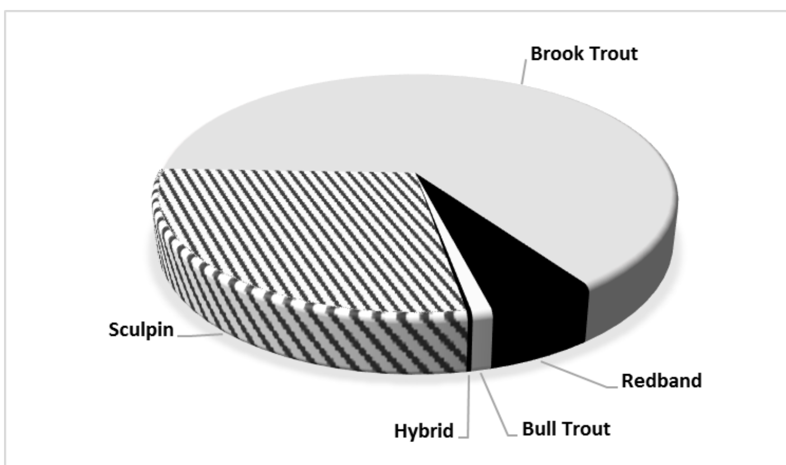

Figure 1-3. Pie chart of captures in Lake Creek below the falls.

(n=135), and sculpin (n=666). Trout that were too small to identify with perceived accuracy to species (generally <60mm) were referred to as 'unknown trout' (n=537). All brook trout and bull/brook trout hybrids were euthanized. There were no incidental mortalities to native fish in 2015. Length-frequency histograms are provided for bull trout and brook trout (Appendix 1-A).

Brook trout were overwhelmingly the most common fish captured below Lake Creek falls followed distantly by sculpin (n=666; Figure 1-3). Redband trout captured were outnumbered by brook trout below the falls 11:1 and bull trout captured were outnumbered 61:1. All bull trout were captured above site 46 while the vast majority of redband trout (130/135) were captured below this point.

No fish were implanted with PIT tags in 2015 due to an extremely cautious sampling approach intended to lower sampling stress on Lake Creek populations subject to yearly electrofishing. Brook trout, bull trout, and hybrids were all still scanned for existing PIT tags. There were 2 recaptured hybrids and zero recapture bull trout or brook trout with PIT tags.

Condition factor results can be found in Appendix 1-B.

1.4 Discussion

Due to the tendency of brook trout to outcompete native bull trout through resource competition and hybridization (Gunckel 2001; DeHaan 2010) the Burns Paiute Tribe has been collaboratively working with private, state, and federal land managers to combat and counter the spread of the invasive to nearly all suitable areas in the watershed. Lake Creek sampling in 2015 was a continuation of a project that began in 2011 to investigate the effectiveness of various mechanical removal methods (primarily electrofishing) to reduce or eliminate brook trout. Protocol was further adjusted in 2015 to ensure that sites that historically yielded high captures were targeted given that the permitted sampling window previously restricted sites completed. This area included approximately one kilometer immediately downstream of Lake Creek's lower-most natural fish barrier. In order to ensure these areas were sampled protocol was streamlined by eliminating site revisits that yielded few fish in the previous year (Figure 1-2) and minimizing handling time of native species by only taking pertinent data such as length and checking for marks and tags. A single upstream pass occurred in all sites. The large and complex project area coupled with a short 60 day sampling window would leave large areas of stream untreated on a yearly basis if a more intensive protocol was used. . Therefore, despite past BPT recommendations to use block nets at each terminus in a site and include a downstream pass as a worthwhile protocol for in-reach capture efficiency (Harper 2012), leaving areas completely untreated was deemed an unacceptable threat to bull trout in those areas. The changes in protocol achieved the desired results and all targeted sites below Lake Creek Falls were sampled in the two month sampling window (June 15-August 15) put forth in permits issued by ODFW and USFWS to protect spawning native trout.

Despite slight changes in protocol the amount of effort (measured in seconds of effort) was nearly identical to the previous year (~112,000 in 2015; ~114,000 in 2014). However, brook trout captures below the falls reflected an increase of nearly 50% (1527 in 2015; 1046 in 2014). The increase in captures is largely a result of inclusion of stream sections in 2015 that were not sampled in 2014. In sites that were sampled in both 2014 and 2015, catch per meter sampled was identical (Appendix 1-C).

Since the field crew and protocol within individual sites (single upstream pass, one electrofishing unit, no block nets) remained the same between these sampling years we conclude that brook trout densities are effectively unchanged between years. This is likely due to the ineffectiveness of mechanical removal to remove enough brook trout in Lake Creek to disrupt spawning (or subadult recruitment) and thus population density. Due to their ability to rapidly reach sexual maturity (Meyer et al. 2006; personal observations), the brook trout population appears to be able to completely recover on a yearly basis after removal, rendering benefits from such an effort minimal and temporary. BPT staff maintain that hydrology, complex habitat features, and time constraints hinder the use of block nets and render depletion efforts impractical. Therefore, we maintain the need to begin a more comprehensive eradication approach such as the use of the piscicide rotenone.

The Canyon Creek Complex wildfire burned approximately 110,000 acres in and adjacent to the study area beginning August 12th. The fire kept crews from sampling from August 12th-October 25th, meaning sampling above the Lake Creek Falls barrier likely took place after brook trout completed spawning. Therefore the majority of sites above the falls (23 of 26) were sampled later in the fall than in previous years. This change in sampling time may explain the lower amount of fish captured in this stream section in 2015 than the prior year (188 in 2014; 79 in 2015). As water temperatures drop and brook trout spawning completes fish likely move downstream to overwinter.

Length and weight data has been collected on a large subset of captured brook trout in Lake Creek since 2013. Given population estimates at the beginning of the study [Harper 2012, 11,797 (95% CI 9,362-14,232)] we suspected the brook trout population was near or over its carrying capacity in Lake Creek. This was evidenced by the condition factor of brook trout captured averaging 1.2 (fair-poor condition; Appendix 1-B). Through yearly removal efforts we expected to see a general trend toward improved body condition as competition for resources was reduced. However, over the last three years of sampling we have seen body condition remain observationally unchanged. There are several factors that may contribute to body condition of fish in the same water body between years such as variations in food availability (Ricker 1975). While acknowledging that factors outside of population abundance could be influencing body condition, this data suggests that if a lower population abundance would lead to decreased competition for food space resulting in increased body condition, then brook trout populations are not being substantially changed by removal efforts. This is further evidenced by comparison of body condition of bull trout between years. Bull trout weights were recorded only in 2013 and

2014 due to changes in protocol in 2015. Over these two seasons we saw condition factor drop from 1.1 (fair/poor) to 0.99 (poor). Small sample size in 2013 and 2014 (n=10 and 8 respectively) suggests that these numbers may be highly variable, but never the less highlights that poor body condition of bull trout is likely persisting despite removal efforts. Condition factors throughout this study lend evidence to a brook trout population capable of rebounding on a yearly basis with current removal methodology. Additionally, due to a combination of the logistics surrounding mechanical removal, the complexity of Lake Creek, a short permitted work window, and staffing (as a function of funding), an increase in effort in attempts to increase the percentage of the population annually removed is not possible.

The number of brook trout captured in 2015 increased from the previous year although the majority of bull trout captured (22 of 25) were captured in sites that were not sampled in 2015. A shift in age class was also observed in 2015 as the most bull trout captured (19 of 25) were juveniles (<150 mm). This is in sharp contrast to 2014 where all bull trout captured were adult sized (>150mm). Based on high temperatures in lower Lake Creek on private land and past telemetry studies (Fenton 2006, Haslick 2015), it is assumed that there is a temperature barrier to bull trout migration for at least a portion of the year. This points to the possibility of these smaller bull trout being spawned and reared in Lake Creek in the past one or two seasons. While it is encouraging to report a likely successful spawn in recent years, the apparent lack of adults currently to spawn is equally troubling. Without robust age structure observed in Lake Creek populations in recent years, the local population remains highly susceptible to extirpation.

1.5 Recommendations

Given recent data showing little to no improvement in brook trout control using mechanical means, the Tribe continues to work toward a more comprehensive approach to brook trout eradication by exploring the possibility of rotenone application. The Tribe is working collaboratively with state and federal agencies on beginning administrative processes for such a project through the Malheur River Technical Advisory Committee. As we begin to explore other options, the Tribe plans to continue mechanical removal in 2016 in a manner that focuses on areas where brook trout numbers are highest in an effort to continue to provide any possible benefit to native trout.

1.6 Acknowledgements

The Burns Paiute Tribe would like to thank Bonneville Power Administration for continuing to fund recovery of bull trout in the Upper Malheur River.

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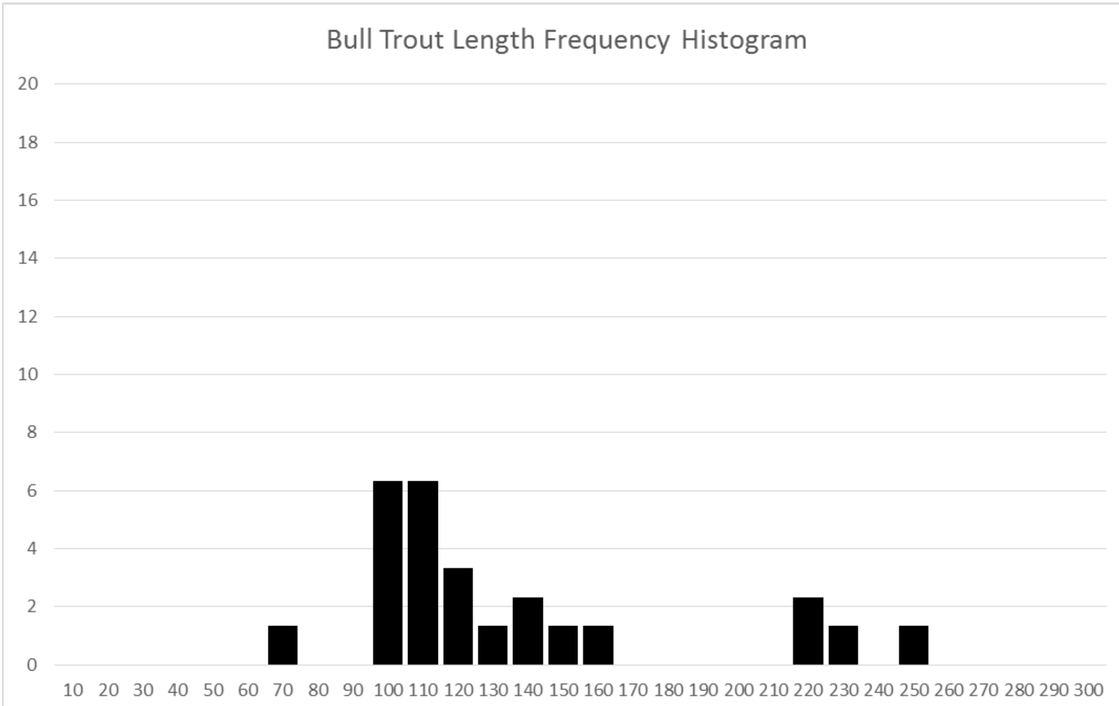
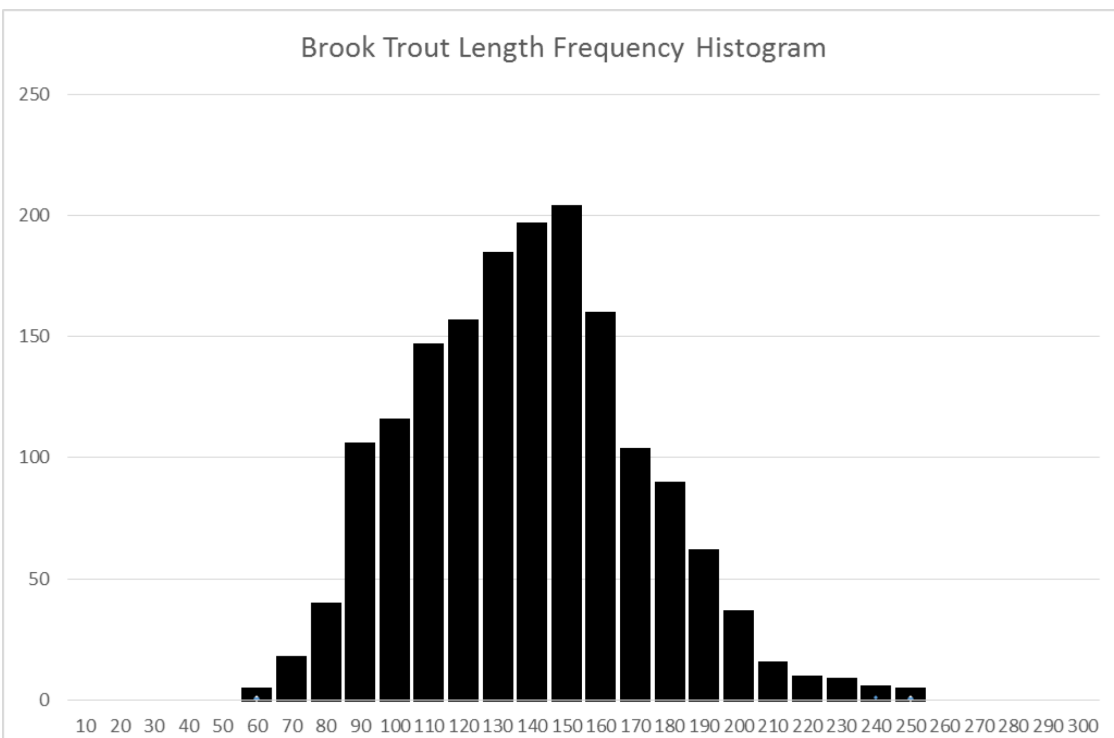
APPENDIX 1-A

Length Frequency Histograms of Bull Trout and Brook Trout in Lake Creek in 2015.





APPENDIX 1-B

Condition Factors of Brook Trout and Bull Trout by year in Lake Creek

	2013	**2014**	**2015**
Brook Trout	1.17	1.20	1.17
Bull Trout	1.10	0.990	NA

APPENDIX 1-C

Average number of Brook Trout captured per meter sampled in Lake Creek among sites that were sampled in both 2014 and 2015. The far right indicates the change in capture efficiency between years.

Site Number	2014 Brook Trout/meter	2015 Brook Trout/meter	Change
9	0.15	0.16	0.01
10	0.12	0.16	0.04
11	0.21	0.16	-0.05
12	0.24	0.29	0.05
13	0.12	0.06	-0.06
14	0.07	0.08	0.01
15	0.07	0.12	0.05
16	0.15	0.20	0.05
17	0.06	0.20	0.14
18	0.05	0.15	0.10
19	0.41	0.59	0.18
20	0.06	0.06	0.00
21	0.15	0.10	-0.05
22	0.17	0.24	0.07
23	0.17	0.06	-0.11
24	0.17	0.06	-0.11
25	0.29	0.48	0.19
26	0.18	0.19	0.01
27	0.13	0.24	0.11
28	0.36	0.24	-0.12
29	0.36	0.24	-0.12
30	0.36	0.24	-0.12
31	0.17	0.28	0.11
32	0.67	0.62	-0.05
33	0.67	0.62	-0.05
34	0.21	0.23	0.02
35	0.28	0.23	-0.06
36	0.23	0.26	0.03
37	0.23	0.26	0.03
38	0.19	0.11	-0.08
39	0.35	0.60	0.25
40	0.76	0.58	-0.18
41	0.28	0.50	0.22
42	0.17	0.03	-0.14
43	0.23	0.12	-0.11
44	0.20	0.16	-0.04
45	0.14	0.17	0.03
46	0.18	0.21	0.03
47	0.16	0.15	-0.01
48	0.10	0.18	0.08
49	0.17	0.17	0.00
50	0.18	0.09	-0.09
51	0.13	0.13	0.00
52	0.12	0.20	0.08
53	0.04	0.06	0.02
54	0.08	0.13	0.05
55	0.08	0.14	0.06
56	0.28	0.07	-0.21
Average	0.22	0.22	0.00

Chapter 2:
2015 Stream Temperature Monitoring in the Upper Malheur River

Logan Valley Wildlife Mitigation Property, Oregon

Brandon Haslick
Burns Paiute Tribe Natural Resources Department
Burns, Oregon

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Logan Valley Wildlife Mitigation Property, Oregon

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2.1 Introduction

The Burns Paiute Tribe Natural Resources Department (BPT) has been monitoring stream temperatures in the headwaters of the Upper Malheur since acquiring the Logan Valley Wildlife Mitigation Property in April 2000. BPT collects stream temperature data on the property in order to evaluate long-term effectiveness of aquatic habitat improvement projects, such as ongoing riparian plantings and livestock exclusion. In select years (including 2015), BPT has also collected stream temperature data elsewhere to evaluate suitability of various habitats to life history stages of both extant and extirpated native fish species, and to identify areas that may benefit from restorative or protective measures. With the ongoing regional efforts to model climate change scenarios based on local empirical datasets, BPT continues to collect stream temperature data to aid in the improvement of these models. Long-term datasets may function to refine model predictions over time and provide understanding of habitat change and loss due to climate change.

2.2 Methods

2.2.1 Study Area

The Logan Valley Wildlife Mitigation Property is located south of the Strawberry Mountain Wilderness in the Malheur National Forest of Grant, Harney, Baker, and Malheur counties, eastern Oregon. The parcel consists of 1760 acres deeded to BPT in April 2000 in which Lake Creek, Big Creek, Crooked Creek and McCoy Creek combine to form the Upper Malheur River. BPT has maintained five temperature sites on the Upper Malheur since acquiring the property in April 2000 (Namitz 2000; Schwabe 2001; Schwabe 2002; Schwabe 2003; Schwabe 2004; Fenton and Schwabe 2005; Fenton 2006; Schwabe 2007; Abel 2008; Abel 2009; Brown 2010; Brown 2011; Brown 2012; Haslick 2014; Haslick 2015). Of these five original sites, two are stationed on Lake Creek (one below the confluence with McCoy Creek and the other below the confluence with Crooked Creek), two on Big Creek, and one where Big and Lake creeks join to form the middle fork of the Malheur River. In 2007 two more sites, with a focus on the Lake Creek drainage, were selected for monitoring (Schwabe 2007). Another site, near BPT's cabin bridge, was added to Lake Creek in 2008 (Abel 2008). For the 2009 field season, two additional monitoring sites were added, one on McCoy Creek and the other on a branch of Lake Creek (Abel 2009). Site locations are mapped in Figure 2-1 and described in Table 2-1.

