Aquatic and Associated Investigations to Guide Conservation Planning for Bull Trout and Westslope Cutthroat Trout in the North Fork Blackfoot River upstream of the North Fork Falls, 2002-2017

by

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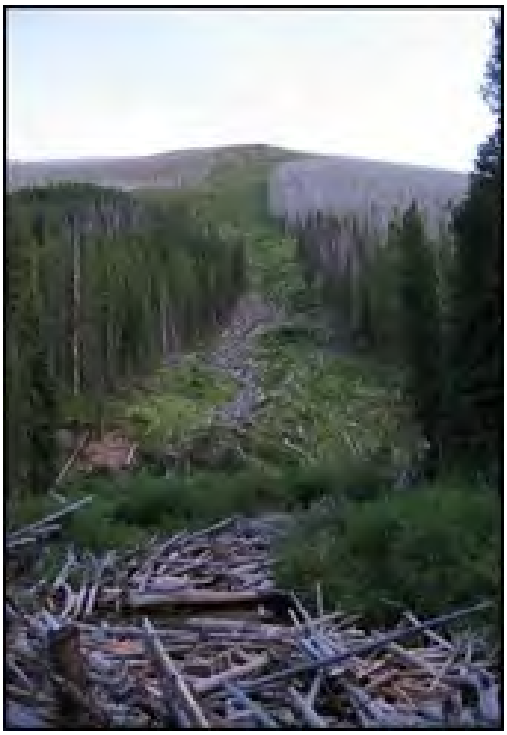

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1 Introduction and Background

The North Fork Blackfoot River within the Scapegoat Wilderness has considerable potential for conservation of Bull Trout *Salvelinus confluentus* and Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi (*WCT). A 50 ft high barrier falls, known locally as the North Fork Falls, contributes to the suitability of the area to provide a secure refuge for native fishes. The barrier protects a 110-mile^2, high-elevation watershed, with 85 miles of perennial stream and 3 connected lakes (Figure 1-1). The diversity, connectivity, and amount of available habitat provides an ideal opportunity to restore native salmonids in a protected area, where they can maintain genetically diverse populations and expression of resident, fluvial and adfluvial life-history strategies. Moreover, fish within this area would be resilient to disturbance, such as wildfires or debris flows, as the large area would provide a source of fish to recolonize streams subjected to catastrophic disturbance. This document summarizes base line biological, hydrologic, physicochemical, and historical investigations conducted to guide decision-making and planning associated with establishment of populations of WCT and Bull Trout upstream of the North Fork Falls. In addition, the document includes associated planning documents prepared for decision-making and environmental compliance.

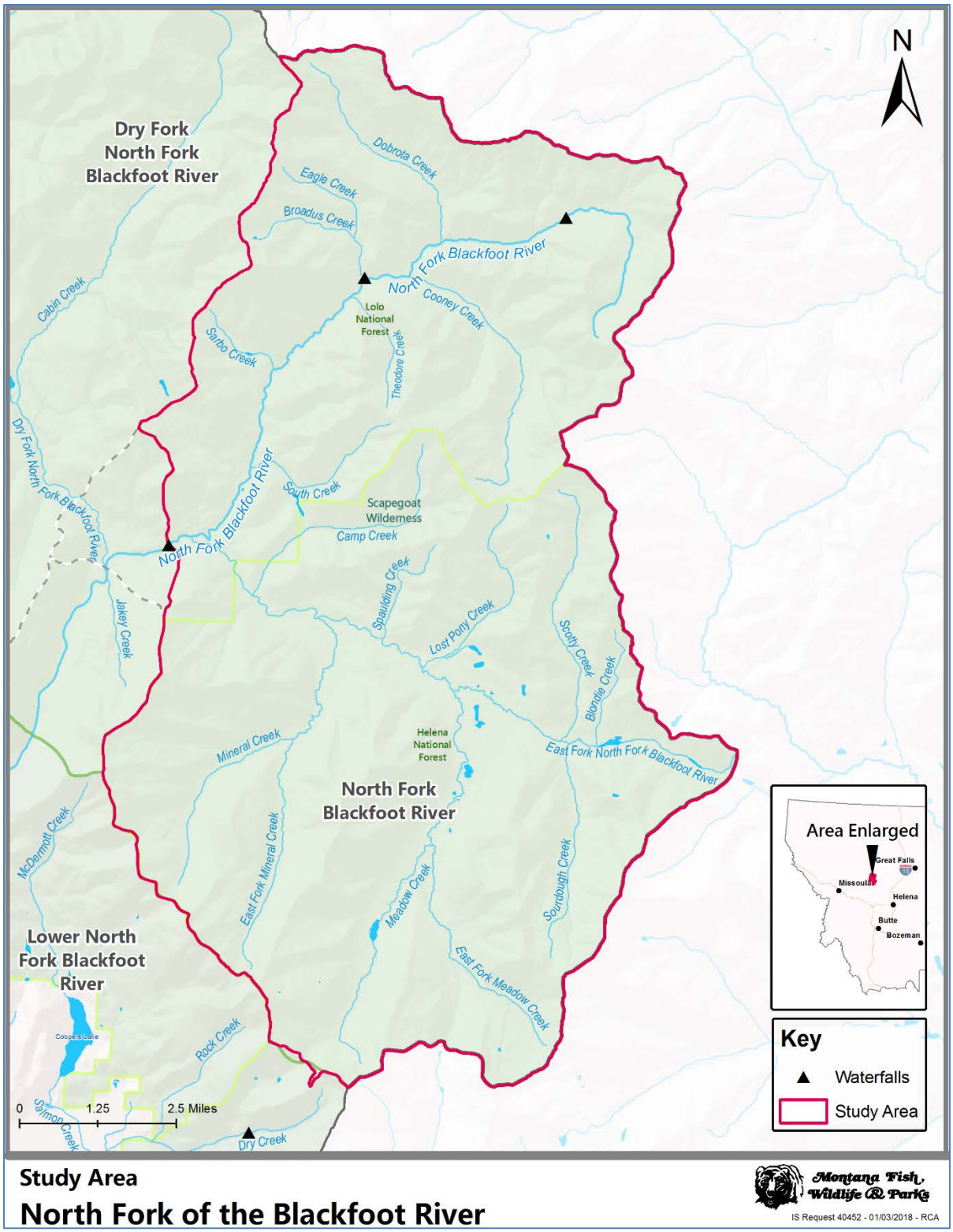

Figure 1-1. Map of the North Fork Blackfoot River project area.

Bull Trout are listed as threatened under the Endangered Species Act, and their decline is attributed to habitat degradation, siltation, dewatering, passage barriers, and increasing water temperatures (MBRT 2000; USFWS 2010, 2015a, 2015b). Nonnative species have also been detrimental. Bull Trout and Brook Trout can interbreed when in sympatry, and their progeny are almost always sterile (Markle 1992; Leary et al. 1993; Kanda 1998). Introduction of Lake Trout *S. namaycush* into lakes has resulted in precipitous declines in Bull Trout populations (Donald and Alger 1993; Fredenberg 2002). Northern Pike *Esox lucius*, and Walleye *Sander vitreus* also present threats to adfluvial Bull Trout, as Bull Trout have not coevolved with predation pressure from these lake-dwelling piscivores. In some cases, nonnative, piscivorous fishes were intentionally introduced in past decades to enhance sport fisheries. Illegal introductions of these nonnative fishes into lakes are unfortunately common and present an ongoing threat to populations of adfluvial Bull Trout.

Declines in WCT are also related to habitat degradation, and hybridization and competition relating to introduction of nonnative species (Liknes and Graham 1988; Behnke 1992; Shepard et al. 1997; 2005). Widespread, decades long introductions of Rainbow Trout, and to a lesser extent YCT, have contributed to declines of native WCT. Considerable niche overlap occurs between Brook Trout and WCT, and Brook Trout tend to displace WCT, especially in headwater streams (Shepard et al.2010).

The Blackfoot River subbasin downstream of the North Fork Falls (Figure 1-2) has been the focus of extensive fish survey and restoration for many years; however, little information had been collected in the North Fork Blackfoot River upstream of the North Fork Falls until the 2000s (Figure 1-2). From 2005 through 2017, Montana Fish, Wildlife & Parks (FWP), in cooperation with the U. S. Forest Service, (USFS), Natural Resource Damage Claim Program, Montana Natural Heritage Program, commercial wilderness outfitters and volunteers, completed a series of fisheries-based investigations for 20 headwater streams, and three fish-bearing mountain lakes, in the upper North Fork Blackfoot River watershed upstream of the North Fork Falls (Figure 1-2). The surveys are the first comprehensive fisheries work in this remote area, which included genetic tests in all fish-bearing waters.

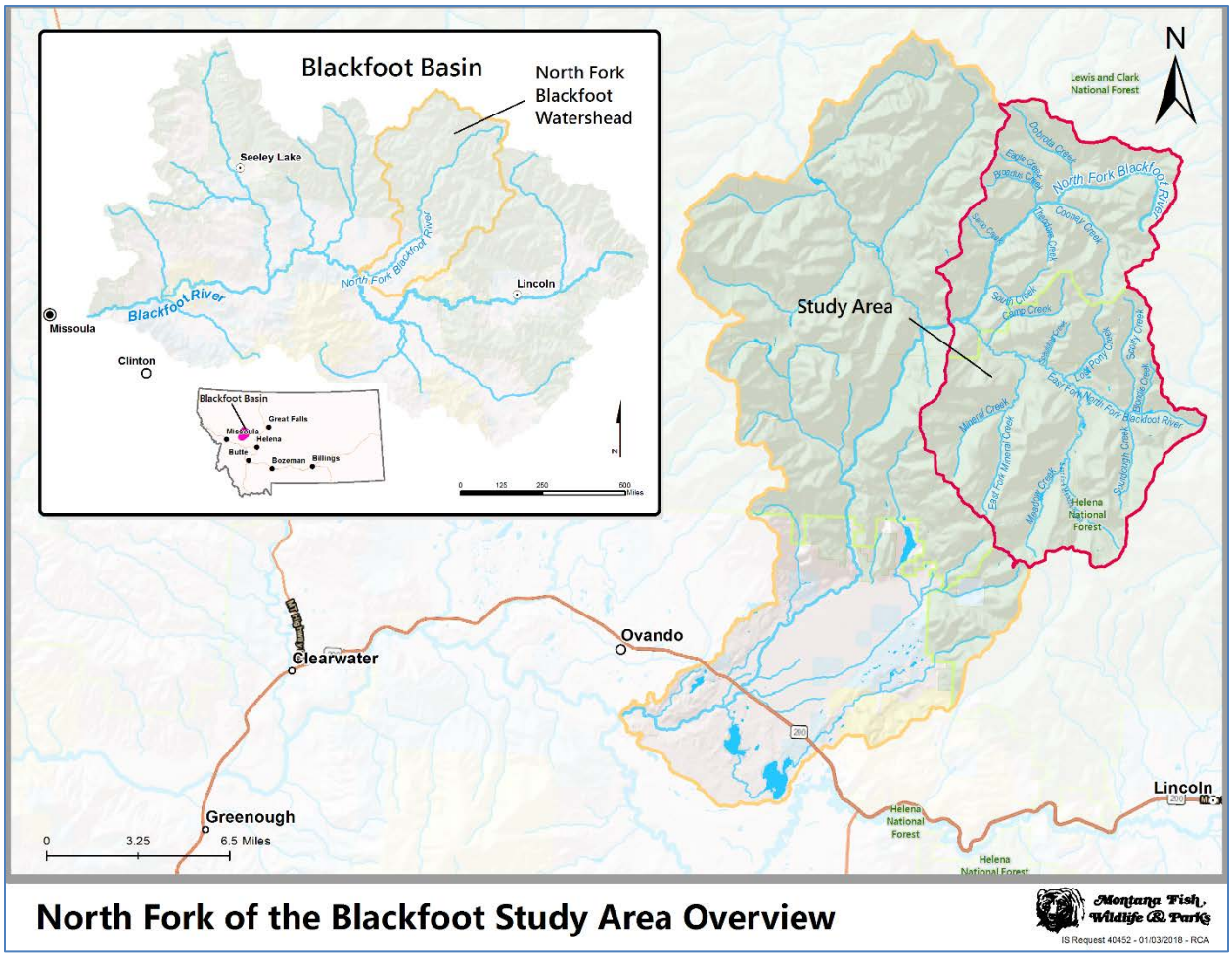

Figure 1-2. The Blackfoot River subbasin and project area.

Genetic tests of fish in the North Fork Blackfoot River study area identified the presence of *Oncorhynchus* hybrid trout with a mostly nonnative rainbow trout (*O. mykiss*) genetic contribution across all fish-bearing waters (Leary 1997; Wright and Leary 2005; Leary 2007; 2008; 2005; 2008; 2009; 2015). The presence of rainbow trout and YCT genes relate to broad-scale introductions that began upstream of the North Fork Falls in the 1920s, when state and federal hatcheries, sportsman's groups, outfitters, the USFS and the Montana Fish and Game introduced undifferentiated cutthroat trout and rainbow trout into waters upstream of the North Fork Falls.

The findings of this admixture of Rainbow Trout, YCT, and WCT genes in this remote headwater area caused concern, as these fish make the headwaters of the North Fork Blackfoot River a perpetual source of nonnative genes that threaten WCT downstream, unless they are removed. The goals of providing a secure area of native Bull Trout and WCT, and elimination of this source of genetic contamination to waters downstream, triggered additional aquatic studies

to assist in evaluating the potential for removal of nonnative hybrid trout, followed by a possible translocation of native trout. Basin-wide surveys of aquatic macroinvertebrates and amphibians, stream flow, lake habitat, and physicochemical properties of surface waters provide a baseline description and information and a foundation for conservation planning.

Although genetic markers for WCT are widespread upstream of the North Fork Falls, our surveys have not detected the presence of a genetically unaltered WCT population upstream of the falls in any of the fish-bearing streams or lakes. The distinction between YCT and WCT was unknown in the early years of fish plants; however, widespread distribution of YCT on the west side of the Continental Divide suggests the majority of hatchery Cutthroat Trout stocked during these years were YCT. Introduction of WCT outside of its native range in the Yellowstone River basin occurred; however, their alleles are exceptionally rare, suggesting WCT were not the preferred Cutthroat Trout for hatchery operations.

Determining with certainty if the WCT were present upstream of the North Fork Falls historically is complicated by the long history of fish stocking, poor record-keeping of hatchery plants in early years, and fish plants conducted by anglers in the early to mid-1900s. Extensive hybridization with stocked fish and catastrophic disturbance resulting in fish kills may have obscured evidence of historically present fish. Historical records and survey data are inconclusive; however, wide-spread distribution of WCT genes throughout the watershed upstream of the North Fork Falls, and relative infrequency of hatchery plants of WCT compared to YCT, suggests WCT could have been present before human intervention.

The ability of trout with a predominance of nonnative genes to persist in this harsh, high-country for 90 years relates to refugia provided by 3 lakes that provide overwintering habitat and sources of recolonization to nearby waters following natural disturbance, such as flooding, wildfire and debris flows. Nevertheless, fish are present in low density but do not occupy all the available habitat. In contrast, neighboring watersheds in the Blackfoot River subbasin, with similar elevation and habitat as the North Fork Blackfoot River watershed, such as Monture Creek and Copper Creek, support considerably higher density of fish throughout perennial waters (Pierce et al. 2008; Pierce and Podner 2013). Rainbow Trout did not evolve in high elevation, cold streams in the Rocky Mountains. In contrast, the amount and complexity of the available habitat is suitable for native cold-water stenotherms like WCT and Bull Trout.

Several factors make the North Fork Blackfoot River watershed upstream of the barrier falls an ideal location for conservation of native Bull Trout and WCT. Reclaiming waters upstream of the North Fork Falls would provide a secure location, with no risk of fish being able to reinvade naturally. Furthermore, the cold thermal regime of the area’s waters, and the vulnerability of these imperiled species to warming, contribute to the suitability of the area to provide protected habitat for the native salmonids. Near-term climate models predict the contraction of cold-water

habitat at lower elevations; however, the North Fork Blackfoot River watershed, within the Scapegoat Wilderness, will likely remain suitable for cold-water obligate species (Isaak et al. 2015). Moreover, establishment or reestablishment of native species will protect neighboring populations of WCT, as the source of downstream dispersion of Rainbow Trout and YCT genes would be eliminated or substantially reduced. Successful completion of similar, large-scale restoration projects in western Montana indicate this project has a high probability of success.

This document provides documentation of wide-ranging efforts to support planning and decision-making regarding the suitability of the project area for translocation of Bull Trout and WCT in the North Fork Blackfoot River project area and provides a pretreatment baseline. The body of the document describes fields investigations of fish, aquatic macroinvertebrates, amphibians, the physical setting, stream flow volume, and select water quality parameters. The appendices include detailed results of field investigations and planning documents prepared to facilitate decision-making regarding potential conservation efforts with an emphasis on ecological values, state and federal laws, and the potential of actions to affect wilderness character and values. This report is a living document and will be updated as new information is available.

2 Project area

The North Fork Blackfoot River is the largest tributary to the Blackfoot River in terms of flow contribution and has a mean annual daily discharge of 385 cfs, as measured at the USGS gage station (Ovando 12338300). The study falls within a high glacial landscape in the northern-most portion of the Blackfoot River watershed (Figure 2-1) and encompasses most of the North Fork Blackfoot River 5th code HUC. This region is the southern extension of a large contiguous wilderness complex that extends from Glacier National Park south through the Bob Marshall and Scapegoat wildernesses and adjacent roadless areas. The Dearborn River drainage, which is in the Missouri River basin, borders the watershed on the east, and the Flathead River drainage, which is in the Columbia River watershed, is to its north.

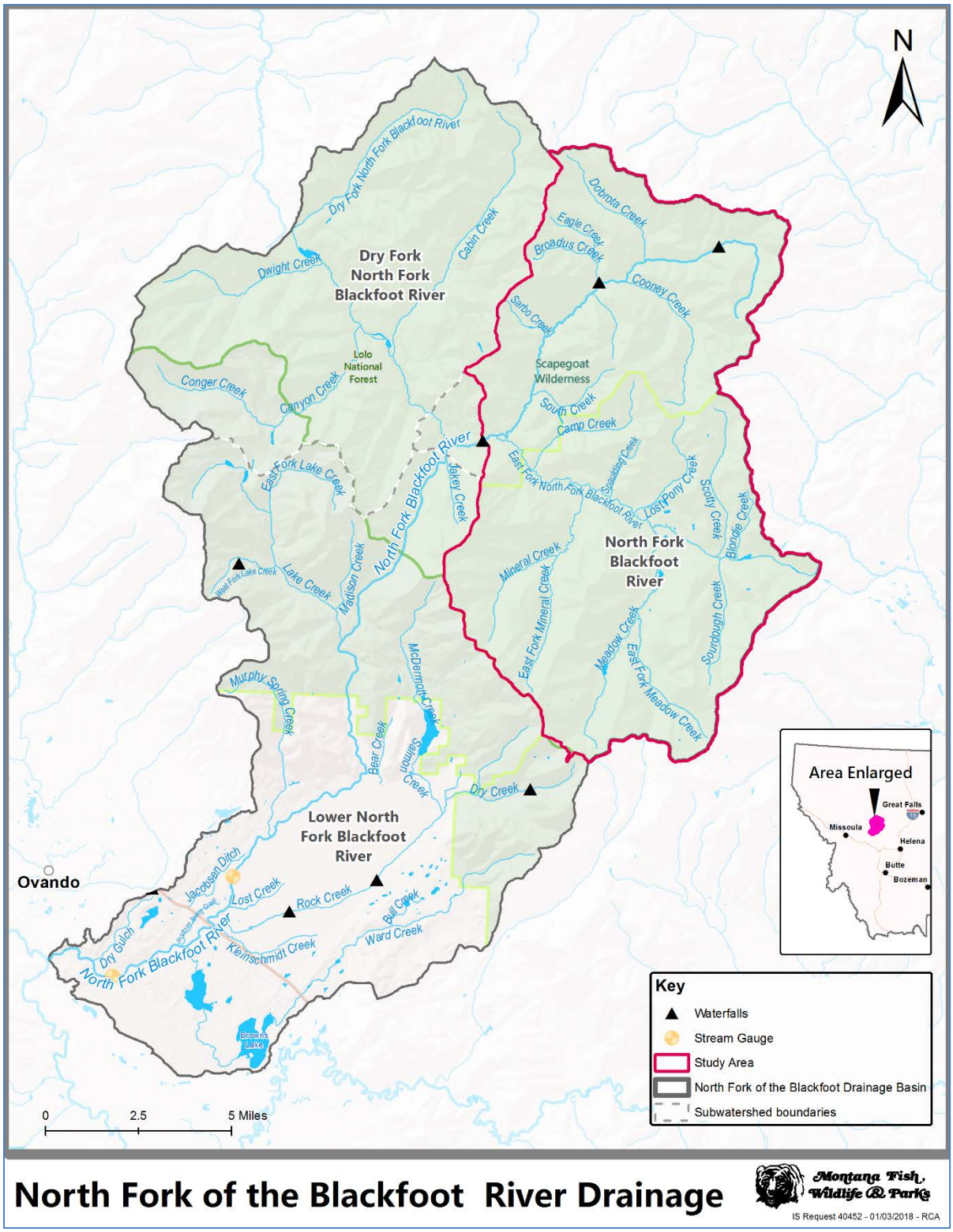

Figure 2-1. Map of the three 5th code HUCs comprising the entire North Fork Blackfoot River watershed.

The North Fork Blackfoot River and its tributaries flow through three 5th code hydrologic units or watersheds (Figure 2-1; Seaber et al. 1987), and these areas differ in their fish communities. The North Fork Blackfoot River watershed upstream of the North Fork Falls is the focus of this document. The Dry Fork North Fork Blackfoot River watershed is a tributary of the North Fork Blackfoot River and its confluence is downstream of the North Fork Falls. The Lower North Fork Blackfoot River watershed originates 2 miles downstream of the barrier falls at the confluence of Dry Creek and flows into the mainstem of the Blackfoot River.

The lower North Fork Blackfoot River and its tributaries support mixed communities of native and nonnative trout. Native trout in this watershed include migratory WCT, along with one of the largest remaining sub-populations of migratory, or fluvial, Bull Trout in western Montana (Swanberg 1997; USFWS 2010; Pierce et al 2013; FWP internal data). The lower portion of this watershed also supports rainbow trout, Brook Trout (*Salvelinus fontinalis*) and Brown Trout (*Salmo trutta*). The Dry Fork of the North Fork Blackfoot River has a seasonally intermittent reach near the mouth. Upstream of this intermittent section, perennial streams support resident and migratory WCT and low abundance of Bull Trout (Pierce et al. 2007; 2008). No Bull Trout reproduction occurs in this reach (Swanberg 1997; Pierce et al. 2008; Appendix A).

The Dry Fork North Fork Blackfoot River watershed also supports an increasing presence of hybrid trout, which provide a source of nonnative genes that threaten nonhybridized WCT in the watershed (Appendix D). This population is an admixture of rainbow and some fish likely ascending the intermittent reach of the Dry Fork in during high water. Based on the proximity to the Dry Fork drainage and of genetic characteristics of the hybrid trout, these fish potentially originate in the North Fork Blackfoot River upstream of the falls, making the fish in the North Fork Blackfoot River project area a threat to downstream populations of WCT.

Upstream of the North Fork Falls, the study area spans a 110-square mile 4th-order drainage within the Lolo National Forest on the west, and the Helena Lewis and Clark National Forest on the east (Figure 1-1). The entire study area falls within the Scapegoat Wilderness and comprises most of the North Fork Blackfoot River 5th code HUC. The mainstem of the North Fork Blackfoot River flows southwest for about 15 miles from the Continental Divide, until it spills over the North Fork Falls. Another 7 miles of stream are within the Scapegoat Wilderness downstream of the barrier falls. The North Fork Blackfoot River flows for another 24 miles, before meeting its confluence with the Blackfoot River.

Within the study area, twenty tributaries form the headwaters of the upper North Fork Blackfoot River (Figure 1-1). This stream network supports about 85 miles of perennial stream, which generate a combined baseflow of approximately 40-60 cfs, as measured upstream of the barrier falls (Appendix D). Tributary streams drain the highest mountain peaks of the Blackfoot River

subbasin. Streams flow within alpine meadows, subalpine forest and montane woodlands and drain landforms including glacial cirques, glacial trough and morainal valleys.

The North Fork Blackfoot River upstream of the North Fork Falls flows within heavily glaciated hanging river valley with an average gradient of 120 ft/mile (Figure 2-2). The North Fork Blackfoot River has 8 tributaries before its confluence with the East Fork North Fork Blackfoot River. The East Fork North Fork Blackfoot River meets the North Fork Blackfoot River at stream mile 26.6. Upstream of the confluence with the East Fork North Fork Blackfoot River, the North Fork Blackfoot River flows through a glacial trough valley where morainal and outwash deposits confine the channel. Substrate type includes areas of gravel, cobble, erratic glacial boulders, and large areas of exposed bedrock. Downstream of the confluence with the East Fork North Fork Blackfoot River, the North Fork Blackfoot River about 0.5-miles through a cascading bedrock channel before it spills about 50 ft vertically over the North Fork Falls. The North Fork Blackfoot River classifies as Rosgen B1-B4 channel types (Rosgen 1996), although stream types are A1 or A2 channel types in the headwaters and near the North Fork Falls.

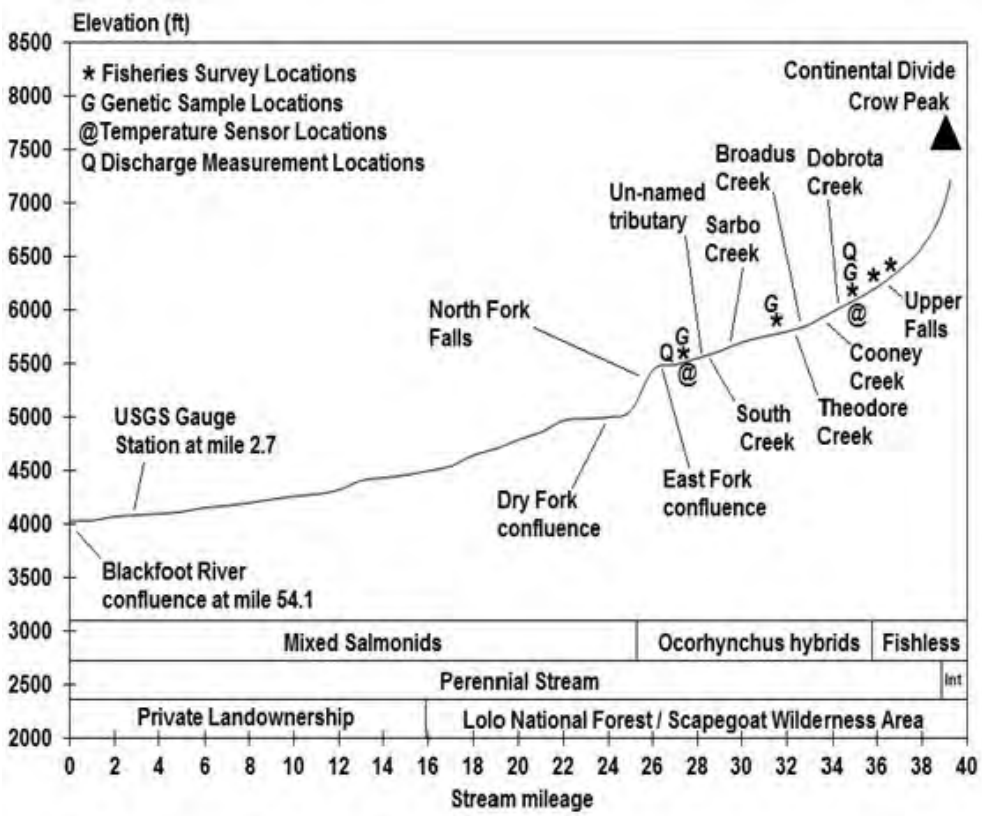

Figure 2-2. Longitudinal profile for the North Fork Blackfoot River and tributaries, from headwater to confluence with the Blackfoot River, locations of confluences of tributaries by stream mile, landownership, and fish community composition

Downstream of the North Fork Falls, the North Fork Blackfoot River watershed supports fluvial Bull Trout, WCT, Brown Trout, Rainbow Trout, and Brook Trout in low abundance. Bull trout occupy the main stem North Fork Blackfoot River downstream of the barrier falls and several tributaries though numbers are low. The North Fork Blackfoot River downstream of the North Fork Falls is designated critical habitat for the recovery of Bull Trout (USFWS 2010), and this reach supports one of the largest spawning run of migratory Bull Trout in the upper Clark Fork River drainage (FWP internal data).

WCT are present throughout the drainage downstream of the North Fork Falls (Pierce et al. 2007; 2013). WCT occupy the Dry Fork North Fork Blackfoot River, and several tributaries in the Lower North Fork Blackfoot River watershed, and migratory and resident life-history strategies are present (Pierce et al. 2007). Brown Trout and Brook Trout variously occupy the lower portions tributaries of the lower North Fork Blackfoot River drainage. These nonnative species have not been detected in the North Fork Blackfoot River watershed upstream of Kleinschmidt Flat. Rainbow trout occupy the lower North Fork Blackfoot River and spawn in two spring creeks that enter the river about 6 miles from its confluence with the Blackfoot River. Hybrid Rainbow Trout × WCT × YCT are incidentally present in the lower Dry Fork North Fork Blackfoot River watershed. Based on the proximity of the Dry Fork North Fork Blackfoot River to the North Fork Falls, this presence is likely the result of fish spilling over the waterfall. Hybrid trout have been observed trapped in pools of the intermittent reach of the Dry Fork North Fork Blackfoot River in July 2004 (Ron Pierce, personal observation).

Wildfire is a common disturbance in forested watersheds like the North Fork Blackfoot River. During a record setting drought in 1988, the Canyon Creek wildfire burned much of the project area. This 188,000-acre fire was one of the largest, fastest-moving and most intense wildfires ever documented in North American (Bushey 1991) and resulted in localized fish kills. The effects of this wildfire continue to exert a controlling influence on ecology of the stream system, as well as the physical features of individual streams. This stand replacing fire and was especially intense in the headwaters, as evidenced by slow recovery of conifers in many areas. Among the existing deadfall, a young riparian forest typically consists of lodgepole pine, Douglas fir, Engelmann spruce and black cottonwood, as well as willow along the immediate streambanks. Over-hanging willow, large boulders, bedrock-formed pools and log-jams are primary instream habitat features. As the result of the Canyon Creek fire, large woody debris is abundant.

3 Methods

3.1 *Stream Fish Surveys*

Fish surveys in the North Fork Blackfoot River watershed entailed 2 multi-year efforts at 30 sampling reaches established on the North Fork Blackfoot River, East Fork North Fork Blackfoot River, and 19 tributaries (Figure 3-1). The first survey occurred from 2006 through 2008, and a second effort occurred from 2013 through 2016.

We used a backpack-mounted battery powered Smith-Root LR-20B electrofishing unit to conduct intensive single-pass catch-per-unit effort (CPUE) fish population surveys. Surveys typically started at downstream riffle and proceeded upstream, then ended at a pool/riffle break. All fish were targeted for captured. Once captured, fish were sedated with MS-222™ (tricane methansulfonate), phenotypically identified to species, measured for total length and weight. To confirm genetic composition of sampled trout, tissue samples were sub-sampled from individual fish. After fish were measured, weighed, and fin-clipped, they were revived in fresh water and returned to the stream. To summarize fisheries field data (Appendix A), we separated age 0 from age 1 and older trout using length-frequency histograms and standardized CPUE samples as catch/100 ft for age-1 and older trout.

Associated data collection included measurement of the length of the reach and collection of coordinates for the upstream and downstream locations of the reach using Garmin™ GPS receivers. Habitat observations included Rosgen channel type classification (Rosgen 1996), characterization of riparian vegetation, classification of landform, and channel slope. Observations of amphibians present in survey reaches were also recorded.

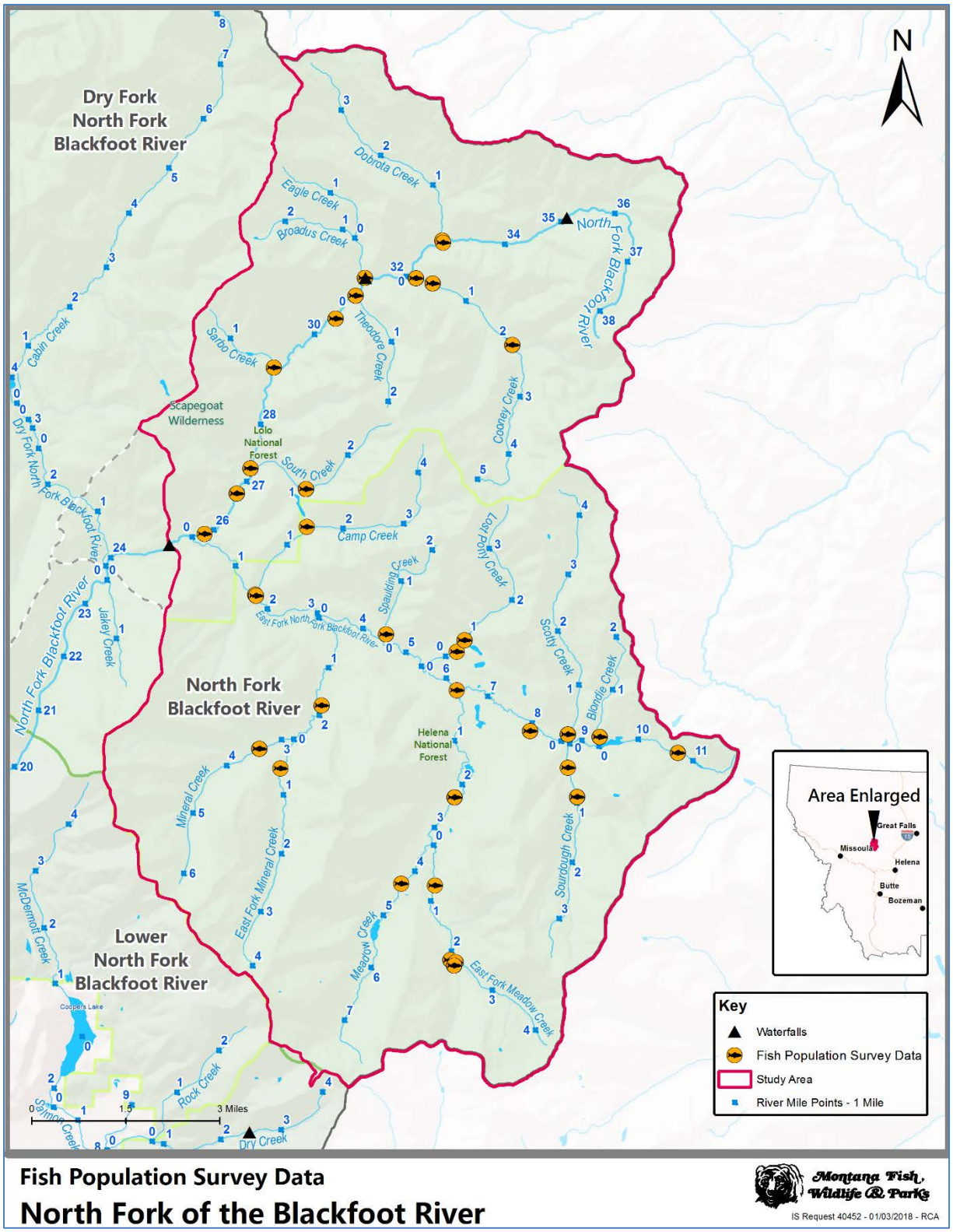

Figure 3-1. Fish survey reaches in the North Fork Blackfoot River watershed upstream of the barrier falls.

3.2 *Lake Investigations*

Lake surveys began in 2005, which was over 20 years since the last survey efforts. Lakes surveyed included Lower Twin Lake, Meadow Lake, and Parker Lake (Figure 3-2). Parker and Lower Twin lakes had been stocked in the 1940s and 1950s with nearly 14,000 undifferentiated Cutthroat Trout each. Records show 1 stocking event for Meadow Lake in 1950, when 50,000 Arctic Grayling (*Thymallus arcticus*) were stocked. Survey of these lakes include gillnet surveys in the 1950s and 1970s.

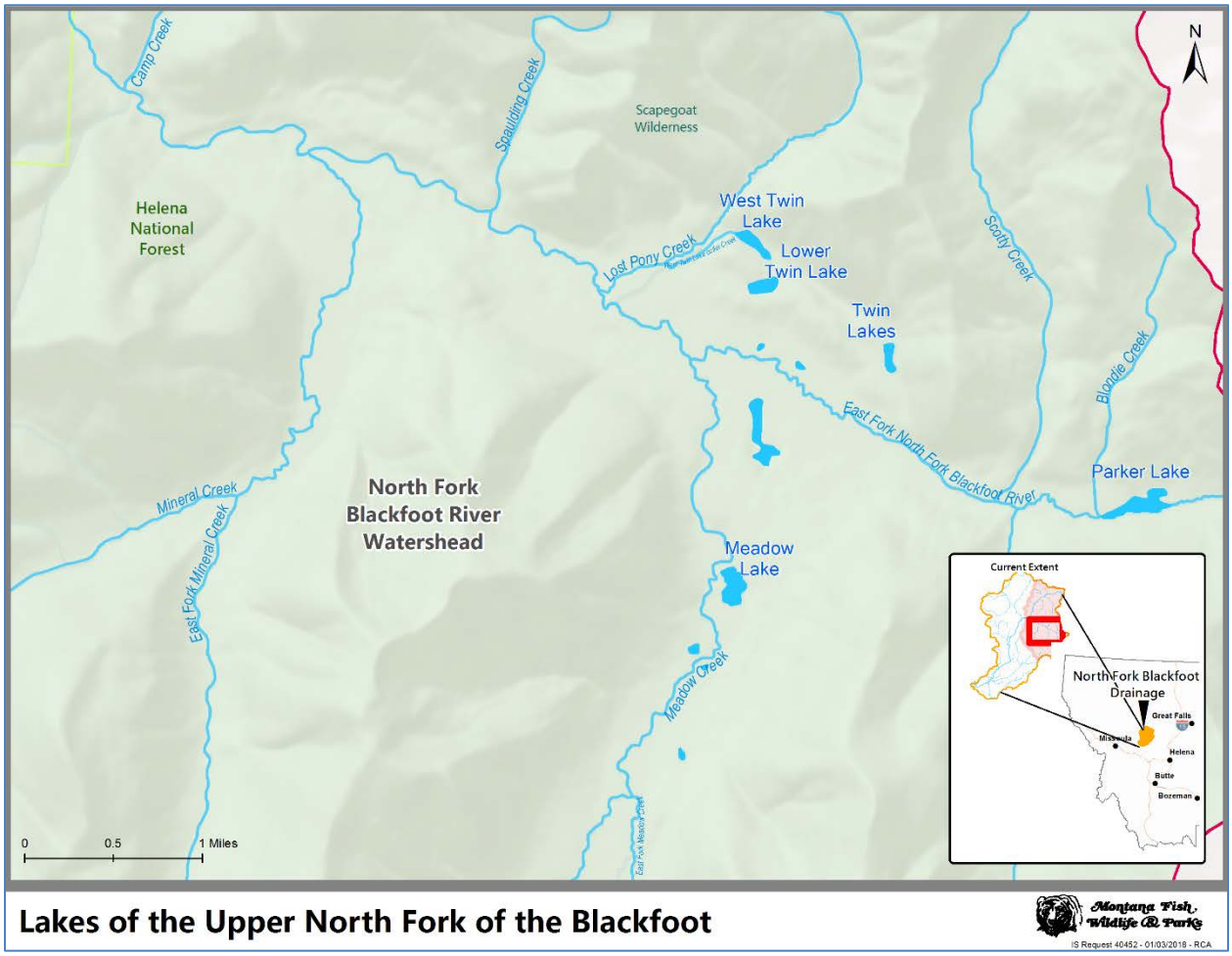

Figure 3-2. North Fork Blackfoot River watershed project area showing surveyed lakes.

Gillnet Surveys

We deployed experimental, sinking, overnight gillnets in Lower Twin, Meadow Lake, and Parker Lake. Where possible, nets were placed according to historical survey locations (FWP internal data). Gillnets had standardized net dimensions and mesh sizes specified for alpine lakes in Montana. Gillnets were set for a single sampling period lasing a minimum of 10 hours, with

set time beginning between 18:00 and 20:00 hours. Due to their small size, we used a single net in these lakes. To compare catch rates among lakes, catch results were standardized by net-hour.

Following collection of fish, we measured total length and weight, collected scales and fin clips for genetic analyses, and recovered observed diet items. From this information, we calculated catch rates, size distribution, growth, condition factor and *Oncorhynchus* genetic composition and food habits information (Pierce et al. 2008).

Lake Bathymetry

To map lake bathymetry, we used Garmin III GPS™ receivers to identify latitude and longitude and Leila LPS-1™ handheld digital depth sounder to measure water depths. Both GPS location and depth data were taken simultaneously from multiple lake transects and at the 5 ft depth contour, with the use of an inflatable 2-person kayak. We mapped lake perimeter on foot, using GPS receivers. The FWP Technical Services Lab in Helena, Montana mapped bathymetry using the GIS ArcView spatial analyst. While mapping lake perimeters, we recovered observations of juvenile fish, amphibians, macroinvertebrates, plant communities, and notable wildlife.

Zooplankton

Zooplankton samples were collected from Parker Lake and Lower Twin Lake in summer 2015. Samples were taken from an inflatable float tube using a 50 ft rope with 1ft graduated markings, and a Wisconsin style vertical plankton net, with a 4.875-inch mouth. Sampling depth was measured with a hand held electronic depth finder, and sampling location was identified with a handheld GPS unit. Zooplankton were collected with 3 replicate vertical tows, beginning 1 ft above the bottom of the lake, to the surface, in the deepest areas of the lake. were completed from 1 ft above the bottom to the surface in the deepest areas of the lake. For each tow, zooplankton were concentrated in a collection jar (tow bucket) at the end of the net using a squirt bottle then preserved in 95% ethanol.

Composite samples for the two lakes were then delivered to Rhithron Laboratories for taxa identification, enumeration and biomass estimates. Zooplankton samples were analyzed using National Lakes Assessment protocols (U.S. EPA 2012). Organisms were identified to the lowest possible level, using a Leica DM2500 compound microscope at varying magnifications. Consistent with NLA protocols, the first 20 encounters per species, per sample were measured during identifications.

3.3 *Fish Genetic Analysis*

Genetic analyses were conducted to validate field identification of species and evaluate the genetic composition of fish collected during electrofishing and gillnetting. The Wild Salmon and Trout Genetics Laboratory at the University of Montana performed genetic analyses. Dr. Robb

Leary supervised all genetic tests and performed all genetic analyses. Genetic tests included the PINE, indel and SNPs techniques.

3.4 *Environmental DNA (eDNA)*

Fisheries scientists are increasingly using eDNA as a relatively inexpensive means to determine the presence or absence of species. The applications include determining the presence or absence of a species and determining the spatial extent of fish in streams, which are valuable in field projects aimed at removing nonnative fishes or determining if nonnative fishes have invaded waters. In 2015, 20 stream locations were sampled for the presence of eDNA using standard protocols.

3.5 *Physicochemical Water Quality Assessment*

Select physicochemical water quality parameters were measured at fish sampling reaches and in and lakes with an Oakton multi-parameter tester 35 series meter (Figure 3-1). This handheld field monitoring device measures conductivity, total dissolved solids, and pH.

The continuous water temperature sensors provided multiple years of water temperature at 22 stations in the project area (Figure 3-3). We deployed water temperature sensors manufactured by the Onset Computer Corporation that have an accuracy of ± 0.2 °C. The sensors were programmed to record water temperature at 50-minute intervals, and their batteries last 5 years, beginning in July 2003 and were retrieved in September 2016.

The large temperature dataset was analyzed to evaluate feasibility of introducing Bull Trout into the project area using a tiered model, known as the Clackamas framework, that qualitatively scores potential projects on the presence and persistence of suitable cold-water habitat (Dunham et al. 2011; Appendix K) Water temperature during spawning and rearing are key considerations in determining the thermal suitability of the habitat. Analysis of water temperature data allowed classification of the stream as highly, moderately, or unsuitable for introduction of Bull Trout.

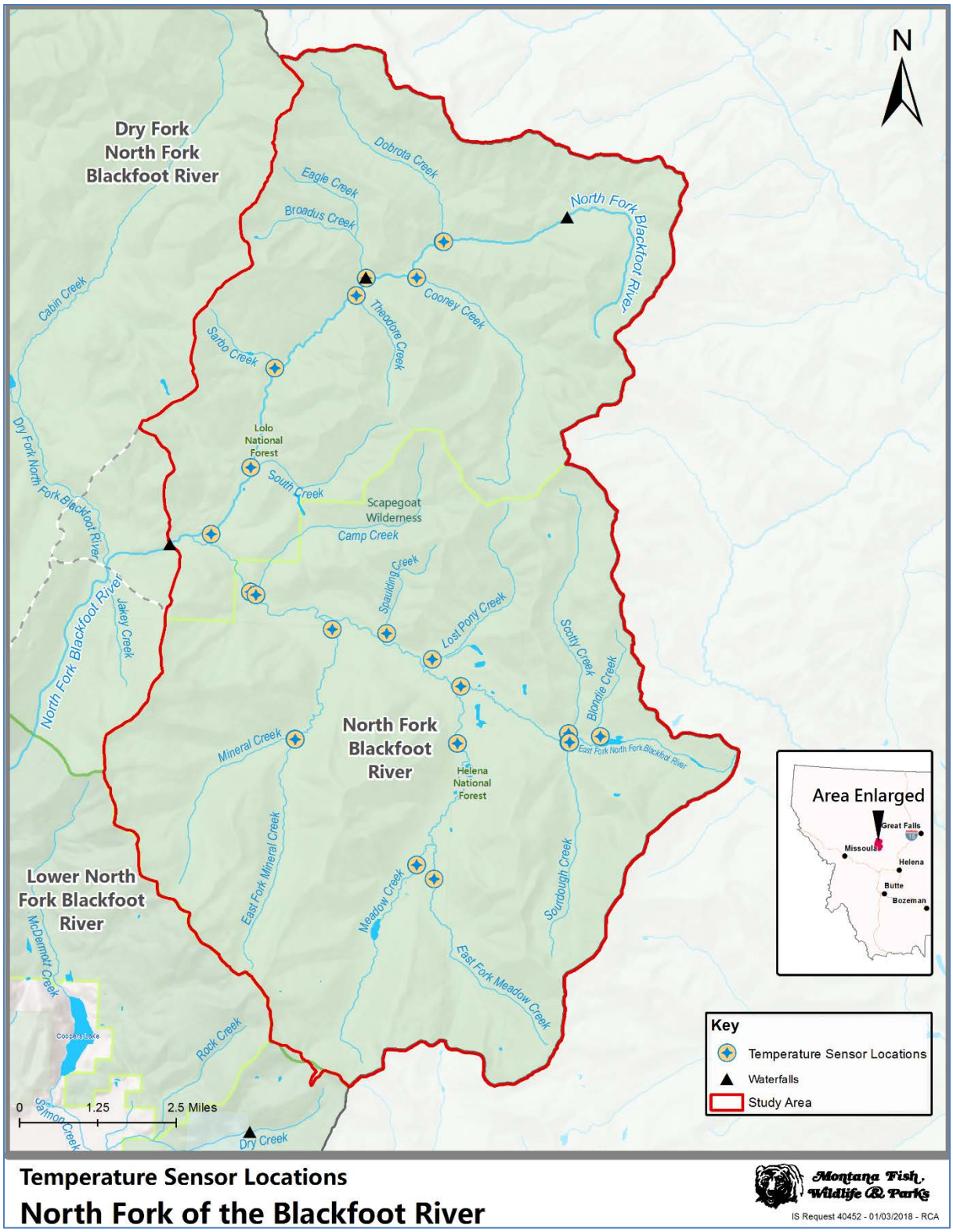

Figure 3-3. Thermograph locations in the North Fork Blackfoot River study area.

3.6 *Historical Review*

Fish introductions have substantially altered distribution and abundance of native trout, and the North Fork Blackfoot River has a long history of plants. A collaboration among FWP, the Mansfield Library at the University of Montana, and Trout Unlimited provided a review of fish stocking records and other information that would allow inference on fish populations before and after the beginning of wide-scale stocking of fish into Montana's waters (Appendix J).

3.7 *Stream Discharge*

Hydrology crews from Lolo National Forest measured stream flow in late September 2013 and late August 2014, at 19 locations on 17 streams within the study area (Figure 3-4). On tributaries, discharge measurements were conducted within 0.2 miles of their mouths. Flows in the East Fork North Fork Blackfoot River and North Fork Blackfoot River were measured near their headwaters and just upstream of their junction, upstream of the North Fork Falls.

Discharge measurements were taken in cross-sections with simple morphology and laminar flow. Areas where groundwater flux between tributaries could influence surface flow were avoided. A Garmin GPS unit documented the location of each survey site and a Marsh-McBirney Flo-Mate 2000™ velocity meter calibrated before field work was used to measure discharge using standard techniques (Gallagher and Stevenson 1999). Efforts were made to measure velocity at points with a depth greater than 0.1ft; however, some of the tributaries were too shallow to conform to this protocol.

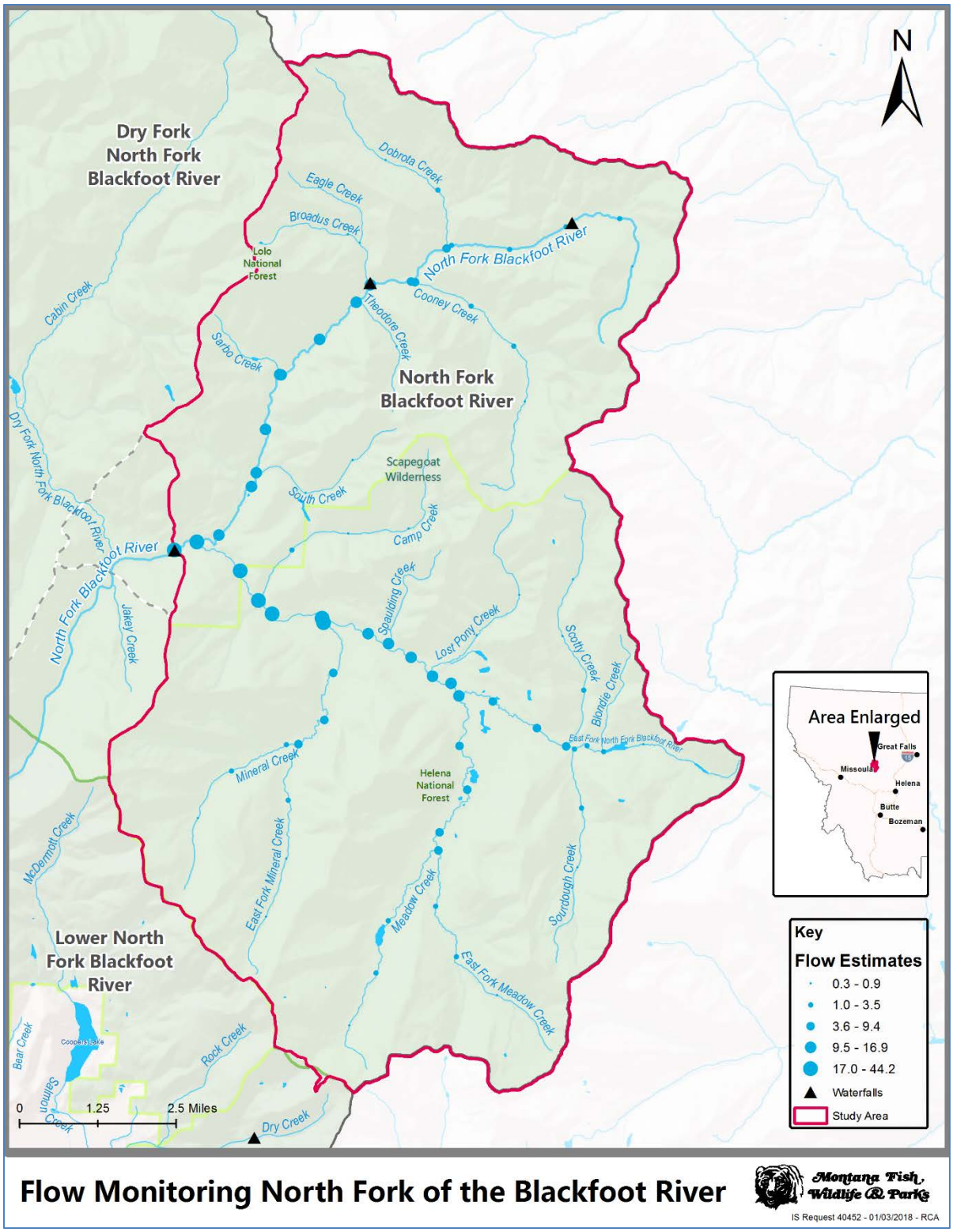

Figure 3-4. Stream flow measuring stations in the North Fork Blackfoot River study area.

3.8 *Macroinvertebrates and Amphibians*

Concurrent with fish sampling, fieldworkers collected benthic macroinvertebrates and recorded observation of amphibians (Stagliano et al. 2015; Appendix D). Macroinvertebrates were collected in a Surber sampler, with 3 replicate samples collected per reach. The Surber sampler covered 1 ft^2 and had a 500 µm mesh. Macroinvertebrate samples were preserved in ethanol and identified to the lowest possible taxon by personnel from the Montana Natural Heritage Program.

4 Results and Discussion - Streams

Sampling of a wide range of parameters has yielded a substantial data set of baseline conditions within the North Fork Blackfoot River project area. This section summarizes the data for each stream. More detailed information and raw data are presented in Appendix A through Appendix I.

4.1 *North Fork Blackfoot River*

Physical Description

The North Fork Blackfoot River upstream of the North Fork Falls flows within heavily glaciated hanging river valley, with an average gradient of 120 ft/mile (Figure 1-1). In the project area, the North Fork Blackfoot River has 8 tributaries, with the East Fork North Fork Blackfoot River being the largest (Figure 2-2). Upstream of its east fork, the North Fork Blackfoot River flows through a glacial trough valley, where morainal and outwash deposits confine the channel. Substrates range from gravel and cobble, to erratic glacial boulders with large areas of exposed bedrock. Downstream of the confluence with its east fork, the North Fork Blackfoot River flows another ½ mile through a cascading bedrock channel before it spills about 50 vertical feet over the North Fork Falls. The North Fork Blackfoot River channel classifies as Rosgen B1-B4 stream types, although stream types transition to an A1-A2 stream type in the headwaters and near the North Fork Falls.

Wildfire has had pronounced influence on the North Fork Blackfoot River watershed. In 1988, the Canyon Creek wildfire swept through most of the upper North Fork Blackfoot River watershed. This stand replacement wildfire led to fish kills (Jerry Burns, USFS retired, personal communication; Don Peters, FWP biologist retired, personal communication) and was especially intense in the headwaters, as evidenced by slow recovery of conifers in many areas. A young riparian forest consisting of lodgepole pine, Douglas fir, Englemann spruce, black cottonwood, and willow lines the stream banks within areas of thick deadfall timber. Overhanging willow, large boulders, bedrock-formed pools and log-jams are primary instream habitat features. As the result of the Canyon Creek fire, the presence of coarse instream wood is generally high within the channel.

Fish Surveys

In 2007, fish surveys at 5 locations on the North Fork Blackfoot River (Figure 3-1; Appendix A) found low numbers of Rainbow Trout hybrids that increased proceeding upstream, until the uppermost reaches, were upstream and downstream of a barrier falls where no fish were collected. CPUE of less than 1 to just over 5 fish per 100 feet indicated exceptionally low fish abundance. The presence of highly hybridized *Oncorhynchus* is consistent with the historical record developed to inform conservation planning in the North Fork Blackfoot River project area (Appendix J).

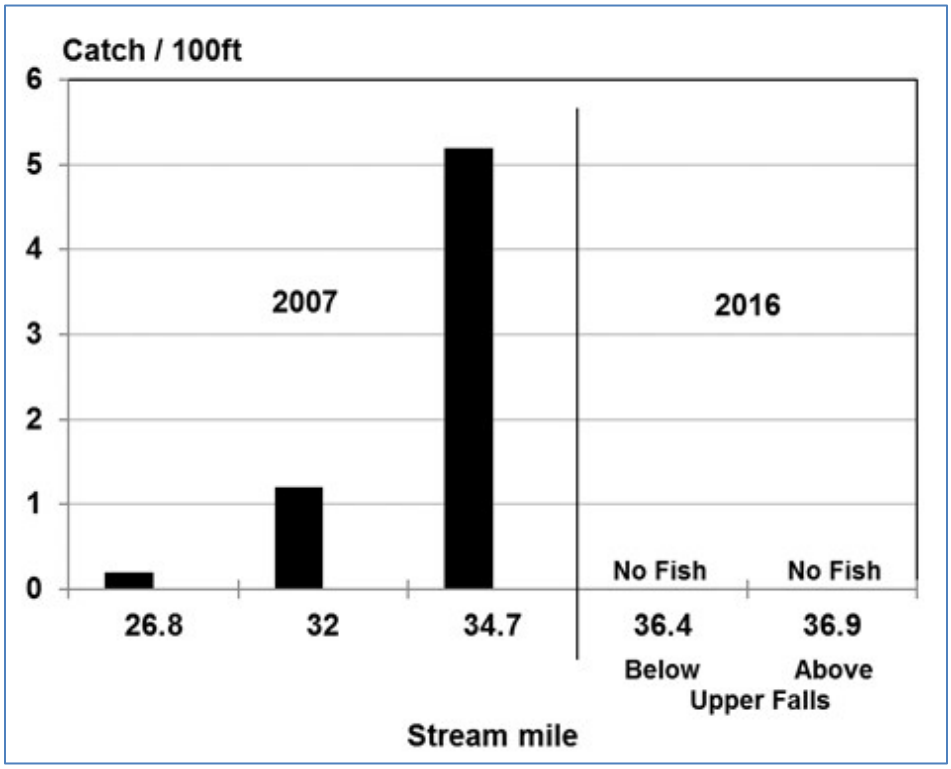

Figure 4-1. CPUE for fish sampling stations on the North Fork Blackfoot River.

Genetic Analyses

Genetic samples were collected at the 3 fish-bearing sample reaches (Leary 2008; Appendix B). Due to low abundance of fish in the North Fork Blackfoot River, only 12 fish were available for genetic analysis. This small sample size was insufficient to validate field identification of hybridization with an acceptable level of statistical certainty. The samples contained alleles from WCT, YCT and Rainbow Trout, with Rainbow Trout providing the predominant contribution.

eDNA

Electrofishing results were consistent with eDNA sampling, with Rainbow Trout and Rainbow Trout eDNA being present at sampling locations along the North Fork Blackfoot River within

the project area (Appendix C). The presence of fish bearing phenotypic resemblance to Rainbow Trout, combined with Rainbow Trout eDNA, validates the conclusion that the North Fork Blackfoot River supports a fishery with predominant contribution of Rainbow Trout genes.

Macroinvertebrates and Amphibians

Incidental observations of amphibians confirm Columbian spotted frogs and Rocky Mountain Tailed Frogs reside in the project area (Pierce et al. 2015). In 2007, we observed a Columbian spotted frog was at the sampling reach at river mile 32 and a Rocky Mountain Tailed Frog near river mile 38. During the 2016 survey, adult and larval Rocky Mountain Tailed Frogs were common at river miles 32 and 37.

Sampling of benthic invertebrates occurred at river miles 27, 32, and 34.7 with samples collected in 2014 and 2015 (Appendix D, Appendix E, and 0) . The North Fork Blackfoot River had among the greatest richness of total taxa and EPT taxa of all sites, and abundance increased proceeding upstream, with the upper 2 stations having exceptionally high numbers compared to other stations in the watershed. Macroinvertebrate samples scored high on the Montana DEQ multimetric indices, which is a statistically-based measure of stream health. No species of concern were collected.

The relatively high abundance of macroinvertebrates is in marked contrast to the low density of Rainbow Trout hybrids in the North Fork Blackfoot River. These results suggest the North Fork Blackfoot River is below carrying capacity of fish, and that Rainbow Trout hybrids are poorly adapted to the cold thermal regime in the project area. In contrast, WCT and Bull Trout are cold-water adapted, and establishment of a native fishery within the project area may provide improved recreational opportunities and an overall more productive fishery.

Physicochemical Water Quality

Water temperature loggers placed at 2 locations in the North Fork Blackfoot River, 1 in the headwaters upstream of Dobrota Creek, and another just upstream of the East Fork North Fork Blackfoot River junction (Figure 3-3), indicated cooling in the downstream direction (Appendix H). During the 2013 to 2017 monitoring period, maximum daily temperatures in July and August ranged from 62 to 71 °F, and daily average temperatures ranged from 57.2 to 51.7 °F. Minimum daily temperatures rarely exceeded 40 °F.

The warmer temperatures in the headwaters may relate to the southerly aspect of the drainage and lack of forest cover in the extreme headwaters. This area burned during the Canyon Creek fire, and the severity of the fire scorched the seedbed of coniferous trees, resulting in slow recovery of the forest. Inflows of cooler tributary streams and groundwater, and a coniferous or shrub canopy that shaded substantial amounts of the North Fork Blackfoot River and tributaries contribute to cooler waters downstream.

Applying the Clackamas framework (Dunham et al. 2011) to the temperature data indicated variable suitability for Bull Trout based on water temperature (Appendix K). The site upstream of Dobrota Creek rated as unsuitable for summer rearing, whereas the site upstream of the confluence with the East Fork North Fork Blackfoot River rated as moderately suitable.

Physicochemical properties of the water at fish sampling reaches varied among the 3 fish-bearing reaches (Appendix G). Conductivity increased proceeding downstream, beginning at 109 µS at the uppermost site, increasing to 157 µS, then 177 µS at the station closest the confluence with the East Fork North Fork Blackfoot River. Likewise, TDS showed a corresponding slight increase along the downstream gradient, beginning at 55 ppm at the furthest fish-bearing site upstream, then increasing to 78 ppm and 89 ppm. These values are typical of montane, headwaters streams and are low compared to larger streams that carry water that has time and the soluble geology to carry more dissolved solids. We measured pH only at the lowermost sampling reach, and it was 8.8, which is typical of mountain streams in Montana, which tend to be slightly alkaline.

Stream Flow

Upstream of its confluence with the East Fork North Fork Blackfoot River, the main stem of the North Fork Blackfoot River drains a 47-mile^2 basin. In 2013 and 2014, baseflow on the uppermost stream flow station (Figure 3-4; Appendix D) ranged from 1 and 4.9 cfs, with 2013 having lower flows. Upstream of its confluence with the East Fork North Fork Blackfoot River, flows were 11.1 cfs and 28.7 cfs in 2013 and 2014, respectively. The combined flow of the major forks of the North Fork Blackfoot River within the project area was nearly 40 cfs in September 2013 and almost 78 cfs in August 2014, which was relatively wet year.

4.2 *Dobrota Creek*

Physical Description

Dobrota Creek is a 1st order tributary to the upper North Fork Blackfoot River (Figure 1-1). Dobrota Creek drains a small basin (5.5-mile^2) on the southern slopes of Scapegoat Mountain. Channel gradients range over 1,400 ft/mile in the upper 2.0 miles of stream to 192 ft/mile in the lower two miles of stream (Figure 4-2). Dobrota Creek classifies as a Rosgen B3 stream type with cobble-dominated substrate along with gravel, boulders mix with large areas of bedrock, which form wood-formed plunge and scour pools and boulder pocket water.

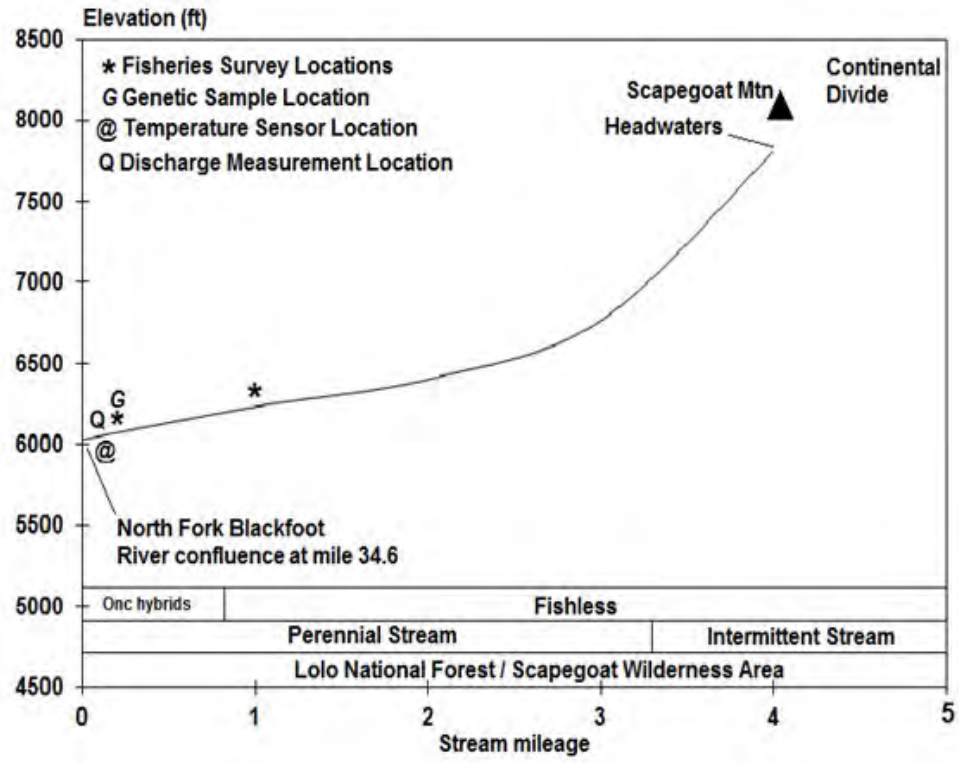

Figure 4-2. Longitudinal profile of Dobrota Creek.

In 1988, the Canyon Creek fire burned the Dobrota basin intensely, resulting in a stand-replacement of lodgepole pine forest. During the time of our surveys, high rates of erosion were still occurring in areas against steep hillsides where plant regrowth is slow. The burn area is contributing considerable amounts of large wood to Dobrota Creek. The riparian plant communities are composed of willow, alder, young lodgepole pine and a robust mixture of grasses and forbs that contributes to bank stability.

Fish Surveys

In 2007, a survey of fish populations near the confluence with the North Fork Blackfoot River in 2007 found low trout numbers (CPUE = 2.7; Appendix A). In 2016, sampling 1 mile upstream of the confluence of the North Fork Blackfoot River found no fish, although Rocky Mountain Tailed Frogs were present.

Genetic Analyses

The small sample of fish available for genetic analyses (n=5) yielded results consistent with most of the project area. Genes from WCT, YCT and Rainbow Trout were present, with Rainbow Trout providing the dominant contribution (Appendix B). Although not a hybrid swarm, this population is comprised of hybridized fish.

eDNA

In September 2015, water samples were collected from Dobrota Creek within a reach where fish had been captured during electrofishing. Consistent with genetic analyses of captured fish, the eDNA of Rainbow Trout was present in the sample (Appendix C).

Macroinvertebrates and Amphibians

Macroinvertebrates sampled near the mouth of Dobrota Creek yielded an abundance of organisms, and overall taxa richness and EPT richness were among the highest of sites sampled (Appendix D, Appendix E, and 0). The community scored within the range of excellent biological integrity. No species of concern were detected in samples.

Rocky Mountain Tailed Frogs were relatively abundant in Dobrota Creek (Appendix D), and this site had the second highest density of the frogs of all sites surveyed. The abundance of Rocky Mountain Tailed Frogs in Dobrota Creek, including reaches that were potentially fishless, makes this stream a potential source of recolonization of Rocky Mountain Tailed Frogs. This abundance of Rocky Mountain Tailed Frogs could mitigate any population level effect within piscicide treated reaches.

Physicochemical Water Quality

Field measures of TDS and conductivity were typical of a high mountain stream with low concentrations of dissolved solids (Appendix G). Conductivity rangedfrom 148 µS to 170 µS, and TDS was 77 ppm. No pH data are available for Dobrota Creek.

Thermal regime in Dobrota Creek was relatively cool, with maximum daily temperatures ranging from 53.6 to 61.1 °F, and average daily temperatures ranging from 46 to 49 °F (Appendix H, Dobrota Creek) and rated as moderately suitable for Bull Trout using the Clackamass framework (Dunham et al. 2011; Appendix K). From 2013 through 2017, maximum water temperatures in July and August ranged from 53.6 °F to 61.1 °F. Mean daily temperatures were cool and never exceeded 49 °F.

Stream Flow

This headwater tributary to the North Fork Blackfoot River has a drainage area of 5.5-mile^2 (Appendix I). In 2013 and 2014, flows measurements near its mouth during base flows were 2.5 to 6.6 cfs respectively

4.3 *Cooney Creek*

Physical Description

Cooney Creek is a 2nd order tributary stream to the upper North Fork Blackfoot River (Figure 1-1). Cooney Creek drains a 9.2 mile^2 headwater basin on northern slopes of Olson Peak and

Galusha Peak. Cooney Creek begins in a cirque basin, flows to the north for about 5.5 miles and enters the North Fork Blackfoot River at stream mile 33.7, near the Carmichael Guard Station. Stream gradient is relatively gentle for its first 4 miles, then gains about 1,000-ft in elevation over its last 1.5 miles (Figure 4-3). Numerous spring seeps and ephemeral streams enter Cooney Creek throughout its entire length.

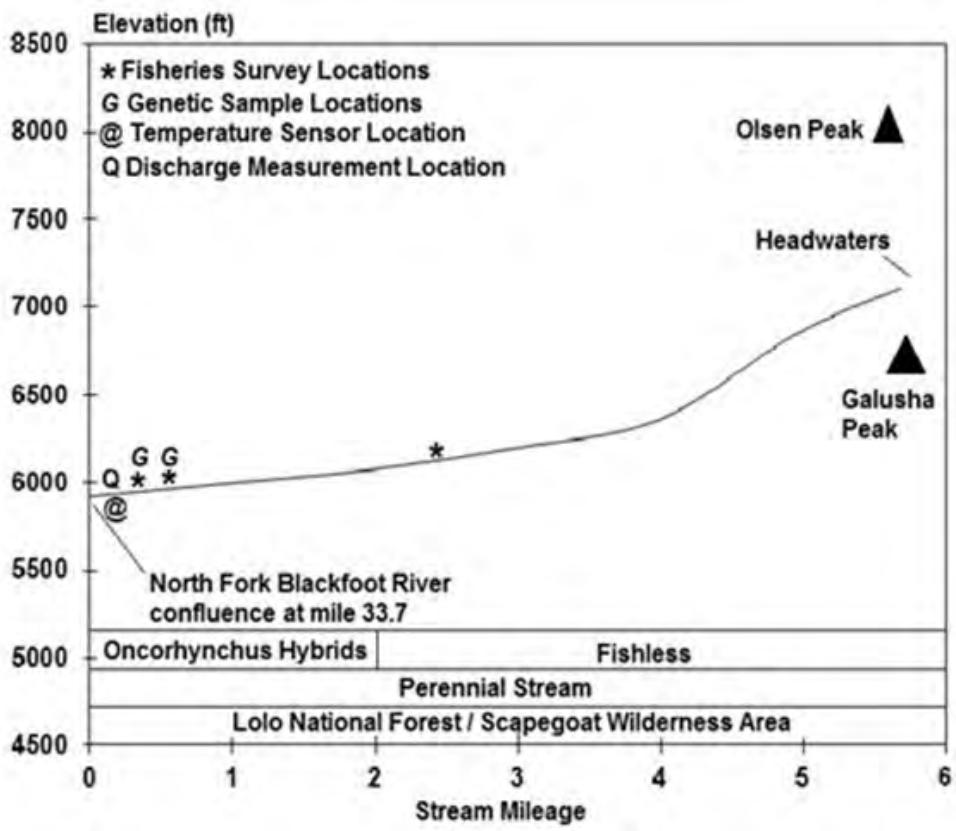

Figure 4-3. Longitudinal profile of Cooney Creek

Cooney Creek classifies as a Rosgen B3-B4 stream type with gravel, cobble, boulder and bedrock substrates. Alder, willow, forbs and grasses line the stream banks beneath a dense riparian forest of Englemann spruce and lodgepole pine in the headwaters of the basin. The headwaters of Cooney Creek support a mature forest although portions the surrounding mountain slopes burned during the 1988 Canyon Creek fire. Currently, the recruitment of wood is extremely high on lower Cooney Creek due in part to avalanche activity in the burn area

Fish Surveys

Stocking records show Cooney Creek was planted with over 20,000 Rainbow Trout in 1941 and with 3,600 undifferentiated trout in 1950 (Appendix J). Despite the substantial stocking effort, fish were rare in Cooney Creek, with abundance substantially less than 1 fish per 1,000-ft and the lower 2 stations, and no fish found at the upper sampling reach (Figure 4-4; Appendix A).

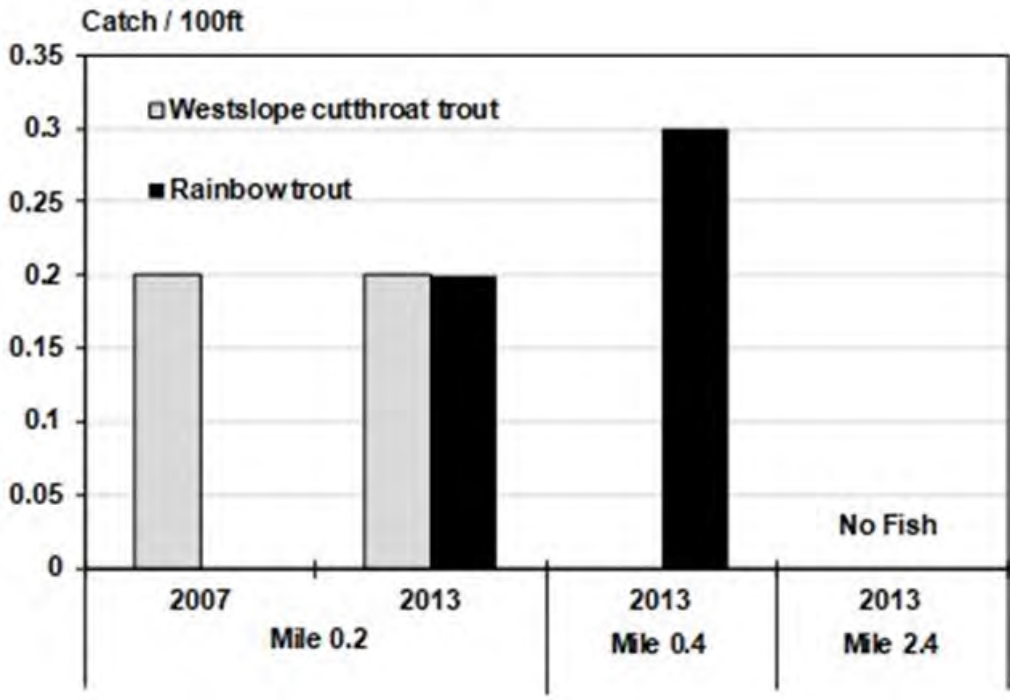

Figure 4-4. CPUE for 3 survey sections on Cooney Creek.

Genetic Analyses

The genetic composition of fish in Cooney Creek was evaluated twice (Appendix B). The first sample of 1 fish showed markers of only WCT and could have been a nonhybridized WCT. Subsequently, results from 8 sampled fish found these to be hybrids of Rainbow Trout and YCT. The anomalous finding of a single nonhybridized WCT is in striking contrast to the finding of nearly 200 fish sampled from within the project area being hybrids of some combination of WCT, YCT, and Rainbow Trout, but with WCT genes being present in low frequency.

eDNA

A water sample collected on Cooney Creek on 10/1/2015 yielded 3 positive reactions to Rainbow Trout eDNA (Appendix C). Combined with electrofishing data and analysis of tissues samples, these results indicated Cooney Creek supports low density of *Oncorhynchus* with a high degree of hybridization, although at least 1 WCT was found.

Macroinvertebrates and Amphibians

Macroinvertebrates were sampled on 3 occasions across 2 sampling stations (Appendix D, Appendix E, and 0). The results suggest a healthy montane stream, with substantial total richness of invertebrates and moderate richness of EPT taxa. A relatively rarely collected stonefly, *Zapada frigida*, was found; however, this species does not have a special status in Montana. Nevertheless, its presence is an indicator of high biological integrity and cold water.

Rocky Mountain Tailed Frogs were observed during biological surveys and were moderately abundant in and along Cooney Creek (Appendix D and Appendix E). The relatively restricted distribution of fish in Cooney Creek suggests fishless waters upstream of the treatment area will provide a source of Rocky Mountain Tailed Frog for expansion into the project area to mitigate for any loss of vulnerable tadpoles.

Physicochemical Water Quality

Results of field measures of pH, conductivity, and TDS was consistent with a headwaters stream with little opportunity to dissolve ions (Appendix G). Conductivity ranged from 133 to 202 µS. TDS was ranged from 68 to 143 ppm. Cooney Creek is slightly alkaline with pH ranging from 7.9 to 8.6.

A thermograph installed 0.2 miles from the confluence with the North Fork Blackfoot River registered cool maximum daily temperatures, which were within the range found to be optimal for growth of Bull Trout (Selong et al. 2000; Appendix H) with a maximum daily temperature of 54.6 °F across all years. Mean daily temperatures were cool year-round with the highest daily temperature of 47.8 °F occurring in August 2013. Application of the Clackamas framework to water temperature measured in Cooney Creek found it to be highly suitable for Bull Trout (Appendix K).

Stream Flow

On September 24, 2013, a USFS hydrology crew measured stream flow on Cooney Creek near its mouth. A small stream, it flowed at 2.9 cfs (Appendix I).

4.4 *Broadus Creek*

Physical Description

Broadus Creek, a 2nd order tributary to the North Fork Blackfoot River, drains a 3.3 mile^2 basin on the eastern slope of Evans Peak. It flows east and south for 2.5 miles and enters the North Fork Blackfoot River near river mile 31. The upper mile of Broadus Creek is intermittent and has a gradient of 1,200 ft/mile, whereas the lower 1.5 miles of stream is perennial and descends at 430 ft/mile and classifies as a Rosgen Aa2 stream type (Figure 4-5).

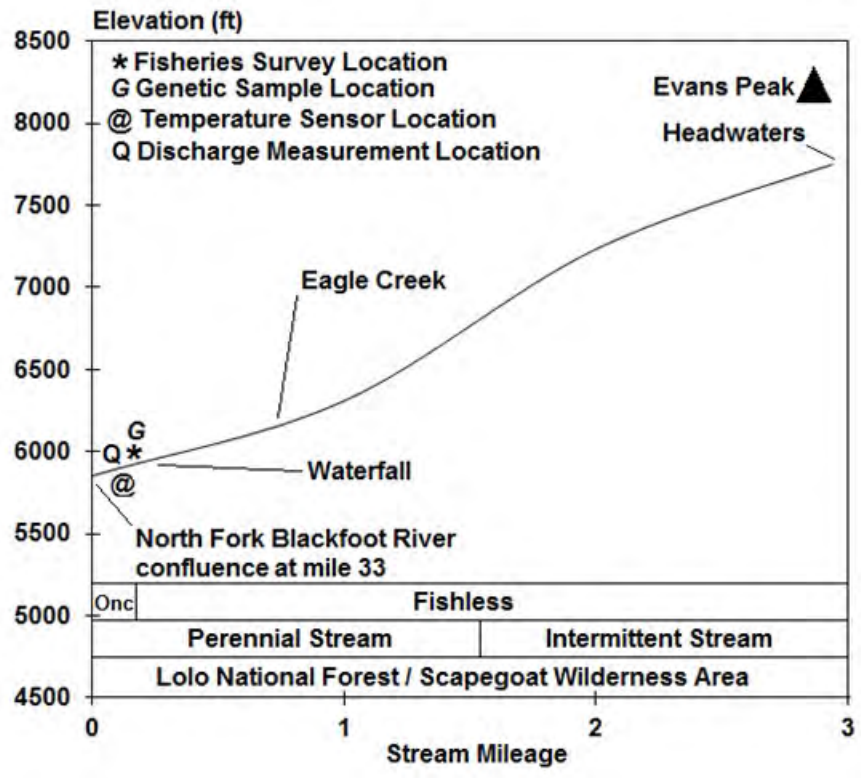

Figure 4-5. Longitudinal profile of Broadus Creek.

This high gradient stream has a mix of boulder and bedrock substrates and abundant woody debris. The 1988 fire has contributed burned deadfall timber that enters the stream from the burn area, including steep surrounding cliffs. Bedrock contributes to bank stability, but also allows for alder and a mixed community of grasses and forbs. The young riparian forest consists of lodgepole pine and Englemann spruce. Electrofishing surveys suggest a 12-ft waterfall upstream of the mouth acts as an upstream fish passage barrier.

Fish Surveys

In July 2007, we surveyed Broadus Creek upstream and downstream of the waterfall. Low abundance of hybrid *Oncorhynchus* were present downstream of the waterfall with a CPUE of 1.4 (Appendix A). No fish were captured upstream of the apparent barrier falls. Review of stocking records did not find evidence of fish planting in Broadus Creek (Appendix J), likely because its small size and presence of a barrier falls did not make it an appropriate candidate for fish stocking. Introduction of native WCT and Bull Trout upstream of the falls would increase the extent of occupied habitat within the North Fork Blackfoot River project area and provide a headwaters source of fish to waters downstream.

Genetic Analyses

Genetic testing of 4 fish captured in Broadus Creek found genetic contributions from Rainbow Trout and WCT (Appendix B). The absence of YCT genes was atypical of streams in the area; however, this apparent absence may be the related to the small sample size and the resulting low probability of detecting genes from YCT, when Rainbow Trout genes were the dominant contribution.

eDNA

Water was sampled for eDNA upstream of the waterfall on Broadus Creek in 2015 (Appendix C). No Rainbow Trout were captured in electrofishing efforts, and no Rainbow Trout eDNA was detected, providing additional support that the waterfall is a fish barrier.

Macroinvertebrates and Amphibians

Macroinvertebrates were collected upstream and downstream of the barrier falls near the mouth of Broadus Creek. EPT taxa accounted for more than 90% of the individuals collected, and both samples scored within the range of excellent biological integrity (Appendix D). The stonefly *Zapada columbiana* was the most abundant taxon (Appendix E), and this species is among taxa included in Pristine Mountain Stream Ecological System assemblage (Stagliano 2005).

Broadus Creek also supported Rocky Mountain Tailed Frogs, with higher densities observed upstream of the barrier falls (Appendix D). Again, apparently fishless waters supporting Rocky Mountain Tailed Frog provide a source of recolonization to mitigate for potential negative effects on vulnerable life-history stages of this long-lived species. Furthermore, older frogs would not be exposed to toxic concentrations of rotenone, and natural reproduction of tolerant adults in treated water would mitigate for loss of sensitive, young tadpoles.

Physicochemical Water Quality

Field measurements of pH, conductivity, and TDS were typical of a small montane stream (Appendix G). Conductivity and TDS indicated low concentrations of dissolved solids and common ions. The water was slightly basic with a pH of 8.1, which was within the typical range measured within the North Fork Blackfoot River project area.

Water temperature monitoring registered cool to cold water temperatures in July and August in Broadus Creek (Appendix H). Maximum daily temperatures ranged from 55.2 to 60.9 °F, and average daily temperatures ranged from 48.2 to 50.8 °F in these warmest months. The Clackamas framework (Dunham et al. 2011; Appendix K) to summer and fall water temperatures rated Broadus Creek as highly suitable for Bull Trout.

Stream Flow

Stream flow was measured at the mouth of Broadus Creek in 2014 and 2015 (Appendix I). Flows were 0.7 and 1.5 in this 3.3 mile^2 at the downstream extent of this 3.3 mile^2 watershed.

4.5 *Theodore Creek*

Physical Description

Theodore Creek is a small 1st order perennial tributary that flows northerly 2.4 miles before entering the North Fork Blackfoot River at stream mile 32.5 (Figure 1-1). This stream drains a 1.6 mile^2 basin on the northeastern slope of Galusha Peak. Theodore Creek is relatively high gradient, with an average slope of 530 ft/mile along its nearly 3-mile length (Figure 4-6).

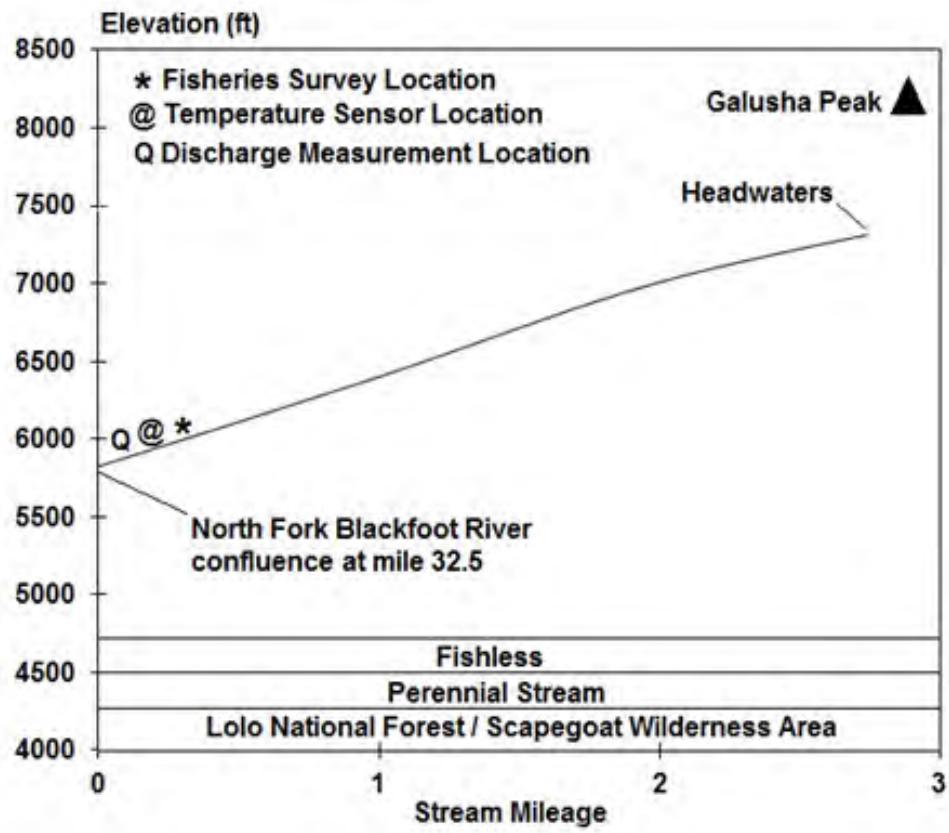

Figure 4-6. Longitudinal profile of Theodore Creek.

The 1988 Canyon Creek wildfire burned the riparian vegetation along Theodore Creek, which now consists of dense community of young lodgepole pine, Englemann spruce and black cottonwood. Willows, forbs and grasses occupy the stream margins. Recruitment of large wood to the stream channel is considerable, and overhanging shrubs contribute extensively to instream

habitat features. The survey location on lower Theodore Creek classifies as a Rosgen C4 stream type with a predominately gravel substrate

Fish Surveys

In 2007, electrofishing yielded no fish. Columbian spotted frogs were abundant (Appendix A).

Genetic Analyses

The absence of fish in the sampling effort precluded genetic analyses.

eDNA

Although no fish were collected during the electrofishing survey, eDNA sampling yielded evidence of fish occupying Theodore Creek (Appendix C). Rainbow Trout genes were detected, with a strong signal of 3 positive reactions. The heavy deadfall timber and abundance large woody debris decreases the probability of capturing fish with electrofishing. These results confirm the value of using eDNA sampling in conjunction with electrofishing in estimating fish distribution.

Macroinvertebrates and Amphibians

Macroinvertebrate samples collected in August 2014 were consistent with high biological integrity, typical of a healthy, headwaters stream (Appendix D, Appendix E, and 0). Stoneflies were the most abundant taxon. As a group, stoneflies tend to be the most sensitive macroinvertebrates, so their richness and abundance in Theodore Creek is further evidence of cold, clean water.

Amphibians observed or captured at the sampling reach on Theodore Creek included relatively low densities of Rocky Mountain Tailed Frog. Columbian spotted frogs were also present along Theodore Creek.

Physicochemical Water Quality

Field measures of conductivity and TDS were made in July 2007 and August 2014, and pH was also measured in 2014 (Appendix G). Field measures of these parameters were typical of headwaters streams flowing through a catchment of relatively insoluble geology, with TDS and conductivity being relatively low. The pH reading indicated slightly basic water, which was in the range of values measured throughout the project area.

Continuous monitoring of water temperature indicated Theodore Creek has a relatively cold thermal regime (Appendix H). Maximum daily temperatures in July and August ranged from 59.5 to 53.2 °F. Average daily temperatures ranged from 47.4 to 50.5 °F. Application of the Clackamas framework rated Theodore Creek as moderately suitable for Bull Trout (Appendix K).

Stream Flow

Stream flow was measured at the mouth of Theodore Creek in September 2013 and August 2014 (Appendix I). Consistent with is small drainage area of under 1 mile^2, flow was 0.1 cfs in 2013 and 0.3 cfs in 2014.

4.6 *Sarbo Creek*

Physical Description

Sarbo Creek, a small 1st order tributary, drains 1.4 mile^2 basin on the southern slopes of Evans Peak, and flows 1.7 miles to its confluence with the North Fork Blackfoot River at river mile 30.4. Stream gradient averages 545 ft/mile for the upper 0.7 mile of stream decreasing to 128 ft/mile in the middle reaches that increases to 332 ft/mile near the mouth (Figure 4-7).

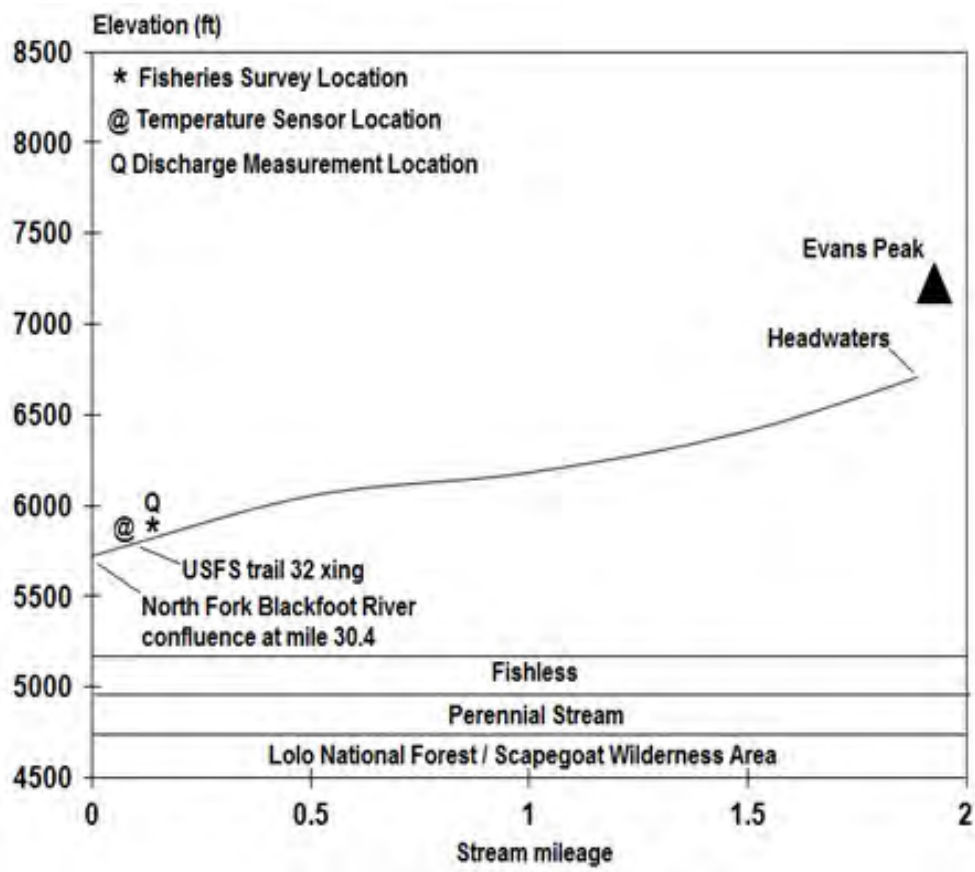

Figure 4-7. Longitudinal profile of Sarbo Creek.

The 1988 Canyon Creek wildfire burned a small portion of the Sarbo Creek watershed, with only the hillsides of the lower 0.2 miles burned; however, its riparian corridor remained untouched. A small confined stream, lower Sarbo Creek classifies as a Rosgen A1+ stream type. Sarbo Creek

has a riparian overstory of mature spruce and lodgepole pine and a dense understory of alder. Large wood recruitment to the stream channel is low to moderate. Large slabs of bedrock and instream boulders provide most of the pool habitat in the form of plunge, scour, and pocket pools.

Fish Surveys

Electrofishing in August 2014 yielded no fish (Appendix A).

Genetic Analyses

The lack of fish captured through electrofishing efforts precluded analysis of fish tissues samples.

eDNA

In September 2015, consistent with electrofishing surveys, no Rainbow Trout eDNA was detected in water samples (Appendix C).

Macroinvertebrates and Amphibians

Macroinvertebrate samples collected near the mouth of Sarbo Creek in 2014 and 2015 indicated a high level of biological integrity (Appendix D, Appendix E, and 0). Density of invertebrates was relatively high, which may be related to the lack of predation pressure from fish. Sarbo Creek also ranked high in terms of the Shannon diversity index compared to other streams.

Physicochemical Water Quality

Field measures of pH, TDS, and conductivity were taken in August 2014 (Appendix G). Sarbo Creek does not have substantial loading of dissolved solids or common ions, as evidenced by TDS concentration of 80 pm and conductivity of 159 µS. Sarbo Creek's pH was slightly alkaline at 8.1, which is like other streams in the watershed.

Continuous water temperature monitoring found Sarbo Creek to have a cold thermal regime (Appendix H). From 2013 through 2017, maximum daily water temperatures ranged from 53.9 to 56.6 °F, and average daily temperatures ranged from 47.2 to 48.8 °F. The thermal regime in Sarbo Creek rates as highly suitable for Bull Trout based on the Clackamas framework (Dunham et al. 2011; Appendix K).

Stream Flow

Stream flows was measured on Sarbo Creek in 2013 and 2014 (Appendix I). Flow was 0.3 cfs in 2013, a drier year, and 0.6 cfs in 2014. These low flow volumes are expected with a drainage area of 1.4 mile^2.

4.7 *South Creek*

Physical Description

South Creek, a small 1st order tributary, drains a 2.2 mile^2 basin on the northern slopes of Galusha Peak (Figure 1-1). South Creek flows northwesterly for approximately 3 miles and joins the North Fork at stream mile 29.3. Stream gradient averages 1,336 ft/mile the upper mile and decrease to 346 ft/mile in the lower two miles of stream (Figure 4-8).

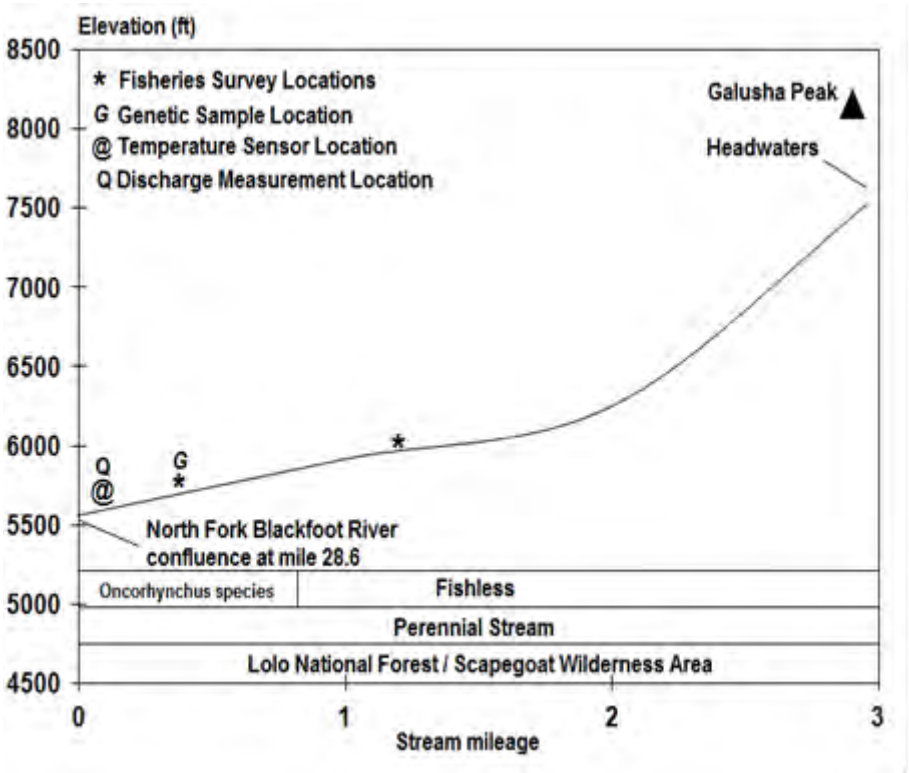

Figure 4-8. Longitudinal profile of South Creek.

South Creek classifies as a Rosgen B2-B3 stream type at mile 1.2 and a B4-B5 near the mouth. A mature Englemann spruce and lodgepole pine overstory, above dense understory of alder, surrounds South Creek's small, confined channel. Recruitment of large wood to the stream channel varies from low to high, depending on proximity to burned areas, and large wood creates some plunge and scour pools. Large in-stream boulders provide pocket water.

Wildfire in 1988 caused considerable disturbance in the lower portion of South Creek, although the riparian corridor in the streams upper 2 miles did not burn, Lower South Creek lacks an overstory a result of the wildfire, but dense alder stands provide a riparian understory. The lack vegetation on areas of the adjacent hillside slopes in the burn area contributes elevated levels of

sand and gravel to the stream. High concentrations of large wood recruited to the stream channel create complexity through formation of plunge and scour pools.

Fish Surveys

Fish surveys in South Creek include electrofishing at 3 locations (Appendix A). In 2013, a section located 1.2 miles from the confluence with the North Fork Blackfoot River yielded no fish, although Rocky Mountain Tailed Frogs were present. In 2014, electrofishing near the mouth of South Creek did not result in capture of fish; however, YOY *Oncorhynchus* were observed. A section about 0.5 miles from the South Creek's mouth yielded 10 Rainbow Trout. The CPUE at this reach was 3.3 fish/100 ft. Combined, these results suggest trout may have limited distribution in South Creek and occur in low abundance where present.

Genetic Analyses

Genetic analyses are not available for fish captured in South Creek. Its neighboring streams support *Oncorhynchus* hybrids with a Rainbow Trout providing the greatest contribution of genes (Appendix B).

Macroinvertebrates and Amphibians

No macroinvertebrate data are available for South Creek. Rocky Mountain Tailed Frogs were present about 1.4 miles from the confluence with the North Fork Blackfoot River, in a reach that yielded no fish. The presence of Rocky Mountain Tailed Frogs in apparently fishless headwaters could provide a source to mitigate for the potential loss of sensitive life stages in reaches treated with piscicide and facilitate natural recovery.

Physicochemical Water Quality

Field measures of TDS, conductivity and pH were conducted in 2013 and 2016, at locations 1.2 and 0.4 miles from South Creek's confluence with the North Fork Blackfoot River respectively (Appendix G). TDS and conductivity were slightly higher than other sampling locations in neighboring streams with TDS of 163 ppm measured at the location close to the mouth in 2013, and conductivities of 216 and 229 µS. Like other streams in the area, South Creek is slightly alkaline, with pH of 8.2 and 8.3.

Continuous temperature monitoring found South Creek to have a relatively cold thermal regime (Appendix H). Maximum daily temperatures ranged from 56.9 to 58.9 °F, and average daily temperatures ranged from 50.8 to 53.5 °F. Application of the Clackamas framework rates South Creek to be highly suitable for Bull Trout (Appendix K).

Stream Flow

A USGS hydrology crew measured stream flow on South Creek in August 2014 (Appendix I). Stream flow was 0.4 cfs, which is within an expected range for a headwater stream with a 2.2 mile^2 during low flows.

4.8 *Unnamed Tributary of the North Fork Blackfoot River*

Physical Description

A small 1st order unnamed stream drains a 1.3-mile^2 basin on the eastern slopes of Falls Point. The stream is 1.6 miles in length and enters the North Fork at river mile 27.8, upstream of the East Fork confluence (Figure 1-1). This stream loses less than 1,000 ft in elevation along its nearly 2-mile length (Figure 4-9).

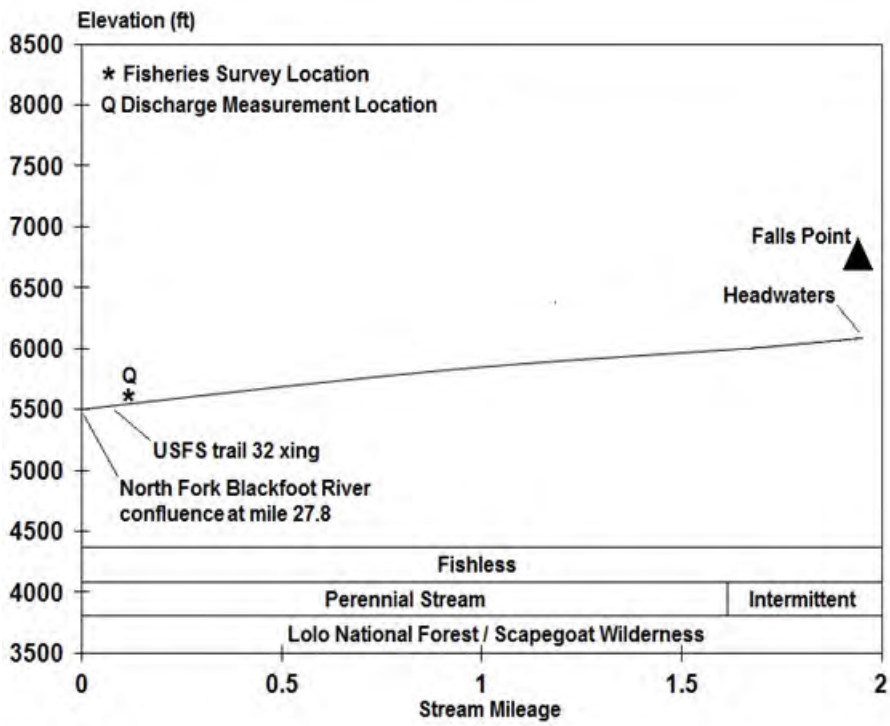

Figure 4-9. Longitudinal profile of unnamed tributary.

The tributary classifies as a Rosgen B3-B4 stream type. The riparian zone has an overstory of mature Englemann spruce and lodgepole pine covering a dense understory of alder, willow, young black cottonwoods and streamside forbs and grasses. Large woody debris has contributed to scour of plunge pools and enhanced lateral scour pools. Large boulders provide pocket water. Most of this un-named tributary's basin was untouched by the 1988 Canyon Creek wildfire. Only the hillsides of the lower reaches were burned.

Fish Surveys

In 2014, we electrofished a 240 ft reach located 0.1 miles from the unnamed tributary of the North Fork Blackfoot River. No fish were captured or observed. Likewise, no amphibians were observed during this event (Appendix A).

Genetic Analyses

No fish were collected in the unnamed tributary, which precluded analyses of fish tissue.

eDNA

No eDNA was detected in a sample collected in September 2015 (Appendix C).