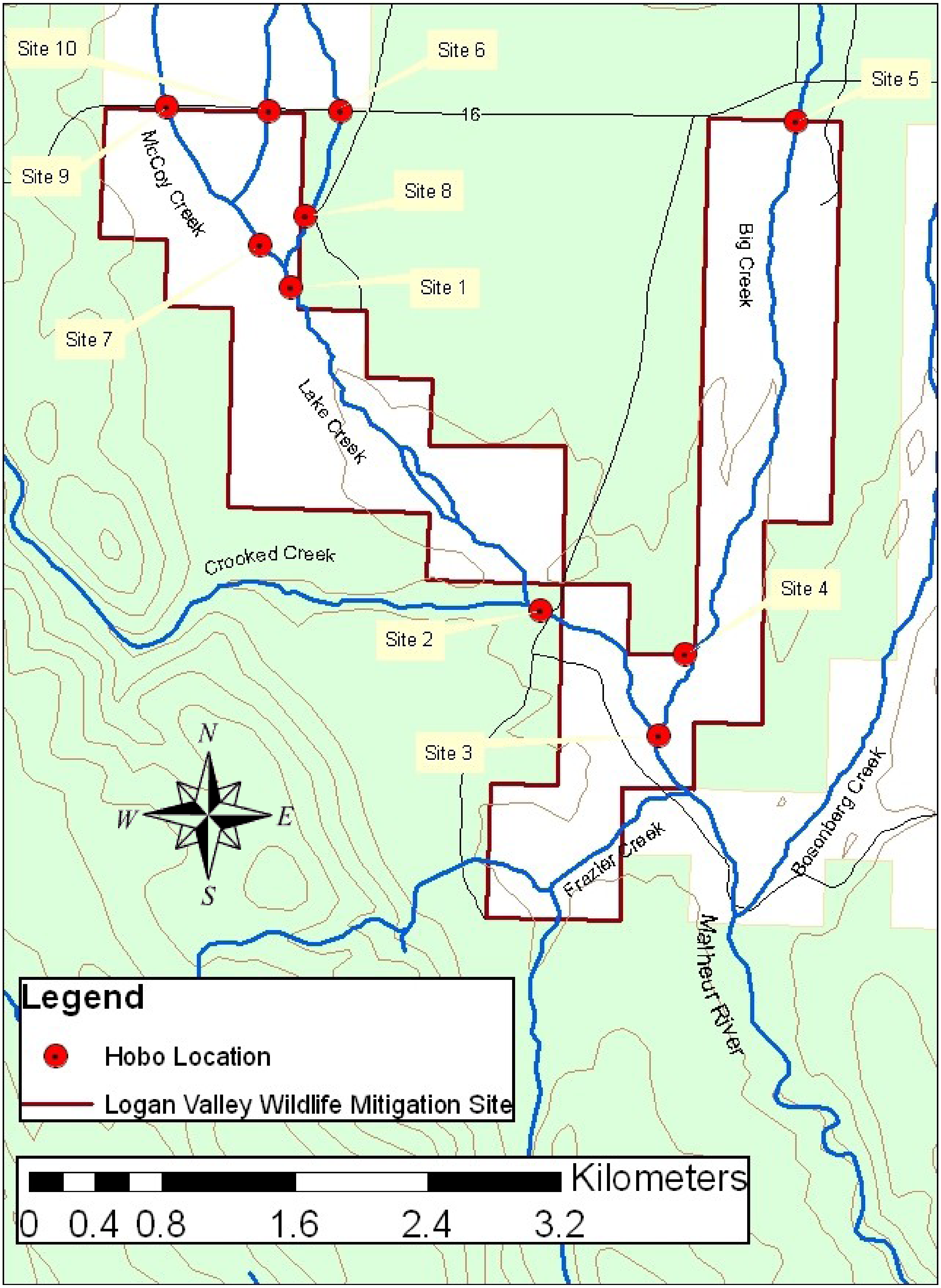

Figure 2-1. BPT Annual Stream Temperature Monitoring Site Locations in Logan Valley.

Site	Location	Year Initiated
1	**Lake Creek below McCoy Creek**	**2000**
2	**Lake Creek below Crooked Creek**	**2000**
3	**Malheur River below Big and Lake Creek**	**2000**
4	**Big Creek one mile below Forest Service 16 Road**	**2000**
5	**Big Creek below Forest Service 16 Road**	**2000**
6	**Lake Creek below Forest Service 16 Road**	**2007**
7	**McCoy Creek above Lake Creek**	**2007**
8	**Lake Creek at Cabin Bridge**	**2008**
9	**McCoy Creek below Forest Service 16 Road**	**2009**
10	**Lake Creek Ditch below Forest Service 16 Road**	**2009**

Table 2-1. BPT Logan Valley Annual Stream Temperature Monitoring Site Descriptions.

2.2.2 Field Techniques

In 2015, Tidbit v2 Temperature Loggers (hobos) manufactured by Onset Computer Corporation were deployed on the 6th of May and retrieved on the 7th of October. Hobos were subjected to accuracy checks pre-deployment using methods recommended by the Oregon Water Quality Monitoring Technical Guidebook (OPSW v2.0 2001). Standards dictate that hobo readings cannot vary from actual by more than ±0.5 °C. All hobos deployed in the 2015 field season were within accuracy parameters.

Eight pound anchors were used to secure the hobos on the bottoms of streams. The anchors were in turn cabled or roped to a stable attachment point along the bank or over the stream. In order to account for as many physical variables as possible, all hobos were set in the deep and swift water of the thalweg and under vegetation and undercut banks when possible. Timing of deployment has varied slightly from year to year, usually as a result of seasonal weather conditions limiting access to sites. Hobo deployment in Logan Valley by the 24th of May and retrieval after September was the objective in 2015 and will be the objective into the future. Deployment at least one week before June 1st and retrieval post-September will allow for a more complete mean weekly temperature dataset over the summer interval.

2.2.3 Data Analysis

Temperature data in this report is commonly summarized by the rolling daily maximum temperature averaged over a seven day period. This is referred to as the Mean Weekly Maximum Temperature (MWMT). This unit of measurement is also known as the Seven Day Average Daily Maximum or 7DADM, and is synonymous with the maximum rolling temperature calculations utilized in previous reports by BPT. The DEQ Stream Temperature Standard is 12 °C MWMT for bull trout migration and juvenile rearing and 16 °C MWMT for salmonid core rearing areas (i.e., an area of moderate to high density use) (OAR 340-041-0028 2004). Sixteen degrees Celsius has been cited as an important benchmark in relation to the thermal tolerance of bull trout as well. Research conducted in a controlled setting indicates that bull trout food consumption declined significantly at temperatures greater than 16 °C (Selong et al. 2001). The same study identified 20.9 °C as the Incipient Lethal Temperature for threatened bull trout (ILT). Temperatures listed above are thus important monitoring benchmarks utilized for comparative analysis throughout this report.

Figures 2-1A to 2-9A in Appendix A plot the 2015 MWMT at each monitoring site against Department of Environmental Quality stream temperature standards (described above). The incompleteness of Figure 2-6A can be explained by streambed dewatering which necessitated the exclusion of data during that time. Figure 2-2 depicts the substantial daily temperature fluctuations recorded at that site over the summer, providing evidence of this air exposure. Also of note, the temperature logger deployed at Lake Creek site 8 was discovered to have been smashed at some point during the course of the monitoring season, rendering data unrecoverable. As a consequence, all site 8 charts were not able to be populated for this report and are excluded.

In addition to MWMT charted in Appendix A, Daily Average Temperature (DAT) at each site in 2015 was calculated and graphed in Appendix B (Figures 2-1B to 2-9B). Tables 2-2 and 2-3 illustrate absolute high temperatures and the amount of time each site spent above the critical temperature thresholds. Tables 2-4, 2-5, and 2-6 present color-coded depictions of initial MWMT threshold obtainment at a subset of five sites across the monitoring zone. Table 2-4 references represents the baseline of average obtainment over the years 2000-13, Table 2-5 displays 2014 data, and Table 2-6 displays 2015 data. For purposes of comparison, the summer monitoring period for these tables is defined as June 7th-September 30th, a range in which a full set of MWMT data is available for all five sites in all years.

2.3 Results

The timeframe July 15th-August 15th was outlined by the Oregon Department of Fish and Wildlife (ODFW) as the critical period for high stream temperatures in the Malheur watershed (Perkins 1999). Although highest stream temperatures fluctuate in temporal occurrence from year to year, it is not unreasonable to expect them to occur within or near this date range according to monitoring over the past decade. This timeframe has been used in previous BPT reports as an index for comparing stream temperature data between years (Namitz 2000; Schwabe 2001; Schwabe 2002; Schwabe 2003; Schwabe 2004; Fenton and Schwabe 2005; Fenton 2006; Schwabe 2007; Abel 2008; Abel 2009; Brown 2010; Brown 2011; Brown 2012; Haslick 2014; Haslick 2015). In 2015, highest stream temperatures for each site were identified to determine whether dates occurred within the 32-day critical period (Table 2-2). Table 2-3 represents the number of days and percent total days in 2015 that MWMT eclipsed critical temperature benchmarks during the monitoring period.

In 2015, the dates of absolute maximum temperatures occurred earlier than the critical stream temperature period (July 15th-August 15th) at all eight sites with a full set of usable data (Table 2-2). These temperatures were instead achieved at the tail end of June or early July. Highest MWMT recorded at each site also occurred around this time, ten days or more before the critical stream temperature interval.

2015 Monitoring Period: June 1st-September 30th					
Stream Name	Site Number	Highest MWMT (°C)	Date of Occurrence	Absolute Maximum (°C)	Date of Occurrence
Lake Creek	1	26.5	7/2/15	27.8	6/30/15
Lake Creek	2	27.1	7/3/15	28.1	6/30/15
Malheur River	3	22.8	7/3/15	24.1	6/30/15
Big Creek	4	21.3	7/3/15	22.6	6/30/15
Big Creek	5	18.6	7/5/15	20.0	7/1/15
Lake Creek	6*	-	-	-	-
McCoy Creek	7	26.9	7/2/15	28.2	6/30/15
Lake Creek	8**	-	-	-	-
McCoy Creek	9	28.7	7/2/15	30.2	6/30/15
Lake Ditch	10	24.6	7/3/15	26.2	7/3/15

Table 2-2. Summary of Temperature Maximums at BPT Monitoring Sites, Summer 2015.
*Dewatered for a substantial portion of the summer season rendering data unusable.
**Hobo smashed, data unrecoverable.

As Table 2-3 illustrates, Logan Valley streams regularly exceeded average weekly temperature maximums based on DEQ standards for bull trout migration and juvenile rearing habitat (12 °C), as well as standards for salmonid core rearing habitat (16 °C) in the summer of 2015 (OAR 340-041-0028 2004). Each site with a complete data set on the Lake Creek drainage spent all of the summer monitoring period (defined as the months of June, July, August, and September) with MWMT exceeding 12 °C. Furthermore, only sites on Big Creek experienced any time at all below 12 °C MWMT, with the vast majority of days in excess of this threshold. Six of the eight sites with usable data (Lake Creek sites 1 and 2, Malheur River site 3, McCoy Creek sites 7 and 9, and Lake Creek Ditch site 10) spent over 90 days in excess of 16 °C MWMT. In the cooler water of Big Creek, site 4 MWMT exceeded 16 °C for 86 days, and site 5 (upstream) exceeded that threshold for 52 days. The ILT for bull trout was surpassed at all sites except site 5 in 2015. MWMT was above 20.9 °C at sites 1, 2, 7, and 9 for 42-59% of the total days monitored, about one third at site 10, and 9% at site 3. Site 4 surpassed the ILT of 20.9 °C for five days in 2015, the implications of which will be discussed below. All sites on average spent 31% of the summer period above the ILT for bull trout.

Site Name and Number	**Days > 12 °C**	**Days > 16 °C**	**Days > 20.9 °C**
#1 Lake Creek below McCoy Creek	122 (100%)	97 (80%)	51 (42%)
#2 Lake Creek below Crooked Creek	122 (100%)	102 (84%)	68 (56%)
#3 Malheur River below Big and Lake Creek	122 (100%)	94 (77%)	11 (9%)
#4 Big Creek one mile below NF-16 Road	121 (99%)	86 (70%)	5 (4%)
#5 Big Creek below NF-16 Road	112 (92%)	52 (43%)	0 (0%)
#6 Lake Creek below NF-16 Road*	-	-	-
#7 McCoy Creek above Lake Creek	122 (100%)	99 (81%)	60 (49%)
#8 Lake Creek at Cabin Bridge**	-	-	-
#9 McCoy Creek below NF-16 Road	122 (100%)	110 (90%)	72 (59%)
#10 Lake Creek Ditch below NF-16 Road	122 (100%)	93 (76%)	38 (31%)

Table 2-3. Number of Days and Percent Total Days at Stations MWMT Exceeded Temperature Benchmarks, Summer 2015.
*Incomplete data (dewatered a substantial portion of the monitoring season).
**Hobo smashed, data unrecoverable.

When comparing this year to last, all sites in 2015 spent nearly identical percentages of days above 12 °C MWMT. Sites ranged from 9% lower to 21% higher in number of days spent above 16 °C and 20.9 °C in 2015 as opposed to the prior year. Overall MWMT highs and absolute highs for the summer were greater in 2015 compared with 2014 at all sites except Big Creek site

4 (highest MWMT was lower but absolute high was higher). Typically, the increase was less than a degree. However, both McCoy Creek sites increased by more than 1 °C, and site 7 recorded highest MWMT and absolute high better than 1.5 °C higher in 2015. Temperatures hit their highs anywhere from about two to three weeks earlier in the summer season of 2015 than they did in 2014. Perhaps unsurprisingly, these numbers indicate that both years produced temperatures exceeding acceptable criteria for threatened bull trout.

From a broader perspective, it becomes observationally clear that the warm water temperature measurements recorded recently are not aberrations. Taking into account the occasional inability to retrieve hobos due to loss, the original five strategically placed sites initiated in 2000 are associated with the longest datasets, thus permitting more detailed comparisons. Baselines were created by averaging the dates that MWMT hit important benchmarks at each of the five original sites from the years 2000-13. Beginning in 2014, temperature loggers were set earlier in the season in order to capture a more complete MWMT picture over the summer monitoring season. MWMT can thus be calculated beginning on June 1st for the years 2014 and 2015, as opposed to June 7th for baseline years. However, when comparisons are made between the baselines and subsequent years, the dates have been normalized to only include those for which a full set of data is available in each year (June 7th to September 30th).

Since BPT began stream temperature monitoring in Logan Valley, water temperatures have consistently surpassed the DEQ Bull Trout Temperature Standard of 12 °C MWMT for a majority of the summer period at all monitoring sites where data was collected. Lake Creek sites 1 and 2 have exceeded the 16 °C salmonid threshold on the very first day MWMT could be calculated (June 7th) for the years 2000-09 and 2013-14. The MWMT of these same sites has consistently exceeded the Incipient Lethal Temperature for bull trout, on average in late June/early July for the years 2000-08 and 2013-14; later in the season for the years 2009 and 2011-12.[1] At Malheur River site 3, the beginning of the summer monitoring season is typically when the MWMT has exceeded 12 °C. The mean date for the years 2000-08 when the MWMT of site 3 surpassed 16 °C was June 16th (later in June the four subsequent years and earlier in 2013 and 2014). The ILT for bull trout based on MWMT has on average been obtained at site 3 in July, but this location never achieved such high temperatures in 2010 or 2011. Big Creek sites 4 and 5 typically obtain the 12 °C and 16 °C MWMT temperature thresholds later in the season. Site 5 MWMT has failed to reach the salmonid temperature threshold of 16 °C MWMT only once in recent years (2011). For the years 2000-12, Big Creek sites did not eclipse the ILT based on MWMT during the summer monitoring period (Namitz 2000; Schwabe 2001; Schwabe 2002; Schwabe 2003; Schwabe 2004; Fenton and Schwabe 2005; Fenton 2006; Schwabe 2007; Abel 2008; Abel 2009, Brown 2010; Brown 2011; Brown 2012). In 2013 and 2014, however, both the

[1]Site 1 experienced one outlier year in 2010 in which it never obtained the ILT for bull trout (Brown 2010).

12 °C and 16 °C MWMT thresholds were in large part[2] achieved at or near the beginning of the summer monitoring season and the ILT was surpassed at site 4 (Haslick 2014; Haslick 2015). Refer to Tables 2-4, 2-5, and 2-6 for a summary of dates each of the five original sites have exceeded MWMT thresholds for the years 2000-13, 2014, and 2015.

2015 temporal temperature threshold obtainment (Table 2-6) differs from the baseline of Table 2-4 in several areas. Although sites 1 and 2 recorded roughly average resolution-limited readings at the 12 °C and 16 °C levels, the ILT was surpassed at both sites more than three weeks earlier than the baseline. Site 3 surpassed the 16 °C MWMT threshold eleven days earlier and the 20.9 °C threshold two weeks earlier. The 12 °C MWMT temperature threshold was exceeded three days earlier at site 4 and nine days earlier at site 5. Site 4 broke the 16 °C MWMT mark sixteen days earlier in 2015 while site 5 surpassed the same mark over three weeks earlier than the baseline. The ILT based on MWMT was obtained for the third year in a row at site 4, this time for five days in early July. This is notable given the first thirteen years of BPT monitoring history (2000-12) had never produced readings at this site above the ILT for bull trout (Haslick 2015). Site 5 once again never achieved such highs.

		Site 1 Lake Creek	Site 2 Lake Creek	Site 3 Malheur River	Site 4 Big Creek	Site 5 Big Creek
2000-13	> 12 °C	June 7th	June 7th	June 7th	June 10th	June 16th
	> 16 °C	June 8th	June 8th	June 18th	June 23rd	July 3rd
	> 20.9 °C	July 5th	July 3rd	July 13th	July 2nd*	no readings > 20.9 □C

Table 2-4. Average Date of First Recorded MWMT over Cited Benchmarks for the Summer Monitoring Intervals from 2000-13. *Site 4 only obtained ILT in 2013.

		Site 1 Lake Creek	Site 2 Lake Creek	Site 3 Malheur River	Site 4 Big Creek	Site 5 Big Creek
2014	> 12 °C	June 7th (1st)*	June 7th (1st)*	June 7th (1st)*	June 7th (1st)*	June 7th
	> 16 °C	June 7th (5th)*	June 7th (4th)*	June 8th	June 11th	July 4th
	> 20.9 °C	July 4th	July 3rd	July 6th	July 16th	no readings > 20.9 □C

Table 2-5. Date of First Recorded MWMT over Cited Benchmarks for the 2014 Summer Monitoring Interval. *Number in parenthesis is actual date based on expanded monitoring season; for comparison purposes, the beginning of the monitoring season is June 7th.

[2]The lone outlier was site 5's 16 °C threshold in 2014 which was achieved on July 4th, more in line with the baseline.