Macroinvertebrates and Amphibians

Sampling for macroinvertebrates and amphibians occurred in August 2014 (Appendix D, Appendix E, and Appendix F). EPT taxa accounted for 95% of individuals, and an exceptional abundance of several stonefly taxa contributed to the large proportion of EPTs. The most abundant stonefly taxa were shredders, organisms that feed on leaf litter, and the dense riparian canopy may have contributed to promoting their high numbers. Depending on scoring criteria, the sample rated as slightly impaired to unimpaired. No amphibians were detected.

Physicochemical Water Quality

Field measures of TDS, conductivity, and pH were collected in August 2014 (Appendix G). TDS and conductivity were low, which is expected in small mountain streams. The water was slightly alkaline, with a pH of 8. No continuous water temperature data are available for this stream.

Stream Flow

Stream flow was measured in 2013 and 2014 at 0.1 miles from the confluence with the North Fork Blackfoot River (Appendix I). Discharge was 1.6 cfs on both occasions. The drainage area upstream of the flow measurement was 1.3 mile^2.

4.9 *East Fork North Fork Blackfoot River*

Physical Description

The East Fork North Fork Blackfoot River is a relatively large, 3rd order stream that originates about 1.5 miles upstream of Parker Lake (Figure 1-1). The stream flows northwest for 10 miles through a glacial trough valley to its confluence with the North Fork Blackfoot River, which is less than 1 mile upstream of the North Fork Falls. The watershed has a drainage area of 65 mile^2, and 8 tributaries enter the East Fork North Fork Blackfoot River after it leaves Parker Lake. Downstream of Scotty Creek, the East Fork North Fork Blackfoot River splits, and the southern braid rejoins the main stem about 2 miles downstream.

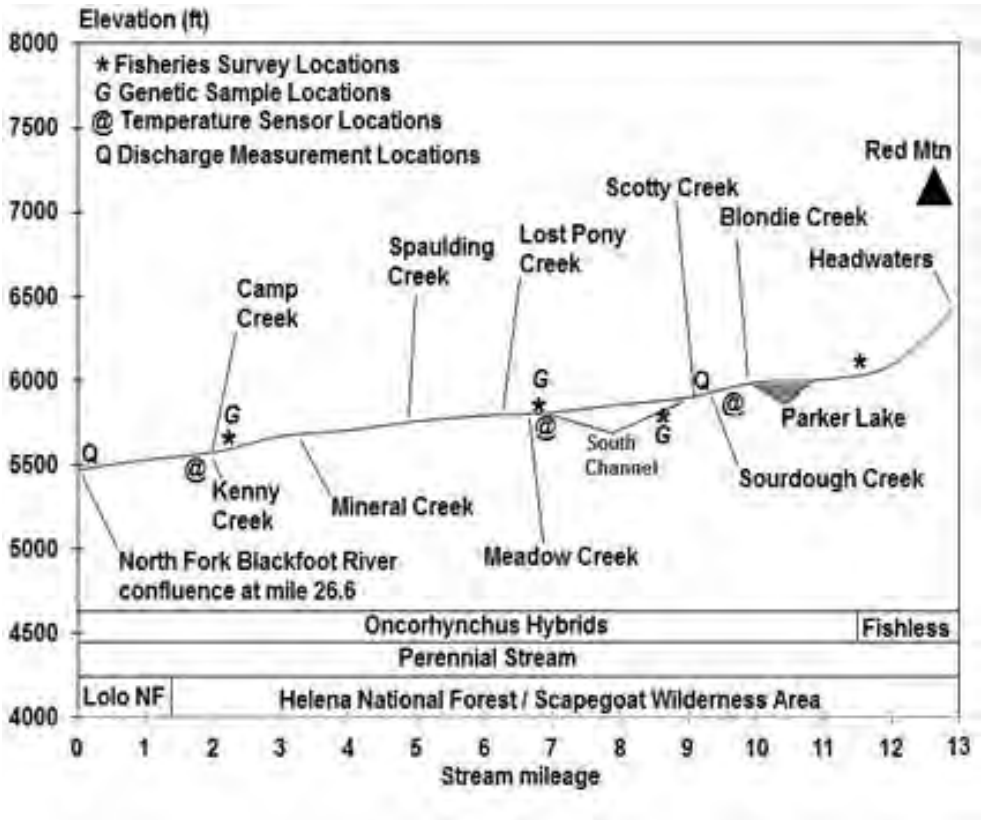

Figure 4-10. Longitudinal profile of the East Fork North Fork Blackfoot River.

Channel morphology varies along the length of the East Fork North Fork Blackfoot River, with gradient and floodplain access influencing geomorphology. Rosgen B3 and C4 channel types are present, providing a diversity of habitat.

The Canyon Creek wildlife burned along the lower 9 miles of the East Fork North Fork Blackfoot River, and the burned stand is contributing large amounts of woody debris. A dense lodgepole pine forest has reestablished in the riparian area, and a corridor of willow, alder, forbs, and graminoids line the channel. Upstream of the burned area, a dense stand of riparian shrubs provides the understory beneath a forest of lodgepole pine.

Fish Surveys

Fish surveys have been conducted at 4 locations in the East Fork North Fork Blackfoot River (Figure 3-1 and Appendix A). The first fish surveys occurred in 2006, with 2 reaches sampled. The uppermost site was upstream of Parker Lake, at river mile 11.7, and the others were at stream miles 0.1, 1.9, and 7. The south channel of the East Fork North Fork Blackfoot River was also sampled near stream mile 9.

In 2006, we surveyed fisheries in the East Fork for the first time. These surveys included one site upstream of Parker Lake (sm 11.7) and one site was upstream of the Meadow Creek confluence, at river mile 7. In 2013, we resurveyed the reach near Meadow Creek and established two additional survey reaches, one about 2 stream miles from the North Fork Blackfoot River and one on the south channel, between Scotty and Meadow creeks.

Fish surveys yielded no fish to relatively low density of *Oncorhynchus*, which were field identified as Rainbow Trout, across sampling reaches (Figure 4-11). Despite proximity to the fish-bearing Parker Lake, no fish were captured at the uppermost reach. CPUE at the lower reaches ranged from 4 to 9 fish/100 ft. Rocky Mountain Tailed Frogs and Columbian Spotted Frogs were observed during several sampling efforts (Appendix A). Western Toads were present at the sampling reach at stream mile 7 in 2006.

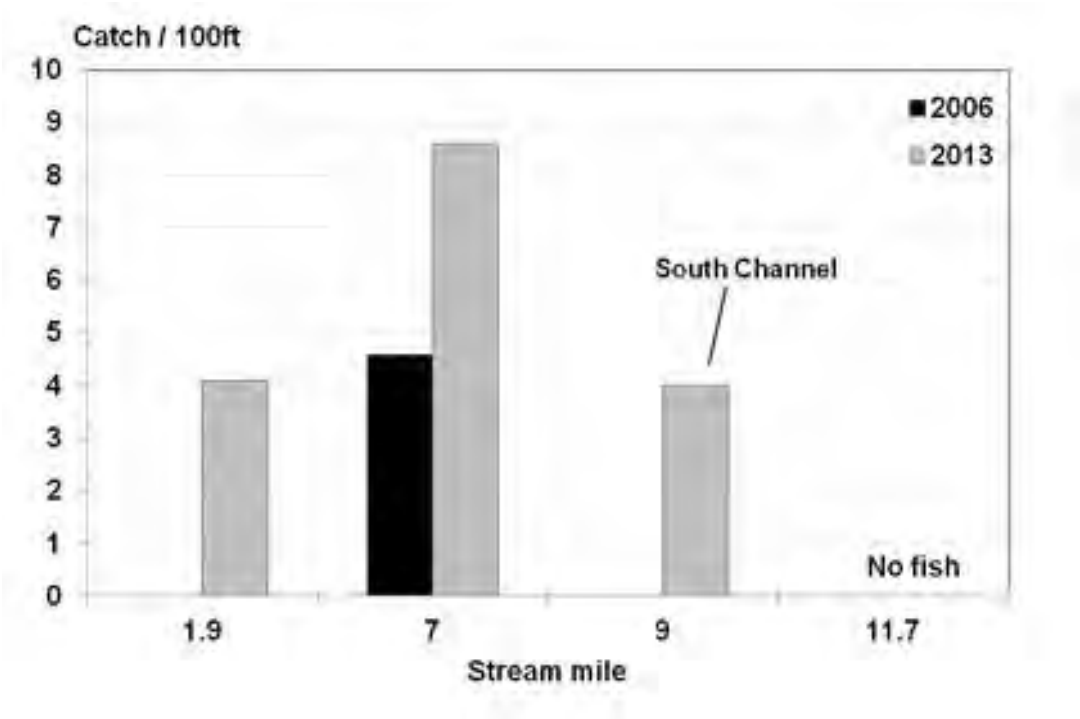

Figure 4-11. CPUE at sampling reaches along the East Fork North Fork Blackfoot River.

Genetic Analyses

Genetic analysis of tissue samples collected from fish in the East Fork North Fork Blackfoot River found fish to be hybrids of Rainbow Trout, WCT and YCT (Appendix B), with Rainbow Trout providing the dominant genetic contribution. Stocking records indicate several stocking events in the 1940s and 1950s, with undifferentiated trout being stocked into Parker Lake and the East Fork North Fork Blackfoot River (Appendix J). Creel surveys suggest at least 1 successful plant of YCT into Parker Lake. The extent of the stocking of fish without formal identification of

species has obscured evaluation of the historical fish presence in the East Fork North Fork Blackfoot River.

eDNA

In 2015, samples were collected for analysis of eDNA at 2 locations in the East Fork North Fork Blackfoot River (Appendix C). Fish identified as Rainbow Trout were captured at both sites, and eDNA results showed strong positive reactions to Rainbow Trout DNA. These results confirm that a substantial proportion of fish stocked into the East Fork North Fork Blackfoot River and Parker Lake were Rainbow Trout.

Macroinvertebrates and Amphibians

Aquatic macroinvertebrates were sampled in 2013 and 2015 at stream mile 7 and in 2013 at stream mile 9 (Appendix D, Appendix E, and 0). Measures of biological integrity were below least impaired reference streams; however, the professional judgment was of a stream with relatively high biological integrity. A rare dipteran species was captured in the East Fork North Fork Blackfoot River; however, this was not a species of concern. Dipterans tend to be resilient to disturbance. Their short life cycles and high reproductive potential make dipterans early colonizers that benefit over the short-term to a pulse disturbance such as flooding or piscicide application.

Physicochemical Water Quality

Field measures of TDS, conductivity, and pH were collected at 3 locations in 2013 (Appendix G). Conductivity ranged from 175 to 245 µS, and TDS ranged from 87 to 173 ppm. The water was slightly alkaline with pH ranging from 8.1 to 8.6. All values are within ranges typical of unpolluted, mountain streams in Montana.

Continuous stream temperature loggers were deployed at stream mile 1.7 and 9.4 from 2013 through August of 2017 (Appendix H). During July and August, maximum daily temperatures ranged from 54.6 to 63.5 °F at the lower monitoring station, and achieved temperatures exceeding 74 °F at the upper monitoring station. Mean daily water temperatures at the downstream stations ranged from 49.5 to 54.7 °F. At the upstream station, mean daily water temperatures ranged from 58.0 to 64.5 °F. Despite the relatively warm maximum daily temperatures, application of the Clackamas framework rated the stations on the East Fork North Fork Blackfoot River moderately to highly suitable for Bull Trout (Appendix K)

Stream Flow

Stream flow was measured at 2 locations in 2013 and 2014 (Appendix I). The East Fork North Fork Blackfoot River drains 66-mile^{mile} and is substantially larger than the 47-mile^2 North Fork Blackfoot River upstream of their confluence, which has a watershed area of 47-mile^2. In 2013, discharge measured upstream of the confluence was 28.7 cfs and was nearly double in 2014 at

59.1 cfs. Flow measured downstream of the outfall of Parker Lake, the headwaters of the East Fork North Fork Blackfoot River, stream flow was 4 cfs in 2013 and 7.2 cfs in 2014. The station has a drainage area of 9-mile^2.

4.10 *Blondie Creek*

Physical Description

Blondie Creek is a small 1st order tributary to the East Fork North Fork Blackfoot River and enters their confluence is downstream of Parker Lake (Figure 1-1). Blondie Creek originates on the western slope of Pyramid Peak and flows for over 2 miles, with an average gradient of 458 ft/mile (Figure 4-12). A dense understory of various grasses, shrubs and forbs line the stream banks beneath a dense riparian overstory of young lodgepole pine. Lower Blondie Creek was untouched by the 1988 Canyon Creek fire, and the amount of in-stream wood is lower than the neighboring burned areas. Large boulders are the primary habitat forming features and provide an abundance of pocket water. In addition, undercut stream banks are a common habitat feature for fish, and the moderate amount of large woody debris provide cover in lateral scour pools.

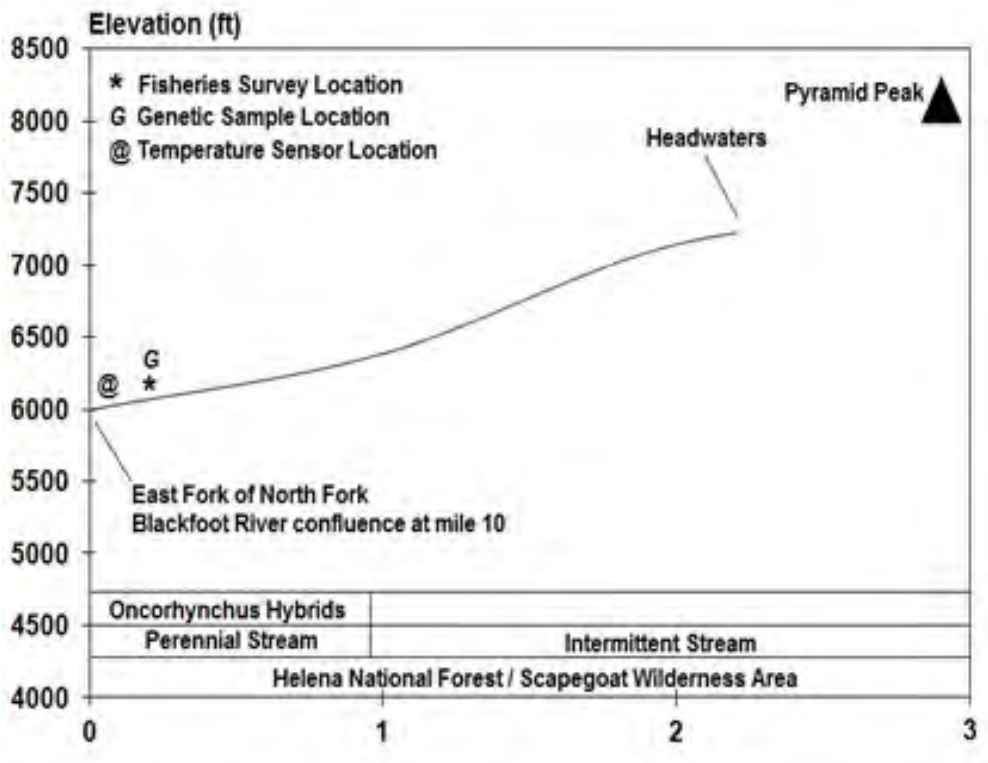

Figure 4-12. Longitudinal profile of Blondie Creek.

Fish Surveys

A 400-ft reach of Blondie Creek was electrofished in August 2013 (Appendix A). Fish identified as Rainbow Trout in the field were present and the CPUE was nearly 7 fish/100-ft. Rocky Mountain Tailed Frogs and Columbia Spotted Frogs were observed during fish surveys.

Genetic Analyses

Genetic analyses of tissue from 10 fish found these to be hybrids of Rainbow Trout, WCT and YCT (Appendix B). WCT had the smallest genetic contribution, whereas Rainbow Trout and YCT were nearly equal. The relatively large component of YCT genetic material is likely related to temporally successful stocking of YCT in Parker Lake reported in creel surveys (Appendix J).

eDNA

No eDNA data are available for Blondie Creek.

Macroinvertebrates and Amphibians

Aquatic invertebrate and amphibian surveys were conducted in August 2013 (Appendix D, Appendix E, and 0). Macroinvertebrate analyses found relatively low percentage of EPT taxa; however, the community scored as unimpaired. No rare taxa or species of concern were present in samples.

Rocky Mountain Tailed Frog abundance was considerable and second only to Scotty Creek. Columbian spotted frogs in Blondie Creek may be reliant of standing waters in nearby Parker Lake and their presence as adults in Blondie Creek provides a source of adults to reproduce following piscicide treatment and mitigate for any loss of tadpoles in the event vulnerable life-history stages are present during piscicide application. Field studies have shown nearly 100% mortality of gilled tadpoles during piscicide treatment; however, populations rebounded the following year through reproduction of invulnerable adults (Billman et al. 2012).

Physicochemical Water Quality

Field measures of conductivity, TDS, and pH were collected in August 2013 (Appendix G). The results were consistent with other high elevation streams with a small drainage area in the project area. Relatively low conductivity and TDS indicated low concentrations of dissolved constituents. The water was slightly alkaline with a pH of 8.1.

Continuous water temperature logger data were collected from 2013 through August 2017 (Appendix H). Maximum daily temperatures ranged from 54 to 59.2 °F, and average daily temperatures ranged from 49.3 to 51.1 °F. Under the Clackamas framework (Dunham et al. 2011), Blondie Creek rated as highly suitable for Bull Trout (Appendix K)

Stream Flow

Stream flow was measured near the mouth of Blondie Creek in September 2014 (Appendix I). Blondie Creek flowed at 0.2 cfs, which is consistent with its small drainage area of 1.1 mile^2.

4.11 *Sourdough Creek*

Physical Description

Sourdough Creek, a 2nd order tributary, originates on the western slope of Red Mountain and drains a 5.1 mile^2 watershed (Figure 1-1). The stream begins in a small cirque lake and flows north 3.4 miles until its confluence with the East Fork North Fork Blackfoot River (Figure 4-13). Stream gradient is variable, with a steep upper section that descends 1,060 ft/mile in the upper mile of stream, then attenuates to 2 to 3 to 185 ft/mile downstream. Sourdough classifies as Rosgen B3-C4 stream type in the lower survey sections.

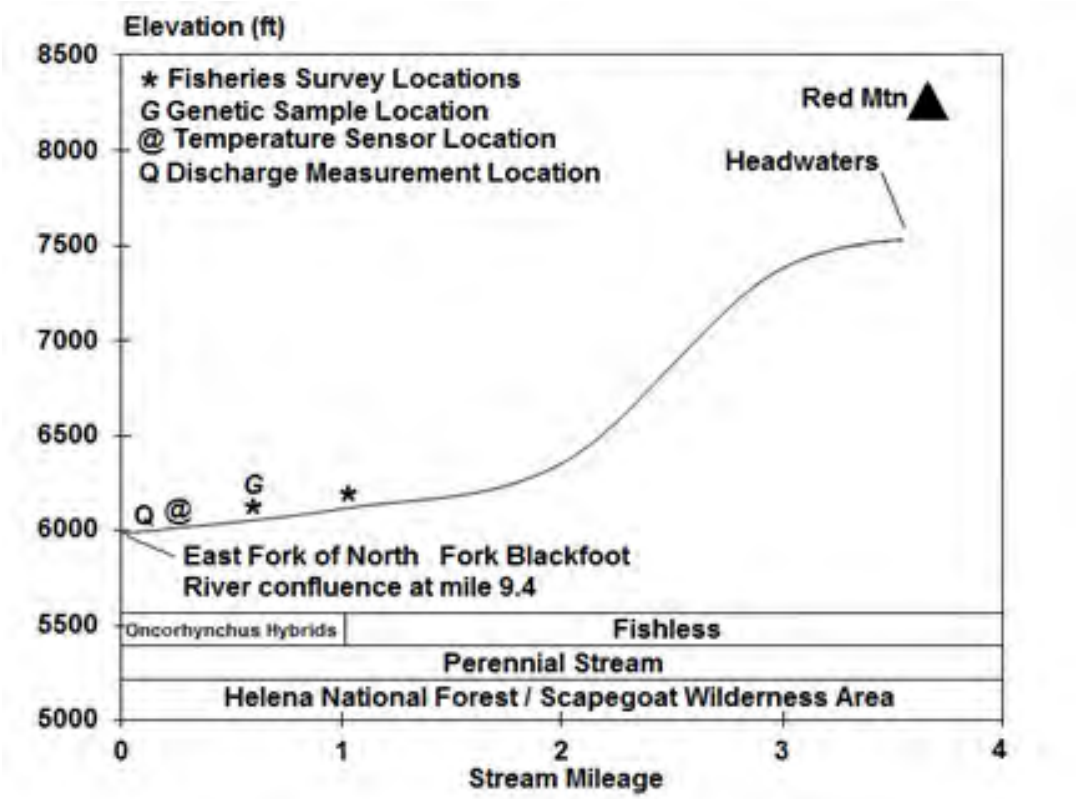

Figure 4-13. Longitudinal profile of Sourdough Creek.

Most of the drainage supports a mature lodgepole pine and subalpine fir forest, and a dense stand of willow, alder, and red-osier dogwood lines the channel and occupies the floodplain. Graminoids and forbs line Sourdough Creek's stream banks. Overhanging vegetation, undercut banks, and large boulders provide habitat features for fish. The Canyon Creek fire burned on the

lower 0.1 mile of Sourdough Creek, so the watershed was largely unaffected by this disturbance and has lower recruitment of woody debris compared to streams that experienced a stand-replacing fire.

Fish Surveys

Fish surveys were conducted at stream mile 0.6 in 2006 and 2013 and at stream mile 1 in 2013 (Appendix A). CPUEs were low for sampling efforts at stream mile 0.6 with both efforts yielding 0.5 fish/100 ft. No fish were captured at the upper reach.

Genetic Analyses

Genetic analyses of 3 fish captured in 2006 found hybridized fish with contributions from Rainbow Trout, WCT, and YCT (Appendix B). The WCT contribution was small, and the preponderance of Rainbow Trout and YCT genes is likely related to extensive stocking of these species into Parker Lake and the East Fork North Fork Blackfoot River (Appendix J).

eDNA

Sourdough Creek was sampled for eDNA at the fish monitoring reaches at miles 0.6 and 1.0 (Appendix C). The results were consistent with fish sampling events, with Rainbow Trout genes being present at the downstream fish-bearing reach, and no evidence of Rainbow Trout DNA at the upstream location.

Macroinvertebrates and Amphibians

Macroinvertebrates were sampled at the fish-sampling reaches at stream miles 0.6 and 1.0 (Appendix D, Appendix E, and 0). Both sites scored within the range of unimpaired. EPT taxa were numerically dominant in all samples. Macroinvertebrates were relatively abundant, suggesting forage base is not limiting to trout within the stream.

Rocky Mountain Tailed Frogs were present at the upper fish sampling station Sourdough Creek, but at relatively low densities (Appendix D). No amphibians were not observed during fish sampling efforts (Appendix A).

Physicochemical Water Quality

Field measures of pH, conductivity and TDS were typical of other streams in the project area (Appendix G). Dissolved solids were relatively low, with conductivity ranging from 156 to 166 µS, and TDS ranging from 76 to 84 ppm. The water was slightly alkaline, with pH of 7.89 to 8.1.

Continuous water temperature loggers registered exceptionally cool water temperatures in Sourdough Creek (Appendix H). During the 2013 to 2017 monitoring period, maximum daily summer temperatures ranged from 50.2 to 53.7 °F, and average daily temperatures ranged from

43.8 to 46.6 °F. This thermal regime ranked Sourdough Creek as highly suitable for Bull Trout using the Clackamas framework (Dunham et al. 2011; Appendix K)

Stream Flow

Stream flow was measured in 2013 and 2014 (Appendix I). Sourdough Creek drains 5 mile^2 at the discharge monitoring station. Consistent with other results for this drier year, discharge was lower in 2013 at 1.1 cfs. In 2014, flows were more than double the previous year at 2.6 cfs.

4.12 *Scotty Creek*

Physical Description

Scotty Creek is a 2nd order tributary to the East Fork North Fork Blackfoot River that originates in a cirque on the western slopes between Olsen and Pyramid peaks (Figure 1-1). Scotty Creek flows 4.8 miles south and joins the East Fork North Fork Blackfoot River downstream of Sourdough Creek. Stream gradients range from 710 ft/mile near the headwaters to 220 ft/mile near the mouth (Figure 4-14). Scotty Creek is a Rosgen B3-B4 stream type and large woody debris provides habitat through formation of step-pools. The Scotty Creek basin was severely burned during the 1988 Canyon Creek fire and is now recruiting high concentrations of wood into the stream. Riparian vegetation is dense and consists of willows and grasses within a young lodgepole pine forest.

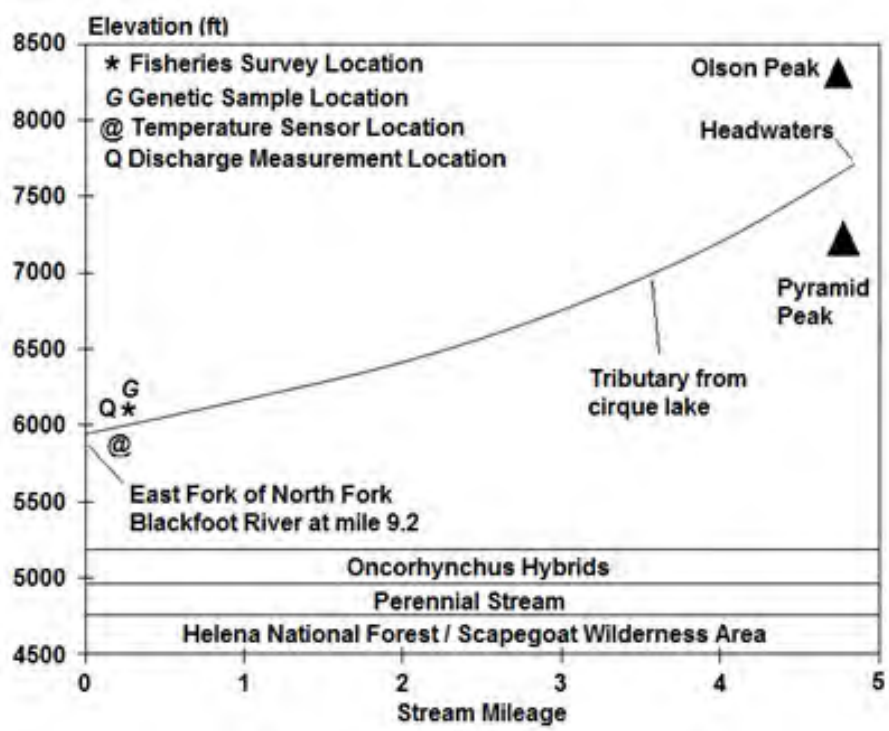

Figure 4-14. Longitudinal profile of Scotty Creek.

Fish Surveys

Fish surveys were conducted in 2006 and 2013 at a reach beginning 0.2 miles from the mouth. In 2006, most fish were field-identified as Rainbow Trout, except for a single Cutthroat Trout (Figure 4-15; Appendix A). In 2013, all fish captured were field-identified as Rainbow Trout.

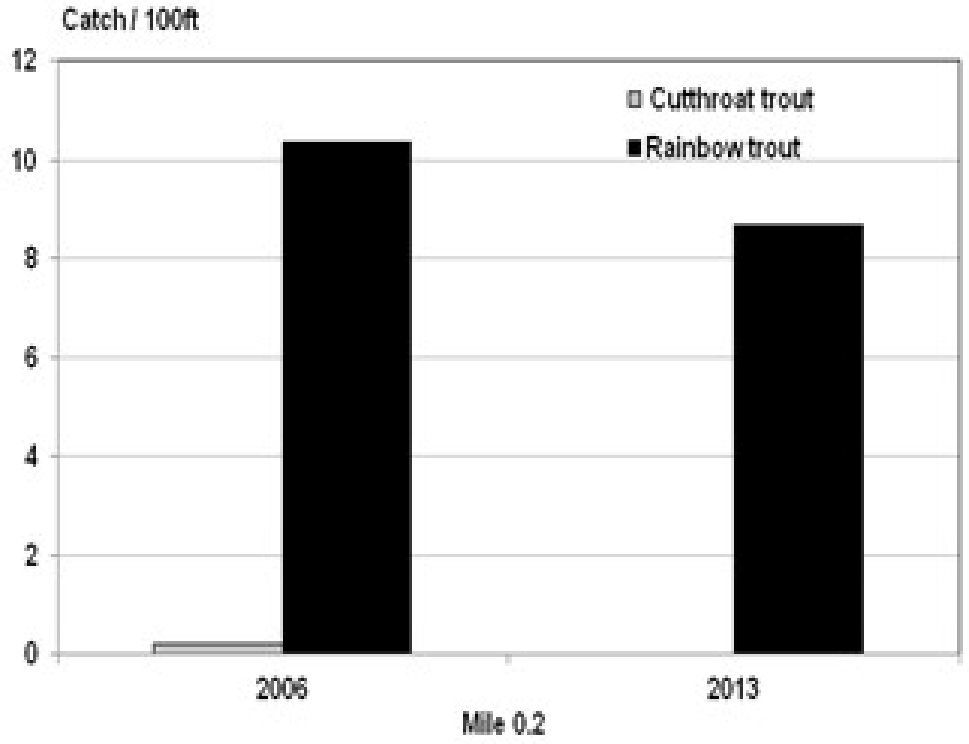

Figure 4-15. CPUE for fish sampling on Scotty Creek.

Genetic Analyses

Genetic analyses were conducted on 6 fish collected during the 2006 sampling effort (Appendix B). Like other streams near Parker Lake, which apparently had substantial stocking of YCT and Rainbow Trout (Appendix J), the fish were hybrids with mostly genes of Rainbow Trout and YCT, with a small contribution of WCT genetic material.

eDNA

Scotty Creek was sampled for eDNA in September 2015. Consistent with presence of Rainbow Trout hybrids being present at the site, eDNA samples had 3 positive reactions to the presence of Rainbow Trout eDNA (Appendix C)

Macroinvertebrates and Amphibians

Aquatic macroinvertebrates were sampled in August 2006 (Appendix D, Appendix E, and Appendix F). Scotty Creek had an abundance of individuals, with several taxa of midge and

stonefly being exceptionally numerous. Nevertheless, measures of biological integrity were slightly depressed, although within the range of nonimpairment.

Rocky Mountain Tailed Frogs were abundant in Scotty Creek, making this stream a potential source of recruitment of this frog in the event piscicide treatment has a population level effect on Rocky Mountain Tailed Frogs in the watershed. Western Toads and Columbian spotted frogs were also present. Parker Lake is a likely breeding area for Western Toads and Columbia Spotted Frogs.

Physicochemical Water Quality

Field measures of TDS, conductivity, and pH were collected in August 2013 (Appendix G). Scotty Creek had among the lowest dissolved constituents with conductivity of 84 µS and TDS of 80 ppm. Scotty Creek was slightly alkaline with a pH of 7.7.

A continuous water temperature logger installed at 0.1 miles from the mouth of Scotty Creek recovered maximum daily temperatures in July and August ranging from 55.7 to 60.2 °F (Appendix H). Average daily temperatures ranged from 49.9 to 53.5 °F. Application of the Clackamas framework (Dunham et al. 2011; Appendix K) rated Scotty Creek as moderately suitable for introduction of Bull Trout.

Stream Flow

Stream flow was measured near the mouth of Scotty Creek (Figure 3-4) in 2012 and 2014 (Appendix I).Flows were lower in 2013 at 0.6 cfs, and were 2.0 in 2014. The watershed area draining to the flow monitoring sites was 4.2-mile^2.

4.13 *Meadow Creek*

Physical Description

Meadow Creek, is a large 2nd order tributary of the East Fork North Fork Blackfoot River that enters the East Fork North Fork Blackfoot River about 7 stream miles from the confluence with the North Fork Blackfoot River (Figure 1-1). Meadow Creek flows to the north for about 10 miles and drains a 22.5 mile^2 watershed. Its headwaters originate in the northern slopes of Daily Peak, Arrastra Mountain, and Red Mountain (Figure 4-16). Tributaries include its east and west forks. The uppermost 2 miles of Meadow Creek and its forks are steep, but gradient becomes gradual in the lower 7.5 miles of stream. Meadow Lake has connectivity with Meadow Creek about 1.5 miles from its confluence with the East Fork North Fork Blackfoot River.

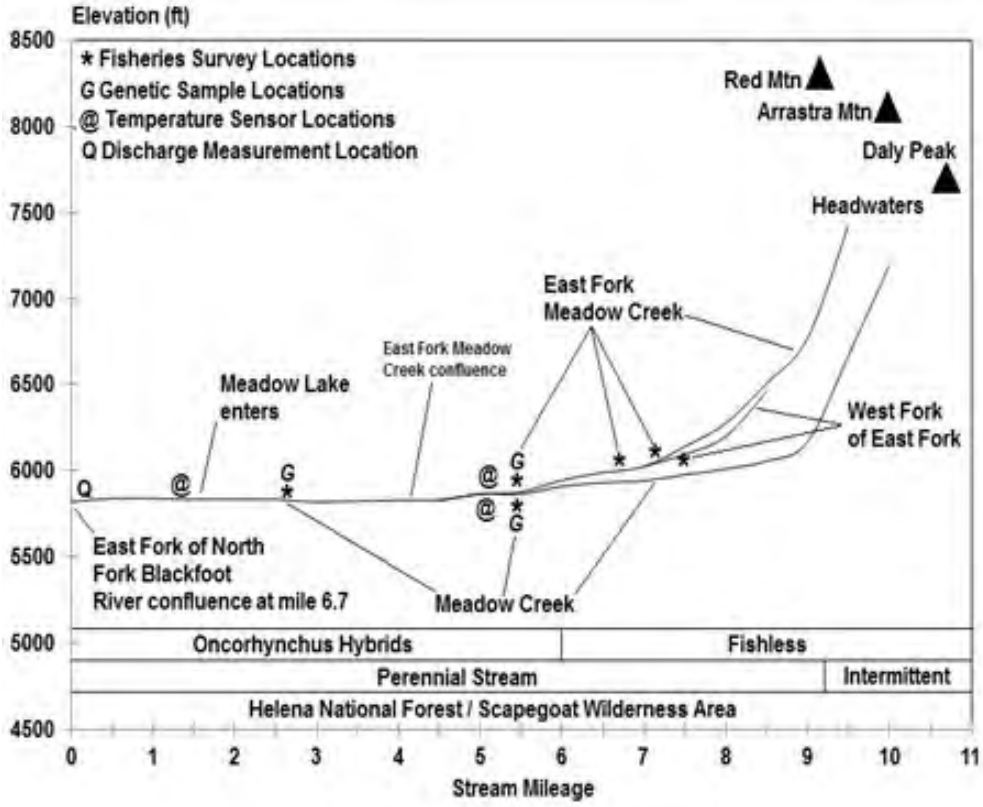

Figure 4-16. Longitudinal profile of Meadow Creek.

Upper Meadow Creek and its headwater tributaries classify as Rosgen B2-B3 stream types. The riparian plant communities in the upper reaches of Meadow Creek consist of Subalpine fir and lodgepole pine overlies a dense understory of rocky mountain maple mixed with willow, alders, young conifers and various shrubs and grasses. Fish habitat consists of under-cut banks, boulder pocket pools and wood-formed plunge pools.

About 7 miles upstream of Meadow Creek's confluence with the East Fork North Fork Blackfoot River, Meadow Creek transitions from a forested confined channel to a broad alluvial stream valley. Channel types vary from C4 to E5 Rosgen channel types. The riparian area is largely a marsh wetland and riparian plant community comprised of willow and sedges. Deep undercut banks beneath overhanging willows provide high quality fish habitat. Sand, gravel, and clay are the dominant channel material. Recruitment of large wood to the channel is limited due to the transition from a coniferous forest to shrub plant community. Beaver activity is substantial in the low gradient portions of Meadow Creek and beaver dams and small woody debris are common. Downstream of the Meadow Lake outlet, the lower 1.4 miles of Meadow Creek transitions back to a confined channel. The lower reach Meadow Creek drainage burned in the 1988 Canyon Creek fire, resulting in the dense regeneration of an early seral lodgepole pine forest and moderate concentrations of instream wood.

Fish Surveys

In 2008, we establish six fish population surveys in the Meadow Creek drainage (Figure 3-1). Fish identified phenotypically as Rainbow Trout were present in low densities at the 2 sampling reaches on Meadow Creek and at the lowermost sampling reach on East Fork Meadow Creek (Figure 4-17; Appendix A). No fish were captured in the upper 2 sampling reaches in East Fork Meadow Creek or the reach on West Fork Meadow Creek. In 2013, we resurveyed the upstream site on Meadow Creek and the downstream reach on East Fork Meadow Creek and found lower densities than were present in 2008.

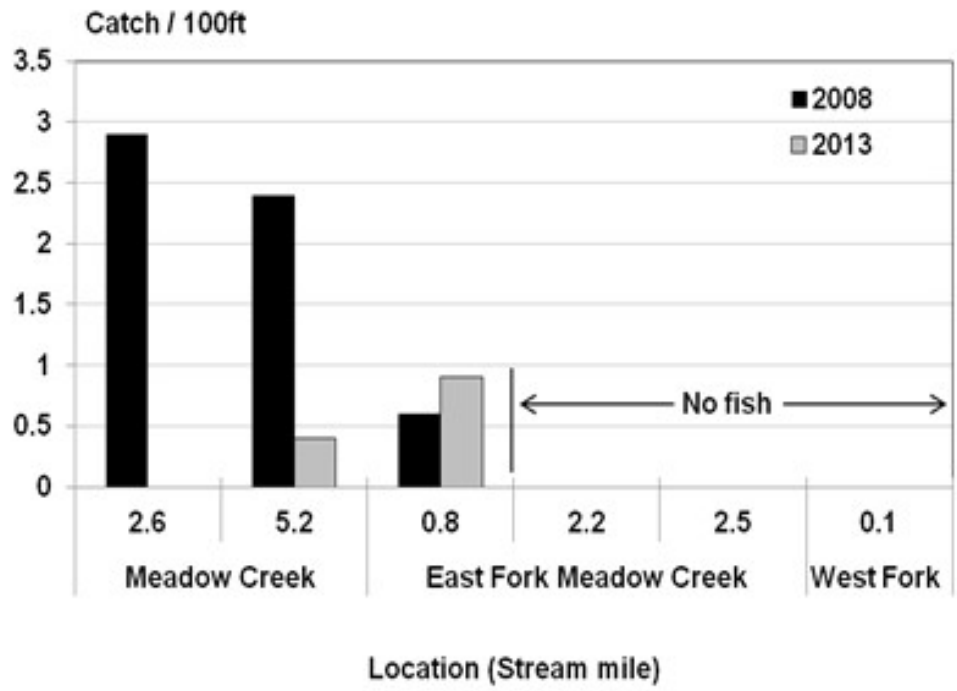

Figure 4-17. CPUE for fish sampling efforts in the Meadow Creek watershed.

Genetic Analyses

Genetic tests identified hybrids of Rainbow Trout, YCT and WCT (Appendix B). Rainbow Trout genes comprised more than 90% of the examined loci. The Meadow Creek watershed population was determined to be a hybrid swarm of the 3 taxa, with a dominant Rainbow Trout contribution.

The dominance of Rainbow Trout genes is surprising based on fish stocking records for Meadow Creek (Appendix J). In the first half of the 20th Century, over 500,000 undifferentiated cutthroat trout were introduced into Meadow Creek, compared to about 39,000 Rainbow Trout. No official records of stocking Meadow Lake were available; however, newspaper articles from the 1920s report back-country horsemen introduced fish into the lake (Appendix J).

eDNA

Samples for eDNA were collected at 1 location in the Meadow Creek watershed (Appendix C). Rainbow Trout were collected at this site, and the eDNA sample signaled presence of Rainbow Trout DNA.

Macroinvertebrates and Amphibians

Aquatic macroinvertebrate samples collected in Meadow Creek and East Fork Meadow Creek scored within the range of unimpaired for montane streams (Appendix D, Appendix E, and 0). Measures of total abundance, taxa richness, EPT richness, and % EPT were relatively high. Several taxa of stonefly were superabundant in some samples. The rare stonefly *Zapada frigida* was present in some samples.

Amphibians observed in the Meadow Creek watershed included Rocky Mountain Tailed Frogs, Columbia Spotted Frogs and Western Toads (Appendix A and Appendix D). Meadow Lake provides potential breeding habitat for Western Toads and Columbia spotted frogs. Rocky Mountain Tailed Frogs were present in reaches within the Meadow Creek watershed where fish densities were low, or where fish were not found. The presence of Rocky Mountain Tailed Frogs in apparently fishless reaches would provide a source of recolonization in the event piscicide treatment adversely affected 1 or more year classes of tadpole.

Physicochemical Water Quality

Field measures of TDS, conductivity, and pH were collected at 3 locations in the Meadow Creek watershed (Appendix G). Dissolved solids were low and resulted in conductivity readings ranging from 57 to 152 µS and TDS readings of 30 to 78 ppm. Water in the drainage is slightly alkaline, with pH ranging from 8.0 to 8.7.

Water temperature was variable at temperature logging stations on the main stem and East Fork Meadow Creek (Appendix H). A confound in characterizing temporal and longitudinal trends in temperature is movement of 2 of the temperature loggers after 1 to 2 years of data collection. The warmest water temperatures were measured at the station 1.4 miles from the confluence with the East Fork North Fork Blackfoot River, where maximum daily temperatures during summer months ranged from 63.6 to 70.0 °F, and average daily temperatures ranged from 52.4 to 58.6 °F. The temperature logger on East Fork Meadow Creek recovered the second warmest temperatures, with maximum daily temperatures ranged as high as 69.4 °F. The logger established first at stream mile 4.7, which was moved to stream mile 6.3, measured maximum daily temperatures from 51.4 to 62.7 and average daily temperatures of 47.5 to 51.6 °F.

Application of the Clackamas framework to water temperature data indicated variable suitability for introduction of Bull Trout (Appendix K). the downstream site on Meadow Creek was

unsuitable for Bull Trout, whereas the upper station on Meadow Creek and the station on East Fork Meadow Creek rated as moderately suitable for Bull Trout.

Stream Flow

Stream flow was measured in 2013 and 2014 near the mouth of Meadow Creek (Appendix I). As with all other flow measurements conducted in the watershed, flows were considerably lower in 2013 than 2014. In 2013, stream flow was 10.9 cfs, compared to 17.4 cfs in 2014. Meadow Creek is the largest tributary watershed to the East Fork North Fork Blackfoot River with a drainage area of 18.8-mile^2.

4.14 *Lost Pony Creek*

Physical Description

Lost Pony Creek is a 1st order tributary to the middle reaches of the East Fork North Fork Blackfoot River (Figure 1-1). Lost Pony Creek drains a small 3.6 mile^2 basin on the southern slopes of Galusha Peak and flows southerly for nearly 4 miles to its confluence with the East Fork North Fork Blackfoot River. Stream gradients range from 750 ft/mile in the upper reaches to 208 ft/mile near the mouth (Figure 4-18). The lower reaches of Lost Pony Creek are Rosgen B3-B4 stream types. During low flows, Lost Pony Creek goes intermittent between at 0.2 to 0.5 stream miles from its confluence with the East Fork North Fork Blackfoot River. The outfall of Lower Twin Lake is the stream's only tributary.

Lost Pony Creek has largely recovered from the Canyon Creek fire of 1988 with regeneration of the surrounding lodgepole pine forest. Moreover, the stream has benefitted from the resulting recruitment of woody debris to the channel. Dense stands of riparian shrubs underlaid by sedges, forbs, and grasses maintain bank and channel stability and stream shading. Overhanging vegetation, dense amounts of coarse wood, alder roots and undercut banks provide high quality fish habitat.

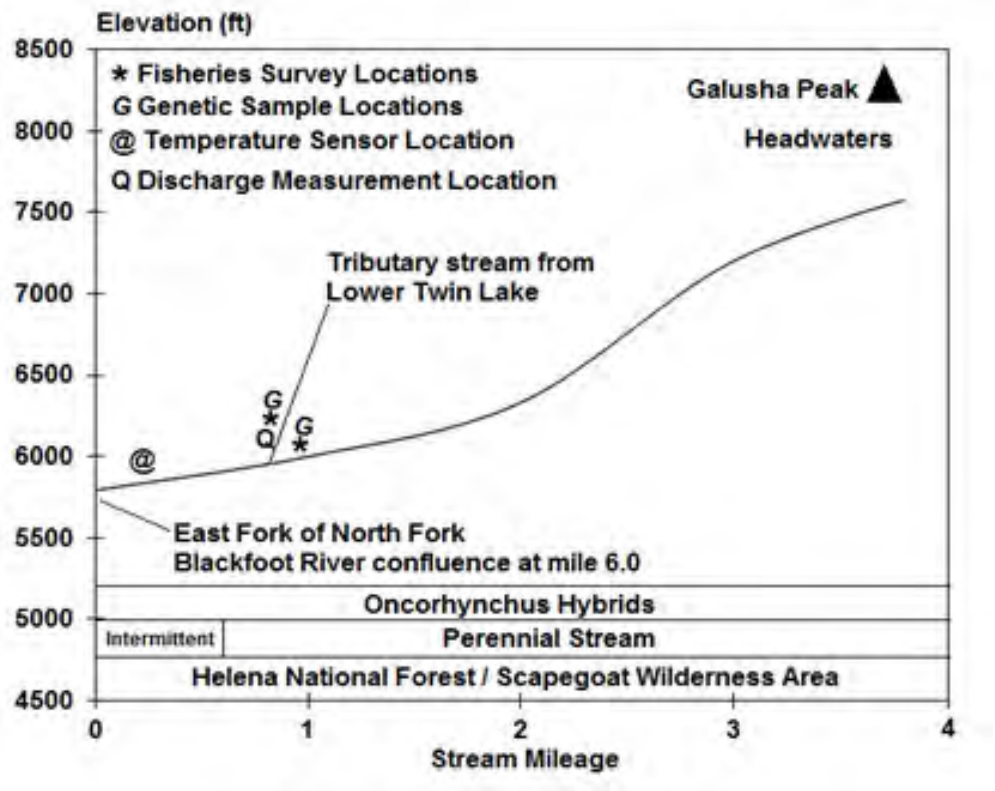

Figure 4-18. Longitudinal profile of Lost Pony Creek.

Fish Surveys

A fish surveys in the Lost Pony watershed include sampling the outlet from Lower Twin Lake in 2006 sampling a reach less than 1 mile from the confluence with the East Fork North Fork Blackfoot River in 2013 (Appendix A). Fish identified as Rainbow Trout were captured in both efforts. The reach on Lost Pony Creek had a high CPUE at 15.5 fish/100-ft. The outlet from Lower Twin Lake had CPUE of 2.6 fish/100-ft. Columbia Spotted Frogs were observed in the lake outlet.

Genetic Analyses

Genetic analyses of fish from Lost Pony Creek indicated presence of a hybrid swarm of Rainbow Trout × WCT × YCT (Appendix B). Rainbow Trout provided the predominant genetic contribution.

No records for fish plants to Lost Pony Creek are available; however, stocking records and old newspaper articles document stocking of Lower Twin Lake (Appendix J). Interestingly, although the available information report stocking of undifferentiated cutthroat trout, but no records of Rainbow Trout were available. The preponderance of Rainbow Trout genes is the result of their

movement into the watershed from elsewhere, or reflect poor record keeping in early days of fish stocking.

eDNA
No eDNA data were available for Lost Pony Creek.

Macroinvertebrates and Amphibians
Macroinvertebrates were sampled in Lost Pony creek in (Appendix D, Appendix E, and 0). The community scored within the range of excellent biological integrity. The proportion of EPT individuals was relatively high, and several taxa of stonefly were exceptionally abundant.

Amphibians were observed during fish and macroinvertebrate sampling (Appendix A and Appendix D). Columbia Spotted Frogs were observed during fish sampling, and their presence is potentially related to proximity of breeding habitat in Twin Lake. Rocky Mountain Tailed Frogs were present in relatively high numbers during macroinvertebrate sampling effort. The presence of Columbia Spotted Frogs in the stream suggests running waters and the adjacent uplands will provide a continued source of recruitment should piscicide be applied to waters in the basin. Adults in streams will not be vulnerable to piscicide (Grisak et al. 2007; Billman et al. 2011), and natural reproduction can be substantial in lakes in the spring following piscicide treatment (Billman et al. 2012).

Physicochemical Water Quality
Field measures of conductivity, TDS, and pH were like readings from throughout the project area (Appendix G). Measures of dissolved solids were typical of small, montane streams with a conductivity of 133 µS and TDS of 66 ppm. The water was slightly alkaline with a pH of 8. No temperature logger data were available for Lost Pony Creek.

Stream Flow
No stream flow data are available for Lost Pony Creek.

4.15 *Spaulding Creek*

Physical Description
Spaulding Creek is a 1st order tributary that originates on the southern slopes of Galusha Peak and flows southwest, before entering the East Fork North Fork Blackfoot River at stream mile 4.7 (Figure 1-1 and Figure 4-19). Spaulding Creek has an average gradient of 484 ft/mile, and its lower mile has a relatively gentle gradient. Channel types are A3 in the headwaters and B3 in the lower reaches.

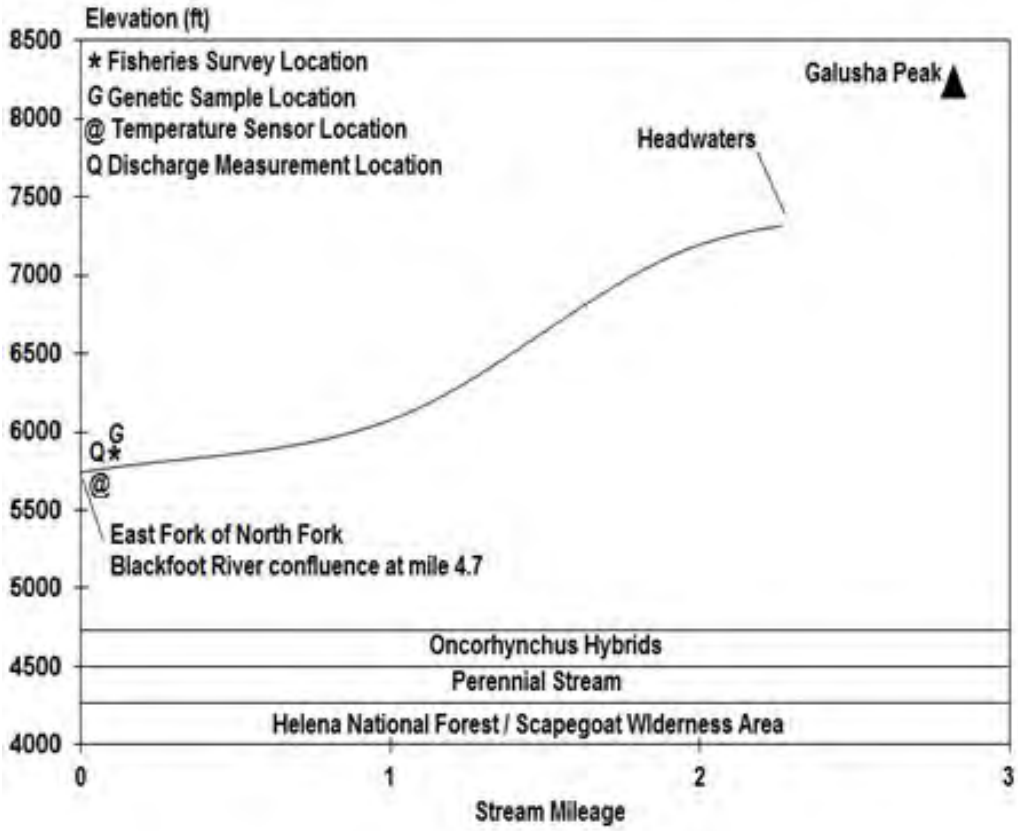

Figure 4-19. Longitudinal profile of Spaulding Creek.

The riparian area and adjacent hillsides burned in the Canyon Creek fire in 1988. The forest is now an early seral lodgepole pine forest with young Engelmann spruce also present. The riparian zone supports dense willows and other shrubs, along ground cover of forbs and graminoids. Recruitment of woody debris to the channel from burned hill slopes is considerable. Overhanging vegetation provides substantial overhead cover for fish.

Fish Surveys

A fish survey was conducted in Spaulding Creek in 2013 (Appendix A). Few fish were captured in this effort, yielding a CPUE of 0.7 fish/100-ft. Hybridized Rainbow Trout were the only fish identified.

Genetic Analyses

The low abundance of fish yielded a sample size of 2 fish for genetic analyses (Appendix B). These fish were hybrids of Rainbow Trout and YCT. The small sample size may have missed the rarer WCT genes.

eDNA

No eDNA data were available for Spaulding Creek.

Macroinvertebrates and Amphibians

Macroinvertebrates were sampled in 2013 (Appendix D, Appendix E, and Appendix F). The community had several indicators typical of high biological integrity. It scored within the range of excellent biological integrity, had a high percentage of EPT taxa, and several stonefly taxa were exceptionally abundant. The dense riparian shrubs likely had considerable influence on the in-stream trophic functioning, as invertebrates consuming leaf litter of terrestrial origin were extremely abundant. These results would also be consistent with cool water temperatures, they suggest considerable shading from riparian shrubs. The rare *Zapada frigida* was collected in Spaulding Creek and is an indicator of 'pristine" mountain stream biological integrity (Stagliano 2005) and a cold thermal regime (Richards et al. 2018).

No amphibians were observed during the fish survey (Appendix A); however, Rocky Mountain Tailed Frogs were present in relatively high density during macroinvertebrate and amphibian sampling efforts (Appendix D). This abundance of Rocky Mountain Tailed Frogs in an area of low fish density, which may be close to upper extent of fish in the watershed, suggest a substantial amount of stream that is not currently fish-bearing may provide a source of Rocky Mountain Tailed Frogs to expand into treated reaches if piscicide treatment has a population level effect on this species.

Physicochemical Water Quality

Field measures of conductivity, TDS, and pH were collected in 2013 (Appendix G). The measures of dissolved constituents were slightly elevated compared to other streams in the watershed, but still within the expected range with conductivity of 249 µS and TDS of 123 ppm. The water was slightly alkaline with a pH of 8.1.

Water temperature loggers ran from July 2013 to June 2017. Water temperatures were cool to cold with maximum daily temperatures ranging from 53.2 to 56.7 °F, and average daily temperatures ranging from 44.7 to 49.6 °F. Application of the Clackamas framework indicated Spaulding Creek was highly suitable for Bull Trout (Appendix K).

Stream Flow

Stream flow was measured in September 2013 and August 2014 (Appendix I). This small stream, with a drainage area of 1.1-mile^2 flowed 0.1 cfs in 2013 and 0.2 cfs in 2014.

4.16 *Mineral Creek*

Physical Description

Mineral Creek, a 2nd order stream, drains a 14.6 mile^2 watershed on the northeastern slopes of Arrastra Mountain and Iron Mountain (Figure 1-1and Figure 4-20). The main stem Mineral Creek flows for 7.4 miles, with gradients ranging from a high of 545 ft/mile in its upper 2 miles to a low of 18 ft/mile in the lower three miles of stream. Mineral Creek enters the East Fork North Fork Blackfoot River about 3 miles upstream of the confluence with the North Fork Blackfoot River. The East Fork of Mineral Creek is the largest tributary to Mineral Creek and flows for about 2 miles before entering Mineral Creek.

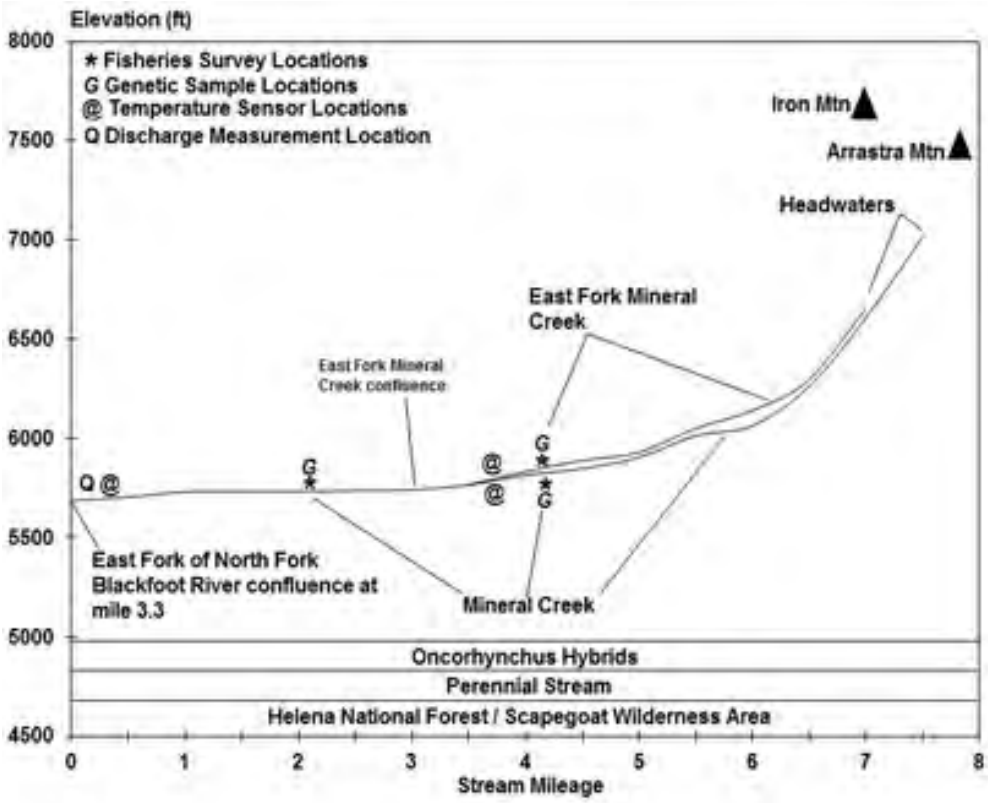

Figure 4-20. Longitudinal profile of Mineral Creek.

Most of the Mineral Creek watershed burned in 1988, and large amounts of woody debris are entering the channel. The forest is recovering, and a dense stand of lodgepole pine provides overstory to the channel. The riparian area supports willows, alders, forbs, and graminoids.

Fish Surveys

Fish surveys were conducted at 2 locations in Mineral Creek and a reach on East Fork Mineral Creek, located within 0.6 miles of its confluence with Mineral Creek (Figure 3-1; Appendix A).

Rainbow Trout hybrids varied in density, with the sampling reach at stream mile 4.2 having the highest CPUE in the Mineral Creek watershed of nearly 10 fish/100-ft. Fish were less abundant at the fish sampling station about 2 miles from Mineral Creek's mouth, with a CPUE of about 5 fish/100-ft. East Fork Mineral Creek had the lowest fish abundance of the 3 sites, with about 2 fish/100-ft.

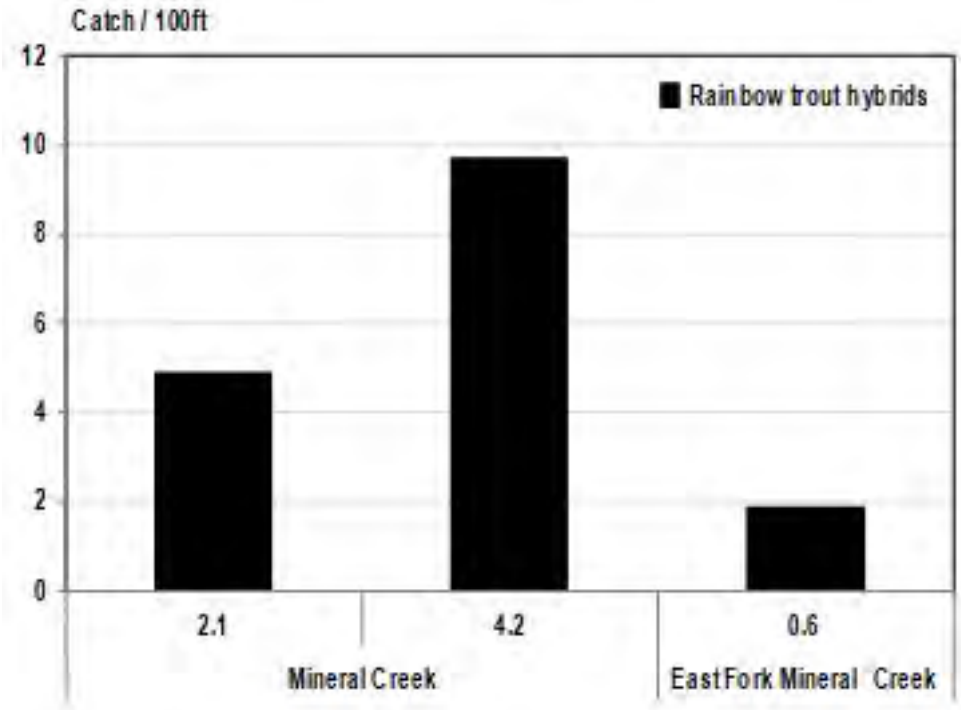

Figure 4-21. CPUE of Rainbow Trout in Mineral Creek and East Fork Mineral Creek.

Genetic Analyses

Genetic analyses found fish to be Rainbow Trout × YCT × WCT hybrids (Appendix B). The population of fish in the Mineral Creek watershed is a hybrid swarm with Rainbow Trout contributing nearly 89% of genes. No fish stocking data were available for Mineral Creek (Appendix J). Nevertheless, the dominance of Rainbow Trout genes is typical for streams in the project area, especially those that are not close to lakes that received plants of Cutthroat Trout in the mid-1900s.

Macroinvertebrates and Amphibians

Macroinvertebrates were sampled in Mineral Creek in 2015 (Appendix D, Appendix E, and 0). The sampling effort indicated an abundance of aquatic macroinvertebrates, and the community scored within the range of excellent biological integrity. Mayflies were especially abundant, resulting in a high percentage of EPT taxa abundance. Amphibians were not documented in Mineral Creek during fish or amphibian surveys.

Physicochemical Water Quality

Field measures of conductivity, TDS and pH were collected at fish sampling reaches in 2008 (Appendix G). Measures of dissolved constituents were consistent with other sites in the watershed. Conductivity ranged from 141 to 178 µS, and TDS ranged from 72 to 91 ppm. Stream water was slightly alkaline, with pH readings of 8.1 and 8.4.

Continuous temperature loggers were deployed at stream miles 0.3 and 3.5 (Appendix H). Mineral Creek had a relatively cool thermal regime, with maximum daily temperatures in July and August ranging from 62.2 to 63.9 °F at stream mile 0.3 and 52.0 to 63.6 °F at stream mile 3.5. Average daily temperatures during July and August ranged from 50.4 to 52.1 at stream mile 0.3 and 49.0 to 50.4 at stream mile 3.5. Application of the Clackamas framework rates Mineral Creek as moderately suitable for Bull Trout (Appendix K).

Stream Flow

Stream flow was measured in 2013 and 2014 (Appendix I). Mineral Creek is among the larger sub-watersheds contributing flow to the East Fork North Fork Blackfoot River, with a drainage area of 18.8-mile^2. Stream flow was 7.7 in September 2013 and 11.7 in August 2014.

4.17 *Kenny Creek*

Physical Description

Kenny Creek is a small 2nd order stream that drains a 1.7-mile^2 basin in the lower portion of the East Fork North Fork Blackfoot River drainage. Draining the southeastern and northwestern slopes of two surrounding unnamed mountains, Kenny Creek flows easterly for 2.3 miles where it enters the East Fork at stream mile 1.7, which is directly opposite the Camp Creek watershed. It has an average gradient of 750 ft/mile.

Kenny Creek is a Rosgen B2-B3 stream type with pool-riffle features. Habitat forming features include boulders and a substantial volume of large woody debris, which form pocket and plunge pools. Undercut banks are common, and combined, these habitat features provide high quality habitat for fish. The 1988 Canyon Creek wildfire burned a large portion of the upper basin; however, the riparian corridor in the lower watershed remained undisturbed, and the streamside vegetation is a dense mixed vegetation community of lodgepole pine, Douglas fir and young aspen, above and understory of alders, willows, red osier dogwoods, forbs and graminoids. Combined, these vegetative features promote bank stability and stream shading.

Fish Surveys

Fisheries surveys are limited to spot sampling in Kenny Creek in 2016, which resulted in capture of 3 apparent Rainbow Trout hybrids (Appendix A).

Genetic Analyses
No genetic data are available for Kenny Creek.

eDNA
No eDNA data are available for Kenny Creek.

Macroinvertebrates and Amphibians
No macroinvertebrate or amphibian sampling data are available for Kenny Creek.

Physicochemical Water Quality
Field measures of conductivity, TDS, and pH were conducted in 2016 (Appendix G). Kenny Creek had relatively high concentrations of dissolved solids with a conductivity reading of 275 µS and TDS of 137 ppm; however, these levels are within the typical range for montane streams in western Montana. The water was slightly alkaline with a pH of 8.4. Continuous temperature loggers were not deployed in Kenny Creek.

Stream Flow
No flow data are available for Kenny Creek; however, visual estimates place the base flow at 1.0-2.0 cfs.

4.18 *Camp Creek*

Physical Description
Camp Creek is a small 2nd order stream that originates on the western slope of Galusha Peak and flows to the west for 4.7 miles before it confluence of the East Fork North Fork Blackfoot River (Figure 1-1and Figure 4-22). Galusha Peak. Stream gradients range from 713 ft/mile in its upper 1.7 miles and decreasing to 214ft/mile in its lower 3.0 miles (Figure 25). The lower 2.5 miles of Camp Creek classify as a Rosgen B3-B4 stream type with pool-riffle features with large instream wood and under-cut streambanks. The riparian area of upper Camp Creek consists of a mature Englemann spruce forest above and understory of alder and willow, which create stable banks and a shaded channel. Along lower Camp Creek, the riparian community transitions to an aspen overstory, with mixed willow, alder, forbs and grasses beneath.

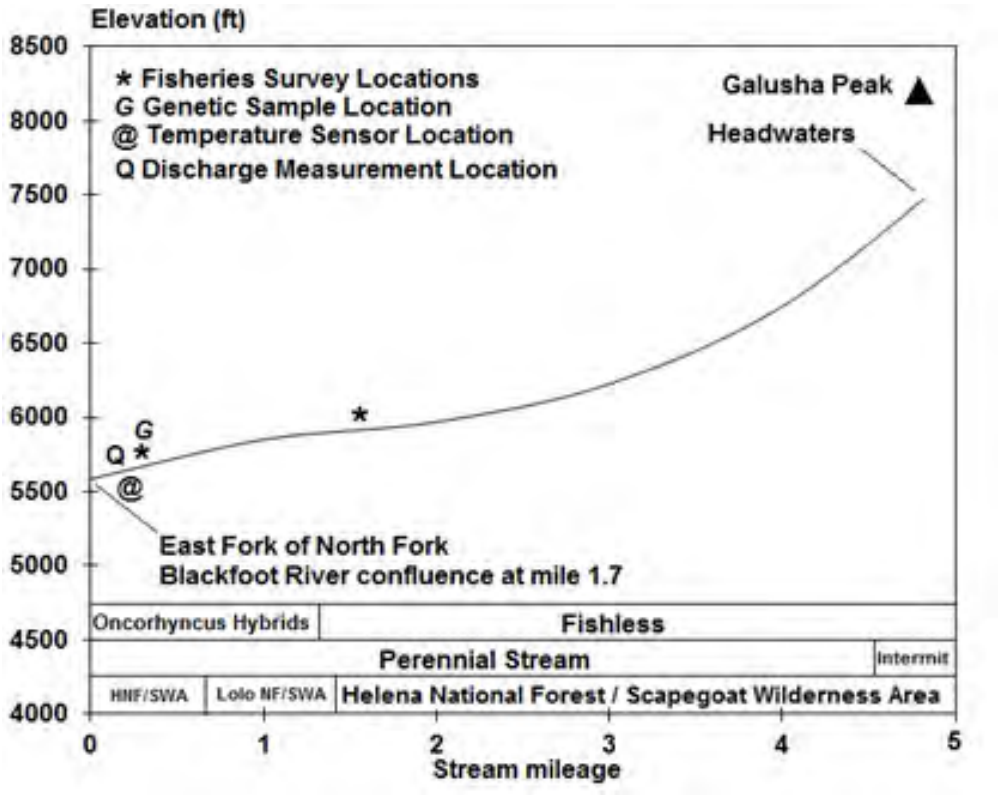

Figure 4-22. Longitudinal profile of Camp Creek.

Fish Surveys

Fish populations were surveyed in 2 reaches on Camp Creek in 2013 (Figure 3-1; Appendix A). The upper site, located a stream mile 1.6, did not yield fish. Low numbers of field-identified Rainbow Trout were present at the site near the confluence with the East Fork North Fork Blackfoot River.

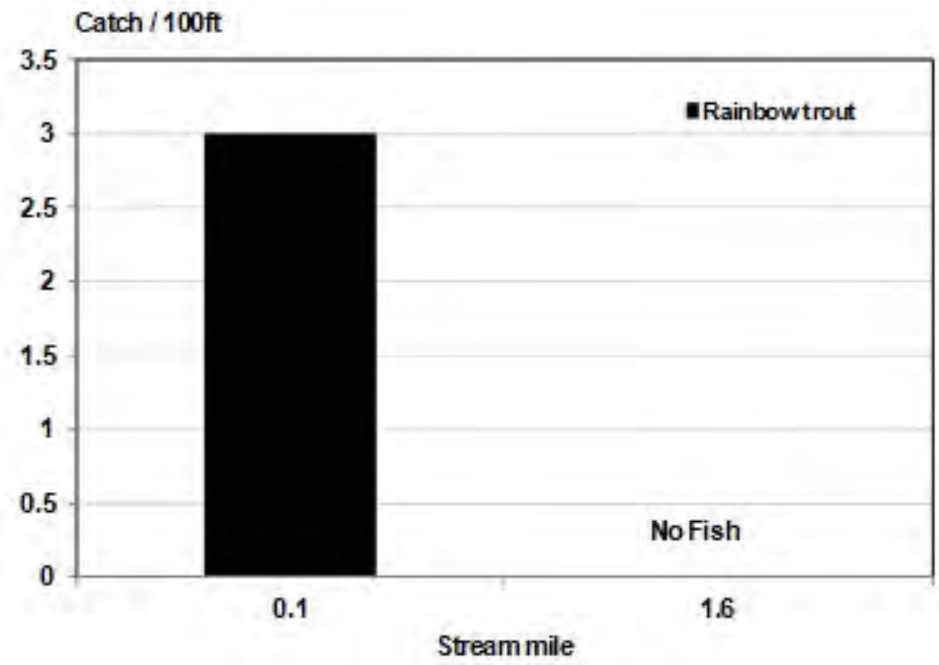

Figure 4-23. CPUE for Rainbow Trout hybrids in Camp Creek.

Genetic Analyses

Analysis of fish tissue samples collected in 2013 indicated the fish were a hybrid swarm with an admixture of Rainbow Trout, YCT, and WCT (Appendix B). Rainbow Trout genetic contribution was greater than 93%.

eDNA

Sampling for eDNA was conducted at the electrofishing sites in 2015 (Appendix C). the lower site had fish in 2013, and eDNA samples gave a strong signal of the presence of Rainbow Trout genes in the stream. Although no fish were collected at the upstream site, Rainbow Trout genes were present. This finding suggests the upper extent of fish is upstream of the sampling reach at stream mile 1.6 that did not yield fish in 2013.

Macroinvertebrates and Amphibians

Macroinvertebrates were collected at stream miles 0.1 and 1.6 (Appendix D, Appendix E, and 0). Invertebrates were especially abundant at the downstream site, and large numbers of mayflies and stoneflies resulted in a high percentage of the sample being comprised of EPT taxa. Both sites scored high on measures of biological integrity.

Amphibians were observed during fish surveys (Appendix A) and macroinvertebrate sampling (Appendix D). Rocky Mountain Tailed Frogs were present at the upper site in both efforts. Although eDNA indicates Rainbow Trout are present, this upper sampling station may be near

the upstream extent of fish. Rocky Mountain Tailed Frogs may be present upstream of fish-bearing reaches and these frogs could expand into the treatment area in the event piscicide treatment has a negative effect on sensitive tadpoles. Nevertheless, Rocky Mountain Tailed Frogs are resilient to piscicide (Grisak et al. 2007; Billman et al. 2011; Frieda et al. in press), so long-term effects on Rocky Mountain Tailed Frogs would be unlikely to be significant.

Physicochemical Water Quality

Field measures of conductivity, TDS, and pH were collected near the mouth in September 2013 (Appendix G). All measures were within the ranges typical of montane streams in western Montana. Conductivity varied from 22 to 258 µS, and TDS ranged from 103 to 123 ppm. The water was slightly alkaline with pH being around 8.

Stream Flow

Base flows were measured near the mouth of Camp Creek in September 2013 and August 2014 (Appendix I). Stream flow was lower in 2013 at 0.6 cfs compared to 1.4 cfs in 2014. The flow monitoring station captured the flow drained within a 4.1 mile^2 watershed.

5 Results and Discussion – Lakes

5.1 *Parker Lake*

Physical Description

Parker Lake is an on-stream lake, located on the upper main stem of the East Fork North Fork Blackfoot River (Figure 3-2 and Figure 5-1). Most of the perimeter is brushy, heavily timbered, and moderately steep, although some areas provide access to shore anglers. Angling pressure is light.

Figure 5-1. Photo and close-up map of Parker Lake.

Lake Dimensions

Parker lake covers 24.7 acres and lies at 6,000 ft above sea level (Figure 5-2). The lake volume is 68.9 acre-ft. Its maximum depth is 6.2 ft.

Figure 5-2. Parker Lake bathymetry and gillnet sampling location.

Fish Surveys

A sinking gillnet was deployed near the inlet Parker lake in 2005. The CPUE was 3 trout/hour. Fish ranged in length from 5.9 to 14.9 inches. Fish in Parker Lake can maintain their population, with inlet and outlet streams providing access to spawning habitat.

Genetic Analyses

Tissue analyses of 26 fish captured in Parker Lake indicate the lake supports a hybridized fishery, with YCT providing the predominant genetic contribution (Appendix B). These results differ from stream samples, where Rainbow Trout genes typically dominant. A review of stocking records and other historical information indicate Parker Lake received was stocked with over 50,000 undifferentiated Cutthroat Trout in the mid-1900s (Appendix J). YCT were likely the fish introduced into Parker Lake, as subsequent creel surveys and gillnetting yielded fish phenotypically identified as YCT.

Zooplankton and Amphibians

Zooplankton was sampled with 3 plankton net tows in September 2015 (Table 1). Each tow was to a depth of 3.3 ft. Cladocerans, copepods, and rotifers were present, with rotifiers being numerically dominant, but the cladoceran Daphnia providing the bulk of the planktonic biomass (Table 2).

Table 1. Location and description of plankton tows in Parker Lake.

Tow	Latitude	Longitude	Depth (ft)
1	48.15325	-112.74017	3.3
2	47.15319	-112.73973	3.3
3	47.15320	-112.73966	3.3

Table 2. Results of zooplankton sampling in Parker Lake.

Division	Taxon	Count	x̄ length (mm)	# per m^3	Estimated dry weight individual (µg)	µg per m^3
Cladocera	*Daphnia*	34	976.86	11.52	4.26	49.13
Copepoda	Calanoida					
	Copepoda nauplus	2	208.50	8.14	0.40	0.2
	Cyclopidae					
Rotifera	*Ascomorpha*	24	170.95	8.14	0.06	0.49
	Conchilius					
	Kellicottia longispina	110	167.71	37.29	0.1	0.54
	Keratella quadrata					
	Polyarthra	4	115	1.36	0.04	0.05
	Total	174	1639.02	59	4.78	50.48

Amphibians observed at Parker Lake include Columbia Spotted Frogs and Western Toads. Standing waters provide breeding and rearing habitat for these species, and their presence in neighboring streams is likely related to reproduction in Parker Lake.

Physicochemical Water QualityField readings of dissolved solids were slightly higher than most surface water sampling sites, although pH was similar with running waters in the North Fork Blackfoot River project area. Conductivity was 291 µS and TDS was 142 ppm. The lake's waters were slightly alkaline, with a pH of 8.3.

5.2 *Lower Twin Lake*

Physical Description

Lower Twin Lake is a small lake located within a glacial trough within the Lost Pony Creek watershed (Figure 3-2 and Figure 5-3). Upper Twin Creek lies upgradient from Lower Twin Lake; however, this shallow lake is fishless. Angling pressure in Lower Twin Lake is light.

Figure 5-3. Photo and close-up of Lower Twin Lake.

Lake Dimensions

Lower Twin Lake is 8.6 acres in surface area and lies at 5,900 ft above sea level (Figure 5-4). Its volume is 29.5 acre-ft. Its maximum depth is 11.6 ft.

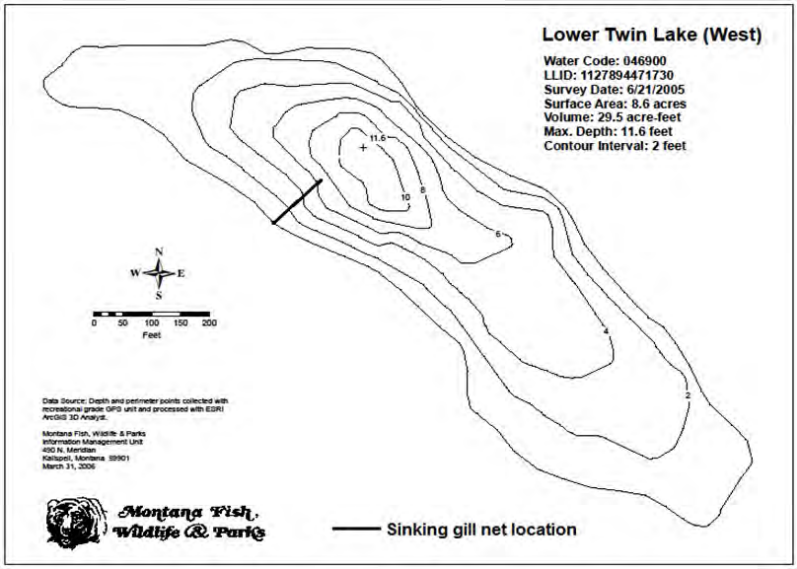

Figure 5-4. Bathymetry of Lower Twin Lake and location of gillnet set.

Fish Surveys

A sinking gillnet was deployed from the southwest bank of Lower Twin Lake in 2005 (Figure 5-4). Hybridized Rainbow Trout were present at low density, with a CPUE of 3.6 fish/hour. Condition factor of trout was low; however, one individual reached over 23 inches. Fish in Lower Twin Creek have access to spawning habitat, and the population is self-perpetuating.

Genetic Analyses

Analysis of fin clips of fish captured during gillnetting found fish to be hybrids of Rainbow Trout, YCT, and WCT (Appendix B). Interestingly, the results suggested 2 populations occupy the lake, and these populations may be reproductively isolated. One population appeared to have a predominant Rainbow Trout contribution, and the other had a significant WCT and YCT contribution. Nevertheless, all fish in the sample were of hybrid origin, so from a practical perspective, the lake should be considered as supporting a hybridized population of Rainbow Trout, WCT, and YCT.

Historical review of stocking records and other evidence found over 15,000 undifferentiated trout were planted in Lower Twin Lake in mid-1900s (Appendix J). Creels surveys report presence of YCT hybrids. The stocking history that happened before fish surveys were conducted obscured the presence of any native fish that may have been present before fish plants began.

Zooplankton and Amphibians

Three zooplankton hauls were conducted in Lower Twin Lake in September 2015 (Table 3 and Table 4). Rotifers as a group were the most abundant; however, Daphnia comprised 96% of the zooplankton biomass. The zooplankton community was slightly richer in Lower Twin Lake than Parker Lake.

Table 3. Location and description of plankton tows on Lower Twin Lake.

Tow	Latitude	Longitude	Depth (ft)
1	47.17324	-112.78905	7.2
2	47.17333	-112.78917	8.5
3	47.17336	-112378926	9.1

Table 4. Results of zooplankton sampling in Lower Twin Lake.

Division	Taxon	Count	$\bar{x}$ length (mm)	# per m^3	Estimated dry weight individual (µg)	µg per m^3
Cladocera	*Daphnia*	42	1158	16.59	6.60	109.48
Copepoda	Calanoida	4	576	1.58	0.40	0.63
	Copepoda nauplius	9	159	3.55	0.40	1.42
	Cyclopidae	1	850	0.39	0.40	0.16
Rotifera	*Ascomorpha*	1	130	0.39	0.03	0.01
	Conochilus	30	150	11.85	0.09	1.04
	Kellicottia longispina	13	157	5.13	0.01	0.06
	Keratella quadrata	7	153	2.76	0.08	0.23
	Polyarthra	8	118	3.16	0.04	0.13
	Total	174	1639	45.41	8.05	113.16

Columbia Spotted Frogs were the only amphibian observed during survey efforts on Lower Twin Lake. This species was also observed in Lost Pony Creek, Lower Twin Lake's receiving stream. In the North Fork Blackfoot River project area, the presence of Western Toad and Columbia Spotted Frogs was strongly related to presence of a neighboring lake.

Physicochemical Water Quality

Field measures of dissolved solids, conductivity, and pH were consistent with readings throughout the watershed. Conductivity was 226 µS, and TDS was 112 ppm. Lower Twin Lake was slightly alkaline with a pH of 8.7.

5.3 *Meadow Lake*

Physical Description

Meadow Lake is within the Meadow Creek watershed and its outlet stream enters Meadow Creek near stream mile 1.5 (Figure 3-2 and Figure 4-16). Its valley bottom is marshy, and this wetland likely provides substantial habitat to a diversity of wild animals.

Lake Dimensions

Meadow lake is 8.5 acres and lies at 5,800 ft elevation. Meadow Lake is shallow, with a maximum depth of 4 feet. It holds a volume of 17.8 acre-ft of water (Figure 5-5).

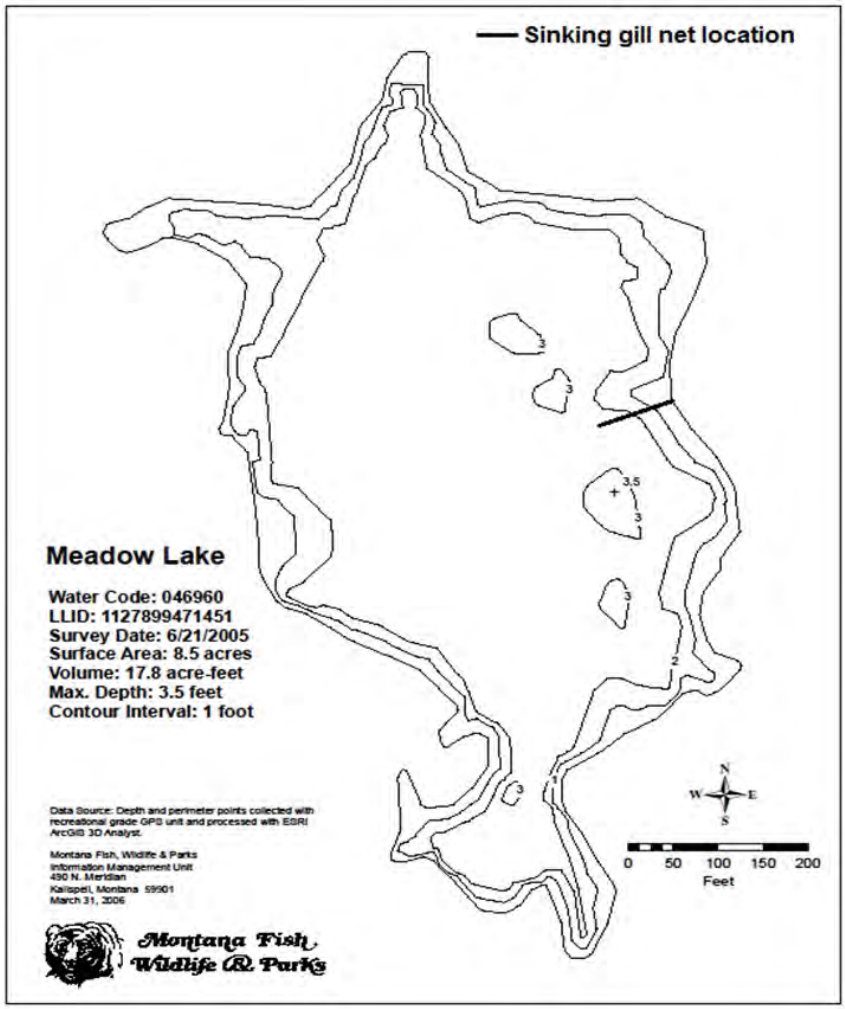

Figure 5-5. Bathymetry and gillnet location in Meadow Lake.

Fish Surveys

Gillnets were deployed in June of 2005; however, no fish were captured in gillnets. Angling yielded 3 fish, which were phenotypically identified in the field as Rainbow Trout hybrids. Natural recruitment was observed to be occurring but was limited.

Genetic Analyses

Genetic analyses found fish to be hybrids of Rainbow Trout and WCT, with Rainbow Trout providing the predominant contribution (Appendix B). The small sample size of fish available for genetic analyses limits statistical certainty in determining whether the population is a hybrid swarm. Nevertheless, the population is not native WCT and should be managed as hybridized with a predominant Rainbow Trout contribution.

FWP has no records of fish plants from hatchery operations; however, anglers and back-country recreationists were documented moving fish into Meadow Lake (Appendix J). In the mid-1920s, the Helena Rod and Gun Club stocked fish in Meadow Lake, and in the 1950s, outfitters moved fish into Meadow Creek from downstream of the North Fork Falls. Meadow Lake has a surface water connection to Meadow Creek, and stocking of nearly 0.5 million undifferentiated trout into Meadow Creek undoubtedly had an influence on fish species composition in Meadow Lake.

Zooplankton and Amphibians

No zooplankton data are available for Meadow Lake. Columbia Spotted Frogs are present in and near Meadow Lake, and this body of water provides suitable breeding and rearing habitat for this species of frog.

Physicochemical Water Quality

Field measures of dissolved solids, conductivity, and pH were consistent with readings throughout the watershed. Conductivity was 181 µS, and TDS was 91 ppm. Lower Twin Lake was slightly alkaline with a pH of 8.03.

6 Conclusions

The North Fork Blackfoot River watershed provides a promising setting for establishing secure, cold, high quality, connected habitat for native WCT and Bull Trout. The presence of a barrier falls would protect the area from invasion by nonnative trout. The size and complexity of the watershed would provide a diversity of habitats to support a variety of life history strategies in a large, connected watershed. Most of the watershed has a thermal regime suitable for the native salmonids, and this area is within a climate shield that will be resilient to climate change (Isaak et al. 2015).

The historical presence of fish in the project area is uncertain; however, hybrids of Rainbow Trout, YCT, and WCT are currently present in the watershed. The relative proportion of genes contributed from each taxon varied across the watershed and related largely to decades of stocking of undifferentiated trout of the genus *Oncorhynchus*. In general, Rainbow Trout genes were the most abundant, although YCT genes contributed an increased proportion near lakes that likely received plants of YCT. The historical presence of WCT in the watershed is conjectural, especially given limitations in fish identification in early fish plants. Nevertheless, the distribution of WCT genes throughout the basin, and their presence upstream of waterfalls in neighboring watersheds, provide evidence that they could have been present historically. In this case, stocking WCT would reestablish the species to waters from which nonhybridized WCT had been extirpated.

Extensive fish survey in the North Fork Blackfoot River project area found no evidence of Bull Trout in the watershed. Likewise, Bull Trout are not present in neighboring watersheds that support WCT upstream of waterfalls. Stocking Bull Trout in the project area would expand the occupied distribution of Bull Trout within their historical range. Furthermore, climate change is contracting the extent of habitat that is suitable for Bull Trout, and the project area currently has habitat that is highly or moderately suitable for Bull Trout and is within a climate shield that is predicted to be resilient to climate change (Isaak et al. 2015).

A single sculpin (*Cottus sp.*) found in the North Fork Blackfoot River project area in 2007, If it can be determined that a sculpin population was present historically, then they should be replaced if the project area is reclaimed for native fish. Nevertheless, extensive survey throughout the basin, including efforts specifically looking for sculpin (Appendix A) indicate this incidental observation was likely an escaped bait fish. Additional survey, potentially augmented with sampling for eDNA, will continue.

The low density of Rainbow Trout hybrids in streams that have relatively high production of macroinvertebrates suggests temperature limits abundance and not food limited. Native WCT and Bull Trout are cold-water adapted (Selong et al. 2001; Sloat et al. 2005; Bear et al. 2007). Therefore, in addition to the considerable conservation value, a native fishery has potential to provide a wider distribution, higher overall abundance, and higher recreational values than the current fishery.

Macroinvertebrate communities were typical of healthy Rocky Mountain streams in Montana. Several relatively rare taxa were collected, but none were species of concern. Several specimens of *Utacapnia* were present in a tributary. This genus includes designated species of concern; however, adults are required for a positive identification to species level. The sensitivity of *Utacapnia* to piscicide is unknown; however, natural recolonization of treated waters from drift will likely mitigate for mortality associated with piscicide treatment. Additional mitigative measures, such as using mechanical removal in streams with *Utacapnia* would be protective.

The North Fork Blackfoot River project area also supports 4 species of amphibian. Rocky Mountain Tailed Frogs are the most widely distributed and present in the North Fork Blackfoot River and East Fork North Fork Blackfoot River watersheds. Columbia Spotted Frogs and Western Toads are also present and were most frequently encountered in streams near lakes that provide suitable habitat for reproduction and rearing. Long-toed Salamanders were observed in the outlet of Twin Lake, suggesting they breed in this lake. Review of life-history information, toxicity of piscicide to amphibians, and implementation of mitigative measures employed to protect amphibians indicates any effect of piscicide application on amphibians would be minor and short-lived (Appendix O).

Additional planning and analysis provides information to evaluate the feasibility and consequences of native fish conservation in the North Fork Blackfoot River project area (Appendix J through Appendix O). This information will be incorporated into the National Environmental Protection Act (NEPA) and the Montana Environmental Protection Act (MEPA) review processes, which require examination of proposed projects under federal and state law, respectively. Combined, NEPA and MEPA will evaluate the potential for a proposed action to alter the biological or physical environment and provide the public opportunity to comment.

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Appendix A. : Summary of Fisheries Investigations (2006 – 2017)

Stream	River Mile	T	S	R	Date Sampled	Section Length (ft)	Species	Total Number Captured	Number Captured 1st Pass	YOY Captured 1st Pass	Range of Lengths (in)	Mean Length (in)	CPUE (#/100') in 1st Pass	YOY CPUE (#/100') in 1st Pass
Blondie Creek	0.2	16N	9W	9C	5-Aug-13	405	RB*	28	28	0	2.2 - 5.0	3.1	6.9	0.0
							Tailed frogs common, spotted frogs and western toad present							
Broadus Creek	0.1	17N	10W	2A	12-Jul-07	280	RB*	4	4	0	5.6 - 8.7	6.8	1.4	0.0
Camp Creek	0.1	17N	10W	34B	4-Sep-13	330	RB*	10	10	6	1.2 - 6.9	2.8	3.0	1.8
	1.6	17N	10W	26B	4-Sep-13	562	No fish found							
							Tailed frogs present							
Cooney Creek	0.2	17N	10W	1A	12-Jul-07	639	CT	1	1	0	7.9	7.9	0.2	0.0
					5-Sep-13	1155	CT*	2	2	0	6.2 - 6.4	6.3	0.2	0.0
							RB*	2	2	0	5.9 - 6.2	6.1	0.2	0.0
	0.4	17N	10W	1A	6-Sep-13	1200	RB*	4	4	0	5.1 - 9.8	6.8	0.3	0.0
	2.4	17N	9W	8B	6-Sep-13	770	No fish found							
Dobrota Creek	0.1	18N	9W	31C	13-Jul-07	1044	RB*	28	28	0	4.6 - 10.7	7.7	2.7	0.0
	1	18N	10W	25D	20-Jul-16	328	No fish found, tailed frog tadpoles present							
East Fork of North Fork Blackfoot River	0.1	17N	10W	28C	18-Jul-16	187	Sculpin survey, no sculpins found							
	1.9	17N	10W	34C	4-Sep-13	490	RB*	20	20	0	3.7 - 8.9	5.4	4.1	0.0
	7	16N	9W	7B	11-Jul-06	689	RB*	32	32	21	2.0 - 9.1	4.0	4.6	3.0
							Western toads present							
					8-Aug-13	690	RB*	59	59	0	2.8 - 9.2	4.5	8.6	0.0
"south channel"	9	16N	9W	8C	6-Aug-13	630	RB*	25	25	0	2.9 - 8.2	4.8	4.0	0.0
	11.7	16N	9W	10D	10-Jul-06	330	No fish found							
Kenny Creek	0.1	17N	10W	34C	18-Jul-16	360	RB*	3	3		4.4 -6.3	5.6		
Spot shocked, No CPUE generated														
Lost Pony Creek	0.85	16N	9W	6B	8-Aug-13	251	RB*	39	39	16	2.1 - 6.6	3.7	15.5	6.4
"Effluent channel from "Lower Twin Lake"	0.8	16N	9W	6B	11-Jul-06	540	RB*	14	14	8	1.3 - 6.3	3.5	2.6	1.5

Stream	River Mile	T	S	R	Date Sampled	Section Length (ft)	Species	Total Number Captured	Number Captured 1st Pass	YOY Captured 1st Pass	Range of Lengths (in)	Mean Length (in)	CPUE (#/100') in 1st Pass	YOY CPUE (#/100') in 1st Pass
Effluent channel from Lower Twin Lake continued														
	2.6	16N	9W	18A	6-Sep-08	1025	RB*	30	30	3	2.8 - 9.1	4.2	2.9	0.3
							Western toads present							
	5.2	16N	10W	24D	7-Sep-08	986	RB*	24	24	9	2.6 - 6.5	4.3	2.4	0.9
							Tailed frogs present							
Meadow Creek					7-Aug-13	986	RB*	4	4	0	5.8 - 8.1	6.9	0.4	0.0
	0.8	16N	10W	25A	7-Sep-08	1026	RB*	6	6	1	3.0 - 8.2	5.7	0.6	0.1
					7-Aug-13	1026	RB*	9	9	0	4.7 - 8.7	6.3	0.9	0.0
East Fork	2.2	16N	9W		7-Sep-08	500	No fish found							
Meadow Creek	2.5	16N	9W		7-Sep-08	354	No fish found							
West Fork of East Fork Meadow Creek	0.1	16N	9W		7-Sep-08	347	No fish found							
							Tailed frogs present							
Mineral Creek	2.1	16N	10W	10C	8-Sep-08	669	RB*	33	33	15	3.4 - 10.3	5.1	4.9	2.2
	4.2	16N	10W	10C	8-Sep-08	310	RB*	30	30	14	2.8 - 7.5	4.8	9.7	4.5
East Fork Mineral Creek	0.6	16N	10W	10C	8-Sep-08	516	RB*	10	10	0	4.7 - 9.4	6.6	1.9	0.0
North Fork Blackfoot River Above North Fork Falls, survey conducted to determine the presence of sculpins	26.4	17N	10W	28C	18-Jul-16	1500	No Sculpins found							
	26.6	17N	10W	28C	11-Jul-07	858	RB*	2	2	0	7.8 - 11.9	9.8	0.2	0.0
							Sculpin	1	1	0	3.0	3.0	0.1	0.0
Survey conducted to determine the presence of sculpins	27.2	17N	10W	28D	27-Aug-14	1182	RB	3	3	0	8.0	8.0	0.3	0.0
							No Sculpins							
	32	17N	10W	2C	12-Jul-07	2400	RB*	28	28	0	5.5 - 13.2	8.6	1.2	0.0

Stream	River Mile	T	S	R	Date Sampled	Section Length (ft)	Species	Total Number Captured	Number Captured 1st Pass	YOY Captured 1st Pass	Range of Lengths (in)	Mean Length (in)	CPUE (#/100') in 1st Pass	YOY CPUE (#/100') in 1st Pass
							Columbia spotted frogs present							
	34.7	18N	9W	31C	13-Jul-07	660	RB*	34	34	8	2.5 - 8.7	5.4	5.2	1.2
downstream of upper falls	36.4	18N	9W	32D	19-Jul-16	360	No fish	adult tailed frogs	common	tadpoles	abundant			
upstream of upper falls	36.9	18N	9W	33B	19-Jul-16	328	No fish	adult tailed frogs	common	tadpoles	abundant			
Sarbo Creek	0.1	17N	10W	10C	27-Aug-14	114	No fish found							
Scotty Creek	**0.2**	**16N**	**9W**	**8D**	**12-Jul-06**	**403**	**RB***	**42**	**42**	**20**	**2.1 - 8.1**	**4.2**	**10.4**	**5.0**
							CT*	**1**	**1**	**0**	**8.9**	**8.9**	**0.2**	**0.0**
							Western toads present							
					6-Aug-13	403	RB*	35	35	0	3.1 - 7.6	4.7	8.7	0.0
							Tailed frogs present							
Sourdough Creek	0.6	16N	9W	17A	12-Jul-06	651	RB*	3	3	0	5.4 - 9.4	7.2	0.5	0.0
					6-Aug-13	650	RB*	3	3	0	6.0 - 7.3	6.8	0.5	0.0
	1	16N	9W	17D	5-Aug-13	600	No fish found							
South Creek	0.1	17N	10W	22B	27-Aug-14		YOY Oncorhynchus species observed							
	0.4	17N	10W	22B	20-Jul-16	300	ONC	10	10	3	2.6 - 6.9	4.4	3.3	1.0
	1.2	17N	10W	23C	4-Sep-13	310	No fish found, Tailed frogs present							
Spaulding Creek	0.1	16N	10W	2A	7-Aug-13	275	RB*	2	2	0	5.1 - 5.2	5.1	0.7	0.0
Theodore Creek	0.2	17N	10W	2D	12-Jul-07	450	No fish found							
							Columbia spotted frog present							
Un-named tributary stream entering North Fork Blackfoot River near stream mile 27.8	0.1	17N	10W	21D	27-Aug-14	240	No fish found							
All CPUE based on year class sizes		*** Sample may include rainbow trout / cutthroat trout hybrids**												

Stream	River Mile	T	S	R	Date Sampled	Section Length (ft)	Species	Total Number Captured	Number Captured 1st Pass	YOY Captured 1st Pass	Range of Lengths (in)	Mean Length (in)	CPUE (#/100') in 1st Pass	YOY CPUE (#/100') in 1st Pass
CT = Cutthroat trout														

Appendix B.: Upper North Fork Blackfoot River Project Area Genetics Summaries

Stream / Lake name	Date collected	Stream mile	Location T,R,S	Lat	Long	Species	Sample number	# of genetic samples collected	genetic samples tested	Taxa ID*
Blondie Creek	5-Aug-13	0.2	16N,9W,9C	47.15471	112.74631	Hyb	4763	20	10	RBT x YCT x WCT
Broadus Creek	12-Jul-07	0.1	17N,10W,2A	47.25801	112.83223	Hyb	3505	4	4	RBTx WCT
Cabin Creek (Tributary to Dry Fork of the North Fork Blackfoot River)	13-Jul-04	0.5	17N,11W,13B	47.23086	112.94829	Hyb	2977	29	26	WCT x RBT
Camp Creek	4-Sep-13	0.1	17N,10W,34C	47.18376	112.86497	Hyb	4770	10	10	RBT x YCT
Canyon Creek (Tributary to Dry Fork of the North Fork Blackfoot River)	14-Jul-07	1.5	17N,11W,14C	47.21952	112.97434	WCT	3508	30	25	WCT
Cooney Creek	12-Jul-07	0.2	17N,10W,1A	47.25836	112.81499	WCT	3510	1	1	WCT
Cooney Creek	5-Aug-13	0.2-0.4	17N,10W,1A	47.25836	112.81499	Hyb	4764	8	8	RBT x YCT
Dobrota Creek	13-Jul-07	0.1	18N,9W,31C	47.26928	112.80687	Hyb	3511	28	5	RBT x WCT x YCT
Dry Fork of the North Fork Blackfoot River	20-Jul-16	3	17N,11W24A	47.2143	112.93836	HYb		22	16	WCT x RBT
Effluent channel from Lower Twin Lake, (Lost Pony Creek drainage)	11-Jul-06	0.8	16N,9W,6B	47.17254	112.79581	Hyb	3363	10	5	RBT x YCT x WCT
Kenny Creek	18-Jul-16	0.1	17N,10W,34C	47.18263	112.86499	RBT		3		
Lost Pony Creek	8-Aug-13	0.8	16N,9W,6B	47.1752811	112.79342	Hyb	4766	24	10	RBT x YCT x WCT
Meadow Creek	6-Sep-08	2.6	16N,9W,18	47.13887	112.79452	Hyb	3856	28	4	RBT x YCT x WCT
Meadow Creek	7-Sep-08	5.2	16N,10W,24D	47.11841	112.81139	Hyb	3857	15	4	RBT x YCT x WCT
East Fork Meadow Creek	7-Sep-08	0.8	16N,10W,25A	47.11820	112.80013	Hyb	3858	6	4	RBT x YCT x WCT
East Fork Meadow Creek	7-Aug-13	0.8	16N,10W,25A	47.1183065	112.79995	Hyb	4765	9	9	RBT x YCT x WCT
Mineral Creek	8-Sep-08	2.1	16N,10W,10A	47.1588	112.84092	Hyb	3863	28	8	RBT x YCT x WCT
Mineral Cr above E.F Mineral	8-Sep-08	4.2	16N,10W,10C	47.14819	112.86125	Hyb		28		
East Fork Mineral Creek	8-Sep-08	0.6	16N,10W,15B	47.14387	112.85385	Hyb	3864	10	5	RBT x YCT x WCT
North Fork Blackfoot River (below South Cr)	11-Jul-07	26.8	17N,10W,28C	47.19729	112.88304	Hyb	3522	2	2	RBT x YCT x WCT
North Fork Blackfoot River (below Theodore Cr)	12-Jul-07	32	17N,10W,2C	47.24827	112.84461	Hyb	3523	28	5	RBT x YCT x WCT
North Fork Blackfoot River (above Dobrota Cr)	13-Jul-07	34.7	18N,9W,31C	47.2675	112.80538	Hyb	3521	30	5	RBT x YCT x WCT
East Fork of NFBLKFT	4-Sep-13	1.9	17N,10W,34C	47.18352	112.86468	Hyb	4762	10	10	RBT x YCT x WCT
East Fork of NFBLKFT	11-Jul-06	7	16N,9W,7B	47.16365	112.7952	Hyb	3360	28	5	RBT x YCT x WCT
East Fork of NFBLKFT (South Channel)	6-Aug-13	9	16N,9W8C	47.15493	112.76985	Hyb	4762	22	22	RBT x YCT x WCT
Scotty Creek	12-Jul-06	0.2	16N,9W,8D	47.1545	112.75689	Hyb	3362	29	5	RBT x YCT x WCT
Sourdough Creek	12-Jul-06	0.6	16N,9W,17A	47.14685	112.75656	Hyb	3361	3	3	RBT x YCT x WCT
South Creek	20-Jul-16	0.4	17,10W,22B	47.21439	112.86357	ONC		10		
Spaulding Creek	7-Aug-13	0.1	16N,10W,2A	47.1759062	112.8201	Hyb	4767	2	2	RBT x YCT
Lower Twin Lake	21-Jun-05		16N,9W,6C	47.1732	112.78976	Hyb	3099	25	25	RBT x YCT x WCT
Meadow Lake	22-Jun-05		16N,9W,18B	47.14576	112.78877	Hyb	3279	3	3	RBT x WCT
Parker Lake	20-Jul-05		16N,9W,9D	47.15379	112.73933	Hyb	3098	28	26	YCT x RBT x WCT

RBT = Rainbow trout
WCT = Westslope cutthroat trout
YCT = Yellowstone cutthroat trout
ONC = Oncorhynchus species
Hyb = Hybrid

* All taxa ID in order of predominant genetic contribution

Summary of *Oncorhynchus* Genetic Tests

Summaries of all genetic analyses are from genetic samples collected from the North Fork Blackfoot River and its tributaries upstream of the North Fork falls and two samples from the Dry Fork of the North Fork drainage (Dry Fork and Cabin Creek). All *Oncorhynchus* genetic analyses are organized below in alphabetical order. The summaries include the genetic sample lot number as well as the individual sample size. These analyses were conducted at the University of Montana Conservation Genetics Laboratory and were written by Dr. Robb Leary. All other information related to genetic samples can be obtained from Montana Fish, Wildlife and Parks by referencing the sample # ID.

Blondie Creek: Sample # 4763 (n=10)

In the sample from Blondie Creek, alleles characteristic of rainbow trout were detected at all of the rainbow markers, alleles characteristic of Westslope Cutthroat Trout were detected at only four of the westslope markers, and alleles characteristic of Yellowstone cutthroat trout were detected at all of the Yellowstone markers. This sample, therefore, provided conclusive evidence of hybridization among westslope cutthroat, rainbow, and Yellowstone cutthroat trout. The Yellowstone cutthroat (X^2_{19}=31.561, P<0.05) and rainbow trout (X^2_{18}=65.332, P<0.001) allele frequencies were statistically heterogeneous among the respective markers and the alleles were clearly not randomly distributed among the fish in the sample (Figures 3 and 4). All the fish in the sample, however, were definitely of hybrid origin among all three taxa. The trout in Blondie Creek, therefore, should simply be considered to be hybrids among rainbow, Yellowstone cutthroat, and Westslope Cutthroat Trout with a major rainbow (about 50 percent) and Yellowstone cutthroat (about 48 percent) and minor Westslope Cutthroat Trout (about two percent) genetic contribution.

Broadus Creek: Sample #3505 (n=4)

Alleles characteristic of both westslope cutthroat and rainbow trout were detected at seven of the 13 diagnostic loci between these species that were analyzed in the sample from Broadus Creek. The allele frequencies were statistically homogeneous (X^2_{12}=7.448; P>0.05) among the diagnostic loci and the rainbow trout alleles appeared to be randomly distributed (X^2_3=2.879; P>0.10) among the fish in the sample. This sample, therefore, appears to have come from a hybrid swarm between westslope cutthroat and rainbow trout with a predominant (0.93) rainbow trout genetic contribution.

Cabin Creek: Tributary to Dry Fork of the North Fork Blackfoot River sample # 2977 (n=26)

PINE fragments characteristic of westslope cutthroat and rainbow trout were detected at three of the six diagnostic markers between these fishes that were analyzed in the sample. Although the

frequency of rainbow trout alleles among the marker loci was statistically homogeneous (P>0.50), the markers characteristic of rainbow trout was not randomly distributed (P<0.001) among the fish in the sample. In contrast, all the rainbow markers were detected in only one fish. All the other fish possessed markers characteristic of only Westslope Cutthroat Trout. These results suggest this population is a mixture of hybridized and non-hybridized Westslope Cutthroat Trout. The vast predominance of what appears to be non-hybridized Westslope Cutthroat Trout in the sample and the relatively high frequency of rainbow fragments (0.30) in the fish definitely of hybrid origin suggest the latter is a recent migrant into the population. Thus, interbreeding between non-hybridized Westslope Cutthroat Trout and fish of hybrid origin may not have begun at the time of sampling. The presence of fish of hybrid origin in the population seriously threatens the continued genetic integrity of the non-hybridized fish.

Camp Creek: Sample #4770 (n=10)

Alleles characteristic of rainbow trout were detected at all of the rainbow markers, no alleles characteristic of Westslope Cutthroat Trout were detected at the westslope markers, and alleles characteristic of Yellowstone cutthroat trout were detected at six of the Yellowstone markers in the sample from Camp Creek. This sample, therefore, provided conclusive evidence of hybridization between rainbow and Yellowstone cutthroat trout. Although the Yellowstone cutthroat trout allele frequencies were statistically heterogeneous (X^2_{38}=148.388, P<0.001) among the rainbow and Yellowstone markers, the Yellowstone cutthroat trout alleles appeared to be randomly distributed (X^2_{10}=6.338, P>0.50) among the fish in the sample. Furthermore, all of the fish in the sample were definitely of hybrid origin (Figure 8). Camp Creek, therefore, appears to contain a hybrid swarm between rainbow and Yellowstone cutthroat trout with a predominant (0.932) rainbow trout genetic component.

Canyon Creek: Tributary to Dry Fork of the North Fork Blackfoot River Sample #3508 (n=25)

Alleles characteristic of only Westslope Cutthroat Trout were detected at all the loci analyzed in the sample from Canyon Creek (Table 5). With the sample size of 25, we have better than a 99% chance of detecting as little as a one percent rainbow trout and better than a 98% chance of detecting as little as a one percent Yellowstone cutthroat trout genetic contribution to a hybrid swarm that once was non-hybridized Westslope Cutthroat Trout. Canyon Creek, therefore, likely contains a non-hybridized Westslope Cutthroat Trout population.

Cooney Creek: Sample #3510 (n=1)

A single fish believed to be a rainbow trout was collected from Cooney Creek. In contrast to the expectation, alleles characteristic of only Westslope Cutthroat Trout were detected at all the loci analyzed in this fish. This fish, therefore, was undoubtedly not a rainbow trout and in fact may possibly have been a non-hybridized Westslope Cutthroat Trout.

Cooney Creek: Sample #4764 (n=8)

Alleles characteristic of rainbow trout were detected at all of the rainbow markers, no alleles characteristic of Westslope Cutthroat Trout were detected at the westslope markers, and alleles characteristic of Yellowstone cutthroat trout were detected at 13 of the Yellowstone markers in the sample from Cooney Creek. Thus, this sample provided good evidence of hybridization between rainbow and Yellowstone cutthroat trout. Although the Yellowstone cutthroat and rainbow trout allele frequencies were statistically heterogeneous (X^2_{38}=71.423, P<0.001) among the markers all fish in the sample were definitely of hybrid origin (Figure 5). The fish in Cooney Creek, therefore, should simply be considered to be hybrids between rainbow and Yellowstone cutthroat trout with a major rainbow trout (about 88 percent) genetic contribution.

The above results are in stark contrast to those obtained from an indel/microsatellite analysis of a single trout collected from Cooney Creek (#3510, col. 7/12/07, 47.258 112.81). This fish was believed to be a rainbow trout but, the results suggested it was a non-hybridized Westslope Cutthroat Trout. If such fish still persist in Cooney Creek, the recent results suggest that they are relatively uncommon.

Dobrota Creek: Sample #3511 (n=5)

Alleles characteristic of rainbow, Yellowstone cutthroat, and Westslope Cutthroat Trout were detected in the sample collected from Dobrota Creek. The westslope cutthroat (X^2_6=19.027; P<0.01) and Yellowstone cutthroat trout (X^2_7=23.563; P<0.01) allele frequencies were statistically heterogeneous among the diagnostic loci and they were not randomly distributed (X^2_{11}=123.008; P<0.001) among the fish in the sample. Although Dobrota Creek does not appear to contain a hybrid swarm, all the fish in the sample were definitely of hybrid origin. From a management perspective, therefore, Dobrota Creek should simply be considered to contain hybrids among westslope cutthroat, Yellowstone cutthroat, and rainbow trout with a predominant rainbow trout genetic contribution.

Dry Fork of the North Fork Blackfoot River: Sample # (n=22)

Alleles characteristic of rainbow trout were detected at 17 of the rainbow markers and 19 of the westslope markers were polymorphic in the sample from Dry Fork. In the sample, all of the Yellowstone markers possessed alleles characteristic of rainbow or Westslope Cutthroat Trout except at *OclYGD106457_Garza*. The allele usually characteristic of Yellowstone cutthroat trout at *OclYGD106457-Garza* could indicate a small amount of hybridization with Yellowstone cutthroat trout or a Westslope Cutthroat Trout polymorphism. This locus has been found to be polymorphic in numerous other samples we have analyzed that otherwise appeared to be non-hybridized Westslope Cutthroat Trout (Table 3). In this case, therefore, we strongly favor the Westslope Cutthroat Trout polymorphism interpretation for the presence of variation at

OclYGD106457_Garza in the sample. Thus, this sample contained conclusive evidence of hybridization only between westslope cutthroat and rainbow trout.

Lost Pony Creek drainage (Twin Lake Outlet Channel): Sample #3363 (n=5)
Alleles characteristic of both rainbow and Yellowstone cutthroat trout were detected at eight of the 14 diagnostic loci between these fishes that were analyzed in the sample from effluent channel from Twin Lake in the Lost Pony Creek drainage. The allele frequencies were statistically heterogeneous (X2 13=36.252; P<0.001) among the diagnostic loci but, the Yellowstone cutthroat trout alleles appeared to be randomly distributed (X 27=3.228; P>0.50) among the fish in the sample. At Ssa408* and Omm1037-1*, alleles characteristic of Westslope Cutthroat Trout were detected in the 368 sample. Although, the allele frequencies were statistically heterogeneous (X2 12=77.509; P<0.001) among the diagnostic loci, the Westslope Cutthroat Trout alleles appeared to be randomly distributed (X2 3=2.486; P>0.10) among the fish in the sample. Considering all the data, therefore, the sample from the effluent channel of Twin Lake appears to contain a hybrid swarm among rainbow, Yellowstone cutthroat, and Westslope Cutthroat Trout with a predominant (0.839) rainbow trout genetic contribution.

Lost Pony Creek: Sample #4766 (n=10)
Alleles characteristic of rainbow trout were detected at all of the rainbow markers, alleles characteristic of Westslope Cutthroat Trout were detected at seven of the westslope markers, and alleles characteristic of Yellowstone cutthroat trout were detected at ten of the Yellowstone markers in the sample from Lost Pony Creek. This sample, therefore, provided good evidence of hybridization among rainbow, Yellowstone cutthroat, and Westslope Cutthroat Trout. Disregarding the small (0.025) Westslope Cutthroat Trout genetic component, the Yellowstone cutthroat trout allele frequencies were statistically heterogeneous (X^2_{38}=89.392, P<0.001) among the rainbow and Yellowstone markers. All fish in the sample, however, were definitely of hybrid origin (Figure 7). Thus, Lost Pony Creek should simply be considered to contain hybrids among rainbow, Yellowstone cutthroat, and Westslope Cutthroat Trout with a substantial rainbow (about 88 percent) and minor Yellowstone (about 9.5 percent) and Westslope Cutthroat Trout genetic contribution.

The above results are highly concordant with those obtained from a previous indel/microsatellite analysis of a sample of trout collected from Lost Pony Creek (#3363, col. 7/11/06, T16N R10W S1 47.173 112. 796, N=5). This analysis also indicated the creek contained hybrids among rainbow, Yellowstone cutthroat, and Westslope Cutthroat Trout with a substantial rainbow and minor Yellowstone and Westslope Cutthroat Trout genetic component.

Meadow Creek combined (n=12)

Samples were collected from two reaches of Meadow Creek. Evidence of hybridization with rainbow and Yellowstone cutthroat trout was detected in both samples. Because of the small sample sizes, we increased statistical power to detect evidence of genetic differences by comparing the frequency of westslope cutthroat, Yellowstone cutthroat, and rainbow trout alleles averaged over all the diagnostic loci between the samples. Contingency table chi-square analysis indicates that the average frequency of westslope cutthroat and rainbow trout alleles was statistically heterogeneous (X^2_1=4.020, P<0.05) between the samples but, the average frequency of Yellowstone cutthroat trout alleles was statistically homogeneous (X^2_1=2.798, P>0.05). Because of the former difference, the samples were treated separately for further analysis.

Meadow Creek (lower): Sample #3856 (n=4)

Alleles characteristic of Westslope Cutthroat Trout were detected at one of the diagnostic loci for this fish that were analyzed in the sample from upper Meadow Creek. In the sample, alleles characteristic of Yellowstone cutthroat trout were detected at two diagnostic loci for this fish that were analyzed. At 12 loci analyzed, alleles characteristic of only rainbow trout were detected. Normally, we would be uncertain whether the apparent westslope and Yellowstone cutthroat trout alleles represented evidence of hybridization or if they were simply rainbow trout genetic variation. In this situation, however, we favor the hybridization interpretation because fish lower in the drainage clearly appear to be hybrids among rainbow, westslope cutthroat, and Yellowstone cutthroat trout (see #3857). The rainbow and Yellowstone cutthroat trout allele frequencies were statistically homogeneous (X^2_{12}=19.283, P>0.05 and X^2_7=7.404, P>0.10, respectively) among the diagnostic loci and the alleles appeared to be randomly distributed (rainbow X^2_2=0.693, P>0.50, Yellowstone X^2_1=0.148, P>0.50) among the fish in the sample. Thus, this reach of Meadow Creek appears to contain a hybrid swarm among rainbow, westslope cutthroat, and Yellowstone cutthroat trout with a predominant (0.971) rainbow trout genetic contribution.

Meadow Creek (upper): Sample #3857 (n=4)

In the sample from lower Meadow Creek, alleles characteristic of Westslope Cutthroat Trout were detected at four diagnostic loci for this fish that were analyzed. Also, alleles characteristic of Yellowstone cutthroat trout were detected at four of the diagnostic loci for this fish that were analyzed. At six loci analyzed alleles characteristic of only rainbow trout were detected. The rainbow and Yellowstone cutthroat trout allele frequencies were statistically homogeneous (X^2_{12}=9.065, P>0.50 and X^2_7=6.776, P>0.10, respectively) among the diagnostic loci and the alleles appeared to be randomly distributed (rainbow X^2_3=5.953, P>0.10, Yellowstone X^2_2=1.803, P>0.10) among the fish in the sample. Thus, lower Meadow Creek appears to contain a hybrid swarm among rainbow, westslope cutthroat, and Yellowstone cutthroat trout with a predominant (0.904) rainbow trout genetic component.

East Fork Meadow Creek: Sample #3858 (n=4)

Alleles characteristic of Westslope Cutthroat Trout were detected at nine of the diagnostic loci for this fish that were analyzed in the sample from East Fork Meadow Creek. In the sample, alleles characteristic of Yellowstone cutthroat trout were detected at five diagnostic loci for this fish that were analyzed. At two loci analyzed, alleles characteristic of only rainbow trout were detected (Tables 2 and 4). The rainbow and Yellowstone cutthroat trout allele frequencies were statistically homogeneous (X212=10.437, P>0.50 and X27=6.858, P>0.10, respectively) among the diagnostic loci and the alleles appeared to be randomly distributed (rainbow X26=4.549, P>0.50, Yellowstone X23=2.276, P>0.10) among the fish in the sample. East Fork Meadow Creek, therefore, appears to contain a hybrid swarm among rainbow, westslope cutthroat, and Yellowstone cutthroat trout with a substantial (0.788) rainbow trout genetic contribution.

East Fork Meadow Creek: Sample #4765 (n=9)

In the sample from East Fork Meadow Creek, alleles characteristic of rainbow trout were detected at all of the rainbow markers, alleles characteristic of Westslope Cutthroat Trout were detected at only two of the westslope markers, and alleles characteristic of Yellowstone cutthroat trout were detected at 18 of the Yellowstone markers. This sample, therefore, provided evidence of hybridization among westslope cutthroat, rainbow, and Yellowstone cutthroat trout. Ignoring the small (0.009) Westslope Cutthroat Trout genetic component, the Yellowstone cutthroat trout allele frequencies were statistically homogeneous (X238=51.216, P>0.05) among the rainbow and Yellowstone markers and all the fish in the sample were definitely of hybrid origin (Figure 6). East Fork Meadow Creek, therefore, should be considered to contain hybrids among rainbow, Yellowstone cutthroat, and Westslope Cutthroat Trout with a substantial rainbow (about 88 percent) and minor Yellowstone (about 11 percent) and Westslope Cutthroat Trout genetic contribution.

The above results are highly concordant with those obtained from a previous indel/microsatellite analysis of a sample of trout collected from East Fork Meadow Creek (#3858, col. 9/7/08, 47.11820 112. 80013, N=4). This analysis also indicated the creek contained hybrids among rainbow, Yellowstone cutthroat, and Westslope Cutthroat Trout with a substantial rainbow and minor Yellowstone and Westslope Cutthroat Trout genetic component.

Mineral Creek: Sample #3863 (n=8)

Samples were collected from two reaches of Mineral Creek. Evidence of hybridization with rainbow and Yellowstone cutthroat trout was detected in both samples. Because of the small sample sizes, we increased statistical power to detect evidence of genetic differences by comparing the frequency of westslope cutthroat, Yellowstone cutthroat, and rainbow trout alleles averaged over all the diagnostic loci between the samples. Contingency table chi-square analysis

indicates that the average frequency of westslope cutthroat and rainbow trout alleles (X^2_1=0.753, P>0.50) and the average frequency of westslope and Yellowstone cutthroat trout alleles (X^2_1=0.000, P>0.99) were statistically homogeneous between the samples. Thus, the samples were combined for further analysis.

Alleles characteristic of Westslope Cutthroat Trout were detected at five of the diagnostic loci for this fish that were analyzed in the sample from Mineral Creek. In the sample, alleles characteristic of Yellowstone cutthroat trout were detected at eight diagnostic loci for this fish that were analyzed. At two loci analyzed, alleles characteristic of only rainbow trout were detected. The rainbow and Yellowstone cutthroat trout allele frequencies were statistically homogeneous (X^2_{12}=10.856, P>0.50 and X^2_7=2.604, P>0.90, respectively) among the diagnostic loci and the alleles appeared to be randomly distributed (rainbow X^2_6=4.185, P>0.50, Yellowstone X^2_5=8.779, P>0.10) among the fish in the sample. Mineral Creek, therefore, appears to contain a hybrid swarm among westslope cutthroat, Yellowstone cutthroat, and rainbow trout with a predominant (0.885) rainbow trout genetic contribution.

East Fork Mineral Creek: Sample #3864 (n=5)

Alleles characteristic of Westslope Cutthroat Trout were detected at nine of the diagnostic loci for this fish that were analyzed in the sample from East Fork Mineral Creek. In the sample, alleles characteristic of Yellowstone cutthroat trout were detected at seven diagnostic loci for this fish that were analyzed. The rainbow trout allele frequencies were statistically heterogeneous (X^2_{12}=21.902, P<0.05) among the diagnostic loci but, the Yellowstone cutthroat trout allele frequencies were statistically homogeneous (X^2_7=11.178, P>0.10) among the diagnostic loci. The rainbow trout alleles were not randomly distributed (X^2_8=16.453, P<0.05) among the fish in the sample but the Yellowstone cutthroat trout alleles were (X^2_7=11.005, P>0.10). The distribution of rainbow trout hybrid indices was highly variable among the fish (Figure 18) resulting in the non-random distribution. Despite this, all the fish in the sample were definitely of hybrid origin and the Yellowstone cutthroat trout alleles were randomly distributed among the fish. From a management perspective, therefore, the simplest approach would be to consider East Fork Mineral Creek to contain a hybrid swarm among westslope cutthroat, Yellowstone cutthroat, and rainbow trout with a substantial (0.700) rainbow trout genetic component.

North Fork Blackfoot River upstream of Dobrota Creek: Sample #3521 (n=5)

Alleles characteristic of rainbow, Yellowstone cutthroat, and Westslope Cutthroat Trout were detected in the sample collected from the North Fork Blackfoot River above Dobrota Creek. The westslope cutthroat (X^2_6=8.805; P>0.10) and Yellowstone cutthroat trout (X^2_7=10.051; P>0.10) allele frequencies were statistically homogeneous among the diagnostic loci but the alleles did not appear to be randomly distributed (X^2_5=9.327; P<0.05) among the fish in the sample. Thus,

this sample clearly contained hybrids among rainbow, westslope cutthroat, and Yellowstone cutthroat trout with a predominant rainbow trout genetic contribution but it does not appear to have come from a hybrid swarm.

North Fork Blackfoot River downstream of South Creek: Sample #3522 (n=2)
This sample also contained alleles characteristic of rainbow, Yellowstone cutthroat, and Westslope Cutthroat Trout. The westslope cutthroat (X^2_6=5.897; P>0.10) and Yellowstone cutthroat trout (X^2_7=6.731; P>0.10) allele frequencies were statistically homogeneous among the diagnostic loci but the alleles did not appear to be randomly distributed (X^2_1=4.564; P<0.05) among the fish in the sample. Thus, this sample also clearly contained hybrids among rainbow, westslope cutthroat, and Yellowstone cutthroat trout with a predominant rainbow trout genetic contribution but it does not appear to have come from a hybrid swarm.

North Fork Blackfoot River downstream of Theodore Creek: Sample #3523 (n=5)
This sample also contained alleles characteristic of rainbow, Yellowstone cutthroat, and Westslope Cutthroat Trout. In this sample, the Westslope Cutthroat Trout (X^2_6=28.561; P<0.001) alleles were not statistically homogeneous among the diagnostic loci but, the Yellowstone cutthroat trout allele frequencies were (X^2_7=12.276; P>0.05). Also, the westslope and Yellowstone cutthroat trout alleles did not appear to be randomly distributed (X^2_6=19.020; P<0.01) among the fish in the sample. Thus, this sample also clearly contained hybrids among rainbow, westslope cutthroat, and Yellowstone cutthroat trout with a predominant rainbow trout genetic contribution but it does not appear to have come from a hybrid swarm.

North Fork Blackfoot River combined (n=12)
The average rainbow, westslope cutthroat, and Yellowstone cutthroat trout allele frequencies did not statistically differ among the three North Fork Blackfoot River samples. Thus, they were combined into a single sample for further analysis. In the combined sample, the Westslope Cutthroat Trout (X^2_6=35.289; P<0.001) alleles were not statistically homogeneous among the diagnostic loci but, the Yellowstone cutthroat trout allele frequencies were (X^2_7=12.740; P>0.05). Given the previous results, not surprisingly the westslope and Yellowstone cutthroat trout alleles did not appear to be randomly distributed (X^2_6=14.062; P<0.05) among the fish in the combined sample. A likely explanation for the heterogeneity of allele frequencies at some of the diagnostic loci and the nonrandom distribution of the westslope and Yellowstone cutthroat trout alleles among the fish is that when this reach of the North Fork Blackfoot River was sampled it contained fish from two or more hybridized populations of rainbow, westslope cutthroat, and Yellowstone cutthroat trout with different amounts of hybridization.

East Fork North Fork Blackfoot River (middle): Sample #3360 (n=5)

Alleles characteristic of both rainbow and Yellowstone cutthroat trout were detected at ten of the 14 diagnostic loci between these fishes that were analyzed in the sample from the East Fork of the North Fork Blackfoot River. The allele frequencies were statistically homogeneous (X213=15.396; P>0.10) among the diagnostic loci but, the Yellowstone cutthroat trout alleles were not randomly distributed (X 29=18.940; P<0.05) among the fish in the sample. All of the fish in the sample, however, were definitely of hybrid origin between rainbow and Yellowstone cutthroat trout. At Omm1037-1*, a single copy of the 147 allele was detected in the sample. This allele is usually characteristic of Westslope Cutthroat Trout and its presence, therefore, suggests that at least some of the fish in the East Fork of the North Fork Blackfoot River may have a minor Westslope Cutthroat Trout genetic contribution. Considering all the data the East Fork of the North Fork Blackfoot River should be considered to contain hybridized fish with a predominant rainbow trout genetic contribution, a moderate Yellowstone cutthroat trout genetic contribution, and a minor contribution from westslope 367cutthroat trout. These results are highly concordant with those obtained from a previous allozyme analysis of fish collected from the East Fork of the North Fork Blackfoot River (sample #1203; col. 8/1/96; N=9). The previous results also indicated the population to contain hybrids among rainbow, Yellowstone cutthroat, and Westslope Cutthroat Trout with a predominant rainbow trout genetic contribution.

East Fork North Fork Blackfoot River: Sample # 4762 (n=20)

Fish were collected from stream mile 1.9 and 9.0 in the East Fork of the North Fork Blackfoot River. Between the samples, 38 loci were polymorphic. The allele frequencies were statistically heterogeneous between the samples at two of these loci. These differences, however, were not significant at the modified level indicating they most likely represented chance departures from homogeneity rather than evidence of genetic differences between the samples. The samples, therefore, were combined for further analysis.

Alleles characteristic of rainbow trout were detected at all of the rainbow markers, 18 of the westslope markers were polymorphic, and alleles characteristic of Yellowstone cutthroat trout were detected at all of the Yellowstone markers in the sample from the East Fork of the North Fork Blackfoot River. This sample, therefore, provided conclusive evidence of hybridization among westslope cutthroat, rainbow, and Yellowstone cutthroat trout. Although the Yellowstone cutthroat (X^2_{19}=22.115, P>0.10) and Westslope Cutthroat Trout (X^2_{19}=11.725, P>0.50) allele frequencies were statistically homogeneous among the respective markers, the Yellowstone cutthroat (X^2_8=41.184, P<0.001, Figure 1) and Westslope Cutthroat Trout (X^2_5=46.967, P<0.001, Figure 2) alleles did not appear to be randomly distributed among the fish in the sample. The non-random distribution of the Yellowstone cutthroat trout alleles was due to two fish with a hybrid index of ten or 11. When these two individuals are removed from the data, the

Yellowstone cutthroat trout alleles appear to be randomly distributed (X^2_5=5.599, P>0.50) among the remaining fish. The non-random distribution of the Westslope Cutthroat Trout alleles was due to three fish with a hybrid index of five, six, or 11. When these fish are removed from the data, the Westslope Cutthroat Trout alleles appear to be randomly distributed (X^2_3=7.237, P>0.0.05) among the remaining fish. Considering both the westslope and Yellowstone markers, only one fish in the sample showed no evidence of hybridization. The fish in the East Fork of the North Fork Blackfoot River, therefore, should simply be considered to be hybrids among rainbow, Yellowstone cutthroat, and Westslope Cutthroat Trout with a major rainbow (about 87 percent) and minor Yellowstone (about nine percent) and Westslope Cutthroat Trout (about four percent) genetic contribution.

The East Fork of the North Fork Blackfoot River was previously sampled twice. Allozyme (#1203, col. 8/1/96, T16N R10W S1, N=9) and indel/microsatellite (#3360, col. 7/11/06, T16N R9W S7, N=5) analyses also indicated the fish to be hybrids among westslope cutthroat, rainbow, and Yellowstone cutthroat trout with a predominant rainbow trout genetic component.

Scotty Creek: Sample #3362 (n=5)

Alleles characteristic of both rainbow and Yellowstone cutthroat trout were detected at all 14 diagnostic loci between these fishes that were analyzed in the sample from Scotty Creek. Although the allele frequencies were statistically homogeneous (X213=10.202; P>0.50) among the diagnostic loci, the Yellowstone cutthroat trout alleles were not randomly distributed (X 212=346.963; P<0.001) among the fish in the sample. All of the fish in the sample except one, however, were definitely of hybrid origin between rainbow and Yellowstone cutthroat trout. The exception was one individual that may have been a non-hybridized rainbow trout. The conclusion that this individual was a non-hybridized rainbow trout is tentative because the small sample size precludes a reliable assessment of this likelihood. At Oki10*, a single copy of the 145allele was detected in the sample. A single copy of the 77 allele was also detected at Omy0004*. These alleles are usually characteristic of Westslope Cutthroat Trout and their presence indicates that at least some of the fish in Scotty Creek may have a minor Westslope Cutthroat Trout genetic contribution. Thus, considering all the data Scotty Creek should be considered to contain hybridized fish with a substantial rainbow and Yellowstone cutthroat trout genetic contribution and a minor contribution from Westslope Cutthroat Trout.

Spaulding Creek: Sample #4767 (n=2)

Only two trout were collected from Spaulding Creek. Both fish were definitely of hybrid origin between rainbow and Yellowstone cutthroat trout with hybrid indices calculated using only the Yellowstone cutthroat trout alleles at the rainbow and Yellowstone markers of four and five.

Sourdough Creek: Sample #3361 (n=3)

Alleles characteristic of both rainbow and Yellowstone cutthroat trout were detected at 13 of the 14 diagnostic loci between these fishes that were analyzed in the sample from Sourdough Creek. The allele frequencies were statistically homogeneous (X213=10.628; P>0.50) among the diagnostic loci but, the Yellowstone cutthroat trout alleles were not randomly distributed (X 212=346.963; P<0.001) among the fish in the sample. All of the fish in the sample, however, were definitely of hybrid origin between rainbow and Yellowstone cutthroat trout. At Omy0004*, two copies of the 77allele were detected in the sample. This allele is usually characteristic of Westslope Cutthroat Trout and its presence, therefore, suggests that at least some of the fish in Sourdough Creek may have a minor Westslope Cutthroat Trout genetic contribution. Thus, considering all the data Sourdough Creek should be considered to contain hybridized fish with a substantial rainbow and Yellowstone cutthroat trout genetic contribution and a minor contribution from Westslope Cutthroat Trout.

Twin Lake: Sample: #3099 (n=25)

PINE fragments characteristic of Yellowstone cutthroat trout were detected in the sample at all four diagnostic loci for this fish that were analyzed. PINE fragments characteristic of rainbow trout were also detected in the sample at all six of the diagnostic loci for this fish that were analyzed. Finally, PINE fragments characteristic of Westslope Cutthroat Trout were also detected in the sample at both of the diagnostic loci for this fish that were analyzed. The Yellowstone cutthroat trout fragments appeared to be randomly distributed (chi-square; P>0.025) among the fish in the sample, but the rainbow trout fragments were not as significantly (chi-square; P<0.001) more fish lacked rainbow trout fragments or possessed them at all diagnostic loci than expected by chance. This suggests the lake may be inhabited by two somewhat reproductively isolated populations both of which are hybridized. One population may have a predominant rainbow trout genetic contribution and the other a significant westslope and Yellowstone cutthroat trout genetic contribution. Despite this possibility, since all the fish in the sample were definitely of hybrid origin from a practical perspective the lake should simply be considered to possess a hybridized population of westslope cutthroat, Yellowstone cutthroat, and rainbow trout.

Meadow Lake: Sample #3279 (n=3)

All three individuals in the sample possessed PINE fragments usually characteristic of rainbow trout at all six diagnostic loci analyzed that usually distinguish rainbow from Westslope Cutthroat Trout. At two of the seven diagnostic loci analyzed that usually distinguish Westslope Cutthroat Trout from rainbow trout, one fish in the sample possessed a PINE fragments characteristic of Westslope Cutthroat Trout. This fish, therefore, was almost certainly a later than first generation hybrid between rainbow and Westslope Cutthroat Trout. Because of the small

sample size, it is not possible for us to reliably determine whether or not the Meadow Lake population appears to be a hybrid swarm between westslope cutthroat and rainbow trout. Regardless of this statistical problem, the population clearly is not native Westslope Cutthroat Trout and from a management perspective it should be considered to be hybridized with a predominant (98%) rainbow trout genetic contribution.

Parker Lake: Sample #3098 (n=26)

All of the fish in this sample possessed PINE fragments characteristic of Yellowstone cutthroat trout at two or more of the four diagnostic loci for this fish that were analyzed. PINE fragments characteristic of rainbow trout were also detected in the sample at five of the six diagnostic loci for this fish that were analyzed. Finally, PINE fragments characteristic of Westslope Cutthroat Trout were detected in the sample at both of the diagnostic loci for this fish that were analyzed. Neither the Yellowstone cutthroat nor the rainbow trout fragments were randomly distributed among the fish in the sample. Significantly (chi-square; $P<0.001$) more fish possessed Yellowstone cutthroat trout fragments at all the diagnostic loci analyzed and significantly fewer fish lacked or possessed a Yellowstone cutthroat trout fragment at only one locus than expected by chance. Likewise, significantly (chi-square; $P<0.001$) more fish possessed rainbow trout fragments at four or five diagnostic loci and significantly fewer possessed them at only one or two diagnostic loci than expected by chance. Thus, although this population definitely contains individuals of hybrid origin among Yellowstone cutthroat, westslope cutthroat, and rainbow trout it does not appear to be a hybrid swarm. In contrast, the fish in the sample tend to have a higher Yellowstone cutthroat trout or rainbow trout genetic contribution than expected in a hybrid swarm. This suggests that the lake may be inhabited by two somewhat reproductively isolated populations both of which are hybridized. Despite this possibility, from a practical perspective the lake should simply be considered to contain a hybridized population with a predominant Yellowstone cutthroat trout and a relatively minor westslope cutthroat and rainbow trout genetic contribution.

Appendix C.: eDNA

Environmental DNA sampling for detection of rainbow trout in the North Fork of the Blackfoot River by Montana Fish, Wildlife and Parks

by

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Introduction

Environmental DNA (eDNA) is DNA extracted from an environmental sample, such as soil, water, or air, without directly sampling the target organism (Lodge et al. 2012; Taberlet et al. 2012). Researchers have demonstrated that detection of target organisms using eDNA can be more sensitive, efficient, and cost-effective than traditional sampling methods, particularly when the organism of interest has a limited distribution or is rare (Dejean et al. 2012). For example, the eDNA-based detection probability of a single trout in 100 m of stream is ~0.85, substantially greater than that of electrofishing (Wilcox et al. *in review*). As a result, eDNA sampling has received a great deal of attention for its potential to detect early invasions of nonnative species (Darling and Blum 2007; Dejean et al. 2012; Ficetola et al. 2008; Goldberg et al. 2013; Jerde et al. 2011) and the presence and distribution of rare native species (Goldberg et al. 2011; Olson et al. 2012; Thomsen et al. 2012; McKelvey et al. in press) such as species currently listed under the U.S. Endangered Species Act. In addition, it also shows promise for detecting individuals of nonnative species that may remain after chemical or mechanical treatments to remove them.

Rainbow trout (*Oncorhynchus mykiss*) are native to the western half of North America from California to Alaska, and inland to Idaho, Oregon, Washington, and a small portion of Montana. This species has also been widely introduced outside its native range. Where rainbow trout and inland cutthroat trout (*O. clarkii)* co-occur, hybridization is often observed. Hybridization with introduced rainbow trout has led to population decline and loss for several subspecies of cutthroat trout. As a result, managers wishing to establish genetically pure populations of cutthroat trout in a stream may start by attempting to eradicate rainbow trout and hybrid fish. Determining when eradication has

been successful, however, is difficult and often relies on repeating the removal effort. Because chemical or mechanical treatments are expensive and time-consuming, an alternative method for determining the success of removal efforts is desirable. We hypothesize that eDNA sampling could be that alternative.

Methods

Supplies and equipment for eDNA sample collection were delivered to Montana Fish, Wildlife and Parks on 2 September 2015. Samples were collected by Montana Fish Wildlife & Parks between 3 September and 1 October 2015 to evaluate the presence of rainbow trout in the North Fork Blackfoot River watershed, Montana. Samples were collected by pumping 5 L of stream water through a glass filter (GE HealthCare) using a peristaltic pump (GeoTech Environmental Equipment, Inc.) following the protocol developed by Carim et al. (2015). Used filters were placed in plastic bags with silica desiccant and packaged in individual envelopes labeled with field information (e.g., date and sampling location).

Sampling locations for eDNA were spread throughout the North Fork Blackfoot River watershed within the Scapegoat Wilderness (Figure 7-1). Each station was assigned a numeric identifier (Figure 7-2 and Figure 7-3).

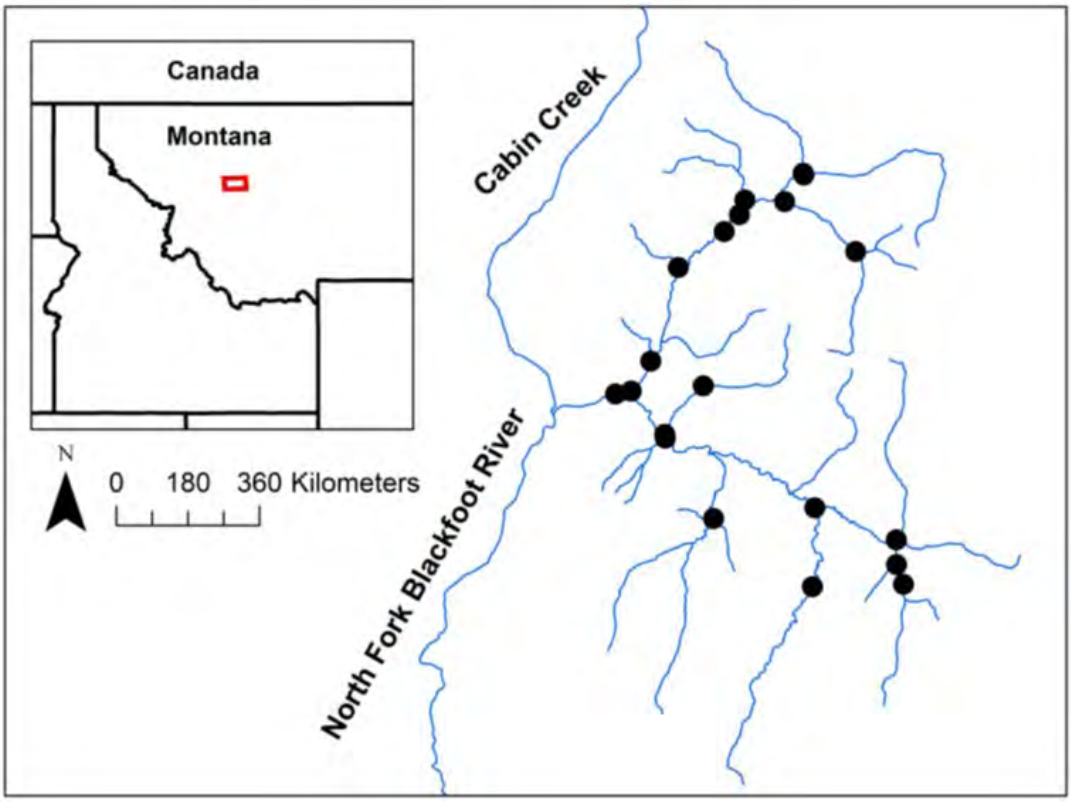

Figure 7-1. Overview of eDNA sampling locations.

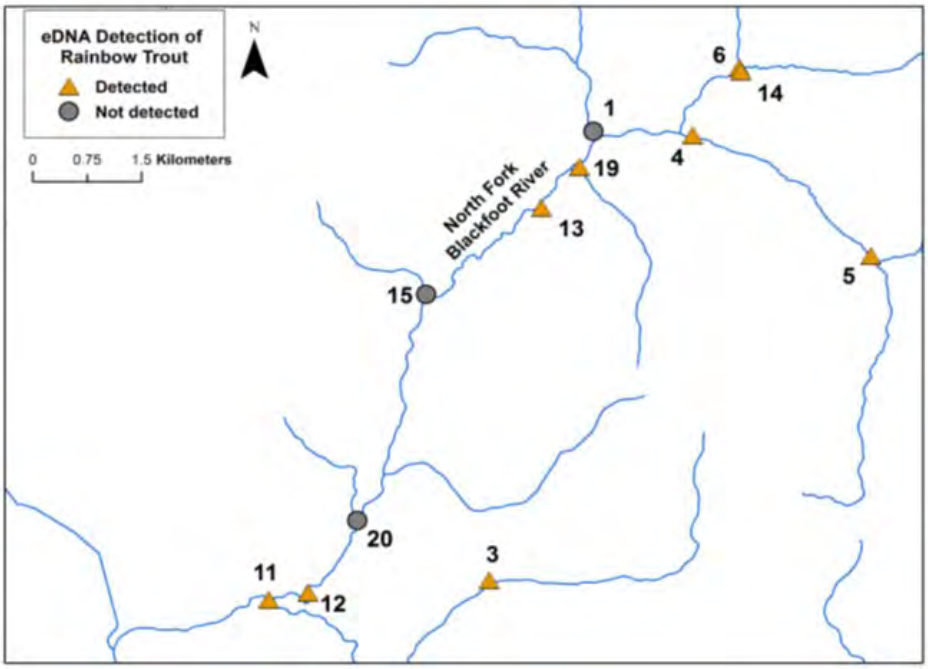

Figure 7-2. eDNA sampling sites and numeric identifiers for the North Fork Blackfoot River and its tributaries, excluding the East Fork North Fork Blackfoot River.

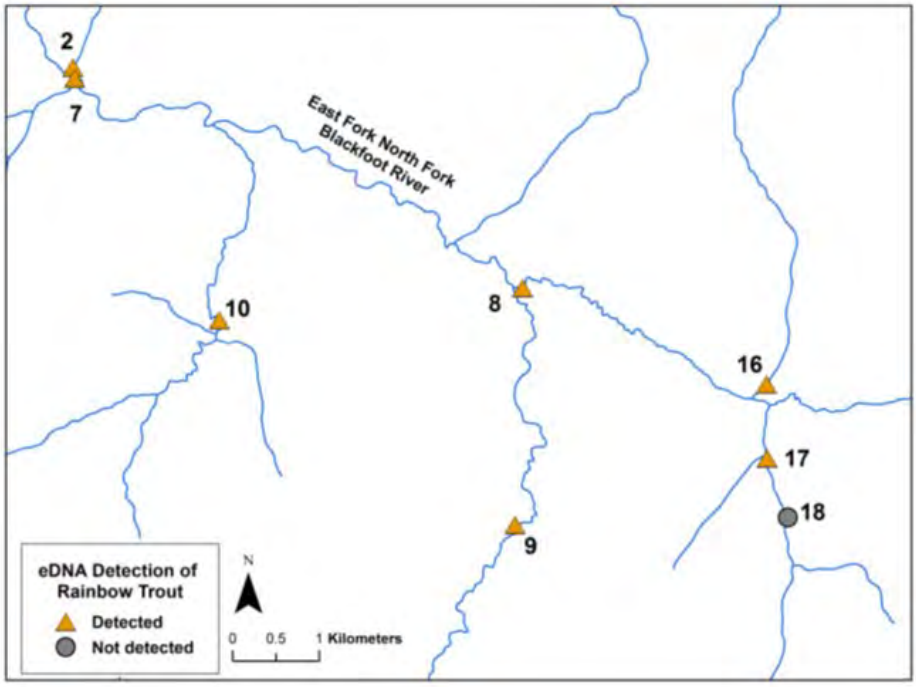

Figure 7-3. eDNA sampling sites and numeric identifiers for the East Fork North Fork Blackfoot River and its tributaries.

Upon receipt of samples at the National Genomics Center for Wildlife and Fish Conservation (NGCWFC), sampling data were catalogued, and samples were stored at -20 °C until analyzed. We extracted DNA from half of the sample filter using the Qiagen DNEasy® Blood and Tissue Kit with a modified protocol adapted from Goldberg et al. (2011). The other half of the sample filter was stored at -20 °C and retained for future analysis.

Samples were analyzed for the presence of rainbow trout using the RBT quantitative PCR (qPCR) assay developed at the NGCWFC (Wilcox et al. 2015). Each sample was analyzed in triplicate with a qPCR instrument. A sample was considered positive for the presence of rainbow trout if at least one of the three PCR reactions amplified rainbow trout DNA (see supplement below). The number of triplicate PCR reactions for each sample that amplified was used as a rough estimate of relative DNA concentration i.e., samples with amplification in all three reactions usually have more DNA than those with amplification in only one reaction.

All reactions included an internal positive control to ensure that the reaction was effective and sensitive to detection of rainbow trout DNA. If the internal positive control was inhibited i.e., DNA amplification was delayed or suppressed (Figure S2), we treated the sample with an inhibitor removal kit (Zymo Research) and re-analyzed the sample in triplicate. All laboratory experiments were conducted with negative controls to ensure that there was no contamination during DNA extraction or qPCR setup.

Results and Discussion

No samples showed evidence of inhibition during qPCR analysis. Rainbow trout DNA was detected in 16 of 20 field samples (Table 5). Additionally, rainbow trout eDNA was detected at all 12 locations where the species has been observed during previous electrofishing surveys and an additional four locations in Camp, Cooney, Mineral and Theodore Creeks where they had not been previously observed.

Table 5. Results of eDNA sampling for sampling stations corresponding with numeric identifiers in Figure 7-2 and Figure 7-3.

	Stream	Collection date	Latitude	Longitude	Rainbow detected electrofishing?	Rainbow eDNA detected?	# Rainbow positive reactions
1	Broadus Creek	9/30/2015	47.25840	-112.83279	N	N	0
2	Camp Creek	9/5/2015	47.19995	-112.84816	N	**Y**	**3**
3	Camp Creek	9/5/2015	47.18434	-112.86488	Y	**Y**	**3**
4	Cooney Creek	9/30/2015	47.24381	-112.78121	N	**Y**	**1**
5	Cooney Creek	10/1/2015	47.25840	-112.81465	Y	**Y**	**3**
6	Dobrota Creek	9/30/2015	47.26740	-112.80672	Y	**Y**	**3**
7	E. F. North Fork Blackfoot River	9/5/2015	47.18321	-112.86454	Y	**Y**	**3**
8	E. F. North Fork Blackfoot River	9/4/2015	47.16347	-112.79491	Y	**Y**	**3**
9	Meadow Creek	9/4/2015	47.13887	-112.79452	Y	**Y**	**3**
10	Mineral Creek	9/5/2015	47.15880	-112.84092	N	**Y**	**3**
11	North Fork Blackfoot River	9/6/2015	47.19629	-112.88811	Y	**Y**	**3**
12	North Fork Blackfoot River	9/6/2015	47.19739	-112.88104	Y	**Y**	**3**
13	North Fork Blackfoot River	9/30/2015	47.24827	-112.84164	Y	**Y**	**3**
14	North Fork Blackfoot River	9/30/2015	47.26690	-112.80636	Y	**Y**	**3**
15	Sarbo Creek	9/30/2015	47.23647	-112.86195	N	N	0
16	Scotty Creek	9/3/2015	47.15455	-112.75713	Y	**Y**	**3**
17	Sourdough Creek	9/3/2015	47.14083	-112.75302	N	N	0
18	Sourdough Creek	9/3/2015	47.14688	-112.75656	Y	**Y**	**2**
19	Theodore Creek	9/30/2015	47.25372	-112.83504	N	**Y**	**3**
20	Un-named tributary	9/30/2015	47.20696	-112.87268	N	N	0

Although eDNA detection is generally more sensitive than traditional methods, it may still fail to detect an organism that is present. A variety of factors influence the detection and abundance of DNA in an environmental sample. For example, greater animal abundance and sampling proximity may increase probability of detection. Furthermore, eDNA production rate may vary with life history stage (e.g., high production during the breeding season; McKelvey et al. in press; Turner et al. 2014). Environmental DNA degradation is also influenced by factors such as water temperature and UV exposure (Pilliod et al. 2014). Additionally, some types of chemical compounds naturally found in streams may inhibit laboratory detection of eDNA (Jane et al. 2014). Field and laboratory methods can also influence eDNA detection (Renshaw et al. 2014).

Because eDNA techniques detect an organism's DNA and not the organism itself, the precise nature of what is being detected must be inferred. A single migrant, for example, can produce a positive detection. This, along with occurrence of false negative detections, can be resolved through repeated sampling. The probability of receiving a false negative result will decline exponentially with multiple sampling visits across time. Furthermore, populations will produce repeated, positive detections in a basin, whereas individual migrants produce local and ephemeral detections.

Conclusions

Given the present methods, our interpretation of these results is that one or more rainbow trout were present upstream from those locations with positive detections. Locations in which rainbow trout eDNA was not detected may have lacked rainbow trout, or this species may have been present in low numbers or at some distance upstream from the sampling point. If you have any questions about the results or wish for help interpreting these data, please contact us. We look forward to working with you in the future.

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* Indicates publications from the National Genomics Center for Wildlife and Fish Conservation.

Supplement

In a quantitative PCR reaction, light is emitted when DNA from a target species is present. This light is captured by the PCR instrument and plotted on a figure to help visualize the amount of DNA present in a sample (Figure S1). PCR is performed in cycles, wherein the amount target DNA (and thus fluorescence) is doubled with each cycle. Fluorescence will occur at an earlier cycle when there is more DNA present in a sample. If target DNA is not present in a sample, there will be no fluorescent light emitted during the qPCR reaction. 20 25 30 35 40 45 0 1 2 3 4 Cycle DRn Detected- Higher Amount of DNA Detected- Lower Amount of DNA Not Detected

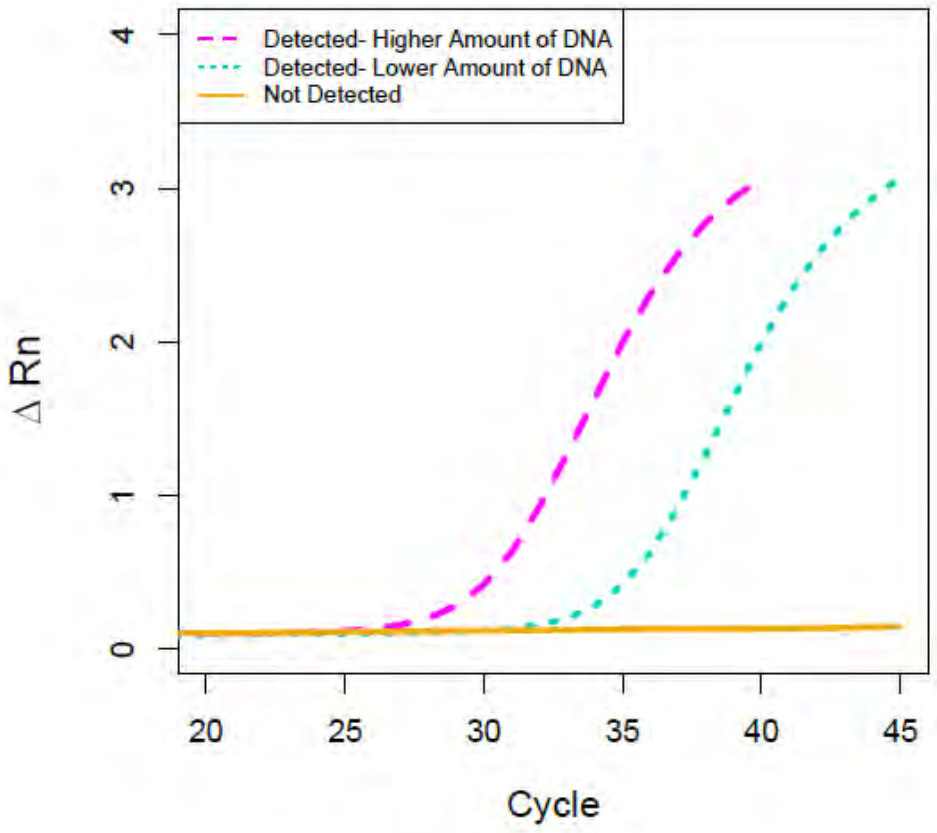

Figure S1. Amplification plot showing the change in normalized fluorescence (ΔRn) versus PCR cycle. When DNA from the target species is present, there is an increase in the amount of fluorescence (pink and blue dashed lines). Conversely, when there is no target DNA present in the sample, there is no increase in fluorescence above background levels (solid yellow line).

Each sample is also run with an internal positive control (IPC). The IPC is a separate, smaller reaction that is added to each sample, and used to determine if inhibitors are present in the sample that might alter our ability to detect DNA from the target species. In water samples, these inhibitors may be tannins or other compounds that lower the pH of water. If inhibition is detected in a sample (Figure S2), it is treated to remove inhibitors and re-analyzed with qPCR.

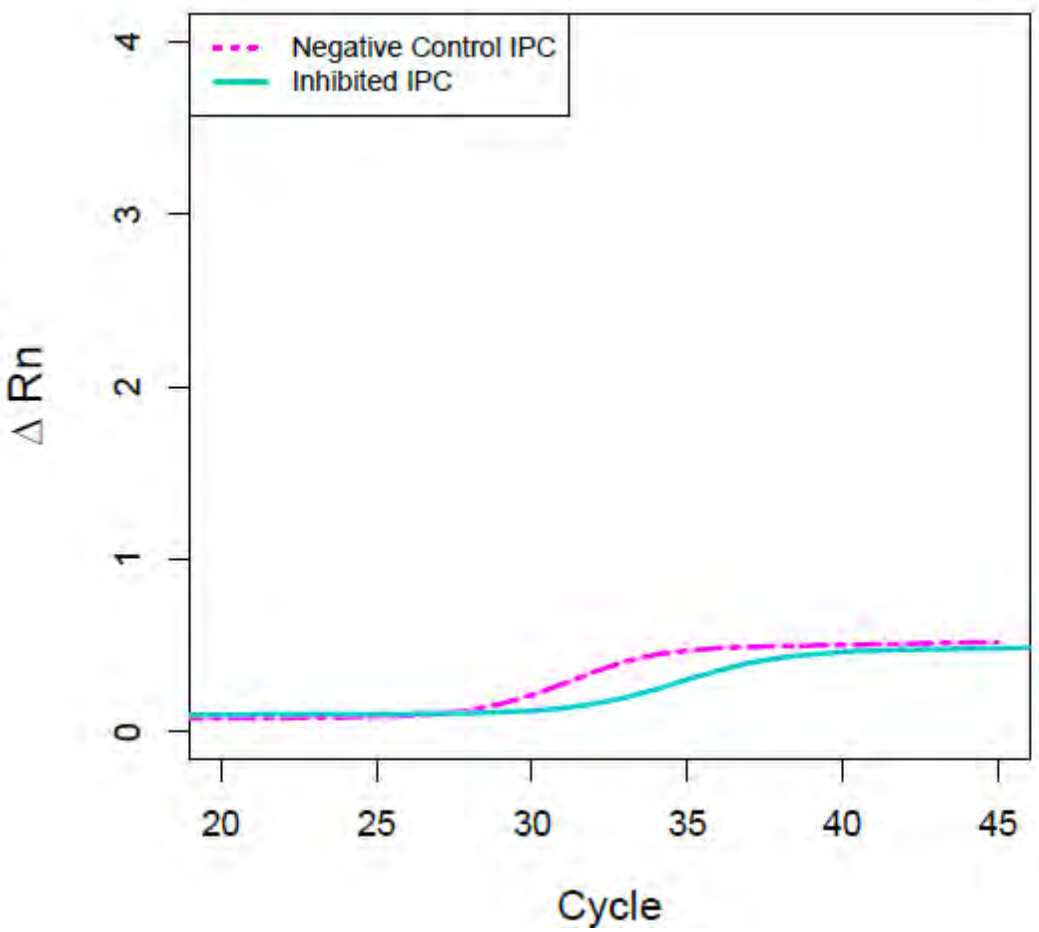

Figure S2. Amplification plot showing the change in normalized fluorescence (ΔRn) versus PCR cycle for the IPC reaction. When inhibitors are present in a sample, the IPC curve will be shifted compared to the negative control.

Appendix D. : Macroinvertebrate and Amphibian Surveys upstream of the North Fork Falls

by
David Stagliano
Montana Natural History Program
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Lindsey Gilstrap and Trevor Selch
Montana Fish, Wildlife & Parks

We conducted a series of macroinvertebrate and amphibian surveys to thoroughly inventory aquatic communities. These surveys overlapped with fisheries survey sites and relied on methodologies developed with Montana Natural Heritage Program (amphibians) and Environmental Protection Agency (macroinvertebrates and habitat assessments).

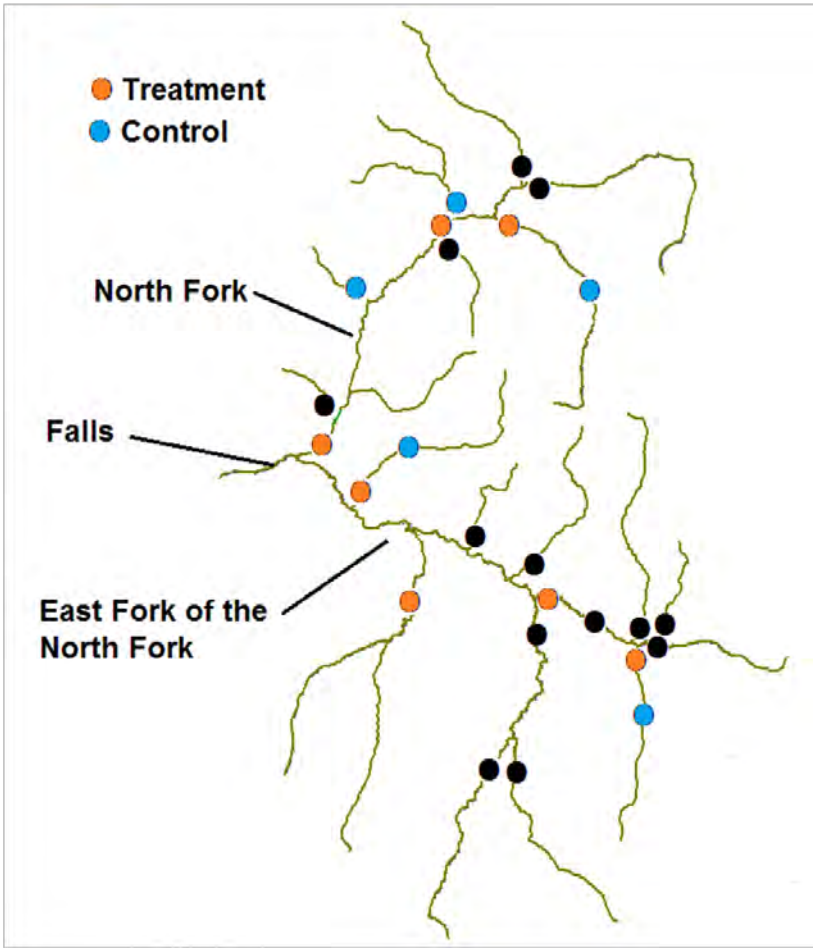

Figure 1. Location map showing the 25 macroinvertebrate and amphibian survey sites. The blue dots show possible controls sites (non fish-bearing streams) and the red dots show treatment sites (fish bearing streams) associated with monitoring.

Study Area and Methods

Aquatic communities (amphibians and macroinvertebrates) were inventoried and assessed upstream of the North Fork Falls in 2013, 2014 and 2015 (Figure 1) using a combination of MT Natural Heritage Program (amphibians), MT Department of Environmental Quality and Environmental Protection Agency (macroinvertebrates and habitat assessments) protocols and methodology. In addition to

Photo 1. David Stagliano collecting macroinvertebrates with a Surber sampler, September 2013.

inventories, data were collected in a manner that enables a BACI and upstream/downstream comparison that could apply to a possible rotenone treatment (Figure 1).

Amphibian Surveys

We conducted opportunistic, visual encounter surveys (VES) along at least 75 meters of the riparian area of the banks of each stream reach visited. This involved walking the high-water mark of the banks flipping over cover objects (trees, flat rocks) and visually identifying and counting the species observed. Rocky mountain tailed frog, *Ascaphus montanus* (ASMO) larvae and adults were collected with the macroinvertebrate net during the riffle sampling or reported during the electrofishing surveys. When collected in the macroinvertebrate surber sampler, ASMO densities were calculated to individuals per m^2. ASMO were counted and released before sample preservation, except one voucher specimen per stream kept in 95% ETOH for DNA analysis.

Macroinvertebrate Collection and Analysis

A semi-quantitative, standardized macroinvertebrate sampling method was used for collecting aquatic benthic communities within the North Fork Blackfoot River study area. The EPA EMAP Targeted Riffle Protocol (8 composited Surber samples, area sampled = 0.744 square meter) was used to sample three riffle habitat areas within the designated sampling reach (Lazorchak 1998, Peck et al. 2003) (Figure 1). To reduce seasonal macroinvertebrate variation, these samples were collected within the MDEQ recommended summer sampling time-frame (June 21 to October 1) (Richards 1996). Samples are preserved with 95% ethanol in 1-liter Nalgene™ bottles and processed (sorting, identification and data analysis) at the Helena Stag Benthics laboratory following standardized protocols (MDEQ 2012). Macroinvertebrates were identified to the genus/species taxonomic level, counted and entered into spreadsheets and database forms. Data analysis included computation of indices of community structure, such as the total number and proportion of EPT taxa (Ephemeroptera, Plecoptera and Trichoptera) in the sample and other biological metrics used in calculating the MDEQ multimetric indices (MMI) (Jessup et al. 2005, Feldman 2006). Metric results were then scored using the MT DEQ bioassessment criteria and

each sample categorized as non-impaired or impaired according to mountain stream threshold values of >63. The macroinvertebrate MMI score is based upon a series of metrics that measure attributes of benthic macroinvertebrate communities regarding condition changes to a stream system (in the form of pollution or pollutants). The index score represents the condition of the macroinvertebrate community at the time the sample was collected within that past year. If the index score is below the impairment threshold, the individual metrics can be used to provide insight as to why the communities are different from the reference condition (Barbour et. al 1999, Jessup et. al. 2005). We calculated Shannon's Diversity Index (H') for each sample as a measure of initial species diversity at a site prior to piscicide treatment. According to some studies, high diversity at a site have H' values >2.5 to >3 (Hill 1973, Jost 2006). We analyzed metrics of the macroinvertebrate data using a one-way ANOVA and the Percent Similarity Index as the comparison of macroinvertebrate communities, taxa richness and tolerance values between years and control or treatments (0). Differences were considered significant at p values less than 0.05.

RESULTS

Amphibian Results Summary

We documented the presence of three amphibian species across the 25 stream sites (Table 6). In order of frequency of occurrence; the Rocky Mountain Tailed Frog, *Ascaphus montanus* (ASMO) was detected during 63% of site visits, Columbia Spotted Frog, *Rana luteiventris* (RALU) detected at 20% of site visits overall (45% at 2013 sites, one reported in 2014), and the Western Toad, *Anaxyrus boreas* (BUBO) detected at 6% of sites (18% of 2013 sites, none reported in 2014) (Pierce et al. 2015). Only adults of the spotted frog and Western Toad were observed in the stream surveys. The Western Toad is a MT SOC and a USFS sensitive species with a substantial confirmed breeding area at Lower Twin Lake and potentially at Meadow and Parker Lakes (Pierce et al. 2015). These lakes also provide Columbia Spotted Frog breeding habitats within the EF NF Blackfoot River sub-basin. A wetland complex in upper Sarbo Creek and South Creek may provide some of the only amphibian breeding habitat in the NF Blackfoot basin. The number of amphibian species and the densities of ASMO larvae/adults were higher at sites in south facing drainages compared to the northerly facing drainages (Pierce et al. 2015). We observed significantly higher densities of ASMO in the treatment stream reaches (average ~3 per m^2, n=25) compared to the control stream sites (average 0.9 per m^2, n=7) (ANOVA, p=0.04). Four of the treatment streams (Blondie, Dobrota, Lost Pony and Scotty Creeks) had high densities of ASMO, averaging 9.3 per m^2. We incidentally observed Long-toed Salamander larvae, *Ambystoma macrodactylum* in the outlet wetland area of Lower Twin Lake in 2013 indicating a breeding area.

Macroinvertebrate Communities Summary

Overall, 124 unique invertebrate taxa were reported from 32 EMAP Targeted-riffle samples collected from 25 sites in 18 streams in 2013, 2014 and 2015 (Appendix E). No Montana invertebrate species of concern (SOC) were documented within the NF Blackfoot River basin, although some stonefly taxa which can only be identified to genus (*Suwallia* and *Isoperla)* or species group *(Zapada oregonensis gr.*), without examining the adults, have the potential to contain SOC species (Appendix E). The Nemourid stonefly, *Zapada frigida*, is a rarely-collected, but not state-listed, taxa that was documented at five sites, Cooney (Upper and Lower), Dobrota, East Fork Meadow and Spaulding Creeks. In 2013, the East Fork North Fork Blackfoot reported a rare and recently described (Zloty et al. 2005) dipteran species, *Oreolepsis torrenticola*. Macroinvertebrate taxa richness per site averaged 31.6 taxa in 2013, 37.2 in 2014 and 37.3 in 2015, which is lower than expected for reference condition streams in the Rocky Mountain ecoregion (40 taxa; Whittier et al. 2006), although previous MT studies have placed this threshold at >28 taxa (Bukantis 1996). EPT taxa richness per sample averaged 20.6 (2013), 23.4 (2014) and 25.3 (2015); this is slightly above the threshold expected for non-impacted, mountain streams (>19 taxa; Bukantis 1996), but lower than other least disturbed mountain streams (26 EPT taxa; Whittier et al. 2006) (Table 1). When samples from multiple years were collected from the same site, the cumulative EPT richness was always at or above the 26-taxon threshold, except at the Sourdough treatment site (Table 1). Average % EPT across sites (74.1%, 2013; 77.9% in 2014 and 78.1% in 2015) is above reference condition threshold values (>70%, Bukantis 1996) and therefore, stream assemblages are considered un-impaired.

Table 6. Results of select parameters for macroinvertebrate communities and Rocky Mountain Tailed Frog presence at sampling sites in the North Fork Blackfoot River planning area.

Stream	River Mile	BACI Treatment	BACI Control	Drain Aspect	Total Ind. sample	Number per m^2	Total Taxa	EPT Taxa	H'	MMI	% EPT	ASMO per m^2
Blondie Creek	0.2	08/05/13		S	664	883	25	16	2.72	79.6	63.9	8.0
Broadus Creek	0.1	08/28/14		S	772	1027	26	21	2.75	85.9	91.7	2.7
Broadus Creek U/S falls	0.15		09/30/15	S	804	1005	29	25	2.83	92.7	97.1	4.0
Camp Creek	0.1	09/05/15		W	2704	3380	39	25	2.74	86.8	81.9	0.0
Camp Creek	1.6		09/05/15	W	840	1050	35	25	3.13	90.1	83.0	1.3
Cooney Creek	0.2	08/27/14		N	1216	1617	40	23	3.13	78.5	75.0	2.7
	0.2	10/01/15		N	1136	1420	38	24	3.27	85.3	78.9	1.3
				avg.	**1176**	**1519**	**46(T)**	**29(T)**	**3.20**	**81.9**	**77.0**	**2.0**
Cooney Creek	2.4		09/30/15	N	1416	1770	29	23	2.78	92.9	83.5	1.3
Dobrota Creek	0.1	08/28/14		S	2008	2671	50	31	3.01	82.3	79.3	9.3
EF NF Blackfoot River	7	08/08/13		EW	920	1224	33	19	2.86	69.6	49.8	4.0
	7	09/04/15		EW	1236	1545	39	26	2.97	84.8	68.2	1.3
				avg.	**1078**	**1385**	**49(T)**	**27(T)**	**2.92**	**77.2**	**59.0**	**2.7**
EF NF Blackfoot River	9	08/06/13		EW	876	1165	28	19	2.71	83.9	75.3	2.7
Lost Pony Creek	0.8	08/08/13		S	1476	1963	32	24	3.06	85.5	73.2	9.3
Meadow Creek	2	08/07/13		N	1564	2080	34	15	2.76	75.5	61.4	0.0
Meadow Creek	5.2	08/07/13		N	668	888	31	22	2.72	81.2	85.6	5.3
Meadow Creek (EFork)	0.8	08/07/13		N	992	1319	34	26	2.73	89.3	92.3	6.7
Mineral Creek	2.1	09/05/15		NE	2406	3008	44	28	2.99	82.1	70.4	0.0
NF Blackfoot River	27	08/27/14		EW	968	1287	42	25	3.13	70.2	50.8	1.3
	27	09/06/15		EW	1392	1740	49	31	3.23	86.7	66.8	0.0
				avg.	**1180**	**1514**	**51 (T)**	**32(T)**	**3.18**	**78.45**	**58.8**	**0.7**
NF Blackfoot River	32	08/28/14		EW	3096	4118	49	29	3.16	86.9	80.4	1.3
	32	09/30/15		EW	2512	3140	47	31	3.44	88.5	68.5	0.0
				avg.	**2804**	**3629**	**66 (T)**	**40(T)**	**3.30**	**87.7**	**74.5**	**0.7**
NF Blackfoot River	34.7	08/28/14		EW	4016	5341	39	25	1.86	86.2	80.7	0.0
Sarbo Creek	0.1		08/27/14	S	2012	2676	37	23	3.06	82.3	75.4	0.0
	0.1		09/30/15	S	1608	2010	39	24	3.21	84.6	79.4	0.0
				avg.	**1810**	**2343**	**43 (T)**	**26(T)**	**3.14**	**83.45**	**77.4**	**0.0**
Scotty Creek	0.2	08/06/13		S	2176	2894	34	18	3.15	76.3	51.1	10.6
Sourdough Creek	0.6	08/06/13		N	1488	1979	35	21	2.41	84.3	94.1	0.0
	0.6	09/03/15		N	1398	1748	30	25	2.53	83.3	91.8	1.3
				avg.	**1443**	**1863**	**37 (T)**	**26(T)**	**2.47**	**83.8**	**93.0**	**0.7**
Sourdough Creek	1		08/05/13	N	784	1043	30	19	2.36	77.4	80.9	0.0
	1		09/30/15	N	1040	1300	29	18	2.59	71.6	68.1	0.0
				avg.	**912**	**1172**	**33 (T)**	**20(T)**	**2.48**	**74.5**	**74.5**	**0.0**
Spaulding Creek	0.1	08/08/13		S	2124	2825	37	28	2.98	84.7	87.9	5.3
Theodore Creek	0.1	08/28/14		N	1024	1362	33	21	2.89	76.7	73.1	1.3
NFBLKFT unnamed trib.	0.1	08/27/14		S	964	1282	20	13	1.82	73.4	95.0	0.0

Only Blondie Creek, EF NF Blackfoot and the North Fork Blackfoot samples reported % EPT scores below this 70% impairment threshold but were still ranked unimpaired with the DEQ MMI scores (Table 6). Macroinvertebrate densities (number per m^2) were similar among most sites in the NF Blackfoot basin, averaging ~1,000-2,000 individuals per m^2, but some sites in the NF Blackfoot mainstem and lower Camp Creek had significantly higher densities >3,000-5,000 individuals per m^2 (Table 6). Average Shannon's Diversity, MT DEQ MMI index and %EPT were similar between sites in both basins (Table 1). All samples were ranked unimpaired with the MT DEQ MMI (scores >63 threshold) and, in fact, all samples have scores greater than 70, and 75% of the samples have high scores >80 (Table 1, Appendix E). Most sites ranked high in diversity with Shannon's (H') >2.7, except Sourdough Creek (H'=2.5), and one site on the NF Blackfoot River (Table 1). The most diverse communities measured with Shannon's Index (H') were NF Blackfoot River sites (RM 27 and 32), Cooney and Sarbo Creeks with scores ≥ 3.2 (Table 6). Highest taxa richness reported from a single sample was at Dobrota Creek with 50 taxa, followed by the NF Blackfoot River sites at RM32 and RM27 with 49 unique taxa each, but the cumulative taxa richness from 2 years of sample data at these NF Blackfoot mainstem sites was 66 and 51 total taxa, respectively (Table 6). Interestingly, despite the NF Blackfoot River RM32 site gaining 17 additional taxa with the 2015 sample, only nine additional taxa were added with the second sample at the NF Blackfoot River RM27 (Table 6). EF North Fork Blackfoot River RM 7 site also gained 10 additional taxa with the second sample taken in 2015.

Macroinvertebrate Community Similarity

Percent taxa similarity between control and treatment sites (n=5 pairs) averaged 64.5% (47.5-80.6%), while taxa similarity between years at the same site (n=7 pairs) was only slightly higher at 68% (49-78.8%) (Appendix E). There is no difference between taxa similarity at control vs. treatment sites compared to between years at the same site (ANOVA, p=0.32). Between year average % taxa similarity at the sites (n=7) was lowered because of the low taxa numbers shared between samples from the EF NF Blackfoot and NF Blackfoot Rivers (Table 2, Appendix E). These mainstem sites continued to add large numbers of new taxa to the site's assemblage list with a second sample from 2015. Percent whole community similarity between control and treatment was lower at 52.6% (40.5-69.9%) compared to a between year similarity of 62.4% (53.1-70%) (Table 2); this was significantly different (ANOVA, p=0.03).

Table 7.. Percent taxa similarity and macroinvertebrate community similarity indices between years and Control vs. Treatment sites.

Stream	River Mile	Treatment	Control	% Taxa Similarity	% Commun. Similarity
Broadus Creek	0.1	08/28/14		80.6	49.6
Broadus Creek U/S falls	0.15		09/30/15		
Camp Creek	0.1	09/05/15		80.5	65.4
Camp Creek	1.6		09/05/15		
Cooney Creek	0.2	08/27/14		69.6	69.9
Cooney Creek	0.2	10/01/15			
Cooney Creek	2.4		09/30/15	60.0	52.1
EF NF Blackfoot River	7	08/08/13		49.0	57.9
EF NF Blackfoot River	7	09/04/15			
NF Blackfoot River	27	08/27/14		76.5	53.1
NF Blackfoot River	27	09/06/15			
NF Blackfoot River	32	08/28/14		50.0	55.9
NF Blackfoot River	32	09/30/15			
Sarbo Creek	0.1		08/27/14	76.7	67.7
Sarbo Creek	0.1		09/30/15		
Sourdough Creek	0.6	08/06/13		75.7	70.0
Sourdough Creek	0.6	09/03/15			
Sourdough Creek	1		08/05/13	78.8	62.4
Sourdough Creek	1		09/30/15		
Sourdough Creek		2015 Treat x Control		52.4	55.5
Sourdough Creek		2013 Treat x Control		47.5	40.5

Conclusions

We documented macroinvertebrate communities high in diversity and biological integrity in 18 streams across both sub-basins of the NF Blackfoot River study. With the 2015 sampling revisits at 7 sites, we continued to add substantial numbers of taxa to the cumulative taxa richness (up to 17 additional spp. per site for the NF Blackfoot River). We can conclude that for the mainstem North Fork Blackfoot River and the East Fork NF Blackfoot sites, we are not close to approaching the asymptote for total macroinvertebrate species richness documented at a site with only 2 years of data. No Montana invertebrate species of concern (SOC) were documented over the three years of sampling within the NF Blackfoot River basin. Although, we did collect some stonefly taxa (*Isoperla* and *Zapada*) which can only be identified to genus (without examining the adults) that have the potential to contain SOC species. Many fishless control streams with similar macroinvertebrate taxa will remain in the basin that could provide a means for macroinvertebrate populations to recolonize rotenoned stream sections. Most control reaches shared, on average, ~65% of the taxa present in the treatment reaches resembling the % taxa similarity between yearly samples taken at the same site. Surprisingly though, the control and treatment reaches of

Sourdough Creek are less than a ½ mile apart, but had the most dis-similar macroinvertebrate assemblages, sharing only about 50% of the taxa between the sites. In addition, we observed no tailed-frog larvae in the control reach of Sourdough, while in the treatment reach ASMO larvae averaged 0.7 individuals per m^2.

Following minimum recommended rotenone dosing and treatment duration has been shown to have minimal long-term effects on benthic macroinvertebrate densities or assemblage structure (Vinson et al 2010). Macroinvertebrate communities have recovered up to 90% of the documented pretreatment common taxa after just 1 year post-rotenone treatment; though rare taxa may take multiple years to recover (Vinson et al 2010). Therefore, the judicious use of rotenone throughout the basin will not likely have long-term adverse effects on the macroinvertebrate communities. The Western Toad, a MT SOC and USFS sensitive species, was reported in good numbers at two sites within the East Fork NF Blackfoot Basin and is likely breeding in the fringe wetland areas of Lower Twin Lake, Meadow and Parker Lakes. Fewer amphibian breeding areas exist in the NF Blackfoot Sub-basin, barring a couple of higher elevation wetland areas of Sarbo and South Creeks, where we did not report any additional amphibian species in 2014. Treatment streams proposed for piscicide in this study have higher densities of the Rocky Mountain tailed-frog than the control stream sites. Therefore, the use of rotenone throughout the basin will likely have an adverse effect on the Rocky Mountain Tailed Frog populations occurring in fish-bearing streams. Since the Western Toad and Columbia Spotted Frog are largely using streams for feeding and dispersal (Maxell 2000), proposed treatment will only influence these amphibian populations if those previously mentioned lakes are treated with the piscicide during the breeding season. A late-summer, early fall piscicide treatment to the lakes will avoid the amphibian breeding window. Western Toad tadpoles' metamorphosis to toadlets from mid-July-September (Black and Brunson 1971, Maxell et al 2002); at this point they can avoid the lake areas being treated. Obviously, continued monitoring across these established sites will occur post-treatment to document recovery of the macroinvertebrate communities and Rocky Mountain tailed-frog populations.

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Appendix E.: Benthic Macroinvertebrate Taxa Lists

North Fork Blackfoot River

North Fork Blackfoot River (lower)

Body of Water	North Fork Blackfoot River	Benthic Sample ID:	18178
Station ID:	WS_NFBLF473 (lower)	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E02-T500-M
Rep. Num		Collection Date	8/27/2014
		Collection Method	MAC-T-500
		Total Number	968

Order:	*OTU name:*	*FinalID:*	*Count*	*Tol Val:*	*FFG:*	*Habit:*
Ephemeroptera		*Epeorus longimannus*	48			
Diptera		*Nostoccocladius*	112			
		Thienimannimyia gr.	8			
.	Turbellaria	*Polycelis coronata*	4	4	CG/PR	SP
Coleoptera	Heterlimnius	*Heterlimnius corpulentus*	120	3	SC/CG	"CN/50%, BU/50%"
Diptera	Ceratopogoninae	*Probezzia*	4	6	PR/CG	SP/BU/SW
Diptera	Diamesinae	*Pagastia*	4	4	CG	sp
Diptera	Hexatoma	*Hexatoma*	8	2	PR	BU
Diptera	Orthocladiinae	*Eukiefferiella devonica*	8		CG/SC	SP/BU
Diptera	Orthocladiinae	*Eukiefferiella gracei*	12		CG/SC	SP/BU
Diptera	Orthocladiinae	*Orthocladius*	16		CG/SC	SP/BU
Diptera	Orthocladiinae	*Parakiefferiella*	4		CG/SC	SP/BU
Diptera	Orthocladiinae	*Rheocricotopus*	4		CG/SC	SP/BU
Diptera	Orthocladiinae	*Tvetenia vitracies*	8		CG/SC	SP/BU
Diptera	Pericoma/Telmatos	*Pericoma*	4	4	CG	BU
Diptera	Simuliidae	*Prosimulium*	32	6	CF	CN
Diptera	Simuliidae	*Simulium*	72	6	CF	CN
Ephemeroptera	Ameletus	*Ameletus validus*	4	0	SC	"SW/10%, CN/90%"
Ephemeroptera	Baetis	*Baetis tricaudatus*	88	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Cinygmula	*Cinygmula*	4	0	SC	CN
Ephemeroptera	Epeorus	*Epeorus deceptivus*	16	2	CG	CN
Ephemeroptera	Epeorus	*Epeorus grandis*	60	2	CG	CN
Ephemeroptera	Paraleptophlebia	*Paraleptophlebia*	4	1	CG	SW/CN/SP
Ephemeroptera	Rhithrogena	*Rhithrogena*	20	0	CG	CN
Ephemeroptera	Serratella	*Serratella tibialis*	8	2	CG	CN
Non-Insect ta	Nematoda	*Nematoda*	8	5	unk	BU
Plecoptera	Chloroperlidae	*Sweltsa*	32	1	PR	CN
Plecoptera	Doroneuria	*Doroneuria theodora*	36	0	unk	CN

Plecoptera	Leuctridae	*Despaxia augusta*	8	1	SH	CN
Plecoptera	Megarcys	*Megarcys*	32	1	PR	CN
Plecoptera	Zapada	*Zapada cinctipes*	4	2	SH	CN
Plecoptera	Zapada	*Zapada columbiana*	52	2	SH	CN
Plecoptera	Zapada	*Zapada oregonensis gr.*	4	2	SH	CN
Trichoptera	Cryptochia	*Cryptochia pilosa*	4	3	SC	SP
Trichoptera	Dicosmoecus	*Dicosmoecus atripes*	4	2	SC	SP
Trichoptera	Neothremma	*Neothremma alicia*	4	1	SC	CN
Trichoptera	Parapsyche	*Parapsyche elsis*	48	0	CF	CN
Trichoptera	Rhyacophila betten	Rhyacophila Betteni Gr.	12	1	PR	CN
Trichoptera	Rhyacophila brunn	Rhyacophila Brunnea Gr.	16	0	PR	CN
Trichoptera	Rhyacophila hyalin	Rhyacophila Hyalinata Gr.	24	1	PR	CN
Trichoptera	Rhyacophila sibiric	Rhyacophila narvae	4	0	PR	CN
Trichoptera	Rhyacophila sibiric	Rhyacophila pellisa	4	0	PR	CN

North Fork Blackfoot River (middle)

Body of Water	North Fork Blackfoot River below Broadus Cr.	Benthic Sample ID:	18180
Station ID:	WS_NFBFL481 (middle)	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E06-T500-M
Rep. Num		Collection Date	8/27/2014
		Collection Method	MAC-T-500
		Total Number	774

Order:	***OTU name:***	***FinalID:***	***Count***	***Tol Val:***	***FFG:***	***Habit:***
		Drunella doddsii	6			
		Neophylax splendans	2			
		Nostoccocladius	2			
		Onocomoecus unicolor	2			
	Turbellaria	Polycelis coronata	4	4	CG/PR	SP
Coleoptera	Heterlimnius	Heterlimnius corpulentus	32	3	SC/CG	"CN/50%, BU/50%"
Diptera	Ceratopogoninae	Probezzia	4	6	PR/CG	SP/BU/SW
Diptera	Chelifera_Metachel	Chelifera	2	5	unk	SP
Diptera	Chironominae	Micropsectra	22	7	CG/CF/ PR	BU/CN/SP
Diptera	Chironominae	Stempellina	8	7	CG/CF/ PR	BU/CN/SP
Diptera	Diamesinae	Diamesa	18	4	CG	sp
Diptera	Dicranota	Dicranota	2	0	PR	SP
Diptera	Hexatoma	Hexatoma	10	2	PR	BU
Diptera	Orthocladiinae	Brillia	2		CG/SC	SP/BU
Diptera	Orthocladiinae	Corynoneura	2		CG/SC	SP/BU

Order:	OTU name:	FinalID:	Count	Tol Val:	FFG:	Habit:
Diptera	Orthocladiinae	Eukiefferiella gracei	4		CG/SC	SP/BU
Diptera	Orthocladiinae	Orthocladius	6		CG/SC	SP/BU
Diptera	Orthocladiinae	Parakiefferiella	2		CG/SC	SP/BU
Diptera	Orthocladiinae	Rheocricotopus	2		CG/SC	SP/BU
Diptera	Pelecorhynchidae	Glutops	4	1	PR	SP
Diptera	Pericoma/Telmatos	Pericoma	2	4	CG	BU
Diptera	Simuliidae	Prosimulium	4	6	CF	CN
Ephemeroptera	Baetis	Baetis tricaudatus	26	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Cinygmula	Cinygmula	18	0	SC	CN
Ephemeroptera	Drunella coloraden	Drunella coloradensis	2	1	SC	"CN/75%, SP/25%"
Ephemeroptera	Epeorus	Epeorus deceptivus	50	2	CG	CN
Ephemeroptera	Epeorus	*Epeorus grandis*	6	2	CG	CN
Ephemeroptera	Rhithrogena	*Rhithrogena*	46	0	CG	CN
Ephemeroptera	Serratella	*Serratella tibialis*	8	2	CG	CN
Haplotaxida	Oligochaeta	*Lumbricina*	2	8	CG	BU
Lumbriculida	Oligochaeta	*Lumbriculidae*	8	8	CG	BU
Plecoptera	Chloroperlidae	*Sweltsa*	92	1	PR	CN
Plecoptera	Doroneuria	*Doroneuria theodora*	10	0	unk	CN
Plecoptera	Isoperla	*Isoperla*	16	2	PR	CN
Plecoptera	Leuctridae	*Despaxia augusta*	66	1	SH	CN
Plecoptera	Megarcys	*Megarcys*	36	1	PR	CN
Plecoptera	Visoka	*Visoka cataractae*	4	0	SH	CN
Plecoptera	Yoraperla	*Yoraperla brevis*	14	0	SH	CN
Plecoptera	Zapada	*Zapada columbiana*	136	2	SH	CN
Plecoptera	Zapada	*Zapada oregonensis gr.*	6	2	SH	CN
Trichoptera	Dicosmoecus	*Dicosmoecus atripes*	6	2	SC	SP
Trichoptera	Glossosoma	*Glossosoma*	4	0	SC	CN
Trichoptera	Neothremma	*Neothremma alicia*	2	1	SC	CN
Trichoptera	Parapsyche	*Parapsyche elsis*	16	0	CF	CN
Trichoptera	Rhyacophila betten	*Rhyacophila Betteni Gr.*	16	1	PR	CN
Trichoptera	Rhyacophila brunn	*Rhyacophila Brunnea Gr.*	6	0	PR	CN
Trichoptera	Rhyacophila hyalin	*Rhyacophila Hyalinata Gr.*	8	1	PR	CN
Trichoptera	Rhyacophila sibiric	*Rhyacophila pellisa*	8	0	PR	CN
Trichoptera	Rhyacophila vagrit	*Rhyacophila vagrita*	14	0	PR	CN
Trichoptera	Rhyacophila vofixa	*Rhyacophila vofixa gr.*	6	0	PR	CN

North Fork Blackfoot River (upper)

Body of Water	North Fork Blackfoot River	Benthic Sample ID:	18179
Station ID:	WS_NFBLF478 (upper)	Rep. Num.	0

Reference Status			
Classification		STORET Activity ID	E05-T500-M
Rep. Num		Collection Date	8/28/2014
		Collection Method	MAC-T-500
		Total Count	502

Order:	OTU name:	FinalID:	Count	Tol Val:	FFG:	Habit:
		Drunella doddsii	5			
		Epeorus longimannus	5			
		Thienimannimyia gr.	18			
	Turbellaria	*Polycelis coronata*	4	4	CG/PR	SP
Coleoptera	Heterlimnius	*Heterlimnius corpulentus*	22	3	SC/CG	"CN/50%, BU/50%"
Coleoptera	Optioservus	*Optioservus quadrimaculatus*	1	5	SC	"CN/50%, BU/50%"
Diptera	Chelifera_Metachel	*Chelifera*	1	5	unk	SP
Diptera	Chironominae	*Micropsectra*	16	7	CG/CF/PR	BU/CN/SP
Diptera	Chironominae	*Stempellina*	8	7	CG/CF/PR	BU/CN/SP
Diptera	Dicranota	*Dicranota*	1	0	PR	SP
Diptera	Hexatoma	*Hexatoma*	3	2	PR	BU
Diptera	Orthocladiinae	*Brillia*	3		CG/SC	SP/BU
Diptera	Orthocladiinae	*Orthocladius*	3		CG/SC	SP/BU
Diptera	Orthocladiinae	*Rheocricotopus*	3		CG/SC	SP/BU
Diptera	Pelecorhynchidae	*Glutops*	2	1	PR	SP
Diptera	Simuliidae	*Prosimulium*	2	6	CF	CN
Ephemeroptera	Baetis	*Baetis tricaudatus*	48	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Cinygmula	*Cinygmula*	10	0	SC	CN
Ephemeroptera	Drunella coloraden	*Drunella coloradensis*	1	1	SC	"CN/75%, SP/25%"
Ephemeroptera	Epeorus	*Epeorus deceptivus*	40	2	CG	CN
Ephemeroptera	Epeorus	*Epeorus grandis*	1	2	CG	CN
Ephemeroptera	Rhithrogena	*Rhithrogena*	18	0	CG	CN
Plecoptera	Chloroperlidae	*Sweltsa*	71	1	PR	CN
Plecoptera	Doroneuria	*Doroneuria theodora*	36	0	unk	CN
Plecoptera	Isoperla	*Isoperla*	8	2	PR	CN
Plecoptera	Leuctridae	*Despaxia augusta*	24	1	SH	CN
Plecoptera	Megarcys	*Megarcys*	22	1	PR	CN
Plecoptera	Yoraperla	*Yoraperla brevis*	1	0	SH	CN
Plecoptera	Zapada	*Zapada cinctipes*	2	2	SH	CN
Plecoptera	Zapada	*Zapada columbiana*	56	2	SH	CN
Trichoptera	Glossosoma	*Glossosoma*	2	0	SC	CN
Trichoptera	Micrasema	*Micrasema bactro*	2	1	SH	CN
Trichoptera	Neothremma	*Neothremma alicia*	5	1	SC	CN
Trichoptera	Parapsyche	*Parapsyche elsis*	20	0	CF	CN

Trichoptera	Rhyacophila betten	*Rhyacophila Betteni Gr.*	17	1	PR	CN
Trichoptera	Rhyacophila brunn	*Rhyacophila Brunnea Gr.*	5	0	PR	CN
Trichoptera	Rhyacophila sibiric	*Rhyacophila pellisa*	4	0	PR	CN
Trichoptera	Rhyacophila vagrit	*Rhyacophila vagrita*	7	0	PR	CN
Trichoptera	Rhyacophila vofixa	Rhyacophila vofixa gr.	5	0	PR	CN

Dobrota Creek

Body of Water	Dobrota Creek	Benthic Sample ID:	18177
Station ID:	WS_Dobrota	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E09-T500-M
Rep. Num		Collection Date	8/28/2018
		Collection Method	MAC-T-500
		Total Count	502

Order:	*OTU name:*	*FinalID:*	*Count*	*Tol Val:*	*FFG:*	*Habit:*
		Drunella doddsii	3			
		Epeorus longimannus	3			
		Neophylax splendans	1			
		Nostoccocladius	41			
		Thienimannimyia gr.	3			
.	Turbellaria	Polycelis coronata	2	4	CG/PR	SP
Coleoptera	Heterlimnius	Heterlimnius corpulentus	6	3	SC/CG	"CN/50%, BU/50%"
Diptera	Chelifera_Metachel	Chelifera	1	5	unk	SP
Diptera	Chironominae	Micropsectra	3	7	CG/CF/PR	BU/CN/SP
Diptera	Diamesinae	Diamesa	20	4	CG	sp
Diptera	Diamesinae	Pagastia	5	4	CG	sp
Diptera	Dicranota	Dicranota	1	0	PR	SP
Diptera	Hexatoma	Hexatoma	2	2	PR	BU
Diptera	Orthocladiinae	Brillia	1		CG/SC	SP/BU
Diptera	Orthocladiinae	Corynoneura	1		CG/SC	SP/BU
Diptera	Orthocladiinae	Eukiefferiella gracei	1		CG/SC	SP/BU
Diptera	Orthocladiinae	Orthocladius	3		CG/SC	SP/BU
Diptera	Orthocladiinae	Parakiefferiella	1		CG/SC	SP/BU
Diptera	Orthocladiinae	Rheocricotopus	1		CG/SC	SP/BU
Diptera	Pelecorhynchidae	Glutops	2	1	PR	SP
Diptera	Pericoma/Telmatos	Pericoma	1	4	CG	BU
Diptera	Simuliidae	Prosimulium	2	6	CF	CN
Ephemeroptera	Ameletus	Ameletus validus	4	0	SC	"SW/10%, CN/90%"
Ephemeroptera	Baetis	Baetis tricaudatus	68	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Cinygmula	Cinygmula	3	0	SC	CN
Ephemeroptera	Drunella coloraden	Drunella coloradensis	11	1	SC	"CN/75%, SP/25%"

Ephemeroptera	Epeorus	Epeorus deceptivus	30	2	CG	CN
Ephemeroptera	Epeorus	Epeorus grandis	8	2	CG	CN
Ephemeroptera	Rhithrogena	Rhithrogena	12	0	CG	CN
Plecoptera	Chloroperlidae	Sweltsa	38	1	PR	CN
Plecoptera	Doroneuria	Doroneuria theodora	2	0	unk	CN
Plecoptera	Leuctridae	Despaxia augusta	88	1	SH	CN
Plecoptera	Megarcys	Megarcys	13	1	PR	CN
Plecoptera	Taeniopterygidae	Taeniopterygidae	2	2	SH	CN
Plecoptera	Yoraperla	Yoraperla brevis	10	0	SH	CN
Plecoptera	Zapada	Zapada columbiana	39	2	SH	CN
Plecoptera	Zapada	Zapada frigida	1	2	SH	CN
Plecoptera	Zapada	Zapada oregonensis gr.	28	2	SH	CN
Trichoptera	Dicosmoecus	Dicosmoecus atripes	1	2	SC	SP
Trichoptera	Ecclisomyia	Ecclisomyia maculosa	1	4	CG	CN/SP/CM
Trichoptera	Glossosoma	Glossosoma	2	0	SC	CN
Trichoptera	Neothremma	Neothremma alicia	1	1	SC	CN
Trichoptera	Parapsyche	Parapsyche elsis	5	0	CF	CN
Trichoptera	Rhyacophila betten	Rhyacophila Betteni Gr.	11	1	PR	CN
Trichoptera	Rhyacophila brunn	Rhyacophila Brunnea Gr.	6	0	PR	CN
Trichoptera	Rhyacophila hyalin	Rhyacophila Hyalinata Gr.	3	1	PR	CN
Trichoptera	Rhyacophila sibiric	Rhyacophila narvae	3	0	PR	CN
Trichoptera	Rhyacophila sibiric	Rhyacophila pellisa	4	0	PR	CN
Trichoptera	Rhyacophila vagrit	Rhyacophila vagrita	1	0	PR	CN
Trichoptera	Rhyacophila vofixa	Rhyacophila vofixa gr.	3	0	PR	CN

Cooney Creek

Cooney 2014

Body of Water	Cooney Creek	Benthic Sample ID:	18176
Station ID:	WS_COONEY	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E03-T500-M
Rep. Num		Collection Date	8/27/2014
		Collection Method	MAC-T-500
		Total Count	304

Order:	*OTU name:*	*FinalID:*	*Count*	*Tol Val:*	*FFG:*	*Habit:*
		Epeorus longimannus	2			
		Thienimannimyia gr.	2			
	Turbellaria	Polycelis coronata	18	4	CG/PR	SP
Coleoptera	Heterlimnius	Heterlimnius corpulentus	7	3	SC/CG	"CN/50%, BU/50%"
Coleoptera	Optioservus	Optioservus quadrimaculatus	2	5	SC	"CN/50%, BU/50%"

Diptera	Chironominae	Micropsectra	2	7	CG/CF/PR	BU/CN/SP
Diptera	Diamesinae	Diamesa	8	4	CG	sp
Diptera	Diamesinae	Pagastia	1	4	CG	sp
Diptera	Ormosia	Ormosia	1	6	CG	BU
Diptera	Orthocladiinae	Corynoneura	1		CG/SC	SP/BU
Diptera	Orthocladiinae	Eukiefferiella gracei	1		CG/SC	SP/BU
Diptera	Orthocladiinae	Parakiefferiella	1		CG/SC	SP/BU
Diptera	Orthocladiinae	Parametriocnemus	1		CG/SC	SP/BU
Diptera	Orthocladiinae	Rheocricotopus	1		CG/SC	SP/BU
Diptera	Orthocladiinae	Tvetenia vitracies	2		CG/SC	SP/BU
Diptera	Simuliidae	Prosimulium	8	6	CF	CN
Ephemeroptera	Ameletus	Ameletus validus	7	0	SC	"SW/10%, CN/90%"
Ephemeroptera	Baetis	Baetis tricaudatus	6	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Cinygmula	Cinygmula	6	0	SC	CN
Ephemeroptera	Drunella coloraden	Drunella coloradensis	3	1	SC	"CN/75%, SP/25%"
Ephemeroptera	Epeorus	Epeorus deceptivus	8	2	CG	CN
Ephemeroptera	Paraleptophlebia	Paraleptophlebia	1	1	CG	SW/CN/SP
Ephemeroptera	Rhithrogena	Rhithrogena	24	0	CG	CN
Lumbriculida	Oligochaeta	Lumbriculidae	17	8	CG	BU
Non-Insect	Nematoda	Nematoda	1	5	unk	BU
Plecoptera	Chloroperlidae	Sweltsa	31	1	PR	CN
Plecoptera	Doroneuria	Doroneuria theodora	11	0	unk	CN
Plecoptera	Leuctridae	Despaxia augusta	23	1	SH	CN
Plecoptera	Megarcys	Megarcys	15	1	PR	CN
Plecoptera	Yoraperla	Yoraperla brevis	10	0	SH	CN
Plecoptera	Zapada	Zapada columbiana	35	2	SH	CN
Plecoptera	Zapada	Zapada oregonensis gr.	4	2	SH	CN
Trichoptera	Chyrandra	Chyranda centralis	1	2	SH	SP
Trichoptera	Glossosoma	Glossosoma	2	0	SC	CN
Trichoptera	Parapsyche	Parapsyche elsis	17	0	CF	CN
Trichoptera	Rhyacophila betten	Rhyacophila Betteni Gr.	15	1	PR	CN
Trichoptera	Rhyacophila brunn	Rhyacophila Brunnea Gr.	5	0	PR	CN
Trichoptera	Rhyacophila sibiric	Rhyacophila narvae	1	0	PR	CN
Trichoptera	Rhyacophila sibiric	Rhyacophila pellisa	1	0	PR	CN
Trichoptera	Rhyacophila vofixa	Rhyacophila vofixa gr.	2	0	PR	CN

Cooney 2015

Order:	*OTU name:*	*FinalID:*	*Count*	*Tol Val:*	*FFG:*	*Habit:*
		Nostoccocladius	16			
		Thienimannimyia gr.	8			
.	Turbellaria	Polycelis coronata	96	4	CG/PR	SP

Coleoptera	Heterlimnius	Heterlimnius corpulentus	24	3	SC/CG	"CN/50%, BU/50%"
Coleoptera	Optioservus	Optioservus quadrimaculatus	8	5	SC	"CN/50%, BU/50%"
Diptera	Diamesinae	Diamesa	16	4	CG	sp
Diptera	Diamesinae	Pagastia	8	4	CG	sp
Diptera	Hexatoma	Hexatoma	8	2	PR	BU
Diptera	Orthocladiinae	Parakiefferiella	8		CG/SC	SP/BU
Diptera	Orthocladiinae	Rheocricotopus	8		CG/SC	SP/BU
Diptera	Orthocladiinae	Tvetenia vitracies	8		CG/SC	SP/BU
Diptera	Simuliidae	Prosimulium	8	6	CF	CN
Ephemeropte	Ameletus	Ameletus validus	40	0	SC	"SW/10%, CN/90%"
Ephemeropte	Baetis	Baetis tricaudatus	16	5	CG	"SW/10%, CN/90%"
Ephemeropte	Cinygmula	Cinygmula	32	0	SC	CN
Ephemeropte	Epeorus	Epeorus deceptivus	8	2	CG	CN
Ephemeropte	Epeorus	Epeorus grandis	40	2	CG	CN
Ephemeropte	Paraleptophlebia	Paraleptophlebia	8	1	CG	SW/CN/SP
Ephemeropte	Rhithrogena	Rhithrogena	72	0	CG	CN
Lumbriculida	Oligochaeta	Lumbriculidae	16	8	CG	BU
Non-Insect ta	Nematoda	Nematoda	8	5	unk	BU
Plecoptera	Chloroperlidae	Sweltsa	80	1	PR	CN
Plecoptera	Doroneuria	Doroneuria theodora	64	0	unk	CN
Plecoptera	Isoperla	Isoperla	24	2	PR	CN
Plecoptera	Leuctridae	Despaxia augusta	40	1	SH	CN
Plecoptera	Megarcys	Megarcys	88	1	PR	CN
Plecoptera	Yoraperla	Yoraperla brevis	24	0	SH	CN
Plecoptera	Zapada	Zapada columbiana	64	2	SH	CN
Plecoptera	Zapada	Zapada frigida	16	2	SH	CN
Plecoptera	Zapada	Zapada oregonensis gr.	16	2	SH	CN
Trichoptera	Chyrandra	Chyranda centralis	8	2	SH	SP
Trichoptera	Glossosoma	Glossosoma	16	0	SC	CN
Trichoptera	Parapsyche	Parapsyche elsis	96	0	CF	CN
Trichoptera	Rhyacophila betten	Rhyacophila Betteni Gr.	72	1	PR	CN
Trichoptera	Rhyacophila brunn	Rhyacophila Brunnea Gr.	32	0	PR	CN

Broadus Creek

Body of Water	Broadus Creek	Benthic Sample ID:	18175
Station ID:	WS_BROADUS	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E09-T500-M
Rep. Num		Collection Date	8/28/2018
		Collection Method	MAC-T-500
		Total Count	772

Order:	OTU name:	FinalID: Indi	Count	Tol Val	: FFG:	Habit:
Coleoptera	Heterlimnius	*Heterlimnius corpulentus*	4	3	SC/CG	"CN/50%, BU/50%"
Diptera	Chironominae	*Micropsectra*	8	7	CG/CF/PR	BU/CN/SP
Diptera	Diamesinae	*Diamesa*	40	4	CG	sp
Diptera	Orthocladiinae	*Tvetenia vitracies*	8		CG/SC	SP/BU
Ephemeroptera	Ameletus	*Ameletus*	16	0	SC	"SW/10%, CN/90%"
Ephemeroptera	Baetis	*Baetis tricaudatus*	84	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Cinygmula	*Cinygmula*	8	0	SC	CN
Ephemeroptera	Drunella coloraden	*Drunella coloradensis*	4	1	SC	"CN/75%, SP/25%"
Ephemeroptera	Epeorus	*Epeorus deceptivus*	4	2	CG	CN
Ephemeroptera	Epeorus	*Epeorus grandis*	28	2	CG	CN
Ephemeroptera	Rhithrogena	*Rhithrogena*	92	0	CG	CN
Non-Insect ta	Nematoda	*Nematoda*	4	5	unk	BU
Plecoptera	Chloroperlidae	*Sweltsa*	48	1	PR	CN
Plecoptera	Doroneuria	*Doroneuria theodora*	20	0	unk	CN
Plecoptera	Leuctridae	*Despaxia augusta*	96	1	SH	CN
Plecoptera	Megarcys	*Megarcys*	36	1	PR	CN
Plecoptera	Visoka	*Visoka cataractae*	8	0	SH	CN
Plecoptera	Yoraperla	*Yoraperla brevis*	32	0	SH	CN
Plecoptera	Zapada	*Zapada columbiana*	132	2	SH	CN
Trichoptera	Dicosmoecus	*Dicosmoecus atripes*	8	2	SC	SP
Trichoptera	Parapsyche	*Parapsyche elsis*	28	0	CF	CN
Trichoptera	Rhyacophila betten	*Rhyacophila Betteni Gr.*	16	1	PR	CN
Trichoptera	Rhyacophila brunn	*Rhyacophila Brunnea Gr.*	20	0	PR	CN
Trichoptera	Rhyacophila hyalin	*Rhyacophila Hyalinata Gr.*	16	1	PR	CN
Trichoptera	Rhyacophila sibiric	*Rhyacophila narvae*	8	0	PR	CN
Trichoptera	Rhyacophila sibiric	*Rhyacophila pellisa*	4	0	PR	CN

Theodore Creek

Body of Water	Theodore Creek	Benthic Sample ID:	18182
Station ID:	WS_Theodore	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E08-T500-M
Rep. Num		Collection Date	8/28/2014
		Collection Method	MAC-T-500
		Total Number	512

Order:	OTU name:	FinalID:	Count	Tol Val:	FFG:	Habit:
	Turbellaria	Polycelis coronata	30	4	CG/PR	SP
Coleoptera	Optioservus	Optioservus quadrimaculatus	2	5	SC	"CN/50%, BU/50%"
Diptera	Chelifera_Metachel	Chelifera	2	5	unk	SP
Diptera	Chironominae	Micropsectra	14	7	CG/CF/PR	BU/CN/SP