		Site 1 Lake Creek	Site 2 Lake Creek	Site 3 Malheur River	Site 4 Big Creek	Site 5 Big Creek
2015	> 12 □	June 7th (1st)*	June 7th (1st)*	June 7th (1st)*	June 7th (1st)*	June 7th (1st)*
	> 16 □	June 7th (1st)*	June 7th (1st)*	June 7th (3rd)*	June 7th	June 10th
	> 20.9 □	June 12th	June 11th	June 29th	July 1st	no readings > 20.9 □

Table 2-6: Date of First Recorded MWMT over Cited Benchmarks for the 2015 Summer Monitoring Interval.

*Number in parenthesis is actual date based on expanded monitoring season; for comparison purposes, the beginning of the monitoring season is June 7th

A quick comparison with 2014's temperature threshold chart (Table 2-5) is merited at this point. Temperature threshold obtainment in 2014 was considered somewhat rapid as compared to the baseline average. However, the even earlier warming (often substantially) of all stream MWMTs possible to compare in 2015 commands attention. A logical assumption that could be made is that that MWMTs were higher for a much longer period of time this past summer. However, when Table 2-3 was compared year over year earlier, mixed results emerged. Sites 1, 2, 7, and 9 (Lake Creek and McCoy Creek) followed a trend of less time spent above the salmonid temperature standard but a somewhat greater percentage of time spent above the ILT for bull trout. Sites 4, 5, and 10 (Big Creek and Malheur River) spent a somewhat greater percentage of time above the salmonid temperature standard but less or about the same amount of time above the ILT. Site 10 (Lake Creek Ditch) and the 12 °C temperature standard for all sites were roughly equivalent in time expenditures year over year. Therefore, even though MWMT threshold obtainment was on the whole much more rapid in 2015 than before, the rest of the summer monitoring season saw temperatures decrease, muting the earlier rises.

In 2015, as in previous years, Lake Creek sites 6 and 8 were dewatered to the point of hobo exposure to air. In reference to site 6, this occurred about a month later in the summer monitoring period as compared with 2014. Site 8's hobo was broken at some point, rendering data unrecoverable and the extent of dewatering unknown. Causes of the dewatering are explained in section 3.4 of this report. Figure 2-2 displays high fluctuations in daily temperature ranges at site 6 that closely resembled the corresponding local air temperatures in Logan Valley, providing evidence of the air exposure. Dates with data indicating hobo exposure to air have been excluded from temperature analysis.

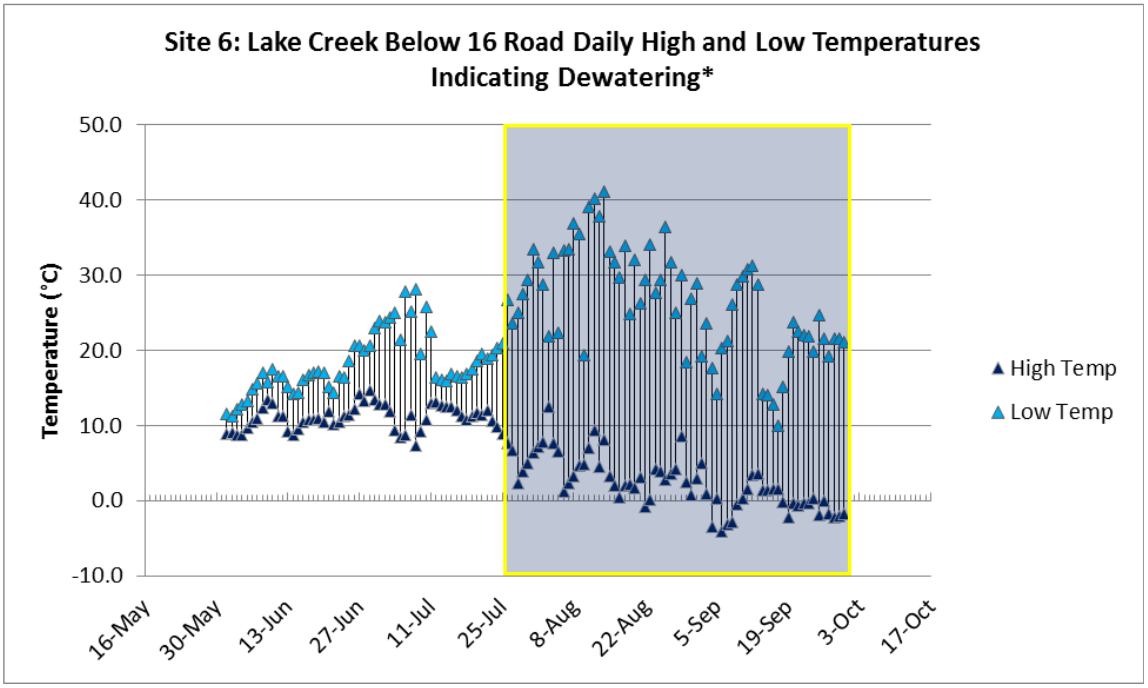

Figure 2-2: Evidence of Site 6 Hobo Air Exposure.
*Dates in shaded box experienced hobo exposure to air.

Because mean weekly maximum temperature measurements form the basis of the DEQ salmonid and bull trout standards, they remain the primary focus of stream temperature analysis in Logan Valley. However, higher resolution of the stream temperature trend picture can be obtained when other measurements are considered. Last year's report utilized all historic temperature records available for all sites without a tendency to dewater to publish mean daily maximum and average water temperatures over the critical period of July 15th-August 15th for the years 2000-13 as compared with 2014. The fire in BPT's IT building in the spring of 2015 destroyed most baseline and raw temperature data files, however. Therefore, comparisons from last year cannot be used and built upon for this report. The raw data gathered in 2015 will form the basis of a new stream temperature archive which will be added to in subsequent years to manufacture a new baseline to monitor and compare to.

2.4 Discussion

In 2000, the Burns Paiute Tribe entered into a cooperative effort with the USDA Forest Service and the Oregon Department of Fish and Wildlife to document stream temperature trends in the Upper Malheur (Namitz 2000). The primary purpose of the monitoring effort was to utilize stream temperature data as an indicator of habitat suitability for the federally threatened bull trout (Namitz 2000), native to BPT's study site and nearby drainages. Bull trout are stenothermal, requiring a narrow range of cold water temperature conditions to rear and reproduce (Buchanan and Gregory 1997). In western North America, the bull trout is believed to be among the most thermally sensitive species in coldwater habitats (Buchanan and Gregory 1997; Haas 2001; Selong et al. 2001; Dunham et al. 2003), and maximum temperature has consistently been suggested as likely the most critical variable determining bull trout presence (Haas 2001). All monitoring sites in this report occur in U.S. Fish and Wildlife Service designated bull trout Critical Habitat (75 FR 63897 2010).

MWMT data plotted against temperature benchmarks in Figures 2-1A to 2-9A (Appendix A) coupled with site location from Figure 2-1 yield several basic observations that have ramifications to bull trout: 1) Lake Creek sites reached much higher maximum temperatures and sustained bull trout ILT for longer durations than Big Creek sites. 2) Big Creek lowers the temperature of the Malheur River (site 3). 3) McCoy Creek (sites 7 and 9) is a major driver to the high stream temperatures noted in Lake Creek. 5) Stream temperature patterns at all sites show considerable similarity. 6) A lack of continuous flow throughout the summer at sites 6 and 8 present barriers to migrating fish and could potentially lead to entrainment.

The patterns and observations evident in 2015 and prior years, with particular emphasis on the essential bull trout corridors and habitats of Lake and Big creeks and general trend of sites exceeding temperature thresholds, have specific implications for these stenothermic fish. Given that cooler water temperatures are important indicators of bull trout habitat utilization, the clear differences in recordings between Big and Lake Creek have potential implications to bull trout use. However, bull trout are migratory and rates of movement to cooler upstream waters have been found to correlate with rising daily maximum water temperatures (Swanberg 1997). Thus, migratory patterns could be hypothesized to stay ahead of the curve of rising temperatures and overcome summer temperature extremes. Previous bull trout migration studies in Logan Valley point to a mid-summer concentration of activity in Big Creek and avoidance of Lake. These studies also suggest that, at least for fluvial bull trout populations, migration through the Logan Valley property occurs before the critical stream temperature period generally associated with annual temperature maximums and the temperatures of Lake Creek may become a barrier to migration (Schwabe 2000; Fenton and Schwabe 2001). It is important to note, however, that stream temperatures at all monitoring sites in those studies did not peak until late July/early August. In 2015, temperatures peaked several weeks earlier, possibly forcing bull trout to adjust migratory patterns accordingly.

Assuming bull trout are in fact migrating ahead of lethally warm summer water temperatures, they are still likely subjected to temperatures in excess of the DEQ salmonid standard of 16 °C (Figures 2-4A and 2-5A). Thus, exploring ways to lessen exposure and maintain adequate stream temperatures to allow a longer suitable migration window could prove beneficial to success of the spawning population, especially in regard to Lake Creek. Because stream temperatures in Lake Creek during the primary migration period (June 1st-July 14th) reach critical thresholds sooner than in Big Creek (Tables 2-4, 2-5, and 2-6), the result is a potential thermal barrier that may prevent both upstream and downstream movements of fluvial bull trout. A thermal barrier early in the primary migration period might explain why no radio-tagged bull trout were observed using the Lake Creek corridor to access upstream spawning grounds in previous tribal studies. In 2001, a tagged bull trout attempted migration up Lake Creek but retreated to join tagged Big Creek migrants. Stream temperatures in Lake Creek had already surpassed bull trout ILT when the Lake Creek migration attempt was made. It is important to note that sample size was small for this study (n=20) (Fenton and Schwabe 2001).

Bull trout redd counts for the past two years were not completed, last year because of wildfire in the basin. In 2013, redd counts were about average for periods of drought and 17 were documented at Lake Creek spawning grounds (Hurn 2014). However, the reliability of redd count data is muddled by difficulty distinguishing between bull and invasive brook trout redds (Brown 2012).

Based on current temperature data and past tracking efforts, it is likely that the Lake Creek breeding population is comprised of an isolated non-migratory population. The current status of the entire Upper Malheur bull trout metapopulation is considered to be at a high risk of extinction (Buchanan et al. 1997, USFWS 2002). If the small Lake Creek subpopulation truly is isolated, predation, hybridization, and competition resulting from interactions with non-native brook trout better equipped to thrive and undergo range expansion in warmer water temperatures, as well as a reduction in gene flow, may contribute to a high risk status.

It is worth discussing Lake Creek sites 6 and 8 in detail, given their propensity to become dry in a typical year. Both stations lie in the historic Lake Creek main channel, a stream course that has largely been diverted and rerouted just above NF-16 (16 Road) for many years for grazing and irrigation purposes on private land. After supplying irrigation, the remaining water flows into another Lake Creek channel, referred to by BPT as Lake Creek Ditch, the location of site 10 (K.A. Heinrick and E.M. Maltz, personal communication). As a consequence of this diversion, hobos at both sites 6 and 8 experienced exposure to air in 2015. This is a common occurrence at both sites, with site 6 becoming dewatered six out of nine monitored years and site 8 six of eight (Schwabe 2007; Abel 2008; Abel 2009; Brown 2010; Brown 2011; Brown 2012; Haslick 2014; Haslick 2015).

The consequences of water management on Lake Creek upstream of site 6 include reductions in flow, increased water temperatures, and a disjointed historic channel unsuitable for bull trout migration. Any resident fish attempting to use this channel instead of Lake Creek Ditch for migration between overwintering areas before or after spawning are exposed to temperature stress, the risk of entrainment, and potential lethal take. The BPT Natural Resources Department has been in contact with the landowner to seek a solution.

2.5 Recommendations

Based on the challenges and difficulties comparing and analyzing temperature data, the following recommendations, if implemented, should permit more efficient and accurate temperature data collection. Hobos should always be accuracy checked both prior to deployment and after retrieval. Hobos that are malfunctioning, low on battery, or not within the accuracy brackets for proper recording should be replaced. If accidentally used, an entire season of temperature data could be compromised for that location. Additionally, hobo depths and station flows should be taken at a minimum upon deployment and retrieval if staff time allows. This would facilitate a greater understanding of temperature in the context of site-specific depth and discharge.

Water temperatures at BPT's Logan Valley Wildlife Mitigation Property monitoring sites were higher in 2015 than in years past and the effects of climate change will likely only continue to increase readings. Land managers should focus on strategies they can control to address this concern and its impacts on threatened bull trout. As discussed above, bull trout are a highly temperature sensitive coldwater species (Buchanan and Gregory 1997; Haas 2001; Selong et al. 2001; Dunham et al. 2003). In addition, they have also been shown to be positively correlated with deep pools, undercut banks, large substrate, and riparian habitat dominated by trees and shrubs (Watson and Hillman 1997). Recommendations to create better habitat should focus on water withdrawals, pool creation, riparian restoration, and potentially substrate alteration. Most of these activities, discussed below, would likely lower water temperature as well.

With the exception of Big Creek, stream channels through the mitigation property exist in largely open environments with depleted riparian zones, a result of prior land management activities. Historically, riparian willow and sedge coverage was estimated at 40 percent and 60 percent, respectively (K.A. Heinrick, personal communication). Changes in composition and density of riparian vegetation have been shown to produce corresponding changes in water temperature (Rosgen 1996). In 2009, a large scale native revegetation project was undertaken on the Logan Valley Wildlife Mitigation parcel in the riparian corridors of Lake, McCoy, and lower Big Creek. 100,000 willows were planted with only an estimated 18 percent survival rate due to subcontractor quality control issues. An additional 2,000 willows are planted annually to supplement the original mass planting (K.A. Heinrick, personal communication). Although it is too soon for the surviving willows to have any impact on reducing stream temperature, it is expected that the current level of willow restoration will begin to have an effect in about twenty years. Establishing riparian zones that create shade and store water in the floodplain are practical and effective ways to cool stream temperatures to create more suitable bull trout habitat. Therefore, it is imperative that the willow restoration in Logan Valley be continued and if possible, augmented.

Other avenues to pursue include bank stabilization, large woody debris placement in stream corridors, or encouraging beaver activity in Logan Valley. The principle goal of these activities would be to slow water velocity enough to create deep backwaters, supplying cool water refugia to potential bull trout migrants. At the same time, large wood would increase available cover for bull trout and bank stabilization has the potential to lessen total dissolved solids, improving both water quality and fines deposition rates.

Finally, negotiations with private landowners upstream of BPT's property should continue. Grazing and water withdrawals just north of the mitigation lands have substantial negative effects on stream temperatures and quality and quantity of water downstream. Alleviating those negative impacts through property acquisition or some other means would likely lower stream temperatures and create more suitable bull trout habitat.

2.6 Acknowledgements

The Burns Paiute Tribe thanks Bonneville Power Administration for their continued financial support of this project.

2.7 References

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APPENDIX 2-A

STREAM TEMPERATURES EXPRESSED BY MWMT

FIGURE 2-1A: LAKE CREEK BELOW MCCOY CREEK (SITE 1)

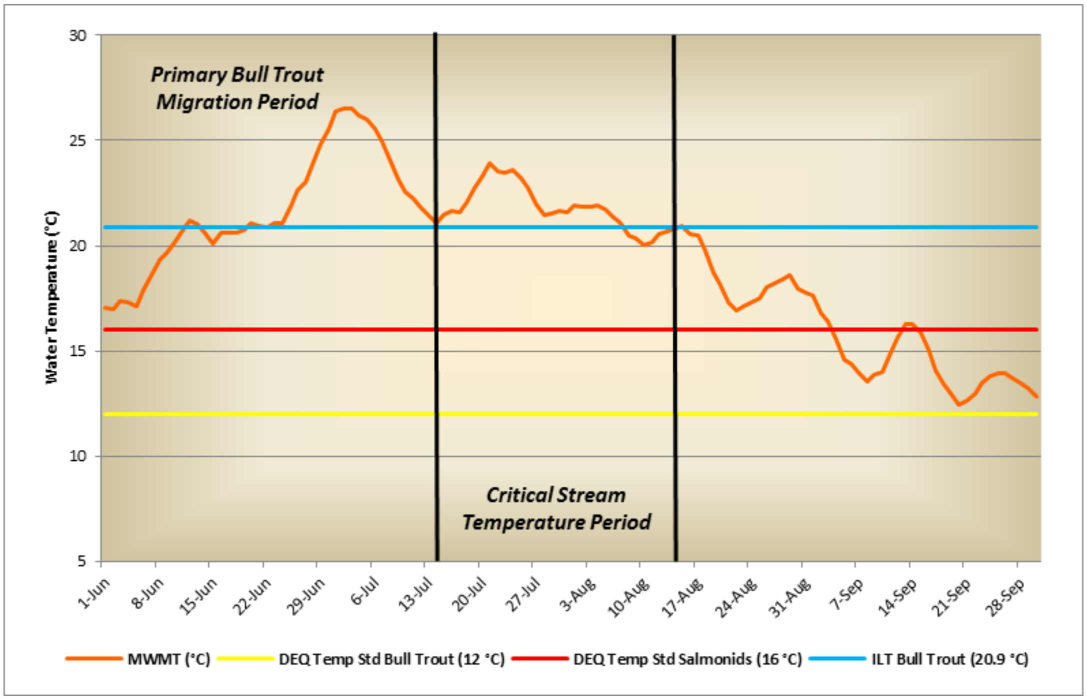


FIGURE 2-2A: LAKE CREEK BELOW CROOKED CREEK (SITE 2)

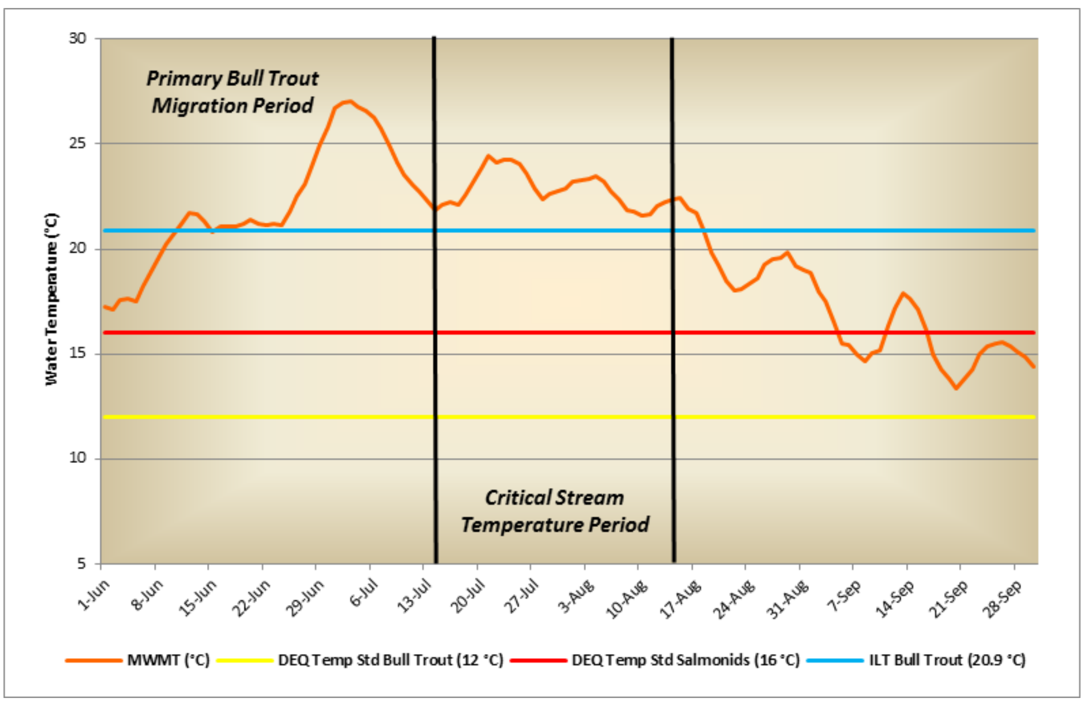


FIGURE 2-3A: MALHEUR RIVER BELOW BIG AND LAKE CREEK (SITE 3)