Diptera	Clinocera	Clinocera	4	5	unk	CN
Diptera	Dicranota	Dicranota	4	0	PR	SP
Diptera	Orthocladiinae	Brillia	6		CG/SC	SP/BU
Diptera	Orthocladiinae	Hydrobaenus	10		CG/SC	SP/BU
Diptera	Orthocladiinae	Parakiefferiella	4		CG/SC	SP/BU
Diptera	Orthocladiinae	Parametriocnemus	6		CG/SC	SP/BU
Diptera	Orthocladiinae	Tvetenia vitracies	26		CG/SC	SP/BU
Ephemeroptera	Baetis	Baetis bicaudatus	56	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Cinygmula	Cinygmula	26	0	SC	CN
Ephemeroptera	Drunella coloraden	Drunella coloradensis	2	1	SC	"CN/75%, SP/25%"
Ephemeroptera	Epeorus	Epeorus deceptivus	6	2	CG	CN
Ephemeroptera	Epeorus	Epeorus grandis	10	2	CG	CN
Ephemeroptera	Rhithrogena	Rhithrogena	2	0	CG	CN
Lumbriculida	Oligochaeta	Lumbriculidae	30	8	CG	BU
Plecoptera	Chloroperlidae	Sweltsa	58	1	PR	CN
Plecoptera	Doroneuria	Doroneuria theodora	22	0	unk	CN
Plecoptera	Isoperla	Isoperla	4	2	PR	CN
Plecoptera	Leuctridae	Despaxia augusta	10	1	SH	CN
Plecoptera	Visoka	Visoka cataractae	8	0	SH	CN
Plecoptera	Yoraperla	Yoraperla brevis	76	0	SH	CN
Plecoptera	Zapada	Zapada columbiana	58	2	SH	CN
Trichoptera	Dicosmoecus	Dicosmoecus atripes	2	2	SC	SP
Trichoptera	Neothremma	Neothremma alicia	4	1	SC	CN
Trichoptera	Parapsyche	Parapsyche elsis	6	0	CF	CN
Trichoptera	Rhyacophila betten	Rhyacophila Betteni Gr.	8	1	PR	CN
Trichoptera	Rhyacophila brunn	Rhyacophila Brunnea Gr.	10	0	PR	CN
Trichoptera	Rhyacophila hyalin	Rhyacophila Hyalinata Gr.	2	1	PR	CN
Trichoptera	Rhyacophila sibiric	Rhyacophila narvae	2	0	PR	CN
Trichoptera	Rhyacophila sibiric	Rhyacophila pellisa	2	0	PR	CN

Sarbo Creek

Body of Water	Sarbo Creek	Benthic Sample ID:	18181
Station ID:	WS_Sarbo	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E01-T500-M
Rep. Num		Collection Date	8/27/2014
		Collection Method	MAC-T-500
		Total Number	503

Order:	*OTU name:*	*FinalID:*	*Count*	*Tol Val:*	*FFG:*	*Habit:*
		Drunella doddsii	5			
		Epeorus longimannus	7			

.	Turbellaria	*Polycelis coronata*	9	4	CG/PR	SP
Coleoptera	Heterlimnius	*Heterlimnius corpulentus*	21	3	SC/CG	"CN/50%, BU/50%"
Diptera	Chelifera_Metachel	*Chelifera*	2	5	unk	SP
Diptera	Chironominae	*Micropsectra*	4	7	CG/CF/PR	BU/CN/SP
Diptera	Clinocera	*Clinocera*	1	5	unk	CN
Diptera	Diamesinae	*Diamesa*	5	4	CG	sp
Diptera	Diamesinae	*Pagastia*	12	4	CG	sp
Diptera	Dixa	*Dixa*	1	4	CG	SW
Diptera	Orthocladiinae	*Brillia*	12		CG/SC	SP/BU
Diptera	Orthocladiinae	*Eukiefferiella devonica*	4		CG/SC	SP/BU
Diptera	Orthocladiinae	*Eukiefferiella gracei*	22		CG/SC	SP/BU
Diptera	Orthocladiinae	*Parakiefferiella*	2		CG/SC	SP/BU
Diptera	Orthocladiinae	*Rheocricotopus*	15		CG/SC	SP/BU
Diptera	Pelecorhynchidae	*Glutops*	2	1	PR	SP
Ephemeroptera	Ameletus	*Ameletus validus*	14	0	SC	"SW/10%, CN/90%"
Ephemeroptera	Baetis	*Baetis tricaudatus*	72	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Cinygmula	*Cinygmula*	22	0	SC	CN
Ephemeroptera	Drunella spinifera	*Drunella spinifera*	2	0	PR	"CN/75%, SP/25%"
Ephemeroptera	Epeorus	*Epeorus grandis*	19	2	CG	CN
Ephemeroptera	Rhithrogena	*Rhithrogena*	6	0	CG	CN
Plecoptera	Chloroperlidae	*Sweltsa*	40	1	PR	CN
Plecoptera	Isoperla	*Isoperla*	2	2	PR	CN
Plecoptera	Leuctridae	*Despaxia augusta*	34	1	SH	CN
Plecoptera	Megarcys	*Megarcys*	18	1	PR	CN
Plecoptera	Setvena	*Setvena bradleyi*	4	0	PR	CN
Plecoptera	Yoraperla	*Yoraperla brevis*	45	0	SH	CN
Plecoptera	Zapada	*Zapada columbiana*	55	2	SH	CN
Plecoptera	Zapada	*Zapada oregonensis gr.*	4	2	SH	CN
Trichoptera	Micrasema	*Micrasema bactro*	3	1	SH	CN
Trichoptera	Neothremma	*Neothremma alicia*	10	1	SC	CN
Trichoptera	Parapsyche	*Parapsyche elsis*	10	0	CF	CN
Trichoptera	Rhyacophila betten	*Rhyacophila Betteni Gr.*	12	1	PR	CN
Trichoptera	Rhyacophila brunn	*Rhyacophila Brunnea Gr.*	4	0	PR	CN
Trichoptera	Rhyacophila sibiric	*Rhyacophila narvae*	2	0	PR	CN
Trichoptera	Rhyacophila sibiric	*Rhyacophila pellisa*	1	0	PR	CN

Unnamed Tributary of the North Fork Blackfoot River

Body of Water	Unnamed tributary to NFBLF	Benthic Sample ID:	18183
Station ID:	W S _Unn474	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E04-T500-M
Rep. Num		Collection Date	8/27/2014

Collection Method	MAC-T-500
Total Number	946

Order:	OTU name:	FinalID:	Count	Tol Val:	FFG:	Habit:
Coleoptera	Ochthebius	*Ochthebius*	4		unk	unk
Diptera	Chelifera_Metachel	*Chelifera*	4	5	unk	SP
Diptera	Limnophila	*Limnophila*	4	3	PR	BU
Diptera	Orthocladiinae	*Lopescladius*	4		CG/SC	SP/BU
Diptera	Orthocladiinae	*Orthocladius*	12		CG/SC	SP/BU
Diptera	Pelecorhynchidae	*Glutops*	16	1	PR	SP
Diptera	Simuliidae	*Simulium*	4	6	CF	CN
Ephemeropte	Ameletus	*Ameletus validus*	4	0	SC	"SW/10%, CN/90%"
Plecoptera	Chloroperlidae	*Sweltsa*	48	1	PR	CN
Plecoptera	Isoperla	*Isoperla*	8	2	PR	CN
Plecoptera	Setvena	*Setvena bradleyi*	16	0	PR	CN
Plecoptera	Yoraperla	*Yoraperla brevis*	300	0	SH	CN
Plecoptera	Zapada	*Zapada columbiana*	160	2	SH	CN
Trichoptera	Dicosmoecus	*Dicosmoecus atripes*	4	2	SC	SP
Trichoptera	Glossosoma	*Glossosoma*	4	0	SC	CN
Trichoptera	Micrasema	*Micrasema bactro*	20	1	SH	CN
Trichoptera	Neothremma	*Neothremma alicia*	312	1	SC	CN
Trichoptera	Rhyacophila sibiric	*Rhyacophila narvae*	4	0	PR	CN
Trichoptera	Rhyacophila vagrit	*Rhyacophila vagrita*	4	0	PR	CN
Trichoptera	Rhyacophila vofixa	*Rhyacophila vofixa gr.*	32	0	PR	CN

East Fork North Fork Blackfoot River

East Fork North Fork Blackfoot River Lower

Order:	OTU name:	FinalID:	Count	Tol Val:	FFG:	Habit:
		Epeorus longimannus	10	8		
Coleoptera	Heterlimnius	*Heterlimnius corpulentus*	190	3	SC/CG	"CN/50%, BU/50%"
Coleoptera	Narpus	*Narpus concolor*	2	2	CG	"CN/50%, BU/50%"
Coleoptera	Optioservus	*Optioservus quadrimaculatus*	82	5	SC	"CN/50%, BU/50%"
Diptera	Ceratopogoninae	*Probezzia*	6	6	PR/CG	SP/BU/SW
Diptera	Chelifera_Metachel	*Chelifera*	8	5	unk	SP
Diptera	Diamesinae	*Pagastia*	90	4	CG	sp
Diptera	Hexatoma	*Hexatoma*	4	2	PR	BU
Diptera	Limonia	*Limonia*	2		SH	BU
Diptera	Orthocladiinae	*Brillia*	14		CG/SC	SP/BU
Diptera	Orthocladiinae	*Cricotopus bicinctus*	18		CG/SC	SP/BU
Diptera	Orthocladiinae	*Tvetenia vitracies*	20		CG/SC	SP/BU

Diptera	Simuliidae	*Prosimulium*	14	6	CF	CN
Diptera	Tipula	*Tipula*	2	4	SH	BU
Ephemeroptera	Baetis	*Baetis tricaudatus*	80	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Cinygmula	*Cinygmula*	68	0	SC	CN
Ephemeroptera	Epeorus	*Epeorus deceptivus*	50	2	CG	CN
Ephemeroptera	Paraleptophlebia	*Paraleptophlebia*	8	1	CG	SW/CN/SP
Ephemeroptera	Rhithrogena	*Rhithrogena*	28	0	CG	CN
Ephemeroptera	Serratella	*Serratella tibialis*	4	2	CG	CN
Plecoptera	Chloroperlidae	*Sweltsa*	44	1	PR	CN
Plecoptera	Doroneuria	*Doroneuria theodora*	12	0	unk	CN
Plecoptera	Hesperoperla	*Hesperoperla pacifica*	46	1	PR	CN
Plecoptera	Megarcys	*Megarcys*	24	1	PR	CN
Plecoptera	Zapada	*Zapada cinctipes*	10	2	SH	CN
Plecoptera	Zapada	*Zapada columbiana*	24	2	SH	CN
Trichoptera	Arctopsyche	*Arctopsyche grandis*	4	2	CF	CN
Trichoptera	Micrasema	*Micrasema bactro*	8	1	SH	CN
Trichoptera	Parapsyche	*Parapsyche elsis*	12	0	CF	CN
Trichoptera	Rhyacophila brunn	*Rhyacophila Brunnea Gr.*	8	0	PR	CN

East Fork North Fork Blackfoot River (upper)

Body of Water	East Fork North Fork Blackfoot River	Benthic Sample ID:	18163
Station ID:	W S_EFNFBL (upper)	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E05-T500-M
Rep. Num		Collection Date	8/6/2013
		Collection Method	MAC-T-500
		Total Number	876

Order:	***OTU name:***	***FinalID:***	***Count***	***Tol Val:***	***FFG:***	***Habit:***
		Drunella doddsii	8			
		Oreolepsis	4			
Coleoptera	Heterlimnius	*Heterlimnius corpulentus*	160	3	SC/CG	"CN/50%, BU/50%"
Diptera	Ceratopogoninae	*Probezzia*	4	6	PR/CG	SP/BU/SW
Diptera	Chironominae	*Micropsectra*	8	7	CG/CF/PR	BU/CN/SP
Diptera	Dixa	*Dixa*	8	4	CG	SW
Diptera	Hexatoma	*Hexatoma*	4	2	PR	BU
Diptera	Orthocladiinae	*Brillia*	8		CG/SC	SP/BU
Diptera	Orthocladiinae	*Parakiefferiella*	8		CG/SC	SP/BU
Diptera	Orthocladiinae	*Tvetenia vitracies*	12		CG/SC	SP/BU
Ephemeroptera	Ameletus	*Ameletus*	24	0	SC	"SW/10%, CN/90%"
Ephemeroptera	Baetis	*Baetis tricaudatus*	132	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Cinygmula	*Cinygmula*	100	0	SC	CN

Ephemeroptera	Epeorus	*Epeorus deceptivus*	20	2	CG	CN
Ephemeroptera	Paraleptophlebia	*Paraleptophlebia*	16	1	CG	SW/CN/SP
Ephemeroptera	Rhithrogena	*Rhithrogena*	32	0	CG	CN
Ephemeroptera	Serratella	*Serratella tibialis*	4	2	CG	CN
Plecoptera	Chloroperlidae	*Sweltsa*	76	1	PR	CN
Plecoptera	Doroneuria	*Doroneuria theodora*	48	0	unk	CN
Plecoptera	Hesperoperla	*Hesperoperla pacifica*	4	1	PR	CN
Plecoptera	Leuctridae	*Despaxia augusta*	20	1	SH	CN
Plecoptera	Megarcys	*Megarcys*	56	1	PR	CN
Plecoptera	Zapada	*Zapada columbiana*	16	2	SH	CN
Trichoptera	Parapsyche	*Parapsyche elsis*	8	0	CF	CN
Trichoptera	Rhyacophila betten	*Rhyacophila Betteni Gr.*	68	1	PR	CN
Trichoptera	Rhyacophila brunn	*Rhyacophila Brunnea Gr.*	4	0	PR	CN
Trichoptera	Rhyacophila sibiric	*Rhyacophila narvae*	16	0	PR	CN
Trichoptera	Rhyacophila sibiric	*Rhyacophila pellisa*	8	0	PR	CN

Blondie Creek

Body of Water	Blondie Creek	Benthic Sample ID:	18160
Station ID:	WS_BLOND	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E01-T500-M
Rep. Num		Collection Date	8/6/2013
		Collection Method	MAC-T-500
		Total Number	332

Order:	*OTU name:*	*FinalID:*	*Individuals*	*Tol Val:*	*FFG:*	*Habit:*
		Ameletus similior	4			
		Drunella doddsii	4			
		Nostoccocladius	22			
		Thienimannimyia gr.	4			
Coleoptera	Heterlimnius	Heterlimnius corpulentus	58	3	SC/CG	"CN/50%, BU/50%"
Diptera	Diamesinae	Pagastia	6	4	CG	sp
Diptera	Forcipomyiinae	Forcipomyia	2	6	PR/CG/SC	sp
Diptera	Orthocladiinae	Brillia	14		CG/SC	SP/BU
Diptera	Orthocladiinae	Parakiefferiella	10		CG/SC	SP/BU
Diptera	Simuliidae	Simulium	2	6	CF	CN
Ephemeroptera	Drunella coloraden	Drunella coloradensis	16	1	SC	"CN/75%, SP/25%"
Ephemeroptera	Paraleptophlebia	Paraleptophlebia	4	1	CG	SW/CN/SP
Plecoptera	Chloroperlidae	Suwallia	4	1	PR	CN
Plecoptera	Chloroperlidae	Sweltsa	50	1	PR	CN
Plecoptera	Doroneuria	Doroneuria theodora	2	0	unk	CN
Plecoptera	Leuctridae	Despaxia augusta	34	1	SH	CN
Plecoptera	Megarcys	Megarcys	18	1	PR	CN

Plecoptera	Visoka	Visoka cataractae	10	0	SH	CN
Plecoptera	Yoraperla	Yoraperla brevis	16	0	SH	CN
Plecoptera	Zapada	Zapada cinctipes	2	2	SH	CN
Plecoptera	Zapada	Zapada columbiana	30	2	SH	CN
Trichoptera	Dicosmoecus	Dicosmoecus atripes	2	2	SC	SP
Trichoptera	Neothremma	Neothremma alicia	2	1	SC	CN
Trichoptera	Rhyacophila betten	Rhyacophila Betteni Gr.	10	1	PR	CN
Trichoptera	Rhyacophila sibiric	Rhyacophila pellisa	6	0	PR	CN

Sourdough Creek

Sourdough Creek (lower)

Body of Water	Sourdough Creek (lower)	Benthic Sample ID:	18169
Station ID:	WS_SOURL	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E9-T500-M
Rep. Num		Collection Date	8/6/2013
		Collection Method	MAC-T-500
		Total Count	1488

Order:	OTU name:	FinalID:	Individuals	Tol Val:	FFG:	Habit:
		Epeorus longimannus	6			
		Isoperla punctata	6			
		Rhyacophila siberica gr.	6			
		Utacapnia sopladora	6			
. Diptera	Turbellaria	Polycelis coronata	54	4	CG/PR	SP
Diptera	Chironominae	Micropsectra	12	7	CG/CF/PR	BU/CN/SP
Diptera	Diamesinae	Diamesa	12	4	CG	sp
Diptera	Diamesinae	Pagastia	6	4	CG	sp
Diptera	Dicranota	Dicranota	6	0	PR	SP
Diptera	Limnophila	Limnophila	6	3	PR	BU
Diptera	Oreogeton	Oreogeton	6	4	PR	SP
Diptera	Orthocladiinae	Rheocricotopus	12		CG/SC	SP/BU
Ephemeropte	Simuliidae	Prosimulium	6	6	CF	CN
Ephemeropte	Ameletus	Ameletus	18	0	SC	"SW/10%, CN/90%"
Ephemeropte	Baetis	Baetis bicaudatus	30	5	CG	"SW/10%, CN/90%"
Ephemeropte	Cinygmula	Cinygmula	162	0	SC	CN
Ephemeropte	Drunella coloraden	Drunella coloradensis	30	1	SC	"CN/75%, SP/25%"
Ephemeropte	Epeorus	Epeorus deceptivus	498	2	CG	CN
Ephemeropte	Epeorus	Epeorus grandis	6	2	CG	CN
Lumbriculida	Rhithrogena	Rhithrogena	138	0	CG	CN
Plecoptera	Oligochaeta	Lumbriculidae	12	8	CG	BU
Plecoptera	Chloroperlidae	Suwallia	30	1	PR	CN
Plecoptera	Chloroperlidae	Sweltsa	96	1	PR	CN
Plecoptera	Doroneuria	Doroneuria theodora	6	0	unk	CN
Plecoptera	Leuctridae	Despaxia augusta	6	1	SH	CN
Plecoptera	Megarcys	Megarcys	66	1	PR	CN
Plecoptera	Paraperla	Paraperla Yoraperla	6	1	unk	unk
Plecoptera	Yoraperla	brevis Zapada	12	0	SH	CN
Plecoptera	Zapada	columbiana	30	2	SH	CN
Trichoptera	Zapada	Zapada oregonensis gr.	66	2	SH	CN
Trichoptera	Parapsyche	Parapsyche elsis	18	0	CF	CN
Trichoptera	Rhyacophila betten	Rhyacophila Betteni Gr.	6	1	PR	CN
Trichoptera	Rhyacophila sibiric	Rhyacophila narvae	24	0	PR	CN
Trichoptera	Rhyacophila sibiric	Rhyacophila pellisa	6	0	PR	CN
	Rhyacophila vagrit	Rhyacophila vagrita gr.	6	0	PR	CN

Sourdough Creek (upper)

Body of Water	Sourdough Creek (upper)	Benthic Sample ID:	18170
Station ID:	WS_SOURU	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E10-T500-M
Rep. Num		Collection Date	8/6/2013
		Collection Method	MAC-T-500
		Total Count	784

Order:	OTU name:	FinalID:	Count	Tol Val:	FFG:	Habit:
		Epeorus longimannus	4			
	Turbellaria	*Polycelis coronata*	50	4	CG/PR	SP
Coleoptera	Optioservus	*Optioservus quadrimaculatus*	8	5	SC	"CN/50%, BU/50%"
Diptera	Diamesinae	*Pagastia*	4	4	CG	sp
Diptera	Dicranota	*Dicranota*	4	0	PR	SP
Diptera	Oreogeton	*Oreogeton*	24	4	PR	SP
Diptera	Orthocladiinae	*Brillia*	6		CG/SC	SP/BU
Diptera	Orthocladiinae	*Eukiefferiella gracei*	4		CG/SC	SP/BU
Diptera	Orthocladiinae	*Orthocladius*	6		CG/SC	SP/BU
Diptera	Orthocladiinae	*Parakiefferiella*	4		CG/SC	SP/BU
Diptera	Orthocladiinae	*Rheocricotopus*	22		CG/SC	SP/BU
Ephemeroptera	Ameletus	*Ameletus*	24	0	SC	"SW/10%, CN/90%"
Ephemeroptera	Baetis	*Baetis bicaudatus*	22	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Cinygmula	*Cinygmula*	154	0	SC	CN
Ephemeroptera	Drunella coloraden	*Drunella coloradensis*	10	1	SC	"CN/75%, SP/25%"
Ephemeroptera	Epeorus	*Epeorus deceptivus*	270	2	CG	CN
Ephemeroptera	Rhithrogena	*Rhithrogena*	48	0	CG	CN
Lumbriculida	Oligochaeta	*Lumbriculidae*	18	8	CG	BU
Plecoptera	Chloroperlidae	*Suwallia*	6	1	PR	CN
Plecoptera	Chloroperlidae	*Sweltsa*	36	1	PR	CN
Plecoptera	Doroneuria	*Doroneuria theodora*	4	0	unk	CN
Plecoptera	Isoperla	*Isoperla*	2	2	PR	CN
Plecoptera	Leuctridae	*Despaxia augusta*	4	1	SH	CN
Plecoptera	Megarcys	*Megarcys*	16	1	PR	CN
Plecoptera	Yoraperla	*Yoraperla brevis*	2	0	SH	CN
Plecoptera	Zapada	*Zapada columbiana*	24	2	SH	CN
Trichoptera	Ecclisomyia	*Ecclisomyia maculosa*	2	4	CG	CN/SP/CM
Trichoptera	Glossosoma	*Glossosoma*	2	0	SC	CN
Trichoptera	Homophylax	*Homophylax*	2	2	SH	CN/SP
Trichoptera	Rhyacophila brunn	*Rhyacophila Brunnea Gr.*	2	0	PR	CN

Scotty Creek

Body of Water	Scotty Creek	Benthic Sample ID:	18168
Station ID:	WS_SCOTTY	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E08-T500-M
Rep. Num		Collection Date	8/6/2013
		Collection Method	MAC-T-500
		Total Count	2176

Order:	OTU name:	FinalID:	Count	Tol Val:	FFG:	Habit:
		Isoperla punctata	8			
.	Turbellaria	Polycelis coronata	16	4	CG/PR	SP
Coleoptera	Heterlimnius	Heterlimnius corpulentus	64	3	SC/CG	"CN/50%, BU/50%"
Diptera	Ceratopogoninae	Probezzia	16	6	PR/CG	SP/BU/SW
Diptera	Chelifera_Metachel	Chelifera	8	5	unk	SP
Diptera	Chironominae	Micropsectra	112	7	CG/CF/PR	BU/CN/SP
Diptera	Clinocera	Clinocera	24	5	unk	CN
Diptera	Diamesinae	Pagastia	64	4	CG	sp
Diptera	Oreogeton	Oreogeton	24	4	PR	SP
Diptera	Orthocladiinae	Brillia	216		CG/SC	SP/BU
Diptera	Orthocladiinae	Eukiefferiella gracei	40		CG/SC	SP/BU
Diptera	Orthocladiinae	Parakiefferiella	160		CG/SC	SP/BU
Diptera	Orthocladiinae	Parametriocnemus	32		CG/SC	SP/BU
Diptera	Orthocladiinae	Rheocricotopus	120		CG/SC	SP/BU
Diptera	Orthocladiinae	Tvetenia vitracies	32		CG/SC	SP/BU
Ephemeroptera	Baetis	Baetis tricaudatus	72	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Cinygmula	Cinygmula	24	0	SC	CN
Ephemeroptera	Drunella coloraden	Drunella coloradensis	32	1	SC	"CN/75%, SP/25%"
Ephemeroptera	Rhithrogena	Rhithrogena	64	0	CG	CN
Ephemeroptera	Serratella	Serratella tibialis	32	2	CG	CN
Lumbriculida	Oligochaeta	Lumbriculidae	16	8	CG	BU
Plecoptera	Chloroperlidae	Suwallia	24	1	PR	CN
Plecoptera	Doroneuria	Doroneuria theodora	120	0	unk	CN
Plecoptera	Leuctridae	Despaxia augusta	72	1	SH	CN
Plecoptera	Megarcys	Megarcys	48	1	PR	CN
Plecoptera	Setvena	Setvena bradleyi	32	0	PR	CN
Plecoptera	Zapada	Zapada columbiana	304	2	SH	CN
Trichoptera	Parapsyche	Parapsyche elsis	40	0	CF	CN
Trichoptera	Rhyacophila betten	Rhyacophila Betteni Gr.	8	1	PR	CN
Trichoptera	Rhyacophila brunn	Rhyacophila Brunnea Gr.	112	0	PR	CN
Trichoptera	Rhyacophila hyalin	Rhyacophila Hyalinata Gr.	40	1	PR	CN

Trichoptera	Rhyacophila sibiric	Rhyacophila narvae	32	0	PR	CN
Trichoptera	Rhyacophila vagrit	Rhyacophila vagrita	48	0	PR	CN
Trichoptera	Stactobiella	Stactobiella	120		SH	CN

Meadow Creek

Meadow Creek (upper)

Body of Water	Meadow Creek (upper)	Benthic Sample ID:	18161
Station ID:	WS_MEADCRU	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E02-T500-M
Rep. Num		Collection Date	8/7/2013
		Collection Method	MAC-T-500
		Total Count	668

Order:	*OTU name:*	*FinalID:*	*Count*	*Tol Val:*	*FFG:*	*Habit:*
		Drunella doddsii	2			
		Epeorus longimannus	2			
		Isoperla punctata	4			
.	Turbellaria	*Polycelis coronata*	8	4	CG/PR	SP
Coleoptera	Heterlimnius	*Heterlimnius corpulentus*	44	3	SC/CG	"CN/50%, BU/50%"
Diptera	Diamesinae	*Pagastia*	2	4	CG	sp
Diptera	Hexatoma	*Hexatoma*	4	2	PR	BU
Diptera	Orthocladiinae	*Brillia*	4		CG/SC	SP/BU
Diptera	Orthocladiinae	*Eukiefferiella gracei*	22		CG/SC	SP/BU
Diptera	Orthocladiinae	*Rheocricotopus*	8		CG/SC	SP/BU
Diptera	Rhabdomastix	*Rhabdomastix*	2	1	unk	BU
Ephemeroptera	Ameletus	*Ameletus oregonensis*	8	0	SC	"SW/10%, CN/90%"
Ephemeroptera	Ameletus	*Ameletus validus*	4	0	SC	"SW/10%, CN/90%"
Ephemeroptera	Baetis	*Baetis tricaudatus*	38	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Cinygmula	*Cinygmula*	110	0	SC	CN
Ephemeroptera	Drunella coloraden	*Drunella coloradensis*	2	1	SC	"CN/75%, SP/25%"
Ephemeroptera	Epeorus	*Epeorus deceptivus*	68	2	CG	CN
Ephemeroptera	Epeorus	*Epeorus grandis*	20	2	CG	CN
Ephemeroptera	Rhithrogena	*Rhithrogena*	52	0	CG	CN
Ephemeropte	Serratella	*Serratella tibialis*	4	2	CG	CN
Plecoptera	Chloroperlidae	*Sweltsa*	84	1	PR	CN
Plecoptera	Doroneuria	*Doroneuria theodora*	8	0	unk	CN
Plecoptera	Hesperoperla	*Hesperoperla pacifica*	2	1	PR	CN
Plecoptera	Leuctridae	*Despaxia augusta*	16	1	SH	CN
Plecoptera	Visoka	*Visoka cataractae*	4	0	SH	CN
Plecoptera	Zapada	*Zapada cinctipes*	2	2	SH	CN

Plecoptera	Zapada	*Zapada columbiana*	78	2	SH	CN
Trichoptera	Glossosoma	*Glossosoma*	16	0	SC	CN
Trichoptera	Parapsyche	*Parapsyche elsis*	44	0	CF	CN
Trichoptera	Rhyacophila betten	*Rhyacophila Betteni Gr.*	4	1	PR	CN
Trichoptera	Rhyacophila sibiric	*Rhyacophila pellisa*	2	0	PR	CN

Meadow Creek (lower)

Body of Water	Meadow Creek (lower)	Benthic Sample ID:	18167
Station ID:	WS_MEADCRL	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E07-T500-M
Rep. Num		Collection Date	8/8/2013
		Collection Method	MAC-T-500
		Total Count	1564

Order:	***OTU name:***	***FinalID:***	***Individuals***	***Tol Val:***	***FFG:***	***Habit:***
		Ameletus similior	8			
		Isoperla punctata	40			
		Thienimannimyia gr.	4			
Arhynchobde	Erpobdellidae	*Erpobdella punctata*	4	8	PR	SW
Coleoptera	Heterlimnius	*Heterlimnius corpulentus*	96	3	SC/CG	"CN/50%, BU/50%"
Coleoptera	Optioservus	*Optioservus quadrimaculatus*	120	5	SC	"CN/50%, BU/50%"
Coleoptera	Zaitzevia	*Zaitzevia parvula*	8	5	SC/CG	"CN/50%, BU/50%"
Diptera	Ceratopogoninae	*Probezzia*	12	6	PR/CG	SP/BU/SW
Diptera	Diamesinae	*Pagastia*	20	4	CG	sp
Diptera	Hexatoma	*Hexatoma*	12	2	PR	BU
Diptera	Orthocladiinae	*Eukiefferiella gracei*	4		CG/SC	SP/BU
Diptera	Orthocladiinae	*Parametriocnemus*	4		CG/SC	SP/BU
Diptera	Orthocladiinae	*Rheocricotopus*	36		CG/SC	SP/BU
Diptera	Orthocladiinae	*Tvetenia vitracies*	32		CG/SC	SP/BU
Diptera	Tipula	*Tipula*	12	4	SH	BU
Ephemeroptera	Baetis	*Baetis flavistriga*	24	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Baetis	*Baetis tricaudatus*	60	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Cinygmula	*Cinygmula*	280	0	SC	CN
Ephemeroptera	Drunella coloraden	*Drunella coloradensis*	8	1	SC	"CN/75%, SP/25%"
Ephemeroptera	Drunella grandis	*Drunella grandis*	4	2	PR	"CN/75%, SP/25%"
Ephemeroptera	Epeorus	*Epeorus deceptivus*	20	2	CG	CN
Ephemeroptera	Paraleptophlebia	*Paraleptophlebia*	104	1	CG	SW/CN/SP
Ephemeroptera	Rhithrogena	*Rhithrogena*	28	0	CG	CN

Ephemeroptera	Serratella	*Serratella tibialis*	56	2	CG	CN
Haplotaxida	Oligochaeta	*Tubificidae*	8	8	CG	BU
Non-Insect ta	Nematoda	*Nematoda*	4	5	unk	BU
Plecoptera	Capniidae	*Capniidae*	8	1	SH	CN
Plecoptera	Chloroperlidae	*Sweltsa*	208	1	PR	CN
Plecoptera	Doroneuria	*Doroneuria theodora*	60	0	unk	CN
Plecoptera	Megarcys	*Megarcys*	52	1	PR	CN
Plecoptera	Zapada	*Zapada cinctipes*	220	2	SH	CN
Trichoptera	Dicosmoecus	*Dicosmoecus gilvipes*	8	2	SC	SP

Meadow Creek (East Fork)

Body of Water	East Fork Meadow Creek	Benthic Sample ID:	18162
Station ID:	WS_EFMEAD	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E03-T500-M
Rep. Num		Collection Date	8/7/2013
		Collection Method	MAC-T-500
		Total Count	992

Order:	***OTU name:***	***FinalID:***	***Count***	***Tol Val:***	***FFG:***	***Habit:***
		Drunella doddsii	10			
		Epeorus longimannus	8			
Coleoptera	Heterlimnius	Heterlimnius corpulentus	6	3	SC/CG	"CN/50%, BU/50%"
Coleoptera	Optioservus	Optioservus quadrimaculatus	6	5	SC	"CN/50%, BU/50%"
Diptera	Limonia	Limonia	2		SH	BU
Diptera	Orthocladiinae	Brillia	8		CG/SC	SP/BU
Diptera	Orthocladiinae	Eukiefferiella gracei	16		CG/SC	SP/BU
Diptera	Orthocladiinae	Orthocladius	8		CG/SC	SP/BU
Diptera	Orthocladiinae	Parakiefferiella	2		CG/SC	SP/BU
Diptera	Orthocladiinae	Rheocricotopus	28		CG/SC	SP/BU
Ephemeroptera	Ameletus	Ameletus	6	0	SC	"SW/10%, CN/90%"
Ephemeroptera	Baetis	Baetis tricaudatus	40	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Cinygma	Cinygma	2	0	SC	CN
Ephemeroptera	Cinygmula	Cinygmula	60	0	SC	CN
Ephemeroptera	Drunella coloraden	Drunella coloradensis	12	1	SC	"CN/75%, SP/25%"
Ephemeroptera	Epeorus	Epeorus deceptivus	220	2	CG	CN
Ephemeroptera	Epeorus	Epeorus grandis	8	2	CG	CN
Ephemeroptera	Rhithrogena	Rhithrogena	90	0	CG	CN
Ephemeroptera	Serratella	Serratella tibialis	8	2	CG	CN
Plecoptera	Chloroperlidae	Suwallia	14	1	PR	CN

Plecoptera	Chloroperlidae	Sweltsa	120	1	PR	CN
Plecoptera	Chloroperlidae	Triznaka	10	1	PR	CN
Plecoptera	Doroneuria	Doroneuria theodora	18	0	unk	CN
Plecoptera	Kogotus	Kogotus	4	1	PR	CN
Plecoptera	Leuctridae	Despaxia augusta	44	1	SH	CN
Plecoptera	Megarcys	Megarcys	60	1	PR	CN
Plecoptera	Paraperla	Paraperla	20	1	unk	unk
Plecoptera	Yoraperla	Yoraperla brevis	2	0	SH	CN
Plecoptera	Zapada	Zapada columbiana	120	2	SH	CN
Plecoptera	Zapada	Zapada frigida	2	2	SH	CN
Trichoptera	Glossosoma	Glossosoma	2	0	SC	CN
Trichoptera	Parapsyche	Parapsyche elsis	24	0	CF	CN
Trichoptera	Rhyacophila betten	Rhyacophila Betteni Gr.	10	1	PR	CN
Trichoptera	Rhyacophila hyalin	Rhyacophila Hyalinata Gr.	2	1	PR	CN

Lost Pony Creek

Body of Water	Lost Pony Creek	Benthic Sample ID:	18165
Station ID:	WS_LOSTPONY	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E06-T500-M
Rep. Num		Collection Date	8/6/2013
		Collection Method	MAC-T-500
		Total Count	1476

Order:	OTU name:	FinalID:	Individuals	Tol Val:	FFG:	Habit:
		Drunella doddsii	36			
		Nostoccocladius	16			
Diptera	Diamesinae	Pagastia	28	4	CG	sp
Diptera	Dixa	Dixa	8	4	CG	SW
Diptera	Hexatoma	Hexatoma	8	2	PR	BU
Diptera	Orthocladiinae	Brillia	16		CG/SC	SP/BU
Diptera	Orthocladiinae	Eukiefferiella gracei	132		CG/SC	SP/BU
Diptera	Orthocladiinae	Parakiefferiella	68		CG/SC	SP/BU
Diptera	Orthocladiinae	Parametriocnemus	40		CG/SC	SP/BU
Diptera	Orthocladiinae	Rheocricotopus	80		CG/SC	SP/BU
Ephemeropte	Ameletus	Ameletus	12	0	SC	"SW/10%, CN/90%"
Ephemeropte	Baetis	Baetis tricaudatus	128	5	CG	"SW/10%, CN/90%"
Ephemeropte	Cinygmula	Cinygmula	36	0	SC	CN
Ephemeropte	Drunella coloraden	Drunella coloradensis	12	1	SC	"CN/75%, SP/25%"
Ephemeropte	Drunella spinifera	Drunella spinifera	8	0	PR	"CN/75%, SP/25%"
Ephemeropte	Epeorus	Epeorus deceptivus	24	2	CG	CN
Ephemeropte	Rhithrogena	Rhithrogena	68	0	CG	CN
Ephemeropte	Serratella	Serratella tibialis	8	2	CG	CN
Plecoptera	Chloroperlidae	Suwallia	20	1	PR	CN
Plecoptera	Chloroperlidae	Sweltsa	124	1	PR	CN
Plecoptera	Doroneuria	Doroneuria theodora	52	0	unk	CN
Plecoptera	Leuctridae	Despaxia augusta	44	1	SH	CN
Plecoptera	Megarcys	Megarcys	56	1	PR	CN
Plecoptera	Paraperla	Paraperla Yoraperla	8	1	unk	unk
Plecoptera	Yoraperla	brevis Zapada	28	0	SH	CN
Plecoptera	Zapada	columbiana	252	2	SH	CN
Trichoptera	Dicosmoecus	Dicosmoecus atripes	4	2	SC	SP
Trichoptera	Glossosoma	Glossosoma	72	0	SC	CN
Trichoptera	Parapsyche	Parapsyche elsis	28	0	CF	CN
Trichoptera	Rhyacophila betten	Rhyacophila Betteni Gr.	28	1	PR	CN
Trichoptera	Rhyacophila hyalin	Rhyacophila Hyalinata Gr.	20	1	PR	CN
Trichoptera	Rhyacophila sibiric	Rhyacophila pellisa	4	0	PR	CN
Trichoptera	Rhyacophila verrul	Rhyacophila verrula	8	0	PR	CN

Spaulding Creek

Body of Water	Spaulding Creek	Benthic Sample ID:	18171
Station ID:	WS_SPAULD	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E11-T500-M
Rep. Num		Collection Date	8/8/2013
		Collection Method	MAC-T-500
		Total Count	2124

Order:	OTU name:	FinalID:	Count	Tol Val:	FFG:	Habit:
		Ameletus similior	16			
		Isoperla punctata	4			
.	Turbellaria	*Polycelis coronata*	32	4	CG/PR	SP
Coleoptera	Heterlimnius	*Heterlimnius corpulentus*	140	3	SC/CG	"CN/50%, BU/50%"
Coleoptera	Zaitzevia	*Zaitzevia parvula*	4	5	SC/CG	"CN/50%, BU/50%"
Diptera	Chelifera_Metachel	*Chelifera*	4	5	unk	SP
Diptera	Clinocera	*Clinocera*	12	5	unk	CN
Diptera	Diamesinae	*Pagastia*	8	4	CG	sp
Diptera	Orthocladiinae	*Eukiefferiella gracei*	16		CG/SC	SP/BU
Diptera	Orthocladiinae	*Parakiefferiella*	32		CG/SC	SP/BU
Diptera	Orthocladiinae	*Parametriocnemus*	8		CG/SC	SP/BU
Ephemeropte	Ameletus	*Ameletus oregonensis*	76	0	SC	"SW/10%, CN/90%"
Ephemeropte	Baetis	*Baetis tricaudatus*	256	5	CG	"SW/10%, CN/90%"
Ephemeropte	Cinygmula	*Cinygmula*	104	0	SC	CN
Ephemeropte	Drunella coloraden	*Drunella coloradensis*	4	1	SC	"CN/75%, SP/25%"
Ephemeropte	Epeorus	*Epeorus deceptivus*	24	2	CG	CN
Ephemeropte	Epeorus	*Epeorus grandis*	4	2	CG	CN
Ephemeropte	Rhithrogena	*Rhithrogena*	200	0	CG	CN
Ephemeropte	Serratella	*Serratella tibialis*	32	2	CG	CN
Plecoptera	Chloroperlidae	*Sweltsa*	84	1	PR	CN
Plecoptera	Doroneuria	*Doroneuria theodora*	188	0	unk	CN
Plecoptera	Leuctridae	*Despaxia augusta*	100	1	SH	CN
Plecoptera	Megarcys	*Megarcys*	44	1	PR	CN
Plecoptera	Setvena	*Setvena bradleyi*	4	0	PR	CN
Plecoptera	Yoraperla	*Yoraperla brevis*	140	0	SH	CN
Plecoptera	Zapada	*Zapada columbiana*	268	2	SH	CN
Plecoptera	Zapada	*Zapada frigida*	4	2	SH	CN
Trichoptera	Chyrandra	*Chyranda centralis*	4	2	SH	SP
Trichoptera	Dolophilodes	*Dolophilodes*	16	0	CF	CN
Trichoptera	Micrasema	*Micrasema bactro*	24	1	SH	CN
Trichoptera	Parapsyche	*Parapsyche elsis*	64	0	CF	CN

Trichoptera	Rhyacophila betten	*Rhyacophila Betteni Gr.*	100	1	PR	CN
Trichoptera	Rhyacophila brunn	*Rhyacophila Brunnea Gr.*	12	0	PR	CN
Trichoptera	Rhyacophila sibiric	*Rhyacophila narvae*	20	0	PR	CN
Trichoptera	Rhyacophila sibiric	*Rhyacophila pellisa*	36	0	PR	CN
Trichoptera	Rhyacophila vagrit	*Rhyacophila vagrita*	12	0	PR	CN
Trichoptera	Rhyacophila vofixa	*Rhyacophila vofixa gr.*	28	0	PR	CN

Mineral Creek

Body of Water	Mineral Creek	Benthic Sample ID:	19818
Station ID:	WS_MINERAL	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E22-T500-M
Rep. Num		Collection Date	9/5/2015
		Collection Method	MAC-T-500
		Total Count	2496

Order:	***OTU name:***	***FinalID:***	***Count***	***Tol Val:***	***FFG:***	***Habit:***
	Turbellaria	*Polycelis coronata*	72	4	CG/PR	SP
Coleoptera	Heterlimnius	*Heterlimnius corpulentus*	252	3	SC/CG	"CN/50%, BU/50%"
Diptera	Ceratopogoninae	*Probezzia*	24	6	PR/CG	SP/BU/SW
Diptera	Chironominae	*Micropsectra*	48	7	CG/CF/PR	BU/CN/SP
Diptera	Diamesinae	*Pagastia*	108	4	CG	sp
Diptera	Hexatoma	*Hexatoma*	12	2	PR	BU
Diptera	Orthocladiinae	*Brillia*	6		CG/SC	SP/BU
Diptera	Orthocladiinae	*Corynoneura*	6		CG/SC	SP/BU
Diptera	Orthocladiinae	*Cricotopus*	30		CG/SC	SP/BU
Diptera	Orthocladiinae	*Eukiefferiella*	30		CG/SC	SP/BU
Diptera	Orthocladiinae	*Hydrobaenus*	6		CG/SC	SP/BU
Diptera	Orthocladiinae	*Parakiefferiella*	30		CG/SC	SP/BU
Diptera	Orthocladiinae	*Rheocricotopus*	18		CG/SC	SP/BU
Diptera	Orthocladiinae	*Tvetenia vitracies*	18		CG/SC	SP/BU
Diptera	Tipula	*Tipula*	6	4	SH	BU
Ephemeroptera	Ameletus	*Ameletus*	90	0	SC	"SW/10%, CN/90%"
Ephemeroptera	Baetis	*Baetis tricaudatus*	132	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Cinygmula	*Cinygmula*	672	0	SC	CN
Ephemeroptera	Drunella coloraden	*Drunella coloradensis*	24	1	SC	"CN/75%, SP/25%"
Ephemeroptera	Drunella doddsi	*Drunella doddsii*	84	1	SC	"CN/75%, SP/25%"
Ephemeroptera	Epeorus	*Epeorus deceptivus*	90	2	CG	CN
Ephemeroptera	Epeorus	*Epeorus longimanus*	6	2	CG	CN
Ephemeroptera	Rhithrogena	*Rhithrogena*	102	0	CG	CN
Ephemeroptera	Serratella	*Serratella tibialis*	18	2	CG	CN

Lumbriculida	Oligochaeta	*Lumbriculidae*	48	8	CG	BU
Plecoptera	Chloroperlidae	*Sweltsa*	180	1	PR	CN
Plecoptera	Doroneuria	*Doroneuria theodora*	18	0	unk	CN
Plecoptera	Isoperla	*Isoperla*	6	2	PR	CN
Plecoptera	Leuctridae	*Despaxia augusta*	24	1	SH	CN
Plecoptera	Megarcys	*Megarcys*	6	1	PR	CN
Plecoptera	Setvena	*Setvena bradleyi*	6	0	PR	CN
Plecoptera	Taeniopterygidae	*Taeniopterygidae*	30	2	SH	CN
Plecoptera	Visoka	*Visoka cataractae*	18	0	SH	CN
Plecoptera	Yoraperla	*Yoraperla brevis*	6	0	SH	CN
Plecoptera	Zapada	*Zapada columbiana*	72	2	SH	CN
Plecoptera	Zapada	*Zapada oregonensis gr.*	30	2	SH	CN
Trichoptera	Ecclisomyia	*Ecclisomyia maculosa*	6	4	CG	CN/SP/CM
Trichoptera	Glossosoma	*Glossosoma*	18	0	SC	CN
Trichoptera	Neophylax	*Neophylax occidentis*	12	3	SC	CN
Trichoptera	Rhyacophila betten	*Rhyacophila Betteni Gr.*	18	1	PR	CN
Trichoptera	Rhyacophila brunn	*Rhyacophila Brunnea Gr.*	6	0	PR	CN
Trichoptera	Rhyacophila sibiric	*Rhyacophila narvae*	96	0	PR	CN
Trichoptera	Rhyacophila vagrit	*Rhyacophila vagrita gr.*	6	0	PR	CN
Trichoptera	Rhyacophila vofixa	*Rhyacophila vofixa gr.*	6	0	PR	CN

Camp Creek

Camp Creek 2015

Body of Water	Camp Creek	Benthic Sample ID:	19815
Station ID:	WS_CAMP15	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E13-T500-M
Rep. Num		Collection Date	9/5/2015
		Collection Method	MAC-T-500
		Total Count	2704

Order:	*OTU name:*	*FinalID:*	*Individuals*	*Tol Val:*	*FFG:*	*Habit:*
		Nostoccocladius	16			
	Turbellaria	*Polycelis coronata*	88	4	CG/PR	SP
Coleoptera	Heterlimnius	*Heterlimnius corpulentus*	160	3	SC/CG	"CN/50%, BU/50%"
Diptera	Chelifera_Metachel	*Chelifera*	8	5	unk	SP
Diptera	Chironominae	*Micropsectra*	16	7	CG/CF/PR	BU/CN/SP
Diptera	Chironominae	*Stempellina*	8	7	CG/CF/PR	BU/CN/SP
Diptera	Diamesinae	*Diamesa*	32	4	CG	sp
Diptera	Diamesinae	*Pagastia*	24	4	CG	sp

Diptera	Orthocladiinae	*Brillia*	8		CG/SC	SP/BU
Diptera	Orthocladiinae	*Hydrobaenus*	40		CG/SC	SP/BU
Diptera	Orthocladiinae	*Parakiefferiella*	16		CG/SC	SP/BU
Diptera	Orthocladiinae	*Tvetenia vitracies*	8		CG/SC	SP/BU
Diptera	Simuliidae	*Prosimulium*	24	6	CF	CN
Ephemeroptera	Baetis	*Baetis tricaudatus*	96	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Cinygmula	*Cinygmula*	88	0	SC	CN
Ephemeroptera	Drunella coloraden	*Drunella coloradensis*	8	1	SC	"CN/75%, SP/25%"
Ephemeroptera	Drunella doddsi	*Drunella doddsii*	8	1	SC	"CN/75%, SP/25%"
Ephemeroptera	Drunella spinifera	*Drunella spinifera*	8	0	PR	"CN/75%, SP/25%"
Ephemeroptera	Epeorus	*Epeorus deceptivus*	16	2	CG	CN
Ephemeroptera	Epeorus	*Epeorus grandis*	16	2	CG	CN
Ephemeroptera	Paraleptophlebia	*Paraleptophlebia*	16	1	CG	SW/CN/SP
Ephemeroptera	Rhithrogena	*Rhithrogena*	896	0	CG	CN
Ephemeroptera	Serratella	*Serratella tibialis*	16	2	CG	CN
Lumbriculida	Oligochaeta	*Lumbriculidae*	40	8	CG	BU
Plecoptera	Chloroperlidae	*Sweltsa*	128	1	PR	CN
Plecoptera	Doroneuria	*Doroneuria theodora*	128	0	unk	CN
Plecoptera	Isoperla	*Isoperla*	24	2	PR	CN
Plecoptera	Leuctridae	*Despaxia augusta*	144	1	SH	CN
Plecoptera	Megarcys	*Megarcys*	136	1	PR	CN
Plecoptera	Yoraperla	*Yoraperla brevis*	8	0	SH	CN
Plecoptera	Zapada	*Zapada columbiana*	112	2	SH	CN
Plecoptera	Zapada	*Zapada oregonensis gr.*	32	2	SH	CN
Trichoptera	Dicosmoecus	*Dicosmoecus atripes*	8	2	SC	SP
Trichoptera	Parapsyche	*Parapsyche elsis*	8	0	CF	CN
Trichoptera	Rhyacophila betten	*Rhyacophila Betteni Gr.*	144	1	PR	CN
Trichoptera	Rhyacophila brunn	*Rhyacophila Brunnea Gr.*	88	0	PR	CN
Trichoptera	Rhyacophila hyalin	*Rhyacophila Hyalinata Gr.*	8	1	PR	CN
Trichoptera	Rhyacophila sibiric	*Rhyacophila narvae*	72	0	PR	CN
Trichoptera	Rhyacophila sibiric	*Rhyacophila pellisa*	8	0	PR	CN

Camp Creek (upper)

Body of Water	Camp Creek upper	Benthic Sample ID:	19816
Station ID:	WS_CAMPU15	Rep. Num.	0
Reference Status Classification		STORET Activity ID	E20-T500-M
Rep. Num		Collection Date	9/5/2015
		Collection Method	MAC-T-500
		Total Count	840

Order:	OTU name:	FinalID:	Count	Tol Val:	FFG:	Habit:
	Turbellaria	*Polycelis coronata*	32	4	CG/PR	SP
Coleoptera	Heterlimnius	*Heterlimnius corpulentus*	16	3	SC/CG	"CN/50%, BU/50%"
Diptera	Chelifera_Metachel	*Chelifera*	8	5	unk	SP
Diptera	Diamesinae	*Diamesa*	16	4	CG	sp
Diptera	Diamesinae	*Pagastia*	16	4	CG	sp
Diptera	Orthocladiinae	*Brillia*	8		CG/SC	SP/BU
Diptera	Orthocladiinae	*Parakiefferiella*	16		CG/SC	SP/BU
Diptera	Orthocladiinae	*Tvetenia vitracies*	8		CG/SC	SP/BU
Diptera	Simuliidae	*Prosimulium*	8	6	CF	CN
Ephemeroptera	Baetis	*Baetis tricaudatus*	8	5	CG	"SW/10%, CN/90%"
Ephemeroptera	Cinygmula	*Cinygmula*	72	0	SC	CN
Ephemeroptera	Drunella doddsi	*Drunella doddsii*	8	1	SC	"CN/75%, SP/25%"
Ephemeroptera	Drunella spinifera	*Drunella spinifera*	8	0	PR	"CN/75%, SP/25%"
Ephemeroptera	Epeorus	*Epeorus deceptivus*	8	2	CG	CN
Ephemeroptera	Epeorus	*Epeorus grandis*	8	2	CG	CN
Ephemeroptera	Paraleptophlebia	*Paraleptophlebia*	8	1	CG	SW/CN/SP
Ephemeroptera	Rhithrogena	*Rhithrogena*	112	0	CG	CN
Lumbriculida	Oligochaeta	*Lumbriculidae*	16	8	CG	BU
Plecoptera	Chloroperlidae	*Sweltsa*	64	1	PR	CN
Plecoptera	Doroneuria	*Doroneuria theodora*	88	0	unk	CN
Plecoptera	Isoperla	*Isoperla*	24	2	PR	CN
Plecoptera	Leuctridae	*Despaxia augusta*	24	1	SH	CN
Plecoptera	Megarcys	*Megarcys*	40	1	PR	CN
Plecoptera	Paraperla	*Paraperla*	16	1	unk	unk
Plecoptera	Yoraperla	*Yoraperla brevis*	8	0	SH	CN
Plecoptera	Zapada	*Zapada columbiana*	40	2	SH	CN
Plecoptera	Zapada	*Zapada oregonensis gr.*	8	2	SH	CN
Trichoptera	Dicosmoecus	*Dicosmoecus atripes*	8	2	SC	SP
Trichoptera	Glossosoma	*Glossosoma*	8	0	SC	CN
Trichoptera	Parapsyche	*Parapsyche elsis*	8	0	CF	CN
Trichoptera	Rhyacophila betten	*Rhyacophila Betteni Gr.*	64	1	PR	CN
Trichoptera	Rhyacophila brunn	*Rhyacophila Brunnea Gr.*	16	0	PR	CN
Trichoptera	Rhyacophila hyalin	*Rhyacophila Hyalinata Gr.*	8	1	PR	CN
Trichoptera	Rhyacophila sibiric	*Rhyacophila narvae*	32	0	PR	CN
Trichoptera	Rhyacophila sibiric	*Rhyacophila pellisa*	8	0	PR	CN

Appendix F.: Aquatic Macroinvertebrate Community Metrics

North Fork Blackfoot River

Waterbody Name: North Fork Blackfoot River nr. EFBLF confluen
Benthic Sample ID: 18178
Rep. Num 0
Station ID: WS_NFBLF473 (lower)
Reference Status:
STORET Activity ID: E02-T500-M
Site Classification:
Collect. Date: 08/27/2014
Four Code HUC:
Collect Method: MAC-T-500
TMDL Plan. Area:
Total Indiv. in Sample: 968
Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: ***70.2***

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	6	*62.7*
Plecoptera Taxa:	5	*70.7*
EPT Percent:	50.8	*56.5*
Non-Insect Percent:	1.2	*95.6*
Predator Percent:	14.5	*37.1*
Burrower Taxa %:	20.6	*87.9*
HBI:	2.64	*81.0*

Waterbody Name: North Fork Blackfoot River below Broadus Cr
Benthic Sample ID: 18180
Rep. Num 0
Station ID: WS_NFBLF481 (middle)
Reference Status:
STORET Activity ID: E06-T500-M
Site Classification:
Collect. Date: 08/28/2014
Four Code HUC:
Collect Method: MAC-T-500
TMDL Plan. Area:
Total Indiv. in Sample: 774
Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: ***86.9***

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	6	*56.1*
Plecoptera Taxa:	8	*100.0*
EPT Percent:	80.4	*89.3*
Non-Insect Percent:	1.8	*93.5*
Predator Percent:	33.1	*84.8*
Burrower Taxa %:	19.0	*90.1*
HBI:	1.84	*94.3*

Waterbody Name: NF Blackfoot River
Station ID: WS_NFBLF2015
Reference Status:
Site Classification:
Four Code HUC:
TMDL Plan. Area:

Benthic Sample ID: 19819
Rep. Num 0
STORET Activity ID: E23-T500-M
Collect. Date: 09/06/2015
Collect Method: MAC-T-500
Total Indiv. in Sample: 2512

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: ***86.7***

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	8	*77.4*
Plecoptera Taxa:	7	*98.4*
EPT Percent:	74.5	*82.8*
Non-Insect Percent:	1.6	*94.3*
Predator Percent:	25.8	*66.1*
Burrower Taxa %:	18.5	*90.8*
HBI:	1.66	*97.3*

Waterbody Name: North Fork Blackfoot River
Station ID: WS_NFBLF478 (upper)
Reference Status:
Site Classification:
Four Code HUC:
TMDL Plan. Area:

Benthic Sample ID: 18179
Rep. Num 0
STORET Activity ID: E05-T500-M
Collect. Date: 08/28/2014
Collect Method: MAC-T-500
Total Indiv. in Sample: 502

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: ***86.2***

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	5	*46.0*
Plecoptera Taxa:	7	*94.2*
EPT Percent:	80.7	*89.6*
Non-Insect Percent:	0.8	*97.2*
Predator Percent:	34.5	*88.4*
Burrower Taxa %:	16.1	*94.3*
HBI:	1.88	*93.6*

Waterbody Name: NF Blackfoot River
Station ID: WS_NFBLF2015
Reference Status:
Site Classification:
Four Code HUC:
TMDL Plan. Area:

Benthic Sample ID: 19819
Rep. Num 0
STORET Activity ID: E23-T500-M
Collect. Date: 09/06/2015
Collect Method: MAC-T-500
Total Indiv. in Sample: 2512

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: *86.7*

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	8	*77.4*
Plecoptera Taxa:	7	*98.4*
EPT Percent:	74.5	*82.8*
Non-Insect Percent:	1.6	*94.3*
Predator Percent:	25.8	*66.1*
Burrower Taxa %:	18.5	*90.8*
HBI:	1.66	*97.3*

Waterbody Name: NF Blackfoot River Upper
Station ID: WS_NFBLFU2015
Reference Status:
Site Classification:
Four Code HUC:
TMDL Plan. Area:

Benthic Sample ID: 19820
Rep. Num 0
STORET Activity ID: E24-T500-M
Collect. Date: 09/30/2015
Collect Method: MAC-T-500
Total Indiv. in Sample: 1392

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: *88.5*

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	10	*99.5*
Plecoptera Taxa:	7	*95.1*
EPT Percent:	65.5	*72.8*
Non-Insect Percent:	2.2	*92.3*
Predator Percent:	29.3	*75.2*
Burrower Taxa %:	18.5	*90.9*
HBI:	1.87	*93.8*

Dobrota Creek

Waterbody Name: Dobrota Creek
Station ID: WS_DOBROTA
Reference Status:
Site Classification:
Four Code HUC:
TMDL Plan. Area:

Benthic Sample ID: 18177
Rep. Num 0
STORET Activity ID: E07-T500-M
Collect. Date: 08/28/2014
Collect Method: MAC-T-500
Total Indiv. in Sample: 502

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: ***82.3***

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	6	*59.1*
Plecoptera Taxa:	7	*95.4*
EPT Percent:	79.3	*88.1*
Non-Insect Percent:	0.4	*98.6*
Predator Percent:	18.3	*47.0*
Burrower Taxa %:	14.2	*96.9*
HBI:	2.03	*91.1*

Cooney Creek

Waterbody Name: Cooney Creek
Station ID: WS_COONEY
Reference Status:
Site Classification:
Four Code HUC:
TMDL Plan. Area:

Benthic Sample ID: 18176
Rep. Num 0
STORET Activity ID: E03-T500-M
Collect. Date: 08/27/2014
Collect Method: MAC-T-500
Total Indiv. in Sample: 304

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: ***78.5***

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	7	*69.9*
Plecoptera Taxa:	6	*85.7*
EPT Percent:	75.0	*83.3*
Non-Insect Percent:	11.8	*57.7*
Predator Percent:	29.6	*75.9*
Burrower Taxa %:	23.3	*84.1*
HBI:	1.92	*93.0*

Waterbody Name: Cooney Creek Lower
Station ID: WS_C0NYL15
Reference Status:
Site Classification:
Four Code HUC:
TMDL Plan. Area:

Benthic Sample ID: 19813
Rep. Num 0
STORET Activity ID: E18-T500-M
Collect. Date: 09/05/2015
Collect Method: MAC-T-500
Total Indiv. in Sample: 1136

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: 85.2

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	6	*59.1*
Plecoptera Taxa:	7	*100.0*
EPT Percent:	78.9	*87.6*
Non-Insect Percent:	10.6	*62.3*
Predator Percent:	38.7	*99.3*
Burrower Taxa %:	20.2	*88.4*
HBI:	1.43	*100.0*

Waterbody Name: Cooney Creek Upper
Station ID: WS_C0NYU15
Reference Status:
Site Classification:
Four Code HUC:
TMDL Plan. Area:

Benthic Sample ID: 19814
Rep. Num 0
STORET Activity ID: E19-T500-M
Collect. Date: 10/01/2015
Collect Method: MAC-T-500
Total Indiv. in Sample: 1416

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: 92.9

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	8	*75.1*
Plecoptera Taxa:	7	*97.6*
EPT Percent:	94.4	*100.0*
Non-Insect Percent:	2.3	*91.9*
Predator Percent:	33.3	*85.5*
Burrower Taxa %:	8.3	*100.0*
HBI:	1.01	*100.0*

Broadus Creek

Waterbody Name: Broadus Creek
Station ID: WS_BROADUS
Reference Status:
Site Classification:
Four Code HUC:
TMDL Plan. Area:

Benthic Sample ID: 18175
Rep. Num 0
STORET Activity ID: E09-T500-M
Collect. Date: 08/28/2014
Collect Method: MAC-T-500
Total Indiv. in Sample: 772

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: ***85.9***

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	6	*58.4*
Plecoptera Taxa:	7	*99.7*
EPT Percent:	91.7	*100.0*
Non-Insect Percent:	0.5	*98.1*
Predator Percent:	20.2	*51.8*
Burrower Taxa %:	15.7	*94.8*
HBI:	1.61	*98.2*

Waterbody Name: Broadus Creek
Station ID: WS_BROAD15
Reference Status:
Site Classification:
Four Code HUC:
TMDL Plan. Area:

Benthic Sample ID: 19812
Rep. Num 0
STORET Activity ID: E14-T500-M
Collect. Date: 09/05/2015
Collect Method: MAC-T-500
Total Indiv. in Sample: 800

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: ***92.7***

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	6	*57.0*
Plecoptera Taxa:	7	*99.9*
EPT Percent:	97.5	*100.0*
Non-Insect Percent:	0.5	*98.2*
Predator Percent:	36.5	*93.6*
Burrower Taxa %:	7.6	*100.0*
HBI:	1.16	*100.0*

Theodore Creek

Waterbody Name: Theodore Creek
Benthic Sample ID: 18182
Station ID: WS_THEODOR
Rep. Num 0
Reference Status:
STORET Activity ID: E08-T500-M
Site Classification:
Collect. Date: 08/28/2014
Four Code HUC:
Collect Method: MAC-T-500
TMDL Plan. Area:
Total Indiv. in Sample: 512

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: ***76.7***

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	5	*46.6*
Plecoptera Taxa:	7	*99.6*
EPT Percent:	73.0	*81.2*
Non-Insect Percent:	11.7	*58.1*
Predator Percent:	26.2	*67.1*
Burrower Taxa %:	14.8	*96.0*
HBI:	2.22	*88.0*

Sarbo Creek

Waterbody Name: Sarbo Creek
Benthic Sample ID: 18181
Station ID: WS_SARBO
Rep. Num 0
Reference Status:
STORET Activity ID: E01-T500-M
Site Classification:
Collect. Date: 08/27/2014
Four Code HUC:
Collect Method: MAC-T-500
TMDL Plan. Area:
Total Indiv. in Sample: 503

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: ***82.3***

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	6	*58.3*
Plecoptera Taxa:	7	*97.3*
EPT Percent:	75.3	*83.7*
Non-Insect Percent:	1.8	*93.6*
Predator Percent:	19.9	*51.0*
Burrower Taxa %:	11.3	*100.0*
HBI:	1.96	*92.4*

Waterbody Name:	Sarbo Creek	**Benthic Sample ID:**	19821
Station ID:	WS_SARBO15	**Rep. Num**	0
Reference Status:		**STORET Activity ID:**	E17-T500-M
Site Classification:		**Collect. Date:**	09/30/2015
Four Code HUC:		**Collect Method:**	MAC-T-500
TMDL Plan. Area:		**Total Indiv. in Sample:**	1752
Latitude:	GIS_LAT	**Longitude:**	GIS_LONG:

Mountain MMI: ***84.6***

Metric:	***Value***	***Score***
Ephemeroptera Taxa:	**6**	***59.9***
Plecoptera Taxa:	**8**	***100.0***
EPT Percent:	**50.7**	***56.3***
Non-Insect Percent:	**4.1**	***85.3***
Predator Percent:	**42.5**	***100.0***
Burrower Taxa %:	**13.7**	***97.6***
HBI:	**1.91**	***93.2***

Unnamed Tributary of the North Fork Blackfoot River

Waterbody Name:	Unnamed tributary to NFBLF	**Benthic Sample ID:**	18183
Station ID:	WS_UNN474	**Rep. Num**	0
Reference Status:		**STORET Activity ID:**	E04-T500-M
Site Classification:		**Collect. Date:**	08/27/2014
Four Code HUC:		**Collect Method:**	MAC-T-500
TMDL Plan. Area:		**Total Indiv. in Sample:**	964
Latitude:	GIS_LAT	**Longitude:**	GIS_LONG:

Metric:	***Value***	***Score***

Mountain MMI:

73

East Fork North Fork Blackfoot River

Waterbody Name:	East Fork NF Blackfoot	**Benthic Sample ID:**	18163
Station ID:	WS_EFNFBL (lower)	**Rep. Num**	0
Reference Status:		**STORET Activity ID:**	E04-T500-M
Site Classification:		**Collect. Date:**	08/08/2013
Four Code HUC:		**Collect Method:**	MAC-T-500
TMDL Plan. Area:		**Total Indiv. in Sample:**	920
Latitude:	GIS_LAT	**Longitude:**	GIS_LONG:

Mountain MMI: ***69.6***

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	6	*57.5*
Plecoptera Taxa:	5	*71.3*
EPT Percent:	48.9	*54.3*
Non-Insect Percent:		*100.0*
Predator Percent:	16.5	*42.4*
Burrower Taxa %:	25.6	*80.8*
HBI:	2.63	*81.1*

Waterbody Name:	East Fork NF Blackfoot	**Benthic Sample ID:**	18164
Station ID:	WS_EFNFBL (upper)	**Rep. Num**	0
Reference Status:		**STORET Activity ID:**	E05-T500-M
Site Classification:		**Collect. Date:**	08/06/2013
Four Code HUC:		**Collect Method:**	MAC-T-500
TMDL Plan. Area:		**Total Indiv. in Sample:**	876
Latitude:	GIS_LAT	**Longitude:**	GIS_LONG:

Mountain MMI: ***83.9***

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	7	*68.1*
Plecoptera Taxa:	6	*83.0*
EPT Percent:	74.4	*82.7*
Non-Insect Percent:		*100.0*
Predator Percent:	28.3	*72.6*
Burrower Taxa %:	20.9	*87.4*
HBI:	1.89	*93.5*

Waterbody Name: EF NF Blackfoot Upper
Station ID: WS_EFNFBLU15
Reference Status:
Site Classification:
Four Code HUC:
TMDL Plan. Area:

Benthic Sample ID: 19817
Rep. Num 0
STORET Activity ID: E21-T500-M
Collect. Date: 09/04/2015
Collect Method: MAC-T-500
Total Indiv. in Sample: 1236

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: *84.8*

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	8	*82.2*
Plecoptera Taxa:	7	*100.0*
EPT Percent:	61.8	*68.7*
Non-Insect Percent:	1.3	*95.4*
Predator Percent:	25.6	*65.6*
Burrower Taxa %:	21.2	*87.0*
HBI:	1.80	*95.0*

Blondie Creek

Waterbody Name: Blondie Creek
Station ID: WS_BLOND
Reference Status:
Site Classification:
Four Code HUC:
TMDL Plan. Area:

Benthic Sample ID: 18160
Rep. Num 0
STORET Activity ID: E01-T500-M
Collect. Date: 08/06/2013
Collect Method: MAC-T-500
Total Indiv. in Sample: 332

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: *79.6*

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	2	*20.0*
Plecoptera Taxa:	7	*99.9*
EPT Percent:	62.0	*68.9*
Non-Insect Percent:		*100.0*
Predator Percent:	27.1	*69.5*
Burrower Taxa %:	11.1	*100.0*
HBI:	1.56	*99.0*

Sourdough Creek

Waterbody Name: Sourdough Creek (lower) **Benthic Sample ID:** 18169
Station ID: WS_SOURL **Rep. Num** 0
Reference Status: **STORET Activity ID:** E09-T500-M
Site Classification: **Collect. Date:** 08/06/2013
Four Code HUC: **Collect Method:** MAC-T-500
TMDL Plan. Area: **Total Indiv. in Sample:** 1488

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: *84.3*

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	5	*49.7*
Plecoptera Taxa:	8	*100.0*
EPT Percent:	93.5	*100.0*
Non-Insect Percent:	1.3	*95.2*
Predator Percent:	20.7	*53.1*
Burrower Taxa %:	14.8	*96.0*
HBI:	1.72	*96.4*

Waterbody Name: Sourdough Creek lower **Benthic Sample ID:** 19822
Station ID: WS_SOURL15 **Rep. Num** 0
Reference Status: **STORET Activity ID:** E15-T500-M
Site Classification: **Collect. Date:** 09/03/2015
Four Code HUC: **Collect Method:** MAC-T-500
TMDL Plan. Area: **Total Indiv. in Sample:** 1416

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: *83.3*

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	6	*59.9*
Plecoptera Taxa:	6	*88.9*
EPT Percent:	89.0	*98.9*
Non-Insect Percent:	4.7	*83.4*
Predator Percent:	22.5	*57.6*
Burrower Taxa %:	15.2	*95.5*
HBI:	1.55	*99.2*

		Benthic Sample ID:	19823
Waterbody Name:	Sourdough Creek upper	Rep. Num	0
Station ID:	WS_SOURU15	STORET Activity ID:	E16-T500-M
Reference Status:		Collect. Date:	09/30/2015
Site Classification:		Collect Method:	MAC-T-500
Four Code HUC:		Total Indiv. in Sample:	1040
TMDL Plan. Area:			

Latitude: GIS_LAT Longitude: GIS_LONG:

Mountain MMI: *71.6*

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	5	*47.4*
Plecoptera Taxa:	6	*92.4*
EPT Percent:	53.5	*59.4*
Non-Insect Percent:	20.8	*25.8*
Predator Percent:	33.1	*84.8*
Burrower Taxa %:	13.0	*98.5*
HBI:	1.95	*92.5*

Scotty Creek

		Benthic Sample ID:	18168
Waterbody Name:	Scotty Creek	Rep. Num	0
Station ID:	WS_SCOTTY	STORET Activity ID:	E08-T500-M
Reference Status:		Collect. Date:	08/06/2013
Site Classification:		Collect Method:	MAC-T-500
Four Code HUC:		Total Indiv. in Sample:	2176
TMDL Plan. Area:			

Latitude: GIS_LAT Longitude: GIS_LONG:

Mountain MMI: *76.3*

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	5	*49.6*
Plecoptera Taxa:	6	*85.2*
EPT Percent:	56.3	*62.5*
Non-Insect Percent:	1.5	*94.7*
Predator Percent:	23.5	*60.3*
Burrower Taxa %:	17.9	*91.7*
HBI:	2.09	*90.1*

Meadow Creek

Waterbody Name: Meadow Creek (lower)
Station ID: WS_MEADCR
Reference Status:
Site Classification:
Four Code HUC:
TMDL Plan. Area:

Benthic Sample ID: 18167
Rep. Num 0
STORET Activity ID: E07-T500-M
Collect. Date: 08/08/2013
Collect Method: MAC-T-500
Total Indiv. in Sample: 1564

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: ***75.5***

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	7	*73.8*
Plecoptera Taxa:	5	*68.8*
EPT Percent:	72.9	*81.0*
Non-Insect Percent:	1.0	*96.3*
Predator Percent:	18.7	*47.9*
Burrower Taxa %:	35.4	*67.1*
HBI:	1.87	*93.8*

Waterbody Name: Meadow Creek (upper)
Station ID: WS_MEADCR
Reference Status:
Site Classification:
Four Code HUC:
TMDL Plan. Area:

Benthic Sample ID: 18161
Rep. Num 0
STORET Activity ID: E02-T500-M
Collect. Date: 08/07/2013
Collect Method: MAC-T-500
Total Indiv. in Sample: 668

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: ***81.2***

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	7	*66.0*
Plecoptera Taxa:	6	*80.0*
EPT Percent:	84.7	*94.1*
Non-Insect Percent:	1.2	*95.7*
Predator Percent:	15.6	*39.9*
Burrower Taxa %:	17.1	*92.8*
HBI:	1.32	*100.0*

Waterbody Name:	East Fork Meadow Creek	**Benthic Sample ID:**	18162
Station ID:	WS_EFMEAD	**Rep. Num**	0
Reference Status:		**STORET Activity ID:**	E03-T500-M
Site Classification:		**Collect. Date:**	08/07/2013
Four Code HUC:		**Collect Method:**	MAC-T-500
TMDL Plan. Area:		**Total Indiv. in Sample:**	992
Latitude:	GIS_LAT	**Longitude:**	GIS_LONG:

Mountain MMI: ***89.3***

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	7	*73.3*
Plecoptera Taxa:	7	*100.0*
EPT Percent:	90.5	*100.0*
Non-Insect Percent:		*100.0*
Predator Percent:	22.2	*56.9*
Burrower Taxa %:	15.7	*94.8*
HBI:	1.38	*100.0*

Lost Pony

Waterbody Name:	Lost Pony Creek	**Rep. Num**	0
Station ID:	WS_LOSTPONY	**STORET Activity ID:**	E06-T500-M
Reference Status:		**Collect. Date:**	08/08/2013
Site Classification:		**Collect Method:**	MAC-T-500
Four Code HUC:		**Total Indiv. in Sample:**	1476
TMDL Plan. Area:			
Latitude:	GIS_LAT	**Longitude:**	GIS_LONG:

Mountain MMI: ***85.5***

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	8	*75.4*
Plecoptera Taxa:	7	*97.7*
EPT Percent:	70.7	*78.6*
Non-Insect Percent:		*100.0*
Predator Percent:	18.7	*47.9*
Burrower Taxa %:	7.6	*100.0*
HBI:	1.55	*99.1*

Spaulding Creek

Waterbody Name: Spaulding Creek
Station ID: WS_SPAULD
Reference Status:
Site Classification:
Four Code HUC:
TMDL Plan. Area:

Benthic Sample ID: 18171
Rep. Num 0
STORET Activity ID: E11-T500-M
Collect. Date: 08/08/2013
Collect Method: MAC-T-500
Total Indiv. in Sample: 2124

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: ***84.7***

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	6	*64.4*
Plecoptera Taxa:	6	*92.2*
EPT Percent:	87.0	*96.7*
Non-Insect Percent:	1.5	*94.6*
Predator Percent:	17.5	*44.9*
Burrower Taxa %:	9.3	*100.0*
HBI:	1.46	*100.0*

Waterbody Name: Mineral Creek
Station ID: WS_MINERAL
Reference Status:
Site Classification:
Four Code HUC:
TMDL Plan. Area:

Benthic Sample ID: 19818
Rep. Num 0
STORET Activity ID: E22-T500-M
Collect. Date: 09/05/2015
Collect Method: MAC-T-500
Total Indiv. in Sample: 2496

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: ***82.1***

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	8	*78.6*
Plecoptera Taxa:	8	*100.0*
EPT Percent:	71.4	*79.3*
Non-Insect Percent:	4.8	*82.8*
Predator Percent:	19.5	*49.9*
Burrower Taxa %:	21.1	*87.2*
HBI:	1.68	*97.0*

Camp Creek

Waterbody Name: Camp Creek
Station ID: WS_CAMP15
Reference Status:
Site Classification:
Four Code HUC:
TMDL Plan. Area:

Benthic Sample ID: 19815
Rep. Num 0
STORET Activity ID: E13-T500-M
Collect. Date: 09/05/2015
Collect Method: MAC-T-500
Total Indiv. in Sample: 2704

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: *86.8*

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	8	*75.0*
Plecoptera Taxa:	7	*93.6*
EPT Percent:	82.0	*91.1*
Non-Insect Percent:	4.7	*83.1*
Predator Percent:	26.9	*69.0*
Burrower Taxa %:	14.9	*95.9*
HBI:	1.24	*100.0*

Waterbody Name: Camp Creek upper
Station ID: WS_CAMPU15
Reference Status:
Site Classification:
Four Code HUC:
TMDL Plan. Area:

Benthic Sample ID: 19816
Rep. Num 0
STORET Activity ID: E20-T500-M
Collect. Date: 09/05/2015
Collect Method: MAC-T-500
Total Indiv. in Sample: 840

Latitude: GIS_LAT **Longitude:** GIS_LONG:

Mountain MMI: *90.1*

Metric:	*Value*	*Score*
Ephemeroptera Taxa:	7	*68.8*
Plecoptera Taxa:	8	*100.0*
EPT Percent:	82.9	*92.1*
Non-Insect Percent:	5.7	*79.6*
Predator Percent:	35.2	*90.4*
Burrower Taxa %:	10.5	*100.0*
HBI:	1.22	*100.0*

Similiarity Tables

Broadus Control vs. Treatment							
Total	**804**	**773**	**28**	**28**	**25**	**31**	**100.71**
cum ttl		**1577**					
% COMM. Similarity	**49.64**						
% TAXA Similarity	**80.65**						
Taxon	**2015 Control**	**2014 Treatment**	**TAXA 1**	**TAXA 2**	**COMMON**	**TAXA 1+2**	**,ai-bi,**
Ameletus	40	**16**	1	1	1	1	2.91
Anagapetus	8	**0**	1	0	0	1	1.00
Baetis tricaudatus	16	**84**	1	1	1	1	8.88
Calineuria californica	52	**1**	1	1	1	1	6.34
Cinygmula	4	**8**	1	1	1	1	0.54
Despaxia augusta	36	**96**	1	1	1	1	7.94
Diamesa	8	**40**	1	1	1	1	4.18
Dicosmoecus atripes	4	**8**	1	1	1	1	0.54
Doroneuria theodora	12	**20**	1	1	1	1	1.09
Drunella coloradensis	4	**4**	1	1	1	1	0.02
Epeorus deceptivus	4	**4**	1	1	1	1	0.02
Epeorus grandis	108	**28**	1	1	1	1	9.81
Heterlimnius corpulentus	8	**4**	1	1	1	1	0.48
Megarcys	80	**36**	1	1	1	1	5.29
Micropsectra	0	**8**	0	1	0	1	1.03
Nematoda	4	**4**	1	1	1	1	0.02
Neothremma alicia	4	**0**	1	0	0	1	0.50
Parapsyche elsis	104	**28**	1	1	1	1	9.31
Rhithrogena	40	**92**	1	1	1	1	6.93
Rhyacophila betteni gr.	56	**16**	1	1	1	1	4.90
Rhyacophila brunnea gr.	16	**20**	1	1	1	1	0.60
Rhyacophila hyalinata gr.	20	**16**	1	1	1	1	0.42
Rhyacophila narvae	4	**8**	1	1	1	1	0.54
Rhyacophila pellisa	0	**4**	0	1	0	1	0.52
Rhyacophila vofixa gr.	8	**0**	1	0	0	1	1.00
Sweltsa	56	**48**	1	1	1	1	0.76
Tvetenia vitracies	4	**8**	1	1	1	1	0.54
Visoka cataractae	0	**8**	0	1	0	1	1.03
Yoraperla brevis	16	**32**	1	1	1	1	2.15
Zapada columbiana	16	**122**	1	1	1	1	13.79
Zapada oregonensis gr.	72	**10**	1	1	1	1	7.66

Camp Creek Treatment vs Control							
Total	**2704**	**840**	**39**	**35**	**33**	**41**	**69.15187377**
cum ttl		**3544**					
% COMM. Similarity	**65.42**						
% TAXA Similarity	**80.49**						
taxa	Treatment	Control	TAXA 1	TAXA 2	COMMON	TAXA 1+2	,ai-bi,
Baetis tricaudatus	96	8	1	1	1	1	2.60
Brillia	8	8	1	1	1	1	0.66
Chelifera	8	8	1	1	1	1	0.66
Cinygmula	88	72	1	1	1	1	5.32
Despaxia augusta	144	24	1	1	1	1	2.47
Diamesa	32	16	1	1	1	1	0.72
Dicosmoecus atripes	8	8	1	1	1	1	0.66
Doroneuria theodora	128	88	1	1	1	1	5.74
Drunella coloradensis	8	0	1	0	0	1	0.30
Drunella doddsii	8	8	1	1	1	1	0.66
Drunella spinifera	8	8	1	1	1	1	0.66
Epeorus deceptivus	16	8	1	1	1	1	0.36
Epeorus grandis	16	8	1	1	1	1	0.36
Glossosoma	0	8	0	1	0	1	0.95
Heterlimnius corpulentus	160	16	1	1	1	1	4.01
Hydrobaenus	40	0	1	0	0	1	1.48
Isoperla	24	24	1	1	1	1	1.97
Lumbriculidae	40	16	1	1	1	1	0.43
Megarcys	136	40	1	1	1	1	0.27
Micropsectra	16	0	1	0	0	1	0.59
Nostoccocladius	16	0	1	0	0	1	0.59
Pagastia	24	16	1	1	1	1	1.02
Parakiefferiella	16	16	1	1	1	1	1.31
Paraleptophlebia	16	8	1	1	1	1	0.36
Paraperla	0	16	0	1	0	1	1.90
Parapsyche elsis	8	8	1	1	1	1	0.66
Polycelis coronata	88	32	1	1	1	1	0.56
Prosimulium	24	8	1	1	1	1	0.06
Rhithrogena	896	112	1	1	1	1	19.80
Rhyacophila betteni gr.	144	64	1	1	1	1	2.29
Rhyacophila brunnea gr.	88	16	1	1	1	1	1.35
Rhyacophila hyalinata gr.	8	8	1	1	1	1	0.66
Rhyacophila narvae	72	32	1	1	1	1	1.15
Rhyacophila pellisa	8	8	1	1	1	1	0.66
Serratella tibialis	16	0	1	0	0	1	0.59
Stempellina	8	0	1	0	0	1	0.30
Sweltsa	128	64	1	1	1	1	2.89
Tvetenia vitracies	8	8	1	1	1	1	0.66
Yoraperla brevis	8	8	1	1	1	1	0.66
Zapada columbiana	112	40	1	1	1	1	0.62
Zapada oregonensis gr.	32	8	1	1	1	1	0.23

Cooney Treatment vs Control							
Total	1472	1432	31	41	27	45	95.85256255
cum ttl		2904					
% COMM. Similarity	52.07						
% TAXA Similarity	60.00						
taxa	2015 Control	2015 Treatment	TAXA 1	TAXA 2	COMMON	TAXA 1+2	,ai-bi,
Ameletus validus	24	40	1	1	1	1	1.16
Baetis tricaudatus	8	16	1	1	1	1	0.57
Chyranda centralis	0	8	0	1	0	1	0.56
Cinygmula	16	32	1	1	1	1	1.15
Corynoneura	0	0	0	0	0	0	0.00
Despaxia augusta	8	40	1	1	1	1	2.25
Diamesa	8	16	1	1	1	1	0.57
Doroneuria theodora	16	64	1	1	1	1	3.38
Drunella coloradensis	16	0	1	0	0	1	1.09
Drunella doddsii	8	0	1	0	0	1	0.54
Epeorus deceptivus	16	8	1	1	1	1	0.53
Epeorus longimannus	0	0	0	0	0	0	0.00
Epeorus grandis	96	40	1	1	1	1	3.73
Eukiefferiella gracei	0	0	0	0	0	0	0.00
Glossosoma	0	16	0	1	0	1	1.12
Heterlimnius corpulentus	0	24	0	1	0	1	1.68
Hexatoma	0	8	0	1	0	1	0.56
Isoperla	0	24	0	1	0	1	1.68
Lumbriculidae	24	16	1	1	1	1	0.51
Megarcys	160	88	1	1	1	1	4.72
Micropsectra	0	0	0	0	0	0	0.00
Nematoda	0	8	0	1	0	1	0.56
Nostoccocladius	0	16	0	1	0	1	1.12
Optioservus quadrimaculatus	0	8	0	1	0	1	0.56
Ormosia	0	0	0	0	0	0	0.00
Pagastia	24	8	1	1	1	1	1.07
Parakiefferiella	0	8	0	1	0	1	0.56
Paraleptophlebia	8	8	1	1	1	1	0.02
Parametriocnemus	0	0	0	0	0	0	0.00
Parapsyche elsis	32	96	1	1	1	1	4.53
Polycelis coronata	8	96	1	1	1	1	6.16
Prosimulium	0	8	0	1	0	1	0.56
Rheocricotopus	16	8	1	1	1	1	0.53
Rhithrogena	248	72	1	1	1	1	11.82
Rhyacophila betteni gr.	88	72	1	1	1	1	0.95
Rhyacophila brunnea gr.	32	32	1	1	1	1	0.06
Rhyacophila hyalinata gr.	8	8	1	1	1	1	0.02
Rhyacophila narvae	40	24	1	1	1	1	1.04
Rhyacophila pellisa	0	8	0	1	0	1	0.56
Rhyacophila vofixa gr.	8	0	1	0	0	1	0.54
Setvena bradleyi	40	0	1	0	0	1	2.72
Sweltsa	88	80	1	1	1	1	0.39
Thienimannimyia gr.	0	8	0	1	0	1	0.56
Tvetenia vitracies	0	8	0	1	0	1	0.56
Yoraperla brevis	168	24	1	1	1	1	9.74
Zapada columbiana	160	64	1	1	1	1	6.40
Zapada frigida	8	16	1	1	1	1	0.57
Zapada oregonensis gr.	40	16	1	1	1	1	1.60
Zapada columbiana	52	128	1	1	1	1	5.41
Zapada frigida	0	8	0	1	0	1	0.56
Zapada oregonensis gr.	4	160	1	1	1	1	10.90

Cooney Creek lower 2014 vs. 2015

Total	**1216**	**1136**	40	38	32	46	60.21126761
cum ttl		**2352**					
% COMM. Similarity	**69.89**						
% TAXA Similarity	**69.57**					cooney lower	
taxa	**2014**	**2015**	TAXA 1	TAXA 2	COMMON	TAXA 1+2	,ai-bi,
Ameletus validus	**28**	**40**	1	1	1	1	1.22
Baetis tricaudatus	**24**	**16**	1	1	1	1	0.57
Chyranda centralis	**4**	**8**	1	1	1	1	0.38
Cinygmula	**24**	**32**	1	1	1	1	0.84
Corynoneura	**4**	**0**	1	0	0	1	0.33
Despaxia augusta	**92**	**40**	1	1	1	1	4.04
Diamesa	**32**	**16**	1	1	1	1	1.22
Doroneuria theodora	**44**	**64**	1	1	1	1	2.02
Drunella coloradensis	**12**	**0**	1	0	0	1	0.99
Epeorus deceptivus	**32**	**8**	1	1	1	1	1.93
Epeorus longimannus	**8**	**0**	1	0	0	1	0.66
Epeorus grandis	**0**	**40**	0	1	0	1	3.52
Eukiefferiella gracei	**4**	**0**	1	0	0	1	0.33
Glossosoma	**8**	**16**	1	1	1	1	0.75
Heterlimnius corpulentus	**28**	**24**	1	1	1	1	0.19
Hexatoma	**0**	**8**	0	1	0	1	0.70
Isoperla	**0**	**24**	0	1	0	1	2.11
Lumbriculidae	**68**	**16**	1	1	1	1	4.18
Megarcys	**60**	**88**	1	1	1	1	2.81
Micropsectra	**8**	**0**	1	0	0	1	0.66
Nematoda	**4**	**8**	1	1	1	1	0.38
Nostoccocladius	**0**	**16**	0	1	0	1	1.41
Optioservus quadrimaculatus	**8**	**8**	1	1	1	1	0.05
Ormosia	**4**	**0**	1	0	0	1	0.33
Pagastia	**4**	**8**	1	1	1	1	0.38
Parakiefferiella	**4**	**8**	1	1	1	1	0.38
Paraleptophlebia	**4**	**8**	1	1	1	1	0.38
Parametriocnemus	**4**	**0**	1	0	0	1	0.33
Parapsyche elsis	**68**	**96**	1	1	1	1	2.86
Polycelis coronata	**72**	**96**	1	1	1	1	2.53
Prosimulium	**32**	**8**	1	1	1	1	1.93
Rheocricotopus	**4**	**8**	1	1	1	1	0.38
Rhithrogena	**96**	**72**	1	1	1	1	1.56
Rhyacophila betteni gr.	**60**	**72**	1	1	1	1	1.40
Rhyacophila brunnea gr.	**20**	**32**	1	1	1	1	1.17
Rhyacophila hyalinata gr.	**0**	**8**	0	1	0	1	0.70
Rhyacophila narvae	**4**	**24**	1	1	1	1	1.78
Rhyacophila pellisa	**4**	**8**	1	1	1	1	0.38
Rhyacophila vofixa gr.	**8**	**0**	1	0	0	1	0.66
Sweltsa	**124**	**80**	1	1	1	1	3.16
Thienimannimyia gr.	**8**	**8**	1	1	1	1	0.05
Tvetenia vitracies	**8**	**8**	1	1	1	1	0.05
Yoraperla brevis	**40**	**24**	1	1	1	1	1.18
Zapada columbiana	**140**	**64**	1	1	1	1	5.88
Zapada frigida	**0**	**16**	0	1	0	1	1.41
Zapada oregonensis gr.	**16**	**16**	1	1	1	1	0.09

NF Blackfoot 2014 vs. 2015							
Total	**968**	**2512**	**42**	**48**	**39**	**51**	**93.76217297**
cum ttl		**3480**					
% COMM. Similarity	**53.12**						
% TAXA Similarity	**76.47**					**NF BLKFOOT**	
taxa	2014	**2015**	TAXA 1	TAXA 2	COMMON	TAXA 1+2	, ai-bi,
Ameletus validus	4	**80**	1	1	1	1	2.77
Baetis tricaudatus	88	**24**	1	1	1	1	8.14
Calineuria californica	0	**16**	0	1	0	1	0.64
Caudatella hystrix	0	**8**	0	1	0	1	0.32
Cinygmula	4	**48**	1	1	1	1	1.50
Cryptochia pilosa	4	**0**	1	0	0	1	0.41
Despaxia augusta	8	**16**	1	1	1	1	0.19
Dicosmoecus atripes	4	**8**	1	1	1	1	0.09
Diphetor hageni	0	**8**	0	1	0	1	0.32
Doroneuria theodora	36	**8**	1	1	1	1	3.40
Ecclisomyia maculosa	0	**8**	0	1	0	1	0.32
Epeorus deceptivus	16	**16**	1	1	1	1	1.02
Epeorus grandis	60	**112**	1	1	1	1	1.74
Epeorus longimannus	48	**8**	1	1	1	1	4.64
Eukiefferiella devonica	8	**8**	1	1	1	1	0.51
Eukiefferiella gracei	12	**8**	1	1	1	1	0.92
Heterlimnius corpulentus	120	**80**	1	1	1	1	9.21
Hexatoma	8	**40**	1	1	1	1	0.77
Lumbriculidae	0	**32**	0	1	0	1	1.27
Megarcys	32	**88**	1	1	1	1	0.20
Nematoda	8	**0**	1	0	0	1	0.83
Neothremma alicia	4	**8**	1	1	1	1	0.09
Nostocodadius	112	**40**	1	1	1	1	9.98
orthodadius	16	**32**	1	1	1	1	0.38
Pagastia	4	**8**	1	1	1	1	0.09
Parakiefferiella	4	**8**	1	1	1	1	0.09
Paraleptophlebia	4	**8**	1	1	1	1	0.09
Paraperla	0	**16**	0	1	0	1	0.64
Parapsyche elsis	48	**216**	1	1	1	1	3.64
Pericoma	4	**112**	1	1	1	1	4.05
Polycelis coronata	4	**8**	1	1	1	1	0.09
Probezzia	4	**8**	1	1	1	1	0.09
Prosimulium	32	**64**	1	1	1	1	0.76
Rheocricotopus	4	**8**	1	1	1	1	0.09
Rhithrogena	20	**368**	1	1	1	1	12.58
Rhyacophila betteni gr.	12	**104**	1	1	1	1	2.90
Rhyacophila brunnea gr.	16	**24**	1	1	1	1	0.70
Rhyacophila hyalinata gr.	24	**56**	1	1	1	1	0.25
Rhyacophila narvae	4	**24**	1	1	1	1	0.54
Rhyacophila pellisa	4	**0**	1	0	0	1	0.41
Rhyacophila vofixa gr.	0	**160**	0	1	0	1	6.37
Serratella tibialis	8	**16**	1	1	1	1	0.19
Simulium	72	**144**	1	1	1	1	1.71
Sweltsa	32	**120**	1	1	1	1	1.47
Thienimannimyia gr.	8	**16**	1	1	1	1	0.19
Tvetenia vitracies	8	**16**	1	1	1	1	0.19
Yoraperla brevis	0	**8**	0	1	0	1	0.32
Zapada cinctipes	4	**8**	1	1	1	1	0.09
Zapada columbiana	52	**128**	1	1	1	1	0.28
Zapada frigida	0	**8**	0	1	0	1	0.32
Zapada oregonensis gr.	4	**160**	1	1	1	1	5.96

Sarbo Treatment vs Control							
Total	2012	1604	37	39	33	43	64.63066985
cum ttl		3616					
% COMM. Similarity	67.68						
% TAXA Similarity	76.74						
taxa	2014	2015	TAXA 1	TAXA 2	COMMON	TAXA 1+2	,ai-bi,
Ameletus validus	56	8	1	1	1	1	2.28
Baetis tricaudatus	288	88	1	1	1	1	8.83
Brillia	48	8	1	1	1	1	1.89
Chelifera	8	0	1	0	0	1	0.40
Cinygmula	88	112	1	1	1	1	2.61
Clinocera	4	8	1	1	1	1	0.30
Despaxia augusta	136	24	1	1	1	1	5.26
Diamesa	20	40	1	1	1	1	1.50
Dicranota	0	8	0	1	0	1	0.50
Doroneuria theodora	0	40	0	1	0	1	2.49
Dixa	4	0	1	0	0	1	0.20
Drunella coloradensis	0	8	0	1	0	1	0.50
Drunella doddsii	20	8	1	1	1	1	0.50
Drunella spinifera	8	8	1	1	1	1	0.10
Epeorus grandis	76	56	1	1	1	1	0.29
Epeorus longimannus	28	8	1	1	1	1	0.89
Eukiefferiella devonica	16	16	1	1	1	1	0.20
Eukiefferiella gracei	88	40	1	1	1	1	1.88
Glutops	8	8	1	1	1	1	0.10
Heterlimnius corpulentus	84	16	1	1	1	1	3.18
Isoperla	8	12	1	1	1	1	0.35
Megarcys	72	64	1	1	1	1	0.41
Micrasema bactro	12	0	1	0	0	1	0.60
Micropsectra	16	24	1	1	1	1	0.70
Neothremma alicia	40	16	1	1	1	1	0.99
Oreogeton	0	8	0	1	0	1	0.50
Pagastia	48	40	1	1	1	1	0.11
Parakiefferiella	8	8	1	1	1	1	0.10
Parapsyche elsis	40	64	1	1	1	1	2.00
Pericoma	0	16	0	1	0	1	1.00
Polycelis coronata	36	56	1	1	1	1	1.70
Rheocricotopus	60	32	1	1	1	1	0.99
Rhithrogena	24	160	1	1	1	1	8.78
Rhyacophila betteni gr.	48	88	1	1	1	1	3.10
Rhyacophila brunnea gr.	16	16	1	1	1	1	0.20
Rhyacophila narvae	8	16	1	1	1	1	0.60
Rhyacophila pellisa	4	0	1	0	0	1	0.20
Rhyacophila vofixa gr.	0	16	0	1	0	1	1.00
Setvena bradleyi	16	24	1	1	1	1	0.70
Swelts a	160	128	1	1	1	1	0.03
Yoraperla brevis	180	176	1	1	1	1	2.03
Zapada columbiana	220	112	1	1	1	1	3.95
Zapada oregonensis gr.	16	24	1	1	1	1	0.70

EF North Fork Blackfoot 2013 vs. 2015							
Total	920	1237	33	40	24	49	84.28526238
cum ttl		2157					
% COMM. Similarity	57.86						
% TAXA Similarity	48.98					EFNF BLK	
taxa	2013	2015	TAXA 1	TAXA 2	COMMON	TAXA 1+2	,ai bi,
Ameletus	0	4	0	1	0	1	0.32
Arctopsyche grandis	4	4	1	1	1	1	0.11
Baetis tricaudatus	80	52	1	1	1	1	4.49
Brillia	14	4	1	1	1	1	1.20
Chelifera	8	0	1	0	0	1	0.87
Caudatella hystrix	0	8	0	1	0	1	0.65
Cinygmula	68	120	1	1	1	1	2.31
Cleptelmis addenda	0	4	0	1	0	1	0.32
Cricotopus bicinctus	18	0	1	0	0	1	1.96
Despaxia augusta	0	8	0	1	0	1	0.65
Dicosmoecus atripes	0	12	0	1	0	1	0.97
Doroneuria theodora	12	36	1	1	1	1	1.61
Drunella doddsii	0	16	0	1	0	1	1.29
Epeorus deceptivus	50	20	1	1	1	1	3.82
Epeorus longimannus	10	0	1	0	0	1	1.09
Ephemerella excrulans	0	80	0	1	0	1	6.47
Hesperoperla pacifica	46	80	1	1	1	1	1.47
Heterlimnius corpulentus	190	220	1	1	1	1	2.87
Hexatoma	4	24	1	1	1	1	1.51
Isoperla punctata	8	8	1	1	1	1	0.22
Limonia	2	0	1	0	0	1	0.22
Megarcys	24	8	1	1	1	1	1.96
Micropsectra	0	32	0	1	0	1	2.59
Micrasema bactro	8	0	1	0	0	1	0.87
Narpus concolor	2	0	1	0	0	1	0.22
Optioservus quadrimaculatus	82	0	1	0	0	1	8.91
Ochrotrichia	0	8	0	1	0	1	0.65
Ostracoda	0	8	0	1	0	1	0.65
Pagastia	90	48	1	1	1	1	5.90
Parakiefferiella	0	8	0	1	0	1	0.65
Paraleptophlebia	8	48	1	1	1	1	3.01
Paraperla	0	4	0	1	0	1	0.32
Parapsyche elsis	12	8	1	1	1	1	0.66
Pericoma	0	16	0	1	0	1	1.29
Polycelis coronata	0	8	0	1	0	1	0.65
Probezzia	6	8	1	1	1	1	0.01
Prosimulium	14	0	1	0	0	1	1.52
Rheocricotopus	0	8	0	1	0	1	0.65
Rhithrogena	28	128	1	1	1	1	7.30
Rhyacophila betteni gr.	0	8	0	1	0	1	0.65
Rhyacophila brunnea gr.	8	4	1	1	1	1	0.55
Rhyacophila narvae	18	32	1	1	1	1	0.63
Rhyacophila pellisa	2	4	1	1	1	1	0.11
Serratella tibialis	4	4	1	1	1	1	0.11
Sweltsa	44	100	1	1	1	1	3.30
Tipula	2	0	1	0	0	1	0.22
Tvetenia vitracies	20	4	1	1	1	1	1.85
Zapada cinctipes	10	40	1	1	1	1	2.15
Zapada columbiana	24	1	1	1	1	1	2.53

Sourdough Lower 2013 vs. 2015

Total	1416	1488	35	30	28	37	60.04191726
cum ttl		2904					
% COMM. Similarity	69.98						
% TAXA Similarity	75.68						
Taxon	2013	2015	TAXA 1	TAXA 2	COMMON	TAXA 1+2	,al-bl,
Ameletus	18	0	1	0	0	1	1.27
Baetis bicaudatus	30	56	1	1	1	1	1.64
Brillia	0	12	0	1	0	1	0.81
Cinygmula	162	40	1	1	1	1	8.75
Despaxia augusta	6	72	1	1	1	1	4.41
Diamesa	12	0	1	0	0	1	0.85
Dicranota	6	0	1	0	0	1	0.42
Doroneuria theodora	6	12	1	1	1	1	0.38
Drunella coloradensis	30	16	1	1	1	1	1.04
Epeorus deceptivus	498	484	1	1	1	1	2.64
Epeorus grandis	6	8	1	1	1	1	0.11
Epeorus longimannus	6	4	1	1	1	1	0.15
Isoperla punctata	6	4	1	1	1	1	0.15
Limnophila	6	4	1	1	1	1	0.15
Lumbriculidae	12	8	1	1	1	1	0.31
Megarcys	66	76	1	1	1	1	0.45
Micropsectra	12	12	1	1	1	1	0.04
Oreogeton	6	20	1	1	1	1	0.92
Pagastia	6	4	1	1	1	1	0.15
Paraperla	6	24	1	1	1	1	1.19
Parapsyche elsis	18	8	1	1	1	1	0.73
Polycelis coronata	54	12	1	1	1	1	3.01
Prosimulium	6	8	1	1	1	1	0.11
Rheocricotopus	12	8	1	1	1	1	0.31
Rhithrogena	138	120	1	1	1	1	1.68
Rhyacophila alberta	0	4	0	1	0	1	0.27
Rhyacophila betteni gr.	6	8	1	1	1	1	0.11
Rhyacophila narvae	24	0	1	0	0	1	1.69
Rhyacophila pellisa	6	8	1	1	1	1	0.11
Rhyacophila siberica gr.	6	0	1	0	0	1	0.42
Rhyacophila vagrita gr.	6	0	1	0	0	1	0.42
Suwallia	30	80	1	1	1	1	3.26
Sweltsa	96	84	1	1	1	1	1.13
Utaperla sopladora	6	12	1	1	1	1	0.38
Yoraperla brevis	12	20	1	1	1	1	0.50
Zapada columbiana	30	260	1	1	1	1	15.35
Zapada oregonensis gr.	66	0	1	0	0	1	4.66

Sourdough 2013 Control vs. Treatment							
Total	1488	1040	30	29	19	40	118.974359
cum ttl		2528					
% COMM. Similarity	40.51						
% TAXA Similarity	47.50						
taxa	Control 2013	Treatment 2013	TAXA 1	TAXA 2	COMMON	TAXA 1+2	,ai-bi,
Ameletus	0	144	0	1	0	1	13.85
Anagapetus	0	4	0	1	0	1	0.38
Baetis bicaudatus	56	4	1	1	1	1	3.38
Brillia	12	4	1	1	1	1	0.42
Cinygmula	40	136	1	1	1	1	10.39
Despaxia augusta	72	16	1	1	1	1	3.30
Diamesa	0	4	0	1	0	1	0.38
Dicranota	0	8	0	1	0	1	0.77
Doroneuria theodora	12	12	1	1	1	1	0.35
Drunella coloradensis	16	20	1	1	1	1	0.85
Epeorus deceptivus	484	116	1	1	1	1	21.37
Epeorus grandis	8	0	1	0	0	1	0.54
Epeorus longimannus	4	4	1	1	1	1	0.12
Homophylax	0	8	0	1	0	1	0.77
Isoperla punctata	4	4	1	1	1	1	0.12
Limnophila	4	0	1	0	0	1	0.27
lumbriculidae	8	20	1	1	1	1	1.39
Megarcys	76	32	1	1	1	1	2.03
Micropsectra	12	0	1	0	0	1	0.81
Oreogeton	20	48	1	1	1	1	3.27
Optioservus quadrimaculatus	0	4	0	1	0	1	0.38
orthocladius	0	12	0	1	0	1	1.15
Pagastia	4	8	1	1	1	1	0.50
Paraperla	24	0	1	0	0	1	1.61
Parapsyche elsis	8	0	1	0	0	1	0.54
Parakiefferiella	0	12	0	1	0	1	1.15
Polycelis coronata	12	192	1	1	1	1	17.66
Prosimulium	8	0	1	0	0	1	0.54
Rheocricotopus	8	20	1	1	1	1	1.39
Rhithrogena	120	124	1	1	1	1	3.86
Rhyacophila alberta	4	0	1	0	0	1	0.27
Rhyacophila betteni gr.	8	0	1	0	0	1	0.54
Rhyacophila brunnea gr.	0	4	0	1	0	1	0.38
Rhyacophila pellisa	8	0	1	0	0	1	0.54
Suwallia	80	0	1	0	0	1	5.38
Sweltsa	84	52	1	1	1	1	0.65
Testudacarus	0	4	0	1	0	1	0.38
Utacapnia	12	0	1	0	0	1	0.81
Yoraperla brevis	20	4	1	1	1	1	0.96
Zapada columbiana	260	20	1	1	1	1	15.55