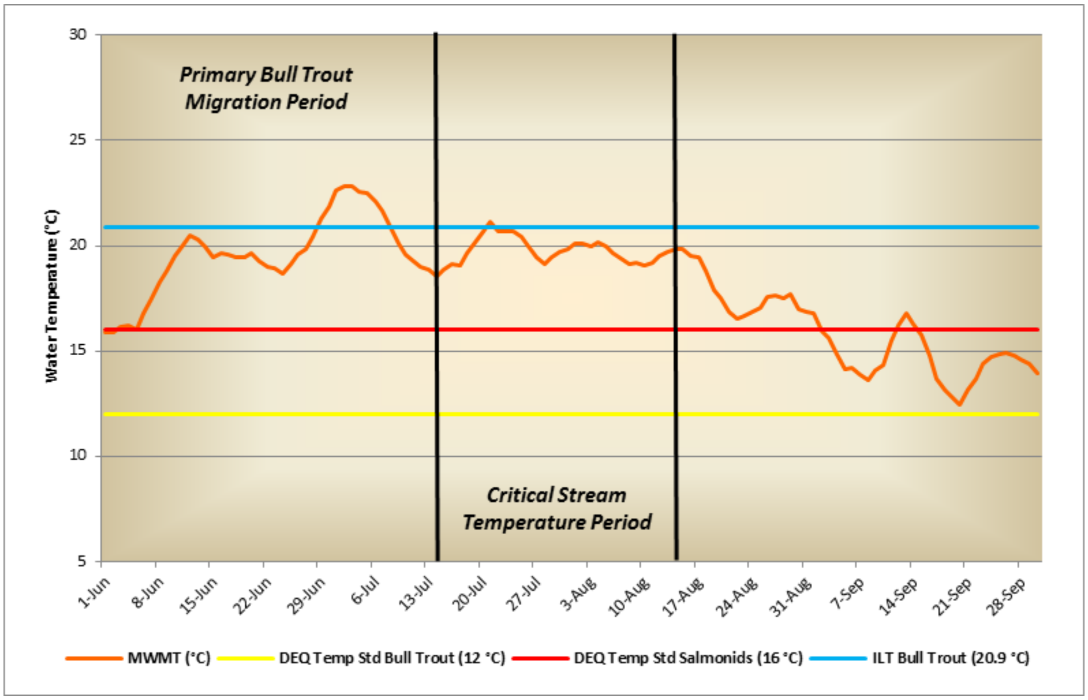


FIGURE 2-4A: BIG CREEK ONE MILE BELOW NF-16 ROAD (SITE 4)

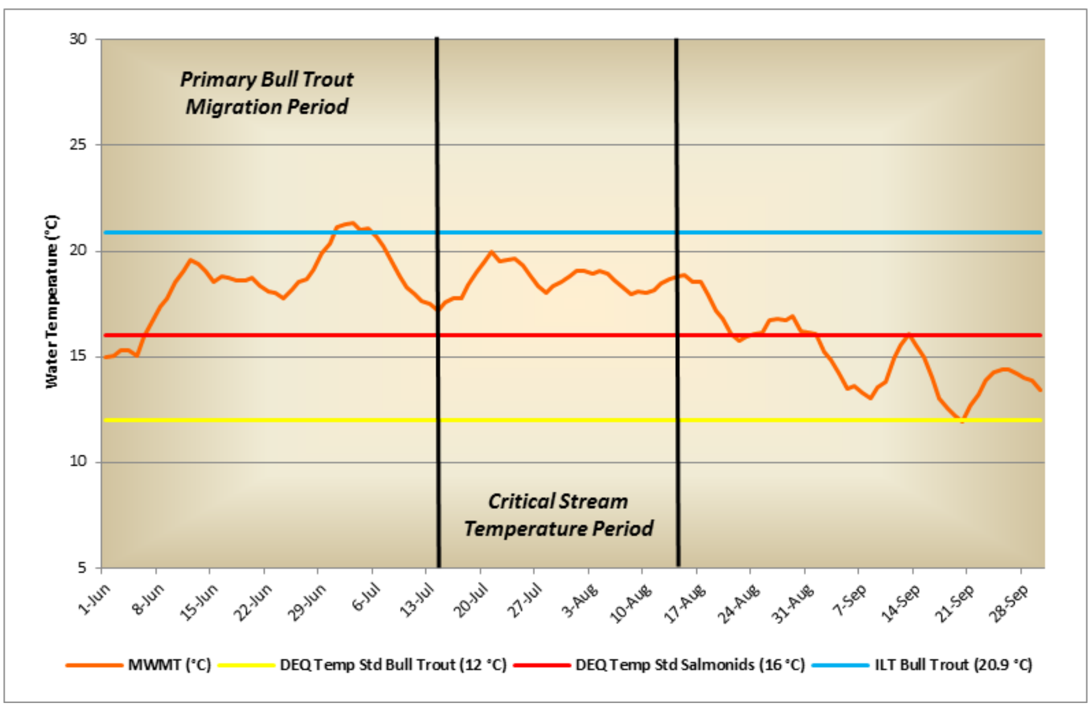


FIGURE 2-5A: BIG CREEK BELOW NF-16 ROAD (SITE 5)

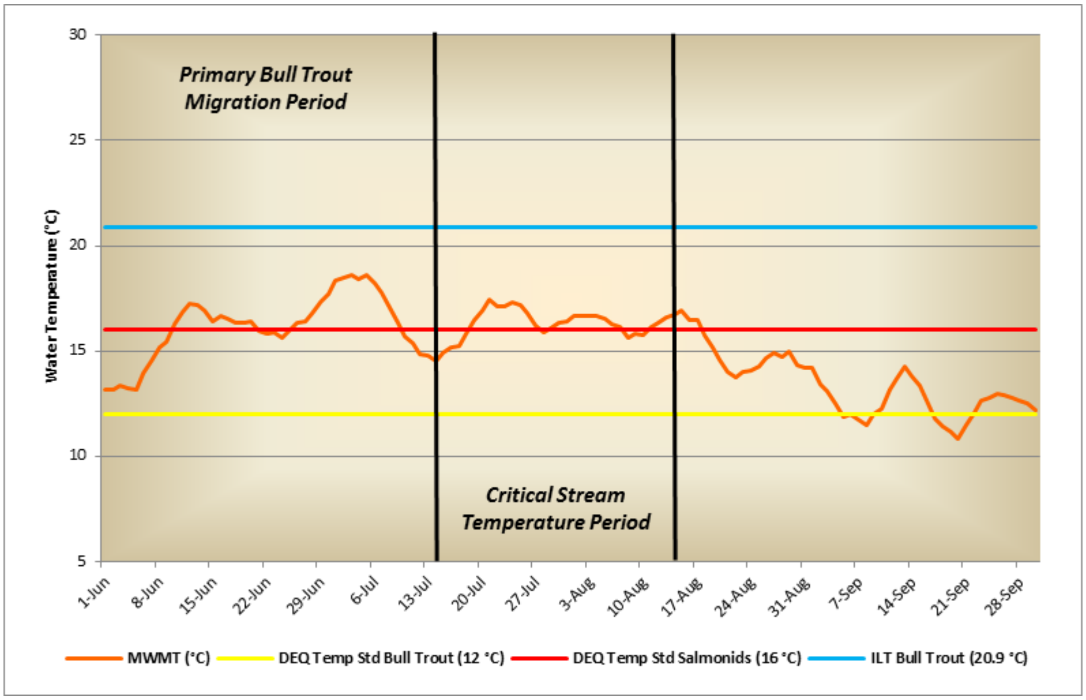
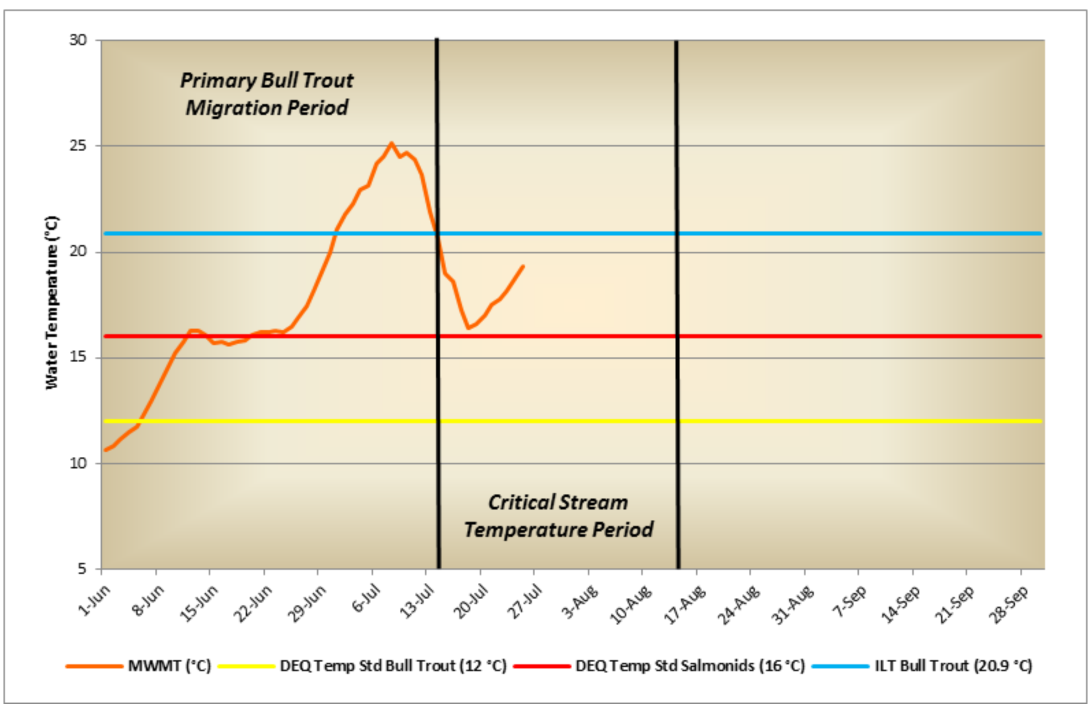


FIGURE 2-6A: LAKE CREEK BELOW NF-16 ROAD (SITE 6)*



*Incomplete data set due to air exposure

FIGURE 2-7A: MCCOY CREEK ABOVE LAKE CREEK (SITE 7)

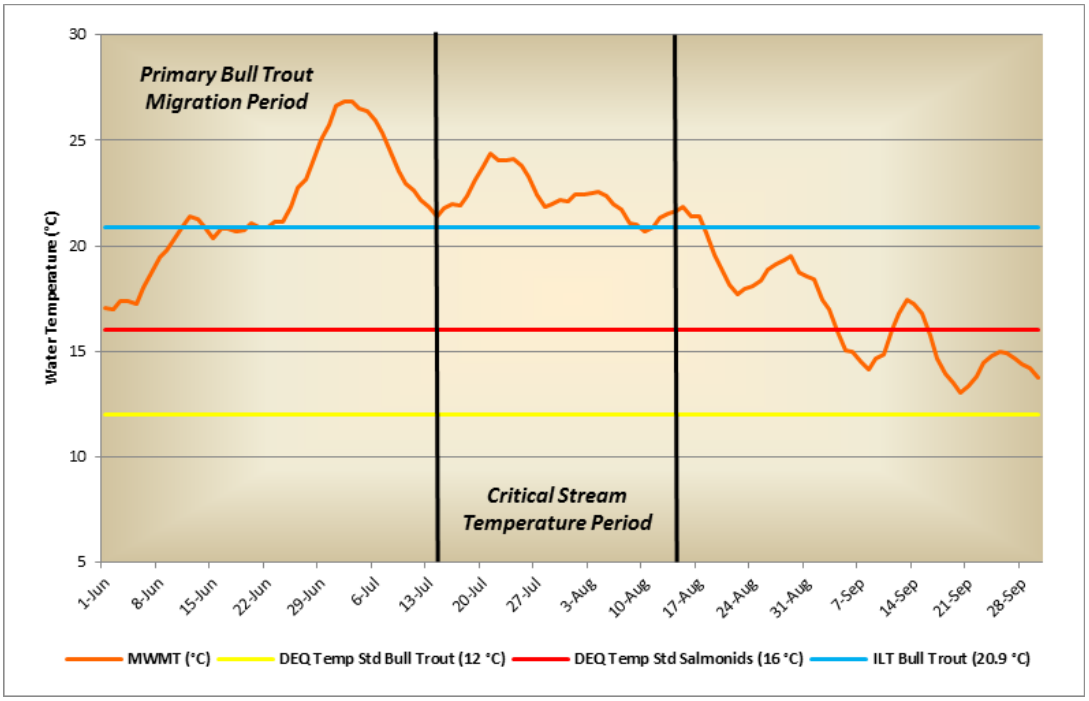


FIGURE 2-8A: MCCOY CREEK BELOW NF-16 ROAD (SITE 9)

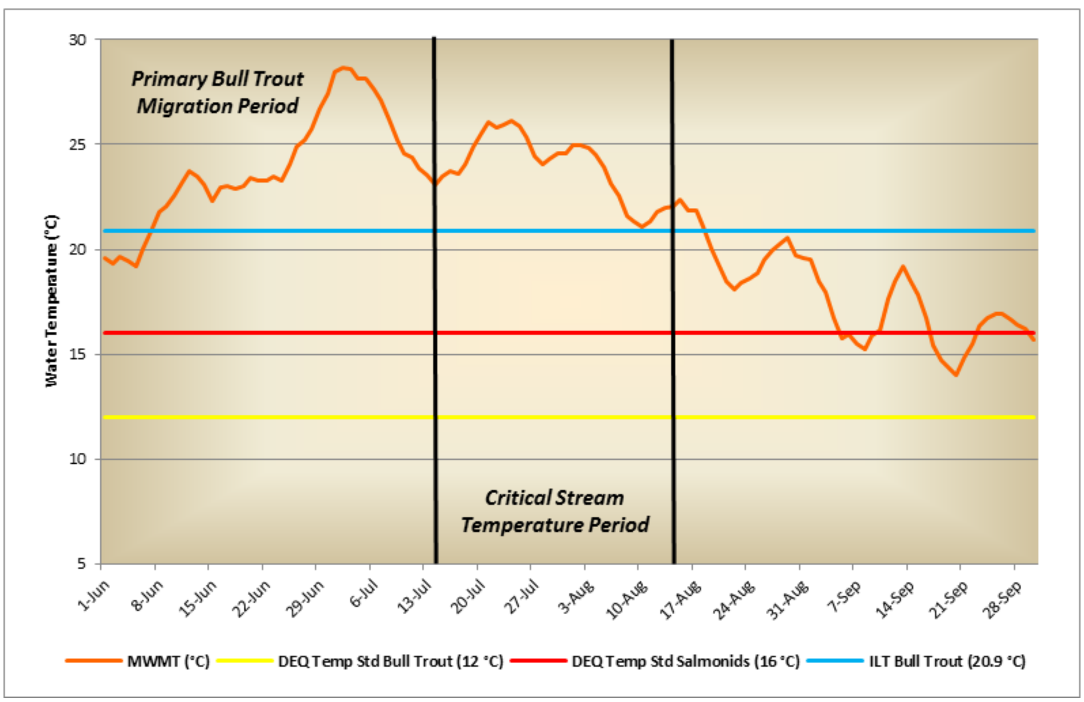
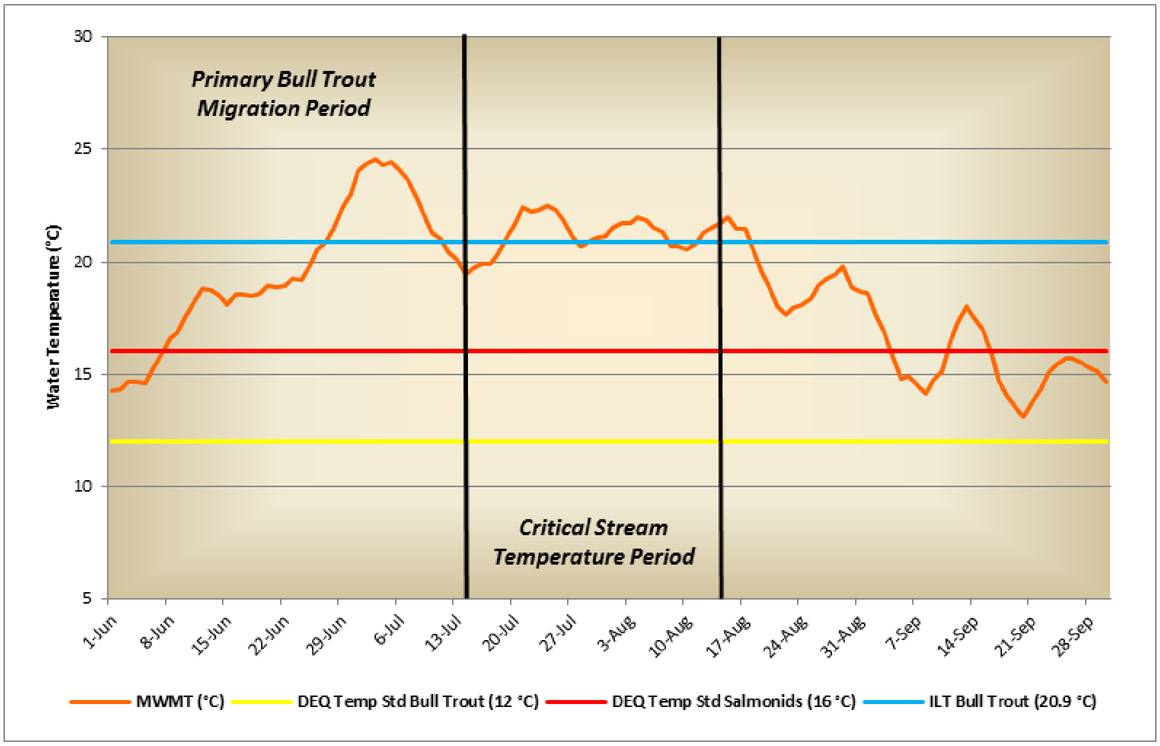