Sourdough 2013 Control vs. Treatment							
Total	1488	1040	30	29	19	40	118.974359
cum ttl		2528					
% COMM. Similarity	40.51						
% TAXA Similarity	47.50						
taxa	Control 2013	Treatment 2013	TAXA 1	TAXA 2	COMMON	TAXA 1+2	,ai-bi,
Ameletus	0	144	0	1	0	1	13.85
Anagapetus	0	4	0	1	0	1	0.38
Baetis bicaudatus	56	4	1	1	1	1	3.38
Brillia	12	4	1	1	1	1	0.42
Cinygmula	40	136	1	1	1	1	10.39
Despaxia augusta	72	16	1	1	1	1	3.30
Diamesa	0	4	0	1	0	1	0.38
Dicranota	0	8	0	1	0	1	0.77
Doroneuria theodora	12	12	1	1	1	1	0.35
Drunella coloradensis	16	20	1	1	1	1	0.85
Epeorus deceptivus	484	116	1	1	1	1	21.37
Epeorus grandis	8	0	1	0	0	1	0.54
Epeorus longimannus	4	4	1	1	1	1	0.12
Homophylax	0	8	0	1	0	1	0.77
Isoperla punctata	4	4	1	1	1	1	0.12
Limnophila	4	0	1	0	0	1	0.27
lumbriculidae	8	20	1	1	1	1	1.39
Megarcys	76	32	1	1	1	1	2.03
Micropsectra	12	0	1	0	0	1	0.81
Oreogeton	20	48	1	1	1	1	3.27
Optioservus quadrimaculatus	0	4	0	1	0	1	0.38
orthocladius	0	12	0	1	0	1	1.15
Pagastia	4	8	1	1	1	1	0.50
Paraperla	24	0	1	0	0	1	1.61
Parapsyche elsis	8	0	1	0	0	1	0.54
Parakiefferiella	0	12	0	1	0	1	1.15
Polycelis coronata	12	192	1	1	1	1	17.66
Prosimulium	8	0	1	0	0	1	0.54
Rheocricotopus	8	20	1	1	1	1	1.39
Rhithrogena	120	124	1	1	1	1	3.86
Rhyacophila alberta	4	0	1	0	0	1	0.27
Rhyacophila betteni gr.	8	0	1	0	0	1	0.54
Rhyacophila brunnea gr.	0	4	0	1	0	1	0.38
Rhyacophila pellisa	8	0	1	0	0	1	0.54
Suwallia	80	0	1	0	0	1	5.38
Sweltsa	84	52	1	1	1	1	0.65
Testudacarus	0	4	0	1	0	1	0.38
Utacapnia	12	0	1	0	0	1	0.81
Yoraperla brevis	20	4	1	1	1	1	0.96
Zapada columbiana	260	20	1	1	1	1	15.55

Sourdough Upper 2013 vs. 2015

Total	784	1040	30	29	26	33	75.18838305
cum ttl		1824					
% COMM. Similarity	62.41						
% TAXA Similarity	78.79				Sourdough between years		
taxa	2013	2015	TAXA 1	TAXA 2	COMMON	TAXA 1+2	,ai-bi,
Ameletus	24	144	1	1	1	1	10.78
Anagapetus	0	4	0	1	0	1	0.38
Baetis bicaudatus	22	4	1	1	1	1	2.42
Brillia	6	4	1	1	1	1	0.38
Cinygmula	154	136	1	1	1	1	6.57
Despaxia augusta	4	16	1	1	1	1	1.03
Diamesa	0	4	0	1	0	1	0.38
Dicranota	4	8	1	1	1	1	0.26
Doroneuria theodora	4	12	1	1	1	1	0.64
Drunella coloradensis	10	20	1	1	1	1	0.65
Ecclisomyia maculosa	2	0	1	0	0	1	0.26
Epeorus deceptivus	270	116	1	1	1	1	23.28
Epeorus longimannus	4	4	1	1	1	1	0.13
Eukiefferiella gracei	4	0	1	0	0	1	0.51
Glossosoma	2	0	1	0	0	1	0.26
Homophylax	2	8	1	1	1	1	0.51
Isoperla	2	4	1	1	1	1	0.13
lumbriculidae	18	20	1	1	1	1	0.37
Megarcys	16	32	1	1	1	1	1.04
Opticservus quadrimac	8	4	1	1	1	1	0.64
Oreogeton	24	48	1	1	1	1	1.55
orthocladius	6	12	1	1	1	1	0.39
Pagastia	4	8	1	1	1	1	0.26
Parakiefferiella	4	12	1	1	1	1	0.64
Polycelis coronata	50	192	1	1	1	1	12.08
Rheocricotopus	22	20	1	1	1	1	0.88
Rhithrogena	48	124	1	1	1	1	5.80
Rhyacophila brunnea gr	2	4	1	1	1	1	0.13
Suwallia	6	0	1	0	0	1	0.77
Sweltsa	36	52	1	1	1	1	0.41
Testudacarus	0	4	0	1	0	1	0.38
Yoraperla brevis	2	4	1	1	1	1	0.13
Zapada columbiana	24	20	1	1	1	1	1.14

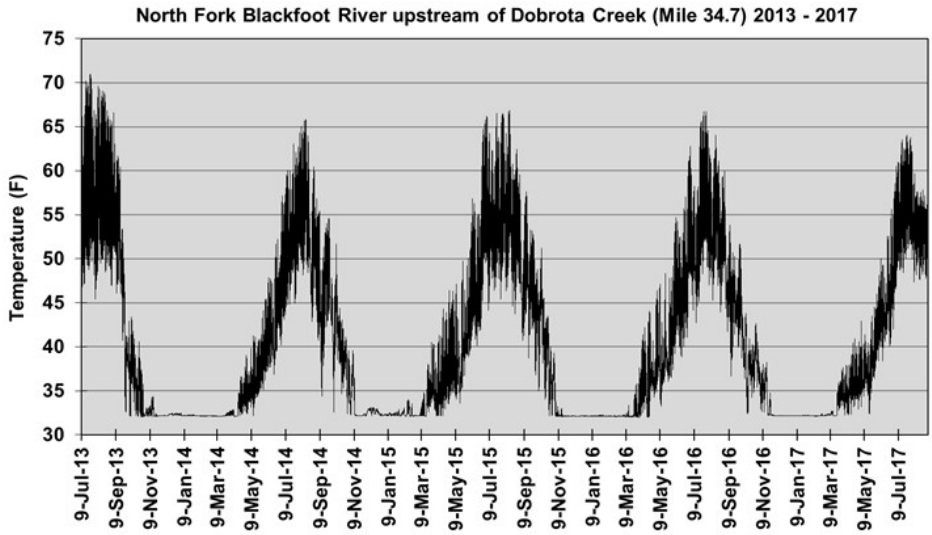
Sourdough 2015 Control vs. Treatment							
Total	1040	1416	29	35	22	42	89.0612777
cum ttl		2456					
% COMM. Similarity	55.47						
% TAXA Similarity	52.38						
taxa	Control 2015	Treatment 2015	TAXA 1	TAXA 2	COMMON	TAXA 1+2	,ai-bi,
Ameletus similior	144	18	1	1	1	1	12.57
Anagapetus	4	0	1	0	0	1	0.38
Baetis bicaudatus	4	30	1	1	1	1	1.73
Brillia	4	0	1	0	0	1	0.38
Cinygmula	136	162	1	1	1	1	1.64
Despaxia augusta	16	6	1	1	1	1	1.11
Diamesa	4	12	1	1	1	1	0.46
Dicranota	8	6	1	1	1	1	0.35
Doroneuria theodora	12	6	1	1	1	1	0.73
Drunella coloradensis	20	30	1	1	1	1	0.20
Epeorus deceptivus	116	498	1	1	1	1	24.02
Epeorus grandis	0	6	0	1	0	1	0.42
Epeorus longimannus	4	6	1	1	1	1	0.04
Homophylax	8	0	1	0	0	1	0.77
Isoperla	4	6	1	1	1	1	0.04
Limnophila	0	6	0	1	0	1	0.42
lumbriculidae	20	12	1	1	1	1	1.08
Megarcys	32	66	1	1	1	1	1.58
Micropsectra	0	12	0	1	0	1	0.85
Optioservus quadrimaculatus	4	0	1	0	0	1	0.38
Oreogeton	48	6	1	1	1	1	4.19
orthocladius	12	0	1	0	0	1	1.15
Pagastia	8	6	1	1	1	1	0.35
Paraperla	0	6	0	1	0	1	0.42
Parakiefferiella	12	0	1	0	0	1	1.15
Parapsyche elsis	0	18	0	1	0	1	1.27
Polycelis coronata	192	54	1	1	1	1	14.65
Prosimulium	0	6	0	1	0	1	0.42
Rheocricotopus	20	12	1	1	1	1	1.08
Rhithrogena	124	138	1	1	1	1	2.18
Rhyacophila alberta	0	0	0	0	0	0	0.00
Rhyacophila betteni gr.	0	6	0	1	0	1	0.42
Rhyacophila brunnea gr.	4	0	1	0	0	1	0.38
Rhyacophila narvae	0	24	0	1	0	1	1.69
Rhyacophila pellisa	0	6	0	1	0	1	0.42
Rhyacophila sibirica gr.	0	6	0	1	0	1	0.42
Rhyacophila vagrita gr.	0	6	0	1	0	1	0.42
Suwallia	0	30	0	1	0	1	2.12
Swelts a	52	96	1	1	1	1	1.78
Testudacarus	4	6	1	1	1	1	0.04
Yoraperla brevis	4	12	1	1	1	1	0.46
Zapada columbiana	20	30	1	1	1	1	0.20
Zapada oregonensis gr.	0	66	0	1	0	1	4.66

Appendix G.: Field measures of pH, Conductivity, and TDS

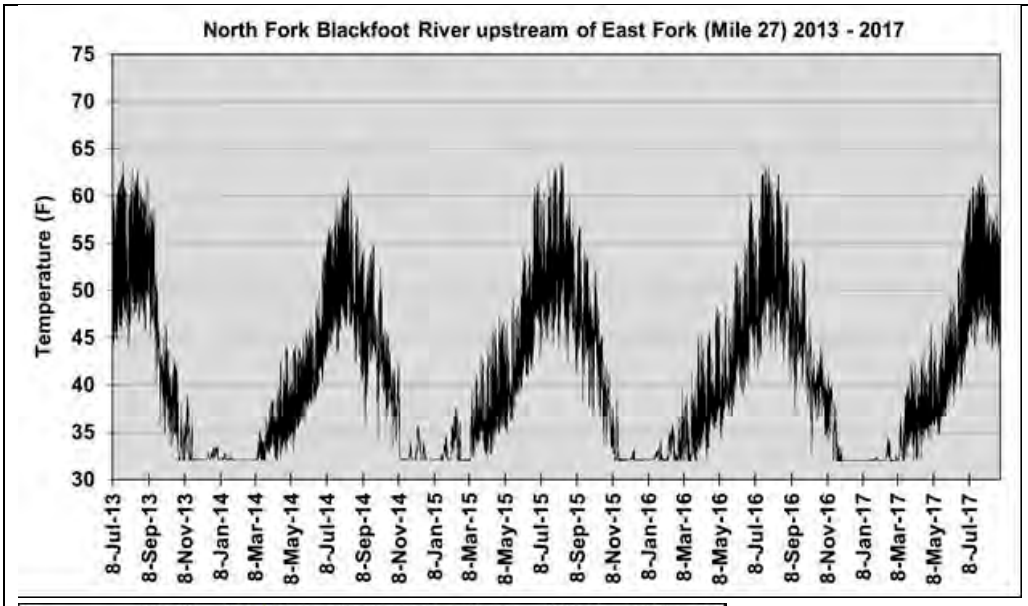
Stream name	Date	Stream Mile	Lat	Long	pH	Conductivity (uS)	TDS (ppm)
Blondie Creek	5-Aug-13	0.2	47.15471	112.7463	8.1	138	78
Broadus Creek	12-Jul-07	0.1	47.25801	112.83223		197	98
	28-Aug-14		47.25772	112.83198	8.1	165	82
Camp Creek	4-Sep-13	0.1	47.18376	112.86497	8.6	258	122
	4-Sep-13	1.6	47.19994	112.84849	8.5	222	103
Cooney Creek	5-Sep-13	0.2	47.25793	112.81074	8.5	202	143
	27-Aug-14		47.25832	112.81521	7.9	133	68
	6-Sep-13	2.4	47.24397	112.78135	8.7	185	131
Dobrota Creek	13-Jul-07	0.1	47.26928	112.80687		148	74
	28-Aug-14		47.26723	112.80679	7.9	127	63
	20-Jul-16	1	47.27949	112.80953		171	
Dry Fork of the North Fork Blackfoot River	20-Jul-16	3	47.2143	112.93836	8.3	201	104
Kenny Creek	18-Jul-16	0.1	47.18263	112.86499	8.4	275	137
Lost Pony Creek	8-Aug-13	0.8	47.17528	112.79342	8	133	66
Meadow Creek	6-Sep-08	2.6	47.13887	112.79452	8.5	152	78
	7-Aug-13	5.2	47.11842	112.81139	8	138	78
East Fork Meadow Creek	7-Aug-13	0.8	47.11831	112.79995	8.1	108	54
	7-Sep-08	2.5	47.10084	112.7918	8.7	95	50
West Fork of East Fork Meadow Creek	7-Sep-08	0.1	47.10002	112.79225	8.1	57	30
Mineral Creek	8-Sep-08	2.1	47.1588	112.84092	8.1	178	91
	8-Sep-08	4.2	47.14819	112.86125	8.4	141	72
East Fork Mineral Creek	8-Sep-08	0.6	47.14387	112.85385	8.5	147	74
North Fork Blackfoot River	18-Jul-16	25.2	47.19194	112.90872	8.5	198	
	18-Jul-16	26.4	47.19658	112.8907		200	
	11-Jul-07	26.8	47.19729	112.88304	8.8	177	89
	27-Aug-14	27.2	47.19725	112.88096	8.1	142	74
	12-Jul-07	32	47.24827	112.84164		157	78
	28-Aug-14		47.25443	112.83547	8.2	142	74
	13-Jul-07	34.7	47.2675	112.80538		109	55
	28-Aug-14		47.26689	112.80644	7.8	85	42
	19-Jul-16	36.9	47.27545	112.76192		97	
East Fork of North Fork Blackfoot River	4-Sep-13	1.9	47.18352	112.86468	8.6	244	173
	8-Aug-13	7	47.16366	112.79526	8.1	175	87
	6-Aug-13	9	47.15443	112.76804	8.2	205	102
Sarbo Creek	27-Aug-14	0.1	47.23628	112.86194	8.1	159	80
Scotty Creek	6-Aug-13	0.2	47.15457	112.75702	7.7	84	41
Sourdough Creek	6-Aug-13	0.6	47.14685	112.75656	7.9	166	84
	5-Aug-13	1	47.14014	112.75302	8.1	156	76
South Creek	20-Jul-16	0.4	47.21439	112.86357	7.7	216	
	4-Sep-13	1.2	47.20865	112.84927	8.3	229	163
Spaulding Creek	8-Aug-13	0.1	47.17591	112.8201	8.2	249	123
Theodore Creek	12-Jul-07	0.2	47.25377	112.83523		166	83
	28-Aug-14		47.25364	112.83527	8.1	125	66
Un-named tributary stream entering North Fork Blackfoot River near stream mile 27.8	27-Aug-14	0.1	47.2075	112.87346	8	125	60

Appendix H. : Water Temperature Monitoring 2013-2017

North Fork Blackfoot River

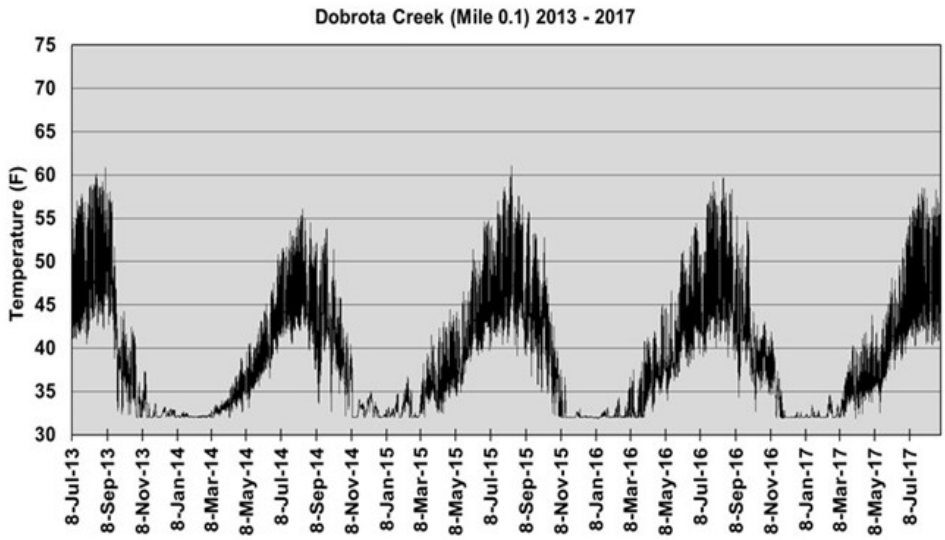


	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	71.0	46.8	57.2	6.1	37.4
	August	69.6	45.4	56.7	5.6	31.2
	September	66.6	32.5	49.4	7.3	53.5
	October	43.4	32	35.3	2.8	7.7
	November	34.4	32	32.4	0.5	0.2
	December	32.5	32.1	32.3	0.1	0.01
2014	January	32.5	32.1	32.2	0.1	0.0
	February	32.2	32.1	32.1	0.0	0.0
	March	32.7	32.1	32.2	0.1	0.0
	April	39.1	32.1	33.3	1.3	1.8
	May	44.1	32.2	36.2	2.3	5.2
	June	52.2	36.2	42.2	3.4	11.5
	July	63.1	40.2	51.7	4.8	22.8
	August	65.8	42.8	54.0	5.2	26.7
	September	56.9	34.4	46.2	4.3	18.7
	October	51.7	32.3	39.6	3.5	12.0
	November	39.6	32.1	33.2	1.8	3.3
	December	33.1	32.1	32.6	0.3	0.1
2015	January	32.9	32.1	32.3	0.1	0.0
	February	34.0	32.1	32.5	0.4	0.2
	March	40.5	32.1	33.6	1.8	3.1
	April	46.4	32.1	36.1	3.0	9.1
	May	50.1	33.6	39.4	3.4	11.4
	June	65.3	39.0	48.4	5.8	33.5
	July	66.6	44.2	54.4	5.0	25.5
	August	66.9	43.8	54.6	5.0	25.1
	September	59.6	36.8	46.9	4.2	17.9
	October	51.2	32.1	39.9	4.2	18.0
	November	39.3	32.0	32.6	1.3	1.7
	December	32.2	32.1	32.1	0.0	0.0
2016	January	32.3	32.1	32.1	0.0	0.0
	February	32.2	32.0	32.1	0.0	0.0
	March	35.9	32.0	32.3	0.7	0.4
	April	44.1	32.0	35.7	2.6	6.6
	May	48.4	33.2	39.2	3.0	9.2
	June	61.6	37.4	47.0	5.1	25.6
	July	66.8	42.7	54.1	5.4	28.9
	August	64.6	43.9	53.6	4.4	18.9
	September	60.0	36.7	45.8	3.7	13.5
	October	48.9	32.4	38.7	2.9	8.3
	November	38.3	32.2	34.1	1.9	3.5
	December	32.2	32.1	32.2	0.0	0.0
2017	January	32.2	32.1	32.2	0.0	0.0
	February	32.4	32.1	32.2	0.0	0.0
	March	37.4	32.1	33.0	1.1	1.3
	April	40.9	32.2	35.2	1.7	3.0
	May	46.0	32.4	37.7	2.6	6.9
	June	55.6	38.4	44.8	3.6	13.2
	July	64.0	44.2	55.3	4.4	19.1
	August	62.2	47.4	53.3	3.0	8.7



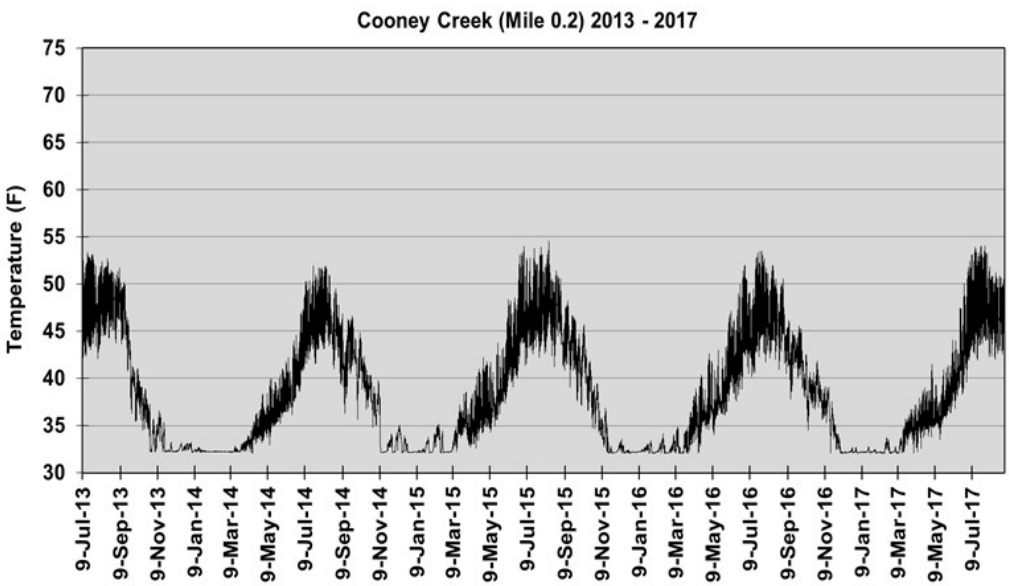
	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	63.7	44.5	52.9	4.8	23.2
	August	63.0	44.0	53.4	4.3	18.8
	September	61.8	35.6	48.9	5.6	31.1
	October	46.3	32.1	37.8	3.2	10.5
	November	39.1	32	33.6	1.8	3.4
	December	33.4	32.1	32.4	0.4	0.1
2014	January	33.5	32.1	32.2	0.3	0.1
	February	32.1	32.1	32.1	0.0	0.0
	March	36.6	32.0	32.9	1.0	1.1
	April	44.1	32.0	35.6	2.3	5.4
	May	44.9	32.8	37.9	2.6	6.7
	June	50.0	37.1	41.9	2.7	7.5
	July	59.6	40.2	49.4	4.0	16.3
	August	61.8	42.4	51.4	4.2	17.7
	September	55.6	35.9	46.4	3.9	15.6
	October	52.5	33.3	41.6	3.4	11.3
	November	42.2	32.0	33.9	2.8	8.0
	December	35.7	32.0	32.7	1.0	0.9
2015	January	34.6	32.0	32.3	0.5	0.3
	February	37.6	31.9	33.3	1.5	2.3
	March	43.3	32.0	34.8	2.5	6.5
	April	47.3	32.0	37.4	3.3	11.0
	May	49.3	34.9	40.3	3.0	9.2
	June	60.9	39.3	47.1	4.6	20.9
	July	62.6	43.0	51.7	4.4	19.2
	August	63.5	42.4	52.7	4.4	19.8
	September	57.7	37.6	47.3	4.0	15.9
	October	52.1	33.7	42.2	3.8	14.4
	November	41.2	32.0	33.8	2.3	5.3
	December	33.2	32.0	32.2	0.2	0.1
2016	January	34.4	32.0	32.4	0.5	0.2
	February	36.7	31.9	33.0	1.1	1.3
	March	41.3	31.9	34.7	2.2	4.6
	April	45.7	32.0	37.6	2.9	8.7
	May	48.6	34.3	40.1	3.0	8.9
	June	60.1	37.8	46.2	4.5	19.9
	July	63.1	41.4	51.4	5.1	25.6
	August	62.2	42.3	51.9	4.5	19.9
	September	59.6	37.4	46.5	3.5	12.0
	October	49.6	32.6	40.6	2.7	7.3
	November	41.1	31.9	35.7	2.7	7.0
	December	33.2	32.0	32.1	0.1	0.0
2017	January	32.4	32.0	32.1	0.1	0.0
	February	34.7	32.0	32.4	0.6	0.4
	March	42.6	32.0	34.1	2.3	5.2
	April	43.5	31.9	36.8	2.4	5.8
	May	46.7	34.2	39.0	2.8	7.6
	June	54.9	37.8	44.1	3.6	12.9
	July	62.4	42.9	52.3	4.8	22.8
	August	61.4	43.9	51.4	4.0	15.7

Dobrota Creek



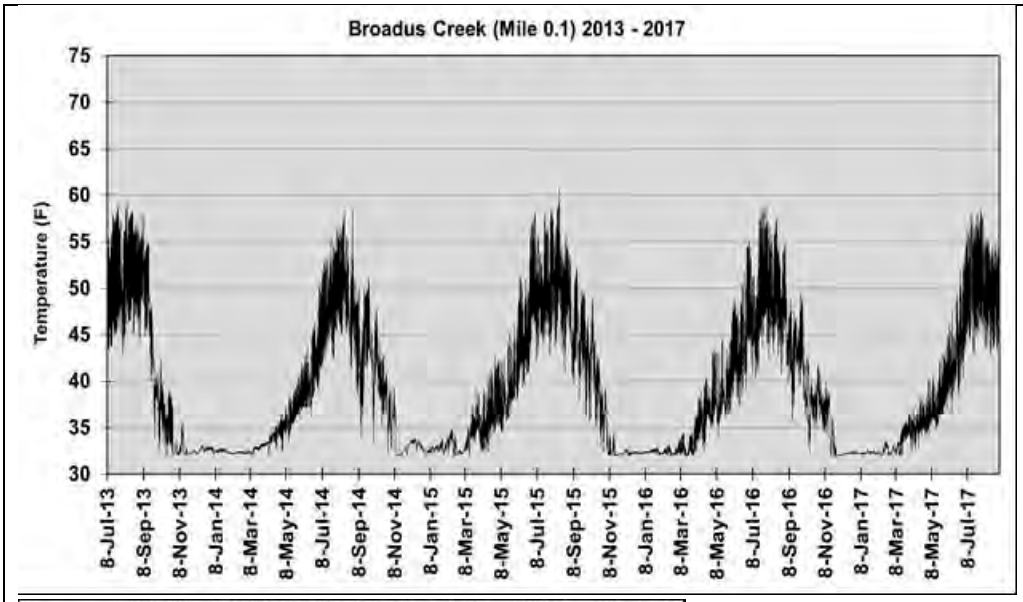
	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	57.8	41.0	47.2	4.5	20.5
	August	60.2	40.4	49.0	4.7	21.9
	September	61	32.7	45.8	5.6	31.1
	October	44.3	32	36.2	2.6	6.9
	November	37.4	32	33	1.2	1.4
	December	33.6	32	32.4	0.34	0.11
2014	January	32.9	32.0	32.2	0.2	0.0
	February	32.2	32.0	32.1	0.0	0.0
	March	33.9	32.0	32.6	0.5	0.2
	April	38.8	32.0	34.1	1.1	1.2
	May	42.3	32.6	36.5	1.7	2.7
	June	47.6	36.5	40.4	2.3	5.1
	July	53.6	39.4	45.1	3.1	9.3
	August	56.1	39.7	46.3	3.5	12.5
	September	53.9	33.6	43.1	4.0	16.0
	October	51.4	32.2	39.5	3.1	9.6
	November	40.4	32.0	33.8	2.1	4.4
	December	35.0	32.0	32.9	0.8	0.7
2015	January	34.8	32.0	32.5	0.5	0.3
	February	36.7	32.0	33.0	1.0	1.1
	March	41.5	32.0	34.4	1.9	3.5
	April	44.5	32.4	36.1	2.4	5.8
	May	46.6	34.5	38.7	2.5	6.2
	June	54.6	38.5	43.7	3.3	11.0
	July	58.1	39.7	46.3	3.9	15.5
	August	61.1	39.1	48.2	4.5	20.6
	September	56.6	35.8	44.4	4.1	16.5
	October	52.8	32.2	40.1	3.9	14.9
	November	39.7	31.9	32.9	1.7	2.8
	December	33.0	32.0	32.1	0.2	0.0
2016	January	33.2	31.8	32.2	0.2	0.1
	February	34.3	32.0	32.3	0.4	0.2
	March	38.5	31.9	33.0	1.3	1.7
	April	42.0	32.0	36.3	2.0	3.9
	May	46.7	33.9	38.7	2.3	5.4
	June	54.0	37.2	43.5	3.6	12.9
	July	59.2	39.0	46.2	4.4	19.5
	August	59.7	38.9	47.5	4.5	20.3
	September	58.4	34.3	43.4	3.8	14.3
	October	47.1	32.6	38.8	2.3	5.1
	November	41.9	31.9	35.4	2.5	6.0
	December	32.8	32.0	32.1	0.1	0.0
2017	January	33.5	32.0	32.2	0.3	0.1
	February	34.7	31.9	32.4	0.6	0.3
	March	40.3	31.9	33.9	1.5	2.2
	April	41.8	31.9	35.7	1.8	3.1
	May	45.1	32.5	37.5	2.2	4.6
	June	51.6	37.5	42.1	2.7	7.2
	July	58.5	40.3	46.8	4.5	20.4
	August	58.5	40.3	47.1	4.3	18.3

Cooney Creek



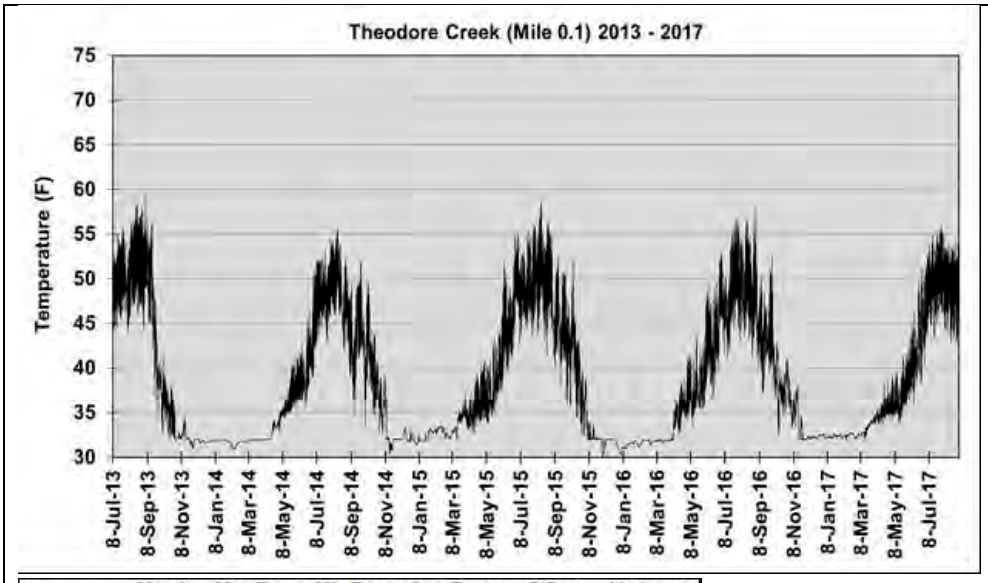
	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	53.4	42.2	43.7	3.0	9.0
	August	52.7	42.1	47.8	2.3	5.2
	September	51.7	36.3	45.2	3.5	12.2
	October	41.1	32.2	36.7	2.2	4.6
	November	36.6	32.2	33.5	1.3	1.6
	December	33.3	32.2	32.6	0.3	0.08
2014	January	33.2	32.1	32.4	0.2	0.0
	February	32.3	32.2	32.2	0.0	0.0
	March	33.3	32.1	32.4	0.2	0.1
	April	38.2	32.1	34.0	1.1	1.2
	May	40.4	32.9	36.0	1.4	2.0
	June	44.6	35.9	38.9	1.8	3.1
	July	51.9	38.7	44.9	2.6	6.9
	August	51.9	41.0	46.4	2.4	5.6
	September	47.8	36.3	42.7	2.2	4.7
	October	44.9	34.8	39.6	1.9	3.7
	November	39.8	32.1	33.9	2.2	5.0
	December	35.1	32.1	32.9	0.8	0.7
2015	January	33.8	32.1	32.4	0.4	0.1
	February	35.2	32.0	32.9	0.9	0.8
	March	38.6	32.1	34.0	1.5	2.3
	April	42.2	32.5	35.6	1.9	3.5
	May	43.8	34.3	37.7	1.9	3.4
	June	53.3	37.4	43.1	3.2	10.5
	July	54.0	41.3	46.7	2.8	7.8
	August	54.6	41.2	47.5	2.6	6.8
	September	50.5	37.6	43.7	2.3	5.1
	October	45.7	34.7	39.9	2.5	6.4
	November	39.5	32.0	33.9	1.8	3.4
	December	33.6	32.1	32.4	0.3	0.1
2016	January	33.4	32.1	32.4	0.3	0.1
	February	34.1	32.0	32.4	0.4	0.2
	March	35.1	32.0	32.8	0.7	0.5
	April	40.4	32.1	35.4	1.5	2.4
	May	43.3	34.0	37.6	1.7	3.0
	June	51.9	36.5	42.2	3.0	8.9
	July	53.5	40.1	46.0	3.1	9.7
	August	52.7	41.0	46.5	2.5	6.2
	September	50.6	37.8	43.0	1.9	3.7
	October	44.9	34.5	39.3	1.7	2.9
	November	39.3	32.0	36.0	1.8	3.3
	December	34.1	32.1	32.3	0.3	0.1
2017	January	32.8	32.1	32.2	0.1	0.0
	February	33.7	32.0	32.4	0.4	0.2
	March	36.7	32.1	33.3	1.2	1.3
	April	39.0	32.1	35.2	1.3	1.7
	May	41.5	33.5	36.5	1.5	2.2
	June	50.1	36.4	40.8	2.8	7.6
	July	54.1	41.0	47.3	3.3	10.8
	August	53.3	42.0	46.9	2.4	5.9

Broadus Creek



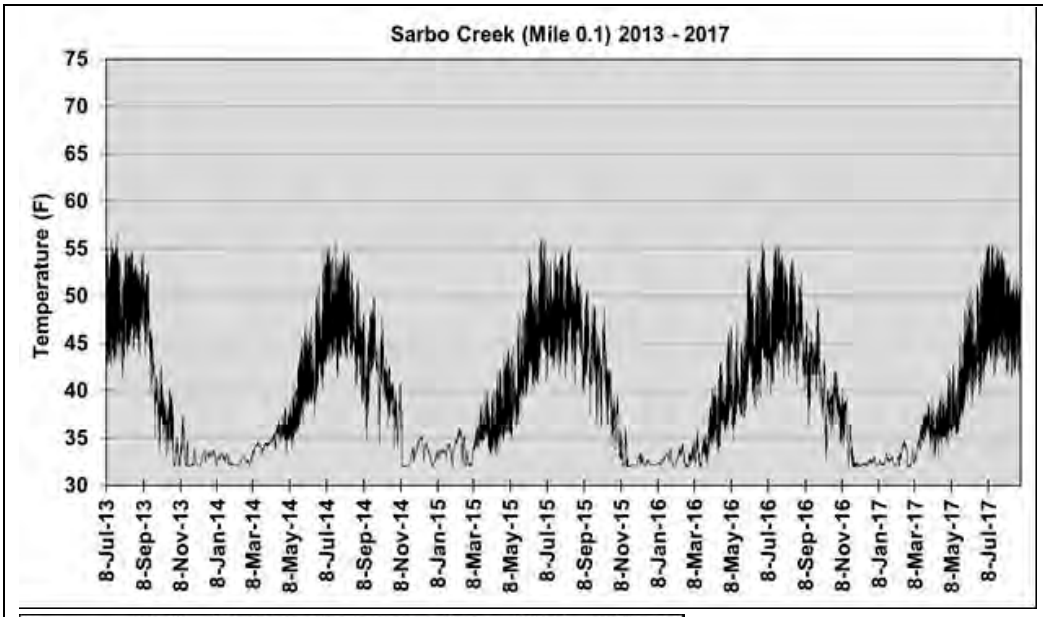
	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	59.1	43.5	49.9	3.6	13.2
	August	59.2	42.8	50.8	3.4	11.5
	September	57.8	33.7	46.8	5.4	29.3
	October	42.3	32	35.5	2.3	5.2
	November	35.7	32.1	32.6	0.7	0.5
	December	33.1	32.2	32.6	0.2	0.04
2014	January	32.9	32.2	32.5	0.2	0.0
	February	32.5	32.1	32.3	0.1	0.0
	March	33.3	32.1	32.7	0.3	0.1
	April	36.4	32.1	33.9	0.7	0.5
	May	40.9	32.3	36.1	1.4	2.0
	June	46.3	36.2	39.8	2.0	4.2
	July	55.5	39.1	47.0	3.3	11.2
	August	58.5	41.3	49.1	3.3	11.0
	September	51.1	33.8	43.7	3.5	12.1
	October	47.6	32.1	39.6	2.9	8.4
	November	39.4	32.0	33.4	1.9	3.8
	December	33.9	32.2	33.1	0.4	0.2
2015	January	33.7	32.1	32.7	0.3	0.1
	February	34.9	32.0	33.0	0.7	0.5
	March	39.1	32.1	34.0	1.5	2.2
	April	42.7	32.4	35.7	2.0	3.9
	May	46.2	34.5	38.3	2.1	4.4
	June	57.0	38.0	44.9	4.0	15.8
	July	58.4	42.1	49.2	3.3	10.9
	August	60.9	40.9	50.3	3.6	12.9
	September	53.6	36.2	44.8	3.3	11.0
	October	48.9	32.4	39.9	3.5	12.5
	November	39.3	32.0	32.8	1.5	2.2
	December	32.7	32.0	32.3	0.1	0.0
2016	January	32.9	32.1	32.4	0.1	0.0
	February	33.2	32.0	32.3	0.2	0.1
	March	35.0	32.0	32.7	0.6	0.4
	April	40.4	32.3	35.7	1.6	2.6
	May	44.6	34.0	38.3	2.0	3.9
	June	54.6	37.0	43.5	3.6	12.6
	July	59.3	40.3	48.2	4.0	15.7
	August	57.7	40.8	48.9	3.5	11.9
	September	54.9	35.7	43.8	2.9	8.4
	October	46.6	32.0	38.5	2.4	5.9
	November	40.1	32.0	34.9	2.3	5.3
	December	32.6	32.0	32.2	0.1	0.0
2017	January	32.7	32.1	32.3	0.1	0.0
	February	33.6	32.0	32.4	0.4	0.1
	March	36.5	32.1	33.5	1.0	1.0
	April	38.2	32.3	35.1	1.0	1.0
	May	43.1	34.0	37.3	1.7	2.8
	June	51.9	36.7	42.1	3.0	8.8
	July	58.5	42.2	49.7	3.7	13.4
	August	57.6	42.8	49.2	3.1	9.6

Theodore Creek



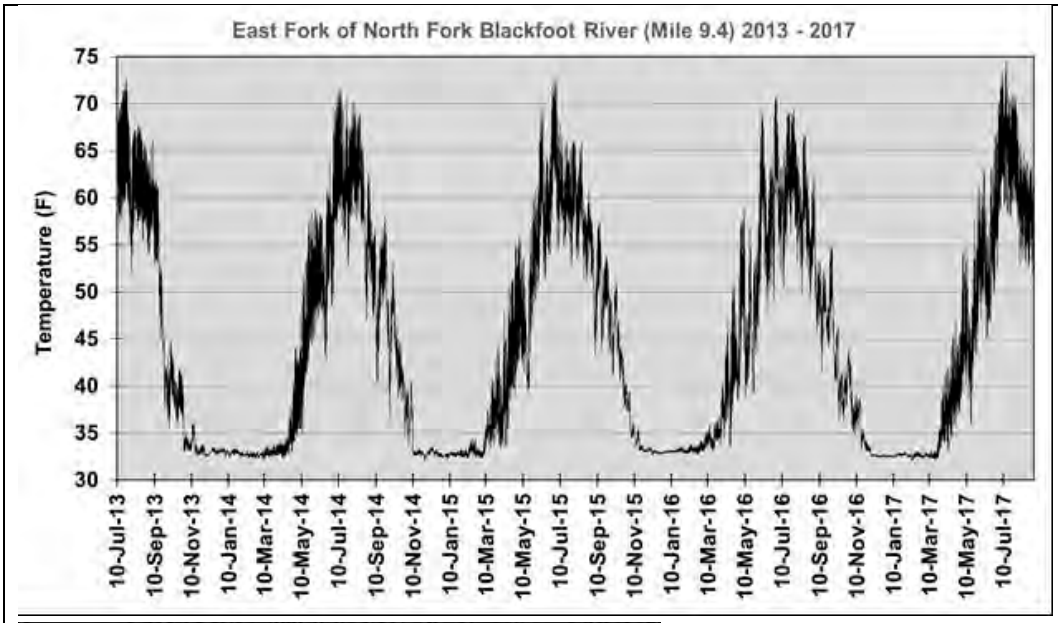
	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	55.8	44.4	49.5	2.6	6.5
	August	58.3	43.8	50.5	3.1	9.5
	September	59.5	34.1	46.4	5.4	29
	October	41.1	31.8	34.9	2.2	4.7
	November	34.6	31	32.2	0.6	0.4
	December	32	31.5	31.8	0.1	0.02
2014	January	32.0	31.7	31.8	0.1	0.0
	February	31.8	30.9	31.5	0.3	0.1
	March	32.0	31.5	31.8	0.1	0.0
	April	34.2	31.9	32.6	0.8	0.6
	May	41.1	32.6	35.8	1.5	2.1
	June	46.4	35.4	39.3	2.2	4.9
	July	53.2	38.9	47.4	2.8	7.7
	August	55.7	41.7	48.6	2.8	7.6
	September	51.8	34.4	43.3	3.2	10.1
	October	49.7	32.4	39.2	3.1	9.9
	November	39.4	30.4	32.9	2.0	4.1
	December	33.4	31.5	32.1	0.4	0.2
2015	January	33.2	31.4	32.2	0.5	0.3
	February	33.5	32.1	32.9	0.4	0.1
	March	36.8	32.0	33.6	1.2	1.3
	April	40.5	32.6	35.2	1.5	2.2
	May	44.0	33.6	37.4	2.1	4.4
	June	54.9	37.5	44.8	3.8	14.4
	July	55.4	42.8	48.7	2.5	6.5
	August	59.5	41.2	49.7	3.3	10.8
	September	54.7	35.9	44.5	3.2	10.1
	October	52.1	32.4	39.7	3.8	14.1
	November	38.8	28.0	32.6	1.5	2.3
	December	32.1	26.4	31.4	1.1	1.1
2016	January	31.9	30.4	31.3	0.4	0.2
	February	31.9	31.1	31.7	0.2	0.1
	March	32.1	31.6	31.8	0.1	0.0
	April	38.7	31.9	34.5	1.7	2.8
	May	43.8	33.4	37.3	1.9	3.5
	June	52.7	35.9	43.3	3.5	12.3
	July	56.7	41.0	48.0	3.2	10.4
	August	56.6	41.1	48.5	3.2	10.2
	September	57.9	37.1	43.6	3.1	9.5
	October	48.5	32.2	38.2	2.4	5.8
	November	38.0	31.9	34.1	1.8	3.3
	December	32.6	32.0	32.3	0.2	0.0
2017	January	32.6	32.0	32.3	0.1	0.0
	February	32.8	32.0	32.4	0.2	0.0
	March	34.4	32.1	33.1	0.6	0.4
	April	38.6	33.5	34.9	0.7	0.5
	May	41.7	33.8	36.6	1.6	2.6
	June	51.2	35.8	41.7	3.2	10.2
	July	56.0	42.3	49.2	2.8	7.8
	August	55.3	42.8	48.4	2.7	7.5

Sarbo Creek

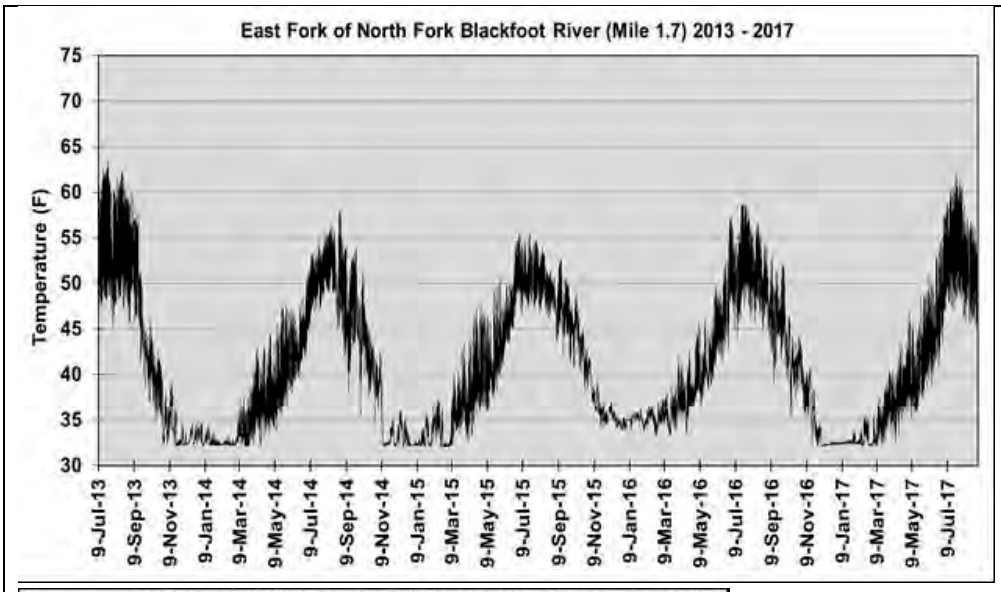


	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	56.6	42.5	48.6	3.7	13.5
	August	54.8	41.4	48.8	3.0	8.8
	September	54.6	35	45.9	4.3	18.5
	October	42.7	32	36.6	2.3	5.4
	November	37.4	32	33.3	1.3	1.8
	December	33.8	32.1	33	0.6	0.3
2014	January	33.7	32.1	32.8	0.4	0.2
	February	33.0	32.1	32.4	0.3	0.1
	March	34.6	32.1	33.8	0.7	0.4
	April	38.3	33.6	35.3	0.8	0.6
	May	45.6	33.3	37.5	2.4	5.7
	June	51.1	37.4	42.5	2.7	7.2
	July	55.7	40.1	47.6	3.4	11.9
	August	54.7	40.5	47.6	3.1	9.4
	September	50.0	34.7	43.6	2.9	8.5
	October	47.8	33.9	40.2	2.5	6.5
	November	40.9	32.0	33.8	2.4	5.6
	December	35.1	32.1	33.8	0.8	0.7
2015	January	34.4	32.2	33.4	0.5	0.3
	February	36.0	31.9	33.9	1.2	1.4
	March	40.1	32.0	34.9	1.7	2.9
	April	43.8	33.0	36.6	2.2	5.0
	May	48.5	35.0	39.9	2.8	7.9
	June	55.9	39.4	45.7	3.6	13.2
	July	55.9	40.9	47.6	3.3	10.7
	August	55.4	40.6	48.2	3.0	8.8
	September	51.1	36.7	44.2	2.8	7.9
	October	48.8	33.8	40.2	3.1	9.5
	November	39.5	31.9	33.3	1.8	3.1
	December	33.4	32.1	32.4	0.3	0.1
2016	January	33.8	32.1	32.7	0.5	0.2
	February	34.5	32.0	32.8	0.7	0.5
	March	36.2	32.0	33.4	0.9	0.8
	April	42.9	33.4	37.0	1.9	3.5
	May	47.2	34.8	40.0	2.5	6.2
	June	55.7	37.8	45.1	3.8	14.5
	July	55.4	39.7	47.3	3.7	13.6
	August	54.1	40.7	47.5	2.9	8.6
	September	52.4	36.1	43.6	2.4	5.7
	October	46.0	32.5	39.1	2.3	5.2
	November	40.2	31.9	35.2	2.4	5.6
	December	33.0	32.0	32.3	0.3	0.1
2017	January	33.5	32.1	32.5	0.4	0.1
	February	34.8	32.0	33.0	0.8	0.7
	March	38.5	32.1	34.7	1.6	2.4
	April	39.7	32.9	36.0	1.3	1.6
	May	48.5	34.3	38.7	2.7	7.1
	June	53.4	38.2	44.1	3.0	8.8
	July	55.5	41.7	48.3	3.7	13.4
	August	53.9	41.3	47.2	2.9	8.3

East Fork North Fork Blackfoot River

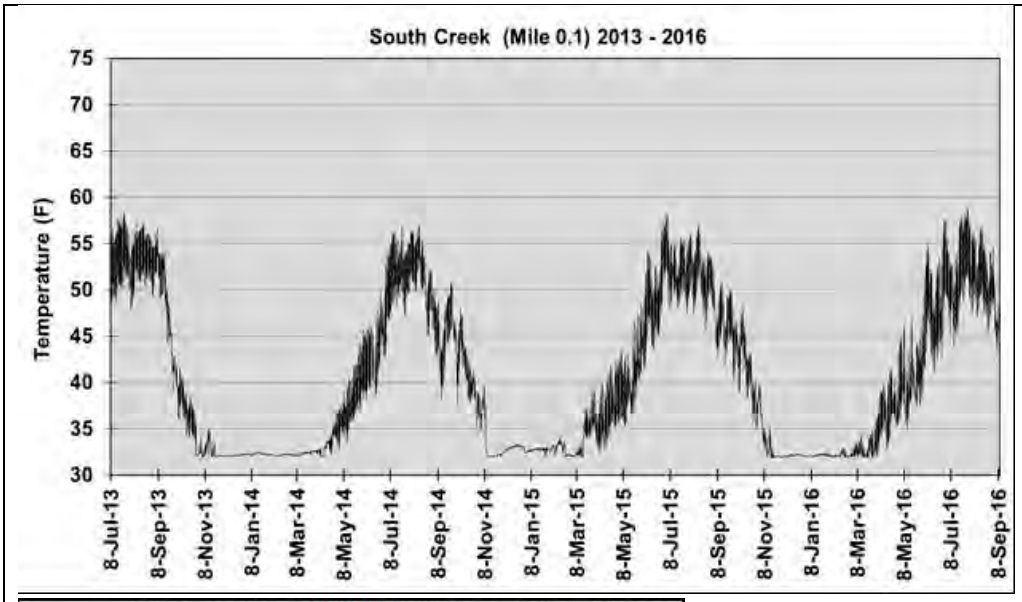


	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	72.6	55.8	64.5	3.8	14.5
	August	67.7	52.1	61.0	3.3	10.8
	September	66.1	37.4	52.5	7.5	56.1
	October	44.7	33	38.6	2.5	6.5
	November	36	32.5	33.6	0.7	0.5
	December	33.4	32.5	32.9	0.2	0.05
2014	January	33.5	32.3	32.9	0.2	0.0
	February	33.1	32.3	32.7	0.1	0.0
	March	33.8	32.2	32.8	0.3	0.1
	April	44.0	32.3	34.4	2.1	4.5
	May	58.5	34.7	44.4	5.9	34.5
	June	63.8	42.7	52.6	4.1	16.9
	July	71.7	49.9	62.4	4.2	18.0
	August	70.3	46.9	60.5	5.0	25.3
	September	58.0	40.4	50.7	3.7	13.9
	October	53.2	34.5	42.6	3.9	15.1
	November	40.3	32.0	34.1	2.1	4.6
	December	33.6	32.4	32.8	0.2	0.1
2015	January	33.3	32.2	32.7	0.1	0.0
	February	34.5	32.4	33.0	0.4	0.2
	March	44.5	32.4	35.6	2.5	6.3
	April	55.1	33.2	41.7	5.0	24.9
	May	60.9	39.2	48.3	4.8	23.2
	June	71.9	50.2	60.3	4.9	24.3
	July	72.5	52.7	61.2	3.8	14.5
	August	66.0	51.2	58.3	3.3	11.1
	September	57.3	43.2	50.1	3.3	11.2
	October	51.4	37.3	43.3	3.6	13.2
	November	39.4	33.0	34.4	1.5	2.2
	December	33.5	32.6	33.0	0.2	0.0
2016	January	33.6	32.8	33.1	0.1	0.0
	February	34.3	32.7	33.2	0.3	0.1
	March	36.8	33.1	34.4	0.8	0.6
	April	50.9	33.5	40.5	3.6	12.7
	May	58.9	38.9	47.3	4.6	21.4
	June	70.6	46.3	58.3	5.2	27.2
	July	70.8	50.5	61.4	4.2	17.6
	August	66.6	49.2	58.0	3.7	13.6
	September	62.2	41.5	49.3	3.4	11.7
	October	52.5	36.2	41.5	3.2	9.9
	November	39.4	33.1	35.7	1.8	3.4
	December	33.5	32.3	32.6	0.2	0.0
2017	January	32.9	32.4	32.6	0.1	0.0
	February	33.1	32.1	32.6	0.1	0.0
	March	38.7	32.2	33.1	1.1	1.3
	April	46.8	33.1	38.7	2.9	8.4
	May	61.3	36.0	46.5	4.8	23.1
	June	66.9	45.0	54.6	4.8	22.9
	July	74.6	55.5	65.5	3.8	14.8
	August	68.8	51.9	59.4	3.4	11.7



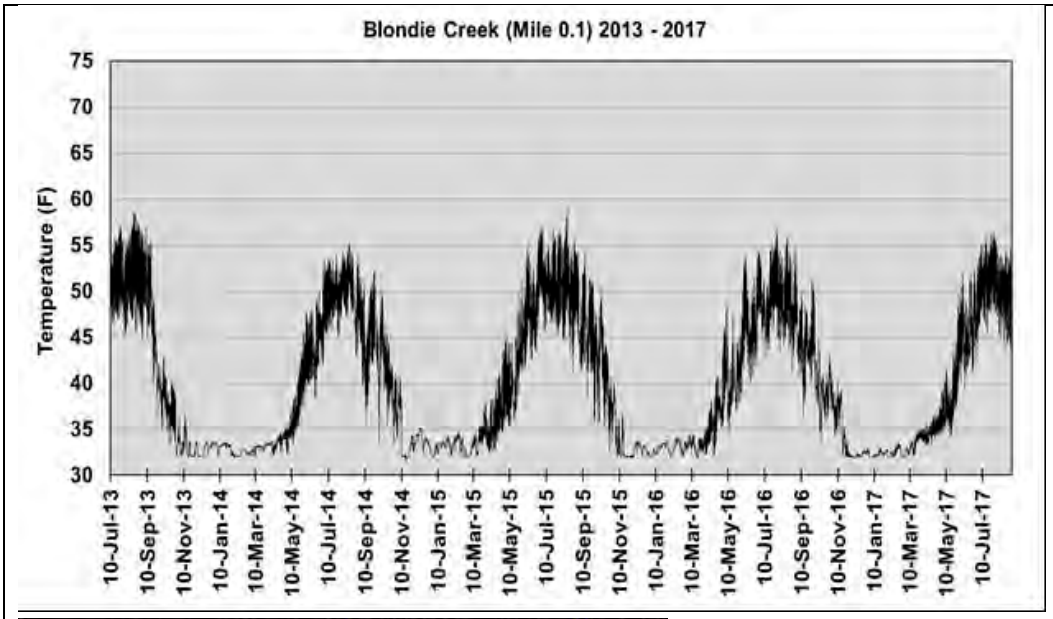
	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	63.5	47.1	54.7	4.2	17.6
	August	62.2	45.0	53.7	3.8	14.3
	September	60	38.6	48.9	4.8	23.3
	October	46.1	32.3	38.8	2.9	8.4
	November	39.1	32.1	34.3	1.9	3.5
	December	38.8	32.2	33	0.7	0.4
2014	January	34.6	32.1	32.7	0.5	0.3
	February	33.2	32.2	32.4	0.2	0.0
	March	38.5	32.1	34.0	2.0	0.4
	April	44.5	32.1	37.0	2.4	5.9
	May	47.8	33.8	39.5	3.2	10.4
	June	48.3	37.9	42.9	2.3	5.1
	July	55.1	42.5	49.7	2.3	5.4
	August	58.0	45.1	51.6	2.6	6.6
	September	54.9	37.8	47.1	3.2	10.5
	October	51.4	34.7	42.1	2.9	8.4
	November	42.3	32.1	34.7	3.0	9.3
	December	36.2	32.1	33.1	1.0	1.1
2015	January	35.8	32.1	32.8	0.8	0.6
	February	37.1	32.1	33.6	1.4	2.0
	March	43.4	32.1	35.4	2.5	6.2
	April	47.6	32.4	38.7	3.3	10.8
	May	50.6	36.0	41.6	3.0	9.2
	June	54.6	40.6	46.8	3.0	9.0
	July	55.5	46.6	50.8	2.0	4.0
	August	54.6	46.0	49.8	1.7	3.0
	September	52.6	41.3	47.1	2.1	4.6
	October	48.8	38.0	43.2	2.4	5.6
	November	41.9	34.1	37.0	1.7	2.9
	December	37.0	33.8	35.1	0.7	0.5
2016	January	36.2	33.8	35.1	0.4	0.2
	February	37.0	33.3	35.0	0.7	0.6
	March	39.1	33.4	35.6	1.1	1.2
	April	42.6	33.5	37.7	1.6	2.6
	May	46.0	36.7	40.7	2.0	3.9
	June	57.0	39.5	46.6	3.4	11.4
	July	58.7	43.9	51.7	3.3	10.6
	August	57.0	44.6	50.7	2.6	6.5
	September	54.1	39.0	46.7	2.6	6.6
	October	49.8	35.1	41.7	2.2	5.0
	November	40.7	32.1	36.5	2.4	5.8
	December	34.8	32.1	32.4	0.4	0.2
2017	January	33.7	32.3	32.6	0.2	0.1
	February	35.6	32.1	32.9	0.8	0.6
	March	40.5	32.2	34.6	1.9	3.6
	April	43.7	32.3	37.6	2.2	4.7
	May	48.8	35.2	40.6	3.0	9.1
	June	54.6	38.6	45.5	3.6	12.8
	July	61.9	45.4	53.5	3.7	13.4
	August	60.8	45.0	51.6	3.2	10.2

South Creek



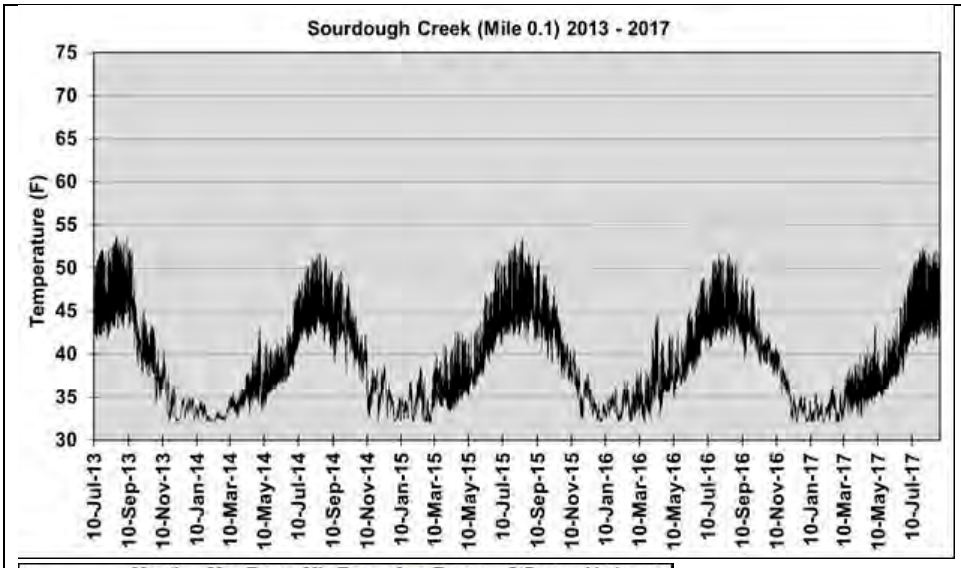
	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	58.4	48.8	53.5	2.3	5.1
	August	57.3	47.6	53.2	1.9	3.7
	September	56.6	39	49.1	4.4	19.7
	October	41.8	32	36.5	2.5	6.2
	November	35	32	32.6	0.7	0.5
	December	32.3	32	32.1	0.07	0.005
2014	January	32.4	32.1	32.3	0.1	0.0
	February	32.3	32.0	32.2	0.1	0.0
	March	32.6	32.0	32.4	0.2	0.0
	April	36.8	32.0	33.3	1.0	1.0
	May	44.3	32.7	37.4	2.2	4.9
	June	49.9	38.1	42.9	2.6	6.6
	July	56.9	42.7	51.3	2.5	6.1
	August	57.1	45.1	51.8	2.5	6.5
	September	50.8	38.2	45.6	2.5	6.3
	October	47.9	35.1	41.0	2.6	7.0
	November	39.6	32.0	33.6	2.4	5.6
	December	33.2	32.3	32.9	0.3	0.1
2015	January	33.1	32.0	32.7	0.2	0.0
	February	33.9	32.0	32.8	0.5	0.3
	March	39.5	32.0	33.8	1.8	3.3
	April	42.5	32.3	36.2	2.1	4.3
	May	48.8	35.2	40.1	2.6	7.0
	June	57.3	41.3	48.6	3.4	11.7
	July	58.0	47.3	52.0	2.1	4.4
	August	57.2	45.6	51.7	2.1	4.5
	September	52.9	40.3	46.5	2.3	5.3
	October	48.3	35.0	41.4	3.0	9.2
	November	40.0	31.9	33.4	1.9	3.7
	December	32.3	31.8	32.1	0.1	0.0
2016	January	32.3	32.0	32.1	0.1	0.0
	February	32.9	31.9	32.1	0.2	0.0
	March	35.0	31.9	32.6	0.6	0.3
	April	41.5	32.1	36.2	1.9	3.6
	May	47.4	34.6	40.0	2.3	5.4
	June	57.5	38.8	47.3	3.4	11.7
	July	58.9	43.9	51.1	3.0	9.0
	August	56.9	45.3	50.8	2.2	4.8
	September	54.6	43.4	47.2	2.4	5.7

Blondie Creek



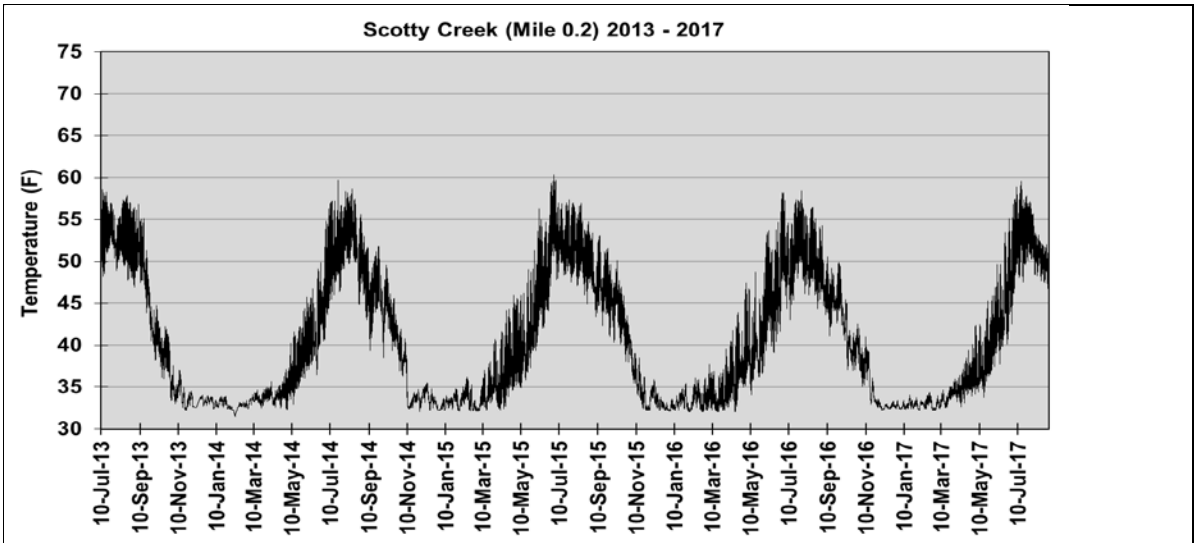
	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	57.1	46.2	51.1	2.5	6.2
	August	58.7	45.0	51.0	2.9	8.3
	September	56.9	36	47.1	4.7	21.6
	October	42.9	32.1	37	2.4	5.5
	November	36.7	32	33	1.1	1.3
	December	33.7	32	32.8	0.6	0.4
2014	January	33.6	32.0	33.0	0.4	0.2
	February	32.8	32.0	32.4	0.3	0.1
	March	33.5	32.0	33.0	0.4	0.1
	April	35.2	32.2	33.6	0.5	0.3
	May	45.7	32.3	36.9	2.8	7.9
	June	50.1	38.4	43.6	2.6	6.5
	July	54.0	42.0	49.3	2.3	5.2
	August	55.2	42.7	49.8	2.5	6.4
	September	52.3	35.3	44.4	3.2	9.9
	October	50.1	33.4	40.8	3.0	9.3
	November	40.9	31.5	34.0	2.4	5.9
	December	35.2	32.0	33.6	0.9	0.7
2015	January	34.3	32.0	33.2	0.6	0.3
	February	34.7	32.0	33.2	0.8	0.7
	March	37.8	32.0	33.6	1.1	1.3
	April	43.8	32.4	35.8	2.3	5.1
	May	51.3	35.3	40.9	3.3	10.7
	June	56.5	41.4	48.3	3.4	11.5
	July	57.0	45.1	50.5	2.6	6.5
	August	59.2	41.0	50.0	3.2	10.2
	September	54.3	35.9	45.3	3.3	10.9
	October	50.4	32.7	40.8	3.6	13.2
	November	39.8	32.0	33.2	1.8	3.4
	December	33.9	32.0	32.8	0.6	0.3
2016	January	34.3	32.0	33.2	0.6	0.3
	February	34.7	32.0	33.2	0.8	0.7
	March	37.8	32.0	33.6	1.1	1.3
	April	43.8	32.4	35.8	2.3	5.1
	May	51.3	35.3	40.9	3.3	10.7
	June	56.5	41.4	48.3	3.4	11.5
	July	57.0	45.1	50.5	2.6	6.5
	August	59.2	41.0	50.0	3.2	10.2
	September	54.9	36.3	44.3	2.8	7.9
	October	48.7	33.3	39.6	2.4	5.8
	November	40.4	32.0	35.2	2.4	6.0
	December	32.8	32.0	32.2	0.3	0.1
2017	January	32.9	32.0	32.3	0.3	0.1
	February	33.5	32.0	32.4	0.5	0.2
	March	35.1	32.0	33.3	0.8	0.6
	April	37.6	33.1	34.7	0.7	0.6
	May	49.7	33.9	38.2	2.9	8.4
	June	52.4	39.4	45.4	2.8	7.6
	July	56.5	44.4	50.9	2.6	6.5
	August	55.4	43.7	49.5	2.6	6.7

Sourdough Creek



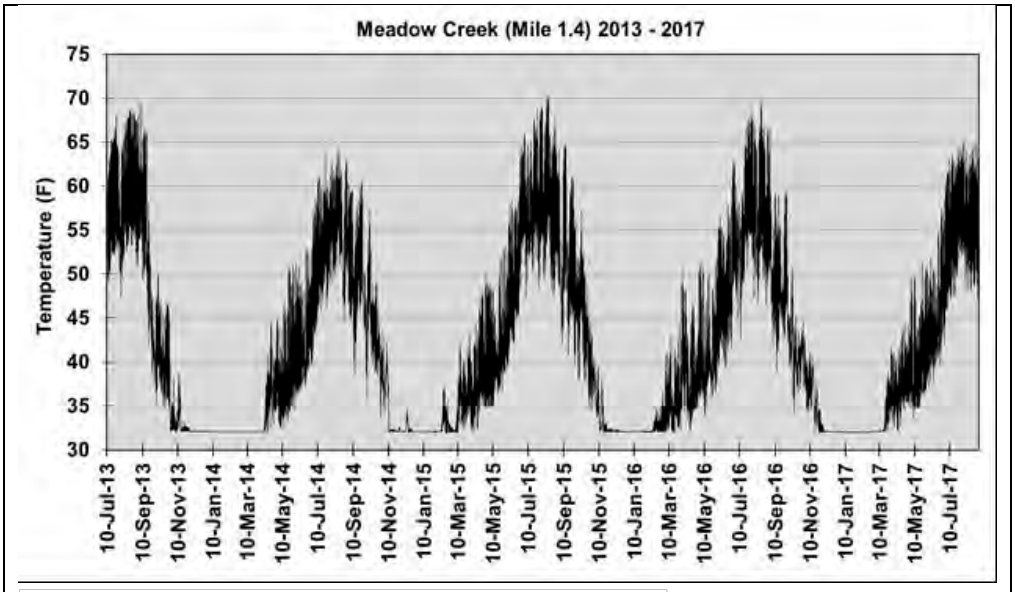
	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	52.2	41.7	45.5	2.9	8.2
	August	53.7	41.7	46.6	2.9	8.3
	September	53.7	38.4	45.1	3.1	9.4
	October	45	34.3	40	2	3.9
	November	40.6	32.3	35.8	1.8	3.4
	December	35.6	32.3	33.5	0.9	0.8
2014	January	34.8	32.2	33.3	0.6	0.4
	February	33.3	32.2	32.6	0.3	0.1
	March	36.0	32.2	33.9	0.7	0.5
	April	41.8	33.0	36.0	1.4	2.0
	May	43.0	33.5	36.8	1.7	3.1
	June	43.3	36.2	38.7	1.5	2.3
	July	50.2	37.9	43.8	2.3	5.3
	August	51.8	41.5	45.4	2.4	5.6
	September	49.9	38.9	43.8	2.3	5.4
	October	48.2	37.0	41.4	2.0	4.0
	November	42.3	32.1	36.6	2.3	5.2
	December	38.7	32.1	35.0	1.6	2.6
2015	January	36.8	32.2	33.8	1.0	1.1
	February	38.5	32.1	34.3	1.5	2.3
	March	41.1	32.1	35.3	1.8	3.4
	April	42.7	33.1	36.1	2.1	4.4
	May	44.0	35.1	37.9	1.7	2.8
	June	50.5	37.6	42.2	2.6	6.6
	July	52.6	41.1	45.2	2.6	7.0
	August	53.6	41.3	46.3	2.7	7.2
	September	51.1	39.4	44.4	2.4	5.5
	October	48.0	37.2	41.6	2.2	4.7
	November	41.1	32.3	36.9	2.1	4.6
	December	37.8	32.2	34.5	1.4	1.9
2016	January	36.3	32.2	33.8	0.9	0.7
	February	36.8	32.2	33.8	1.2	1.4
	March	38.6	32.2	34.6	1.4	1.9
	April	44.5	32.5	37.0	2.2	4.8
	May	42.7	34.9	37.8	1.5	2.2
	June	48.5	36.8	41.2	2.3	5.3
	July	51.7	40.6	44.4	2.5	6.3
	August	51.6	41.1	45.3	2.4	5.9
	September	50.8	39.2	43.6	1.9	3.5
	October	45.9	38.6	40.9	1.3	1.7
	November	41.1	35.2	38.0	1.3	1.7
	December	36.9	32.0	33.9	1.0	1.0
2017	January	35.5	32.1	33.1	0.8	0.7
	February	36.3	32.1	33.4	1.0	1.0
	March	38.9	32.1	34.6	1.4	1.8
	April	41.0	32.4	35.6	1.6	2.6
	May	43.3	34.4	37.0	1.6	2.6
	June	47.0	36.5	40.0	2.3	5.1
	July	52.4	40.3	45.0	2.9	8.2
	August	52.1	41.6	45.7	2.8	7.6

Scotty Creek

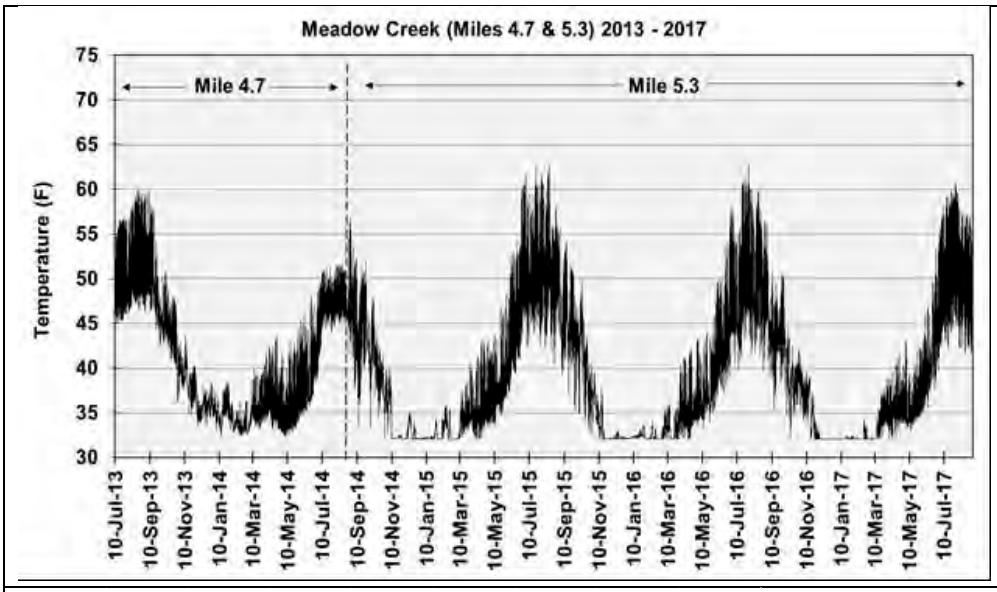


	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	60.2	48.2	53.5	2.1	4.5
	August	57.9	47.2	52.1	2.2	4.9
	September	56.8	40.4	48.2	3.7	13.5
	October	44.8	33.3	38.8	2.3	5.4
	November	37.6	32.2	34	1.1	1.1
	December	34.2	32.5	33.2	0.5	0.2
2014	January	33.9	32.4	33.0	0.4	0.2
	February	33.4	31.4	32.5	0.4	0.2
	March	35.0	32.3	33.5	0.5	0.2
	April	37.1	32.4	33.9	0.7	0.5
	May	44.4	32.3	36.7	2.4	5.8
	June	50.0	36.4	41.5	2.9	8.4
	July	59.7	40.6	50.4	3.5	12.6
	August	58.7	44.9	52.0	2.8	8.0
	September	53.0	39.3	46.1	2.5	6.4
	October	49.5	36.8	42.3	2.4	5.7
	November	41.0	32.1	34.7	2.4	5.8
	December	35.5	32.2	33.5	0.8	0.7
2015	January	34.8	32.1	33.1	0.6	0.3
	February	36.2	32.1	33.3	0.9	0.8
	March	40.8	32.1	34.1	1.6	2.6
	April	45.9	32.2	36.5	2.9	8.3
	May	51.3	34.9	40.0	3.2	9.9
	June	59.6	39.3	48.3	4.5	20.5
	July	60.3	47.5	52.2	2.5	6.3
	August	57.0	44.9	50.5	2.5	6.0
	September	53.4	41.0	46.6	2.4	5.6
	October	50.1	37.9	43.1	2.5	6.2
	November	40.7	32.2	35.2	2.2	5.0
	December	35.9	32.1	33.2	0.9	0.8
2016	January	35.4	32.1	33.1	0.7	0.5
	February	36.1	32.1	33.2	1.0	0.9
	March	37.7	32.1	33.6	1.2	1.4
	April	43.9	32.0	36.1	2.4	5.6
	May	48.7	34.0	39.4	2.8	7.9
	June	58.2	37.5	46.3	4.3	18.2
	July	58.5	43.0	50.9	3.1	9.8
	August	56.5	44.3	49.9	2.6	6.6
	September	54.3	41.1	45.8	1.9	3.7
	October	47.8	36.9	40.8	2.3	5.1
	November	41.0	32.6	35.7	2.2	4.9
	December	33.4	32.2	32.7	0.3	0.1
2017	January	34.0	32.3	32.8	0.4	0.2
	February	34.4	32.2	32.9	0.5	0.3
	March	35.6	32.2	33.5	0.7	0.5
	April	40.1	32.6	35.1	1.2	1.5
	May	45.9	33.7	37.8	2.4	6.0
	June	55.1	37.4	44.0	3.8	14.1
	July	59.5	44.8	52.8	2.9	8.5
	August	55.7	46.7	50.5	1.7	2.9

Meadow Creek

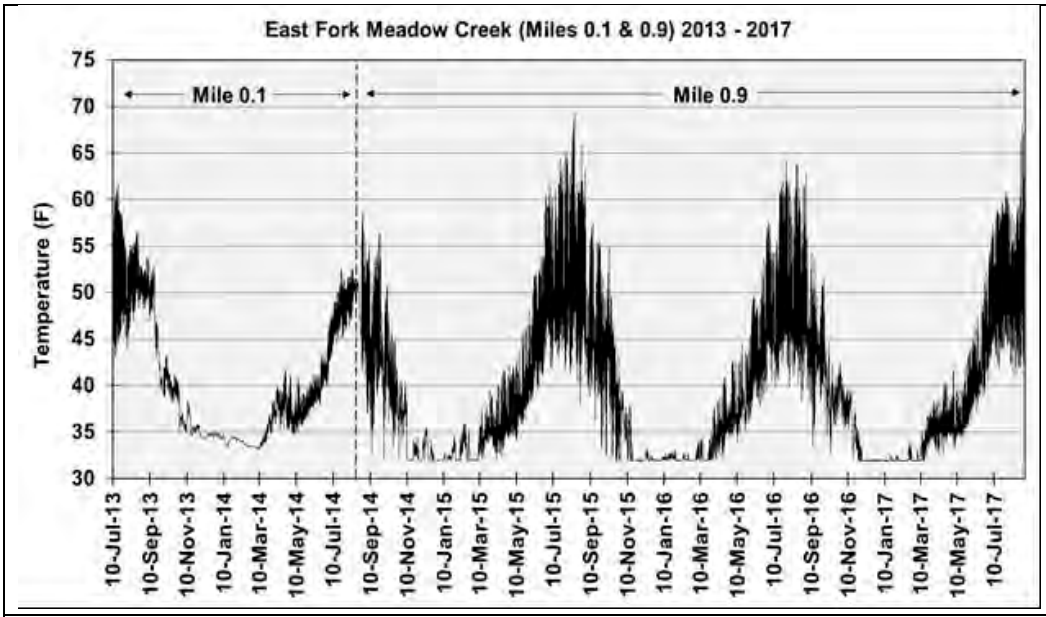


	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	68.1	49.2	58.3	4.2	17.6
	August	68.7	47.4	58.6	4.7	21.9
	September	69.6	37.7	52.2	7.5	56
	October	50.2	32.1	39.1	3.9	15.2
	November	38.8	32.1	32.8	1.2	1.3
	December	32.1	32.1	32.1	0.02	0.0006
2014	January	32.1	32.1	32.1	0.0	0.0
	February	32.1	32.1	32.1	0.0	0.0
	March	32.1	32.1	32.1	0.0	0.0
	April	44.6	32.1	35.4	3.0	9.2
	May	51.1	32.5	39.0	4.4	19.4
	June	52.8	35.8	42.8	4.0	16.0
	July	63.6	40.1	52.4	4.6	20.7
	August	64.2	44.5	55.3	4.0	16.0
	September	60.8	38.5	49.9	4.4	19.5
	October	57.4	33.6	42.9	4.1	16.4
	November	42.2	32.0	33.9	2.9	8.2
	December	34.8	32.0	32.3	0.5	0.2
2015	January	32.2	32.0	32.1	0.0	0.0
	February	37.0	31.9	32.7	1.0	1.0
	March	43.2	32.0	35.2	2.7	7.0
	April	49.9	32.0	38.9	4.1	16.8
	May	53.1	34.8	41.3	4.0	15.9
	June	64.5	39.1	50.5	5.9	34.6
	July	68.8	47.4	57.4	4.4	19.1
	August	70.0	47.4	57.7	5.2	26.9
	September	64.8	39.6	50.6	5.3	28.2
	October	57.3	34.5	43.5	4.6	21.5
	November	40.7	32.0	33.9	2.2	5.0
	December	32.4	32.0	32.1	0.0	0.0
2016	January	32.3	32.0	32.1	0.0	0.0
	February	36.8	32.0	32.6	0.8	0.6
	March	44.4	32.0	35.0	2.6	6.5
	April	50.6	32.1	38.8	3.6	12.8
	May	51.3	33.8	41.0	3.9	15.5
	June	62.8	37.8	48.4	5.2	27.5
	July	69.2	42.6	55.5	5.0	25.4
	August	69.8	46.4	56.0	5.1	25.7
	September	66.8	39.0	49.0	4.5	20.5
	October	52.7	34.2	41.5	3.1	9.3
	November	40.9	32.0	35.8	2.5	6.1
	December	32.9	32.0	32.1	0.1	0.0
2017	January	32.1	32.0	32.0	0.0	0.0
	February	32.1	32.0	32.1	0.0	0.0
	March	41.7	32.1	33.5	2.1	4.5
	April	44.4	32.2	37.7	2.5	6.4
	May	51.3	33.4	40.3	4.1	16.6
	June	57.5	37.1	45.1	4.4	19.2
	July	64.4	44.2	55.5	4.5	19.9
	August	65.3	47.1	55.4	4.2	17.7



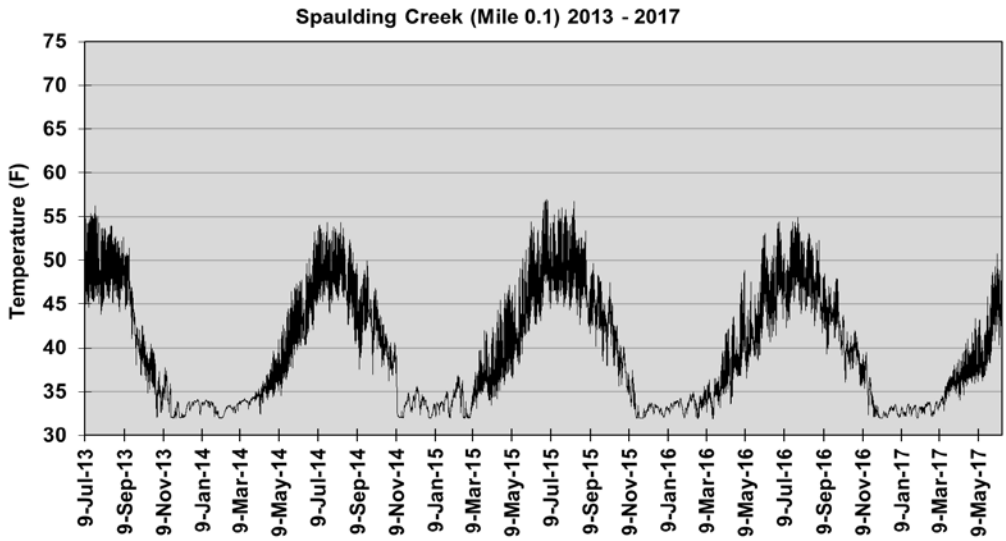
		Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
Mile 4.7	2013	July	57.0	45.0	50.0	3.4	11.2
		August	59.8	46.1	51.6	3.7	13.7
		September	59.8	42.4	49.3	3.7	13.5
		October	50.8	36.2	43.5	2.8	7.7
		November	43.7	34.8	38.5	1.6	2.6
		December	38.4	33.6	35.6	0.9	0.9
	2014	January	38.5	32.4	35.1	1.1	1.2
		February	36.4	32.5	33.8	0.8	0.6
		March	40.6	32.7	35.3	1.6	2.6
		April	43.7	32.8	36.4	2.4	5.8
		May	44.3	32.4	35.8	3.0	7.3
		June	48.1	34.5	39.3	3.0	8.7
		July	51.4	39.0	46.6	2.3	5.5
		26-Aug	51.7	44.7	47.5	1.7	3.1
Mile 5.3	2014	26-Aug	56.8	41.8	48.5	3.9	15.4
		September	53.6	33.6	44.2	3.8	14.8
		October	48.0	32.2	39.5	2.9	8.6
		November	39.8	32.1	33.4	2.1	4.5
		December	35.1	32.1	32.6	0.8	0.6
	2015	January	34.5	32.1	32.3	0.4	0.2
		February	35.8	32.1	32.9	1.0	1.1
		March	40.6	32.1	34.0	1.7	2.9
		April	43.3	32.1	35.5	2.5	6.2
		May	48.4	33.6	37.8	2.8	7.7
		June	60.6	37.3	45.7	5.1	26.4
		July	62.6	42.4	50.8	4.7	21.9
		August	62.7	40.4	50.8	4.6	21.1
		September	55.6	35.2	45.2	3.9	15.0
		October	49.6	32.5	40.2	3.7	13.6
		November	39.5	32.0	33.7	2.0	4.0
		December	33.1	32.1	32.2	0.2	0.0
	2016	January	33.6	32.1	32.4	0.3	0.1
		February	34.1	32.1	32.3	0.4	0.2
		March	38.4	32.1	33.2	1.2	1.4
		April	42.2	32.0	35.3	2.1	4.6
		May	45.7	33.2	37.1	2.4	6.0
		June	57.5	35.6	43.5	4.5	20.7
		July	62.7	40.0	49.4	5.1	25.6
		August	60.1	39.6	49.4	4.6	20.9
		September	56.1	35.3	44.1	3.3	10.9
		October	46.8	32.1	39.0	2.5	6.2
		November	39.8	32.0	35.2	2.2	4.9
		December	32.9	32.0	32.1	0.1	0.0
	2017	January	32.4	32.0	32.1	0.1	0.0
		February	34.3	32.0	32.2	0.4	0.1
		March	38.0	32.0	33.4	1.4	2.1
		April	41.6	32.0	35.3	1.8	3.3
		May	43.0	33.0	35.8	2.1	4.3
		June	53.3	35.1	41.0	3.9	14.9
		July	60.9	41.2	50.2	4.8	22.9
		August	59.6	41.6	49.6	4.2	18.0

East Fork Meadow Creek



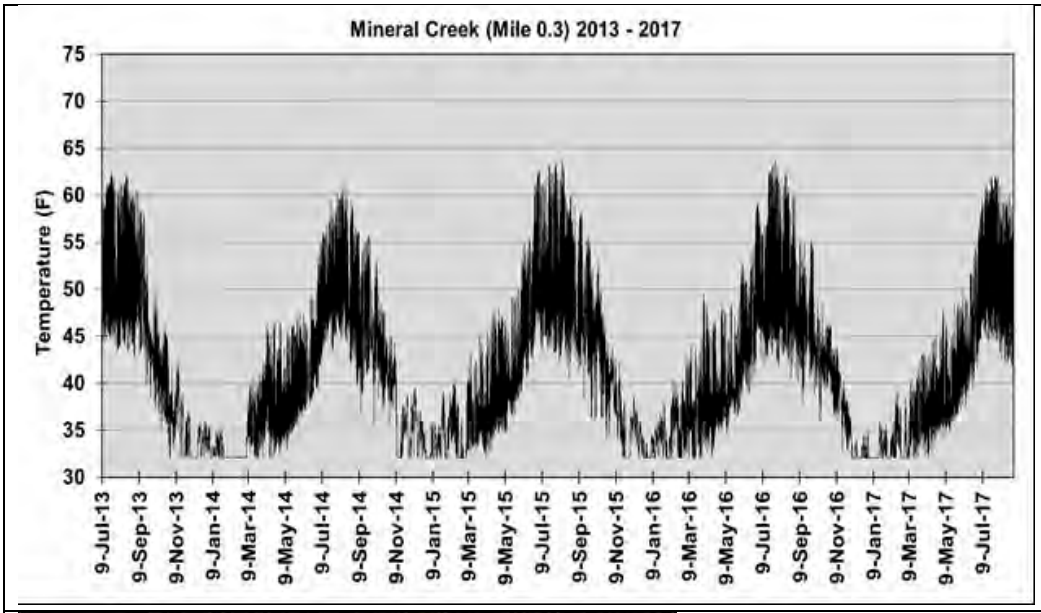
		Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
Mile 0.1	2013	July	61.7	43.1	52.1	4.7	22.4
		August	56.5	43.9	51.1	2.4	5.9
		September	53.8	39.5	47.1	4.2	17.5
		October	43.1	35	39.4	1.7	2.9
		November	38.2	34.6	35.8	0.8	0.7
		December	34.5	34.3	34.6	0.2	0.04
	2014	January	34.7	33.5	34.2	0.3	0.1
		February	34.3	33.4	33.8	0.3	0.1
		March	37.9	33.1	34.3	1.1	1.2
		April	41.6	35.2	37.6	1.3	1.6
		May	40.8	34.7	37.1	1.3	1.6
		June	43.9	37.2	39.9	1.4	2.1
		July	52.6	40.5	46.7	2.2	4.7
		26-Aug	52.5	45.2	49.3	1.7	2.9
Mile 0.9	2014	26-Aug	58.8	41.5	47.6	4.1	16.4
		September	56.5	32.7	43.9	4.5	20.4
		October	50.8	32.0	39.6	3.3	10.8
		November	40.3	31.9	33.8	2.3	5.4
		December	35.5	31.9	32.7	1.0	1.0
	2015	January	34.5	31.9	32.3	0.5	0.3
		February	35.9	31.8	32.8	1.1	1.1
		March	39.5	31.9	34.0	1.6	2.6
		April	42.2	32.1	35.6	2.0	3.8
		May	48.0	34.3	38.4	2.5	6.2
		June	60.6	38.4	45.7	4.5	20.1
		July	64.4	41.6	50.1	5.1	25.8
		August	69.4	37.8	51.2	6.4	40.6
		September	63.2	33.2	45.0	5.0	24.7
		October	54.9	31.8	39.7	4.7	22.4
		November	39.2	31.8	33.7	2.1	4.4
		December	33.1	31.8	32.1	0.3	0.1
	2016	January	33.0	31.9	32.2	0.3	0.1
		February	32.8	31.9	32.0	0.2	0.0
		March	36.7	31.9	32.5	0.7	0.6
		April	40.9	32.1	35.2	1.6	2.6
		May	45.0	33.7	38.0	2.2	4.7
		June	57.0	36.9	43.7	4.0	15.7
		July	64.1	39.8	48.7	5.0	24.6
		August	63.9	38.1	48.9	5.4	29.5
		September	62.9	33.3	43.7	4.0	16.0
		October	47.6	32.7	39.1	2.3	5.4
		November	39.9	31.9	35.9	2.1	4.4
		December	33.5	31.9	32.0	0.2	0.1
	2017	January	32.5	31.9	32.0	0.1	0.0
		February	34.0	31.9	32.1	0.4	0.2
		March	38.2	31.9	33.5	1.4	2.0
		April	40.5	32.3	35.4	1.4	1.8
		May	43.9	33.3	36.6	1.9	3.8
		June	52.3	36.6	41.9	3.1	9.8
		July	60.9	41.8	49.5	4.4	19.2
		August	68.1	41.0	49.7	5.0	25.4

Spaulding Creek

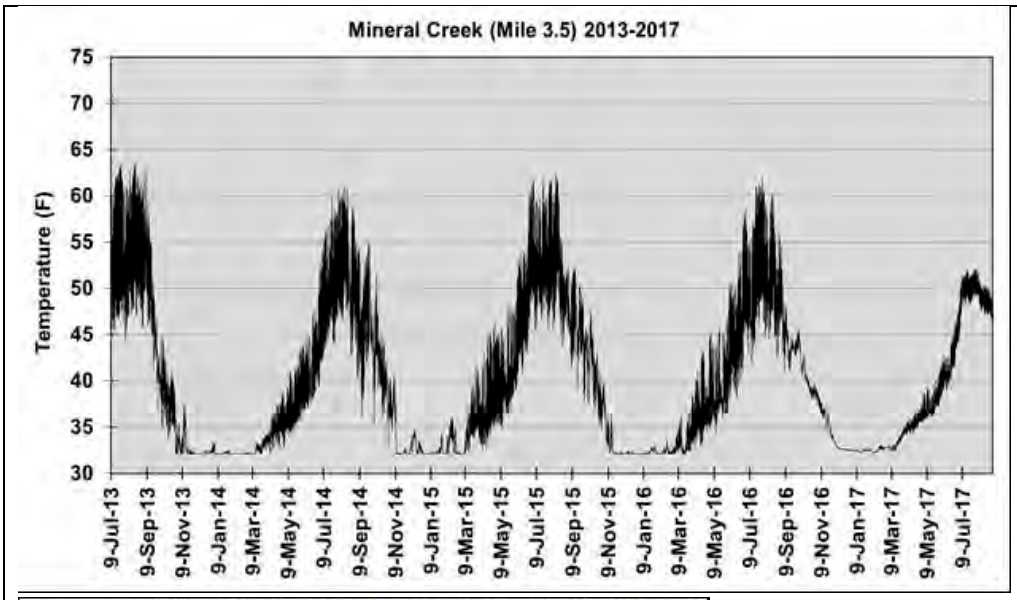


	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	56.3	44.6	49.2	2.6	6.5
	August	54.0	43.8	48.7	2.2	4.7
	September	52.6	38	45.8	3.2	10.2
	October	42.5	32	37.7	2.1	4.4
	November	37.7	32	34.1	1.6	2.4
	December	34.1	32	33	0.7	0.5
2014	January	34.1	32.1	33.5	0.5	0.2
	February	33.4	32.0	32.7	0.5	0.3
	March	34.4	32.5	33.8	0.4	0.2
	April	39.6	32.4	35.1	1.0	1.0
	May	46.4	34.6	38.6	2.5	6.1
	June	50.2	39.2	43.7	2.4	5.7
	July	54.4	42.0	48.5	2.3	5.4
	August	54.3	42.6	48.2	2.3	5.1
	September	50.9	37.5	44.0	2.3	5.2
	October	46.8	36.2	40.9	2.0	3.9
	November	40.6	32.0	34.6	2.7	7.1
	December	35.6	32.0	33.8	0.9	0.8
2015	January	35.1	32.0	33.3	0.8	0.6
	February	36.9	32.0	34.1	1.3	1.7
	March	42.0	32.0	35.0	2.1	4.3
	April	46.2	33.4	37.6	2.5	6.4
	May	51.2	36.5	41.7	2.9	8.3
	June	56.8	41.8	47.6	3.0	9.3
	July	56.9	44.4	49.1	2.4	5.9
	August	56.7	42.6	48.5	2.4	6.0
	September	53.4	38.5	44.7	2.2	4.7
	October	47.5	35.6	40.9	2.4	6.0
	November	40.0	32.0	34.3	2.2	4.7
	December	33.7	32.0	33.0	0.4	0.2
2016	January	34.3	32.0	33.3	0.6	0.3
	February	35.0	31.9	33.3	0.8	0.7
	March	37.4	31.9	34.4	1.0	1.1
	April	43.6	33.6	37.6	2.0	3.9
	May	48.9	36.5	41.2	2.3	5.2
	June	54.3	39.2	46.4	3.0	9.0
	July	55.0	42.2	48.3	2.5	6.5
	August	53.2	42.5	47.7	2.1	4.6
	September	52.3	39.3	44.2	1.8	3.4
	October	46.4	36.1	40.3	1.8	3.1
	November	39.8	32.1	35.9	2.1	4.5
	December	33.6	32.0	32.6	0.5	0.2
2017	January	33.6	32.0	32.8	0.4	0.2
	February	33.8	32.0	32.9	0.5	0.3
	March	37.6	32.4	34.5	1.1	1.3
	April	41.7	34.1	36.8	1.2	1.5
	May	48.7	35.9	39.5	2.5	6.1
	June	50.8	40.3	44.6	2.1	4.5

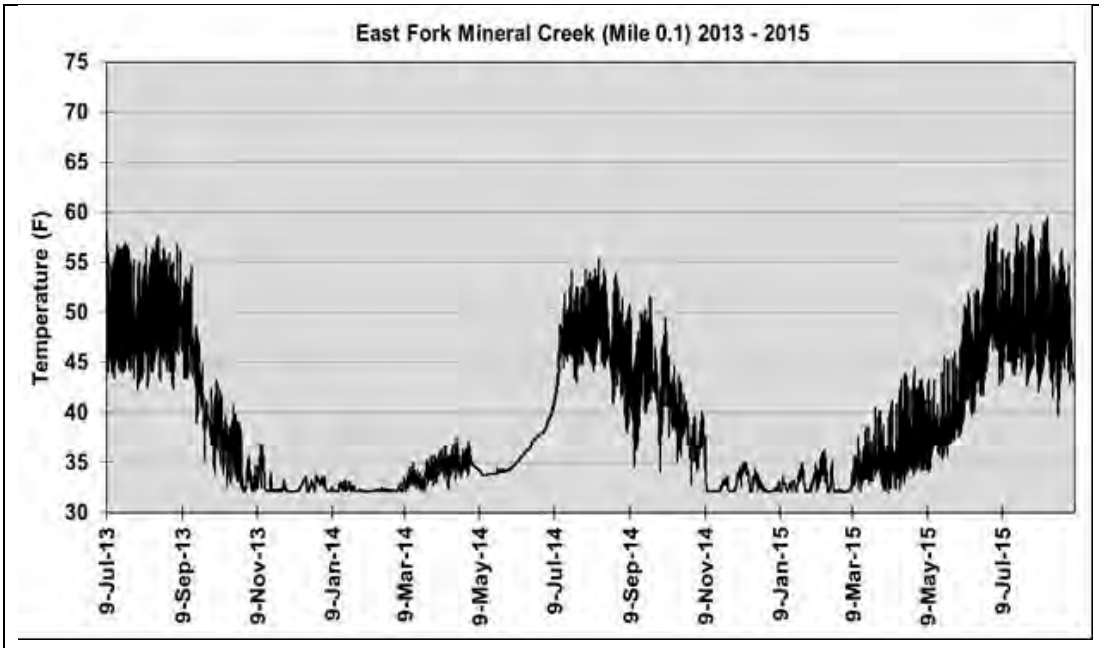
Mineral Creek



	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	62.7	44.0	52.1	5.2	26.8
	August	62.2	43.0	51.6	5.2	27.2
	September	60.6	38.5	48.2	4.9	23.7
	October	49.6	32.1	40.4	3.5	11.9
	November	42.7	32.1	35.8	2.5	6.5
	December	36.4	32.1	33.2	1.2	1.4
2014	January	35.6	32.1	32.8	0.9	0.8
	February	32.2	32.1	32.1	0.0	0.0
	March	41.0	32.1	35.1	2.4	5.9
	April	46.7	32.0	37.9	3.5	12.4
	May	47.1	33.0	38.2	3.4	11.6
	June	49.6	36.3	41.4	3.0	8.9
	July	59.5	39.3	49.1	4.1	17.2
	August	61.2	42.0	50.6	4.6	21.3
	September	56.6	36.8	46.7	4.5	19.8
	October	53.2	35.4	42.8	3.3	10.8
	November	44.4	32.1	36.0	3.4	11.6
	December	39.5	32.1	34.6	2.1	4.4
2015	January	39.0	32.0	33.6	1.7	2.9
	February	40.5	32.0	34.5	2.1	4.6
	March	45.1	32.1	35.7	2.9	8.2
	April	48.0	32.1	38.0	3.7	13.9
	May	50.1	34.7	40.5	3.3	11.0
	June	61.1	38.9	47.7	4.9	23.9
	July	63.3	43.2	51.4	5.4	29.3
	August	63.9	40.5	51.2	5.5	30.7
	September	58.8	36.5	47.3	4.6	21.2
	October	53.3	34.1	42.8	3.8	14.6
	November	43.8	32.1	36.2	3.3	10.7
	December	38.5	32.1	34.2	1.8	3.1
2016	January	38.0	32.0	33.9	1.4	2.0
	February	40.5	32.0	34.8	2.4	5.6
	March	44.8	32.0	36.6	3.1	9.9
	April	49.5	32.4	38.2	3.7	14.0
	May	48.6	34.5	40.0	3.1	9.5
	June	58.9	37.4	45.9	4.4	19.7
	July	63.6	42.1	50.6	5.3	28.3
	August	62.8	40.4	50.4	5.5	29.7
	September	60.0	37.9	46.6	3.9	15.2
	October	49.2	36.0	42.6	2.3	5.4
	November	43.8	32.7	37.8	2.3	5.5
	December	36.6	32.0	32.8	1.0	1.0
2017	January	36.1	32.1	32.7	1.0	0.9
	February	39.1	32.0	33.4	1.7	2.8
	March	43.1	32.0	35.0	2.4	5.9
	April	45.1	32.1	37.1	2.8	7.7
	May	48.5	34.3	39.4	3.3	11.0
	June	54.5	37.0	43.8	3.8	14.6
	July	62.0	43.2	51.7	4.9	23.6
	August	62.1	41.8	50.4	5.1	26.3

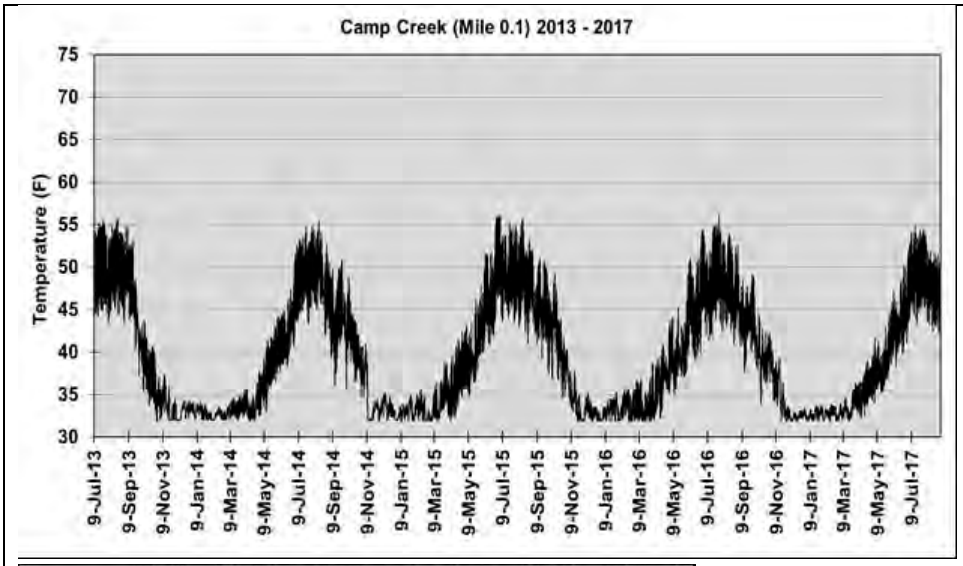


	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	63.3	45.5	53.3	4.7	22.1
	August	63.6	44.5	53.8	4.3	18.5
	September	62.6	36.7	48.4	5.4	29.3
	October	44.9	32.1	37.6	2.7	7.1
	November	37.6	32.1	33	1.2	1.4
	December	33.2	32.1	32.2	0.16	0.02
2014	January	33.2	32.1	32.2	0.2	0.0
	February	32.2	32.1	32.1	0.0	0.0
	March	34.2	32.1	33.0	0.5	0.2
	April	38.9	32.2	34.5	1.2	1.3
	May	43.5	32.6	36.8	2.0	4.1
	June	49.4	36.5	40.6	2.5	6.4
	July	60.0	39.3	49.0	4.2	17.8
	August	61.0	42.8	52.0	4.0	15.9
	September	54.9	36.0	46.5	3.8	14.4
	October	51.7	32.8	41.0	3.3	10.9
	November	40.6	32.1	33.7	2.5	6.1
	December	34.8	32.1	32.8	0.7	0.5
2015	January	34.5	32.1	32.3	0.4	0.2
	February	36.1	32.1	32.9	1.0	1.0
	March	41.8	32.1	34.4	2.0	4.2
	April	46.3	32.4	37.0	2.9	8.5
	May	48.1	35.0	39.6	2.8	7.8
	June	60.6	38.9	47.4	4.8	23.0
	July	62.0	45.5	52.8	3.9	14.9
	August	62.3	43.8	51.9	4.1	17.1
	September	52.3	37.8	45.7	2.7	7.3
	October	47.7	34.6	41.0	3.1	9.4
	November	39.7	32.1	33.5	1.9	3.6
	December	32.4	32.1	32.1	0.1	0.0
2016	January	33.0	32.1	32.3	0.2	0.0
	February	33.7	32.1	32.3	0.3	0.1
	March	37.1	32.1	33.3	1.0	1.1
	April	43.2	32.6	36.1	2.0	4.1
	May	46.2	34.4	38.6	2.4	5.8
	June	58.0	36.9	44.7	4.3	18.6
	July	62.1	41.9	51.1	4.5	20.2
	August	60.6	42.5	50.7	3.7	13.8
	September	54.6	41.0	44.5	2.1	4.5
	October	45.5	37.9	40.4	1.8	3.1
	November	38.8	33.5	36.1	1.5	2.1
	December	33.5	32.5	32.7	0.2	0.1
2017	January	32.7	32.3	32.4	0.1	0.0
	February	33.0	32.3	32.6	0.2	0.0
	March	35.0	32.4	33.2	0.6	0.4
	April	37.4	34.1	35.3	0.6	0.4
	May	41.5	35.5	37.4	1.1	1.3
	June	47.4	38.3	41.6	2.0	4.1
	July	52.0	44.2	49.3	1.6	2.7
	August	52.0	46.8	49.0	1.1	1.1



	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	58.2	43.4	49.1	3.7	13.3
	August	57.5	42.3	48.8	3.5	12.6
	September	56.7	35.3	45.6	4.3	18.7
	October	43.3	32.1	36.3	2.5	6.3
	November	36.8	32.1	33.1	1.1	1.3
	December	33.7	32.1	32.6	0.5	0.2
2014	January	33.6	32.1	32.4	0.3	0.1
	February	32.5	32.1	32.2	0.08	0.006
	March	35.6	32.1	33.1	0.8	0.6
	April	37.5	32.4	34.7	0.96	0.91
	May	36.6	33.7	34.1	0.4	0.2
	June	38.2	34.2	36.1	1.2	1.5
	July	54.1	38.1	44.8	4.1	16.9
	August	55.3	40.9	47.8	2.9	8.6
	September	51.6	34.6	43.4	3.3	11.0
	October	49.5	32.7	39.7	2.8	8.0
	November	40.1	32.1	33.7	2.2	4.8
	December	35.1	32.0	33.1	0.9	0.7
2015	January	35.0	32.0	32.7	0.6	0.4
	February	36.3	32.0	33.0	1.0	1.0
	March	40.5	32.0	34.0	1.7	2.9
	April	44.4	32.0	35.8	2.7	7.2
	May	46.1	34.0	38.0	2.4	5.6
	June	58.1	37.6	45.3	4.5	19.9
	July	58.8	42.6	49.1	3.7	13.4
	August	59.5	39.6	48.8	4.0	16.0
	September	54.8	42.9	45.9	2.7	7.4

Camp Creek



	Month	Max Temp	Min Temp	Avg Temp	StDev	Variance
2013	July	55.4	44.3	49.4	2.9	8.5
	August	55.6	43.4	49.1	2.7	7.3
	September	54.6	37.2	46.1	3.6	13.3
	October	43.7	31.9	37.2	2.5	6.1
	November	37.3	31.9	33.8	1.3	1.6
	December	34.2	31.9	33	0.7	0.5
2014	January	34.1	32.0	32.9	0.5	0.3
	February	33.5	32.0	32.5	0.4	0.1
	March	34.9	32.0	33.1	0.6	0.3
	April	37.8	32.0	33.3	1.0	1.0
	May	43.1	32.6	37.1	2.1	4.5
	June	47.8	37.6	41.6	2.1	4.4
	July	54.8	40.6	48.0	2.7	7.1
	August	55.4	42.0	48.5	2.7	7.1
	September	50.9	36.1	43.9	2.9	8.5
	October	48.9	34.7	40.6	2.6	6.6
	November	41.0	31.9	34.3	2.5	6.3
	December	35.2	31.9	33.3	0.8	0.7
2015	January	35.0	31.9	32.9	0.7	0.4
	February	35.6	31.9	33.0	0.7	0.6
	March	38.8	31.9	33.6	1.4	2.0
	April	42.5	31.9	35.7	2.1	4.6
	May	47.8	34.8	39.4	2.3	5.3
	June	55.9	39.9	45.9	3.3	11.2
	July	56.0	43.5	48.8	2.7	7.4
	August	55.7	41.0	48.3	2.9	8.5
	September	52.0	37.4	44.7	2.7	7.4
	October	49.2	34.6	41.0	3.0	8.9
	November	40.3	31.9	34.3	2.0	4.2
	December	35.3	31.9	33.0	0.8	0.6
2016	January	35.3	31.9	33.1	0.8	0.6
	February	35.8	31.9	33.1	0.9	0.9
	March	37.0	31.9	33.2	1.1	1.2
	April	40.9	32.0	35.7	2.1	4.3
	May	45.2	34.9	39.1	1.9	3.7
	June	54.1	37.8	44.8	3.1	9.9
	July	56.1	41.3	48.0	3.1	9.7
	August	54.1	40.9	47.3	2.8	7.7
	September	52.6	37.6	43.9	2.4	5.6
	October	46.6	33.8	39.7	2.1	4.4
	November	40.3	31.9	35.1	2.1	4.5
	December	33.5	31.9	32.5	0.4	0.1
2017	January	33.7	31.9	32.6	0.5	0.2
	February	33.9	31.9	32.7	0.5	0.2
	March	36.4	31.9	33.1	0.8	0.6
	April	39.4	32.3	35.0	1.3	1.6
	May	44.4	34.1	37.9	1.9	3.6
	June	50.2	38.2	43.0	2.3	5.3
	July	54.9	42.5	48.8	2.8	7.7
	August	54.0	42.4	47.5	2.4	5.9

Appendix I. : Stream Discharge

Stream	Location			September 23-26, 2013 discharge (cfs)	August 25-28, 2014 discharge (cfs)	September 8-10, 2016 discharge (cfs)	Drainage area above sensor ($mile^2$)
	Stream mile	Latitude	Longitude				
Blondie Creek	0.1	47.15448	-112.74642		0.2		1.1
Broadus Creek	0.1	47.25802	-112.83232	0.7	1.5		3.3
Camp Creek	0.1	47.18436	-112.86495	0.6	1.4		4.1
Cooney Creek	0.2	47.25838	-112.81576	2.9	6.3		9.2
Dobrota Creek	0.1	47.26740	-112.80669	2.5	6.6		5.5
East Fork North Fork Blackfoot River	0.1	47.19614	-112.88720	28.7	49.1	25.9	65.1
East Fork North Fork Blackfoot River	9.5	47.15280	-112.75679	4.0	7.2		9.0
Effluent channel from Twin Lake (Lost Pony Drainage)	0.1	47.16992	-112.80357	0.3			
Meadow Creek	0.1	47.16247	-112.79532	10.9	17.4		18.8
Mineral Creek	0.3	47.17613	-112.83837	7.7	11.7		14.6
North Fork Blackfoot River	26.8	47.19652	-112.88673	11.1	28.7	12.4*	39.9
North Fork Blackfoot River	34.7	47.26707	-112.80610	1.1	4.9		7.1
Sarbo Creek	0.1	47.23632	-112.86205	0.3	0.6		1.5
Scotty Creek	0.2	47.15450	-112.75726	0.6	2.0		4.2
Sourdough Creek	0.1	47.15248	-112.75678	1.1	2.6		5.0
South Creek	0.1	47.21288	-112.86847		0.4		2.2
Spaulding Creek	0.1	47.17594	-112.82015	0.1	0.2		1.1
Theodore Creek	0.1	47.25334	-112.83464	0.1	0.3		0.9
Un-named trib entering NFBLKFT at mile 27.8	0.1	47.20767	-112.87333	1.6	1.6		1.3

*** Discharge based on an FWP estimate**

Appendix J. Historical Investigations of Fish Stocking in the North Fork Blackfoot River Project Area

by

Ron Pierce, Craig Podner, Lee Nelson, Angela Smith and Taylor Lipscomb

Montana Fish, Wildlife and Parks.