FIGURE 2-9A: LAKE CREEK DITCH BELOW NF-16 ROAD (SITE 10)



APPENDIX 2-B

DAILY AVERAGE STREAM TEMPERATURES

FIGURE 2-1B

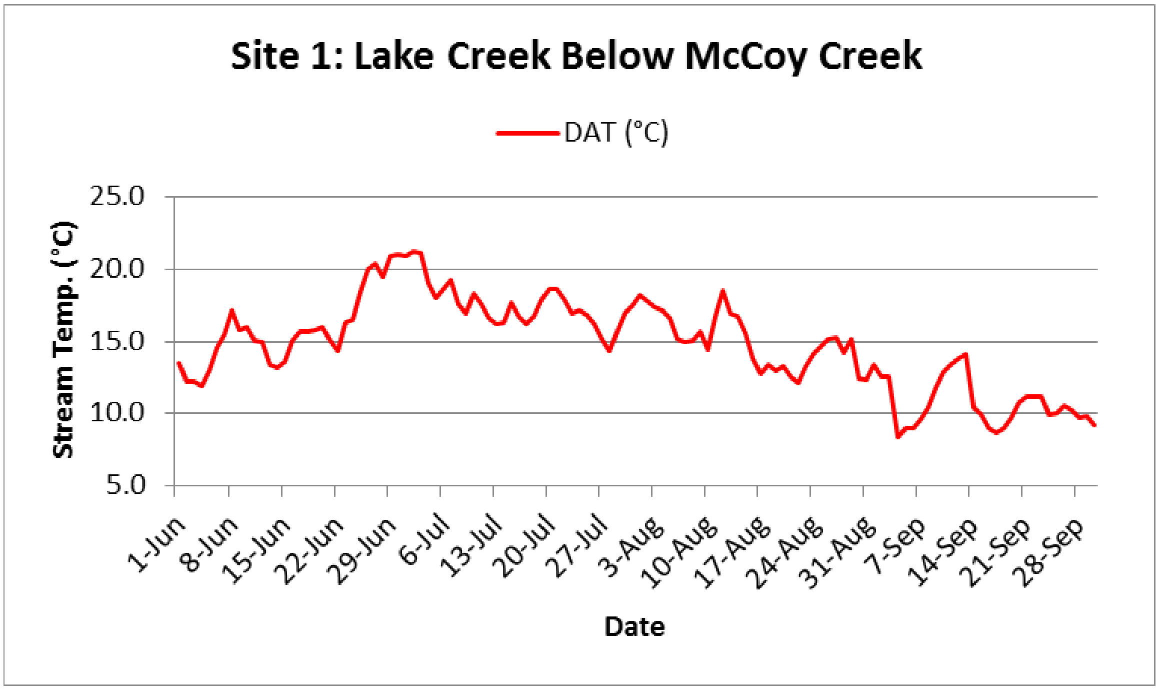


FIGURE 2-2B

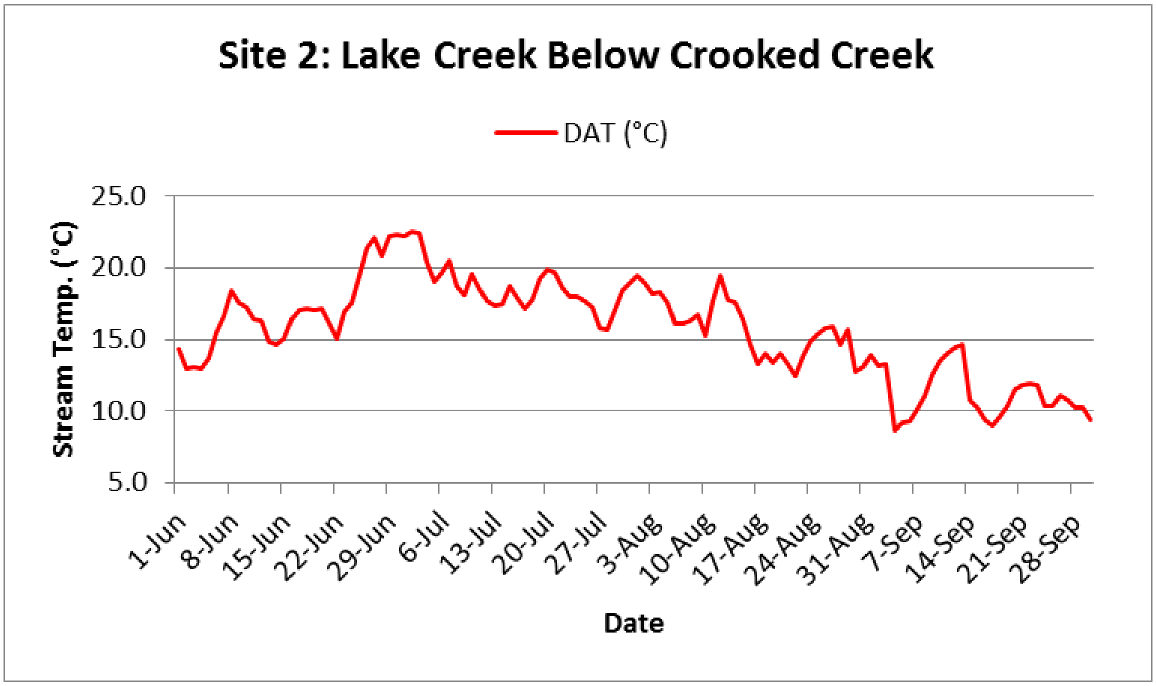


FIGURE 2-3B

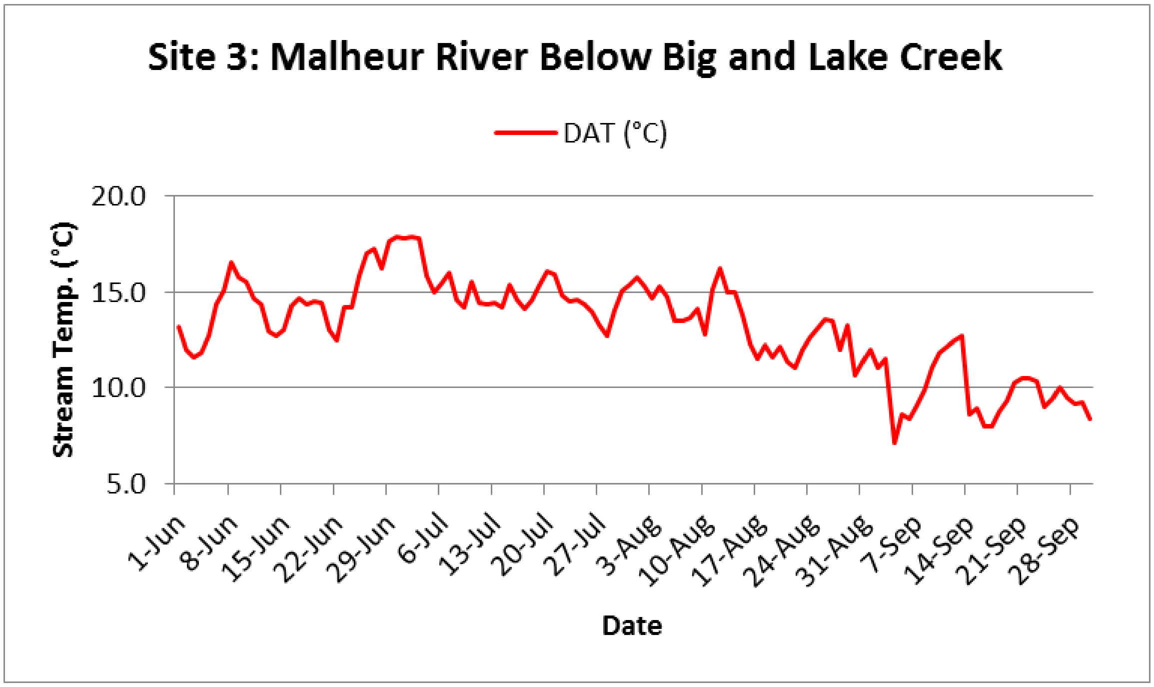


FIGURE 2-4B

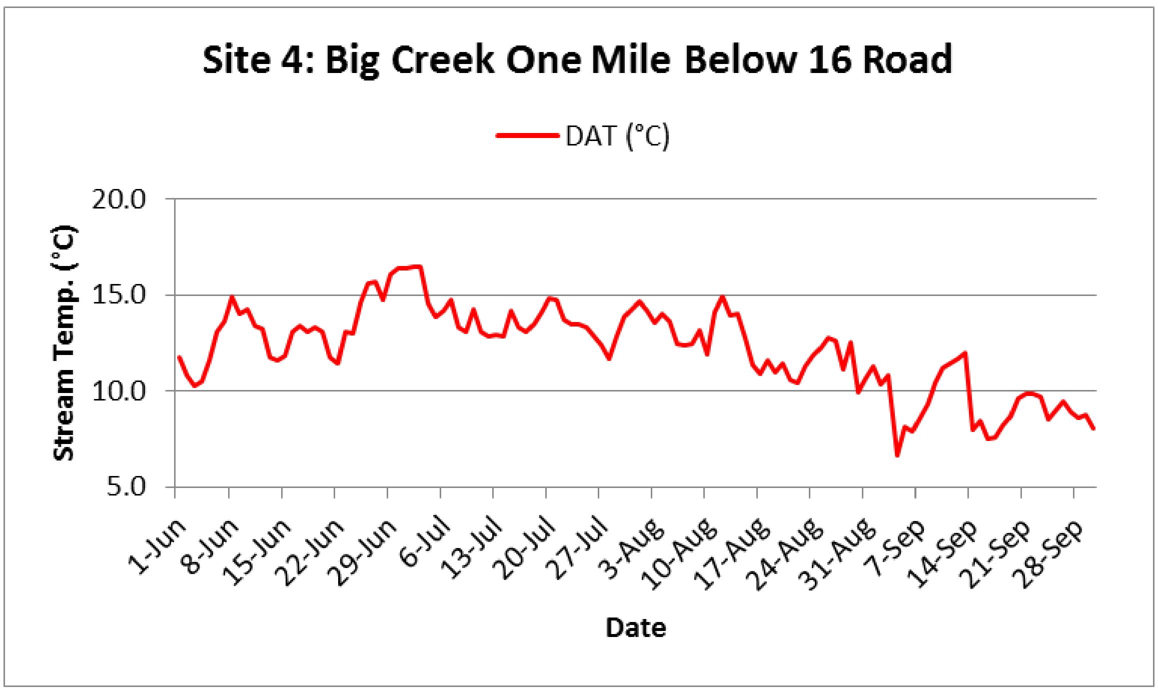


FIGURE 2-5B

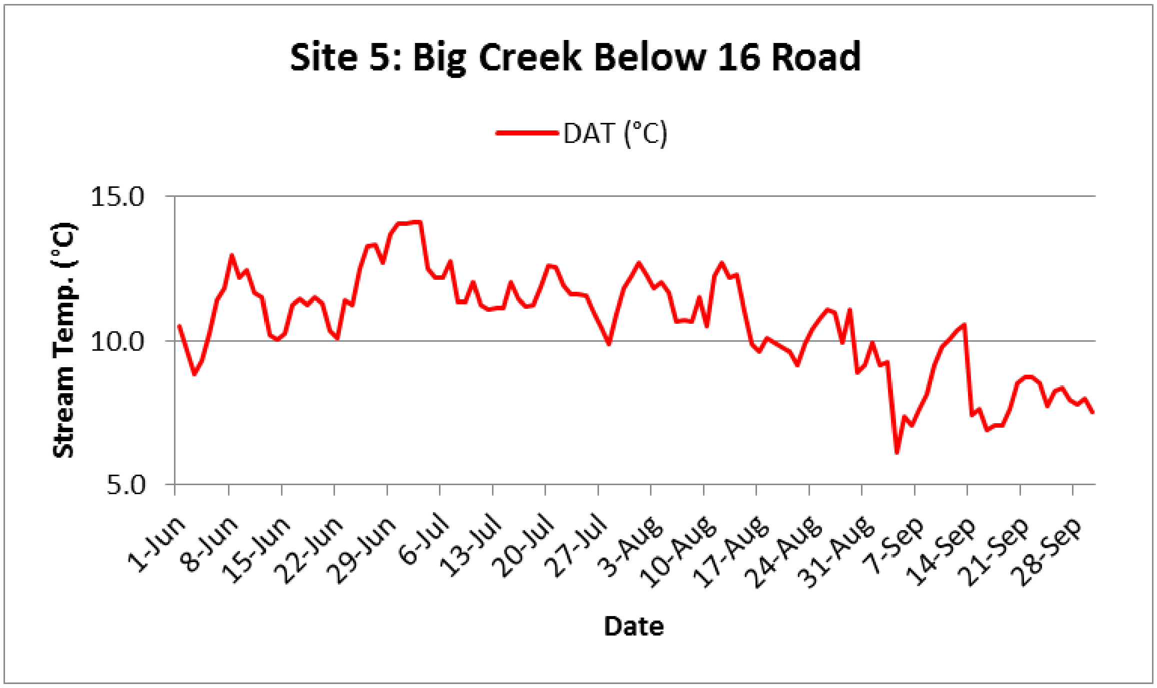
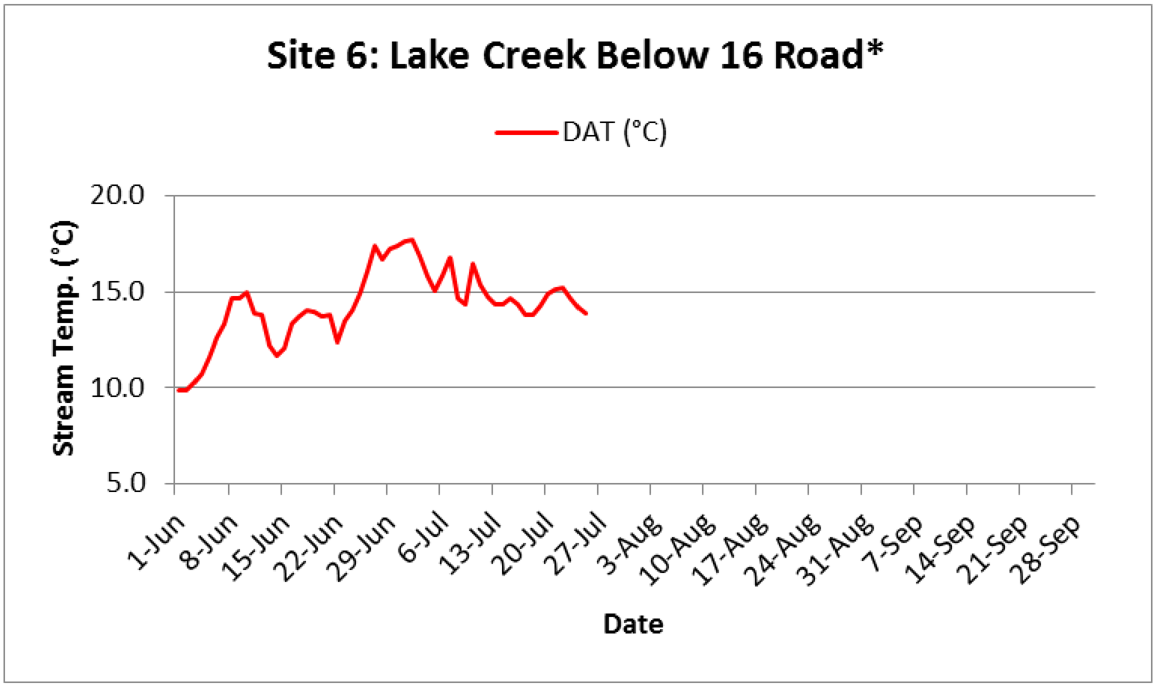