Mark Fritch

Archive Mansfield Library, Archives & Special Collections, University of Montana, Missoula

David Brooks

Montana Trout Unlimited, Missoula, MT

April 2016

Summary

We researched historical files to investigate the possible presence of aboriginal fish and to document past fish stocking practices upstream of the North Fork Falls. We reviewed historical files (newspapers, agency records) from the Montana Historical Society, archives in the Mansfield Library as well as all known relevant records housed in 1) Missoula Montana Fish, Wildlife and Parks (FWP) Regional Headquarters, 2) FWP Helena internal database, 3) FWP Fisheries Library, 4) Washoe Park Trout Hatchery (WPTH), as well as 5) written histories of the Montana Fisheries Division (Alvord 1975, 1991; Zackheim 2005). The WPTH. Montana's first state hatchery, was specifically researched because it provided fish and eggs to waters throughout western Montana, including the Blackfoot Basin.

Our searches of FWP historical files made no mention of the presence/absence of aboriginal fish upstream of the North Fork Falls prior to fish stocking. This lack of documentation may not be surprising given the first formal FWP fish population surveys upstream of the North Fork Falls were completed several decades after fish stocking began. The first documented fish plant in our search occurred in 1926 (Helena Daily Independent, September 15, 1926); whereas, the first lake surveys were completed in 1959 (FWP historical files), and the first stream surveys were completed in 2006 (Appendix A). Like FWP historical records, searches at the Mansfield Library archives found no records of aboriginal fish or early fishing reports from upstream of the North Fork Falls. This Mansfield Library search included collections, catalogs, dissertations and oral stories between 1910 and 1960. Likewise, searches of Montana Historical Society and

scanned newspapers made no mention of fish or fishing prior to stocking programs upstream of the North Fork Falls.

Though records are generally incomplete, historical hatchery records revealed cutthroat trout eggs from Ashley Lake (Flathead drainage), Yellowstone Lake, Lake Tahoe and Lahontan, as well as rainbow trout were at the WPTH between 1908 and 1983. In the early years, the WPTH also produced brook trout, Chinook salmon and grayling. In 1911 alone, the WPTH released >2.6 million *blackspotted cutthroat trout* fry (coded 02, cutthroat trout *undesignated*) from eggs supplied by Yellowstone National Park courtesy of the U. S. Bureau of Fisheries. For decades thereafter, the blackspotted cutthroat trout were often referred to as *natives* in both hatchery records and newspaper accounts. Within a few years of the construction of the WPTH, millions of blackspotted cutthroat trout (eggs and fry) and rainbow trout were widely distributed throughout Montana, including Georgetown Lake, which was a future source of eggs for the WPTH.

Eggs for WPTH were taken from Georgetown Lake cutthroat trout beginning in 1919 and Flint Creek beginning in 1922. During the 1920s and 1930s, an estimated 20 million eggs per year were taken from Georgetown Lake alone. With prior hatchery plant of various strains of cutthroat and rainbow into Georgetown Lake, many of eggs brought into WPTH, and subsequently stocked into streams and lakes, were likely species other than genetically pure westslope cutthroat trout, including Yellowstone Cutthroat trout, rainbow trout and hybrids of all.

The WPTH supplied eggs to the Ovando State Hatchery, which operated during summers from 1921 to 1964; both hatcheries stocked fish (rainbow trout and cutthroat trout) upstream of the North Fork Falls. We found no hatchery records that identify where the Ovando State Hatchery stocked fish between 1921 and 1932, though one article in the Helena Daily Independent (September 15, 1926) reported the Helena Rod and Gun planted 10,000 blackspotted trout in Meadow Creek, Twin Lakes and the North Fork Blackfoot River. Likewise, we found no specific records that identify the subspecies of cutthroat trout that entered the Ovando State Hatchery. However, the WPTH supplied eggs to the Ovando hatchery in years when Yellowstone cutthroat trout eggs were available. In some years, these egg transfers coincide with fish stocking in waters upstream of the North Fork Falls.

In addition to stocking programs promoted by state and federal hatcheries, the USFS promoted the widespread stocking on the Lincoln Ranger District with the assistance of sportsmen's groups (Helena Daily Independent, 11-3-1937). Regardless of pre-existing fisheries, most of the larger streams within the District were stocked, including the North Fork Blackfoot River.

The first documented pure westslope cutthroat trout used in the hatchery system were collected in the Flathead Basin in 1965 - 1967. These fish were held at the Jocko River State Hatchery (Arlee, MT) until 1980, and likely had little bearing on the North Fork because there are records of egg transfers from the Jocho River4 State Hatchery to the WPTH. In 1983, the WPTH developed a genetically unaltered westslope cutthroat trout brood stock, derived from tributaries of the South Fork Flathead River. The only documented plant of genetically unaltered westslope

cutthroat trout stocked upstream of the North Fork Falls occurred in upper Twin Lake in 1988. Fish from this plant did not persist as determined by a 2005 gill net survey that reported upper Twin Lake as fishless.

How fish were planted was also poorly documented, though records show both aircraft and livestock (horses and pack mules) were used to plant fish and to survey lakes upstream of the North Fork Falls. Planes planted fish beginning in 1951 and helicopter plants began in 1960 in western Montana. According to *Fish Stocking and Management Policy of the Fish and Game Department, State of Montana of 1959*, "specific plants in specific waters by airplane shall be allowed when accomplished under the direction of the conservation personnel responsible for the fishery management wherein the fish are to be planted and with the written approval of the Superintendent of Fisheries and the Chief Fisheries Management Biologist of the Montana Fish and Game Department". Though written approvals were not located in our searches, it is possible undocumented aircraft stocking occurred between 1951 and 1959.

Recent genetic tests (2006-2014) of *Oncorhynchus* trout confirm a history of stocking both nonnative rainbow trout and nonnative Yellowstone cutthroat trout upstream of the North Fork Falls. Genetic tests also confirm the widespread presence of westslope cutthroat trout genes upstream of the North Fork Falls. Yet, our review of the historical record remains inconclusive regarding whether the presence of westslope cutthroat trout genes relate to aboriginal fish, hatchery westslope cutthroat trout (hybrids), or both. One sculpin (species unknown) was identified in a survey at mile 26.8 on July 11, 2007 the North Fork upstream of the Falls near the junction with the East Fork. This single sculpin suggests the North Fork upstream of the Falls may not have been historically fishless.

A more detailed summary of all documented histories of fish planting and fish population surveys individual water bodies upstream of the North Fork Falls are described below.

Lower Twin Lake

The Helena Independent Record reported planting of blackspotted cutthroat trout in Twin Lakes in 1926 and 1940. Planting records show lake plants between 1950 and 1952 with 13,584 undifferentiated cutthroat trout from WPTH. There were no comments in historical records confirming how the fish were transported to stock the lake.

Documented in a May 15, 1962 FWP D-J Job Completion Report, Project #: F-12-R-8, Job1. A survey crew packed in by White-Tail Ranch outfitters of Ovando conducted an overnight gill net survey on Lower Twin Lake July 17-18, 1962. Gill net results recovered 7 undifferentiated cutthroat trout caught averaging 11.1 inches in length.

Helicopter survey conducted by FWP biologist Liter Spence on July12, 1968 conducted a 21.5-hour gill net survey caught 54 Yellowstone cutthroat trout averaging 9.3 inches in length and 1 Yellowstone cutthroat trout/ rainbow trout hybrid (13.4 inches in length). Additional comments documented a small inlet spring with spawning potential.

An FWP fisheries survey crew packed in with horses and conducted a 6.5-hour gill net survey July 21, 2005. Gill net results recovered 25 undifferentiated cutthroat trout averaging 12.3 inches in length. Genetic tests (n=25) revealed Yellowstone trout x westslope cutthroat trout x rainbow trout hybrids.

Upper Twin Lake

The Helena Independent Record reported planting of blackspotted cutthroat trout in Twin Lakes in 1926 and 1940.

Documented in a May 15, 1962 FWP D-J Job Completion Report, Project #: F-12-R-8, Job I. A survey crew packed in by White-Tail Ranch outfitters of Ovando, conducted an overnight gill net survey on Upper Twin Lake July 17-18, 1962. Gill net results recovered 17 undifferentiated cutthroat trout caught averaging 15 inches in length.

Helicopter survey conducted by FWP biologist Liter Spence on July 12, 1968 conducted a 21-hour gill net survey caught no fish. Additional comments documented that a winter kill was observed by Warren Ensign District Ranger in Lincoln, MT as reported by Cecil Garland.

"Pre-wilderness stocking aerial stocking precedents for wilderness lakes in Montana" documented that Upper Twin Lake, lake adjacent to Lower Twin Lake, in 1969 was stocked by aircraft with 990 Yellowstone cutthroat trout from the Yellowstone River Trout Hatchery.

FWP regional fish planting report for 1988 and 1989 recovered Upper Twin Lake being planted, as a requested FWP biologist Wayne Hadley, with 3,990 westslope cutthroat trout in 1988 and 4,000 in 1989 from the Washoe Park Trout Hatchery. Lake stocking was completed using horses.

An FWP fisheries crew packed in with horses and conducted a gill net survey on June 20-21, 2005. The survey found no fish in upper Twin Lake.

Meadow Lake

There are no fish planting records for Meadow Lake. However, the Helena Rod and Gun Club planted Meadow Creek as early as the 1920s (Helena Daily Independent 9-26-1926) and outfitters planted the Meadow Lake with fish brought up from below the North Fork Falls into Meadow Creek in the 1940s and 1950s (Smoke Elser, wilderness outfitter, personal communication). Because Meadow Lake connects with Meadow Creek, past stocking of Meadow Creek likely influenced Meadow Lake (*see* Meadow Creek section).

Documented in a May 15, 1962 FWP D-J Job Completion Report, Project # F-12-R-8, Job 1, Ralph W. Boland and a survey crew packed in by White-Tail Ranch outfitters of Ovando, MT conducted an overnight gill net survey on Meadow Lake July 15-16, 1962. Gill net results recovered 17 rainbow trout (*Salmo gairdneri*) caught averaging 10.9 inches in length.

Helicopter survey conducted by FWP biologist Liter Spence on July 12, 1968 conducted a 12.5-hour gill net survey recovered a sample size of 32 fish, 30 fish showed characteristics of Yellowstone cutthroat trout x rainbow trout hybrids. These fish averaged 11.2 inches in length.

A gill net survey of Meadow Lake conducted by FWP biologist Wayne Hadley Aug 19-20, 1986 found no fish.

An FWP fisheries crew packed in with horses, conducted a gill net survey on June 21-22, 2005 and recovered no fish. However, the same survey crew caught three fish by angling. Genetic tests identified these three fish as westslope cutthroat trout x rainbow trout hybrids.

A Meadow Lake creel census conducted on five fishermen in 1963 reported 25 undifferentiated cutthroat trout averaging 10 inches in length over a period of 65 hours of angling.

Parker Lake

Fish planting records show that the only time Parker Lake was stocked was between 1942 and 1952 with 53,157 undifferentiated cutthroat trout from the Ovando Trout Hatchery during the 1940s and Washoe Park Trout Hatchery in the 1950s. Fish planting records do not comment on how the fish were taken to the lake.

A gill net survey was conducted by A. N. Whitney; Aug 20-21, 1959 recovered sample size of 58 cutthroat trout with an average length of 11 inches. Helicopter survey conducted by FWP biologist Liter Spence on July13, 1968 conducted a 20.5-hour gill net survey caught 58 Yellowstone cutthroat trout averaging 9.1 inches in length. FWP biologist Wayne Hadley conducted a gillnet survey August 18-19, 1986 recovered a sample of 19 Yellowstone cutthroat trout averaging 9.2 in length.

An FWP fisheries crew packed in with horses and conducted an 18hr gill net survey July 20-21, 2005. Gill net results recovered 46 Yellowstone cutthroat trout averaging 10.6 inches in length. Genetic test (n=26) identified Yellowstone trout x westslope cutthroat trout x rainbow trout hybrids.

Three different creel censuses were conducted on Parker Lake in 1949, 1958 and 1962. A 1949 census of four fishermen recovered two rainbow trout averaging 18 inches in length over 12 hours of angling produced a catch rate of 0.17fish/hour. A 1958 census recovered two fishermen caught five undifferentiated cutthroat trout averaging 9.0 inches in length during the hours of angling producing a catch rate 1.7fish/hour. A 1962 creel census conducted on one fishermen angling for 0.5 hours recording no catch.

The only Statewide angling pressure estimates documented in the entire the upper North Fork Blackfoot River upstream of the North Fork Falls between 2005 and 2013 occurred on Parker Lake in 2007. Results from 2007 estimate total pressure of 115 $\pm$ 115 angler days over two trips and an angler satisfaction rating of 4 on a scale of 1 (poor) to 5 (excellent).

North Fork Blackfoot River upstream of the North Fork Falls

No agency fish planting records were found for the upper North Fork Blackfoot River upstream of the North Fork Falls. However, the Helena Daily Independent Record on 9-15-1926 reported the planting of 10,000 *blackspotted cutthroat trout* by the Helena Rod and Gun Club in Meadow Creek, Twin Creek and the North Fork of the Blackfoot River. The Helena Daily Independent Record also reported the U.S. Forest Service, Lincoln Ranger District planted 35,000 natives in the North Fork Blackfoot River in conjunction with other Lincoln District plants. All Fish and Game historical files (1932-1992) show that all fish planting only occurred on the lower North Fork Blackfoot River downstream of the Falls, though the exact locations where fish were released were not documented.

In 2007, FWP surveyed fish populations in the North Fork Blackfoot River upstream of the Falls for the first time. These surveys were completed at stream miles 26.8, 32.0 and 34.7. Genetic test from 12 of 64 *Oncorhynchus* trout collected from these locations identify these fish as rainbow trout x Yellowstone cutthroat trout x westslope cutthroat trout hybrids.

One sculpin (species unknown) was identified in a survey at mile 26.8 on July 11, 2007. The fish suggest the North Fork upstream of the Falls was not historically fishless. Additional survey targeting sculpins in 2015 and 2016 failed to collect sculpins.

Creel censuses were conducted on the North Fork Blackfoot River in 1948-1949, 1953, 1956-1964; however, census locations were not specific enough to determine if any censuses were conducted upstream of the North Fork Falls.

Meadow Creek

Stocking history and surveys

Meadow Creek was stocked every two years between 1932 and 1952 with undifferentiated cutthroat trout. Over this 20-year period, records indicate a total of 405,654 cutthroat trout from Ovando Hatchery and 160,906 cutthroat trout from Washoe Park Hatchery were stocked in Meadow Creek. In 1937 and 1945, a total of 29,280 rainbow trout were also planted. Historical records do not mention how fish were transported to Meadow Creek. In addition, the Helena Daily Independent (9-29-1940) mentioned the Helena Fish and Game Association planted the East Fork of Meadow Creek with an unidentified number of “natives” in the summer of 1940.

Three different creel censuses were conducted on Meadow Creek in 1949, 1956 and 1964. Two separate censuses conducted from August 10 – 13, 1949 and August 22 – 25, 1949 recovered a total of seven fishermen angling for 43 hours caught 18 rainbow trout averaging 15 inches in length, plus 52 undifferentiated cutthroat trout averaging 14.2 inches in length. A 1956 census reported four fishermen caught 16 rainbow trout averaging 12.5 inches in length and 12 undifferentiated cutthroat trout averaging 11.7 inches in length during six hours of angling. A 1964 creel census on Meadow Creek recovered one fisherman angling for two hours caught eight undifferentiated cutthroat trout averaging 7.0 inches in length.

In 2008, FWP, for the first time, conducted fish population surveys throughout the Meadow Creek drainage and resurveyed two locations again in 2013. Genetic testing in 2008 (n=12 fish) and 2013 (n=9 fish) identified rainbow trout x Yellowstone cutthroat trout x westslope cutthroat trout hybrids with a substantial genetic contribution from rainbow trout.

East Fork of North Fork Blackfoot River

Stocking history and surveys

Planting records show the East Fork was planted in 1940, 1942 and 1943 with a total of 23,224 undifferentiated cutthroat trout from the Ovando Trout Hatchery. The Helena Independent Record noted in 1940 alone that 22,000 "natives" were planted on the East Fork. Agency records fish plants occurred again in 1950 with two plants totaling 10,800 and in1952 with two plants totaling 6,864 undifferentiated cutthroat trout from Washoe Park Hatchery. No comments in historical records describe how the fish were transported into the East Fork of the North Fork.

Historical records show a creel census in 1956 reported two anglers fishing the East Fork caught three rainbow trout averaging 7 inches in length and six cutthroat trout averaging 7 inches in length during one hour of angling.

FWP fish population surveys were conducted on the East Fork at four locations (stream miles 1.9, 7.0, 9.0 and 11.7) in 2006 and 2013. Survey at stream mile 11.7 produced no fish. Genetic samples collected in 2006 at mile 7.0 (n=4) and from 2013 survey at miles 1.9 and 9.0 (n=20) identified rainbow trout x Yellowstone cutthroat trout x westslope cutthroat trout hybrids.

Cooney Creek

Stocking history and surveys

Historical planting records show Cooney Creek was planted once in September 1941 with 20,160 rainbow trout from the Ovando Trout Hatchery and once in September 1950 with 3,600 undifferentiated cutthroat trout from the Washoe Park Trout Hatchery. Records do not identify how these fish were transported to Cooney Creek.

No historical records were found regarding creel census work or fish population surveys on Cooney Creek prior to 2007.

In 2007, FWP conducted a fish population survey at stream mile 0.2 on Cooney Creek. Only one fish was found. Genetic testing identified that fish as a non-hybridized westslope cutthroat trout. In 2013 additional surveys conducted at miles 0.2, 0.4 and 2.4 collected genetic samples from eight additional fish. Genetic testing (n=8) identified these fish as rainbow trout x Yellowstone cutthroat trout x westslope cutthroat trout hybrids.

Scotty Creek

Stocking history and surveys

Historical planting records show Scotty Creek was planted September 12, 1943 with 3,000 undifferentiated cutthroat trout and again on August 20, 1948 with 2,000 undifferentiated cutthroat trout from the Ovando Trout Hatchery. No additional comments from the historical records identify how the fish were transported to Scotty Creek.

FWP conducted the first fish population survey on Scotty Creek at mile 0.2 in 2006. This sample phenotypically identified 42 rainbow trout and 1 cutthroat trout. Genetic testing (n=5) showed rainbow trout x Yellowstone cutthroat trout x westslope cutthroat trout hybrids. In 2013 a re-survey at stream 0.2 was conducted on Scotty Creek. This survey collected additional genetic samples (n=35) that are currently stored at the FWP Missoula office.

There are no records of historical creel surveys for Scotty Creek.

Historical Reports

Alvord. W. 1975. History of Fisheries Management in Montana (1900 – 1975). Montana Fish and Game publication.

Alvord., B. 1991. A history of Montana's Fisheries Division from 1889 to 1958. Montana Fish, Wildlife and Parks Helena, Montana.

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Appendix K. Assessment of Bull Trout Translocation Feasibility Upstream of the North Fork Falls, Blackfoot River Subbasin, Montana

by

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Introduction

Bull trout (*Salvelinus confluentus*), *a threatened* species under the Endangered Species Act (USFWS 2010), is an obligate cold-water char native to high country of western North America. Though actions to recover bull trout have been ongoing for over two decades, many populations continue to decline, including spawning populations in the lower Blackfoot River watershed (Pierce et al. 2016). In addition to a legacy of ongoing impacts such as overgrazing, excessive timber harvest and road building, future threats now involve climate warming and the projected up-valley contraction of bull trout habitat as a routine outcome of warmer stream temperatures and modified runoff regimes (Isaak et al. 2015). Corresponding with this warming, and already documented as underway, is the range expansion of exotic competitors such as brown trout (Al-Chokhachy et al. 2015). With current declines and future threats in mind, meaningful opportunities to recover bull trout are becoming increasingly rare and urgent and are generally limited to the higher elevations where summer water temperatures are projected to remain cold and suitable for bull trout into the foreseeable future (Isaak et al. 2015).

Translocations are a common activity in species conservation (Seddon et al. 2007), though few examples of translocations are documented for bull trout as the prioritization on recovery of this

species by fisheries managers has been very recent (Barry et al. 2014). Even fewer, if any, translocations with successful reproduction have been documented. To improve the chances for successful bull trout translocation, Dunham et al. (2011) developed a simple and transparent framework for assessing the feasibility of proposed bull trout translocation projects based on a case study in the Clackamas River. This tiered framework qualitatively scores potential projects on an overall scale between +1.0 and -1.0 and relies heavily on the presence and persistence of suitable coldwater habitat for spawning and rearing. In this study, we applied the Dunham et al. (2011) methodology (*hereafter* Clackamas framework) to assess the feasibility of a successful bull trout translocation in the North Fork Blackfoot River upstream of the Falls, using bull trout from below the Falls as a potential donor population.

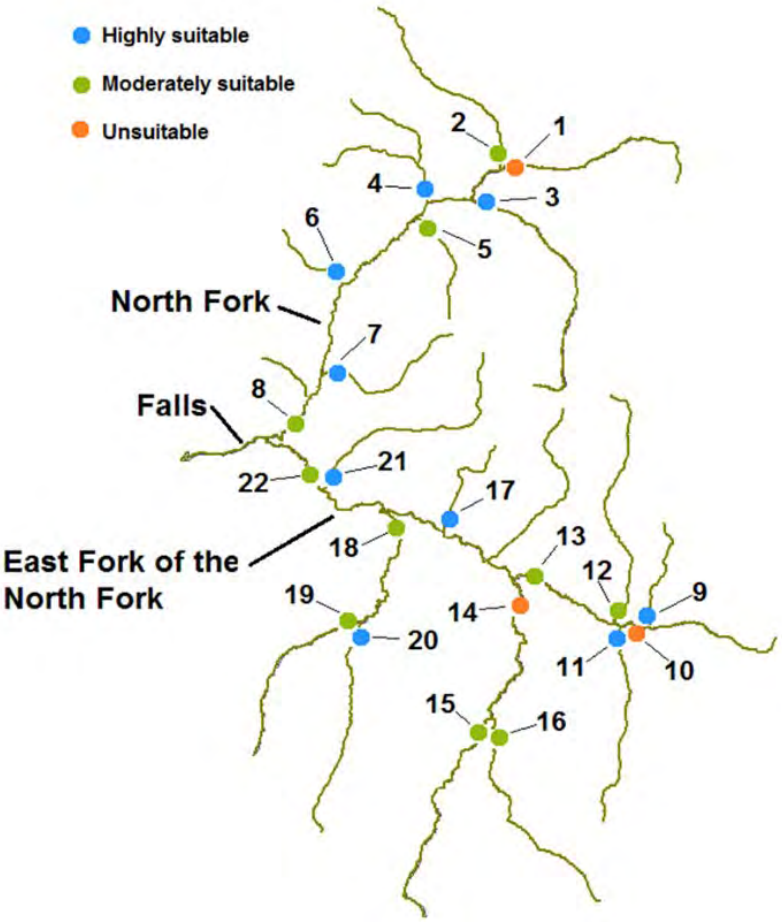

Figure 1: Study area showing temperature monitoring sites and the classification of temperature-related habitat suitability. Numbered monitoring sites reference temperature results in Table 1.

Study area

The study area upstream of the North Fork Falls spans a 110 mile^2 4th order drainage, which includes portions of the Lolo National Forest on the western side of the drainage and the Helena National Forest on the eastern side of the drainage. The entire study area falls within the Scapegoat Wilderness.

In addition to the mainstem of North Fork Blackfoot River and the mainstem East Fork of the North Fork, there are sixteen additional (smaller) headwater tributaries upstream of the North Fork Falls, which together form about an 85-mile network of perennial streams (Figure 1). These streams drain the highest mountain peaks of the Blackfoot Basin and flow though alpine meadows, subalpine forest and montane woodlands, while coursing through landforms ranging from glacial cirques to glacial trough and morainal valleys. Though the proposed project area is prone to natural disturbance (wildfire), there are minimal anthropogenic habitat disturbances. In addition, these headwater streams are considered less prone to thermal enrichment because of climate warming

(Isaak et al. 2015), which more directly threatens the low-elevation bull trout stocks throughout the Blackfoot River basin. These predicted losses of major portions of suitable habitat for the North Fork bull trout by 2040 (Isaak et al. 2015) and the expected ongoing decline in down-valley bull populations in the Blackfoot River core area provide strong biological justification for the proposed translocation concept.

The stream system upstream of the North Fork Falls currently supports *Oncorhynchus* hybrid trout as the only salmonid along with the incidental presence of an unidentified species of sculpin. The stream system contains no other competing salmonid species (e.g., brook or brown trout). Fish-bearing streams and lakes throughout the project area are being considered for a possible rotenone treatment to eliminate the hybrid trout, followed by restocking with nearby sourced native westslope cutthroat trout and bull trout. Both are coadapted, sympatric and widespread within the adjacent Bob Marshall Wilderness Complex (South Fork Flathead), and in the Blackfoot River watershed, including waters downstream of the North Fork Falls. Though bull trout are present and relatively abundant downstream of the Falls, fish populations surveys have failed to detect bull trout upstream of the North Fork Falls. Furthermore, there is no current evidence bull trout were historically present upstream of the Falls.

Methods

To assess the feasibility of a possible bull trout translocation, we identified 1) the potential of the recipient habitat, and 2) the potential of an available donor population for a successful bull trout translocation following the Clackamas framework. To assess the recipient habitat, we generated 5 types of tiered information in response to feasibility questions. These questions are: 1) Was the recipient habitat historically occupied? 2) Are bull trout unlikely to be present now in the recipient habitat? 3) Is the recipient habitat suitable for bull trout spawning and rearing? 4) Have past, present and potential future threats in the recipient habitat been sufficiently mitigated? and 5) Is (re)colonization unlikely to occur in the short-term? In addition, two donor population questions were answered: 1) Is there a donor stock that is an evolutionary match for the recipient habitat? And, if so, 2) Are there enough propagules available without risking the health of the donor population? To identify a cumulative feasibility score under the Clackamas framework, most responses are scored on a scale between +1.0 and -1.0. Scores for each question under the recipient habitat and donor population were averaged for a tier 2 score. The two scores were then averaged to generate a final tier 3 feasibility score.

Four of the five questions associated with the recipient habitat (1,2,4,5) are generally qualitative and easily answered from baseline fisheries studies or study area characteristics (Pierce et al. 2017). The two donor population questions were answered by genetic and life history studies of the North Fork bull trout population (Pierce et al 2016; Swanberg 1997). Thus, the primary

quantitative exercise of this feasibility study was to examine habitat suitability with water temperature data specific to the study area.

To identify suitability of the recipient habitat with water temperature (question #3), we compiled water temperature data for all 22 monitoring sites in the proposed project area (Figure 1). Data were derived from continuous water temperature sensors (Onset Computer Corporation, Pocasset, Massachusetts; accuracy = 0.2^{o}C), programmed at 50-minute intervals, and deployed between 10 July 2013 and 9 September 2016. Following the Clackamas framework, we calculated instantaneous daily maximum water temperatures for the known bull trout spawning period (10 September to 30 September 2013, 2014 and 2015), as well as summer rearing period (1 July through 31 August 2013, 2014 and 2015). We did not include 2016 temperature data because we did not have comparative September data for the July/August dataset.

For identification of spawning and rearing suitability, we classified the temperature data into three suitability classes (highly suitable, moderately suitable and unsuitable) as a function of temperature thresholds specific to bull trout as reported in the Clackamas framework. Threshold values for the spawning season were maximum daily water temperatures of $\leq$ or > 9°C. Threshold values for summer rearing temperatures were classified by $\leq$ and > 16°C. To calculate spawning season suitability and summer rearing suitability over the three-year data collection period, we first calculated mean daily maximum water temperatures (and range) for 2013, 2014 and 2015 spawning and rearing periods respectively, then calculated a grand mean for all three years of data. Grand mean values were used to group the data into the three classes of habitat suitability, whereby 1) highly suitable spawning habitat had maximum daily temperatures $\leq$9°C and rearing temperatures $\leq$16°C, 2) moderately suitability temperatures had >9°C spawning season temperatures and $\leq$16°C summer rearing temperatures, and 3) unsuitable temperatures had summer rearing temperatures >16°C.

Results/Discussion

Tier 1 framework scoring – To assess the recipient habitat and donor populations, we scored a total of seven feasibility questions. The five questions, scores and rationale related to the recipient habitat are as follows:

> 1) *Was the recipient habitat historically occupied*? Fish populations surveys at 43 sites upstream of the North Fork Falls failed to identify presence of bull trout. Likewise, fish populations surveys in adjoining drainages upstream of similar barrier falls (Monture and the Landers Fork) reveal no evidence of bull trout presence. Lacking evidence of bull trout presence and absent historical information, following the Clackamas framework we provided a score of 0.

2) *Are bull trout unlikely to be present now in the recipient habitat*? Because the Clackamas framework asserts that a translocation should not proceed if there is reasonable certainty that the species in question is already present in the recipient habitat, we provided a score +1.0. This positive score reflects reasonable certainty no bull trout occur upstream of the Falls, and that no existing bull trout population will be adversely affected by a translocation.

3) *Is the recipient habitat suitable for bull trout spawning and rearing?* For this question, we compiled temperature data and developed thermal habitat suitability classification for all streams in the proposed project area (Figure 1, Table 1). This exercise identified 19 off 22 sites (86%) with moderate (n=10) to high (n=9) suitability for bull trout, and only three sites thermally unsuitable during the spawning and rearing periods. Interestingly, two of three unsuitable location were among the highest sites in terms of elevation. One site on the East Fork (#10 on Figure 1) is located downstream of Parker Lake, which drains warm water from the lake surface during the summer rearing period. One site on the upper North Fork (#1) has very little up-valley vegetative cover due to intensity of past wildfire. The third site on lower Meadow Creek (#14) is in a wide and shallow, low gradient channel downstream of beaver/wetland complex. Given the overall thermal suitability and interconnected status of the recipient habitat, we gave the recipient habitat a score of +0.75.

4) *Have past, present and potential future threats in the recipient habitat been sufficiently mitigated?* As designated Wilderness, there are no immediate anthropogenic habitat limitations that can be mitigated on site. Climate change is considered a broadscale long-term threat; however, climate projections point to the persistence of large patches of thermally suitable habitat upstream of the North Fork Falls in 2040 and beyond (Isaak et al. 2015). The Clackamas framework makes no mention of climate change threats but emphasizes the presence of cold water. Consistent with this framework, we scored the question with a value of +1.0 because the threats to bull trout based on climate projections are not unique or specific to this landscape (Isaak et al. 2015). Indeed, this protected region is projected to be one of the more resilient landscapes within the range of the species in the Columbia Headwaters Recovery Unit.

Table 8; Temperature summary for the 2013-2015 spawning and rearing periods and related habitat suitability classifications for 22 temperature data collection sites. Classifications are colored by high suitability (blue), moderate suitability (green) and unsuitable (orange). Stream ID relates to monitoring sites and classification mapping on Figure 1.

July 1 to August 31: bull trout summer rearing period						September 10 to September 30: bull trout spawning period				Recipient habitat suitability		
Stream name	Stream ID	2013	2014	2015	Grand mean summer	2013	2014	2015	Grand mean spawning	Highly suitable (≥9 and ≤16)	Moderately suitable (>9 and ≤16)	Unsuitable (>16 summer)
North Fork Streams		mean (range)°C				mean (range)°C						
NF Blackfoot River (Mile 34.7)	1	19(15 - 22)	15(9 - 18)	17(12 - 20)	17	11(6 - 17)	10(7 - 13)	11(8 - 16)	10.7			Unsuitable
Dobrota Creek	2	13(7 - 16)	11(7 - 13)	12(8 - 16)	12	9(4 - 15)	9(6 - 12)	11(7 - 13)	9.7		v	
Cooney Creek	3	11(9 - 12)	10(7 - 11)	11(8 - 13)	10.7	8(4 - 10)	7(5 - 8)	8(6 - 9)	7.7	v		
Broadus Creek (mile 0.1)	4	13(10 - 15)	12(8 - 15)	13(10 - 16)	12.7	9(4 - 13)	8(5 - 11)	9(6 - 11)	8.7	v		
Theodore Creek (Mile 0.1)	5	13(10 - 15)	11(8 - 13)	13(10 - 15)	12	9(4 - 14)	8(5 - 11)	9(7 - 11)	9.6		v	
Sarbo Creek (Mile 0.1)	6	12(9 - 14)	11(7 - 13)	11(9 - 13)	11.3	8(4 - 12)	8(5 - 10)	8(6 - 10)	8	Y		
South Creek (Mile 0.1)	7	13(11 - 15)	12(9 - 14)	12(11 - 15)	12.3	9(5 - 13)	8(6 - 11)	9(8 - 11)	8.7	Y		
NF Blackfoot River (Mile 27)	8	16(11 - 18)	13(9 - 17)	15(11 - 18)	14.7	10(5 - 15)	10(7 - 13)	11(8 - 14)	10.3		v	
East Fork of the North Fork Streams												
Blondie Creek (mile 0.1)	9	13(11 -15)	12(8 - 13)	13(10 - 15)	12.3	9(5 - 13)	9(6 - 11)	10(7 - 12)	9.3	Y		
EF of NF Blackfoot River (mile 0.4)	10	20(15 - 23)	19(13 - 22)	17(13 - 23)	18.7	11(5 - 17)	12(6 - 15)	11(8 - 14)	11.3			Unsuitable
Sourdough Creek (Mile 0.1)	11	11(8 - 13)	9(7 - 11)	10(7 - 12)	10	9(5 - 11)	9(6 - 10)	9(7 - 11)	9	Y		
Scotty Creek (Mile 0.2)	12	14(11 - 16)	13(9 - 16)	13(11 - 16)	13.3	10(6 - 13)	9(7 - 11)	10(8 - 12)	9.7		v	
EF of NF Blackfoot River (mile 7.0)	13	16(11 - 18)	14(10 - 17)	15(12 - 18)	15	11(7 - 15)	11(7 - 13)	12(8 - 14)	11.3		v	
Meadow Creek (Mile 1.4)	14	18(13 - 21)	15(10 - 18)	18(13 - 21)	17	13(5 - 19)	13(8 - 15)	15(10 - 18)	13.7			Unsuitable
Meadow Creek (Mile 4.7)(Mile 5.3)	15	14(10 - 16)	10(8 - 12)	14(10 - 17)	12.7	11(8 - 16)	9(6 - 11)	10(7 - 12)	10		v	
EF Meadow Creek (Mile 0.1)(Mile 0.9	16	15(10 - 17)	10(7 - 12)	16(10 - 21)	13	8(5 - 12)	10(6 - 14)	12(7 - 14)	10		v	
Spaulding Creek (Mile 0.1)	17	12(9 - 14)	11(8 - 13)	12(10 - 14)	11.7	8(5 - 11)	8(7 - 10)	8(7 - 10)	8	Y		
Mineral Creek (Mile 0.3)	18	16(11 - 17)	14(9 - 13)	15(11 - 18)	15	11(7 - 15)	11(7 - 13)	12(8 - 15)	11.3		v	
Mineral Creek (Mile 3.6)	19	16(12 - 18)	14(10 - 16)	14(10 - 17)	14.7	10(5 - 15)	10(7 - 13)	9(7 - 11)	9.6		v	
EF Mineral Creek (mile 0.1)	20	13(10 - 15)	10(4 - 13)	13(10 - 15)	12	9(4 - 13)	9(7 - 11)	9(7 - 13)	9	Y		
Camp Creek (mile 0.1)	21	12(10 - 13)	11(8 - 13)	12(9 - 13)	11.7	9(5 - 12)	9(7 - 11)	9(7 - 11)	9	v		
EF of NF Blackfoot River (mile 1.7)	22	16(12 - 18)	12(9 - 15)	13(10 - 13)	13.3	10(6 - 14)	10(7 - 12)	10(8 - 12)	10		v	

5) *Is (re)colonization unlikely to occur in the short-term?* Under the Clackamas framework, if natural recolonization is likely to occur for a recipient habitat, then a reintroduction effort may not be warranted. Because the North Fork Falls makes (re)colonization impossible, we gave this a score of +1.0.

To specifically assess the donor population, we scored two feasibility questions. The questions, scores and related rational are as follows:

1) I*s there a donor stock that is an evolutionary match for the recipient habitat?* Genetic studies have determined the North Fork bull trout population downstream of the Falls can be differentiated genetically from other bull trout stocks in the Blackfoot Basin (*see* Robb Leary Report *in* Pierce et al. 2016). The selection of the existing North Fork stock is the ideal donor because it is genetically consistent with the existing North Fork stock should any downstream emigrants traverse the Falls. Furthermore, part of the rationale for this translocation is to provide a genetic refugium to ensure that the North Fork stock is perpetuated, should the bull trout population downstream of the Falls eventually fail (Isaak et al. 2015). Though the North Fork stock has a known migratory behavioral trait (Pierce et al. 2016; Swanberg 1997), the 85 miles of available connected and complex habitat appears to be ample space for the replication of the migratory life history form in a somewhat more limited basin. While we acknowledge some inherent uncertainty,

it is difficult to provide a better evolutionary match than a donor stock from the same watershed. Because the project would use the exact evolutionary lineage, we scored this a +1.0.

2) *Are there enough propagules available without risking the health of the donor population?* In this case, our scoring methods differed from that of Dunham et al. (2011). The Clackamas framework subjectively provided only two class values (+1.0 and -1.0) with unrealistically high numbers adult fish (<1000 and >1000) from which to gage adverse donor effects. That is because the Clackamas framework was designed to apply at a more metapopulation and watershed-based scale (e.g., transfer from the Metolius River to the Clackamas River).

Based on a North Fork redd count of 118 in 2016, the North adult spawning population was estimated 375 fish (i. e., 3.2 fish/redd), which does not include non-spawning adults or subadult bull trout. This is one of the more robust populations within the range of the Columbia Headwaters Recovery Unit. Though the number of propagules for the project has yet to be determined, the project currently plans to collect eggs and milt from wild fish and outplant the progeny, versus transfer live fish from the North Fork. This further reduces the potential for unwanted transfer of nontarget organisms and increases the availability of larger numbers.

The project anticipates collecting fewer than 10,000 eggs per year from a handful of females, for a period of up to three years. This number of eggs roughly equals the production of two typical 5 lb adult fluvial female fish (calculated from 1,000 eggs per pound of fish). That equates to about 1-2% of the estimated annual female egg production for the North Fork. With current experience and based on existing incubation success using wild fish at Creston National Fish Hatchery, we anticipate very high (>90%) egg survival. This compares to much lower average survival at emergence (<36%) in spawning tributaries of the Blackfoot River due to natural sediment-induced mortality (Pierce and Podner 2006) or other factors such as incomplete fertilization, which can create less than ideal outcomes for wild fish. The anticipated methods are intended to temporarily boost survival in a controlled incubation environment over the short term to maximize numbers and to foster natural selection by quickly outplanting age 0 progeny into the wild. Thus, we conclude the North Fork Project would minimize impacts to the donor population. Based on these methods, calculated risks to the donor population are considered biologically insignificant. Because some impact is arguably possible, we conservatively scored this question at +0.75.

For this feasibility study, the tier 1 scoring generated an average tier 2 score of +0.75 for the recipient habitat and an average score of +0.87 for the donor population. Thus, the final tier 3 feasibility score was +0.81 (Figure 2). This overall positive score indicates a high likelihood of success if the project is implemented as envisioned.

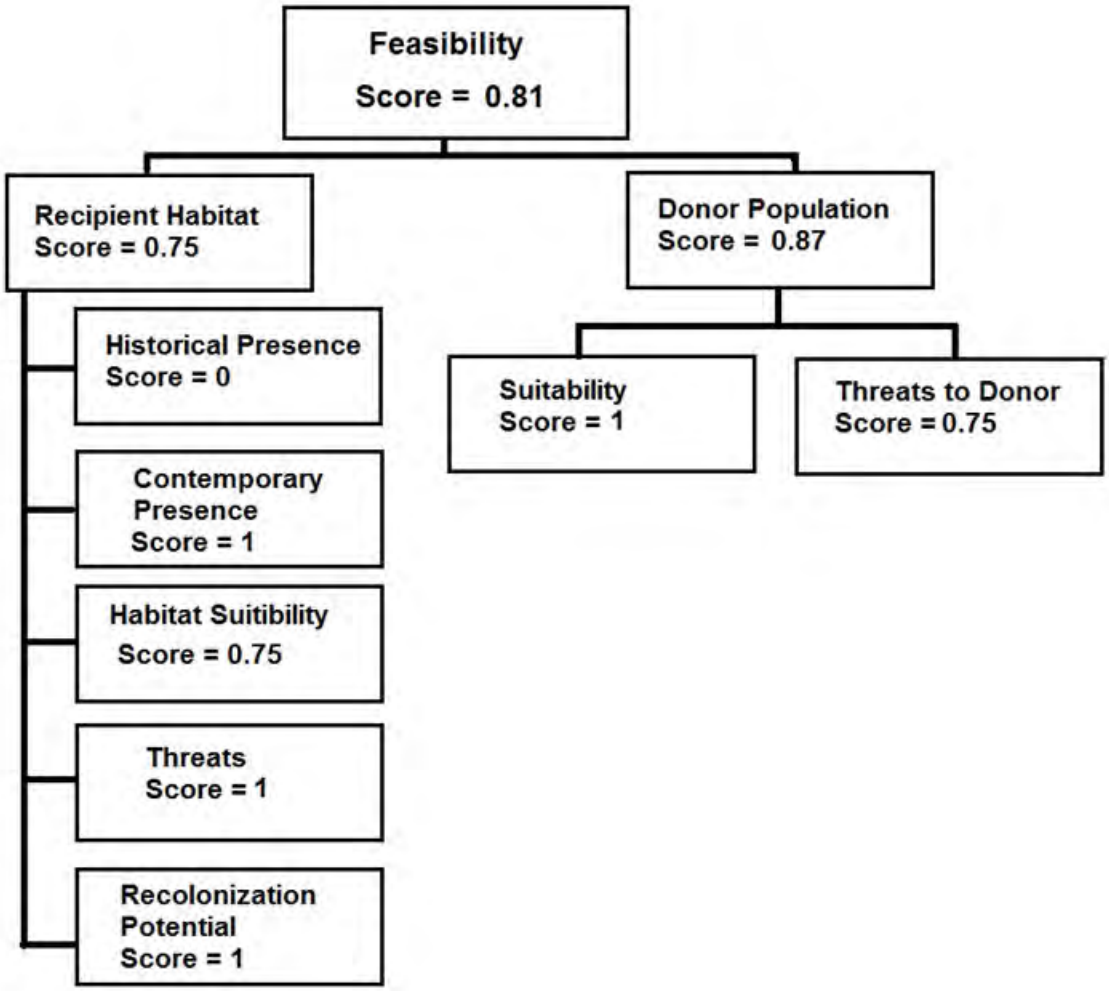

Figure 2. North Fork flowchart showing the scoring for three tiers of the feasibility assessment. The final feasibility score of 0.81 indicate a high level of potential success for a possible bull trout translocation.

In the case of the North Fork upstream of the Falls, it is important to again note the Clackamas framework and the final feasibility score is based largely on metapopulation structure and does not wholly reflect conditions relative to successful bull trout translocation at a smaller scale. For example, the large patch of suitable habitat upstream of the North Fork Falls (110 mile^2 drainage) is larger than watersheds occupied by local populations of bull trout elsewhere in the Blackfoot Core area, in Copper Creek (41 mile^2 drainage), Poorman Creek (43 mile^2 drainage), Gold Creek (63 mile^2 drainage) and Belmont Creek (30 mile^2 drainage), each of which are considered occupied bull trout patches with a known history of ostensibly thousands of years of successful reproduction. Additional key habitat features incorporate major elements of habitat diversity; including groundwater upwelling in potential spawning areas, cold areas providing summer refugia, seasonally productive (warmer water) lakes, beaver complexes generating suitable winter conditions, thermal refugia from drought, and areas of more concentrated seasonal forage. Lastly, the absence of competing nonnative fish species greatly elevate the suitability of upper North Fork for a successful translocation.

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Jason Dunham and Dan Shively who helped develop the Clackamas framework reviewed our report, provided comment and support of our findings.

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Appendix L.: Piscicide Implementation Plan

Native Fish Conservation in the North Fork Blackfoot River Watershed

Piscicide Implementation Plan

January 2018

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1 Introduction

This document describes the methods and equipment necessary for efficient and effective removal of nonnative fish from the North Fork Blackfoot River native fish conservation project area, within the Scapegoat Wilderness (Figure 1-1). A 50-ft high waterfall, known locally as the North Fork Falls, provides a barrier preventing reinvasion of nonnative fishes into the project area. Currently, the project area supports Rainbow Trout × Cutthroat Trout hybrids, with Rainbow Trout providing the predominant genetic contribution.

The project area is an ideal location for conservation of native Westslope Cutthroat Trout (WCT) and Bull Trout, as it provides an estimated 45 miles of interconnected, fish-bearing stream habitat, and 3 connected lakes. The spatial extent, variety of habitat types, and high elevation will allow for large populations, gene flow, expression of migratory life-history strategies, and a cold thermal regime. Combined, these factors will promote the persistence of WCT and Bull Trout in an area that is likely to provide cold water refugia and resiliency to climate change (Isaak et al. 2015).

The proposed action is a native species conservation project with 3 goals:

- Eliminate a source of nonnative genes to the Blackfoot River watershed.
- Reestablish a population of WCT in the project area with less than 1% genetic admixture with nonnative trout.
- Establish a population of Bull Trout in the project area.

Accomplishing the goal of nonhybridized to slightly hybridized WCT will require eradicating, or substantially suppressing, the existing fish population, followed by restocking of native trout. Given the spatial extent and complexity of the habitat within the project area, this level of removal will be challenging. This document provides the strategy to maximize the removal of the existing fish populations, which is one component of meeting the genetic goal for WCT. Moreover, the large number of fish that will be restocked into the project area will vastly outnumber any remaining fish. This technique will genetically and competitively overwhelm the sparse remaining hybridized fish, if any, which will further diminish their genetic contributions.

The strategy to select donor sources of WCT that addresses genetics, fish health, propagation and effects on potential populations is being addressed under a separate plan (Shepard et al. draft). Selection of donor sources and determination of propagation of Bull Trout for introduction will follow consultation with the U.S. Fish and Wildlife Service.

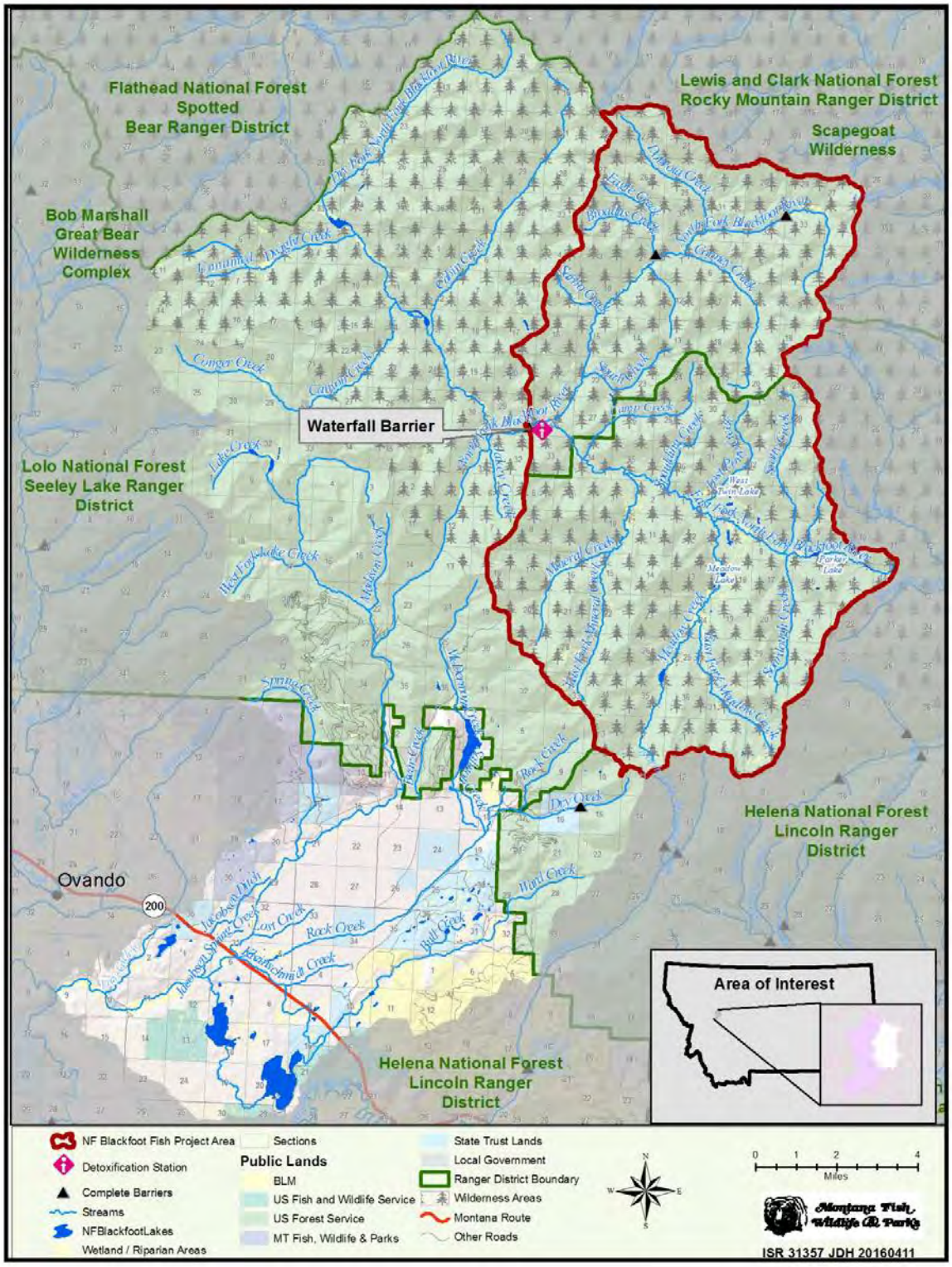

Figure 1-1. Map of the North Fork Blackfoot River watershed, detailing the project area upstream of the barrier falls.

2 Procedures

2.1 *Pre-Project Planning*

Pre-project planning comprises the initial steps needed to define the project area and develop a conceptual approach to guide the next phases. Several of these tasks have been completed, and a description of findings is included in the narrative.

Barrier Identification

Reclaiming streams for native species requires assurance that nonnative fishes cannot reinvade the project area. Ideally, a natural feature, such as a waterfall, is present that prevents upstream movement of fish. In some cases, humans have unintentionally installed a barrier that protects the project area from reinvasion. Perched culverts or irrigation diversions are typical structures that can prevent reinvasion into reclaimed waters. In other cases, a barrier must be constructed, often at considerable cost. Fortunately, an existing waterfall within the Scapegoat Wilderness provides a natural barrier that will protect the project area from reinvasion of nonnative fishes (Figure 1-1 and Figure 2-1).

Figure 2-1. Barrier waterfall at downstream end of the project area.

Deactivation Station

FWP's piscicide application protocol (FWP 2017) requires deactivation of rotenone near or at the downstream end of the project area. Potassium permanganate ($KMnO_4$) is a strong oxidizer and degrades rotenone within ½ hour of stream contact time. The proposed location selected for this procedure is 0.5 miles upstream of the barrier falls, and immediately downstream of the junction of the East Fork of the North Fork and North Fork of the Blackfoot River. The volume of water to be deactivated will require a power volumetric feeder to dispense the potassium permanganate. Because the deactivation station is within designated wilderness, the U.S. Forest Service (USFS) will need to approve the action through the National Environmental Protection Act (NEPA) scoping and environmental assessment procedure, with emphasis on the potential for the use of the power feeder to diminish wilderness values or constitute "trammeling" as defined under the Wilderness Act of 1964 and amendments.

To prevent toxic concentrations of rotenone from carrying beyond the project area, the deactivation station must be 30 minutes water travel time upstream of the barrier falls, as potassium permanganate breaks rotenone down into nontoxic compounds within 30 minutes of exposure. In 2016, an initial dye test was conducted at the proposed deactivation station, and the travel time exceeded 30 minutes. Additional dye tests will be completed before treatment to account for variability in flows and to verify a minimum 30-minute travel time.

Determining the concentration and duration of potassium permanganate to be applied, and the quantity required to meet these targets, are other requirements. Stream discharge at the barrier falls is one of the parameters necessary to quantity potassium permanganate needed for deactivation. FWP piscicide policy requires at least twice the estimated necessary quantity of potassium permanganate be available for deactivation. For example, if stream discharge at the falls is 60 cfs, and the application rate of potassium permanganate is 3 ppm for a duration of 80 hours, 3,235 pounds would be necessary. FWP policy therefore would require 6,470 pounds of potassium permanganate to be on-site, requiring transport of 118 containers of potassium permanganate to the deactivation station. Existing data on stream flow show flows at the barrier falls in August and September ranging from 40 to 78 cfs (Appendix B). Refining the estimate of the amount of potassium permanganate required for deactivation will be based on baseline data of discharge at the water fall, monitoring of snowpack from the previous winter, and monitoring the timing of snowmelt and resulting runoff in the months before treatment.

Identify Fish Distribution

The hybrid trout with a high proportion of Rainbow Trout admixture is the species targeted for removal in the North Fork Blackfoot River and are likely the only species currently occupying the project area (Figure 3). Extensive, basin-wide sampling over the years yielded a single sculpin about a decade ago. Repeated and targeted sampling since has not yielded any sculpin; however, eDNA samples have been collected to test for presence of sculpin. Sculpin are typically

absent upstream of large natural barriers, and a single sculpin could have been the result of release of bait fish by anglers. Nevertheless, the results of the eDNA sampling, combined with electrofishing data, will determine if the project area supports a population of sculpin.

Multiple lines of evidence have been used to estimate Rainbow Trout distribution in the project area, which include electrofishing surveys and eDNA sampling throughout the watershed (Results Part III). Physical factors, such as colder water temperatures in headwaters, appear to limit Rainbow Trout abundance. Extrapolation and interpolation of these data estimated 45 miles of the 85 miles of perennial streams were fish-bearing. Field surveys found fish in 3 lakes, and these lakes are connected to streams. Before application of piscicide, the extent of fish distribution will be further evaluated through electrofishing, eDNA sampling and deployment of drip stations to apply CFT Legumine™, the piscicide formulation that will be used, to ensure all fish-bearing waters are treated.

Measure Stream Flow throughout Watershed

In 2013 and 2014, the USFS measured stream flows at 19 sites throughout the project area (Appendix B). Measurements taken in 2013 when flows were below average; whereas, flow measurements in 2014 were above average. Linear regressions for discharge and drainage area were developed for both 2013 and 2014 at monitoring stations in the project area to predict a range of discharge across the watershed and across the project area (Figure 2-3). The 2013 regression equation was used in the routed GIS hydrography to predict stream discharge by stream mile (Figure 3). The results of the 2013 prediction were calibrated using stream flow data collected at the U.S. Geological Service gage on the North Fork Blackfoot River near Ovando (USGS 12338300). This calibration estimated that the 2013 measured discharge was approximtely18% lower than average of the greater North Fork Blackfoot River. These 2013 analyses provide a basis to estimate average basin discharge as well as quantities of CFT Legumine and potassium permanganate required for treatment and deactivation, which needs to be determined early in the year before treatment to ensure sufficient amounts of these chemicals.

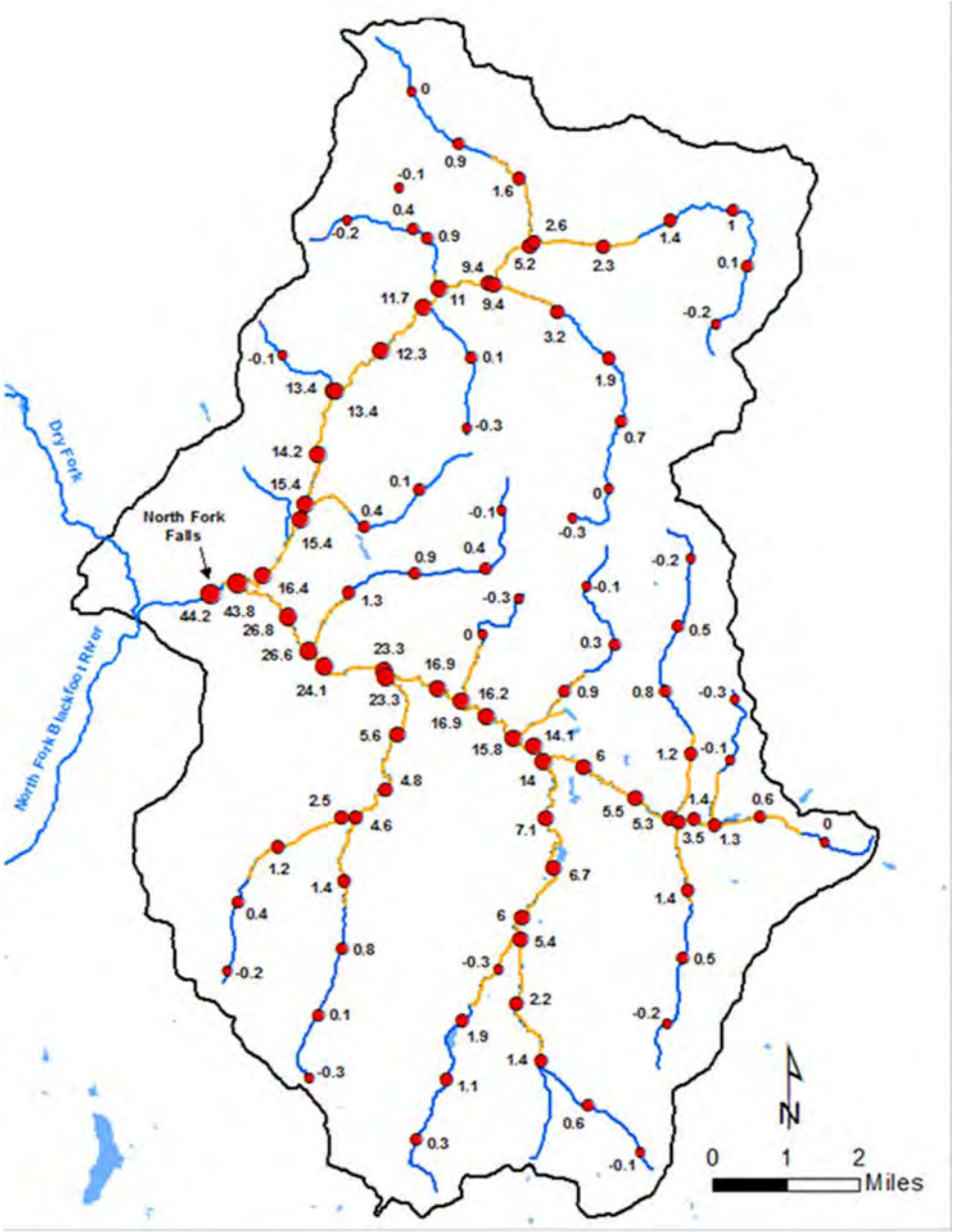

Figure 2-2. North Fork project area and results of the 2013 discharge measurement and regression analysis. The numbers represent predicted 2013 stream discharge (by stream mile). The orange lines show the general distribution of hybrid fish and the blue lines shows the perennial streams that are currently identified as non-fish bearing.

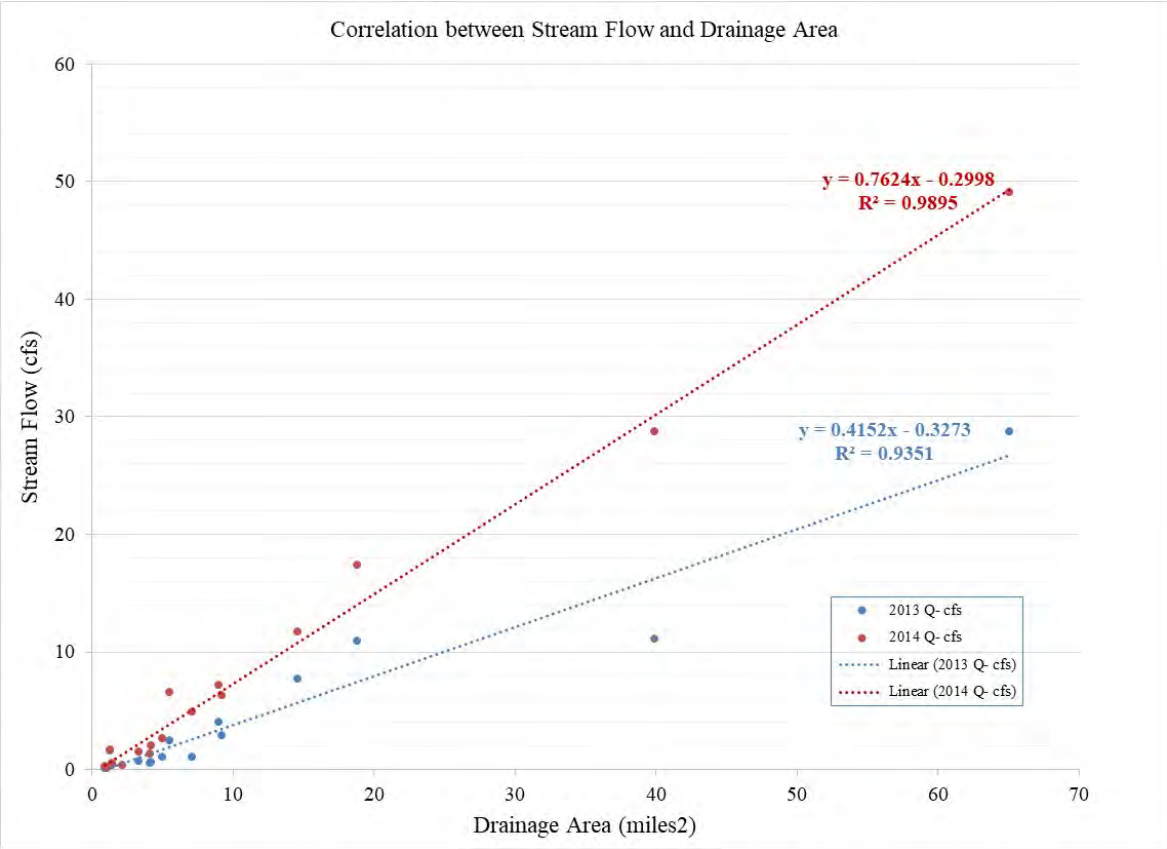

Figure 2-3. Relationship between discharge and drainage area for stream flow monitoring stations in the North Fork Blackfoot River project area in 2013 (a low flow year) and 2014 (a high flow year).

Initial Field Reconnaissance

Numerous features may impede piscicide application, provide refugia for fish, or otherwise complicate a piscicide project. Examples include areas of dead fall timber that are difficult to traverse, or seeps and springs that dilute piscicide or provide a refuge from lethal concentrations. Beaver dams are common in the watershed, and depth and complexity of the habitat affect the ability to attain target concentrations of CFT Legumine within beaver impoundments and prevent the dispersal of CFT Legumine throughout the beaver dam pool. In August of 2017, a field expedition of experienced piscicide applicators spent 3 days in the project area to identify and map these features. Additional field surveys will be conducted in 2018 and 2019 before piscicide treatment.

2.2 *Tasks for 2018*

Tasks for 2018 will include fieldwork and associated planning to promote efficient and effective application of piscicide in 2019 and subsequent years, with treatment in subsequent years occurring as needed to meet project goals. Piscicide projects have numerous components that address the technical considerations of piscicide application, management and safety of

numerous fieldworkers, radio communication, transport of supplies for the piscicide project, and support of fieldworkers during their time within wilderness. The following steps will contribute to smooth operation of the piscicide treatment in 2019.

Bioassays

Bioassays are field studies of toxicity of varying concentrations of chemicals and the duration chemicals remain lethal to fish in receiving waters. Bioassays will be conducted for CFT Legumine and potassium permanganate. Two types of bioassay for CFT Legumine are conducted simultaneously – the travel time and serial dilution bioassays. Combined, the bioassays provide information to develop treatment protocols and allow estimation of the amount of residual rotenone at the terminal end of each treatment interval. Moreover, the results will refine estimates of the amount of rotenone required to treat streams in the project area.

The travel time bioassay determines the duration that CFT Legumine remains lethal, which allows determination of spacing between drip stations. This bioassay entails several actions. A nontoxic, fluorescent green dye applied to streams allows determination of the distance the stream flows within specific reaches over 1/2 hour. The dye is periodically replenished as it disperses and dilutes, so that it remains visible. Sentinel fish are deployed at the 30-minute travel time stations. A single drip station dispenses CFT Legumine to achieve an in-stream concentration of 1 ppm. The point furthest downstream where 100% of sentinel fish succumb to rotenone within 4 hours exposure provides the maximum spacing for drip stations during treatment. The 2 major forks of the project area differ in aquatic habitat and instream organic load; therefore, bioassays will be conducted in at least 1 location in each fork.

The serial dilution bioassay determines the lowest concentration of CFT Legumine that is lethal to fish within the receiving waters. Fish are held in separate buckets with varying concentrations of CFT Legumine. For example, treatment concentrations may be 0.5. 0.25, 0.13 and 0.065 ppm of rotenone. The results of the travel time and serial dilution bioassays will allow determination of the concentration of CFT Legumine to be applied and the spacing of drip stations.

The bioassay for potassium permanganate allows calculation of the concentration needed to deactivate 1 ppm of CFT Legumine and meet the 0.5 to 1 ppm residual limit of potassium permanganate. A drip station releases sufficient CFT Legumine to achieve 1 ppm of CFT Legumine in the stream. A small deactivation station will be established approximately 10 to 15 minutes stream flow time downstream, and the residual concentration of potassium permanganate will be measured 30 minutes travel time downstream of the deactivation station. The amount of potassium permanganate released that results in the target residual concentration after 30 minutes of contact with CFT Legumine will provide data needed to calculate the quantity of potassium permanganate required for the full-scale treatment.

As travel-time bioassays entail release of CFT Legumine into surface water, provisions must be made to contain the spatial extent of treated waters, so a deactivation station will need to be set up and ready to operate each time rotenone is applied. In addition, this component of the project will need to be approved through the NEPA/MEPA process and be included on the 2018 application to Montana Department of Environmental Quality (DEQ) for coverage under their Pesticide General Discharge Permit. Application of potassium permanganate will likewise need to be approved through the NEPA/MEPA process and be included on a discharge permit from DEQ.

Ground-Truth Fish Distribution Estimate

Extensive fish population surveys, eDNA sampling, and water temperature monitoring in the North Fork Blackfoot River project area were all used to estimate the distribution of fish within the North Fork of the Blackfoot River upstream of the North Fork Falls. These techniques estimated about 45 of the 85 miles of perennial stream habitat estimated to support fish (Figure 3). In 2018, crews will ground-truth the fish distribution estimate in select streams by applying CFT Legumine at a single point, approximately 1-hour travel time upstream of the estimated extent of fish distribution. If fish are found about where the estimate predicts, we have high confidence that the estimate is accurate. If fish are found significantly upstream or downstream of the model prediction, appropriate adjustments will be made to ensure fish bearing waters are adequately treated in 2019 and beyond. Additional electrofishing and eDNA sampling may also be used to further refine estimates of fish distribution.

2.3 *Piscicide Treatment*

The piscicide treatment is planned for 2019 and will require 1 or more years of follow-up treatments. The strategy developed under 0 Coordinating Treatment will provide more specific detail; however, the substantial amount of baseline data on fish distribution, stream travel time, eDNA sampling, stream discharge, and field reconnaissance allows for development of the following recommendations for implementing the piscicide application portion of the project.

As the project is in designated wilderness, the approach for all components of the project will be evaluated through USFS's minimum requirements decision guide (MRDG) process. The MRDG evaluates the action and determines the minimum activity to achieve project goals. Numerous factors are considered in identifying the minimum activity, including time constraints and descriptions of alternatives. The alternatives are broken down into discrete components, or phases, called components of the action. The logistics of how each of the components of action would be performed are the component activities, and the effect of each component activity is evaluated for the effect it would have on the qualities of wilderness character. The qualities of wilderness character evaluated for each component activity include untrammeled, undeveloped, natural, solitude or primitive and unconfined recreation, and other features of value.

Piscicide projects are complex, and personnel implementing the project will be assigned numerous tasks. The major tasks and likely personnel needs are described in Table 9.

These estimates are based on field reconnaissance in 2017. Additional field recoverynnaissance will refine these estimates. Factors such as number and size of beaver dams found in the project area will determine the number of people and number of days for specific tasks.

Table 9. Major tasks, estimated number of days and number of people to complete the task per treatment.

Task	***Number of People***	***Number of Days***
Project oversight	3	Every day
Transport of materials (in and out by helicopter)[1/]	4	4
Transport of materials (in and out by pack train)[1/]	33	14
Project implementation	3	20
Breaching beaver dams		
Dye testing		
Electrofishing and sentinel fish deployment	30	20
Tending rotenone stations		
Backpack spraying		
Deactivation	4	5

[1/] Transport of materials is proposed using one or the other of helicopter or pack train, not both.

Communication among personnel and project leaders is critical in promoting project success and safety. Typically, the U.S. Forest Service supplies radios and batteries to fieldworkers. Given the large project area, this project will be of considerable duration, and a sufficient supply of batteries or battery chargers will be needed. If the radios have rechargeable batters, a generator may be necessary to power the battery chargers. In addition, portable repeaters may be needed to allow communications throughout the large project area.

Transport and Staging of Supplies

The North Fork Blackfoot River project area is in rough, remote terrain, within designated wilderness. This strategy for moving supplies, equipment and personnel throughout the project area is based on experience in implementing large-scale piscicide projects in remote country and the Bob Marshall and Lee Metcalf Wilderness areas. For these projects, motorized, mechanized, and aerial support was approved to transport and stage supplies, apply piscicide in lakes, and re-stock lakes with native trout. The type of mechanized support will be determined through the NEPA/MEPA process; however, horse or mule trains and helicopter assistance will be the likely modes of transport for this project.

Piscicide application projects entail a considerable amount of gear, chemicals, and associated supplies. Project materials, personal gear, and chemicals will be transported into the project area

on foot, horseback, or helicopter, with aerial support required to transport large, heavy or awkward items, or items that are too numerous, or too risky, to be transported by other means. Field recoverynnaissance will inform development of plans to transport and stage the diversity of gear and supplies required to support piscicide treatment in 2019.

Specific materials and gear to be transported to the deactivation area are as follows:

- FWP piscicide policy requires 2 independent deactivation systems. The smallest and simplest of these systems is a volumetric feeder that weighs about 80 pounds, plus 2 gas powered generators, such as a Honda 2000 or 2200. Alternative systems include larger and heavier feeders, with the same support system as the small feeder, and two 200-gallon water tanks that require a 2-inch gas-powered pump to fill them.

- At least 2 times the amount of potassium permanganate estimated to be necessary to deactivate rotenone.

- Support equipment needed to operate the power feeder and apply potassium permanganate include motorized pumps, gas-powered generators, hoses, and fuel.

Parameters used in estimating the quantity of CFT Legumine required for the project are length of stream to be treated, results of travel time bioassays, and stream flow. Stream flow monitoring in August 2013 (Figure 2-2) provided the basis for an initial estimate of the quantity of piscicide required to treat streams in the project area; however, stream flow measurement as close as possible to the treatment period will provide the final estimate of quantities needed. Stream flow measurement in August 2013 yielded an estimated need for nine 30-gallon drums of CFT Legumine.

Three fish-bearing lakes are in the project area and will be treated with rotenone (Table 10). The volume of the lake dictates the amount of rotenone required to treat the lake. One gallon of CFT Legumine will treat 3 acre-feet of water to achieve 1 ppm of CFT Legumine, which yields a concentration of 0.05 ppm of rotenone. Application of rotenone will require transport of at least 1 inflatable boat, along with small outboard motor to apply and disperse rotenone. A small battery or gas-powered pump may be needed to disperse piscicide to deeper portions of lakes. The use of gas-powered equipment will require transport of gas cans. In addition, backpack sprayers will be used along the margins of lakes and within connected wetlands. An estimated 12 backpack sprayers should be sufficient.

Table 10. Lakes, lake volumes, and gallons of rotenone required to treat each lake.

Lake	*Volume (acre-feet)*	*Gallons of Rotenone*
Parker Lake	68.9	23.0
Lower Twin Lake	11.6	3.9
Meadow Lake	17.8	5.9
	Total	32.8

Aircraft have been an effective means of applying rotenone to lakes. Single engine air tankers or helicopters with crop-dusting equipment may be used to apply and disperse rotenone to lake surfaces. If feasible, helicopters will likely be appropriate for Lower Twin and Meadow lakes; whereas, a single engine air tanker may be required for Parker Lake. The boats and pumps described above are necessary to disperse rotenone throughout the lakes.

To facilitate development of the MRDG regarding transport of chemical, boats, and associated equipment, FWP estimated the cost of using helicopter support, and the alternative of using wranglers and pack strings to transport equipment and supplies to the detoxification site and treatment supplies to several staging sites within the project area. The necessary equipment and supply distribution could be delivered with about 40 roundtrip flights over 2 days and removed with about 20 roundtrip flights after the project has been completed. In contrast, transporting the same materials and gear by pack animal would require 33 roundtrip pack strings (33 wranglers and 198 mules) for the delivery and 33 pack strings to remove gear and supplies. The duration of transport by pack animals would be 2 weeks, as opposed to 4 days of helicopter flights.

Costs associated with helicopter transport versus pack animals are considerably different. The estimated cost for 40 hours of helicopter time is $19,000, whereas the estimated cost for the necessary pack strings and wranglers is $38,300. Once staged, the equipment and supplies would be distributed throughout the project area as necessary by pack strings and project workers.

Drip stations are the primary method of dispensing rotenone to streams, and up to 30 drip stations (see 0 Drip Stations) will need to be transported to and throughout the project area. These would be distributed by fieldworkers and pack animals. Seeps and small springs are best treated with a mixture of dry rotenone powder, sand and dry gelatin. This project will require several 5-gallon pails of this mixture be available throughout the project area.

Support supplies include personal gear, food, and kitchen supplies for fieldworkers, and these materials will be transported by pack lines throughout the project area, after being delivered to staging areas. To distribute fieldworkers throughout the project area, camp sites will be established in the East Fork of the North Fork and North Forks of the Blackfoot River and equipped with a kitchen tent, food, and cooking supplies. Personal gear will include tents, sleeping bags, head lamps, batteries, and other basic camping equipment.

Using existing USFS cabins and private outfitter camps will reduce disturbance associated with housing and feeding fieldworkers. As the piscicide treatment will proceed from headwaters to downstream, some camps will need to be mobile. Possible scenarios entail moving from existing cabins and camp sites to others downstream. On the East Fork North Fork Blackfoot River, fieldworkers may initially set up camp at the Webb Lake cabin, and then move to the Meadow Creek outfitter camp as the treatment proceeds downstream, and finally move to a temporary satellite camp. On the North Fork Blackfoot River, fieldworkers may initially camp at the Carmichael cabin (at the mouth of Cooney Creek) and then move to a satellite camp. The deactivation station crew will likely stage at the North Fork cabin.

Coordinating Treatment

The treatment strategy is a synthesis of the activities described in this document. Components of planning associated with the field crew include safety, treatment logistics, and location of concentrated staging and camping areas. Proper chemical management must also be determined with identification of on-site storage areas and description of secondary containment and transfer devices. Planning associated with chemical and personnel must incorporate effects on the landscape, with emphasis on limiting disturbance and protecting sensitive natural resources. This portion of the strategy must also ensure radio repeaters are in place for 2-way communications throughout the project area.

The strategy also needs to include activities required shortly before application of rotenone. These actions include measuring stream discharge at strategic locations, conducting dye testing to determine the distance water travels in 30 minutes throughout the treatment area, and developing a plan for coordinated treatment of the main stem and tributaries. The approach to deactivating piscicide is another requirement and includes determining the timing and associated procedures of applying the deactivation agent. Features that may affect the dispersal of rotenone, such as beaver dams, need to be addressed.

Project Oversight

Project oversight will begin with safety training for personnel and end with cessation of application of potassium permanganate with survival of sentinel fish at the downstream end of the project area. A project manager and assistants will supervise field crews, ensure return of all fieldworkers at the end of the day, distribute appropriate quantity of piscicide to applicators for each station, distribute sentinel fish, and maintain communication with all fieldworkers. The project manager and assistants will troubleshoot should problems arise and assign fieldworkers new tasks as they complete their assigned tasks. The project manager will be a certified licensed applicator for rotenone.

Beaver Dam Breaching

To promote effective dispersal of rotenone, beaver dams will be temporarily breached to dewater large pools that are difficult to treat and can provide refugia with sublethal concentrations of rotenone. As beaver impoundments affect downstream flow rates, beaver dam breaching will occur before dye tests. Breaching will maintain flow through the area during piscicide application. Large beaver dam complexes are present on Meadow Creek, a tributary to the East Fork North Fork Blackfoot River, Mineral Creek, and on the North Fork Blackfoot River upstream of Parker Lake. These dams must also be breached to maintain flows until treatment is complete. Field recoverynnaissance will likely discover additional beaver dams, and these dams will receive the same treatment. No beaver control will occur during the project.

Dye Tests

Before application of CFT Legumine, dye tests will be conducted on all fish-bearing waters to determine travel time, which will provide the basis of establishing drip station sites, following the travel time bioassays conducted in 2018 (0 Bioassays). Depending on requirements for safety, workers will work solely or in teams. A nontoxic, fluorescent dye will be released at the location determined to be the uppermost point where rotenone will be applied. The leading edge of the dye is tracked and replenished periodically to maintain an identifiable plume. Flagging is placed at the point of the leading edge at 30-minute intervals, and GPS coordinates are recovered for each flag. Flagging is labeled with the stream name and sequential numbers in 30-minute increments. For dye tests for rotenone, flags are labeled with the stream name and “0” at the first point of application and as the plume travels downstream, the flags are numbered sequentially with numerals, beginning with 1 at the first point of 30 minutes travel time. For the deactivation station, flags are placed at 30-minute travel time locations and labeled in increments of 30.

Dye testing, sentinel fish distribution, and treatment would begin in the headwaters, and proceed stepwise downstream. Dye testing may be implemented throughout the watershed before application of piscicide, or dye testing may proceed step-wise, with piscicide application following individual dye test efforts. Depending on the distance traveled and scheduling of dye test and rotenone application, the camps may need to be mobile, and treatment may be interrupted by a day to move camps.

Drip Stations

Drip stations are the primary method of dispensing piscicide in streams, and drip station trials will be needed in 2018 to conduct reach-scale bioassays and help ground-truth fish distribution estimates. In 2019 and any treatments in subsequent years, drip stations will dispense CFT Legumine throughout fish-bearing reaches in the project area.

Three types of drip station are used in piscicide projects: 5-gallon water cubes (Figure 2-4), Montana buckets (Figure 2-5 and Figure 2-6), and IV bags (Figure 2-7). Water cube drip stations

are equipped with a standing tube with an aperture that releases 5 gallons of CFT Legumine and stream water solution in a thin stream for 4 hours. The Montana bucket is a 3 ½ gallon bucket with a molded plastic elbow coming out of the bottom. A short length of garden hose attached to the plastic elbow leads to an automatic dog watering bowl. A float system in the bowl maintains constant head. A hole drilled in the bottom of the dog bowl delivers CFT Legumine and stream water solution into the stream for 4 hours. Stream water is mixed with the CFT Legumine in both the water cube and Montana bucket system to homogenize the solution and bring each device to its full volume so that it runs for the prescribed duration. The IV bag method entails filling the bag with undiluted CFT Legumine and suspending the bag above the stream. The coiled plastic tubing is adjusted to provide a steady drip into the stream and can be moved up or down to adjust the flow rate. The flow rate is measured using a small graduated cylinder.

Figure 2-4. Five-gallon water cube drip station.

Figure 2-5. Montana bucket piscicide dispersal system. Note sentinel fish in mesh bag upstream of the rotenone application point.

Figure 2-6. Close-up of the Montana bucket system trickling CFT Legumine/stream water solution into a stream. The stream of CFT Legumine and stream water solution is visible in the yellow box.

Figure 2-7. IV bag drip station.

For all drip station types, the amount of CFT Legumine added to the dispensing container needs to result in maintaining the desired in-stream concentration of rotenone for a minimum of 4 hours. Typically, the target in-stream concentration is 1 ppm of CFT Legumine, which results in 0.05 ppm of rotenone. Nevertheless, depending on the results of the bioassay, concentrations of CFT Legumine may be less than 1 ppm or as high as 3 ppm.

Piscicide Application

This task will require the efforts of nearly all personnel. Piscicide application includes monitoring drip stations, dispensing dough balls, and spraying lake margins and wetlands with backpack sprayers. One person is assigned to each drip station. Typically, drip stations run for approximately 4 hours.

Drip station spacing during treatment will be determined by results of the travel time bioassays conducted in 2018 (0 Bioassays) and pretreatment dye tests. The goal is to maintain lethal concentrations of rotenone between drip stations. Fieldworkers assigned to a drip station will monitor sentinel fish placed upstream of a drip station (0 Sentinel Fish), and report their status to the project manager.

Backpack spraying will augment drip stations by treating off-channel waters and peripheral waters that may be fish-bearing. In addition, spraying may be used to treat minor stream flow

upstream of station 0 established during dye tests. One or 2 fieldworkers may be assigned a specific section of stream to spray, with up to 10 people daily being assigned to spraying. Spraying commences 1 hour after drip stations are started and cover the assigned area twice.

Piscicide treatments are initiated at the upstream point and proceed downstream daily. Block nets are not usually necessary to prevent overnight invasion of treated waters from untreated waters below, as the treated distance below the last drip station is generally adequate to prevent overnight invasion. Treatments are slightly overlapped from day-to-day, which also reduces the probability of reinvasion overnight.

Sentinel Fish

Sentinel fish will indicate whether lethal concentrations of rotenone are maintained to the next drip station, with drip station spacing based on bioassays. For example, if bioassays determine that rotenone remains lethal for 90 minutes of stream travel time, sentinel fish would be placed at 90-minute intervals. If sentinel fish indicate lethal concentrations are not maintained between stations, intermediate rotenone stations would be deployed to ensure lethal concentrations reach the next station. Intermediate stations would release a lower concentration of rotenone for a shorter duration and be placed midway between stations.

Deactivation

Deactivation of rotenone is required under FWP's piscicide policy (FWP 2017). Potassium permanganate is a strong oxidizer and the deactivating agent used to degrade rotenone. Deactivation of rotenone is typically achieved within 30 minutes of contact with potassium permanganate. The concentration of potassium permanganate applied to streams must meet 3 requirements:

- The applied concentration must meet the in-stream biochemical demand for the elements in potassium permanganate.
- It must fully neutralize rotenone within 30 minutes.
- It must provide a surplus concentration of potassium permanganate from 0.5 to 1.0 ppm. The surplus potassium permanganate provides evidence that the other two requirements are met, yet remains at a level that itself, is not acutely lethal to fish.

Although FWP's piscicide policy requires limiting the extent of lethal concentrations of rotenone to the 30-minute mixing period, the presence of Bull Trout in the North Fork Blackfoot River downstream of the falls elevates the need to control the area of lethal concentrations. Based on previous dye tests, the preliminary site selected at the confluence of the East Fork North Fork Blackfoot River and the North Fork Blackfoot River will likely allow 30 minutes of contact before flows reach the barrier falls; however, the bioassay process will evaluate this assumption, and the station may need to be moved accordingly.

FWP policy also requires that deactivation must begin 2 hours before the estimated arrival of rotenone at the deactivation site. Deactivation is terminated when sentinel fish at the deactivation site have lived without distress for the requisite period after rotenone is estimated to have passed the deactivation site. Deactivation in watersheds with lakes is longer than when only stream habitat is treated. Timing and duration of deactivation will be determined following completion of dye testing in 2019.

A highly experienced, licensed applicator will lead deactivation, and will be accompanied by 1 or 2 assistants. Tasks performed include operating the deactivation station, monitoring of sentinel fish, and monitoring residual potassium permanganate at the 30-minute site in the deactivation zone.

A large supply of sentinel fish is necessary to monitor the deactivation process. Initially, sentinel fish are deployed immediately upstream of the deactivation station and at 30-minute water travel time intervals downstream of the station, and stations can extend to the 120-minute interval. The fish upstream of the deactivation site indicate whether a lethal concentration of rotenone reaches the downstream end of the project area. Once the initial batch of sentinel fish at the deactivation site have succumbed to rotenone, they are replaced with subsequent batches until sentinel fish survive without distress for the requisite duration.

Effectiveness Monitoring

Following completion of piscicide treatment, project partners may evaluate the effectiveness of the removal effort through electrofishing and collection of water samples to test for eDNA. Gillnets may be deployed in lakes. These efforts may result in a targeted approach to subsequent treatments, with treatment occurring in locations shown or suspected to still support fish.

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Appendix M. Translocation Decision Framework

Considerations in Selection of Westslope Cutthroat Trout Donor Populations and Methods of Translocation into the North Fork Blackfoot River Watershed within the Scapegoat Wilderness

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Executive Summary

Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* (WCT) are a native subspecies of trout that historically occupied most of the Northern Rocky Mountains on both sides of the Continental Divide, but nonhybridized populations are now restricted to about 10% of their historical habitats. FWP and their partners are proposing to replace hybridized trout populations with nonhybridized WCT in about 140 km of stream habitat and three mountain lakes above a natural 15-m high waterfall within the North Fork of the Blackfoot River basin. We review information on the distribution, genetic status, and abundance of extant WCT populations in the Blackfoot River basin that could potentially be used as donor sources to translocate into the North Fork area. Disease testing was also done in each of these potential donor source stream.

A decision-tree is developed to 1) guide managers in their selection of donor stocks to use in this project; 2) determine which life-stages and methods of translocating fish or embryos might be used; and 3) account for the implications of an incomplete eradication of hybridized fish from the project area. Several donor source strategies are suggested, including using only wild donor sources, using only the existing captive Washoe Park Hatchery source, or using a combination of these donors.

Seven potential wild donor sources were screened using the donor source decision-tree. Two streams, Cottonwood and Stonewall creeks, have WCT populations with no evidence of any hybridization with either Rainbow Trout or Yellowstone Cutthroat Trout. Whirling disease has been detected in Cottonwood Creek, but not in Stonewall Creek. We suggest that gametes can be collected from Cottonwood Creek because this stream is accessible during the spawning season and this method will reduce the risk of transferring whirling disease. Cottonwood Creek has an abundant population of WCT, so removing WCT gametes from several locations in this stream should be feasible and could be done annually over several years. We suggest that live juvenile fish can be taken from Stonewall Creek because access to this stream to collect spawning adults would be difficult. The WCT population in Stonewall Creek is less abundant than the population in Cottonwood Creek, so we suggest that about 25 juvenile fish be taken annually from several locations each year in Stonewall Creek over several years. These fish would be reared to maturity in an isolation hatchery, such as Montana FWP's Sekokini Springs Hatchery, to increase the numbers of fish translocated from this source, and their progeny (either embryos or fish) translocated to the North Fork project area.

Several other streams (Arrastra, Copper/Snowbank, and Sauerkraut creeks, and the upper Lander's Fork) have very low levels of detected hybridization and there is uncertainty about whether WCT populations in some of these streams are hybrid swarms or whether individuals with no evidence of hybridization are present. Since whirling disease has been documented in the

Lander's Fork and collecting gametes from the headwaters would be difficult, we suggest removing this stream from consideration as a donor source. Whirling disease has not been detected in the other streams and they could serve as potential donor sources if additional genetic analyses identify individuals with no evidence of hybridization. Where there is uncertainty regarding the possibility of hybridization, it may be necessary to genetically test each wild donor individual to confirm that each fish used for the restoration project has no evidence of hybridization.

The numbers of fish or embryos to translocate should maximize contributions from different parental pairs, and donor stocks, to release as much genetic diversity as feasible into the North Fork project area. An attempt should be made to use at least 100 individuals from different family groups from each donor source over the course of the project to maximize genetic diversity to the extent practical. Contributions for each parental pair should be equalized to the extent practical to maximize the effective population size from each donor source. Numbers of fish or embryos available to translocate will depend on the population abundance of the donor stocks. It may be necessary to bring juveniles from some wild donor stocks into a captive facility, such as Montana FWP's Sekokini Springs Hatchery, to raise them to maturity, spawn them, and then release their progeny to increase the number of fish or embryos released into the project area. We also recommend releasing fish or embryos from each donor source for at least three consecutive years. We estimate that the North Fork project area could support approximately 75,000 age-1 and older fish but point out that this is not the number that will need to be translocated because the population will grow exponentially until habitat capacity is reached. We anticipate that the habitat's carrying capacity will be reached in one to two WCT generations, or three to six years after translocations are completed.

We suggest using remote site incubators (RSIs) to translocate fertilized eggs and incubating these eggs to the eyed-stage prior to placing them in RSIs to increase egg-to-fry survivals. Using fertilized eggs is one way to reduce some of the disease risks because vertical transmission of some diseases does not occur or can be prevented. Translocating fry or older fish would also be an option, but only where testing has found no evidence of disease in the source population. We suggest that release sites be spread throughout the North Fork project area at about two to five km intervals and that initial releases be done at the most upstream sites that now support fish with subsequent annual releases occurring incrementally in a downstream direction.

Introduction

The distributions of many inland native trout species in western North America have been severely reduced (Duff 1996; Rieman et al. 1997; Shepard et al. 1997, 2005; Gresswell 2011; Muhlfeld et al. 2015), including Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* (WCT). WCT were historically the most widely distributed subspecies of Cutthroat Trout, inhabiting both sides of the Continental Divide in Montana and Canada, and west of the divide in the states of Idaho, Oregon, and Washington (Behnke 1992; Shepard et al. 2005). However, in the last 100 years, habitat loss, competition with nonnative species, and hybridization have significantly reduced the distribution and abundance of WCT (Liknes and Graham 1988; Behnke 1992; Shepard et al. 1997; 2005). Currently, populations of WCT with no evidence of hybridization occupy only about 10% of their historical range in the U.S. (Shepard et al. 2005).

Montana Fish, Wildlife & Parks (FWP) fisheries managers in Missoula, Montana propose to translocate WCT into waters of the upper North Fork Blackfoot River basin after removing nonnative Rainbow Trout *O. mykiss* and Rainbow × Cutthroat hybrids (Pierce et al. 2017; Figure 1). Translocations of WCT into suitable habitats where nonnative fish have been eradicated using piscicide is widely used throughout the western U.S. and is an important strategy that managers in Montana use to conserve WCT (Shepard et al. 2005; FWP 2007; Andrews et al. 2016).

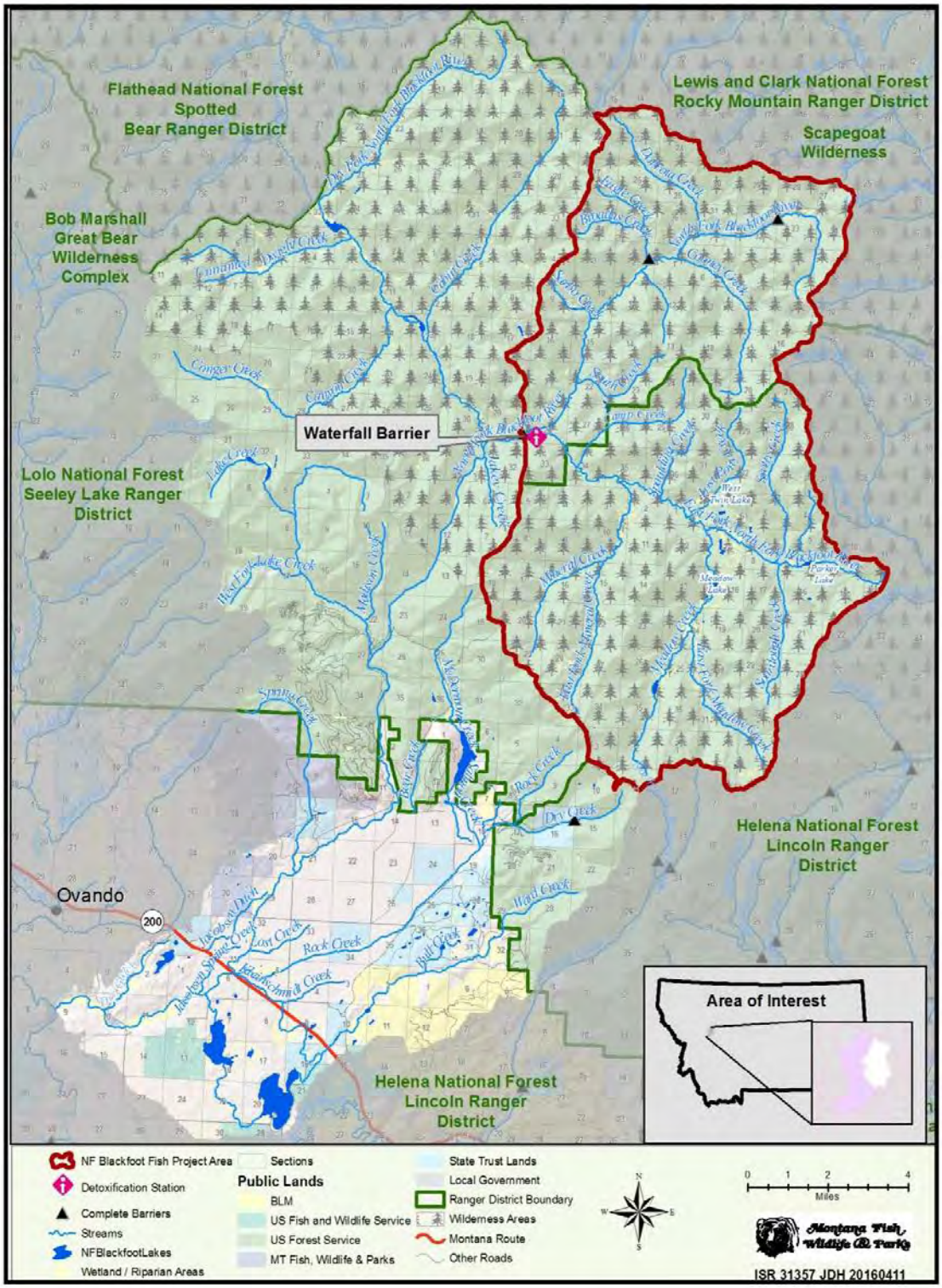

Figure 1. Map of North Fork Blackfoot River watershed showing project area.

The North Fork Blackfoot River restoration project area provides an ideal location for a conservation population of WCT because it is entirely within federally designated wilderness that provides high-quality, pristine habitats, and a 15-m high waterfall prevents upstream movement of nonnative fishes into the project area (Pierce et al. 2017). The project area encompasses about 140 km of perennial streams and three natural lakes that currently support fish. Aquatic habitats within the project area are connected, complex, and diverse. Moreover, temperatures of waters in the project area are projected to remain suitable for cold-water obligate species for the foreseeable future, even in the face of predicted climate changes (Isaak et al. 2015).