FIGURE 2-6B



*Incomplete data set due to air exposure

FIGURE 2-7B

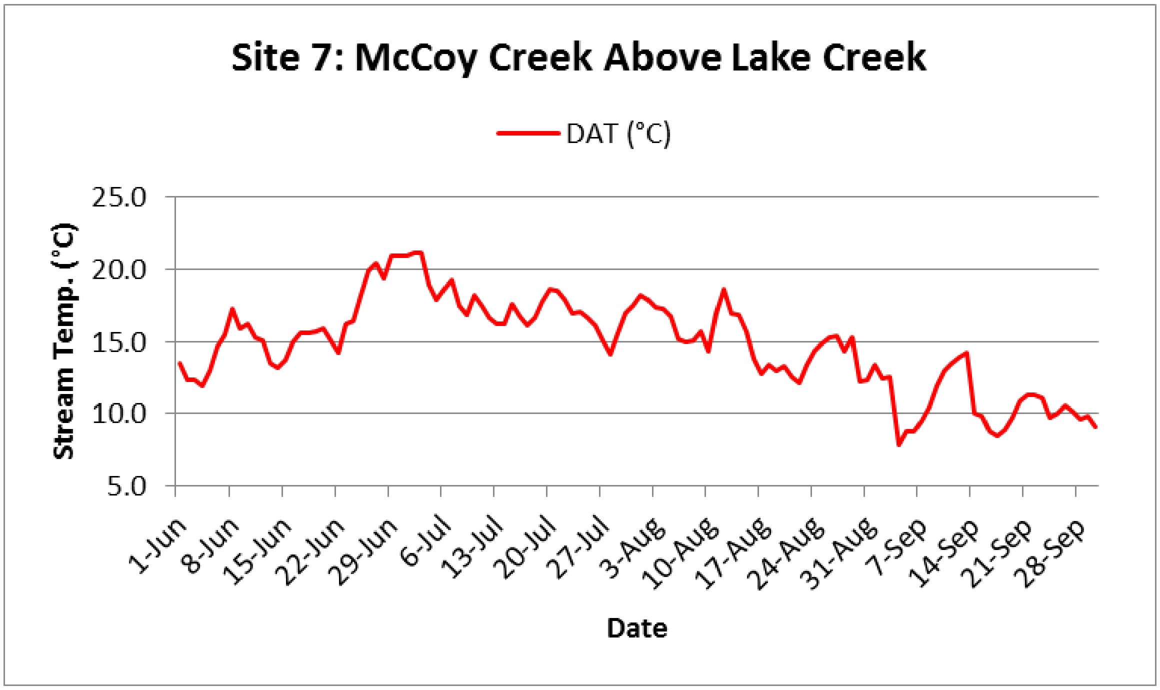


FIGURE 2-8B

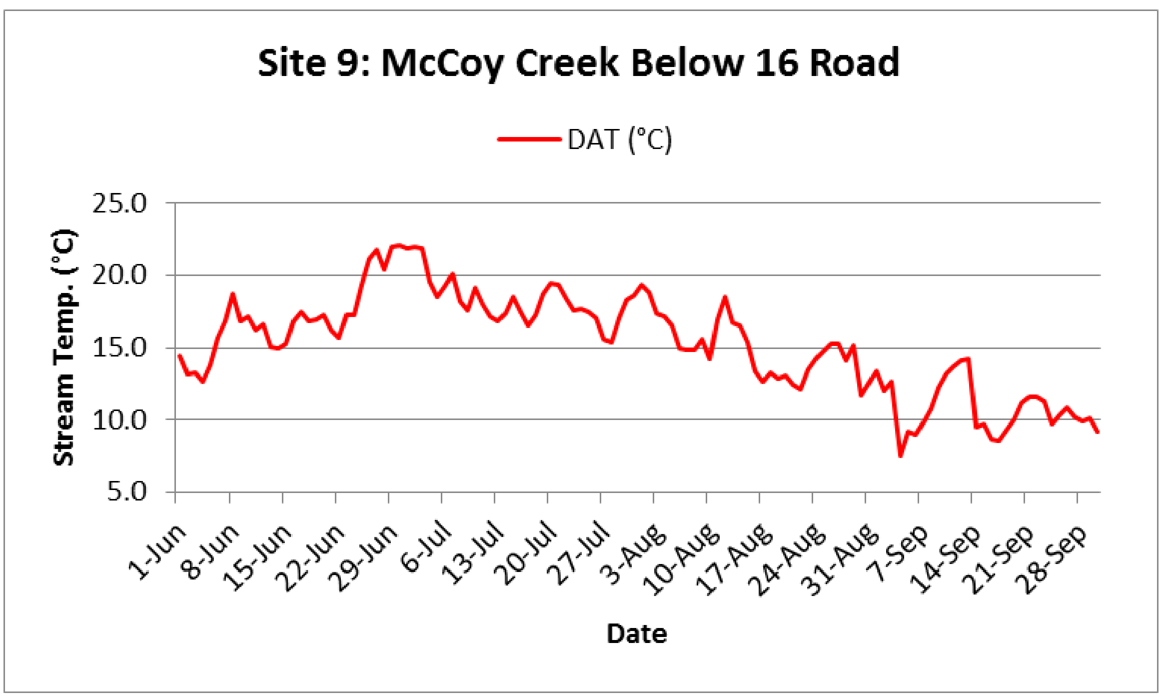
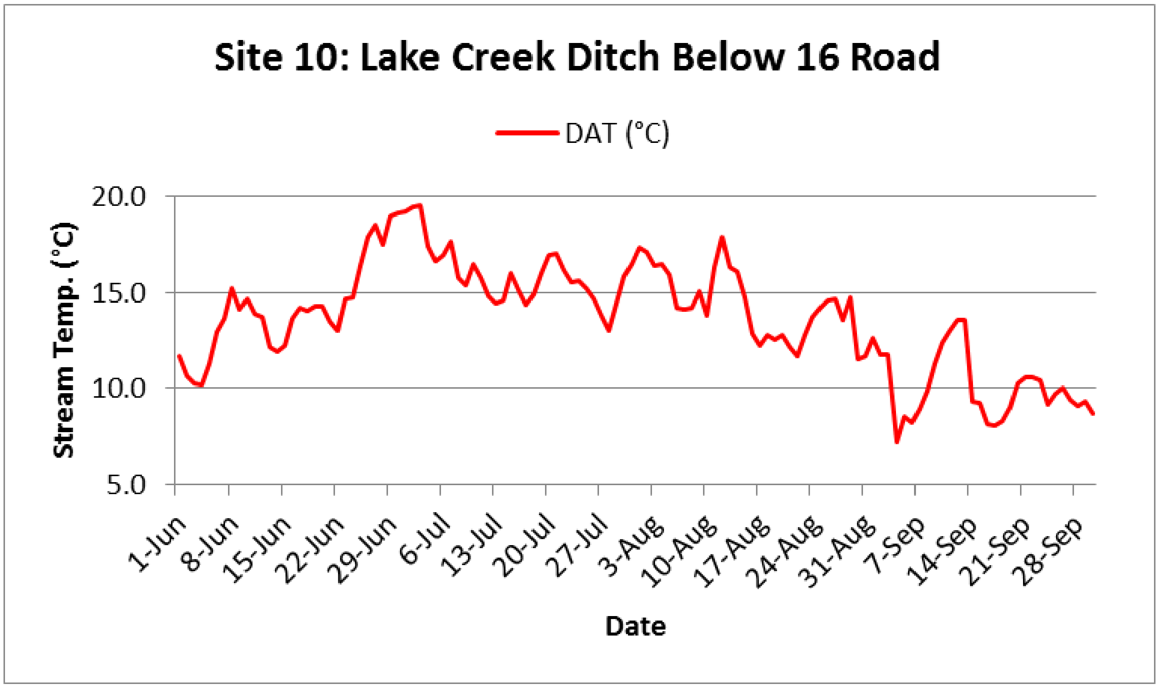


FIGURE 2-9B



Site 10: Lake Creek Ditch Below 16 Road
DAT (°C)
Stream Temp. (°C)
20.0
15.0
10.0
5.0
1-Jun
8-Jun
15-Jun
22-Jun
29-Jun
6-Jul
13-Jul
20-Jul
27-Jul
3-Aug
10-Aug
17-Aug
24-Aug
31-Aug
7-Sep
14-Sep
21-Sep
28-Sep
Date

Chapter 3:
2015 Amphibian Surveying in the Upper Malheur River

Logan Valley Wildlife Mitigation Property, Oregon

Brandon Haslick
Burns Paiute Tribe Natural Resources Department
Burns, Oregon

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Chapter 3: 2015 Amphibian Surveying in the Upper Malheur River: Logan Valley Wildlife Mitigation Property, Oregon

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Chapter 3: 2015 Amphibian Surveying in the Upper Malheur River: Logan Valley Wildlife Mitigation Property, Oregon

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3.1 Introduction

The Burns Paiute Tribe (BPT) acquired the 1760-acre Logan Valley Wildlife Mitigation Property in the Malheur National Forest of eastern Oregon in April 2000 and has been actively engaged in native species habitat and vegetative restoration activities onsite since. One potential roadblock to effective restoration projects includes faunal species inventory. Once individual endemic species are documented to occur, restoration activities can be catered to the unique needs those species require. BPT had never conducted amphibian species inventory on its Logan Valley property until 2015, and the surveys conducted this past year will serve as an adequate starting point to future survey endeavors.

3.2 Methods

Habitat in Logan Valley consists primarily of wetland meadow bisected by several small stream courses. The survey goal was to document amphibian species presence along the extent of the stream courses of McCoy, Lake, and Big creeks on and adjacent to tribal property. A visual representation of survey extent is provided in Figure 3-1.

As depicted in Figure 3-1, all streams flow roughly north to south. Since McCoy Creek confluences with Lake Creek shortly after flowing under U.S. Forest Service 16 Road (which borders BPT's northern property line), the McCoy/Lake surveys included both streams from the 16 Road to just below the confluence with Crooked Creek (which is near one of the BPT's southern property lines). Big Creek was surveyed from the 16 Road to its confluence with Lake Creek (Figure 3-1). The principal channels of Lake and Big required roughly one mile of surveying each. However, side channels, wetlands, and prime habitat of minor tributaries observed increased distance surveyed considerably. Accordingly, Big Creek was surveyed on a separate day than Lake Creek. Time constraints also limited complete coverage of all marshy areas and split channels. However, the amount of potential amphibian habitat not surveyed was kept to a minimum.

Survey protocol was adapted from the amphibian visual encounter survey protocol compiled by the U.S. Geological Survey and Forest Service in "Surveys for presence of Oregon spotted frog (*Rana pretiosa*): Background information and field methods" (Pearl et al. 2010). Surveys were conducted in late spring and early summer, a schedule designed to coincide with high amphibian activity while avoiding logistical difficulties due to latent snowpack. A minimum of two surveyors, typically one on each side of the principle channel of the selected stream course (habitat can dictate otherwise), searched for isolated pools, slow moving channels, marshy habitat, backwater areas, and any other type of habitat with high potential to house amphibians. Searchers weaved back and forth along the floodplain, keeping within proximity of the bank to assure amphibian habitat was not missed. When a split channel was encountered, the fork with the perceived best amphibian habitat was followed if time constraints limited surveying both forks. Overall effort was quantified by timing searches in amphibian habitat and multiplying by number of observers.

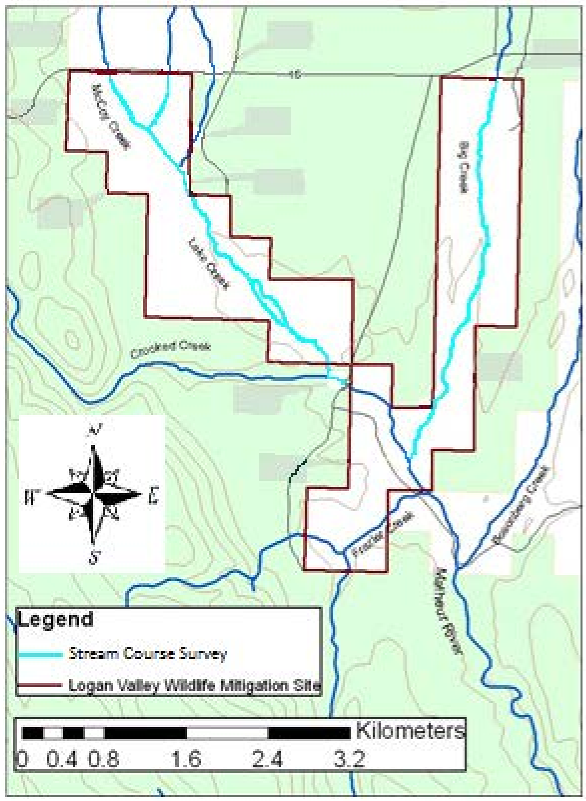

Figure 3-1. Map displaying the stream courses along which amphibian visual encounter surveys were completed in 2015.

All amphibians and egg masses located were keyed (if possible) and tallied. Dip nets were used to capture adult and larval amphibians when necessary for identification or measurement purposes. In order to obtain a temporal estimate of breeding occurrence in Logan Valley, egg masses were classified as early, middle, or late stage if this could be reliably determined. Larval amphibian numbers were simply estimated. Based on species range records and habitat requirements, Logan Valley has the potential for the following amphibian species: long-toed salamander (*Ambystoma macrodactylum*), tiger salamander (*Ambystoma tigrinum*), non-native American bullfrog (*Lithobates catesbeiana*), Columbia spotted frog (*Rana luteiventris*), pacific tree frog (*Pseudacris regilla*), Great Basin spadefoot toad (*Spea* *intermontana*), and western toad (*Anaxyrus boreas*) (Stebbins 2003). Surveyors had resources available to them to assist with species identification.

3.3 Results

Three total surveys were conducted. Lake Creek was surveyed by two individuals on May 7th, Big Creek was surveyed by four individuals on June 1st, and the McCoy/Lake Creek complex was surveyed June 2nd by two individuals. Survey weather ranged from mostly cloudy and cool to mostly sunny and warm. The sunny weather aided observer spotting ability and encouraged amphibian sunning behavior while the cooler temperatures and clouds encouraged amphibian movement with less risk of desiccation. Total times for each survey ranged from 235 to 330 minutes.

Surveys confirmed the presence of Columbia spotted frog (*R. luteiventris*) on tribal property in Logan Valley (Table 3-1). *R. luteiventris* was the only species that could be confirmed present. All reproductive stages were represented from egg mass to tadpole to juvenile and adult. Figure 3-2 displays length-frequency data from measured individuals in the juvenile/adult life stage (29 to 79 mm range). Egg mass counts were highest in the earlier Lake Creek survey. This coincides with the early season breeding tendencies of *R. luteiventris*. By the time the later surveys were conducted, egg masses had decomposed and disintegrated to the point of difficult or impossible to spot. Higher numbers of tadpoles present in the later surveys, however, implies a developmental transition from egg mass to tadpole.

Figure 3-2. Length-Frequency Histogram of *R. luteiventris* (n=48) Sampled During Amphibian Surveys on BPT Logan Valley Wildlife Mitigation Property, Spring 2015

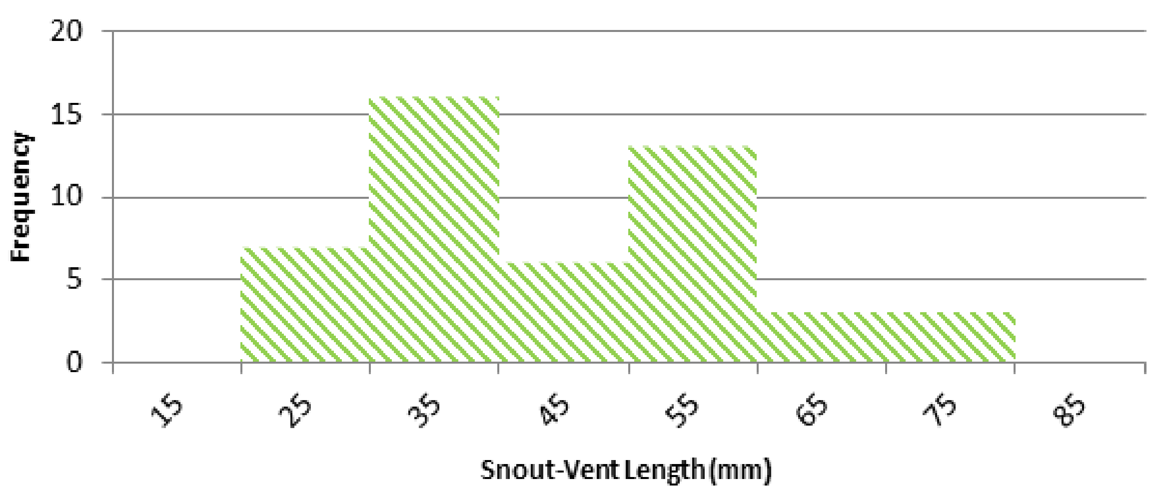

Table 3-1: Evidence of *R. luteiventris* from Burns Paiute Tribe Logan Valley Wildlife Mitigation Property Amphibian Surveys, 2015								
Lake Creek (5/7/15)			Big Creek (6/1/15)			McCoy/Lake Creek (6/2/15)		
Eggmass Tally	Tadpole Estimate	Juveniles/Adults	Eggmass Tally	Tadpole Estimate	Juveniles/Adults	Eggmass Tally	Tadpole Estimate	Juveniles/Adults
17	-	4	-	37	25	3	-	38

3.4 Discussion

Adult and juvenile Columbia spotted frogs (*Rana luteiventris*) represent the only age class observed in all major drainages surveyed on BPT's property. Table 3-2 standardizes the number of adult and juvenile *R. luteiventri*s observed in each survey by the amount of effort expended on each survey reach. Because the number of surveyors and amount of time spent on each reach was variable, standardizing adult and juvenile *R. luteiventris* per minute of survey is a useful exercise to begin to formulate spotted frog drainage preference and rudimentary population density in each reach.

Based on the data presented in Table 3-2, adult and juvenile *R. luteiventris* densities seem to be much higher in the McCoy/Lake Creek survey reach. However, the Lake Creek reach was surveyed at the beginning of May, almost an entire month before the McCoy/Lake Creek and Big Creek surveys were undertaken. Air temperatures were cooler during the May survey and the difference in time of year is probably not a minor consideration. Comparisons must also take into account that the McCoy/Lake Creek survey is composed predominantly of the Lake Creek corridor. Even though the short section of McCoy Creek surveyed had good amphibian habitat and featured numerous *R. luteiventris* sightings, comparisons between Big Creek and McCoy/Lake are probably more informative, as they occurred back-to-back. The earlier Lake Creek survey will be revisited below when the ramifications from the high numbers of egg masses observed will be analyzed.

Table 3-2: Number of Adult/Juvenile *R. luteiventris* Surveyed as a Function of Effort, 2015 Burns Paiute Tribe Logan Valley Wildlife Mitigation Property Amphibian Surveys								
Lake Creek (5/7/15)			Big Creek (6/1/15)			McCoy/Lake Creek (6/2/15)		
Number of Surveyors	Survey Time (min.)	*R. luteiventris*/ min.	Number of Surveyors	Survey Time (min.)	*R. luteiventris*/ min.	Number of Surveyors	Survey Time (min.)	*R. luteiventris*/ min.
2	235	0.0447	4	300	0.0208	2	330	0.0621

Weather during the Big Creek survey was sunny and warm, aiding observer spotting ability and increasing the likelihood of amphibians engaged in sunning behavior. The McCoy/Lake Creek survey was conducted the next day under cloudier conditions, with occasional breaks in cloud cover. Air temperatures were similar both days. Big Creek has higher flows and features a more complex channel with greater beaver activity. Having four surveyors for the Big Creek survey was helpful considering the complexity, but this also increased the chance of multiple sightings of the same amphibian as we were not marking individuals. Surveyors spaced themselves to minimize the chances of this occurring.

Taking the aforementioned into consideration, it appears that the McCoy/Lake Creek complex has better habitat for *R. luteiventris* and features a higher population density than Big Creek based on the sighting rate nearly triple that of Big. This finding may seem surprising given the extensive channel and riparian alteration history of McCoy and Lake Creek compared with that of Big. Logan Valley in general and Lake Creek in specific have a long history of grazing and associated impacts. It is possible that the alterations have been beneficial to *R. luteiventris* by creating better habitat, breeding or otherwise. Evidence from the literature has shown both population benefits and detriments to *R. luteiventris* from cattle grazing, depending on the system (Bull and Hayes 2000, Reaser 2000). Another possibility is simply that *R. luteiventris* has always preferred the McCoy/Lake system for reasons unclear.

Absent from the discussion of adult and juvenile *R. luteiventris* presence is a look at the other reproductive classes. The tadpole life stage was only confirmed present in the Big Creek survey but the May Lake Creek survey was probably too early in the season for tadpoles to have developed. A lack of tadpole sightings in the McCoy/Lake survey in June does not preclude presence as *R. luteiventris* tadpoles disperse, are difficult to observe in general, and may conceal under the ample amount of aquatic vegetation present.

Egg mass tallies are of greater interest. According to life history studies of this species, females lay only one egg mass per season (Dodd 2013). Although the number of males present cannot be determined via egg mass count, each egg mass can be assigned to a unique female. Assuming the adult individuals surveyed were not the individuals responsible for depositing the egg masses in the McCoy and Lake Creek surveys, they become additive to total adults observed.[1] When this is done, the modified sighting rates of Lake Creek and McCoy/Lake become .0447 *R. luteiventris*/minute and .0621 *R. luteiventris*/minute, respectively. This brings the earlier Lake Creek survey more in line with the later McCoy/Lake Creek survey and moves Big Creek more towards outlier status.

It should be noted that the egg masses of *R. luteiventris* are often deposited early in the season (Stebbins 2013). The egg masses from the McCoy/Lakeh survey in June were very late stage (two were already spent) and the vast majority of those from the Lake Creek survey in May were already late stage as well. The gelatinous casings break down quickly after the tadpoles hatch, so a failure to observe egg masses in the Big Creek survey does not necessarily mean they were never present.