The goals of the North Fork Blackfoot River restoration project are to create a genetically diverse, self-sustaining WCT population with little or no genetic introgression and to conserve the North Fork Blackfoot River Bull Trout Salvelinus confluentus in a secure refuge with cold water temperatures and high quality, interconnected habitats. The primary objectives to attain these goals are to remove the existing highly introgressed fish and translocate WCT and Bull Trout into the project area. This document addresses the genetic, demographic, pathological, and logistical considerations of translocating WCT into the North Fork Blackfoot River restoration project area.

Before a WCT translocation can take place in the upper North Fork Blackfoot River basin, FWP proposes to remove introduced nonnative fish from the project area using the piscicide rotenone (Finlayson et al. 2005). The goal of piscicide treatments is to eradicate all nonnative fish, but we acknowledge that the size, complexity and remoteness of the treatment area might affect this desired outcome. If total eradication is not achieved, higher numbers of WCT may need to be translocated so they can competitively/genetically overwhelm (swamp) the remaining nonnative genes. This document provides a decision-making framework for determining how and which WCT will be translocated into the project area after the existing hybridized fish are eradicated, including the sources and numbers of WCT required, the translocation method and age of translocated fish, and the extent to which hatchery assistance will be needed to meet the goals for genetic diversity, local adaptability and preservation of local genetics.

Scientific and Genetic Principles of Translocations

When properly planned and executed, translocations are a proven conservation tool for restoring native Cutthroat Trout populations (e.g., Harig et al. 2000; Al-Chokhachy et al. 2009; Dunham et al. 2011). Appropriate populations must be selected for translocations (Griffith et al. 1989; Minckley 1995; Haight et al. 2000; George et al. 2009). Local adaptation has been demonstrated in many different species of salmonids, resulting in genetic, morphological, meristic, behavioral, developmental, physiological, and biochemical differences at various geographic scales (e.g., Taylor 1991). Genetic and species conservation theory suggest that source populations could affect project success (Stockwell et al. 1996; 2002; Case 2000). For example, WCT may adapt to local thermal regimes (Drinan et al. 2012), as water temperature strongly governs growth,

development, reproductive cycles, migrations, and other life history traits important to the survival of trout (Xu et al. 2010).

Some wild populations of WCT experience genetic bottlenecks, either because they are isolated from gene flow by natural or human-made barriers, or because they suffered a founder effect due to small numbers of individuals founding or restarting a population after a catastrophic event extirpates or reduces the population to a few individuals. These conditions lead to inbreeding, lowered genetic diversity, and potential reduction in fitness due to inbreeding depression (Leary et al. 1988; Drinan et al. 2011). Nonhybridized, isolated WCT populations that occupy relatively small patches of habitat in tributary headwaters may be particularly susceptible to inbreeding depression and lower genetic diversity (Leary et al. 1988; Young et al. 2004; Shepard et al. 2005; Rasmussen et al. 2010; Loxterman et al. 2014). Although such isolation may lead to local adaptation among populations, genetic drift may reduce genetic diversity through time, and inbreeding can result in fitness declines due to phenotypic expression of deleterious recessive alleles.

The effects of inbreeding are highly variable. Some isolated wild populations experience little or no reduction in fitness (e.g., Visscher et al. 2001); whereas, others experience considerable reduction in fitness (e.g., Rall et al. 1988; Lacy et al. 1996). Translocated fish populations typically have relatively low genetic diversity when compared to source populations, which may be attributed to bottlenecks during translocation (Stockwell et al.1996). Using relatively high numbers of parental pairs from a mixed group of donor sources should help alleviate this problem, assuming a high proportion of these crosses are successful and contribute offspring to future generations.

Using captive-origin versus wild-origin sources as donors has trade-offs. Some advantages of bringing wild sources into captivity to create a brood stock are to: 1) produce more and larger offspring (e.g., Primack 2014); 2) increase genetic diversity by using many different source stocks (e.g., Van Doornik et al. 2011); and 3) provide a stable and easily accessible source for translocation (Frankham et al. 2003). Some disadvantages are: 1) captive selection may occur rapidly, such that progeny may lose genetic variability and be less fit in a wild setting (e.g., Heath et al. 2003; Frankham et al. 2003; Araki et al. 2007; Christie et al. 2014, 2016); 2) the expense of maintaining a captive population; and 3) the need for stringent bio-controls to prevent transmission of diseases or parasites into the captive population. Advantages of using wild-origin donors are to preserve the unique genetic legacy of each wild population (Allendorf and Leary 1988) and to take advantage of potential adaptation to local or regional conditions (McKay et al. 2005; Prugh 2009). The disadvantages are the: 1) potential for lower genetic diversity (Frankham et al. 2003); 2) potential demographic effects on the donor source by removing adults or gametes from a small population; and 3) limited numbers of fish or embryos that can be translocated any single year due to small population sizes and small sizes of adult females that produce fewer eggs.

Results of field studies on the potential effects of out-breeding resulting from mixed-source releases have been inconsistent. For example, no loss of fitness occurred in second-generation hybrids of Coho Salmon Oncorhynchus kisutch released into the ocean (Dann et al. 2010) but did occur in hybrids of Pink Salmon (Gharrett and Smoker 1991) and second-generation progeny of Slimy Sculpin Cottus cognatus in Minnesota (Huff et al. 2011). Perhaps intraspecific hybridization is like interspecific hybridization, where first-generation hybrids gain hybrid vigor, but subsequent generations suffer reduced fitness as gene recombination breaks down intact haploid genomes from the parents (Muhlfeld et al. 2009).

Reproductive success is the ultimate measure of translocation success and will therefore be the most reliable metric for evaluating the long-term success of any translocation project (Anderson et al. 2014). Performance of subsequent generations may change after reproduction occurs in the wild, allowing gene recombination to occur, and as fish densities reach carrying capacity, increasing intraspecific competition (Vincenzi et al. 2010; Parra et al. 2011). Furthermore, episodic selection occurring over multiple generations will likely play a role in determining the long-term fitness of individual genes and gene complexes, something that is difficult to quantify in field studies (sensu Weins 1977).

Selection of which life-stage to translocate is an important decision in translocating fish. One option is to translocate fertilized eggs shortly after they have been water-hardened, or shortly after they have eyed-up and are nearly ready to hatch (Chapman and Rogers 1992; Andrews et al. 2016). Advantages to using embryos are: 1) artificial selection while in captivity is minimized, and most selection pressures are from the recipient habitat, which should accelerate their adaptation to these environments (Bamberger 2009; Barlaup and Moen 2001); 2) homing behavior of these introduced embryos, once they mature as adults to spawn in natal areas, should be higher due to environmental cues they receive after they hatch and disperse (Berejikian et al. 2004); 3) risk of disease transmission is reduced as several diseases (e.g., parasitic and bacterial infections) cannot be transmitted vertically from parents to embryos, and it is possible to treat embryos to eliminate most diseases during the water-hardening process and subsequent incubation; and 4) the technology of remote stream incubators (RSIs) for release of these embryos is well-established and allows for high survival of embryos to emergent fry (Donaghy and Verspoor 2000; Kaeding and Boltz 2004, Al-Chokhachy et al. 2009; Shepard et al. In preparation).

Translocation Examples

Similar nonnative fish eradication and native Cutthroat Trout conservation projects have been conducted in about 100 km of upper Cherry Creek, a tributary of the Madison River in Montana, and its tributaries (Bramblett 1998; Kruse et al. 2013; Andrews et al. 2016) and the South Fork Flathead River basin (FWP 2005). Both these projects have complete fish barriers at their lower

project boundaries that prevent upstream movement of nonnative fish into the project areas. As the proposed North Fork Blackfoot River restoration project has a 15-m high waterfall that isolates a 25,900 ha drainage area containing about 140 km of perennial stream and river habitats and three natural lakes that support fish (Pierce et al. 2017), the Cherry Creek and South Fork Flathead projects provide reasonable models for comparison because they are all relatively large projects that contain both stream and lake habitats.

Cherry Creek

Nonnative trout were successfully eradicated from nearly 100 km of stream habitat and a mountain lake in the upper Cherry Creek basin, over the course of eight years (2003 to 2010). These treatments were conducted in four phases. Each phase was treated with the piscicides antimycin A or rotenone from two to three times using both drip stations and backpack sprayers. Research indicated there were short-term effects of piscicide application on some nontarget organisms, such as aquatic macroinvertebrates, frogs, and dippers, but populations of these taxa recovered quickly one to two years after the last piscicide treatment occurred (Billman et al. 2012; Donnelly, In review; C. Kruse and D. McGuire, Turner Enterprises Inc., Bozeman, MT, personal communication). Experience gained during these treatments indicated that piscicides, especially rotenone, could be applied twice in one year (mid-summer and fall) to compress the time needed to eradicate fish.

Releasing wild- or captive-origin WCT embryos using remote site incubators (RSIs) was a successful method for introducing native trout into vacant habitats in Cherry Creek. Collecting wild gametes and maintaining RSIs for this project required two fieldworkers to be in the field for 8 to 10 weeks during the spawning and incubation seasons each year (Shepard et al. In preparation). Since embryos from wild fish can be introduced using RSIs, the need for captive brood or juvenile rearing facilities is unnecessary. However, collection of eggs and sperm from wild adults is challenging, as it requires knowing the locations and timing of congregating adults before the spawning period and spawning usually occurs near the peak of the snowmelt runoff.

Moreover, these areas must be accessible when pre-spawning and spawning adults are present, which is often difficult due to snow cover and/or remote locations.

Incubating embryos to the eyed-stage before their release into RSIs can increase embryo-tofry survival compared to releasing fertilized eggs before the eyed-stage into RSIs. Some type of isolation facility is needed to incubate wild eggs and at least one person is needed to periodically check on incubating eggs, primarily to ensure water flows are adequate. For the Cherry Creek project, eyed-eggs were placed into RSIs, where they developed and hatched, after which fry emerged and dispersed naturally into the stream.

From 2006 to 2010, over 35,000 eyed-eggs from 427 adults that represented 254 pairings were placed in RSIs at eight different locations. Green-egg to eyed-egg survivals of embryos averaged 79% (Shepard et al. In preparation). These eyed-eggs resulted in over 26,000 WCT fry being released into the Cherry Creek basin with eyed-egg to fry survivals averaging 72% (Shepard et al. In preparation). As piscicide eradication treatments were done in the upper three phases from the headwaters down, embryos were placed in RSIs at two locations within each treatment phase at least one year after the final treatment of each phase. This resulted in WCT embryos being placed in RSIs from 2007 to 2010. The year 2006 was a pilot year and very few embryos were placed into RSIs and survivals of embryos were low during that year. By translocating embryos during four successive years, four successive year classes were released, ensuring that all year-classes were represented in the first generation of fish released into the Cherry Creek basin.

Fry emerged from RSIs located throughout Cherry Creek and dispersed to fill habitat progressively downstream, and to a limited extent upstream, during their first two years at large, with wider dispersal occurring the second year (Andrews et al. 2013). WCT progeny from captive adults held at FWP's Washoe Park Hatchery facility moved shorter distances in the

Cherry Creek basin than progeny originating from wild donor stocks (Andrews et al. 2013). Based on the Cherry Creek project, Shepard et al. (In preparation) suggested that locating RSI sites 5 to 10 km apart, with the uppermost release site located near the upper boundary of suitable habitat, should be adequate to seed vacant habitats. First-generation juveniles that originated from captive brood at the Washoe Park Hatchery had a higher median survival rate than wild fish. This disparity may be due to the higher genetic diversity of the captive brood stock (Andrews et al. 2016). Andrews et al. (2016) speculated that that progeny from any of the donor sources used in Cherry Creek would have populated this basin with WCT over time, because some progeny from each donor source survived to age-2.

The fry from initial embryo releases matured in three to five years, depending primarily on water temperatures in the locations where they reared. It appeared that once fry matured, they successfully spawned, and their progeny rapidly filled all suitable habitats in about seven to ten years following the initial embryo releases (Figure 2 and Appendix A: Length Frequencies of Cherry Creek (2007- 2016)). However, in a cold tributary that drained Cherry Lake, successful spawning was sporadic and only occurred during the warmest years (Figure 2 and Appendix A - Length Frequencies of Cherry Creek (2007- 2016)).

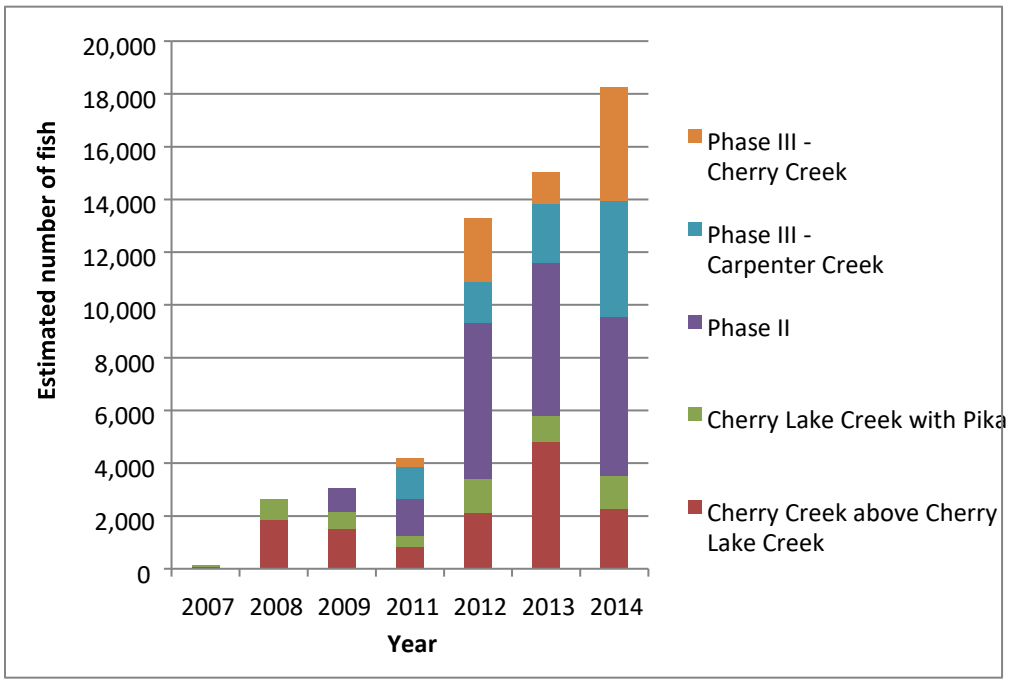

Figure 2. Estimated number of WCT 75 mm and longer in Cherry Creek basin by year and location. Estimates are not presented for the Phase IV area.

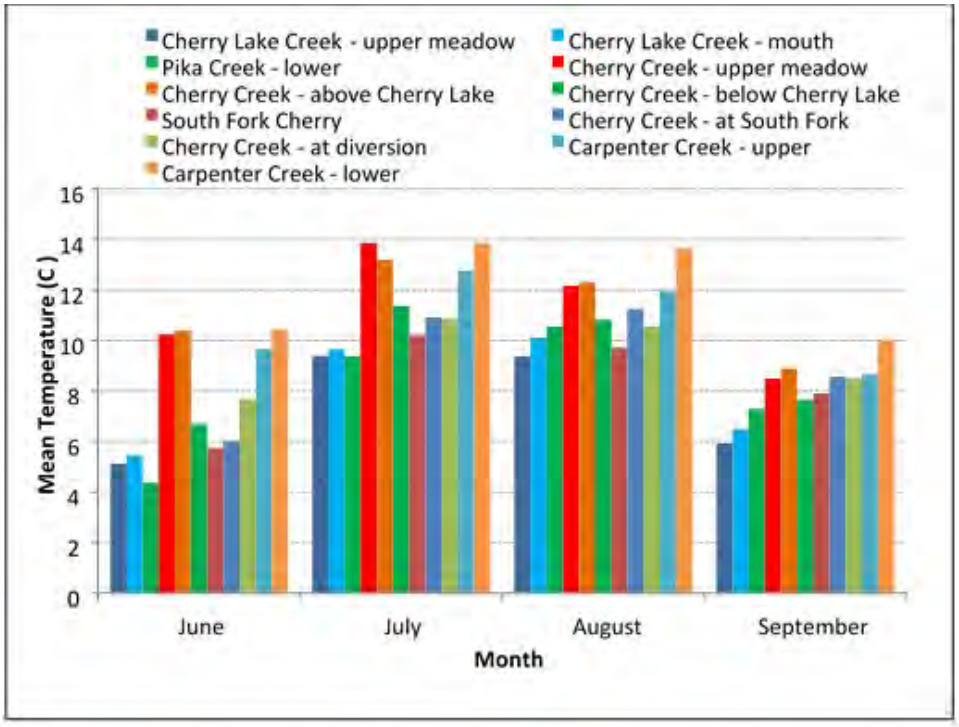

Figure 3. Mean monthly water temperatures at various locations within the Cherry Creek basin from 2008 to 2015. Note the much cooler average water temperatures in the two Cherry Lake Creek sites and in Pika Creek, a tributary to Cherry Lake Creek.

The translocation of WCT into the Cherry Creek basin was successful because 1) nonnative fish were successfully eradicated, 2) translocated embryos experienced relatively high survival rates (about 50% survived from eggs taken from females to fry that dispersed from RSIs) and then successfully reproduced within a few years of their initial release, and 3) all year classes were represented five to ten years post-release. Translocations using a mixture of wild sources, which may have relatively low genetic diversity, either together or along with a more genetically diverse captive source, appeared to be a reasonable strategy to conserve overall genetic diversity of this subspecies in Cherry Creek (Andrews et al. 2016). Using RSIs allowed wild stocks to contribute to translocations, while limiting the risk of disease and parasites being introduced into the restoration area or brought into captive incubation facilities.

South Fork Flathead River Watershed

An extensive WCT restoration project occurred in 20 alpine lakes within the headwaters of the South Fork Flathead River drainage, with the final lake treatment completed in 2017. The goal of this restoration program was to establish secure populations of nonhybridized WCT within the expansive project area. Like the goals of North Fork Blackfoot River restoration project, reestablishing these fisheries created genetic reserves in cold-water refugia.

The remoteness of the area resulted in significant logistical challenges associated with translocating embryos with RSIs. Furthermore, the size of these lakes and associated stream networks required that a substantial number of fish were needed to reduce or eliminate hybridization and provide enough individuals to ensure successful reproduction. Since collection of wild gametes likely would have had population level effects on donor streams due to the large number of fish needed, hatchery-raised fry were used for reintroduction. In a few lakes, where reestablishment of a recreational fishery was important, captive reared age-1 and age-2 fish were released as soon as possible to provide catchable-sized WCT. Helicopters provided the primary method of reintroduction, although packing fry in on horseback was possible for sites that were accessible by trails.

The M012 WCT brood stock from the FWP Washoe Park Hatchery was the source of WCT translocated into several reclaimed lakes. This brood stock was founded in the mid-1980s from 12 donor populations in the South Fork Flathead River watershed, and two populations in the Clark Fork drainage. Infusion of wild gametes into the captive brood stock occurred from 2003 through 2005 and 2009 through 2011. Gametes for this infusion came from nine tributaries in the South Fork Flathead River watershed. In 2013, gametes were again infused from Threemile Creek in the Bitterroot drainage and the South Fork of Willow Creek in the Flint Creek drainage.

The M012 brood stock, held at the Washoe Park Hatchery, is a genetically diverse population of WCT and has been used in many waters to successfully establish naturally reproducing populations. Furthermore, large numbers of fish and multiple year classes are available from this

brood stock, which expedites achieving translocation goals. Nevertheless, this brood stock contains only a fraction of the overall genetic variation present in this taxon and may have experienced some of the hatchery selection pressures inherent to captive brood stocks.

Certainly, interspecific hybridization between WCT and introduced Rainbow Trout and Yellowstone Cutthroat Trout (O. c. bouvieri) is of greater concern than intraspecific hybridization among divergent populations of WCT. Nevertheless, widespread translocations of WCT derived from a common brood stock (e. g., Washoe Park Hatchery's M012) can significantly alter the genetic structure of recipient populations and disrupt locally adapted gene complexes. Therefore, from a conservation genetics perspective, the best strategy to minimize the negative effects of outbreeding depression and preserve locally-adapted WCT populations is to transplant individuals directly descended from within the drainage of transfer, or other proximate wild source, which is known as "local" or "within-drainage" stock (also referred to as "nearest neighbor" in some of the conservation literature).

Consequently, local WCT stocks that were captured from area tributaries and raised at FWP's Sekokini Springs Conservation Hatchery were also used as donor stocks for selected lakes in the South Fork Flathead River WCT project. Juvenile WCT from discrete, nonhybridized, disease free populations in the South Fork Flathead River watershed were captured in the wild and transported to this facility. The wild fish were raised to maturity over one to two years and spawned to create offspring for fry translocations in alpine lakes, following chemical removal of nonnative fish. Initial delivery of live feeds helped transition wild juvenile fish to a pellet diet. Rearing tanks in Sekokini Springs were modified to provide overhead cover and baffled to provide a variety of available water velocities. Fish were fed using automated belt feeders and kept at low rearing densities. These modifications minimized stress, improved fish condition (i.e., weight at a given length), and increased survival rates of these captured wild fish.

Mature males and females were spawned in a 3 × 3 cross using sperm extender to increase sperm motility and maximize the likelihood that an individual produced viable gametes. Postfertilization crosses were kept separate to monitor embryo survival and equalize family contribution, a strategy that maximizes the effective population size (Ne) of each cohort that was translocated to establish a population.

To date, four local WCT populations have been used as donor sources to produce fry for translocation into alpine lakes in the South Fork Flathead River drainage. Genetic monitoring provides the basis to evaluate the degree to which genetic variation from the wild donor source is present in the transplanted fry. Monitoring of the newly established recipient populations will evaluate changes in genetic diversity over time, which will allow inference on potential changes in gene frequency through mechanisms such as genetic drift or natural selection.

North Fork Blackfoot Restoration Project

Like the Cherry Creek and South Fork Flathead River WCT projects, the primary goal of the North Fork Blackfoot restoration project is to create a genetically diverse, self-sustaining population of WCT with no evidence of nonnative interspecific hybridization, in a secure refuge with high quality and interconnected habitats. In addition, the project will remove or significantly reduce or eliminate headwater sources of hybridization to down-gradient populations of WCT. Like the Cherry Creek and South Fork Flathead River watershed projects, the existing nonnative fish will be removed and replaced with nonhybridized WCT.

A secondary objective of the North Fork project will be to translocate, if feasible, fish or gametes from one or more wild WCT donor populations from the Blackfoot River basin that have locally adapted genes, which should increase their ability to thrive in the high-elevation, cold-water project area. This project also offers an opportunity to preserve some of the genetic diversity of extant WCT populations within the Blackfoot River drainage (Muhlfeld et al. 2009; Young et al. 2016). Within this context, a single extant Blackfoot WCT population might be released into a relatively isolated portion of the restoration project area in hopes of establishing a sub-population that retains much of its original genetic diversity, often termed “replication” of an existing population.

Several decisions need to be made regarding which donor sources to use and how to translocate them into the North Fork Blackfoot restoration area. The structured decision process presented in this report considers genetic status, genetic variability, local and regional adaptation, disease risks, translocation methods, and life-stage(s) of fish that are translocated. These factors will be considered using a matrix designed to guide decision-making in the Decision Tree chapter. Logistical and economic feasibility and social acceptance of this proposed project will also be evaluated as part of the environmental assessment.

Oncorhynchus Genetics in the Blackfoot River Watershed

The genetic characteristics of Oncorhynchus spp. varies considerably across the Blackfoot River watershed, and includes native WCT, nonnative Rainbow Trout, nonnative Yellowstone Cutthroat Trout, and hybrids of all three (Figure 4; Table 1). The presence of nonnative Oncorhynchus relates to extensive stocking of hatchery trout into lakes, rivers and streams, which began in the early 1900s and ended in the mid-1970s, when wild trout management was adopted for streams and rivers in western Montana that ended hatchery stocking in these waters (Zackheim 2005).

Decades of stocking that occurred before Montana implemented wild trout management resulted in naturalized Rainbow Trout populations becoming established in the lower elevations of the Blackfoot River watershed, which includes the lower Blackfoot River and the lower reaches of

connected tributaries from the confluence of Nevada Creek down-valley (Pierce et al. 2009, 2016; Carim et al. 2015; Figure 4; Table 1). However, naturalized Rainbow Trout, Yellowstone Cutthroat Trout, and hybrids are also present in some headwater areas, such as the Clearwater River, Cottonwood Creek, North Fork Blackfoot River, Lander's Fork and Nevada Creek drainages, particularly in areas where historical stocking of lakes occurred (Figure 4; Table 1). In the absence of historically stocked lakes and reservoirs, WCT is usually the prevalent Oncorhynchus salmonid in headwater areas of most streams, especially in the upper Blackfoot River basin upstream of the confluence of Nevada Creek (Figure 4; Table 1).

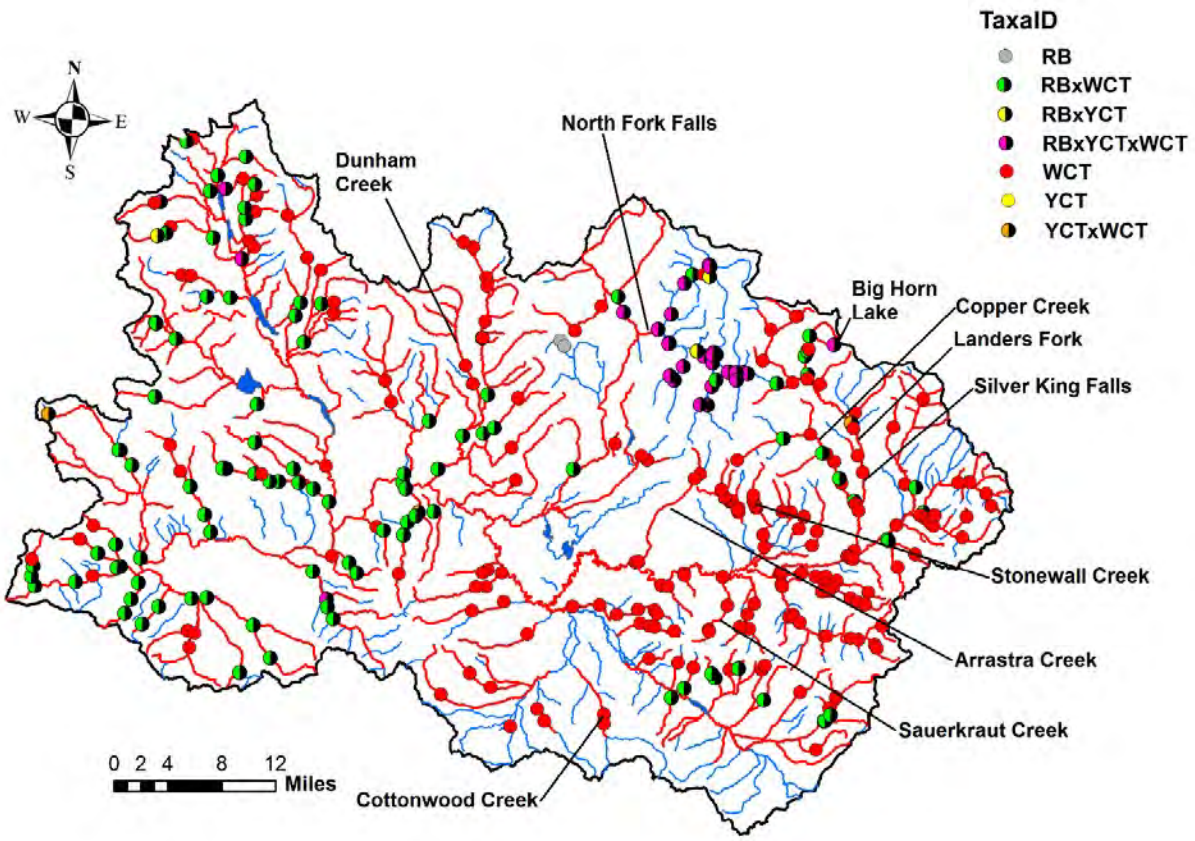

Figure 4. Genetic sampling sites and genetic status of *Oncorhynchus* in the Blackfoot River watershed through 2016. Stream names identify possible donor stocks referenced in Table 1. Barriers falls (Silver King and the North Fork Falls) are show. The red lines show the current distribution of WCT.

Table 1. Genetic sample results (1988-2017) from seven streams considered as possible WCT donors to the North Fork Blackfoot River restoration project. The acronyms RB, WCT, and YCT refer to Rainbow Trout, Westslope Cutthroat Trout, and Yellowstone Cutthroat Trout. The data are organized in ascending order by the drainage, stream, and year of data collection. A "?" in Taxa ID indicates there could be a polymorphism issue.

Drainage	Stream name	Stream mile	Lab Report #	Year	n	Taxa ID	RB %	YCT %	WCT %
Arrastra	Arrastra	9.3	283	1988	9	WCT	0.0	0.0	100.0
Arrastra	Arrastra	0.3	1381	1999	3	WCT	0.0	0.0	100.0
Arrastra	Arrastra	0.7	1380	1999	12	WCT	0.0	0.0	100.0
Arrastra	Arrastra	9.2	1379	1999	16	WCT	0.0	0.0	100.0
Arrastra	Arrastra	4.5	4892	2017	30	WCTxRB?	0.03	0.0	99.7
Arrastra	Arrastra	5.1							
Copper	Copper	3.3	281	1988	11	WCT	0.0	0.0	100.0
Copper	Copper	5.2	297	1989	26	WCT	0.0	0.0	100.0
Copper	Copper	1.1	1377	1999	6	WCT	0.0	0.0	100.0
Copper	Copper	6.2	1376	1999	11	WCT	0.0	0.0	100.0
Copper	Copper	8.9	1375	1999	4	WCT	0.0	0.0	100.0
Copper	Copper	10.8	1378	1999	4	WCT	0.0	0.0	100.0
Copper	Copper	1	4841	2016	1	WCTxRB?	0.0	0.0	0.0
Copper	Copper	3.4	4841	2016	19	WCTxRB?	0.0	0.0	0.0
Copper	Copper	10.8	4841	2016	19	WCTxRB?	0.0	0.0	0.0
Copper	Snowbank	0.1	4064	2009	23	WCT	0.0	0.0	100.0
Copper	Snowbank	0.4	4841	2016	12	WCTxRB?	0.0	0.0	0.0
Copper	Snowbank	0.4	4893	2017	10	WCTxRB?	0.0	0.0	0.0
Copper	Copper	1.0	4893	2017	16	WCTxRB?	0.0	0.0	0.0
Copper	Copper	3.4	4893	2017	15	WCTxRB?	0.0	0.0	0.0
Copper	Copper	10.3	4893	2017	15	WCTxRB?	0.0	0.0	0.0
Douglas	Cottonwood	9.3	4894	2017	30	WCT	0.0	0.0	100.0
Douglas	Cottonwood	11.5	4894	2017					
Dunham	Dunham	2.3	2881	2000	10	WCT	0.0	0.0	100.0
Dunham	Dunham	2.3	2881	2002	10	WCT	0.0	0.0	100.0
Dunham	Dunham	4.2	2881	2002	10	WCT	0.0	0.0	100.0
Dunham	Dunham	5.0	4895	2017	15	WCTxRB	3.4	0.0	96.6
Dunham	Dunham	7.0	4895	2017	15				
Keep Cool	Stonewall	4.4	250	1988	10	WCT	0.0	0.0	100.0
Keep Cool	Stonewall	0.65	4838	2014	4	WCT	0.0	0.0	100.0
Keep Cool	Stonewall	3	4838	2014	4	WCT	0.0	0.0	100.0
Keep Cool	Stonewall	4.7	4838	2014	10	WCT	0.0	0.0	100.0
Keep Cool	Stonewall	5.2	4838	2014	16	WCT	0.0	0.0	100.0

Drainage	Stream name	Stream mile	Lab Report #	Year	n	Taxa ID	RB %	YCT %	WCT %
Table 1 continued									
Keep Cool	Stonewall	5.7	4838	2014	8	WCT	0.0	0.0	100.0
Keep Cool	Stonewall	ditch	4838	2014	8	WCT	0.0	0.0	100.0
Lander's	Indian Meadows	0.4	4700	2014	24	WCT	0.0	0.0	100.0
Lander's	Lander's Fork	11.3	595	1991	11	WCT	0.0	0.0	100.0
Lander's	Lander's Fork	0.1	1372	1999	2	WCT	0.0	0.0	100.0
Lander's	Lander's Fork	4.6	1374	1999	1	WCT	0.0	0.0	100.0
Lander's	Lander's Fork	8.1	1373	1999	5	WCT	0.0	0.0	100.0
Lander's	Lander's Fork	18.1	4840	2015	20	WCT	0.0	0.0	100.0
Lander's	Lander's Fork	9.2	4896	2017	30	WCTxRB	0.3	0.0	99.7
Sauerkraut	Sauerkraut	2.9	4897	2017	15	WCTxRB	0.3	0.0	99.7
Sauerkraut	Sauerkraut	3.2	4897	2017	15				

If feasible, FWP prefers to use local aboriginal stocks of WCT as donor sources for the North Fork Blackfoot River restoration project, adopting a "nearest neighbor" concept for the North Fork restoration effort (Clark and Evans 1954; Ruiz and Peterson 2007; Prugh 2009). However, options of using the existing captive WCT brood population at Montana Washoe Park Hatchery (termed M012 stock) as a donor, or some combination of wild and captive donor sources will also be evaluated. One of the primary criteria for a population to be selected as a donor source population is that there is no evidence of hybridization in the population, or in any of the donor individuals.

WCT exhibit migratory and resident life histories within the Blackfoot River basin, both of which are often present in the same tributary population (Rieman and Dunham 2000; Pierce et al 2007; 2014a). Migratory WCT in the main stem Blackfoot River reproduce in tributaries that are connected during spring runoff. Major tributaries that neighbor the North Fork Blackfoot River project area, which include Copper, Arrastra, and Dunham creeks, are known to support river spawning WCT migrants (Figure 4). Elsewhere in the upper Blackfoot River watershed, resident WCT occupy headwaters tributaries, such as Stonewall, Sauerkraut and Cottonwood creeks (Figure 2), where intensive agricultural activities, natural intermittent reaches, and competitive interactions with nonnative Brown Trout *Salmo trutta* and Brook Trout *Salvelinus fontinalis* tend to isolate/segregate resident WCT in the headwaters reaches (Pierce and Podner 2016). Of the possible donor streams considered for the North Fork project, the Lander's Fork upstream of Silver King Falls represents the only known physically isolated WCT population upstream of a natural waterfall barrier.

Disease Sampling in the Blackfoot River Watershed

Moving fish or gametes brings the risk of transferring pathogens and aquatic invasive species (AIS), and addressing these concerns is challenging. Often, standard bio-security practices are not practical or feasible for a variety of reasons. Standard hatchery practices including iodophore disinfection, and spawning and transporting eggs in secure water, will help reduce but not eliminate these risks to both hatchery fish and wild populations. Translocation efforts must balance the likely risks relative to the overall benefit of the project. With projects that yield high conservation value, slight deviations from normal procedures may be acceptable. The challenge is to use the best available tools to adequately understand and minimize the disease risks to a point where they become ecologically and socially acceptable.

The standard disease panel for testing translocation includes: 1) *Aeromonas salmonicida*, which is the bacteria that causes Furunculosis, 2) infectious hematopoietic necrosis virus, 3) infectious pancreatic necrosis virus, 4) viral hemorrhagic septicemia virus, 5) *Renicterium salmoninarum*, the bacterium that causes bacterial kidney disease, and 6) *Myxobolus cerebralis*, which is the parasite that causes salmonid whirling disease.

Testing fish for pathogens requires sacrificing fish. A sample size of 60 fish provides 95% confidence in identifying the presence of pathogens in the population, assuming a 5% infection rate (AFS-FHS 2014), and this level of testing is consistent with FWP Fish Health Policy (FWP 2004). Results of pathogen screening will be used in the risk assessments that will consider the various options available. In small streams with low population densities, sacrificing 60 fish may be an unacceptable level of mortality to the donor population. Balancing certainty in preventing spread of fish pathogens, relative to an acceptable decrease in donor population size, requires decision-making informed by professional judgment, social acceptability of the selected option, and conservation benefit.

When possible, testing of surrogate species provides a means to identify the presence of pathogens within the local salmonid community without sacrificing donors. Examples of surrogates are sympatric Brook Trout or Rainbow Trout collected downstream of a barrier in the same stream. Proximity to the donor source is an important consideration, as the potential for pathogens to be similar among groups of fish decreases with distance between groups. When using surrogates, managers must make assumptions regarding the potential variability in susceptibility of the surrogates to the pathogens of concern, and risks of spreading pathogens. The scientific literature may assist in evaluating risk; however, variability in susceptibility of other salmonids to all potential pathogens is currently unclear. Again, decision-making requires a balance between an acceptable level of risk and conservation benefit.

Several factors influence the risk of transferring pathogens and AIS with translocation of fish or gametes. The movement of gametes is preferred over the translocation of fish from the wild because it significantly reduces the risk of moving most pathogens and AIS. Nevertheless, transmission of fish pathogens from parent to offspring within the gametes, known as vertical transmission, is possible for some (e.g., viral) pathogens. Although pathogens most often are present in eggs, vertical transmission in sperm is possible in some cases. Pathogens not believed

to be vertically transmitted include *M. cerebralis* and most bacteria. Nevertheless, bacterial kidney disease and most salmonid viruses are all believed to be capable of vertical transmission. Therefore, moving gametes presents less of a risk of moving pathogens and AIS, although there is still some risk of spreading some fish diseases when moving gametes. Screening donor fish or surrogates will inform decision-making; however, as described above, the level of certainty will be influenced by the acceptable level of mortality of donors or assumptions made regarding susceptibility of surrogate species to a given pathogen.

Generally, fish that occur higher in the drainage are less likely to become infected with *R. salmoninarum* and *M. cerebralis.* For example, no pathogens were found in the South Fork Flathead River drainage during pathogen testing associated with the development of brood stock. However, *R. salmoninarum* was detected in streams initially considered as potential donors for the Cherry Creek project. As a result, fish from these streams were rejected as potential donors. Collecting donor fish or gametes from headwater areas of streams tends to be slightly more efficient because of smaller stream size and reduced risk for spreading pathogens.

The use of the FWP hatchery system, including isolation buildings, is another consideration in determining the acceptable level of risk involved. Currently, the logistics of where in the hatchery system fish or eggs may be moved is uncertain. An isolation facility has been proposed for Washoe Park Hatchery, but not constructed, and policies that will guide its use have not yet been developed. Therefore, it is currently difficult to predict where isolation facilities might be available that could incubate or rear wild-origin fish. In the past, live fish were brought into the Sekokini Springs isolation facility from the South Fork Flathead River, and a private individual constructed and operated a hatching and rearing facility totally separate from Montana FWP's captive facilities for the Cherry Creek project.

In summary, reducing risk of potential pathogen transfer to the lowest possible level, while fully considering the tradeoffs and benefits involved, requires informed decision-making.

Approaches to reduce disease risk include movement of gametes rather than live fish whenever possible, testing of donor sources as much as is practical or feasible, and minimizing the proximity and risk to hatchery fish. The FWP Aquatic Health Advisory Committee reviews all proposals to translocate fish and the final decision lies with the FWP Fisheries Chief.

Whirling Disease in the Blackfoot River Basin

Myxobolus cerebralis, the parasite that causes whirling disease, is widespread throughout waters in the lower elevations of the Blackfoot River watershed and its presence will limit available "nearest neighbor" donor stocks that could be used in the North Fork restoration project. *M. cerebralis*, infects six known genera of salmonids, including the genus

Oncorhynchus, which includes WCT. Following the detection of *M. cerebralis* in the Blackfoot River watershed in 1995, FWP began monitoring the expanding range of *M. cerebralis* using exposures of hatchery Rainbow Trout as surrogates for infection in wild fish. Monitoring from

1998 through 2010 identified the rapid range expansion of *M. cerebralis* among low-elevation, sediment-enriched streams of Blackfoot River watershed (Pierce et al 2009, 2011, 2012, 2014b).

Because *M. cerebralis* infection rates varies among tributaries, parameters measuring stream and basin morphology and fine sediment levels were combined with whirling disease testing to develop a predictive model to identify streams environments conducive to *M. cerebralis* (Eby et al. 2015). This study reported higher whirling disease risks for gently sloping alluvial valleys and spring creeks in the Blackfoot River basin. For basin-fed tributaries, the landscape variables of valley slope and forest cover were the best indicators of fine sediment, which provides suitable habitat for *Tubifex tubifex*, the intermediary worm host of *M. cerebralis*. Based on these studies, *M. cerebralis* is likely to be present in low elevation streams that flow through low-gradient alluvial valleys, as well as those streams with strong groundwater influence, elevated levels of fine anthropogenic sediment, or some combination thereof. Conversely, high gradient, higher elevation rocky streams with low sediment, cold water and forested drainages are less likely to support *M. cerebralis* (Figure 5).

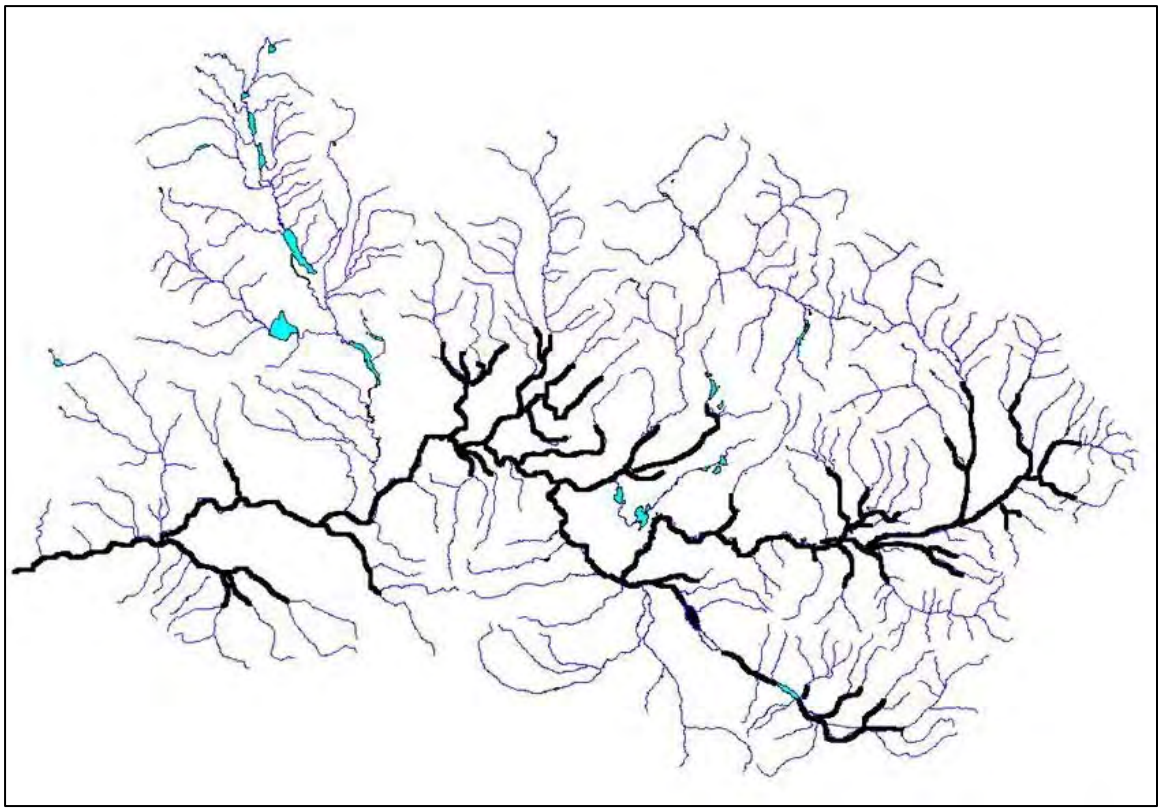

Figure 5. Generalized distribution of *Myxobolus cerebralis* distribution (black lines) based on field sampling and predictive modeling (Pierce and Podner 2011, Eby et al. 2015).

The presence of *M. cerebralis* and other pathogens will influence the selection of wild donor WCT stocks, especially if wild donor fish need to be brought into a hatchery facility.

Identification of nonhybridized populations of WCT in streams that are likely to be free of pathogens is the initial screen for selection of potential donor stocks, although pathogen testing is still necessary as part of risk management and due diligence. *M. cerebralis* distribution research indicates low-elevation streams from the foothills to the valley floor have a higher risk of harboring this organism (Eby et al. 2015). Pathogen testing of seven streams that support potential WCT donor populations occurred in 2017 (Figure 6 and Table 2).

Table 2. Genetic test results (SNPs), adult WCT abundance estimates and disease test results for seven streams that are being considered as possible donor populations (RB = Rainbow Trout; YCT = Yellowstone Cutthroat Trout).

Source Name	Genetic sample size	He	Genetic sample year	Evidence of hybridization	Estimated populaton size (age 1+)	Estimated number of adults	Disease/pathogens present
Arrastra Creek	30	0.147	2017	May have very low (< 1%z0 RB, but might be deviant	2223	447	None detected
Copper/Snowbank Creek	63	0.146	2016	RB possible, but lots of uncertainty	5418	1083	None detected
Copper/Snowbank Creek	56	0.145	2017	RB possible, but lots of uncertainty			
Cottonwood Creek	30	0.140	2017	None	5322	1064	*M. cerebralis* present
Dunham Creek	30	N/A	2017	RB detected, bu nonrandom so not all a hybrid swarm	1837	367	None detected
Lander's Fork (mile 18.1)	20	0.094	2015	None in sample, but RB and YCT stocked	6760	367	*M. cerebralis* present
Lander's Fork (mile 9.2)	30	0.098	2016	Hybrid swarm with slight (0.3%) RB			
Stonewall Creek	60	0.138	2014	None	1777	235	None detected
Sauerkraut Creek	30	0.134	2017	Rainbow slight (0.3%)	4292	858	None detected
Washoe Park Hatchery (M012)		0.127	2013	None	NA	NA	None detetected

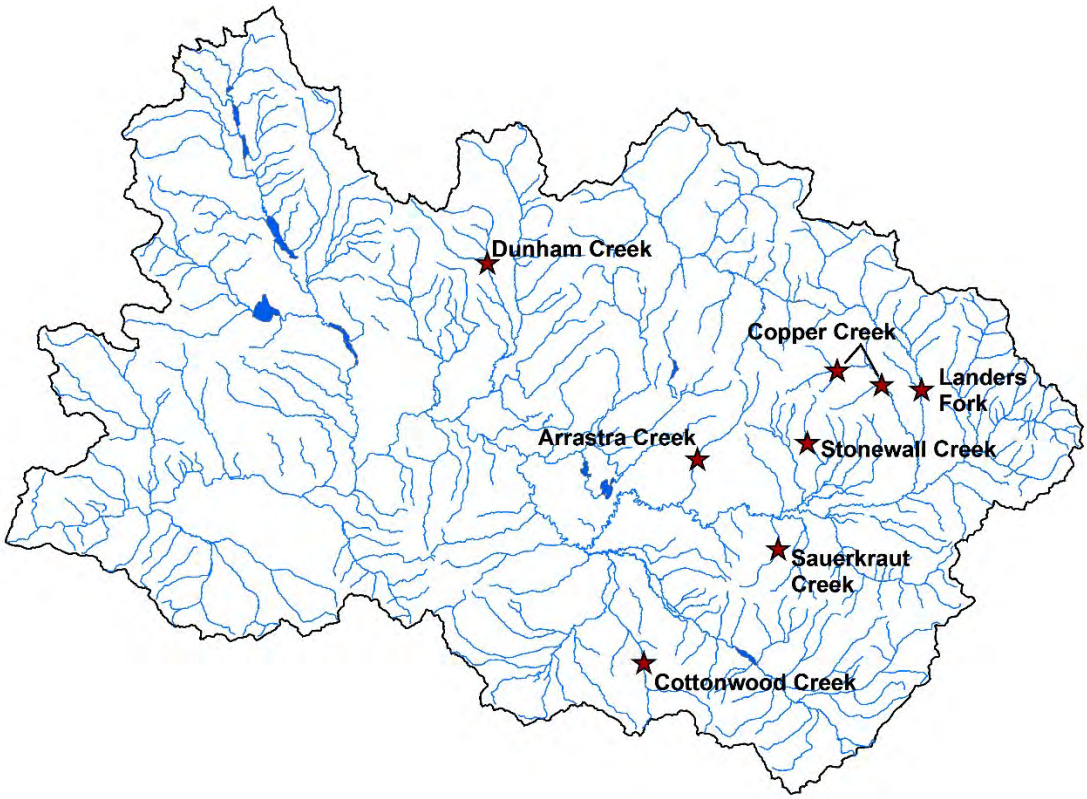

Figure 6. Locations of pathogen testing sites completed in 2017 for seven possible donor populations that support nonhybridized WCT. Additional genetic samples were also taken at/near these locations in 2017. Disease testing results are summarized in Table 2.

Decision Tree

This decision tree will help managers decide what donor sources will be used, what life-stages will be released, and the methods of release. In addition, if eradication treatments are successful, fewer non-hybrid fish or embryos would need to be translocated to the project area than if total eradication was unsuccessful, because there would be no need to "genetically swamp" the remaining population that would retain a small number of hybridized individuals. We organized the time-flow of decisions in a dichotomous key and show the likely flow of these decisions and how different decisions are linked to each other (Figure 7).

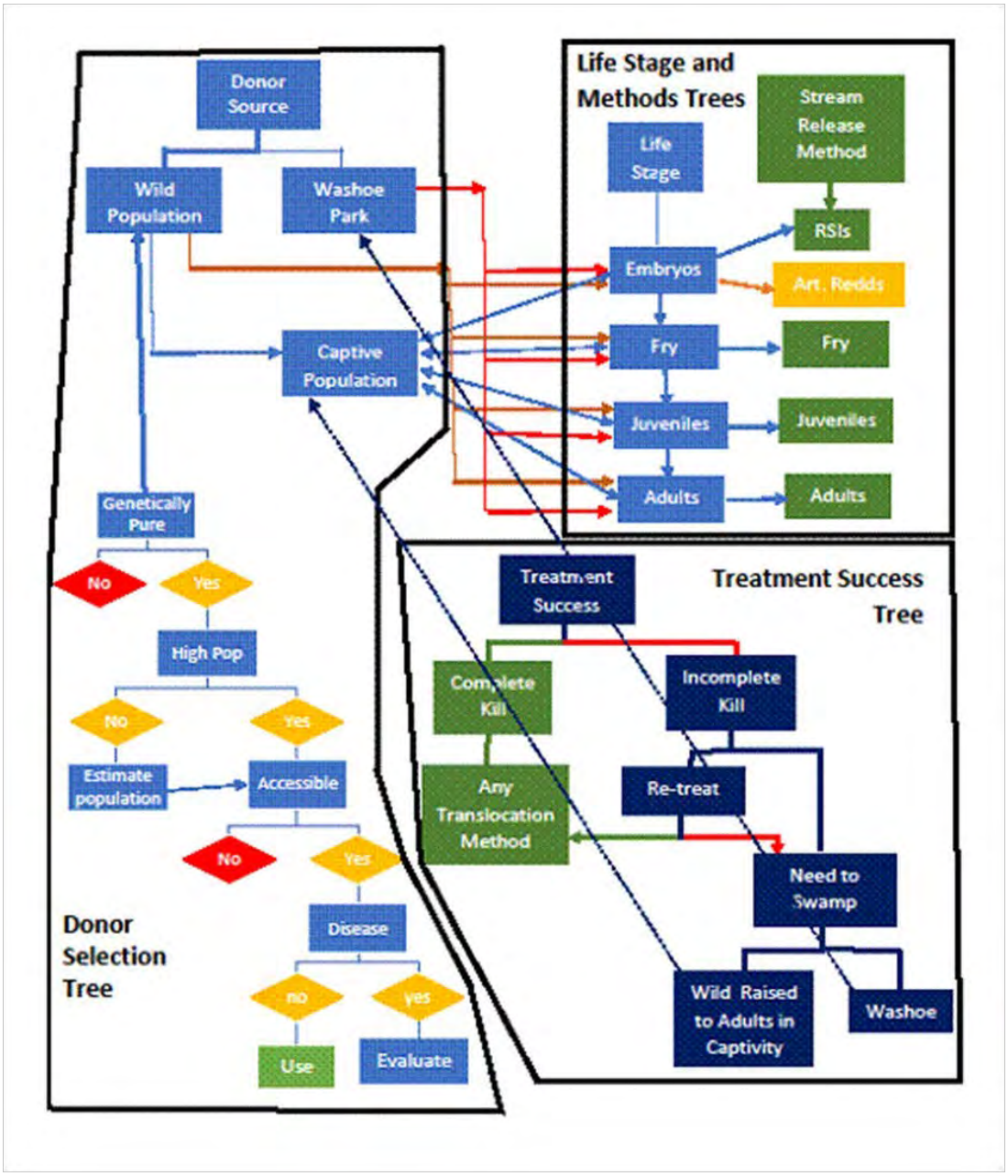

Figure 7. Decision tree conceptual model showing sub-trees for donor selection, life-stage and methods, and treatment success and linkages among these sub-trees.

Treatment Success

Treatment success decisions can be made for each geographic area and probably should be segregated for mountain lakes or streams, as eradication success may be different in these two types of waters. In addition, eradication may be more difficult in stream segments with beaver ponds, complex habitats, and off-channel water sources.

1. Treatments totally eradicate nonnative trout or hybridized trout.
    a. Yes – go to 3.
    b. No – go to 2.
2. Re-treat areas where nonnative trout persist
    a. Yes – go to 1.
    b. No – go to 3, acknowledge that nonnative fish or genes still exist in restoration area.

Selection of Donor Source(s)

The decision regarding which donor source to use will depend on whether any nonnative fish remain in the treatment areas, in addition to the considerations of disease, genetic status and risk of introgression, and population donor size described above. If nonnative fish remain, managers may decide they need to release relatively high numbers of nonhybridized WCT to swamp out nonnative genes. In this case, captive brood will need to be used to increase egg production from each female. Either the current Washoe Park captive brood or nonhybridized wild WCT from nearby populations that are brought into a captive facility, and raised to maturity, could be used to increase the numbers of progeny released into the treatment areas. 3. Wild donor source has no evidence of genetic introgression

    a. Yes – go to 4
    b. No - Wild source inappropriate as donor but may be able to use individual fish as donors with adequate genetic testing.

4. Wild donor source has no evidence of pathogens
    a. Yes – go to 5
    b. No – may be possible to collect gametes at donor stream and treat fertilized eggs during their water-hardening phase to prevent pathogen transmission. Montana FWP Aquatic Health Advisory Committee determines that pathogen risk is acceptable, given the translocation method and level of pathogen testing.
    If so, go to 5. If not, the population is inappropriate to use as a donor.

5. Wild donor source population is large enough to allow removal of gametes (see Table

    2 for initial screen)

a. Yes – go to 6

b. No – Wild source inappropriate as donor but may be able to remove a low number of fish or gametes.

6. Donor stream is accessible to collect fish or to spawn mature adults

    a. Yes – POTENTIAL DONOR – go to 7

    b. No – Stream may not be used as donor source unless fish or gametes can be collected.

7. Treatments totally eradicate nonnative trout

    a. Yes – POTENTIAL WILD DONORS can be used directly from wild, and managers can also opt to use Washoe Park donors – go to 9
    b. No – go to 8

8. May need to use captive fish

    a. Bring wild fish into captivity, most likely the Sekokini Springs Hatchery, and hold to adults (this effort will require one to three additional years until sexually mature) – go to 9
    b. Use Washoe Park as donor source – go to 9

Life-Stage(s) and Methods for Release

Managers will need to decide what life-stage(s) of fish they want to release into the treatment area or bring into captivity. Selection of which life-stage(s) that is/are to be released into the treatment area dictates the release method. For instance, releasing eyed embryos will require the use of RSIs and the need for isolated incubation facilities. We recommend that releases be conducted for at least 3 years following the last piscicide treatment in each treatment area. Releases can be made in consecutive years, or any combination of 3 years over a 5-year period, which is a typical generation for WCT. This recommendation should allow all or most yearclasses of WCT to quickly reside within the restoration area.

9. Determine what life-stage to release into treatment area

    a. Eyed-eggs – go to 10

    b. Fry – go to 12

    c. Juveniles – go to 12

d. Adults – go to 12

10. Equalize contributions from each parental pair as much as feasible

    a. Low numbers of eyed-eggs for a pair – use and do not count for genetic diversity contribution – go to 11
    b. High numbers of eyed-eggs for a pair – go to 11

11. Method for release of eyed-eggs

    a. RSIs – recommended method

    b. Artificial redds

12. Release fry, juveniles, or adults directly into treatment area release locations. Equalize number from each parental pair as much as feasible. (Note: For captive wild populations, may want to restrict releases to embryos or fed-fry to limit hatchery selection.)

Options for Donor Sources for Translocations

Option 1 – Replication of Local Stocks Using Nearest Neighbor Concept
Five major nearest neighbor drainages were examined for their potential as donor stocks. Lander's Fork, Copper, Stonewall, Arrastra and Dunham creeks are all located north of the Blackfoot River within the same mountain range as the North Fork Blackfoot River (Tables 1 and 2; Figure 4). Drainages on the south of the Blackfoot River (e.g., Cottonwood and Sauerkraut) support nonhybridized WCT (Tables 1 and 2); however, these populations are more distant and are in a different mountain range, which may change selection pressures (Figure 4).

Basin-wide, long-term analyses of the genetic status of *Oncorhynchus* in the Blackfoot River watershed was used to screen seven potential donor streams (Figure 4 and Table 1). Genetic testing in potential donor streams began in the late 1980s and continued through 2017 (Tables 1 and 2). Many of these genetic surveys have additional longitudinal coverage within a stream, allowing inference on potential spatial differences in genetic status within a stream. In addition to genetic and disease status, we considered whether a population could sustain removal of adult fish based on abundance of the population (Table 2) and the relative ease of accessibility to collect gametes and/or fish for each potential donor stream (Table 3).

Table 3: Relative ease of access to collect eggs and sperm (gametes) from adult fish during the spawning season and for collecting fish during the summer at low flow, and ease of collecting these from throughout the existing population by stream.

	Ease of collecting gametes of live fish (easy, moderate, hard)		Ease of collecting games or live fish from throughout the existing population (easy, medium, hard)	
Source Name	**Gametes**	**Live fish**	**Gametes**	**Live fish**
Arrastra Creek	moderate	easy	hard	easy
Copper/Snowbank Creek	hard	easy	hard	moderate
Copper/Snowbank Creek				
Cottonwood Creek	easy	easy	easy	easy
Dunham Creek	hard	easy	hard	moderate
Lander's Fork (Mile 18.1)	hard	easy	hard	hard
Lander's Fork (Mile 9.2)			hard	moderate
Stonewall Creek	hard	easy	hard	moderate
Sauerkraut Creek	easy	easy	moderate	easy

Potential Wild Donor Sources and Decision Tree Screening

All seven of the potential wild WCT donor sources were screened using current genetic analysis techniques. The relatively large samples sizes combined with the development of more advanced testing methodologies produces more genetic markers with relatively high statistical power to detect admixture (Allendorf and Leary 1988; Ostberg and Rodriguez 2004; Amish et al. 2012). Unfortunately, we know that genetic marker, which is normally diagnostic of Rainbow Trout, can be potentially related to a suspected polymorphism in nonhybridized WCT (Leary et al. 2016). Generally, if this Rainbow Trout diagnostic marker is the only marker diagnostic for Rainbow Trout in the entire sample and other no other diagnostic markers show evidence of Rainbow Trout, an assumption is made that the sample is not hybridized with a lower statistical power.

Genetic testing indicated that most potential WCT donor populations had relatively high values for expected heterozygosity, except for the population in Lander's Fork (Table 2). Disease screening, estimates of population abundance, assessments of hybridization, and relative ease of access to collect gametes or fish from throughout the existing populations have also been done for all potential donor sources (Tables 2 and 3). These data were used to screen each potential donor source using the decision tree criteria.

Arrastra Creek

Due to its proximity to the North Fork Blackfoot River basin, the WCT population in Arrastra Creek could be considered as a relatively near neighbor. Arrastra Creek was planted with Rainbow Trout from 1933 through 1969 and genetic data indicate that one marker had low levels of an allele characteristic of Rainbow Trout (1.6%), but other diagnostic markers did not (Table 2; Whiteley et al. 2017). Geneticists recommended that the WCT population in Arrastra Creek be conserved, but suggested it not be used as a donor source unless additional genetic testing was done (Whiteley et al. 2017). Decision tree criteria for the WCT population in Arrastra Creek are: 1) possible very slight hybridization; 2) no evidence of disease; 3) moderately abundant population that could withstand some fish or gametes being removed, and 4) the accessibility of the stream is difficult for collection of gametes, but easy to collection of fish (Tables 2 and 3). Since the WCT population in Arrastra Creek has these decision tree criteria, the population should be considered as a donor source, but additional genetic testing needs to be done either at the time fish or gametes are collected, or prior to collecting fish or gametes, to confirm there is no evidence of hybridization. Since the estimated abundance of adult WCT is slightly below 500, fish could be collected (or spawned) annually over several years to reduce impacts to the donor population. Due to the difficult access to collect gametes (Table 3), live fish may need to be collected, moved to a captive facility, and held or reared until they mature, so their gametes/progeny could be translocated to the North Fork project area.

Copper Creek

Due to its proximity to the North Fork Blackfoot River basin, the WCT population in the Copper Creek basin could be considered as a relatively near neighbor. The Copper Creek drainage supports resident as well as a migratory WCT, including adult fish that oversummer and overwinter in the upper Blackfoot River (Pierce et al. 2007; Pierce and Podner 2013). The Copper Creek watershed has a history of fish stocking that makes some level of introgression likely. It was stocked with undifferentiated cutthroat trout from 1940 through 1952. In addition, Copper Lake was planted with Rainbow Trout in 1954, and Snowbank Lake was planted with Rainbow Trout in 1963 and 1989.

Genetic analyses of fish captured in Copper Creek and its tributary, Snowbank Creek, (n = 63 in 2016; n = 56 in 2017) revealed evidence for intra-basin gene flow and uncertainty about whether there was a very small amount of hybridization with Rainbow Trout, or not (Tables 1 and 2). The most recent genetic analyses of WCT from Copper and Snowbank creeks clearly suggest that gene flow has likely occurred between these streams and probably with fish from the main Blackfoot River (Leary et al. 2016; Whiteley et al. 2017). Genetic tests specifically examining WCT in Snowbank Creek in 2009, thirty years after the cessation of stocking, found no evidence of Rainbow Trout markers. Nevertheless, genetic analyses of the 2017 sample indicate low levels

of Rainbow Trout admixture within WCT from Copper Creek. Decision tree criteria for the WCT population in Copper/Snowbank creeks are: 1) possible very slight hybridization; 2) no evidence of disease; 3) an abundant population that could withstand some fish or gametes being removed, and 4) access to the stream to collect gametes is hard, but easy to moderate to collect live fish. Since the WCT population in Copper Creek basin has these decision tree criteria, the population should be considered as a donor source, but additional genetic testing needs to be done at the time fish or gametes are collected to confirm there is no evidence of hybridization in translocated fish. We believe that enough genetic samples have been collected over a long enough time to document the genetic status of WCT in the Copper Creek basin. Due to the difficult access to collect gametes (Table 3), live fish may need to be collected, brought into a captive facility, genetically tested to confirm they have no evidence of hybridization, reared until they are mature, and their gametes/progeny used for the North Fork project.

Cottonwood Creek

Cottonwood Creek is a tributary to the upper Blackfoot River, but it cannot be considered as a nearest neighbor stream compared to some of the other streams. Genetic samples obtained from WCT collected from three areas in Cottonwood Creek during 2017 had no evidence of hybridization (Table 2). An older sample from a “Cottonwood Creek” obtained in 1987 did show evidence of Rainbow Trout hybridization (Whiteley et al. 2017), but this Cottonwood Creek was most likely not the Cottonwood Creek in the Blackfoot River basin (R. Pierce, personal observation). Since genetic analyses completed in both 2000 and 2017 in the Blackfoot River basin’s Cottonwood Creek found only genes diagnostic for WCT, we consider this WCT to have no evidence of hybridization (Tables 1 and 2).

Genetic data from the 2017 samples taken at three locations in Cottonwood Creek indicated that WCT from all three locations were similar enough to be considered as one panmictic population (Whitelely et al. 2017). Decision tree criteria for the WCT population in Cottonwood Creek are: 1) no evidence of hybridization; 2) evidence of whirling disease; 3) abundant population that could withstand some fish or gametes being removed, and 4) good accessibility to the stream to collect fish or gametes. The presence of whirling disease in Cottonwood Creek reduces its suitability as a WCT donor; however, if gametes are collected, especially if gamete collection is restricted to the headwater areas, the risk of disease transmission may be manageable. Since access to Cottonwood Creek for collecting gametes from throughout the existing WCT population is easy, we suggest that this method may be preferred to reduce risk of transferring whirling disease.

Dunham Creek

Dunham Creek's location in the middle portion of the Blackfoot River basin indicates that the WCT population in this stream should not be considered as a nearest neighbor. The Dunham Creek drainage supports resident as well as a migratory WCT, including adult fish that oversummer and overwinter in the middle Blackfoot River (Schmetterling 2001). There are no known fish barriers in Dunham Creek. Dunham Creek was planted with Rainbow Trout once in 1949. Recent genetic data suggest that the WCT population in Dunham Creek consists of a hybrid swarm that has been slightly hybridized with Rainbow Trout along with some individual fish that have been more recently hybridized with Rainbow Trout and contain relatively high admixture (Whiteley et al. 2017). Since the WCT population in Dunham Creek appears to be made up of individuals that all have evidence of some hybridization with Rainbow Trout, Dunham Creek is probably inappropriate to use as a donor source.

Lander's Fork

Due to the Lander's Fork's proximity to the North Fork Blackfoot River basin, the WCT population in the Lander's Fork basin could be considered as a relatively near neighbor. The Lander's Fork appears to support a relatively large isolated population of aboriginal WCT upstream of Silver King Falls that appears to have very low levels (0.3%) of Rainbow Trout hybridization (Tables 1 and 2; Figure 4). The relatively large population of WCT in the Lander's Fork is due to large amount of suitable and occupied habitat in this basin. The main stem of the Lander's Fork was stocked once in 1937 with Rainbow Trout, although records suggest this planting probably occurred downstream of Silver King Falls. Big Horn Lake, located in the headwaters of the drainage and above Silver King Falls, was stocked in 1952 with undifferentiated cutthroat trout, which have now been confirmed by genetic testing as

Yellowstone Cutthroat Trout (Table 1). Although there are no records of Rainbow Trout stocking in Big Horn Lake, genetic testing of fish sampled from Big Horn Lake and Big Horn Creek have detected low levels of Rainbow Trout admixture, which suggests that historical stocking of Rainbow Trout likely occurred, as well as the known stocking of Yellowstone Cutthroat Trout.

Although genetic testing of WCT sampled in the Lander's Fork before 2015 indicated no introgression (Leary et al. 2016), testing of 30 fish captured in 2016 near mile 9.2 found that this sample was from a hybrid swarm with a low proportion of Rainbow Trout (0.3%; Whiteley et al. 2017). This result makes some sense, given the likely presence of Yellowstone Cutthroat Trout and Rainbow Trout in some headwater areas (Tables 1 and 2, Figure 4). Only nonhybridized WCT were found in 20 WCT sampled from the headwaters area of Lander's Fork (mile 18.1) during 2015. Consequently, the genetic status of the WCT population above Silver King Falls

remains unclear and it is possible that the headwaters area of the Lander's Fork may still support WCT that are not hybridized.

Decision tree criteria for the WCT population in Lander's Fork above Silver King Falls are: 1) likely very slight hybridization; 2) evidence of whirling disease; 3) an abundant population that could withstand some fish or gametes being removed, and 4) access to the stream for collecting gametes is difficult and access to collect live fish would be relatively easy near Silver King Falls, but difficult from the headwaters area. Since the WCT population in Lander's Fork above Silver King Falls has these decision tree criteria, the population probably should not be considered as a donor source, unless additional genetic testing of the headwaters portion of the population finds no evidence of hybridization and it is decided that the issue of difficult access to the headwaters area could be managed. If that is the case, additional genetic testing, and perhaps disease testing, could be conducted at the time fish or gametes are collected, to confirm there is no evidence of hybridization or disease in translocated fish or gametes.

Additionally, recent genetic samples for the main stem Lander's Fork upstream of Silver King Falls revealed WCT that contained little within population genetic divergence (Leary et al. 2016; Whiteley et al. 2017). WCT in the Lander's Fork were genetically distinct from WCT in the Keep Cool, Beaver, and Copper sub-basins (Leary et al. 2016). The level of genetic differentiation between Lander's Fork WCT and other WCT populations within the upper Blackfoot River basin was comparable to genetic differences observed between Blackfoot River basin WCT populations and WCT populations in other river basins in western Montana. Leary et al. (2016) suggested that the WCT population in the Lander's Fork upstream of Silver King Falls be considered as a single restoration and conservation unit for WCT.

Since the Lander's Fork WCT population appears unique, it should be conserved within its extant location. Additionally, if it can be shown that the headwaters portion of this WCT population has no evidence of hybridization, perhaps some WCT from this population should be moved elsewhere, so the evolutionary legacy of this unique group is conserved in another location. We are currently uncertain whether WCT from the Lander's Fork might be translocated anywhere due to both genetic and disease concerns; however, if additional information allows a decision to be made to move WCT from the headwaters area of Lander's Fork, it might be worth considering a translocation of these fish to a headwaters area of the North Fork Blackfoot River.

Though there are no isolating barriers within the North Fork project area, a headwater area within the North Fork Blackfoot River drainage may offer an opportunity for supporting a local population of genetically unique WCT, such as occurs in the Lander's Fork. If fish from any single WCT population is translocated to a headwater area within the North Fork Blackfoot River project area as a "replicate" translocation, no other donor stocks should be released in the same area. Ideally, there would be some physical isolation, either a complete or partial barrier,

between the potential release location for these unique fish in the North Fork project area and WCT translocated from other sources.

Stonewall Creek

Stonewall Creek, located in the headwaters of the Keep Cool drainage (Figure 4), is relatively close to the North Fork Blackfoot River and can be considered as a nearest neighbor. Some WCT from Stonewall Creek have been genetically tested and there is no evidence of hybridization, though the lower reaches of Keep Cool Creek and Beaver Creek near the town of Lincoln were planted with Rainbow Trout between 1937 and 1946.

Currently, the headwater streams within of the greater Keep Cool Creek drainage support connected as well as isolated/segregated resident WCT populations (Pierce et al. 2016, Figure 4). Despite the generally segregated nature of these populations, genetic analyses suggested that substantial gene flow has likely occurred among many streams within the drainage (Table 1). Genetic analyses have detected only WCT alleles in fish sampled from most of the small streams in the drainage; however, most samples were small (n = < 10), which had a low power to detect hybridization compared to current techniques. More recent sampling found indications of Rainbow Trout alleles in western and eastern portions of the Beaver Creek drainage. Though there are no stocking records in the area, these genetic results indicate that Rainbow Trout may have been stocked in nearby lakes.

Stonewall Creek is a strong candidate as a donor stream for the North Fork Blackfoot River restoration project. Stonewall Creek is one of the larger streams in drainage, has no connected lakes, no record of Rainbow Trout stocking, supports genetically unaltered WCT, and is spatially separated from potentially introgressed populations within the drainage. Genetic samples from 2014 provide robust evidence that Stonewall Creek is a suitable donor stream (Tables 1 and 2; Leary et al. 2016). Decision tree criteria for the WCT population in Stonewall Creek are: 1) no evidence of hybridization; 2) no evidence of disease; 3) a moderately abundant population that could withstand some fish or gametes being removed, and 4) poor accessibility to the stream to collect gametes, but easy to moderate access to collect live fish. Stonewall Creek appears to be suitable as a donor source and live fish may need to be collected due to the difficult access to collect gametes. Since there is no evidence of fish diseases in Stonewall Creek, collection of live fish should be possible. The estimated moderate abundance of fish in this WCT population (<

2,000 total fish and just over 200 adults), suggests that a few (25 to 50) live adult fish may need to be collected over several years from several different locations to limit impacts of fish removal on this population. Alternatively, higher numbers of juvenile WCT could be collected and reared to maturity in an isolation hatchery and their progeny (either embryos or fish) translocated to the North Fork project area.

Sauerkraut Creek

Sauerkraut Creek is within the upper Blackfoot River watershed, but since it enters the river from the south side it cannot be considered as a nearest neighbor stream compared to some of the other streams. Genetic samples were collected from WCT at two locations in Sauerkraut Creek in 2017 and genetic analyses indicated that these two samples were likely from a single population (Whiteley et al. 2017). These genetic samples indicated that these fish were likely from a hybrid swarm between WCT and Rainbow Trout; however, since Rainbow Trout contributed only about 0.3% of the alleles and there was a low number of Rainbow Trout alleles present, the conclusion that this population represents a hybrid swarm is somewhat uncertain (Whiteley et al. 2017). Decision tree criteria for the WCT population in Sauerkraut Creek are: 1) evidence of slight Rainbow Trout hybridization (0.3%) and possible evidence that it is a hybrid swarm; 2) no evidence of disease; 3) an abundant population that could withstand some fish or gametes being removed, and 4) easy accessibility to the stream to collect gametes and live fish. Based on these decision tree criteria Sauerkraut Creek could only be considered as a donor source if additional genetic testing was done either at the time gametes or live fish were collected or prior to collecting fish or gametes to exclude any fish that had any evidence of Rainbow Trout hybridization.

Summary of Wild Source Decision Tree Results

Two streams, Cottonwood and Stonewall creeks, have WCT populations with no evidence of any hybridization with either Rainbow Trout or Yellowstone Cutthroat Trout. Whirling disease has been detected in Cottonwood Creek, but not in Stonewall Creek. We suggest that gametes can be collected from Cottonwood Creek because this stream is accessible during the spawning season and this method will reduce the risk of transferring whirling disease. We suggest that live juvenile fish can be taken from Stonewall Creek because access to this stream to collect spawning adults would be very difficult. Cottonwood Creek has an abundant population of WCT, so removing WCT gametes from several locations in this stream should be feasible and could be done annually over several years. The WCT population in Stonewall Creek is less abundant than the population in Cottonwood Creek, so we suggest that about 25 live fish be taken from several locations each year in Stonewall Creek, and that these live fish be collected over several years. Juvenile WCT from Stonewall Creek could be collected and reared to maturity in an isolation hatchery and their progeny (either embryos or fish) translocated to the North Fork project area.

Several streams (Arrastra, Copper/Snowbank, and Sauerkraut creeks, and the upper Lander's Fork) have very low levels of detected hybridization and there is uncertainty about whether WCT populations in some of these streams are hybrid swarms or whether individuals with no evidence of hybridization are present. Since whirling disease has been documented in the Lander's Fork, we suggest removing this stream from consideration as a donor because it would be too hard to

collect gametes from the headwaters of this stream. If additional sampling for disease near the headwaters of the Lander's Fork failed to detect any diseases, this area might be re-considered as a donor. Since whirling disease has not been detected in the other streams, they remain as potential donors if additional genetic analyses identify individuals with no evidence of hybridization.

We suggest that additional genetic sampling could be done in Arrastra and Sauerkraut creeks to confirm the genetic status of these two populations if they are further considered as donor sources. We believe that enough genetic sampling has been done in WCT population in the Copper Creek basin. Genetic sampling in Arrastra and Sauerkraut creeks could be done immediately prior to, or at the time, fish are collected or spawned to confirm that no hybridization is detected in fish or gametes that would be translocated. It would be necessary to mark each individual or parental cross, so they could be discarded if genetic analyses indicated any evidence of hybridization (Carim et al. 2015; Leary et al. 2016).

Where there is uncertainty regarding the possibility of hybridization, it may be necessary to genetically test each wild donor individual to confirm that each fish used for the restoration project has no evidence of hybridization. Tissue samples (fin clips) could be taken at the time of their capture. Fish would then be marked with a unique tag (e.g., PIT tag) when tissue is collected for genetic analysis so that the genetic results can be matched for each fish. Fish with indications of hybridization would be culled. Egg lots from each spawning pair of wild adult fish will be accepted for translocation based on the results of genetic tests that show no evidence of hybridization in either of the parents. If genetic analyses show any evidence of hybridization in either parent, the egg lot would be destroyed. Embryos accepted for translocation could be released into the North Fork Blackfoot River project area using RSIs or reared in a captive facility. When live fish are collected, they will be held in a captive facility until genetic analyses determine whether each fish has any evidence of hybridization. After genetic testing verifies that no hybridization is present, live fish could either be released into the project area or incorporated into a captive population.

Considerations of Numbers of Individuals to Translocate

The numbers of translocated embryos or fish will depend on three primary factors. Most importantly, translocation must use enough founders to ensure the genetic diversity of the donor source population is reliably incorporated into the group of fish or gametes translocated to start the recipient population. Meeting this objective will require careful screening of donors from each population to ensure they capture as much genetic diversity as is present in the entire population as possible. Contributions from family groups should be equalized as much as feasible, so that all family groups, and thus the full complement of genetic diversity, are represented within the restoration project area. Secondly, if full eradication of fish currently

residing in the North Fork Blackfoot River project is not achieved, the numbers of translocated embryos or fish will need to be higher to swamp out nonnative genes (Leary et al. 2001; Todesco et al. 2016). In this case, the numbers of embryos or fish required to meet the objective of nonhybridized populations will depend on how many fish remain in the project area following the final piscicide treatment. The third factor relates to the population size that the recipient habitat can support. Based on the abundance of WCT in nearby reference streams, we conservatively estimate the North Fork project area can support about 75,000 age-1 and older WCT. This number approximates the potential population size and does not represent the number of fish that need to be translocated but provides a basis for planning hatchery/stocking needs.

Several studies have provided theoretical evidence for the effective population size (Ne) needed to maintain genetic diversity and allow populations to persist (Jamiesen and Allendorf 2013; Frankham et al. 2014). A minimum of 25 parental pairs (Jamiesen and Allendorf 2012), or preferably 50 parental pairs (Frankham et al. 2014), should be used from donor populations. Theoretically, an Ne of 50 will incorporate 99% of the source population's genetic diversity in terms of heterozygosity, but not necessarily the full complement of allelic diversity (Allendorf and Rieman 2001). Because of likely logistical constraints involving the collection of sexually mature fish, an Ne of at least 100 adults from each donor source is our ideal target for the North Fork Blackfoot River restoration project. Meeting this target would result in a minimum of 300 adults if three donor sources were used. Genetic monitoring will evaluate the degree of diversity in the translocated population and guide decisions whether to augment the population to increase genetic diversity after the initial translocations. A relatively small level of gene flow into a population can maintain substantial genetic variation (Jameison and Allendorf 2012).

Achieving the desired number fish for translocation, or more specifically the number of different family groups, can be accomplished by capturing donors from source populations over several years. Assuming full eradication, gametes or fish can be removed for one year, or over several years. If gametes are collected over the course of more than one year from the same stream reach, each donor adult should be marked to ensure its gametes are collected only once. Furthermore, collecting fish from different locations should reduce or avoid the chances of collecting full siblings. The number of collection events has not been determined for the North Fork project; however, removing gametes or fish over several years with a lower proportion of the adult population removed each year, rather than collecting all the donors in one year is recommended.

It will be necessary to obtain a reasonable estimate of the number of mature adults within each potential donor population to ensure that removal of fish or gametes for translocation will not significantly deplete a donor population. The maximum proportion of the adult or total

population that could be removed during any year (i.e., 10 to 20%) should be established to limit impacts on each donor population.

Progeny of donor adults or donor fish should be tracked by parental pairs to equalize, to the extent practical, the number of progeny released from each parental pair. Equalizing parental pair contributions will reduce the potential for a few parental pairs contributing a disproportionately high number of progeny and reducing overall genetic diversity of translocated donor sources. Often, a few parental crosses will result in relatively few offspring for a variety of reasons. In these cases, we suggest using these progeny, but managers need to understand that these crosses will be under-represented in the restoration population. Post-release genetic sampling will document whether post-release survival was different enough among family groups or donor sources to reduce genetic diversity from that which was initially provided from released embryos or fish (Schreier et al. 2015).

If piscicide treatments fail to remove all fish from the project area, estimating the number of fish that remain within each area of the overall project area will guide efforts to reduce nonnative alleles. For instance, if piscicide treatments do not kill all existing fish in certain mountain lakes, but do kill all fish in the streams, releasing larger numbers of fish into those mountain lakes may be needed to swamp out nonnative genes. This strategy was successful in the South Fork Flathead River WCT restoration project (FWP 2005). The uncertainty of the rotenone outcome will require flexibility for Option 1 because large numbers of fish and the M012 may be needed for swamping.

Option 2 – Use Washoe Park Hatchery Captive Population

The captive WCT population in Montana FWP's Washoe Park Hatchery (i.e., the M012) is nonhybridized and free of pathogens. This population originated by collecting WCT in 1983 and 1984 from 12 populations from South Fork Flathead River tributaries, and Marten Creek and the

Vermillion River, which are major tributaries to the lower Clark Fork River in Montana. The M012 population was infused with wild gametes from 2003 through 2013, which were collected from nine South Fork Flathead River tributaries, Threemile Creek in the Bitterroot River basin, and the South Fork of Lower Willow Creek in the Flint Creek basin. This captive WCT population is Montana's source for WCT for conservation and recreation, and with planning can provide the numbers and life-stages that would be needed to fully stock the North Fork Blackfoot project area. Personnel at Washoe Park Hatchery indicated they could potentially supply up to 100,000 embryos, but their ability to provide fry or older fish would need to be planned at least three years prior to when they would be needed.

The Washoe Park WCT population brings many advantages including lack of hybridization, lack of disease, relatively high genetic variability, relative ease in obtaining the numbers and

lifestages of WCT needed, the likelihood that embryos would be available over a relatively extended period in the spring and early summer, and available assistance from the staff at Washoe Park Hatchery. The disadvantages are the potential hatchery selection that may have occurred and no local Blackfoot River sources of WCT have been incorporated into this captive brood. Consequently, the M012 brood does not provide locally adapted or locally unique genes for translocation. Embryos or fry from Washoe Park Hatchery could be available by 2020.

Option 3 – Combination of Local Stocks (Option 1) and M012 (Option2*)*

Combining Options 1 and 2 would allow incorporation of locally adapted wild WCT donors and provide flexibility that would allow for high numbers of embryos or fish with a relatively high level of genetic diversity to be released, potentially over different seasons and years.

Several methods could be used in combining these two options including:

1. Capturing wild WCT from donor populations and spawning them at their stream of origin, incubating their embryos to the eyed-stage at an isolated incubation facility, and releasing their eyed-embryos directly into the restoration area along with eyedembryos or fish from Washoe Park WCT.
2. Collecting wild WCT from donor populations and moving them to Montana FWP's Sekokini Springs Hatchery, where they could be reared until they mature. After maturation, mature adults could be spawned, and eggs and sperm could be mixed either:
    a. within each original wild stock,
    b. among the different wild stocks, or
    c. with sperm from WCT from the Washoe Park Hatchery.

    Fertilized embryos could then be raised to eyed-stage at Sekokini Springs and released as either eyed-embryos or fry into the project area. If embryos are incubated to hatching, and fry raised to a larger size before their release, they would likely be reared in the Sekokini Springs facility. Eyed-embryos or fry from the Washoe Park Hatchery could also be released along-side those originating from wild sources.

Advantages of the strategies detailed immediately above are that a high amount of genetic diversity would be released, including locally adapted genes. The inclusion of Washoe Park Hatchery progeny would provide assurances that enough fish of the desired life-stages would be available at the right times and the relatively high genetic diversity in this captive population would increase the overall genetic diversity of the translocated population. Many different age classes could be released over relatively short periods, and thereby address possible swamping scenarios. The disadvantages are options 2 and 3 are more logistically and economically complex

than the other options. Proportions of embryos or fry from wild-origin populations and Washoeorigin WCT could be manipulated by modifying incubator trays to hold Schnee cups. A 3-inch diameter Schnee cup can hold up to 2,0000 eggs from fertilization, to eye-up, hatch, and even swim-up (see details in Hatchery Support Section). This also would allow control over the size of each family group. Although initial investment in labor is not trivial, the benefit of having direct control over inputs from not only every source, but every individual, would pay for itself.

Hatchery Support and Three Donor Stock Translocation Options

Sekokini Springs and Washoe Park Hatchery are the two hatcheries under consideration for supporting translocation of WCT into the North Fork Blackfoot River project area. The Sekokini isolation hatchery has been offered for use for the North Fork project, and currently the Washoe Park Hatchery could provide embryos. Decision-making regarding hatchery support and the appropriate hatchery is contingent on the option or options selected for translocation. The Sekokini Springs hatchery could potentially support all the above options but could only rear wild fish to the adult stage for a few separate wild sources. The incubation of fertilized eggs (embryos) in an isolation facility could be done at Washoe Park Hatchery. The hatchery is available to meet the needs of this combined option if planned far enough in advance.

Sekokini Springs has an isolation building that segregates wild trout and potential pathogens from the rest of the hatchery. Treating the effluent with a UV system protects the Flathead River. The UV system can treat up to 90 gpm, however, 30 gpm must be reserved for incubating eggs, rearing fry, and cleaning tanks, which leaves 60 gpm for rearing the wild trout. Adult trout at Sekokini Springs may reach 14.3 inches and 1.25 pounds at time of spawn. Using these data and a flow index of 0.6 (Piper et al. 1982) the permissible weight is roughly 500 pounds or 400 trout at 1.25 pounds apiece. Production hatcheries use a flow index of 1.5, but using a lower value reduces the risk of hatchery selection pressure on the wild trout.

Permissible Weight Formula: $W = F \times L \times I$

W= weight (lbs)

F = flow index

L = length (inches)

I = inflow (gpm)

The building has three 97 ft^3 round rearing tanks that can easily accommodate this number of trout and allow sorting by size during the rearing period. The density index calculated for this size and weight of trout is 0.13 per tank. This density is well under the value of 0.3 which is

considered the maximum density for sensitive species and is calculated with the following formula:

$D = W / (L \times V)$ where

D= density index

W = weight (lbs)

L = length (inches)

V = volume (ft^3)

The isolation building has space for 7 Heath stacks with at least 7 trays apiece. Each tray can have 9 incubation cups for keeping the fry from each cross (fertilization of one female's eggs with the milt of one male) separate. Therefore, at full capacity, the isolation building can incubate 441 crosses. The isolation building has enough room to spawn 294 trout (147 males & 147 females), if they are spawned 3 males on 3 females, and each cross is kept separate until eyeup or swim-up. This approach would allow the contributions from each parent to be equalized as much as possible.

The Sekokini Springs Hatchery has two 37 ft^3 tanks for rearing fry, and 2 portable 14 ft^3 tanks can be "piggy-backed" on top of the rearing tanks. These tanks could hold up to 16,000 fry to a stocking size of 2.2 inches. However, since only four tanks are available, only four lots of fry can be raised. Therefore, the spawning period would have to be limited to around 24 days. Females that ripen after the 4 primary egg takes would not be used for production. Typically, 80-90% of the females ripen within this period.

Methods of Translocations

Embryos and Remote Site Incubators (RSIs)

RSIs are an effective method for translocating eyed-embryos to establish new WCT populations. This method allows the introduction of a relatively large numbers of individuals at one time, reduces the number of fish removed from each donor population, reduces the chance of disease being transferred into new waters, and allows imprinting and habitat selection pressure to operate on translocated individuals from an early life stage. However, egg collection and incubation periods are time consuming, requires hatchery incubation facilities, and year-to-year success can be highly variable, based on such factors as abundance of spawning adults and weather. Other disadvantages of RSI embryo releases are: 1) RSIs must be maintained every two to three days for approximately two weeks for eyed-embryo releases, or six weeks for waterhardened embryo releases; 2) release locations must be carefully selected to provide enough stream gradient to create upwelling in RSI buckets and provide suitable spawning gravels for future spawning; and 3) reduced water flows, high sediment loading, or animal interference can result of failure of

RSIs. More detailed descriptions of egg collection gear and methods, as well as RSI construction and methods of use are presented in Appendix B, Appendix C, and Appendix D.

Fry

Many populations of WCT have been established or augmented by releasing fry into recipient habitats. This method of translocation may be preferred when access to a donor population is logistically difficult, or stream flows at the site are too high to effectively capture ripe adults to create embryos. In this situation, it becomes necessary to access donor sites later in the year during low or base flow conditions, capture individuals, and transport them to a captive propagation facility, where they can be held until maturity and spawned to produce fry a year or two later. Translocating fry provides additional flexibility in selecting a release site(s), especially in situations where recipient waters are too remote or lack suitable locations for RSI placement. Releasing fish at the fry stage also provides increased knowledge and control of the genetic makeup of the individuals being released, as efforts can be made at the hatchery to equalize family contribution to a year class to increase its genetic effective size. Moreover, greater numbers of fish may be produced by translocating fry, and greater numbers may be especially important in situations where swamping is needed to numerically overwhelm fish that may have survived a piscicide application. With adequate water temperatures and dissolved oxygen, fry can be transported in large numbers and over long distances by aircraft, pack stock, or on foot in backpacks. Disadvantages of translocating fry include the logistics and expense associated with captive propagation facilities, and the potential for inadvertent artificial selection on fish held in a captive environment. There is also the possibility that some fish released as fry may not effectively imprint to the release site, although the existence of many self-sustaining trout populations founded from fry transplants suggests that this may not be a significant issue.

Locations of Translocations

Deciding where to release WCT within the treatment areas has two primary considerations. First, managers need to decide if they want to preserve a unique donor stock, by translocating only that unique donor stock to one headwater location. Ideally, this unique donor stock will be translocated to a headwater area which has limited connectivity to the rest of the North Fork Blackfoot restoration project area. This type of strategy has been termed “replicate” stocking. Secondly, locations of releases should allow for the relatively quick dispersal of fish and promote their ability to quickly fill all available habitats vacated by piscicide treatments. In general, fish or embryos should initially be released at the upper ends of treated areas of streams and in all treated lakes. For streams, fish or embryos should probably be released at locations about two to five km apart to facilitate their quick dispersal throughout the treated areas. Releases can occur over several years and we suggest starting at the upstream boundary of treated areas and working downstream.

Monitoring

To evaluate the conservation benefits of the WCT translocation, outcomes of the North Fork WCT translocation effort should be monitored for effectiveness and results made available, preferably through peer-reviewed publications, to provide guidance for future projects (Pullin and Knight 2001; Sheller et al. 2006; Terhune et al. 2010; Anderson et al. 2014). This inherent responsibility relates not only to the size and complexity of the North Fork Blackfoot River project, but also to the current lack of monitoring data on translocation projects, which limits an ability to learn from previous projects and apply that knowledge to future projects (Olden et al. 2011; Vincenzi et al. 2012; Andrews et al. 2016). Evaluations of several recent Cutthroat Trout translocation projects have indicated that translocation into relatively large connected habitats (> 25 km) were successful after one or two generations of wild spawning (Andrews et al. 2016; Cruse et al. 2013). The North Fork Blackfoot River baseline study provides a comprehensive dataset for monitoring the effectiveness of the project (Pierce et al. 2017). Monitoring will contribute to the understanding of factors that affect translocation success, especially factors that relate to the rate of repopulation and measures of genetic diversity in large high elevation systems.

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Appendix A: Length Frequencies of Cherry Creek (2007- 2016)

The following length frequency graphs show the lengths of WCT captured from RSI releases of fry from sites in two tributaries (Cherry Lake Creek and upper Cherry Creek) in 2006, 2007 and 2008 (Table 3). Fry release locations in 2006 and 2007 were near the top of trout distributions prior to piscicide treatments. Fry were released in 2008 from a single RSI site in lower Cherry Lake Creek, but most fish sampled after 2008 were from an area of this stream above that RSI site location. The RSI releases in 2006 were from a pilot study and very few fry were actually released (Table 3). Most fry were released during 2007 into each tributary. The eyed-eggs (embryos) released into RSIs were split from each donor female, so that half her eggs went into Cherry Lake Creek RSIs and the other half went into upper Cherry Creek RSIs.

Summer (fish growth season) monthly water temperatures were about 3 to 4 °C colder in Cherry Lake Creek than in upper Cherry Creek (Figure 7). WCT grew much faster and their growth was more variable in upper Cherry Creek (the warm stream) than in Cherry Lake Creek (the cold stream; Figure 2). WCT matured earlier in upper Cherry Creek and age-1 WCT were captured in 2011 (Figure 2). Age-1 WCT were not captured until 2013 in Cherry Lake Creek (Figure **8**). Recruitment appeared more variable in the cold stream (Cherry Lake Creek). All size classes (year-classes) appeared to be present in upper Cherry Creek by 2012 (Figure 8).

Table 4. Number of fry released into each stream by year. One site of multiple RSIs was used during each year at each stream.