[1] This is a reasonable assumption given the relatively low numbers of one or the other in each survey, the lack of proximity of adults to egg masses, and the substantial geographic extent of the area surveyed.

3.5 Conclusions/Recommendations

BPT's Logan Valley Wildlife Mitigation Property has excellent habitat for *Rana luteiventris*. The sampling completed in the spring of 2015 found *R. luteiventris* throughout the stream courses of all three major creeks onsite. Management actions to increase habitat for *R. luteiventris* include creating shallow pools with submerged and emergent vegetation as this would make excellent reproductive habitat for the species (Davis and Verell 2005). Manually creating pools and ponds or encouraging beaver activity and placing woody debris to increase channel complexity has the potential to create beneficial habitat for reproduction, sunning, foraging, overwintering, and refugia (Dodd 2013).

Future Columbia spotted frog monitoring may include an earlier survey to allow for a more accurate picture of population size as egg masses will not have advanced to such a late stage so as to make detection difficult. Because it is difficult to predict the timing of breeding, multiple survey rounds are one option to decrease the chances of missing egg masses. Year over year trends in observations could also be investigated to obtain insight into population dynamics. Recording more specific habitat where each sighting occurs could prove valuable if the BPT decides to modify habitat to the benefit of the Columbia spotted frog in the future.

The primary purposes of the amphibian surveys conducted by BPT in Logan Valley in 2015 were to garner presence/absence information, to add to species range and occurrence records, and to use data obtained to fine tune future restoration activities aimed at creating or protecting habitat both for native species onsite and desirable species not yet confirmed present. The spring surveys were effective for those purposes but BPT desires a more robust picture of amphibian species assemblages occurring in Logan Valley. It is probable that several additional species are present but simply remained undetected by the visual encounter surveys performed in the spring of 2015. Obtaining this information will serve to guide future BPT vegetative restoration actions but will additionally inform future fisheries management projects as BPT seeks to limit the negative effects to native amphibians of potential Logan Valley chemical treatment options to restore the fisheries of the upper Malheur watershed.

Possibilities to further the scope of the general amphibian survey program include placing cover boards or setting pitfall traps at strategic locations on the mitigation property and in the surrounding forest. Investigations into vernal pools in and around Logan Valley would also help to create a more complete picture of amphibian presence/absence. BPT is in the process of contacting Forest Service biologists that may have information regarding amphibians, ephemeral pools, and previous surveying that has been done in the vicinity and working in conjunction with USFS to streamline our sampling strategy.

3.6 Acknowledgements

The Burns Paiute Tribe thanks the U.S. Fish and Wildlife Service for providing funding for this effort through its Tribal Wildlife Grant program.

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Chapter 4:
Benthic Macroinvertebrate Sampling in the Upper Malheur River, Oregon in Conjunction with a Proposed Piscicide Treatment

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Contents

Chapter 4: Benthic Macroinvertebrate Sampling in the Upper Malheur River, Oregon in Conjunction with a Proposed Piscicide Treatment

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4.1 Introduction

The effects of an application of rotenone, a natural piscicide, are not always limited to the organisms it is intended to eradicate. Impacts to benthic macroinvertebrate species are variable and depend on several factors such as rotenone concentration, duration, and coverage, macroinvertebrate habitat use variability, and life history and morphological differences amongst individual species (Vinson et al. 2010). However, benthic macroinvertebrate populations have been shown to have the capacity to recolonize relatively quickly post-treatment (Hamilton et al. 2009, Magnum and Madrigal 1999, Vinson et al. 2010), depending on the availability of upstream population sources and individual dispersal capabilities. Similar recovery timeframes for benthic macroinvertebrates have been demonstrated following the application of the neutralizing agent potassium permanganate (Gibbs et al. 2015, Walker 2003), which is typically applied in tandem with a piscicide.

The intention of the Burns Paiute Tribe (BPT) is to monitor the effects of the proposed piscicide treatment of High Lake and upper Lake Creek in the Strawberry Mountain Wilderness of the Malheur National Forest of eastern Oregon on non-target organisms such as benthic macroinvertebrates. Because sampling for aquatic macroinvertebrates in a stream setting is inexpensive, commonly done, has a high success rate, and typically results in robust samples (Hayslip 2007), the focus of BPT's macroinvertebrate sampling will be on upper Lake Creek as opposed to High Lake. The overarching goal is to document whether taxa diversity and population numbers have recovered post-treatment to a level that approximates that of pre-treatment condition. In order to accomplish that goal, BPT will sample benthic macroinvertebrates in upper Lake Creek prior to proposed treatment activities and after the treatment has been completed. In late summer 2014, BPT completed pre-treatment benthic macroinvertebrate collection to establish initial taxa composition and relative abundance, a necessary component to the evaluation of the proposed High Lake/upper Lake Creek treatment effects on this particular unit of biodiversity.

4.2 Methods

The section of Lake Creek proposed to be treated with piscicide is a high-elevation (6600-7450'), approximately 2.5-kilometer reach from High Lake downstream to a natural waterfall barrier to fish movement. The upper Lake Creek treatment is expected to occur simultaneously with the treatment of 5.8-acre High Lake. In order to obtain a representative sample of benthic macroinvertebrate populations, the 2.5-kilometer Lake Creek sample frame was broken down into five approximately 400-meter (linear distance) reaches that were sampled independently (Figure 4-1). Based on the Pacific Northwest Aquatic Monitoring Partnership's (PNAMP) report entitled "Methods for the Collection and Analysis of Benthic Macroinvertebrate Assemblages in Wadeable Streams of the Pacific Northwest" (Hayslip 2007), eight samples from each 400-meter reach were obtained and composited together for cost-efficiency, for a total of five samples over the sample frame. The length of each reach was sufficient to account for the repeating patterns of variation in riffle-pool morphology and associated benthic macroinvertebrate assemblages, as the PNAMP guidelines recommend at least forty times the wetted width of the channel (Hayslip 2007). The estimated half-kilometer of stream excluded from sampling consists of sections of subterranean and discontinuous/reduced flow which either do not meet the minimum criteria required to sample or are impossible to access. Figure 4-1 depicts sampled reaches and sections that were unable to be sampled.

Figure 4-1. Map of reaches with sections unable to be sampled in white.

Before sampling, the riffles of each reach were mapped. Riffles were chosen because benthic macroinvertebrate diversity is often highest within this type of habitat and past research indicates that clear and consistent biological signals can be obtained by sampling them (Hayslip

2007). Riffle mapping in the field required taking GPS coordinates at the top and bottom of each. Only riffles large enough for a Surber sampler (the sampling device, described below) to fit were mapped and mapping concentrated on the main channel only, excluding side channels. Once all riffles had been mapped in all reaches, the eight riffles to be sampled were randomly selected. Each riffle had its length calculated (standardized linear length, determined from GPS top and bottom points) to determine the length of each third of the riffle, critical to the sampling design described below. Figure 4-2 depicts a typical riffle found in Lake Creek.

Figure 4-2. Lake Creek riffle.

BPT used the 'grid method' to determine where to sample in each randomly selected riffle. The first sample was taken on the left side (looking upstream) in the bottom third of the first randomly selected riffle. The subsequent sample was taken from center channel somewhere in the bottom third of the next selected riffle, the third sample from the right side of the stream somewhere in the bottom third of the third randomly selected riffle, the fourth sample from the left side in the middle third of the next randomly selected riffle, and so on until eight samples had been collected. A graphical depiction of samples taken is as follows (with each row representing the bottom third, middle third, and top third of the riffle):

7	8	
4	5	6
1	2	3

After the determination of specifically where to sample in the riffle had been made, a one foot by one foot Surber sampler or 'kick net' with 500-micrometer mesh was positioned on the substrate surface. The sampler was firmly dug into the substrate to eliminate gaps and the opening of the net was maneuvered to face upstream. For one minute, the substrate in the Surber sampler frame was agitated to detach as many benthic macroinvertebrates as possible while allowing the current to wash the macroinvertebrates into the net. After time had expired, the current was used to wash all detritus and macroinvertebrates into the bottom of the net. Any large pieces of detritus were removed, but care was taken to make sure no benthic macroinvertebrates were lost in the process. The next step was to turn the net inside out and channel the contents into a plastic sample jar. A water-filled spray bottle was used to help transfer the material from the net into the collection jar. The sample container was a quarter filled with 70-95% ethyl or isopropyl alcohol. All eight samples from each reach were composited into one collection container, which was labeled with reach number, riffle numbers, the date, and the stream name. Samples were stored in a refrigerator until they were to be shipped to the laboratory for processing.

In accordance with PNAMP recommendations, sampling for benthic macroinvertebrates occurred between the timeframe of July 1st- October 15th. This allowed for the greatest range of species representation in easier to identify body sizes while also allowing for aquatic conditions to have stabilized after spring run-off (Hayslip 2007). Specifically, BPT collected all samples on September 12th.

4.3 Results

A subset of at least 500 individuals per composite sample or the entire composite sample if consisting of less than 500 individuals was processed and identified to taxonomic level by Aquatic Biology Associates (ABA) of Corvallis, Oregon. After analyzing the samples, ABA provided a report of the findings. A total of 79 unique taxa were represented collectively. The vast majority (ranging from 89.2-97.9% depending on sample) were members of the order Arthropoda (classes Insecta, Arachnida, and Ostracoda), but Mollusca, Annelida (segmented worms), Nemata (roundworms), and Platyhelminthes (flatworms) were also present. At most sites, the top three most abundant concentrations consisted of the orders Ephemeroptera (mayflies), Diptera (midges), and Plecoptera (stoneflies) in that order. The single exception appears to be reach 4 which replaced midges with mayflies as the overwhelmingly dominant taxa. Figures 4-3 to 4-7 in Appendix 4-A break down benthic macroinvertebrate abundance by reach.

Additional findings by ABA indicate that multiple feeding groups of benthic macroinvertebrates are present in each reach. Predators, omnivores, parasites, collectors, shredders, and scrapers were all documented (Table 4-1). Predictably, the taxa collected from this high-elevation stream had thermal preferences in line with cooler temperatures. Sensitive and intolerant taxa outweigh tolerant by large margins indicating an aquatic ecosystem relatively free from human disturbance. When ABA ran Benthic Invertebrate Index of Biological

Integrity (BIBI) tests, the overall biological condition scores of each reach landed in the 'high biological integrity' category with the exception of reach 5 which scored moderate (Table 4-1). Parameters such as number of long-lived taxa, number of intolerant taxa, total number of taxa,

Waterbody	Lake Creek		Lake Creek		Lake Creek		Lake Creek		Lake Creek	
Reach	1		2		3		4		5	
Date	9/12/14		9/12/14		9/12/14		9/12/14		9/12/14	
METRIC	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
Total number of taxa	53	5	50	5	59	5	51	5	40	3
Number Ephemeroptera taxa	11	5	12	5	11	5	6	3	6	3
Number Plecoptera taxa	14	5	8	5	14	5	11	5	9	5
Number Trichoptera taxa	9	3	6	3	10	5	10	5	5	3
Number of long-lived taxa	16	5	11	5	18	5	18	5	10	5
Number of intolerant taxa	22	5	18	5	23	5	21	5	15	5
% Tolerant taxa	0.8	5	2.8	5	0.2	5	0.2	5	0	5
% Predator	22	5	8.5	1	14	3	10	3	9.8	1
Number of clinger taxa	27	5	23	5	31	5	26	5	19	3
% Dominance (3 taxa)	24	5	47	5	38	5	39	5	52	3
TOTAL SCORE		**48**		**44**		**48**		**46**		**36**
BIOLOGICAL CONDITION CATEGORY										
Maximum score of 50.	Each metric scored: 1=low, 3=moderate, 5=high									
Note that this BIBI based on average/summation of 3 replicates, not on each individual replicate.										
OTHER COMMUNITY COMPOSITION METRICS THAT ARE INDICATIVE OF BIOLOGICAL CONDITION										
Total abundance (m2)	2057		1644		2625		4502		6305	
EPT taxa richness	34		26		35		27		20	
Predator richness	15		8		19		14		9	
Scraper richness	8		8		8		3		2	
Shredder richness	9		8		9		7		7	
%Intolerant taxa	30		64		36		32		21	
%Collector	47		45		62		72		72	
%Parasite	2.1		3.8		1		1.2		1.3	
%Oligochaeta	2.9		1.4		0.8		0.2		0.3	
Number tolerant taxa	0		3		1		1		0	
%Simuliidae	0		0.4		0		0.4		0.2	
%Chironomidae	37		21		46		56		46	
L,M & H comparisons with a Pacific Northwest montane stream with high biological integrity.										
Metric value generally increases with declining biological integrity.										
Metric value generally decreases with declining biological integrity.										
Low biological integrity.			BIBI scores between 0-24.							
Moderate biological integrity.			BIBI scores between 25-39.							
High biological integrity.			BIBI scores >40.							

Table 4-1. Benthic Invertebrate Index of Biological Integrity (BIBI) Scores and Additional Community Composition Metrics Indicative of Biological Condition for each Sampled Lake Creek Reach.

and percent predators constitute a reach's overall BIBI score. Other metrics such as scraper and shredder richness and percent collector taxa constitute additional parameters for assessing the biological condition of each reach in reference to benthic macroinvertebrate diversity. According to Table 4-1, predator, scraper, and shredder richness as well as percent collector and Chironomidae were limiting factors preventing classifications of 'high biological integrity' for many of the reaches sampled in upper Lake Creek for those categories. Despite the limiting factors, all reaches still score relatively highly when including the additional parameters.

4.4 Discussion/Recommendations

The results of BPT's benthic macroinvertebrate assessment of upper Lake Creek indicate an aquatic ecosystem within the expected range of taxa presence for high elevation mountain streams. Based on this finding, confirmation that the impacts of the proposed piscicide treatment are temporary takes on additional importance. BPT continues to rely on the substantial body of scientific research that indicates rapid benthic macroinvertebrate recovery after a piscicide treatment (Hamilton et al. 2009, Magnum and Madrigal 1999, Vinson et al. 2010). However, monitoring post-treatment should include statistical analysis to confirm that population numbers and taxa assemblages have in fact recovered.

Treatment planning discussion has resulted in the establishment of a preferred timeframe of mid-summer for eventual piscicide application. BPT's benthic macroinvertebrate sampling was undertaken in September, the time of year that it was originally believed the treatment would take place. If funding permits, an additional round of benthic macroinvertebrate sampling in July instead of September could provide additional information relevant to treatment timing. It is possible that sampling in July would produce a different macroinvertebrate baseline more appropriate to monitor after treatment.

4.5 Acknowledgements

The Burns Paiute Tribe thanks the U.S. Fish and Wildlife Service for providing funding for this effort through its Tribal Wildlife Grant program.

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APPENDIX 4-A

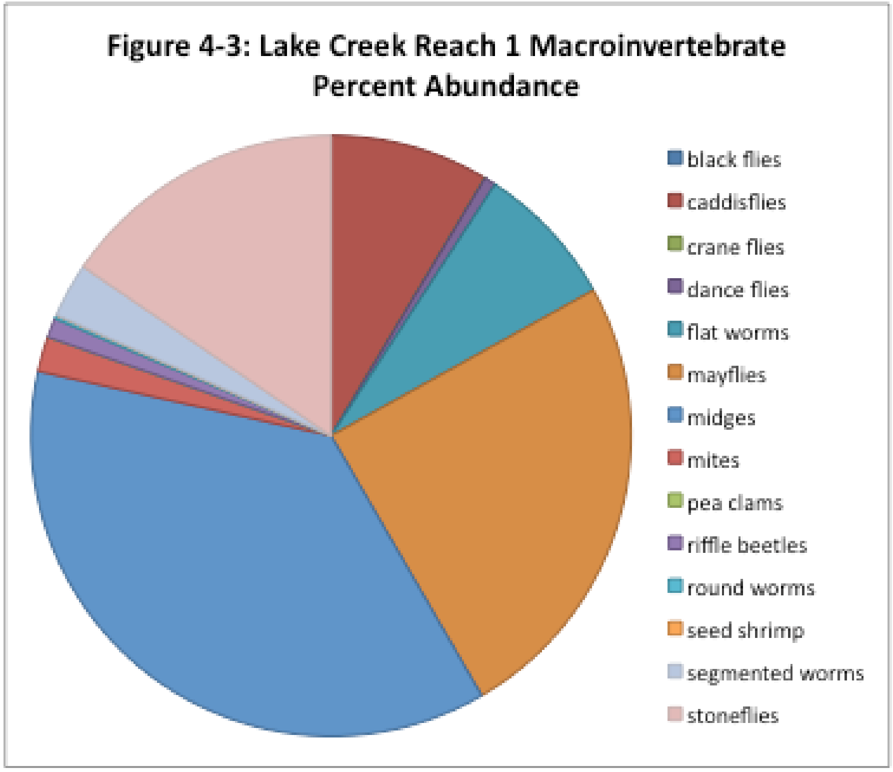
Figure 4-3: Lake Creek Reach 1 Macroinvertebrate Percent Abundance
black flies
caddisflies
crane flies
dance flies
flat worms
mayflies
midges
mites
pea clams
riffle beetles
round worms
seed shrimp
segmented worms
stoneflies

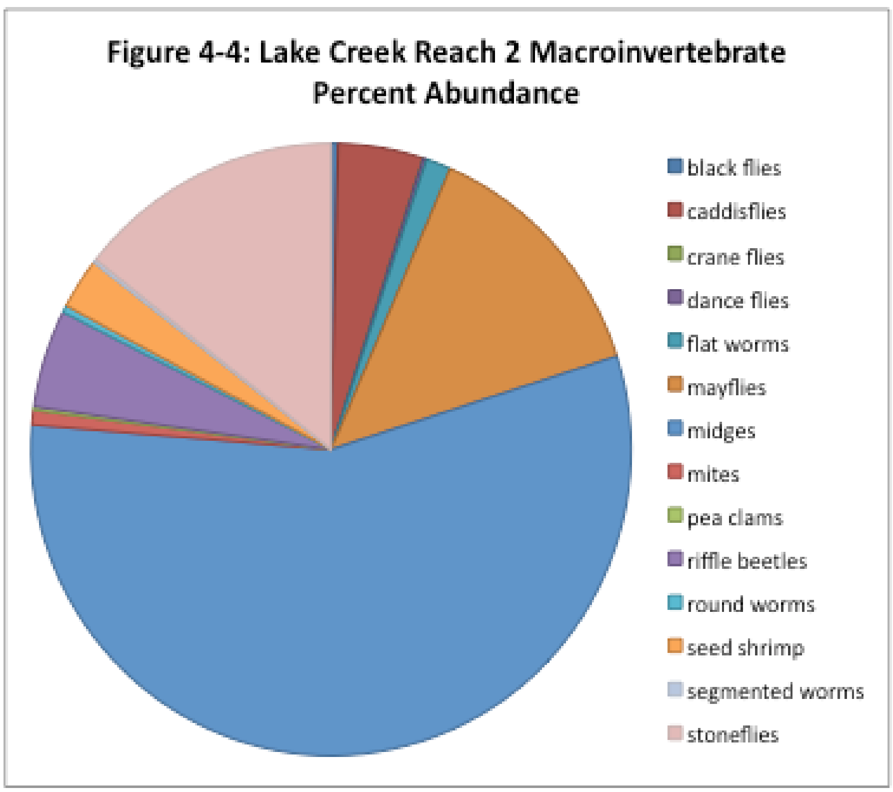
Figure 4-4: Lake Creek Reach 2 Macroinvertebrate Percent Abundance
black flies
caddisflies
crane flies
dance flies
flat worms
mayflies
midges
mites
pea clams
riffle beetles
round worms
seed shrimp
segmented worms
stoneflies

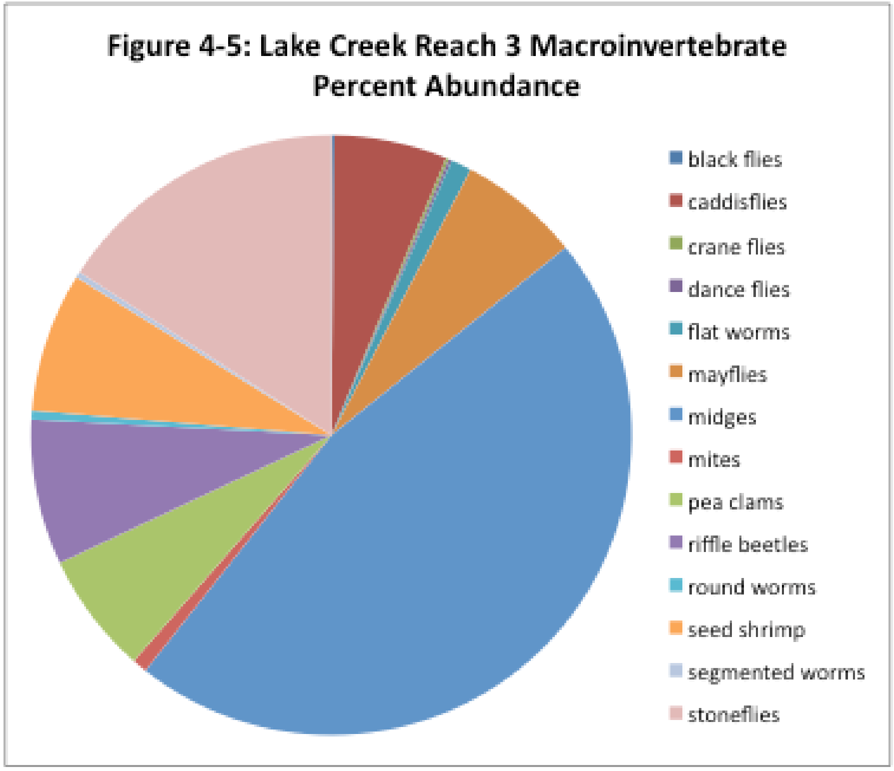
Figure 4-5: Lake Creek Reach 3 Macroinvertebrate Percent Abundance
black flies
caddisflies
crane flies
dance flies
flat worms
mayflies
midges
mites
pea clams
riffle beetles
round worms
seed shrimp
segmented worms
stoneflies

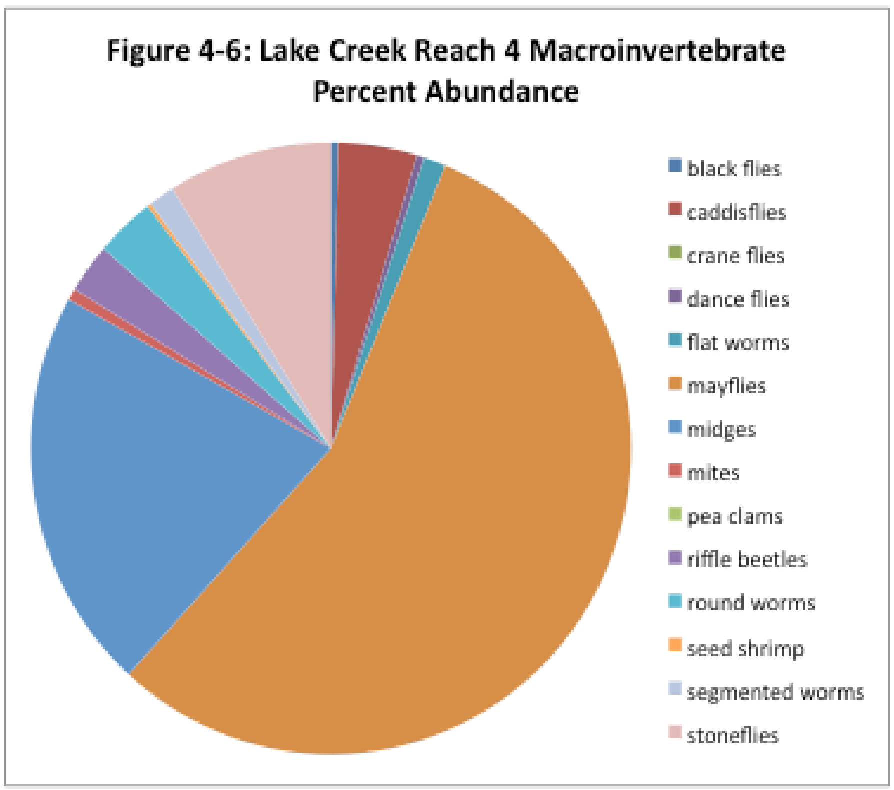
Figure 4-6: Lake Creek Reach 4 Macroinvertebrate Percent Abundance
black flies
caddisflies
crane flies
dance flies
flat worms
mayflies
midges
mites
pea clams
riffle beetles
round worms
seed shrimp
segmented worms
stoneflies

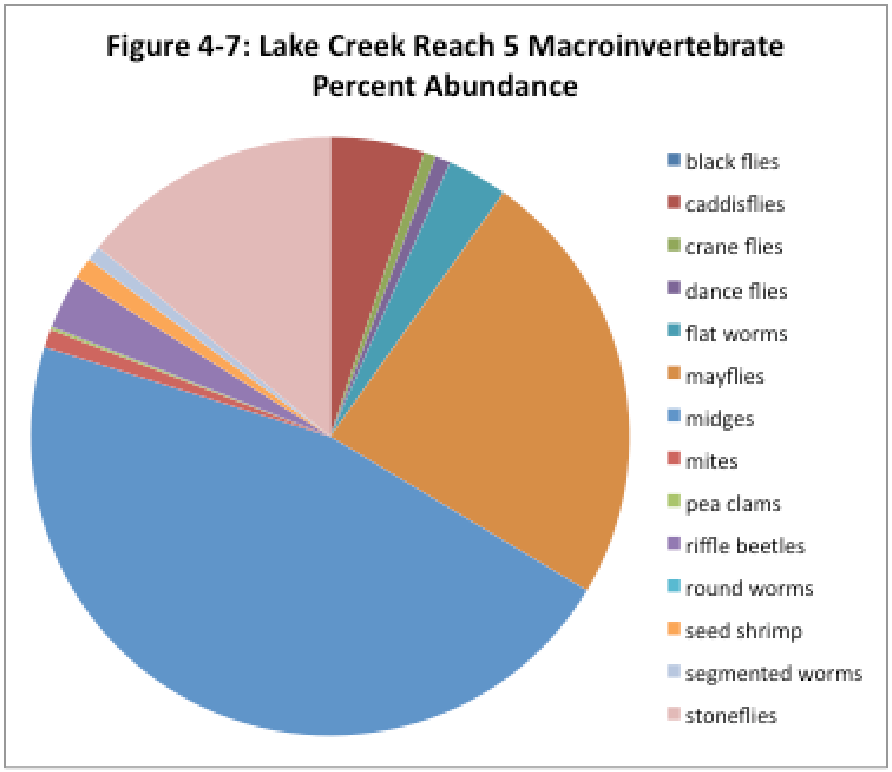
Figure 4-7: Lake Creek Reach 5 Macroinvertebrate Percent Abundance
black flies
caddisflies
crane flies
dance flies
flat worms
mayflies
midges
mites
pea clams
riffle beetles
round worms
seed shrimp
segmented worms
stoneflies

Chapter 5: Monitoring Brook Trout Using Environmental DNA in Lake Creek System

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April , 2016

CRAMER FISH SCIENCES
Oregon • California • Washington • Idaho • Alaska

GENIDAQS
aquatic species sampling, simplified

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INTRODUCTION

Recovery Criteria for the Malheur Recovery Unit Bull Trout (*Salvelinus confluentus*) require stable or increased abundance of local populations and the reestablishment of connectivity between the separated populations (USFWS 2002). Other necessary actions include a reduction or elimination of threats from invasive (non-native) Brook Trout (*Salvelinus fontinalis*) interactions within the Upper Malheur River Basin (USFWS 2002). Full recovery of Malheur River Bull Trout is contingent upon minimizing the threats posed by Brook Trout interaction. Within the Lake Creek system, non-native Brook Trout introduced into a head water impoundment, High Lake, threaten downstream Bull Trout populations in Lake Creek via hybridization (DeHaan 2009). Lake Creek supports spawning populations of the federally threatened Bull Trout. Brook trout suppression and/or eradication activities throughout said essential Bull Trout habitat in the Upper Malheur include Brook Trout removal in High Lake, seasonal fish weir operations to prevent upstream brook trout movements, and a large-scale chemical treatment effort in streams lacking Bull Trout.

The use of environmental DNA (eDNA) as a tool for species detection has been demonstrated in freshwater environments (Jerde et al. 2011, Teletchea 2009; Thomsen et al. 2011). Previous work in High Lake has shown the ability to detect Brook Trout DNA from water samples (Blankenship et al. 2012; Blankenship and Schumer 2015). While the eDNA monitoring tool has had greatest application in detection of “cryptic” (visually-evasive) species, Blankenship et al. (2012) showed eDNA could be used for trend analysis of a non-desirable species. This is an important development, as the distribution of invasive species can be difficult to document, intensive eradication efforts could be prioritized based on distribution information, and the success of removal efforts could be confirmed by the absence of non-native species DNA.

The project reported here extends the initial work reported by Blankenship et al. (2012) and Blankenship and Schumer (2015), in collaboration with the Burns Paiute Tribe, which enhanced field sampling and water filtration protocols. Previous analyses have enabled development of a generalized sampling framework that models expected detection probability, simplifies field collections, and decreases the time from collection to analysis. This previous work was leveraged to inform monitoring the occurrence of Brook Trout under a species eradication scenario. In other words, what is the detection probability of a single individual and how might distance from source affect sampling design? Purposed (mandated) non-native eradication efforts necessitate determining detectability threshold in order to optimize (minimize) compliance monitoring of species removal. We propose to apply established sampling protocols in a controlled fashion to determine the minimum detection distance of eDNA using the quantitative Polymerase Chain Reaction (qPCR) techniques and updated filtration technology developed from previous work.

METHODS

Field Sampling

EDNA samples were obtained from field sites using a water filtration method. Water was pumped from the stream using a battery operated peristaltic pump, with organic material sequestered in a Millipore Sterivex Filter Column (www.millipore.com). Each eDNA sample was collected using sterile materials and filters were kept on ice while in the field. Filters were frozen prior to shipping, and all filters were shipped on wet ice to Cramer Fish Sciences for processing and analysis.

The sampling design was derived from previous information regarding probability of detection. Given previous results, when Brook Trout were present, detection rate was estimated to be 100%. If occupancy is >90% and detection probability is >90%, then duplicate sampling (at an event) provide a 99% probability of detecting species at least once during a survey following:

$$p^* = 1 - (1 - p)^K$$

At a sampling location where the experimental target species (Columbia Redband Trout) was absent, four fixed sites were established at downstream distances of 100m, 250m, 500m, and 1000m (Figure 1). A live car containing one individual was installed prior to water sampling. Twenty-four hours following installation of live car duplicate eDNA samples at each site were collected ascending upstream (i.e, 1000m, 500m, 250m, and 100m).

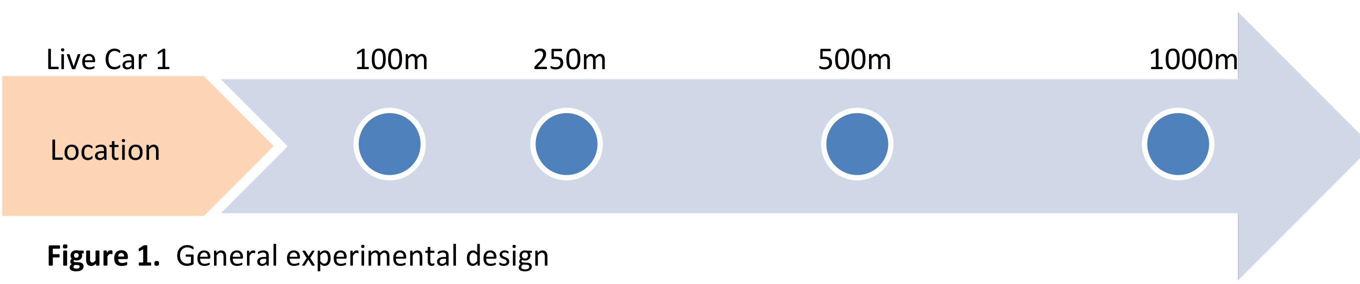

Figure 1. General experimental design

Laboratory Analysis

DNA was isolated from each filter following manufactures extraction protocols (www.mobio.com). Established QA/QC controls were used during each step of laboratory processing. Following extraction of DNA, each sample was analyzed in triplicate for the presence of the Rainbow Trout COI mitochondrial gene using a qPCR primer and probe set and laboratory methods described in Bergman et al. (2016). Template controls are required for each analysis. One template control should replace DNA template within exact reaction volume of ultrapure water (i.e., no template control). There should also be field and DNA extraction no template controls. Positive control reactions consisting of Rainbow Trout genomic DNA template should also be tested in parallel to ensure consistent PCR performance. All PCR master mixes should be made inside a UV PCR enclosed workstation. DNA template should be added to master mix outside of the UV PCR workstation on a dedicated PCR set up workbench. All PCR reactions should be conducted on instruments located outside of the main lab in a separate portion of the building. Following analysis, a sample was considered positive for the presence of Rainbow Trout DNA if any one of the three replicates shows logarithmic amplification within 40 cycles.

RESULTS/DISCUSSION

There were four eDNA sampling sites in Lake Creek for the caging experiment, where a duplicate collection was made at each site (Figure 2; Table 1). An additional site was added at distance zero on top of live car. Trout DNA from a single individual was reliably detected at 100m and 250m. At 100m, 3 of 3 and 2 of 3 replicates were positive for DNA in field duplicates #1 and #2, respectively (Figure 2). At 250m, 3 of 3 and 1 of 3 replicates were positive for DNA in field duplicates #1 and #2, respectively (Figure 2). No trout DNA was detected at 500m or 1000m in the duplicate field collections. Additionally, no trout DNA was detected at zero distance (Table 1), presumably because DNA particles were immediately advected downstream before being intercepted by sampling device. The field control (Lab ID CT) tested positive for Rainbow Trout; however this was not a laboratory artifact, as all three laboratory qPCR controls were negative.

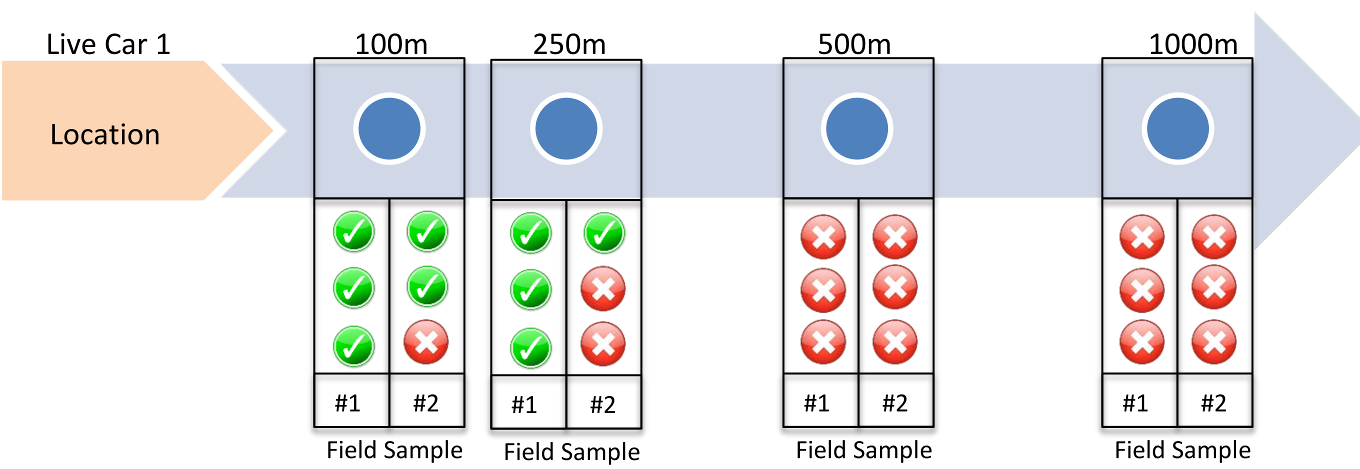

Figure 2. Positive (green) and negative (red) detections of Redband Trout DNA from field collections of eDNA. There were duplicate field collections (columns #1, #2) taken per distance that were laboratory analyzed in triplicate.

Though eDNA is a proven and powerful tool, its application to effectively influence resource management and species recovery requires simple, site specific field validations. A foundation was established here that will provide a basis for future sampling design. From probability of detection observations reported here as well as recently by Wilcox et al. (2016), we would expect an approximate 30% probability of detection for a single fish at 500 meters. Therefore, twelve sample replicates would be needed at 500 meters to produce a 99% change of detecting species at least once if it were present. For comparison, at 100 meters we expect two sample replicates to produce a 99% change of detecting species at least once if it were present, which was corroborated here by field experimentation.

Table 1. 2015 sampling and analysis summary. LabID, average cycling threshold across laboratory triplicates and cycling threshold for each lab replicate, with ND being non-detect. CT is field control, EC is elution control, NTC is no-template (negative qPCR) control and RBT+ is positive qPCR template control.

	Cycling Threshold			
LabID	Average C(t)	Replicate 1 C(t)	Replicate 2 C(t)	Replicate 3 C(t)
0m A	ND			
0m B	ND			
100m A	34.43	33.68	32.96	36.635
100m B	33.96	34.64	33.27	
250m A	33.71	33.75	33.20	34.175
250m B	34.87	34.87		
500m A	ND			
500m B	ND			
1000m A	ND			
1000m B	ND			
CT	34.62	35.33	33.82	34.705
EC1	ND			
EC2	ND			
NTC	ND			
RBT+	15.27	15.34	15.25	15.24

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