Stream	2006	2007	2008
Upper Cherry Creek	182	5,475	
Cherry Lake Creek	95	5,232	
Pika Creek			4,337

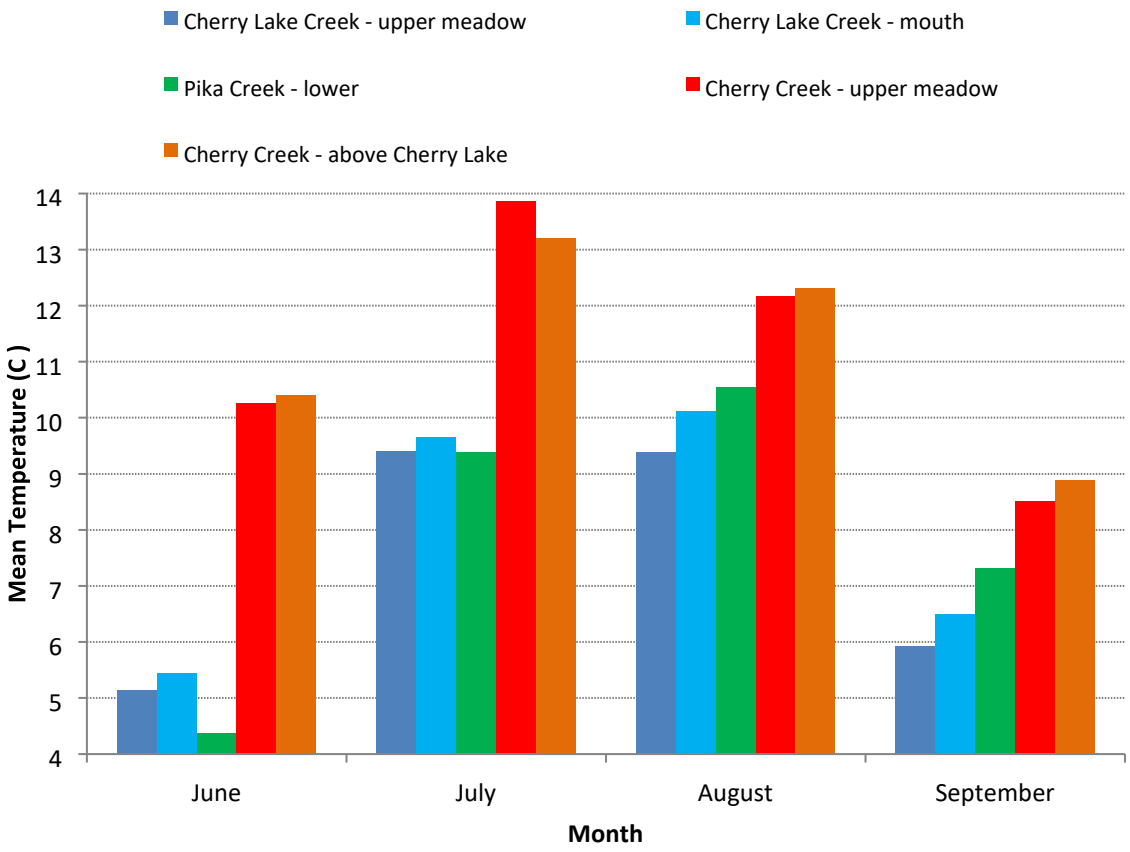
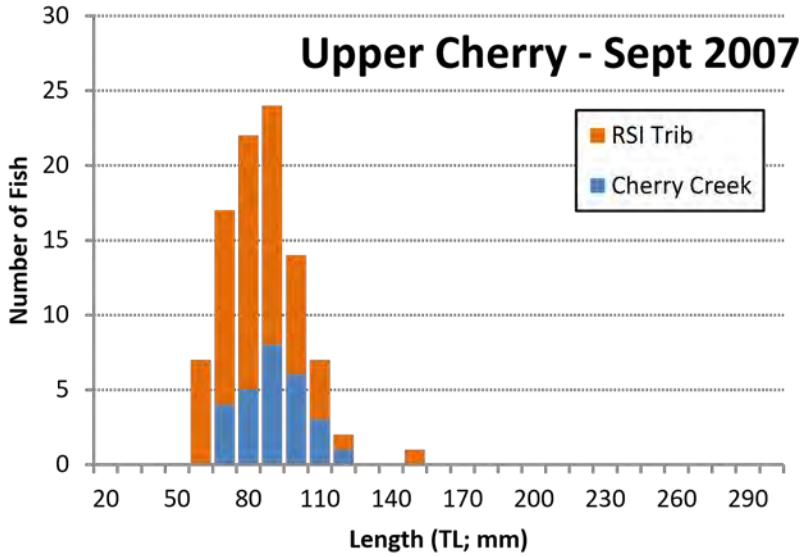
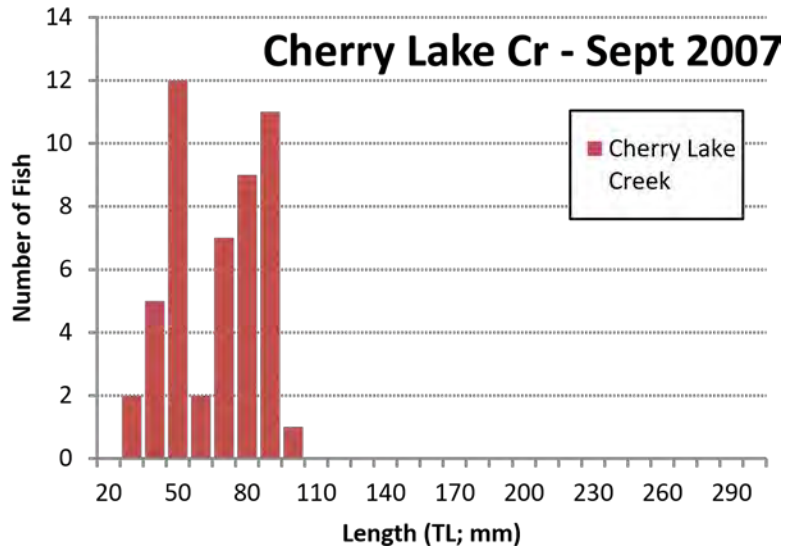
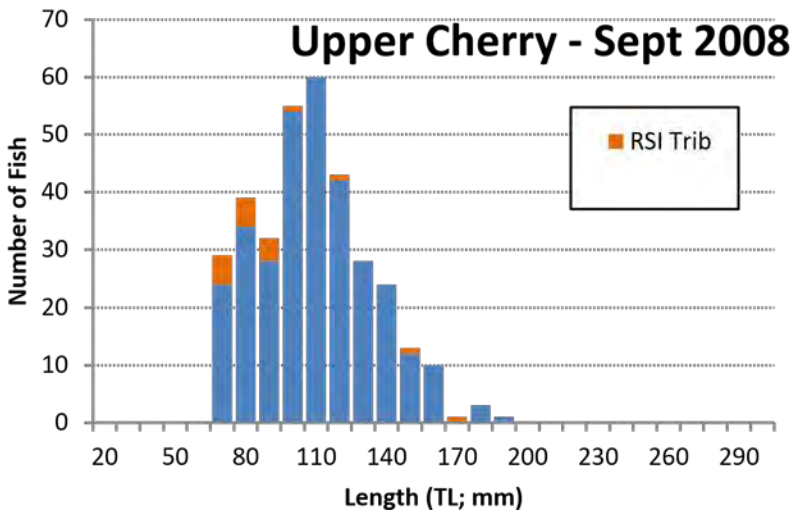
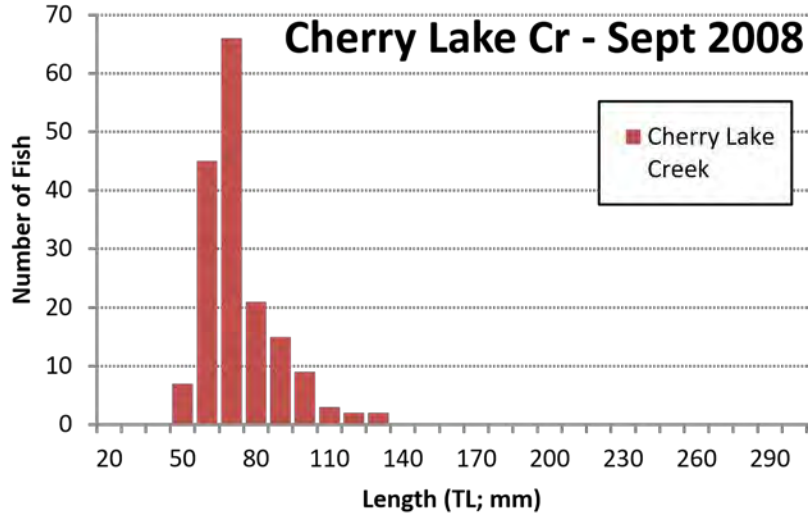


Figure 7. Mean monthly water temperatures by site in Cherry Lake Creek basin (Cherry Lake and Pika creeks) and in upper Cherry Creek

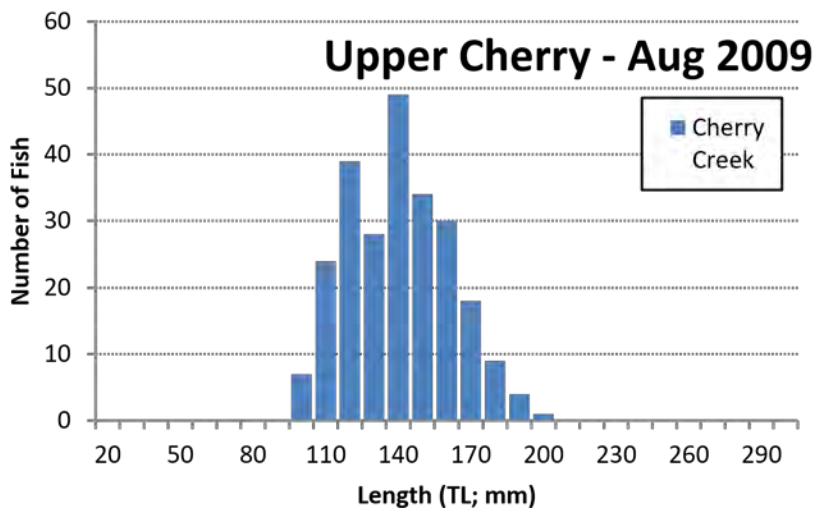

Upper Cherry - Sept 2007
RSI Trib
Cherry Creek
Number of Fish
Length (TL; mm)
0
5
10
15
20
25
30
20
50
80
110
140
170
200
230
260
290

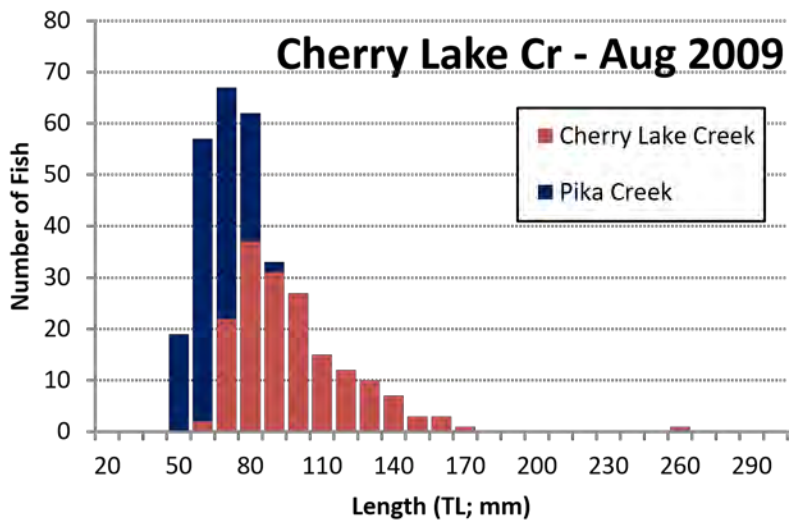

Cherry Lake Cr - Sept 2007
Cherry Lake Creek
Number of Fish
Length (TL; mm)
0
2
4
6
8
10
12
14
20
50
80
110
140
170
200
230
260
290

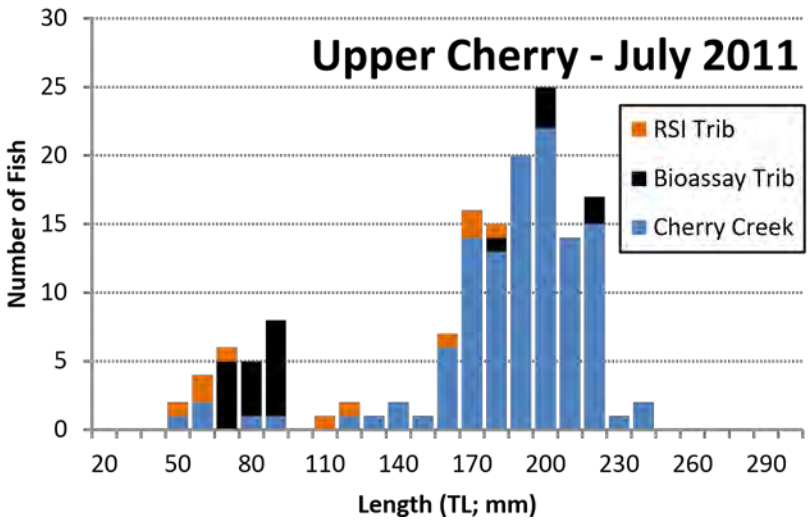

Upper Cherry - Sept 2008
RSI Trib
Number of Fish
Length (TL; mm)

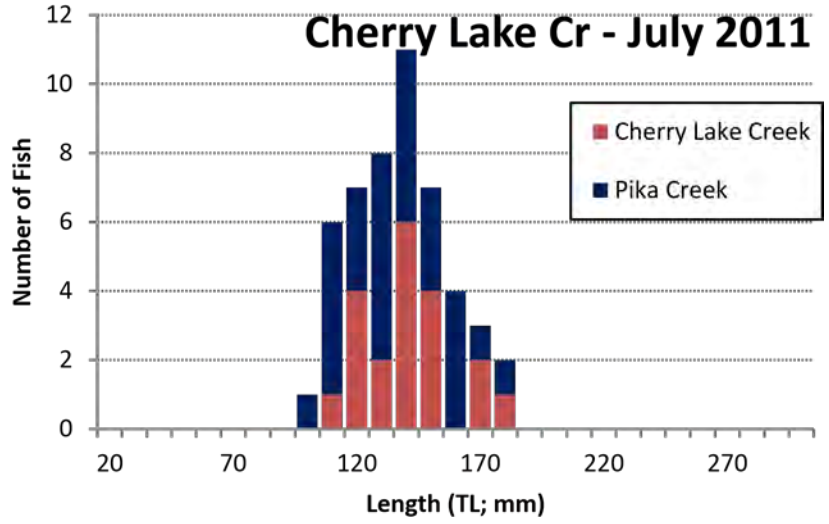

Cherry Lake Cr - Sept 2008
Cherry Lake Creek
Number of Fish
Length (TL; mm)

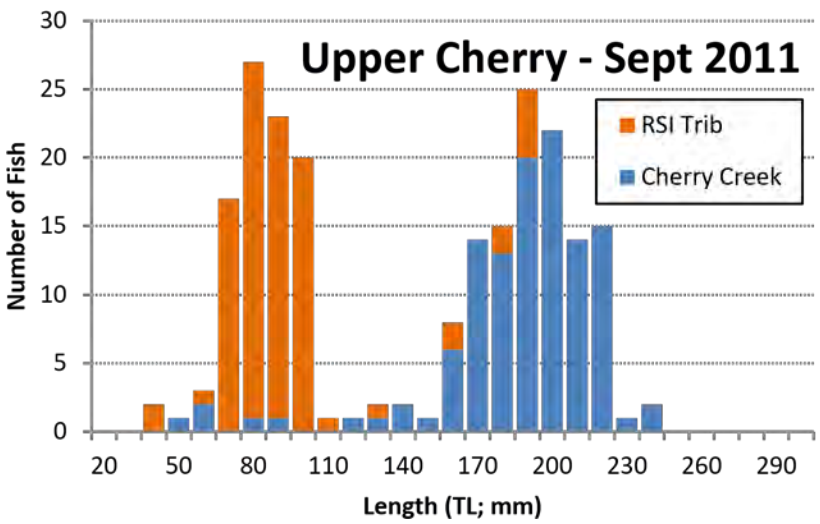
78956

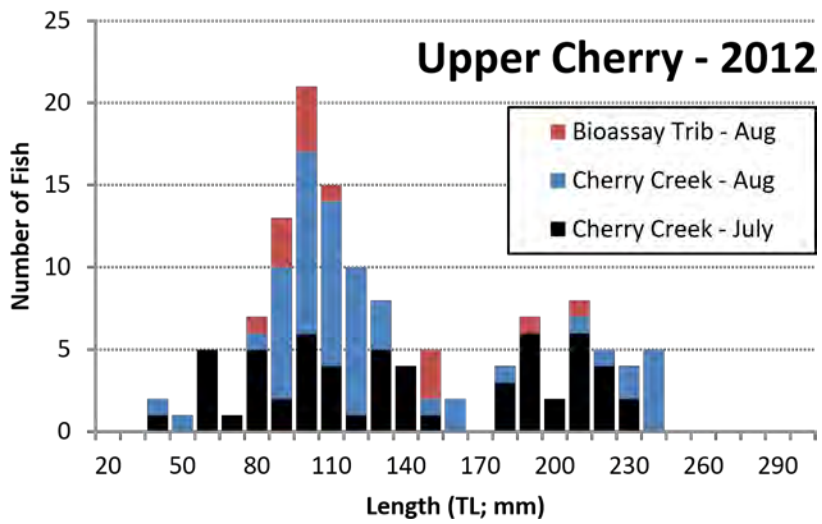

Upper Cherry - Aug 2009
Cherry Creek
Number of Fish
Length (TL; mm)

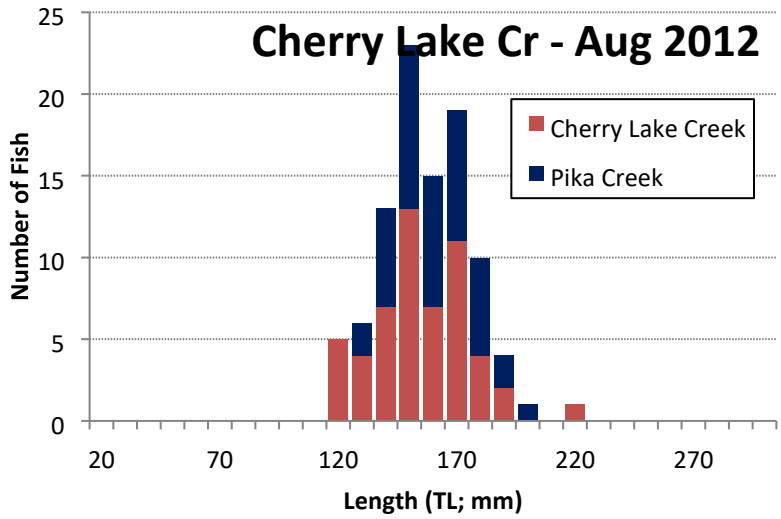

Cherry Lake Cr - Aug 2009
Cherry Lake Creek
Pika Creek
Number of Fish
Length (TL; mm)

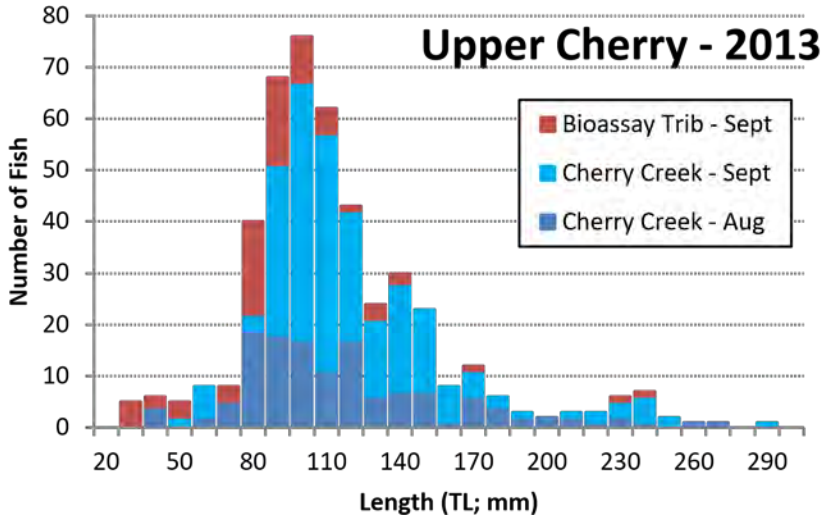

Upper Cherry - July 2011
RSI Trib
Bioassay Trib
Cherry Creek
Number of Fish
Length (TL; mm)

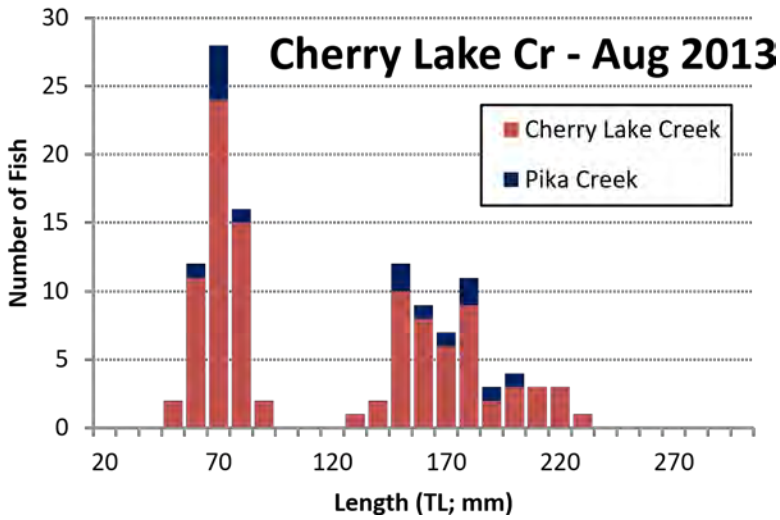

Cherry Lake Cr - July 2011
Cherry Lake Creek
Pika Creek
Number of Fish
Length (TL; mm)

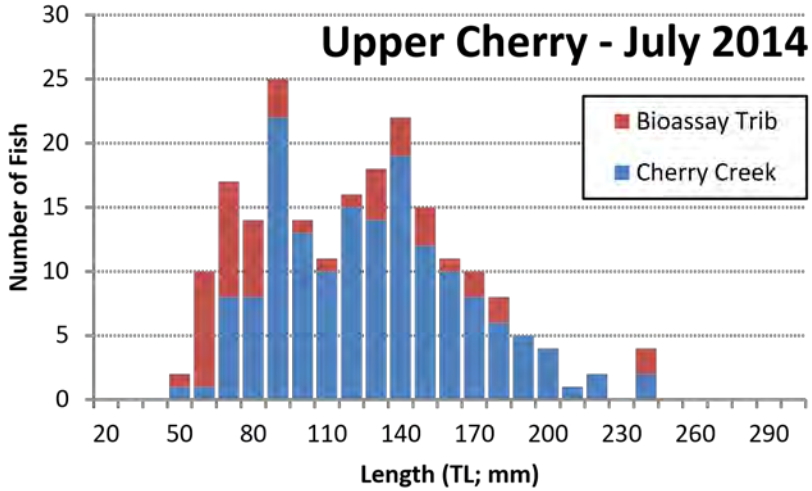

Upper Cherry - Sept 2011
RSI Trib
Cherry Creek
Number of Fish
Length (TL; mm)


Upper Cherry - 2012
Bioassay Trib - Aug
Cherry Creek - Aug
Cherry Creek - July
Number of Fish
Length (TL; mm)


Cherry Lake Cr - Aug 2012
Cherry Lake Creek
Pika Creek
Number of Fish
Length (TL; mm)
0
5
10
15
20
25
20
70
120
170
220
270


Upper Cherry - 2013
Bioassay Trib - Sept
Cherry Creek - Sept
Cherry Creek - Aug
Number of Fish
Length (TL; mm)
0
10
20
30
40
50
60
70
80
20
50
80
110
140
170
200
230
260
290


Cherry Lake Cr - Aug 2013
Cherry Lake Creek
Pika Creek
Number of Fish
Length (TL; mm)
0
5
10
15
20
25
30
20
70
120
170
220
270


Upper Cherry - July 2014
Bioassay Trib
Cherry Creek
Number of Fish
Length (TL; mm)
0
5
10
15
20
25
30
20
50
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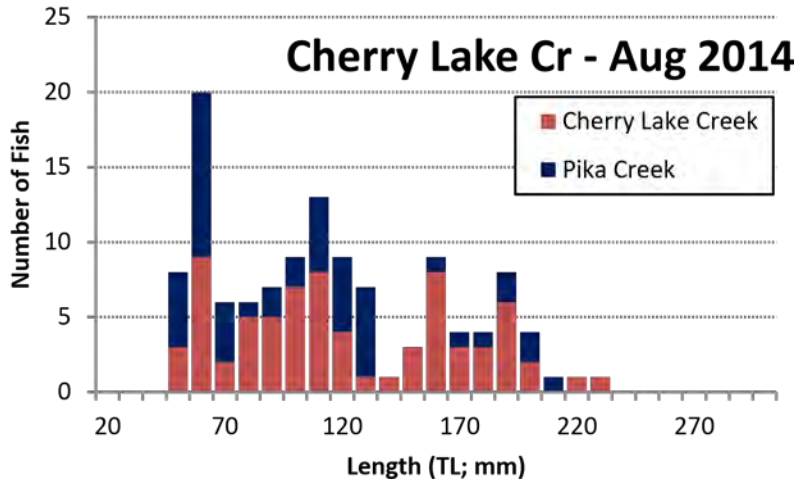
110
140
170
200
230
260
290


Cherry Lake Cr - Aug 2014
Cherry Lake Creek
Pika Creek
Number of Fish
Length (TL; mm)
0
5
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15
20
25
20
70
120
170
220
270

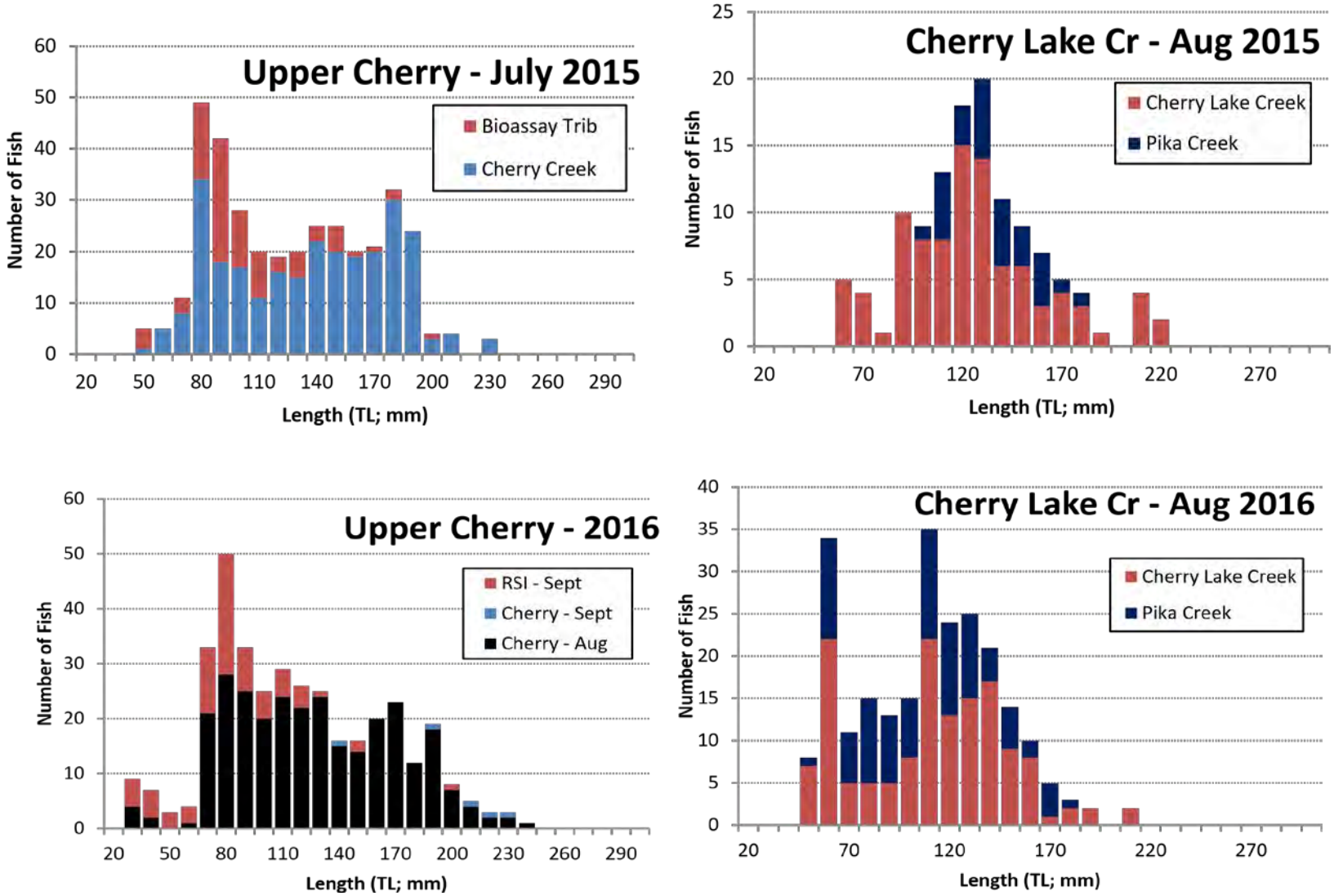

Figure 8. Length frequency distributions of WCT in streams within the Cherry Creek WCT project from 2007 through 2016.

Appendix B: WCT Egg Collection Gear

1. Live cars to hold spawners - plastic tubs with holes drilled into the sides, and lids that seal and can be anchored to the streambed using rebar or rocks.

2. Data sheets to record length and weight and unique code of each parent, and egg lot for each parental cross.

3. Ice chest to carry egg containers. The soft-sided type is preferable, as they fit in backpacks nicely.

4. At least 6 small and medium packets of blue ice. I always have extra, but 4 - 6 would probably do. Small and medium size.

5. Igloo containers (https://www.igloocoolers.com/). You'll need 2 for every female, and several others to help decant. Label each with a unique number. I typically carry 12 containers.

6. Measuring board

7. Five 5-gallon buckets per spawning operation.

8. Portable aerators. Not necessary, but handy.

9. Clove oil or MS22. I use a mixture of 1:10 clove oil to ethanol.

10. Thermometer. Not only for stream temperature, but also to monitor temperature of the containers carrying the eggs.

11. Lots of hand towels to dry fish off. I try to keep a different set (6 or so) for each stream.

12. Scissors to collect fin clips and to ad clip contributing adults. Small stainless steel ones work fine.

13. Iodophor solution and small medicine syringes to measure appropriate amount. You shouldn't need much (500 mL should be more than enough), it only takes a couple of mLs per egg lot. I get the syringes from Walmart in the health section.

14. Genetic vials and holder.

15. A small plastic shoe box to hold all these things.

I try to put together a kit for each donor stream that includes: thermometer, towels, scissors, genetic vials, and syringes of iodophor.

Appendix C: Egg Collection and Hatchery Operations Example

Collection of Ripe Adults and Gametes

The timing of efforts to collect mature WCT for gametes were based on stream conditions, the observation of WCT "pairing-up" activity related to spawning, and previous redd surveys that indicated general spawning period (mid-June). Fish were collected by electrofishing at known spawning locations in Prickly Pear, Hall, Ray, White's, and Muskrat creeks (Figure 1), and Browns Creek near Dillon, MT. While egg collection efforts for Ray and Browns creeks are detailed here, the eggs collected from these streams were used for WCT brood pond efforts, which will be discussed in the next section. All donor populations were previously identified as nonhybridized with no known fish disease concerns. Captured fish were anesthetized using clove oil, measured, and visual characteristics were used to classify sex and reproductive state. Mature fish were separated by sex and held in in-stream live cars until eggs were collected. Females were anesthetized every 3 to 5 days to determine if they were sufficiently ripe to express eggs. Eggs from anesthetized females were expressed into small beverage containers and were fertilized with 2 or 3 male fish from the same stream, or males from other donor populations including those listed and No Name Creek in the upper Gallatin River drainage (near West Yellowstone, MT). Eggs were disinfected on site to reduce the risk of disease transmission to hatchery facilities.

Females were released immediately back into the donor stream after egg collection, while males were held until eggs were collected from remaining females. Some males were used to fertilize more than one female if the number of males was limited. All fish that supplied gametes received an adipose fin clip so they could be identified and not used during subsequent efforts. A small portion of either the anal or one of the pelvic fins was clipped for subsequent genetic analysis and each fin clip sample was uniquely coded and that code matched to a code for information from each individual fish. This allowed identification of each parent that contributed to each pairing that was linked to the genetic tissue sample, so genetic analyses could be linked to each parent.

Hatchery Incubation

Eggs were transported to the Sun Ranch Hatchery (Cameron, MT) within 1 to 4 hours of fertilization. On arrival at the hatchery the eggs were again disinfected to reduce risk of disease transmission. Eggs were placed in a vertical-tray incubator with a 42oF (2004) or 52oF (2005) water supply. Incubator trays were partitioned to allow different groups of eggs to remain separated. Flow-through treatments of iodophor and formalin were periodically conducted to control bacteria and fungus.

Eggs were held at the hatchery until eyed – approximately 30 days in 2004 (42oF), and 13 days in 2005 (52oF). About 1 week pre-hatch, eggs were counted and classified as "eyed", unfertilized, or dead. Eyed eggs from Prickly Pear, Hall and Muskrat creeks (2005) were then placed in the transport containers with hatchery water and transported to introduction sites, and eyed eggs from Brown, Ray and Muskrat creeks (2004) were hatched and reared in the hatchery until mid-October when they were introduced to brood ponds.

Stream Introduction

Eyed eggs were incubated at introduction locations in RSIs constructed using methods described by the Hood River Salmon Enhancement Group (http://www.hcseg.com/). The incubators are designed to simulate water upwelling as occurs in a natural redd. The RSIs consist of a water supply pipe, valve to control flow, a flow diffuser, and a basket with pea-gravel and plastic "bio-saddles" (artificial substrate) where eggs and fry develop. RSI construction is described in detail in Appendix C (below).

Appendix D: Construction and Installation of Remote Site Incubators

Introduction

Remote site incubators (RSIs) are used to rear fish eggs in isolated locations (Figure 9). They provide the eggs and developing fry with protection and habitat, increasing their survival rates. RSIs are easily assembled using parts available from hardware stores and biological supply companies (Table 4) and readily accessible tools (Table 5). The general design of the RSI described here is a 5-gallon bucket fitted with an upstream inlet pipe and outlet hole (Figure 10 and Figure 11). Fresh water enters the inlet pipe that directs the water into the bottom of the bucket, where the water percolates up through the bucket and out the outlet hole. The internal components of the bucket include a basket that contains a layer of gravel, on which the eggs are placed, and a layer of neutrally buoyant bio-media that covers the eggs. The gravel simulates the natural spawning habitat of many trout species, and the bio-media provides habitat for the fry to develop in before escaping through the outlet hole.

Figure 9. A) RSI setup in an inlet to High Lake. B) Recently emerged fry in an RSI.

Materials and Tools

Table 5. Materials for 1 RSI (costs subject to change).

Part	Component	Quantity	Supplier	Price (each)
A	20 ft. of 1in. PVC schedule 40 piping	1	Mountain Supply Co.	$6.48
B	1in. PVC cross fitting	1	Mountain Supply Co.	$1.95
C	1 in. PVC end caps	4	Mountain Supply Co.	$0.36
D	1 in.PVC threaded female end fitting	2	Mountain Supply Co.	$0.36
E	1 in. PVC T fitting	1	Mountain Supply Co.	$0.59
F	1 in. PVC threaded male end fitting	4	Mountain Supply Co.	$0.40
G	1 in. PVC shut off valve fitting	1	Mountain Supply Co.	$9.02
H	1 liter round squirt bottle	1		$2.00
I	2 in. hose clamp	1		$2.00
J	Black 5 gal. buckets with press-on lid	2	U.S. Plastic Corp.	$6.56
K	12 in. × 12 in. stainless mesh screen (size 14)		TWP. Inc.	$6.95
L	12 in. nylon string	2		$1.00
M	Bio-media, Italox saddles poly-pro 35$ $CaCO_3$	1 ft^3		$85.00
N	PVC primer	1	Mountain Supply Co	$8.52
O	PVC glue	1	Mountain Supply Co	$7.12
			Total	$147.51

Table 6. Tools required for the construction of RSIs.

• Reciprocating saw	• 3/8 in. drill bit
• Electric drill	• 1/8 in. drill bit
• Grinder	• Tin snips
• 1 ¼ in. hole saw	• Sand paper
• Propane torch	• Utility knife
• Large 1/8 in. metal plate	• PPE

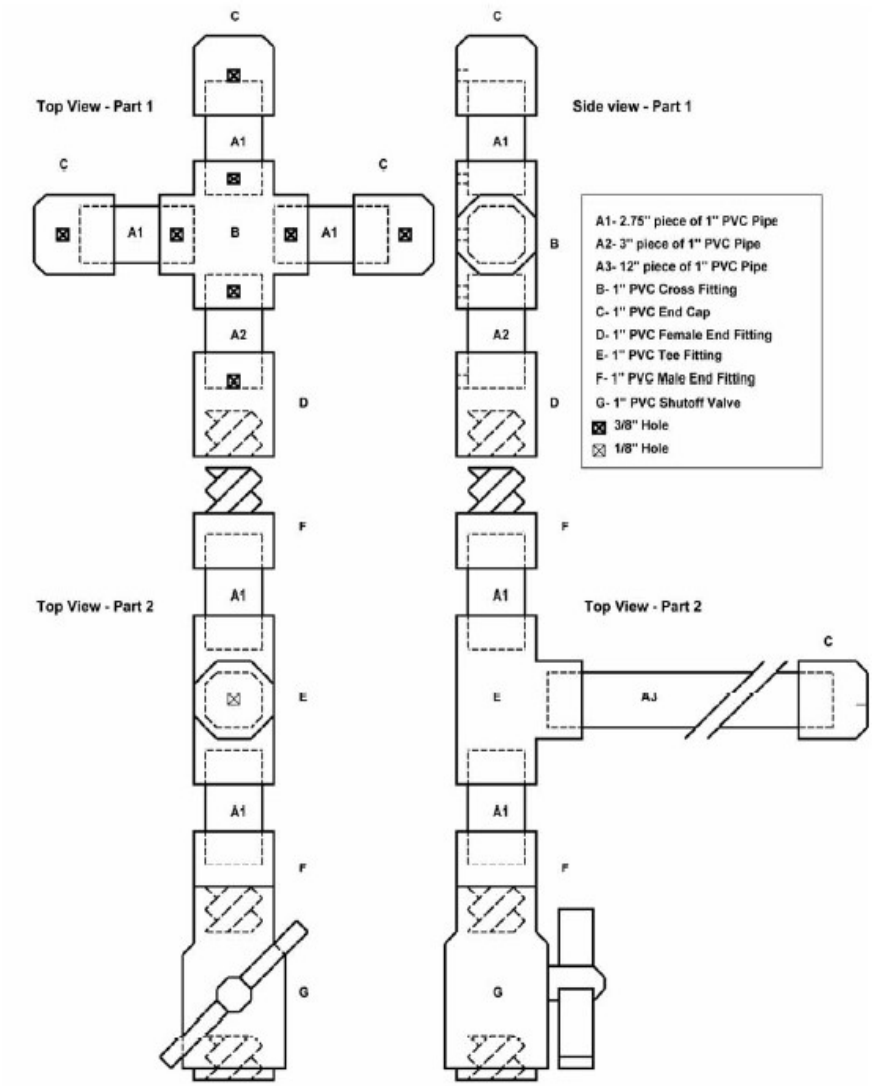

Figure 10. Inner and outer plumbing of an RSI.

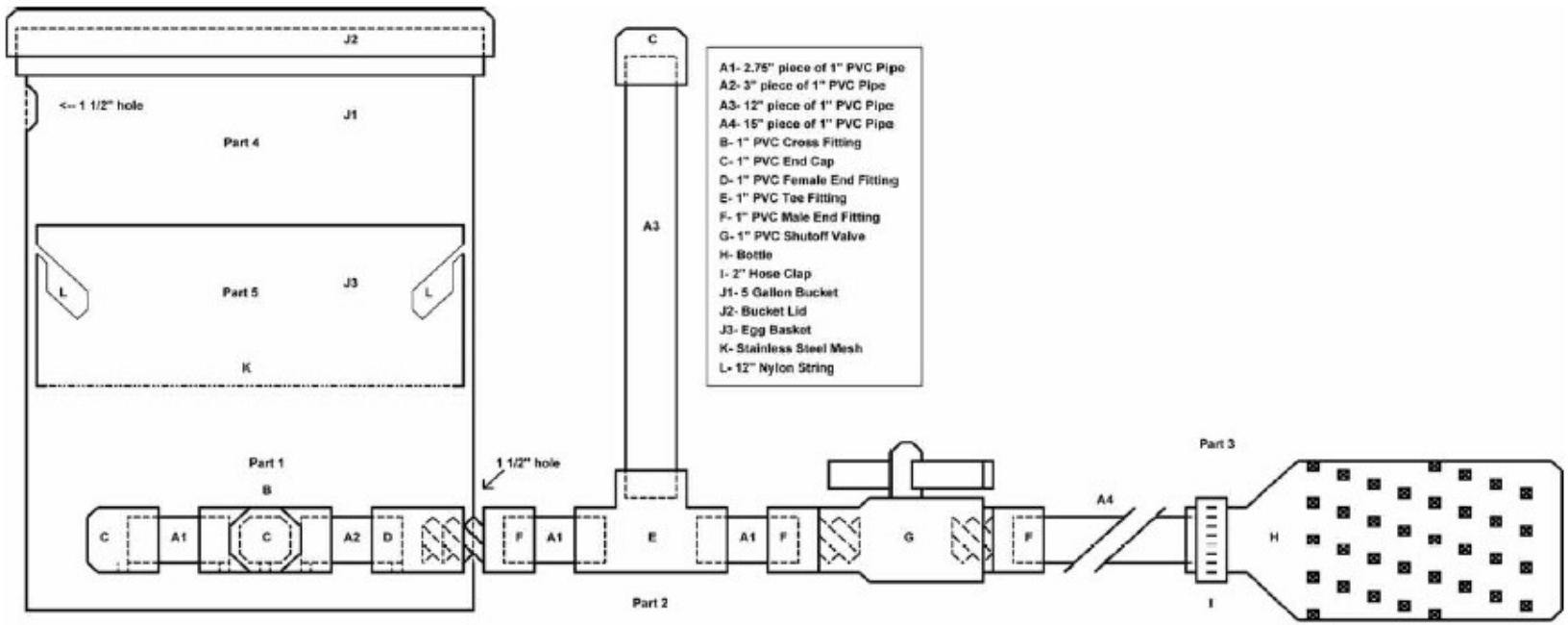

Figure 11. Side view of assembled RSI – Parts 1) inner plumbing, 2) outer plumbing, 3) inlet pipe, 4) bucket and lid, 5) egg basket. Not to scale.

Building the RSI

Park 1 Inner plumbing

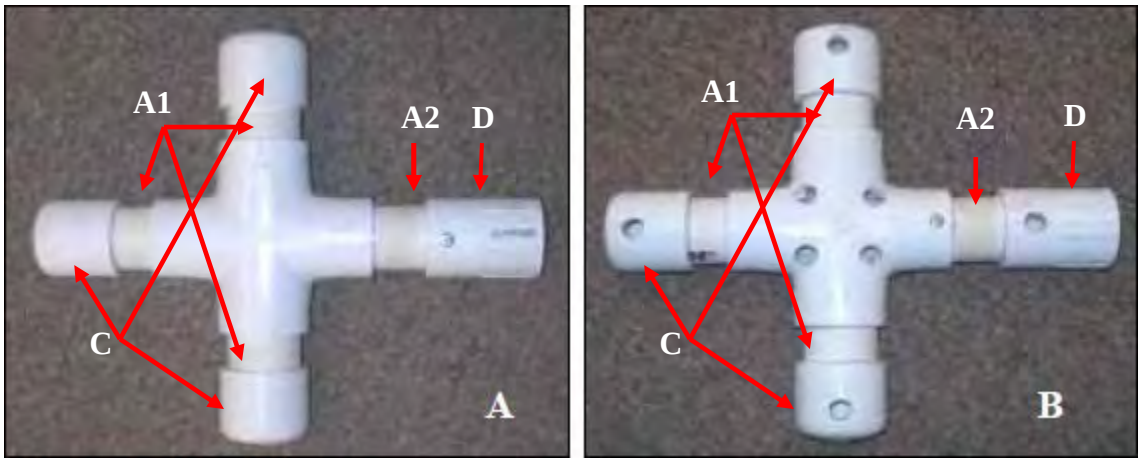

Figure 12. Inner plumbing: A) top side of part 1, B) bottom side of part, notice location of drilled holes.

1. Cut three 2.75 in. pieces (A1) and one 3 in. piece of 1 in. diameter PVC pipe (A2) from part A listed in Table 4). Remove burrs and rough spots with sand paper.
2. Prime and glue the 4 pieces of pipe into the cross fitting (part B in Table 4).
3. Prime and glue 3 end caps (part C in Table 4).
4. Prime and glue a threaded female end fitting (part D) to the remaining 3 in. pipe.
5. Drill eight 3/8 in. holes into one side of part 1 (see Figure 12 [B]).

Part 2 – Outer Plumbing

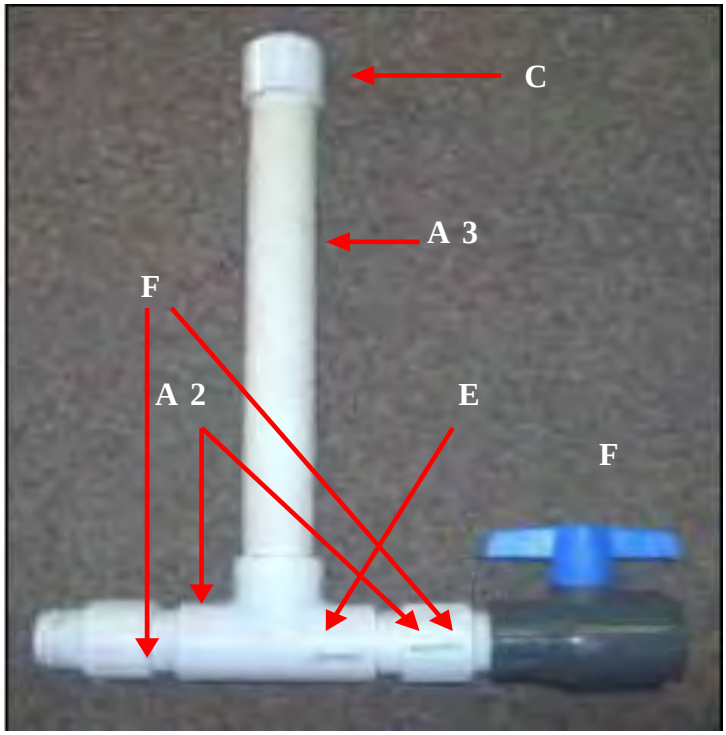

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Figure 13. Outer plumbing assembly.

6. Cut two 3 in. pieces of 1 in. pipe (parts A2). Remove burrs and rough spots with sand paper.
7. Prime and glue two 3 in. pipe pieces into the sides of the tee fitting (part E in Table 4).
8. Cut a 12 in. pipe piece (A3). Remove burrs and rough spots with sand paper.
9. Prime and glue the 12 in. pipe into the top of the tee fitting.
10. Prime and glue the 2 threaded male end fittings (parts F in Table 4)
11. Prime and glue an end cap fitting (C) on to the 12 in. pipe (A3).
12. Drill a 1/8 in. hole through the top of the end cap fitting (C), which is attached to the 12 in. pipe (A3)
13. Screw the shutoff valve fitting (G) on to one of the threaded male ends (F).

Part 3 – Inlet Pipe(s) and Straining Bottle

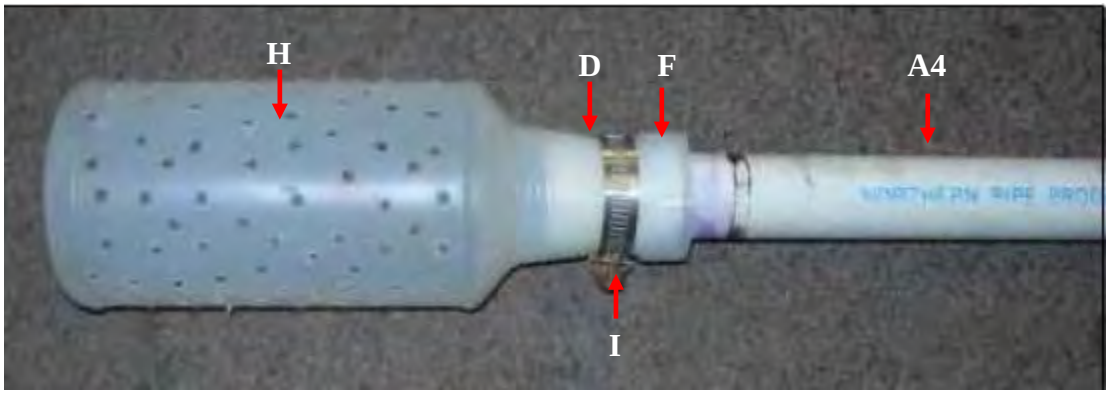

Figure 14. Straining bottle attached to end of inlet pipe.

14. Cut one 15 ft. piece of 1 in. pipe (A4). Remove burrs and rough spots with sand paper. Note: cut three 5 ft. sections if easier transportation is required, also if RSI will be in a low gradient area, add more 5 ft. sections for extended reach.

15. Prime and glue a threaded male (F) and female end fitting (D) onto the ends of the 15 ft. pipe (A4)

16. Cut off the top of a bottle (H), so that the top of the bottle fits on the end of the 15 ft. pipe (A4).

17. Drill several dozen 1/8 in, holes into the side of the bottle (H).

18. Using the pipe clamp (I), attach the bottle to the female end of the fitting D or the 15 ft. pipe (A4).

Part 4 – Bucket and Lid

Figure 15. A) Bucket with hole drilled into opposite sides. B) Bucket lid with all but 2 tabs removed to provide easy access to inner workings.

19. Drill one 1 ¼ in. hole into the side of the bucket (J from Table 4) about 1 in. from the bottom.

20. Drill one 1 ¼ in. hole into the side of the bucket, on the opposite side of the first hole, near the top.

21. Cut lid tabs (perforations around the edge). Remove all tabs except 2 on opposite sides of the lid.

Part 5 – Egg Basket

Figure 16. A) Mesh melted into the plastic bucket. B) Finished egg basket

22. Using the reciprocating saw to cut the bottom out of 5-gallon bucket (J). Use 1 ¼ in. hole saw to cut starter hole. Cut the burrs and high spots off with a sharp knife.

23. Measure and mark up 6 inches from the bottom of the second bucket (J2). Cut around the side of the bucket at the line.

24. Keep only the bottom half of the bucket (J3). Use sand paper and knife to remove the burrs and rough spots.

25. Heat the bottom of the metal plate with the blow torch until the top of themetal plate is hot enough to melt the plastic bucket. Use a scrap of the bucket as a test.

26. Place the mesh screen onto the heated metal plate, them push the rim of the bottomless bucket (J3) into the screen, so that the plastic melts into the mesh (K).

27. Continue rotating the bucket section until the entire bottom of the bucket section is melted into the mesh. Let cool. Note, mesh will likely warp to a bow shape.

28. Trim off mesh around the bottom of the bucket section with tin snips. Use grinder to remove sharp edges.

29. Drill two 1/8-inch diameter holes on both sides near the top of the bucket section (J3).

30. Tie loops of nylon string through holes.

Part 6 – Final Assembly

Figure 17. RSI setup properly in a small stream.

31. Place the inner plumbing into the bucket, with the holes facing down.

32. Push the male end of the outer plumbing into the hole at the bottom of the bucket.

33. Screw the male end of the outer plumbing into the female end of the inner plumbing (make sure holes in part 1 are facing down).

34. Screw the male end of the inlet pipe into the female end of the outer plumbing.

35. Insert the egg basket into the bucket.

36. Add bio-media saddles into the egg basket.

37. Attach lid.

Part 7 – Deployment

Figure 18. A) Looking upstream at an RSI, notice the amount of drop from the filter bottle to the bucket. B) Eggs on the gravel layer before addition of the bio-media.

38. Set the RSI in a stream with the bucket downstream.

39. Make sure the bottle at the end of the pipe is higher than the top of the bucket, or the water will not flow correctly.

40. If necessary, make a small dam in the creek to create a collecting pool and to gain the needed head pressure.

41. Use rocks to stabilize and level the bucket and hold piping down.

42. Once water is flowing correctly, allow RSI to run a few minutes to flush out debris.

43. Remove the egg basket. Fill the basket with a 1 inch layer of small spawning size gravel.

44. Rinse gravel repeatedly, until all loose debris is removed.

45. Place egg basket with gravel in the bucket.

46. Add a 6-inch layer of bio-media into the egg basket.

47. Let the RSI run for several minutes until water is clear.

48. Remove bio-media.

49. Turn off valve.

50. Lift egg basket until the gravel is just under the surface of the water, then gently wash eggs onto gravel layer.

51. Lower basket so eggs swirl into an even distribution on gravel.

52. Place bio-media on top of eggs.

53. Turn on valve.

54. Place lid on bucket.

Appendix N. : Aldo Leopold Wilderness Research Institute: Supplement to Evaluating Proposals for Ecological Intervention in Wilderness

The purpose of this supplement is to provide support to agency staff in completing an MRA or MRDG for proposals that involve ecological intervention in wilderness, including projects related to the preservation of cultural resources. This supplement is needed because ecological intervention proposals commonly entail complex legal, scientific, and ethical questions that may be beyond the realm of a typical MRA or MRDG. By explicitly raising these questions related to ecological interventions early in the MRA or MRDG process, this supplement is intended to help agency staff identify issues that need to be resolved before moving forward with the MRA or MRDG, as well as identify early on whether the goal of the intervention is legally appropriate. This supplement may also be useful in building the administrative record of the project.

The below responses to this Leopold Intervention Framework were authored and/or reviewed by an interagency core team [Ron Pierce and Carol Endicott (FWP), Scott Spaulding, Josh Lattin, Jimmy Gaudry, Shane Hendrickson and George Liknes (USFS) and Wade Fredenberg (USFWS)] with assistance from other agency managers and under the guidance of Beth Hahn at the Aldo Leopold Wilderness Research Institute. The questionnaire was deemed 'adequately answered' by a 94% (range 88-100 for the 16 individual questions) consensus of the core team on January 11th, 2017.

Does the proposal contain essential information for evaluating the MRA/MRDG Step 1 question "Is Action Necessary?"

A. Is there an ecological issue or degradation that is prompting the proposed ecological intervention?

The questions in this section help ensure that the proposal adequately provides a "Description of the Situation" as required in the MRA or MRDG. Note that these questions expand on what is presented in this section of the MRDG because a proposed ecological intervention may have an extraordinarily complex background and context that needs to be described.	ADEQUATE	NOT ADEQUATE	NOT APPLICABLE
1. Does the proposal describe the background and context for the ecological degradation and the intervention? Consider: • Historic information about the ecological degradation, including the source of the degradation, its distribution and rate of spread, and the resulting ecological threats and risks. • Current information about the ecological degradation, especially the known or potential ecological threats and risks. • Whether the intervention intends to restore to a historic condition, or facilitate adaptation to a new condition.	X	☐	☐
2. Does the proposal describe how the ecological intervention will provide long-term adaptation or mitigation to the effects of climate change? Consider: • If climate-driven ecological changes will lead to an irreversible loss of a resource.	X	☐	☐

• If data trends indicate that systems are nearing thresholds outside the historical range of variability that could lead to ecological tipping points. • If there is precedence for ecosystems shifting across the landscape, and indications of significant expansions and contractions of range in response to historic climatic trends and / or disturbances.			
3. Does the proposal describe why action is more important than inaction to preserve wilderness character? Consider: • If the issue is caused by contemporary human actions or legacy land use impacts, or reflects variation in species occurrences or ecological processes. • If the intervention will lead to resilient outcomes without requiring repeated interventions. • If the ecological system will degrade as a result of inaction, and whether this degradation will likely lead to further cascading changes to the ecological system. • If non-intervention will allow the system to self-sort and reorganize. • Given the scientific value of wilderness as an untrammeled baseline, intervention actions will diminish the potential for future wilderness research.	X	☐	☐
4. Does the proposal describe the intervention in terms of preserving the natural quality of wilderness character? Consider: • Spatial scale of the action and its intended outcomes. • Temporal scale of the action, including frequency and seasonality of implementation, and its intended outcomes. • Potential effects (including non-target effects) of activities on ecosystem composition, struture and processes, such as predator-prey relations, disturbance processes, and other effects that cascade throughout the ecological system.	X	☐	☐
5. Does the proposal describe the likelihood of accomplishing the stated objective, and specific plans to address uncertainties? Consider: • Whether this type of intervention has been successful elsewhere, and if so, whether these results apply to this proposal. • Whether follow-up monitoring will be conducted to assess the effectiveness of the intervention, as well as the impacts and benefits of monitoring on wilderness character.[1] • For long-term or repeat interventions, thresholds have been established that will trigger re-evaluation of the ecological intervention.	X	☐	☐

If all rows are ADEQUATE or NOT APPLICABLE, continue the evaluation; if any rows are NOT ADEQUATE, deny proposal and return for potential revision.

A1. Does the proposal describe the background and context for the ecological degradation and the intervention?

Yes. The proposal[1] and the baseline study[27] describe the background and context for the ecological degradation and the need for intervention. This evaluation framework provides further context.

Factors related to the types and causes of ecological degradation and proposed intervention are the result of a long history of stocking nonnative fishes within the project area, the possible

[1] If monitoring will not be conducted, provide rationale (e.g., for some actions, there may be sufficient evidence about intervention outcomes to suggest that monitoring is unnecessary).

elimination of a historically pure population of native Westslope Cutthroat Trout, and the risks this legacy of fish introductions pose to native fish (downstream) outside of the project area. Though the pre-1920 presence of native trout upstream of the North Fork Falls has never been documented[27], the existing fishery is nonetheless drastically altered from the historical (pre-1920) condition. Field surveys from 2004 through 2016 found predominantly *Oncorhynchus* hybrid trout, as an admixture of primarily rainbow trout (*Oncorhynchus mykiss*) genes, with contributions from Westslope Cutthroat Trout (*O. clarkii lewisi*) and Yellowstone cutthroat trout (*O. c. bouvieri*). These fish are widespread within the project area, which is upstream of a barrier falls on the North Fork Blackfoot River (Figure 0-1). Decades of hatchery plants that began in the 1920s are responsible for the compromised genetic status of the existing population[27]. No data or observations on the native fish assemblage present before fish stocking are available; however, the wide-spread distribution of Westslope Cutthroat Trout genes, and their usual presence upstream of other barrier falls in the Blackfoot River watershed suggest the project area possibly provided historical habitat over thousands of years for native Westslope Cutthroat Trout. The existing fishery has little recreational or conservation value. Because of low abundance and a limited distribution, these hybrid trout appear to be poorly suited to cold, high elevation streams[19,27] and thus offer low ecological value to other species such as fish-eating birds and mammals. Perhaps even more importantly, this fishery is a headwater source of hybridization to down valley stocks of nonhybridized native Westslope Cutthroat Trout[27]. The proposal to replace these hybrid trout with native Westslope Cutthroat Trout and native bull trout would reduce hybridization risks, while contributing significantly to ecological function and the conservation of imperiled native trout, especially bull trout.

Westslope cutthroat trout and bull trout are typically sympatric throughout their overlapping range and together they reflect the native trout assemblage to the Montana wilderness landscape west of the Continental Divide. Both are present in the Scapegoat Wilderness immediately downstream of the project area, which includes a four-mile reach of the mainstem North Fork, in addition to about 10 miles of stream in the Dry Fork. Bull trout in the Dry Fork drainage have been surveyed in the mainstem of the Dry Fork, Canyon Creek and Cabin Creek. Both native species broadly occupy neighboring wilderness streams within the Blackfoot River and Flathead River basins. Because these native trout are specifically coadapted to the mountainous streams of western Montana, replacing hybrid trout with drainage-specific stocks of native Westslope Cutthroat Trout and bull trout from neighboring streams would result in a more natural wilderness condition compared to the existing fishery. The headwaters of the adjoining Flathead River Basin (Great Bear and Bob Marshall Wilderness) represent the largest patch of uncompromised native fish habitat in western Montana.

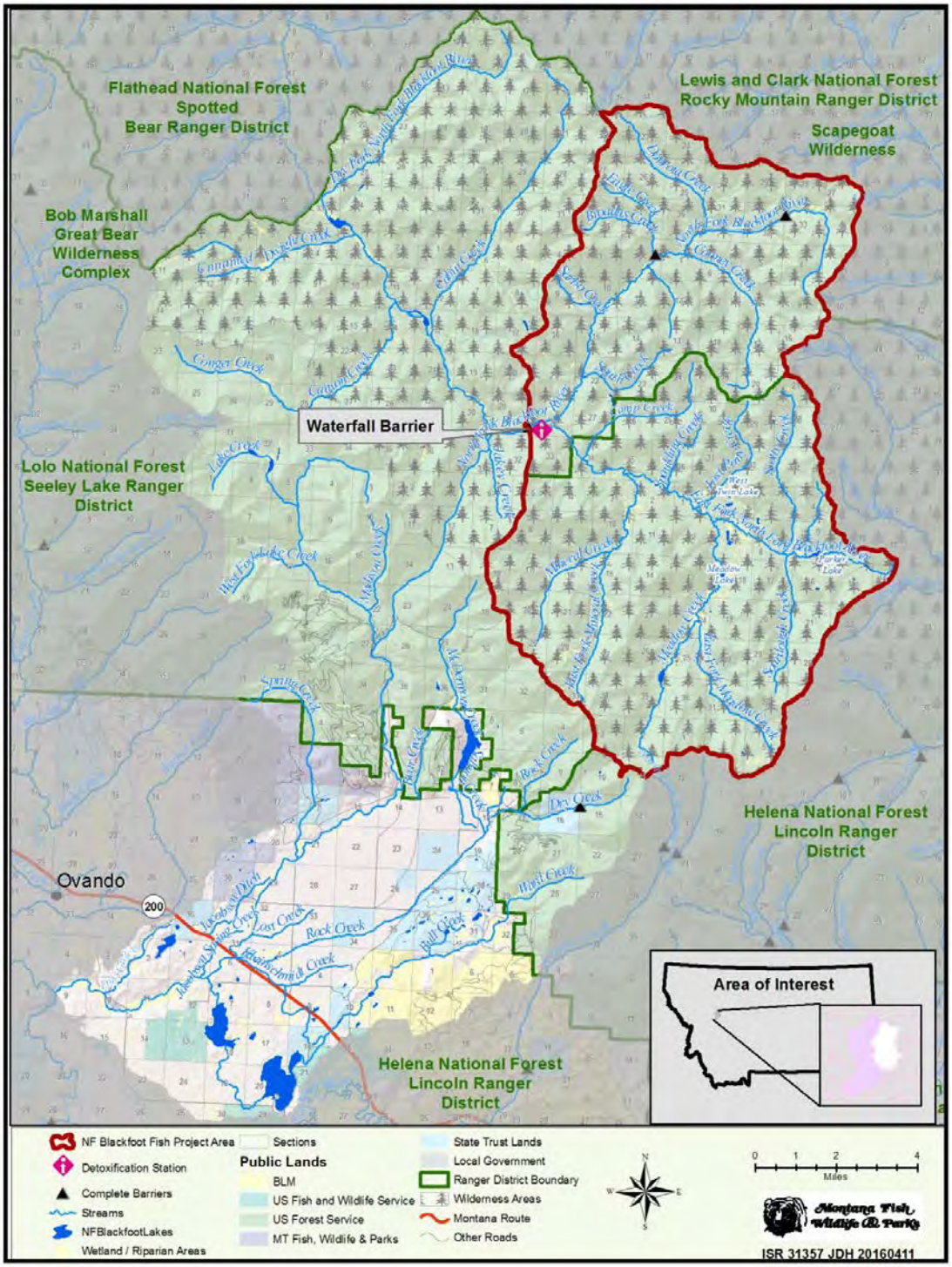

Figure 0-1. North Fork Blackfoot River watershed with location of project area.

The third bullet under question A1 asks whether the intervention intends to restore the resource to a historical condition or facilitate adaptation to a new condition. Decades of stocking of nonnative rainbow trout and Yellowstone cutthroat trout resulted in the loss of the historical condition by the time of wilderness designation in 1972. Likewise, stocking nonnatives has further altered ecological function[27]. Meanwhile, these high elevation waters provide highly suitable habitat for native trout that are less susceptible to warming and protected by the wilderness and the barrier falls from invasion of nonnative species[18,27,41]. As Westslope Cutthroat Trout were possibly present historically, returning this species could return the project area to the historical condition. Compared to westslope cutthroat, the historical presence of bull trout in the project area is less certain. With no evidence of historical bull trout presence, translocating bull trout upstream of the barrier falls would likely facilitate adaptation to a new but natural condition representative of the historical condition of most watersheds west of the Continental Divide in Montana. Therefore, while the condition may be new to the project area, it reflects the native fish assemblage of much of the Clark Fork River drainage and western Montana. Acknowledgment of the need to adapt to a new, more natural condition is a progressive step towards native species conservation, while correcting a legacy of biologically adverse nonnative trout introductions in this wilderness landscape.

The project area was designated wilderness in 1972. The Wilderness Act recognized the role of state jurisdiction and responsibilities related to wildlife and fish in the national forests40. Forest Service Manual (FSM) 2323.343 further defines United States Forest Service (USFS) policy regarding fish stocking in wilderness and provides guidance as to when and where stocking should occur. This USFS policy is intended to: 1) provide an environment where the forces of natural selection and survival rather than human actions determine which and what numbers of wildlife species will exist; 2) protect wildlife and fish indigenous to the area from human caused conditions that could lead to Federal listing as threatened or endangered, and 3) provide protection for known populations and aid recovery in areas of previous habitation, of federally listed threatened or endangered species and their habitats. Furthermore, the FSM defines indigenous species as "any species of flora or fauna that naturally occurs in a wilderness area and that was not introduced by man." Westslope cutthroat and bull trout fit this description. The USFS Policy also recognize State jurisdiction and responsibilities for the protection and management of wildlife and fish populations in wilderness and emphasizes close working relationships with State authorities to help resolve wilderness issues. The FSM also provides guidelines for State and USFS wilderness cooperative agreements. Cooperative agreements between the USFS and Montana Fish, Wildlife and Parks (FWP) that guide fisheries management are now in place for western Montana wilderness areas20,25,37. These agreements basically affirm State jurisdiction over stocking of waters that were stocked before wilderness

designation and provide specific guidance for correcting the ecological degradation by managing for indigenous (native) trout.

Not all waters within the project area will be stocked with Westslope Cutthroat Trout and bull trout, and these areas will remain in their likely historical, fishless condition. Pre-wilderness stocking included, but was not necessarily limited to, four lakes (Parker Lake, Lower and Upper Twin lakes and Meadow Lake) various sections of the East Fork North Fork Blackfoot River, the North Fork Blackfoot River, Meadow Creek, the East Fork of Meadow Creek, Twin Creek, Cooney Creek and Scotty Creek27. Under the current proposal, fish stocking would not occur in fishless lakes or fishless streams segments upstream of the barrier falls on Broadus Creek or the barrier falls located on the North Fork Blackfoot River upstream of Dobrota Creek27. Therefore, these waters would remain in their historical condition.

A2. Does the proposal describe how the ecological intervention will provide long-term adaptation or mitigation to the effects of climate change?

Yes. This project addresses all bullet items under A2, which focus on adaption to, or mitigation for, the effects of climate change, which are major considerations for bull trout and Westslope Cutthroat Trout recovery planning. Long-term National Weather Service data, from 1948 to the present, show current local warming trends along with corresponding reductions in snowpack over the past several decades[38,39]. In addition, climate projections indicate future warming and the continued regional contraction of cold-water habitat[18,41]. Although climate projections do not adequately account for groundwater or lake environments, these models clearly predict an up-valley contraction of thermally suitable spawning and rearing habitat for bull trout by 2040, throughout western Montana. This contraction is ongoing in western Montana[12].

The proposed project area is an excellent candidate for conservation of these thermally sensitive species, as climate models indicate suitable thermal habitat for bull trout and westslope cutthroat in the project area into the foreseeable future,[18]. Bull trout are obligate cold-water species[21], and they are especially at risk in a warming climate[12,18]. Consistent with local and regional warming trends and other anthropogenic stressors[18,28,38,39], bull trout populations are currently in decline at the low elevations of the Clark Fork River basin, including all spawning streams in lower Blackfoot River basin[28]. Climate models further project the loss of the loss of cold water needed for bull trout spawning and rearing in the mainstem North Fork. Because bull trout show genetic and life history variation among tributaries in the Blackfoot River basin[28,34], including the North Fork, continued declines point to the short-term, irreversible loss of landscape-adapted stocks for those streams prone to continued warming[18,28].

Though bull trout recovery actions are occurring in all occupied habitat on private lands in the Blackfoot Basin[28], including the North Fork, future options for bull trout conservation in the face of climate warming are increasingly limited to higher elevation streams[18]. The headwaters of Keep Cool/Beaver Creek drainage, which spans public and private lands and adjoins the project area, is projected to have thermally suitable habitat into at least 2040[18]; however, this drainage is widely subjected to anthropogenic disturbance, including dewatering and riparian livestock damage[28]. Furthermore, nonnative brook trout and brown trout are present, and the area lacks the private land support needed to reverse habitat problems afflicting bull trout. None of these conditions exist within the project area as it is designated Wilderness. The projected low-elevation loss of suitable bull trout habitat includes in the main stem North Fork Blackfoot River downstream of the barrier falls[18]. This loss could further imperil the persistence of bull trout, which are listed as threatened under the Endangered Species Act (ESA). Projects such as this are critical in preventing further reductions in occupied habitat or other populations trends that point to the local extirpation of bull trout[18,27]. Such projects are specifically identified and supported in the Bull Trout Recovery Plan for the Columbia Headwaters Recovery Unit[36].

Westslope cutthroat trout show similar climate-induced up-valley contractions of suitable cold-water habitat[18]. As warming continues, hybrid zones will also shift up-valley in many larger streams[41], especially in those streams with headwater populations of naturalized rainbow trout[27,41]. Thus, by replacing a headwater population of hybrid trout with Westslope Cutthroat Trout, the proposed project would offset projected contractions in the range of Westslope Cutthroat Trout, while eliminating a source of nonnative genes to the watershed downstream of the project area.

A3. Does the proposal describe why action is more important than inaction to preserve wilderness character?

Yes. Inaction would result in a continued altered ecological condition upstream of the barrier falls and would lead to irreversible and likely perpetual ecological damage to native trout downstream of the barrier falls. Failure to correct these threats when we have the capacity to do so would be irresponsible, given FWP, USFWS and USFS current understanding of the threats. Threats posed by nonnative hybrid trout and climate warming for at least this drainage can be largely offset by the proposed project.

The presence of a highly genetically altered population of fish, with nonnative rainbow trout providing the predominant genetic contribution, is fundamentally inconsistent with wilderness character, and is the result of long abandoned stocking programs that have placed native salmonids at risk. The goal of the project is to remove nonnative hybrid trout upstream of the barrier waterfall on North Fork Blackfoot River and replace these fish with self-sustaining

populations of native Westslope Cutthroat Trout and bull trout, both of which are indigenous to the Scapegoat Wilderness. Project objectives are: 1) Treat all known fish-bearing stream reaches upstream of the North Fork Falls with piscicide (rotenone) to eradicate nonnative trout to the full degree feasible; 2) Minimize impacts to non-target species by utilizing appropriate chemical treatments (piscicides), project timing (fall) and geographic scale, including neutralizing piscicides near the North Fork Falls to eliminate risk to fish and aquatic organisms downstream of the project area; 3) Establish self-sustaining westslope cutthroat (<2% introgression) using drainage-specific stock(s), and ensure the persistence of the North Fork bull trout by translocating bull trout or their progeny from downstream of the North Fork Falls to upstream of the North Fork Falls, and to; 4) Monitor the effectiveness of the trout translocation for up to 10 years post-treatment and the recovery of macroinvertebrates and amphibian communities using existing information as the baseline for monitoring[27].

Reestablishment or establishment of a native trout assemblage is a reversal of the existing condition that is the result of human manipulation, and elimination of the preexisting aquatic community that was altered by human interference prior to wilderness designation. Although proposed actions temporarily increase presence by humans, and introduce a chemical disturbance, the quick outcome would be a native Westslope Cutthroat Trout population, which has high conservation and wilderness value. Because bull trout were not known to be present historically upstream of the barrier falls, the establishment of a population of bull trout in the project area would likely not preserve wilderness character, but would contribute considerably to conservation of this ESA threatened species, carry out an ESA recovery action, and provide a future refuge for the native fish assemblage in a protected, wilderness setting within its historical range. It is noteworthy that the post-Wisconsin glacial biogeographical distribution of bull trout and Westslope Cutthroat Trout has largely been in existence for roughly 10,000 years but has only been influenced and documented by European humans in Montana for about the last 150 years. Consequently, the recovered history of native assemblages reflects only a tiny fraction (the most recent 1.5%) of the historical distribution. Whether Westslope Cutthroat Trout and bull trout were native upstream of North Fork Falls cannot be ascertained at this time with any degree of certainty.

Agency partners have considerable experience in fish removal projects and have developed protocols to minimize effects on non-target organisms and limit the number of treatments required to achieve the project objective of < 2% hybridization. Removal of the existing fishery would require the use of rotenone, a plant-derived piscicide that is lethal to fish, some aquatic invertebrates, and gilled amphibians. Piscicide would be applied to all fish-bearing waters within the project area to remove nonnative trout to the greatest extent possible, with the acknowledgment that habitat complexity could prevent full removal given the existence of spring-fed refugial pockets and other features. Some areas may require more than one treatment.

A combination of electrofishing and monitoring with environmental DNA (eDNA) would allow assessment of the success of piscicide treatment and identify discrete areas where fish have persisted, and additional treatments would be limited to those areas. The long-term monitoring plan calls for up to 10 years of post-treatment data collection to evaluate the project. Monitoring would include fisheries, aquatic invertebrates and amphibians to evaluate the response of these taxa to the project.

Compared to the existing condition, restocking with locally-adapted indigenous fish from streams would contribute to preserving wilderness character. Gametes from Westslope Cutthroat Trout would be obtained from yet to be determined neighboring streams, and bull trout or their gametes would be obtained from the North Fork Blackfoot River immediately downstream of the project area. These locally adapted donor stocks would likely have a greater potential for persistence within the project area compared to fish obtained from other areas or solely from hatchery stock. Additionally, the barrier falls, and remoteness of the project area are key features that enable the project and prevent repeated interventions. Following the treatment and restocking with native trout, nonnative fish have no way to naturally access the project area because of the barrier falls. The remoteness of the project area would discourage illegal introductions of nonnative fish.

Compared to Westslope Cutthroat Trout, the likelihood of success is less certain for bull trout. The physical habitat appears highly suitable for bull trout. The large patch size, cold water refugia, groundwater inflows and complex habitat features are all favor potential bull trout establishment[27]. However, donor stock from a population downstream of the falls with established migratory (fluvial) behavior involving the North Fork Blackfoot River, the Blackfoot River and the Clark Fork River and many connected secondary streams may, or may not, successfully residualize[34]. The uncertain success of bull trout translocation is in large measure reflective of limited experience in similar type projects, though pioneering efforts in that regard are underway in other locations and are meeting with some initial success[4,5,11]. To investigate the feasibility of the bull trout translocation in the North Fork, a suitability assessment was completed for the North Fork project[11,46]. The assessment recovered a positive score of 0.81 on a scale of -1.0 to +1.0, indicating a high potential for the recipient habitat for supporting bull trout. To monitor a possible bull trout translocation, post-translocation data collections may include 1) eDNA to identify distribution, 2) electrofishing to identify abundance, size structure and reproduction, and 3) redd counts to identify adult population size should the translocation prove successful. In addition, water temperature data at 22 monitoring sites would allow for an assessment of bull trout habitat use.

The spatial scope of establishment of a native species assemblage within the project area would bring considerable conservation benefit to Westslope Cutthroat Trout and bull trout, given the

extent and diversity of available habitat. Both species are landscape adapted and widespread across adjoining wilderness and both represent the natural trout species assemblage for the North Fork immediately downstream of the barrier falls. Thus, this native trout assemblage better represents wilderness character than the existing condition upstream of the barrier falls. Oncorhynchus hybrids are now established in about 45 miles of stream in the North Fork Blackfoot River basin upstream of the barrier falls on the North Fork Blackfoot River. The proposed project would replace these hybrid trout with native Westslope Cutthroat Trout and native bull trout. Moreover, the project would promote the long-term conservation of both native trout within a headwater basin that offers outstanding native trout habitat, as well as long-term protection within a remote wilderness setting. Inaction would bring no ecological benefit to native species upstream of the falls, perpetuate hybridization in downstream waters, and fail to offset projected habitat loss to downstream populations relating to climate change. The project would protect wilderness character by preventing the potential permanent loss of bull trout from Scapegoat wilderness, while (re)establishing native cutthroat in a protected wilderness setting.

Inaction would contribute to further degradation of the ecological system. Importantly, inaction would further imperil Westslope Cutthroat Trout downstream of the project area, as the existing hybrids would be a perpetual source of nonnative genes. Increased downstream hybridization would also reduce the genetic integrity of the Westslope Cutthroat Trout metapopulation in the middle Blackfoot River because the Dry Fork provides recruitment of genetically pure fish to the Blackfoot River[44]. Restoration cooperators have worked for three decades in efforts to improve native westslope populations in the Blackfoot Basin, which includes the screening of all irrigation diversions on the North Fork and the restoration of all tributaries to the North Fork to improve metapopulation function[27,28]. The presence of hybrid trout and continued hybridization of the headwater populations in the North Fork would ultimately negate some of these improvements to the Blackfoot River metapopulation.

Because of population declines across western Montana and elsewhere, Montana Natural Heritage Program and FWP, and other agencies, list bull trout and Westslope Cutthroat Trout as species of concern [21,22,23,30]. Montana lists these species as S2 species, which applies to species that are at risk because of " limited and/or potentially declining population numbers, range, or habitat, which make it vulnerable to extirpation in the state. Declines in Westslope Cutthroat Trout are especially pronounced east of the Continental Divide where populations typically occupy small (<10 km) isolates upstream of barrier falls[30]. West of the Continental Divide, Westslope Cutthroat Trout populations have also declined significantly; however, populations are more widely distributed, present in greater abundance, and possess higher levels of life history and genetic diversity[10,14,30]. Bull trout, a federally listed threatened species under the ESA[13,36], is a keystone species for the Bob Marshall Wilderness Complex, which includes the Scapegoat Wilderness. A warming climate, loss of connectivity, habitat degradation, and

nonnative species are the primary threats to bull trout[21,36]. The project area provides a rare opportunity to establish a secure population of bull trout.

Grizzly bear and bull trout are key ecological components of the Bob Marshall Wilderness Complex. It is important to note that the wilderness managers from around the complex decided to choose bull trout as one of two priority indigenous species that managers would seek to conserve and/or recover in the Scapegoat Wilderness. This conservation strategy relates directly to bull trout in the North Fork. The implementation of management actions to conserve, recover, and monitor the health of bull trout is a measurable standard to which wilderness managers will be held accountable through the Wilderness Stewardship Performance program. Past intervention, such as stocking of non-native trout, though pre-wilderness designation, has ecologically altered this environment to the detriment of native trout. Climate change is contemporaneous and could lead to a cascade of events in and around this portion of the wilderness, which could erode the natural quality and potentially lead to continued loss of bull trout in the both the Scapegoat Wilderness and non-wilderness portion of the upper Blackfoot River watershed. As part of the Wilderness Stewardship Performance documentation for the Bob Marshall Complex, bull trout and grizzly bear are wilderness character elements, and require continued monitoring as elements of tracking wilderness character.

The 4th bullet under question A3 asks if nonintervention would allow the system to self-sort and reorganize. Because of repeated stocking of nonnative species within the project area, inaction would result in continuation of the existing irreversible alterations in the fish community. Without removal of the existing fishery, self-sorting or reorganization to the historical condition is impossible.

The last A3 bullet addresses whether the existing condition represents the untrammeled baseline, and if intervention would diminish the potential for future wilderness research. The existing condition is a highly-altered population of hybridized fish, with nonnative rainbow trout genes being predominant. Therefore, this project would not diminish the potential for research evaluating an untrammeled ecosystem. Conversely, the project would provide an opportunity to research the effect of (re)establishment of a native trout on aquatic communities. Comprehensive pre-treatment aquatic investigations have been completed for all lakes and tributaries upstream of the barrier falls. Data were collected by USFS and FWP and all data has been shared among cooperators[27]. These baseline investigations point to a range of potential post-treatment wilderness research opportunities, such as evaluation of trophic interactions among diverse taxa, and persistence of native trout in the face of climate change.

Projects restoring Westslope Cutthroat Trout are common and have been documented to be effective in achieving their goals[6], so the project would not present a novel research need. The

addition of bull trout would provide a much-needed example of a successful translocation as a recovery action for this ESA threatened species.

A4. Does the proposal describe the intervention in terms of preserving the natural quality of wilderness character?

Yes. The goals and objectives of the project were developed with wilderness character in mind[25]. For cold-water salmonids, indigenous to the greater landscape, within and outside of wilderness, this project would help restore a more natural wilderness character compared to the existing condition. The spatial scale of the proposed rotenone application and restocking would include all fish-bearing waters. Fish stocking would not occur in currently fishless lakes and fishless streams upstream of barrier falls on Broadus Creek and the upper North Fork Blackfoot River upstream of Dobrota Creek. Considering these exceptions, the spatial extent of available habitat is substantial with about 85 miles of stream and three lakes.

The temporal scale of the treatment would begin with a primary rotenone treatment in the fall of 2019, followed by seven years of restocking by drainage-specific landscape-adapted genetically pure native fish. The project would include reach-scale genetic swamping for westslope cutthroat (i.e., overstocking with pure westslope cutthroat to rapidly dilute the remaining nonnative rainbow gene pool), as needed, to help meet the project objective of < 2% introgression[1]. Monitoring fish, aquatic invertebrates, and amphibians would result in a minimal presence of fieldworkers, which would be a short-term periodic disturbance of the natural quality of wilderness character. These efforts would add to the presence of fieldworkers maintaining trails and controlling weeds.

Timing the piscicide treatment for fall would reduce mortality of nontarget organisms, as most would not be in a vulnerable life history stage[42]. Some invertebrates and gilled amphibians would die; however, natural recovery would allow these taxa to rebound rapidly, especially in the presence of few larger fish. Fishless headwater reaches would not be treated and thereby provide an immediate source of invertebrate recolonization. The proposal includes a white paper literature review of the effects of rotenone on macroinvertebrates and amphibians[42] along with studies repeatedly show either a lack of vulnerability, or rapid recolonization and recovery of macroinvertebrates and amphibians.

Within a context of treatment objectives, short-term implementation ($\leq$ 3 years) and long-term effectiveness monitoring (up to 10 years) will both examine effects to target and non-target aquatic species. Monitoring will rely on pre-treatment inventories of invertebrates, amphibians and fishes[27], as well as similar large-scale treatments in western Montana (e. g., South Fork Flathead[6] and Cherry Creek[7]), and perhaps other research results emphasizing similar wilderness-

related actions[16]. The Westslope Cutthroat Trout component focuses on the elimination of existing hybrids. For Westslope Cutthroat Trout, this is largely mechanical and highly likely to succeed because similar treatments have been broadly applied across Montana. The outcome to bull trout component is less certain because of the low number of existing translocation projects as guidance. The proposal calls for translocating juvenile bull trout (fry) that are captively reared from eggs and milt taken from adults within the North Fork population. Based on the 2016 North Fork redd count of 118 redds, we estimate about 375 adults within the North Fork spawning population. Spawning female fish are typically large (20-36 inches) and depending on size, bull trout can produce between 3,000-15,000 eggs (roughly 1,000 eggs per pound of female). Though the number of eggs to be incubated has yet to be determined, it is expected to be a negligible impact to the donor population, given the current size and fecundity of the spawning population. The translocation of bull trout will focus on maximizing genetic diversity rather than numbers[29], with the expectation that the population would naturally build toward equilibrium over the course of several generations if the habitat remains suitable.

A5. Does the proposal describe the likelihood of accomplishing the stated objective, and specific plans to address uncertainties?

Yes. The use of rotenone in fisheries management and native fish conservation projects has been tested world-wide for decades across hundreds, perhaps thousands, of individual projects. Indeed, similar treatments have been widely employed for the recovery on native trout in wilderness areas of the American West, including Montana. Based on similar large-scale treatments in western Montana, the goals and objectives of this project are highly attainable for Westslope Cutthroat Trout[18]. In western Montana, ongoing monitoring on similar large-scale treatments in the South Fork Flathead River and the Cherry Creek watersheds indicate success[6,7,31], while also providing technical and biological insight into possible future projects[2,3].

Following a primary rotenone treatment, short-term implementation monitoring of three years or less, using electrofishing and eDNA, would dictate localized reach scale follow-up rotenone treatments. Based on early monitoring, genetic swamping will be used as needed on a local scale. Long-term effectiveness monitoring would extend up to 10 years, and would include repeat surveys of trout abundance, species composition and genetics, and would help ensure the project meets intended outcomes[1]. Input from experts in genetics, ecology, fisheries, conservation biology and climate change would help develop, implement and monitor the project. USFS wilderness staff and other planners would help design the monitoring effort to minimize trammeling and qualified field staff from FWP, U.S. Fish and Wildlife Service (USFWS) and USFS would oversee implementation of the project to help ensure success. Once the project is completed over approximately a decade, meeting the objectives of self-sustaining populations of

Westslope Cutthroat Trout with less than 2% introgression, and establishment of a naturally reproducing population of bull trout, there should be no need for further ecological intervention.

Compared to Westslope Cutthroat Trout, the likelihood of establishing a self-sustaining population of bull trout is less certain. Despite being listed as threatened under the ESA since 1998, introduction or reintroduction of bull trout within their historic range has been rare, though not unprecedented. Translocation of bull trout obtained from the Metolius River watershed into the Clackamas River watershed in Oregon entailed reintroduction beginning in 2011 of various life stages, from eggs to subadults[4,5]. Spawning has been observed since 2014, though continued monitoring is needed to confirm successful reproduction. A second restoration action involved the recolonization of bull trout upstream of a barrier occurred in Snowbank Creek[28], a stream near the North Fork Blackfoot River project. Here, bull trout were absent from the stream before restoring habitat connectivity. Following restoration of in-stream flows and the removal of a migration barrier, bull trout from Copper Creek recolonized the stream within two years. Currently, spawning and the presence of multiple year classes (age 0-adult) bull trout are now present in Snowbank Creek[28]. Recently bull trout were translocated above a barrier falls into a small stream-lake complex in Glacier National Park[35], but it's too soon to judge success of that project. Although these projects differ from the North Fork Blackfoot River project in various ways (e. g., wilderness versus non-wilderness, anthropogenic versus natural barriers), the Clackamas and Snowbank case studies show that bull trout can spawn, rear and reoccupy streams where populations have been lost due to barriers. These case studies plus a 0.81 positive score on a feasibility assessment for the bull trout translocation elevate the prospects of a successful outcome[46].

B. Does the proposed intervention need to occur here and now? Yes

The questions in this section help ensure that the proposal adequately considers "Options Outside of Wilderness" as required in the MRA or MRDG. Note that these questions expand on what is presented in this section of the MRDG by asking for a preliminary consideration of the effects of the proposed intervention.

	ADEQUATE	NOT ADEQUATE	NOT APPLICABL[1]
1. Does the proposal describe why the intervention needs to occur in <u>this</u> wilderness? Consider: • If surrounding non-wilderness lands and waters would be suitable for the action (e.g., other types of protected areas, state/local public lands, or private lands).	X	☐	☐
2. Does the proposal describe why the intervention needs to occur <u>now</u> in this wilderness? Consider: • The likely consequences if action is taken now. • The likely consequences if no action is taken now.	X	☐	☐
3. Does the proposal describe if intervention will set a national precedent in wilderness?[2] Consider: • If the action has heretofore occurred in any other wilderness.	X	☐	☐

[2] If the appropriate response is "Unknown" check the "Not Adequate" box.

• If the action is experimental.			
4. Does the proposal describe potential effects—positive, negative, neutral—of the intervention on wilderness character, including strength of evidence? Consider: • Short term effects of the action on each quality of wilderness character. • Long term effects of the action on each quality of wilderness character.	X	☐	☐
5. Does the proposal describe potential cumulative effects—positive, negative, neutral—of the intervention? Consider: • Cumulative effects over time on each quality of wilderness character. • Cumulative effects of the proposed intervention when combined with other administrative, scientific, commercial, and visitor activities.	X	☐	☐

If all rows are ADEQUATE or NOT APPLICABLE, continue the evaluation; if any rows are NOT ADEQUATE, deny proposal and return for potential revision.

B1. Does the proposal describe why the intervention needs to occur in this wilderness?

Yes. As described above, the North Fork Blackfoot River within the Scapegoat Wilderness was selected because of ongoing threats and ecological degradation that are both project area-specific and regionally-specific. Climate modeling projects that the project area is remain suitable for bull trout by 2040 (Isaak et al. 2015). These “climate shields” occur at high elevation and are often in designated wilderness. Thermal regime for most of the rest of the Blackfoot River watershed will be too warm for bull trout. Therefore, the Scapegoat Wilderness provide a rare opportunity to protect this cold-water obligate species in markedly dwindling habitat. In addition to correcting ecological damage and threats to native trout, the project area is among the rare opportunities to provide many connected stream miles, and access to lakes, and has among the highest potential for significant native trout conservation and protection in western Montana. Watersheds of this scope and magnitude, with these desirable attributes and primed for restoration are rare. The result of coordination and planning sessions confirmed the potential for this to have a high probability of success. The proposal has been under development for over 10 years, relies on comprehensive field investigations, and considers the present and future risks to native trout in headwater areas prone to climate warming, both within and outside western Montana wilderness areas. The project would protect bull trout by creating a headwater refugia population within a large protected area that is less prone to low-elevation habitat loss from climate warming. The North Fork Blackfoot River upstream of the barrier falls is further isolated from illegal fish introductions because of its remote location. Without this intervention, wilderness values relating to indigenous fish of the North Fork Blackfoot River watershed will decline[18,28,41].

Like the North Fork, there are at least two additional large wilderness areas in western Montana upstream of barrier waterfalls with similar potential for bull trout translocations. These include the Spotted Bear River of the South Fork Flathead drainage (Bob Marshall Wilderness) upstream of Spotted Bear Falls and the Landers Fork in the upper Blackfoot Basin (Scapegoat Wilderness) upstream of Silver King Falls.

The South Fork Flathead River already supports the largest metapopulation of bull trout in the Bob Marshall Complex with twelve known spawning streams. The habitat is intact, and the area is secure for bull trout because Hungry Horse dam on the lower river is a barrier to invasions of unwanted aquatic organisms. Hungry Horse Reservoir further provides foraging and overwintering habitat for migratory (adfluvial) bull trout. In addition, the South Fork of the Flathead basin is modeled to be less prone to climate-induced warming than the mainstem North Fork Blackfoot River because spawning and rearing sites are widely distributed across the South Fork Flathead Basin[18]. Thus, while the upper Spotted Bear River might be considered as a future bull trout refugium (especially considering the outcome of the North Fork Blackfoot introduction), there is less urgency to accomplish that action.

The headwaters of the Landers Fork offer another opportunity but is not currently being proposed for a bull trout translocation site because all spawning and most of the rearing habitat occurs in an accessible tributary, Copper Creek. Copper Creek is the upstream-most spawning population in the Blackfoot Basin. Unlike spawning tributaries to the lower Blackfoot River, the Copper Creek bull trout population is stable, and summer water temperatures are the coldest of all bull trout streams in the Blackfoot Basin[28]. Additionally, there are no competing or hybridizing species present, and spawning and rearing areas in the headwaters of Copper Creek are projected to remain thermally suitable through at least 2040[18]. Lastly, there is currently little biological information for the watersheds upstream of the Spotted Bear Falls or Silver King Falls to support bull trout translocations. Depending on the outcome of the North Fork project, those sites could be further evaluated over time. There is also additional urgency because the heavily hybridized North Fork salmonid population represents a known threat to downstream native trout, whereas those others do not have similar concerns.

B2. Does the proposal describe why the intervention needs to occur now in this wilderness?

Yes. The headwater source of hybridization threatens the genetic integrity of westslope cutthroat at multiple spatial scales. Climate change models projected through at least 2040 further suggest delays and inaction would fail to offset the ongoing and predicted regional contraction and loss of suitable habitat for both Westslope Cutthroat Trout and bull trout.

Genetic testing indicates project delays would exacerbate hybridization risk to down valley Westslope Cutthroat Trout, such as the Dry Fork population, from hybrid fish upstream of the barrier falls[27]. The Dry Fork supports cutthroat trout spawning and exhibits the complex migratory behavior by these genetically pure cutthroat trout, that mature in the middle Blackfoot River[44]. Thus, continued hybridization will diminish the genetic integrity of the westslope cutthroat metapopulation in the middle Blackfoot River. Indeed, the number of hybrid Westslope

Cutthroat Trout in the lower Dry Fork drainage increased from 4% in 2004[27] to 31% in 2016 (Sally Painter, Wild trout and Salmon Genetics Lab, personal communication) in samples taken within 1 mile of each other. Though the project would greatly reduce or eliminate one source of hybrid fish entering the Dry Fork, the North Fork Blackfoot River project may not eliminate possible future downstream sources of hybridization (e. g., rainbow trout from the Blackfoot River), which could extend upstream in the presence of continued warming[26,41]. Currently, the upstream-most known migratory rainbow trout from the Blackfoot River reproduces in a spring creek 18.7 river miles downstream of the confluence of the Dry Fork. The possible upstream expansion of downstream rainbow trout[41] further elevates the importance of a secure conservation population of Westslope Cutthroat Trout upstream of the North Fork Falls.

Bull trout are currently undergoing regional (low-elevation) population declines[12], which include dramatic declines all lower elevation bull trout stream in the Blackfoot Basin during the last 20 years[28]. Future contractions potentially include the projected loss of spawning and rearing habitat for the North Fork Blackfoot River population of bull trout located downstream of the barrier falls[18]. The North Fork Blackfoot River currently supports the largest run of migratory bull trout in the Blackfoot Basin. This stock differs genetically from other stocks[28]. Additionally, on the current course this stock and many others appear to be in jeopardy within the next 25 years[18]. Per the proposed timeline, the years 2020-2022 would be the earliest age 0 fish could be translocated[1]. The success of the translocation would not be known until 2026-2028, which is earliest time that translocated bull trout could successfully reproduce. With this timeframe in mind, the "why now" question relates to minimum 10-year window. Per USFS climate projections, this 10-year period will begin to approach the time that bull trout habitat in the North Fork will be compromised[18].

The USFWS supports the project because of the potential benefits to bull trout recovery. Section 7 (a)(1) of the ESA requires that federal agencies use their authorities and resources to advance endangered species recovery. This recovery action use current science, agency coopearation, and available funding to expand and secure a bull trout population in a portion of the Blackfoot River watershed that appears suitable to the long-term survival of the species. This recovery action is specifically described in the Recovery Unit Implementation Plan[36] for the Columbia headwaters. Lastly, the project has been funded by the USFS, Natural Resources Damage Program (NRDP) and FWP. The NRDP provides most the funding. This funding is specifically tied to both cutthroat trout and bull trout recovery as mitigation to replace mining-related native trout losses in the upper Clark Fork Basin[45]. Because of its high resource value, the State of Montana, federal partners and other cooperating stakeholders are prepared to advance the proposed action.

B3. Does the proposal describe if intervention will set a national precedent in wilderness?

Yes. Translocations or other methods of stocking native trout into historically fishless wilderness waters that are within their historic range have occurred throughout the American West. These actions were typically led by State agencies with primary jurisdictions over fish and wildlife management under the Wilderness Act[40] and State/USFS management agreements and/or American Fisheries Society stocking policies, most of which are recovery/conservation actions. It is important to point out that because many similar native trout conservation projects have been undertaken elsewhere, the North Fork Blackfoot River project would not set a national USFS or wilderness precedent. Examples of similar wilderness native trout projects include the following: 1) introduction of Westslope Cutthroat Trout into 11 historically fishless lakes in the South Fork of the Flathead River drainage in the Bob Marshall Wilderness[32]; 2) introduction of Arctic grayling (*Thymallus arcticus*) into historically fishless waters the North and South Fork of Sun River in the Bob Marshall Wilderness[15]; 3) introduction of westslope cutthroat into historically fishless Cherry Creek in the Metcalf Wilderness[7]; 4) introduction of Yellowstone cutthroat trout into historically fishless waters in Dead Indian Creek in the North Absaroka Wilderness[8] and Mystery and Dime Lakes in the Teton Wilderness[9]. Colorado also has an extensive record of translocating ESA-listed native fishes into historically fishless waters within wilderness (Table 11).

Table 11. Projects in Colorado where native cutthroat trout were translocated into designated wilderness or national park, including historically fishless waters (Kevin Rogers, Colorado Division of Wildlife, personal communication).

Wilderness Area	*Waters*	*Species*
Lizard Head Wilderness	Woods Lake, Fall Creek, Muddy Creek	Colorado river cutthroat trout
Flat Tops Wilderness	Big Cow Lake	Colorado river cutthroat trout
Holy Cross Wilderness	Timberline Lake, Lake Fork of the Arkansas River	Greenback cutthroat trout
Mount Massive Wilderness	Rock Creek watershed	Greenback cutthroat trout
Rocky Mountain National Park	Big Thompson watershed	Greenback cutthroat trout
Sangre de Cristo Wilderness	South Prong Hayden Creek	Greenback cutthroat trout
Lost Creek Wilderness	Rock Creek	Greenback cutthroat trout
Weminuche Wilderness	Roaring Fork watershed	Greenback cutthroat trout
Greenhorn Mountain Wilderness	Graneros Creek	Greenback cutthroat trout
Sangre de Cristo Wilderness	Sand Creek watershed	Rio Grande cutthroat trout (planned)

Furthermore, the Idaho Fish and Game has stocked bull trout in historically fishless lakes in the Frank Church-River of No Return Wilderness in Idaho to control brook trout (Dave Parris, IDFG, personal communication). The Boise National Forest has translocated bull trout from the North Fork of the Boise River (Sawtooth Wilderness) to Bear Creek, a non wilderness,

historically fishless tributary to the North Fork of the Boise River (Bruce Reiman and Tammy Hoem Neher, personal communication).

Because bull trout reintroductions or translocations are relatively uncommon, owing in part to their need for larger scale habitats and their reputation as a less desirable sport fish, monitoring data is limited compared to Westslope Cutthroat Trout translocations. Examples of other bull trout (re)introductions or translocations include the Clackamas project[4], introduction into Grace Lake in Glacier National Park[35], and Snowbank Creek, which is also in the Blackfoot River watershed. Planned or potential bull trout translocation projects are either being planned or proposed in the lower Clark Fork River watershed and the Pend Oreille watershed of Idaho and Washington.

Specific to the North Fork Blackfoot River project area, the relatively large scale (85 miles of stream of variable size and habitat features that include the presence of interconnected lakes), presence of groundwater inflows, cold-water refugia, and the resulting model projections that water temperatures will remain suitable make this a highly desirable project. The lack of human disturbance and relative security of the wilderness habitat going forward further makes this an ideal location for attempting a bull trout translocation as part of the larger project. A comprehensive pre-treatment inventory of aquatic species and conditions has been completed. An initial bull trout feasibility assessement[46] has been completed, and a ten-year post-treatment monitoring program is planned and has been funded.

Stocking actions associated with the recovery the ESA listed species, like bull trout, are specifically allowed under current USFS policy[43] and USFS/FWP wilderness management agreements[25,37]. Indeed, the USFS and FWP management framework for the Bob Marshall Wilderness complex[37] specifically states that ”chemical treatment may be necessary to prepare water for the reestablishment of indigenous species to protect or recovery Federally listed Threatened and Endangered species or to correct undesirable conditions resulting from the influence of humans (e.g., the establishment of and exotic fish population that threatens a native gene pool)”. The action must be necessary to maintain wilderness values ***or to recover a Threatened or Endangered species***.” Given this background, denial of permission to stock indigenous or ESA listed fish, or other imperiled native trout, into a wilderness setting with a prior (pre-wilderness) history of fish stocking could potentially set an adverse precedent in its’ own right.

B4. Does the proposal describe potential effects—positive, negative, neutral—of the intervention on wilderness character, including strength of evidence?

Yes. The proposal and subsequent analyses will detail the range of potential effects on wilderness character. Short-term presence of fieldworkers, and the use of rotenone would temporarily alter wilderness character. Rotenone, an organic compound originally discovered by natives in South America to have properties allowing them to harvest fish, has a short life and readily breaks down. Restoration of native Westslope Cutthroat Trout would improve the wilderness character and naturalness by restocking native fish to these waters. As an indigenous species to the Scapegoat Wilderness, bull trout also improve character over the status quo and buffer potential down-valley population declines in the Scapegoat Wilderness as currently projected[18]. Piscicide application would have short-term negative effects on some aquatic invertebrates and gill-bearing Rocky Mountain Tailed Frogs (*Ascaphus montanus*). These populations would rebound quickly through natural mechanisms of recovery because the headwaters of most streams would not be treated, and the fall timing of the project would coincide with the period of least impact.

Implementation of the short-term and long-term monitoring plan, and comparison to the baseline data on invertebrate and amphibian communities, trout abundance, species distributions, genetics and trophic structuring would allow evaluation of effects of the project on wilderness character. A comprehensive pre-treatment water temperature dataset is available as a basis for monitoring biotic relationships under present and future climate change scenarios. There are several negative effects to Wilderness Character that are expected with this proposal. There is no question that this action will negatively impact Wilderness Character in the short term. The project constitutes an intentional manipulation of the existing biophysical environment and is therefore a trammeling action. In addition, while in its main implementation stage (1-3 years) there will be significant impacts to Solitude of the area.

The Scapegoat Wilderness operates under the Bob Marshall Great Bear Scapegoat Recreation Management Direction that was signed in 1987 for the entire Bob Marshall Wilderness Complex[33]. Under this direction, the Scapegoat Wilderness utilizes the Limits of Acceptable Change system which “requires managers to define desired wilderness conditions and to undertake actions to maintain or achieve these conditions. A variety of influences affect these desired conditions, including recreation, fire control, grazing, and mining”[33]**.** These desired wilderness conditions have set standards along four Opportunity Classes within the Scapegoat. All four Opportunity Classes are present within the proposed project area. It is expected that as personnel, supplies, and equipment are mobilized; use levels, campsite impacts, and motorized intrusions will temporarily exceed standards set for Solitude and Undeveloped character. In addition, there will be a temporary reduction in the natural abundance of aquatic species found within the project area, thus reducing the Natural Character of the area. These effects of the proposal are expected to be short-term (1-3 years) and the proposal itself should not affect other

aspects of Wilderness Character such as Primitive and Unconfined Recreation or other features of value such as integral cultural or geological features.

If completed, the project will create an increase in natural character in the long term (5 years and beyond) by replacing the non-indigenous fish species with indigenous species. The short-term loss to wilderness character will lead to an improvement of wilderness character in the long term.

B5. Does the proposal describe potential cumulative effects—positive, negative, neutral—of the intervention?

Yes. As the project advances, it will be vetted through the Montana Environmental Policy Act, which will involve 1) an extensive assessment of the potential cumulative effects on the natural and human environments, 2) public review, and 3) a thorough review of the scientific literature on piscicide projects relative to the proposed project. Moreover, questions of cumulative effects to the aquatic community would be monitored up to 10 years post-treatment[1]. A before-after control-impact monitoring design is planned for aquatic invertebrates and amphibians, and an extensive dataset of baseline data on aquatic invertebrates, amphibians, and fish has been collected. These data would provide a basis for response monitoring. Treatment and control comparisons of community structure and composition could also be made with data from adjoining roadless/wilderness drainages that support both cutthroat trout and bull trout (e.g., headwaters of Monture Creek) and from other large-scale wilderness treatments (e.g., South Fork Flathead[6]) and/or other studies[16].

The cumulative effects of this action to wilderness character when viewed at a temporal scale are expected to have no long-term effect to the undeveloped character or the values of primitive and unconfined recreation or other features of value. If the project is successful in its establishment of a healthy cold water native fishery, long term impacts to the solitude of the area could occur with an increase in angling pressure. Nonetheless, this is speculative, and adjacent drainages with healthy fisheries in the Scapegoat Wilderness do not currently show unacceptable degradations of solitude due to angler use. Future FWP angler pressure estimates, which have been ongoing for decades, offer one method to help determine changes in angler use patterns. The current USFS and FWP management framework for the Bob Marshall Wilderness compex[37] outlines mechanisms to protect wilderness resources should visitor use lead to excessive disturbance or overuse.

The Wilderness Act directs managers to retain areas with “primeval character” which suggests managing the landscape to retain the qualities that were present at a set point in time, before the influence of modern man[37,40]. The Act also directs managers to protect the land in “its natural condition”[40]. While there is some debate to the meaning of the term natural, this action would

manipulate the ecosystem of the project area to be more consistent with surrounding ecosystems in the Scapegoat Wilderness and adjacent ecosystems in the Great Bear-Bob Marshall complex and replace non-indigenous species with indigenous genetic stocks. Despite uncertainty of what the aquatic ecosystem of the project area consisted of prior to anthropogenic influences, it seems reasonable to assume that by replacing nonnative species with native species, while undoubtedly trammeling and altering the existing state of the wilderness in the short term, would move the area closer to a natural state than its current condition in the longer term, which would be a positive outcome.

Within the project area, several other management activities will negatively affect wilderness character that also need to be accounted for. Most of these actions are reoccurring maintenance or permitted commercial use that would take place regardless of this proposal, but it is worth considering the cumulative effect to wilderness character that would occur with these actions in concert with the proposal. There are five permitted outfitter and guide camps in the project area that are particularly busy during the fall hunting season, and there are several permits that do not have permitted camps in the project area but do allow for summer roving trips. The USFS maintains a network of trails in the area, and has crews assigned to clear them annually throughout the duration of the project. The USFS is also actively treating invasive weeds species in the project area to increase the naturalness of the area and reduce the alteration of natural ecosystem processes. The USFS maintains one administrative use cabin within the project area, and 2 more are nearby within the Scapegoat Wilderness. The USFS may also be replacing a bridge along the North Fork of the Blackfoot River that is outside of the project area. Nevertheless, this action will still affect a visitor's wilderness experience when accessing the area from the North Fork Blackfoot River trailhead. The cumulative affects to wilderness character in the project area can be mitigated by ensuring that no major trail work, invasive weeds work, or campsite restoration work occurs in the same time frame as the proposal, and that the timing of the treatment actions from this proposal do not coincide with periods of heavy use from permitted outfitter and guide companies.

C. What are the legal and administrative considerations that apply to the proposed intervention? Yes

The questions in this section help ensure that the proposal adequately considers the "Criteria for Determining Necessity" as required in the MRA or MRDG. Note that these questions expand on the legal and administrative aspects of what is presented in this section of the MRDG.	ADEQUATE	NOT ADEQUATE	NOT APPLICABLE
1. Does the proposal describe if there is legal direction that permits the proposed intervention? Consider: • If the action is necessary to meet the Wilderness Act mandate to preserve one or more of the qualities of wilderness character.	X	☐	☐

• If the action is necessary to satisfy valid existing rights or a special provision in wilderness legislation (the Wilderness Act of 1964 or subsequent wilderness laws). • If the action is necessary to meet the requirements of other federal laws (e.g., ESA, ARPA, NHPA, Dam Safety Act, Clean Air Act).			
2. Does the proposal describe if there is administrative direction that affects whether to allow the proposed intervention? Consider: • If the appropriate administrative jurisdiction and the decisionmaker(s) have been identified. • If formal consultation or permits (e.g., for ESA issues) are needed prior to the proposed action.	X	☐	☐
3. Does the proposal describe if potential legal and administrative conflicts and uncertainties have been resolved? Consider: • If there are conflicts or uncertainties in regulations that influence the proposal decision. • If there are conflicts or uncertainties in policies that influence the proposal decision. • If there is other administrative direction, such as management plans or special orders (e.g., Executive Orders), that influence the proposal decision. • If there is guidance from partners that influence the proposal decision (e.g., state wildlife action plans, climate change adaptation strategies).	X	☐	☐

If all rows are ADEQUATE or NOT APPLICABLE, continue the evaluation; if any rows are NOT ADEQUATE, deny proposal and return for potential revision.

C1. Does the proposal describe if there is legal direction that permits the proposed intervention?

Yes. The project agrees with several existing laws, USFS Policy and guidelines, and management plans[13,20,21,24,36,40,43]. There are also two current USFS and FWP cooperative agreements that stipulate that making changes in fish species stocked in areas where stocking was established prior to wilderness desigation is fundamentally a State action and the responsibility of FWP[25,37]. With these laws, regulations, management plans and cooperative agreements all in place, we anticipate a cooperative interagency process, as described in wildernsess policy, whereby FWP, USFWS together with USFS biologists and wilderness staff and other stakeholders all work to identify and minimize wilderness issues associated with trammelling and to improve naturalness.

C2. Does the proposal describe if there is administrative direction that affects whether to allow the proposed intervention?

Yes. Administrative guidance is established through The Wilderness Act[40], USFS policy[43], as well as various cooperative agreements between the USFS and FWP[20,25,37]. The Wilderness Act specifically mentions that “nothing in the act shall be construed as affecting the jurisdictions and responsibilities of the several states with respect to wildlife and fish in the national forests (16

USC 1133)". The USFS Policy Manual[43] identifies the order of preference for stocking fish species in Wilderness is: 1) Federally listed Threatened or Endangered Species; 2) Indigenous species, and 3) Threatened or Endangered native species if species is likely to survive and spawn successfully. Indigenous species under this USFS policy are defined as "any species of flora or fauna that naturally occurs in a wilderness area and that was not introduced by man." Furthermore, the 2008 cooperative agreement for fish, wildlife and habitat management of national forest wilderness lands in Montana[25], mentions that "The State has the responsibility to make the determination as to which wildlife and fish are indigenous." Because both Westslope Cutthroat Trout and bull trout naturally occur in the Scapegoat Wilderness and the North Fork Blackfoot River as a coadapted and sympatric assemblage, FWP considers both appropriate the proposed action. In support of this determination, the Fish, Wildlife, and Management Framework for the Bob Marshall Wilderness Complex[37] specifically permits fish FWP to stock fish in order to "maintain an indigenous species adversely affected by human influence". This involves maintaining genetic refuges in high quality aquatic habitats, and improving genetics of native, sensitive species like Westslope Cutthroat Trout and to perpetuate or recover a threatened and endangered species.

With or without a bull trout component to the project, ESA consultaton would need to occur. Without bull trout, the focus would be on potential impacts downstream of North Fork Falls. With the inclusion of bull trout, the USFWS would complete the Section 7 consultation on behalf of the project including the introduction area, and would permit the translocation of bull trout through a Section 10 Recovery Permit. The USFWS, through their Creston National Fish Hatchery located near Kalispell, would assist as needed with: 1) the collection of eggs and milt, 2) incubation of embryos at the Creston Hatchery, and 3) the stocking of bull trout fry into suitable streams. Since the mid-1990s, the USFWS has experimentally reared bull trout at Creston National Fish Hatchery with great success, and is one of a few facilities with a cold water supply and isolation facilities prepared to handle this task. They are currently conducting a similar operation for Glacier National Park Logging and Grace Lakes translocation project.

C3. Does the proposal describe if potential legal and administrative conflicts and uncertainties have been resolved?

Yes. There are no known direct legal or adminstrative conflicts with the goals and objectives or implementation tasks associated with the proposal. To the contrary, various laws, policys, managment plans and cooperative agreeements are intended to support and guide this type of project[13,20,21,24,25,36,37,40,43] and thereby help resolve philosphical or administrative conflicts and uncertaintees. An example of a cooperative agreement is the Montana Cutthroat Trout Conservation Agreement[20], signed by both FWP and USFS. One objective under this agreement is to seek opportunities to "restore and/or expand populations of each cutthroat trout subspecies

into selected habitats within their respective historical ranges." This objective can apply directly to the Westslope Cutthroat Trout component to the North Fork project. Further clarity regarding bull trout is outlined in the Cooperative Agreement for Fish, Wildlife and Habitat Management on National Forest Wilderness Lands in Montana[25]. This agreement focuses on maintaining genetic refuges in high quality aquatic habitats, improving genetics of native, sensitive species like Westslope Cutthroat Trout, and perpetuating or recovering Threatened and Endangered species, while providing guidance on stocking approval policies.

Because conflicting views of naturalness are inherent to wilderness fisheries management, differences are typically resolved with administrative guidance as specifically outlined in the Wilderness Act[40], the USFS Policy Manual[43] and two USFS/FWP cooperative agreements that identify decision authority[25,37]. Using these and other guiding documents, the USFS, USFWS, and FWP fisheries staff are engaging USFS wilderness staff to minimize short-term trammeling, and to ultimately improve long-term naturalness consistent with the goals and objectives of the project. This engagement begins with this *Leopold Center Decision Guide for Evaluating Proposals for Ecological Intervention in Wilderness* and a feasibility matrix that showed positive potential for a successful bull trout translocation[46]. The project will be further vetted through the MRDG process, as well as public review processes (MEPA/NEPA), which will include various alternatives (e. g., no action, no bull trout) to the proposed action.

Does the proposal contain essential information for comparing alternatives in Step 2 of the MRA/MRDG "Determine the Minimum Activity"?

D. Have essential issues related to stakeholders, values, and implementation been considered in developing a range of alternatives? Yes

The questions in this section help ensure that the proposal adequately considers issues that may be of particular importance in developing and considering alternatives if ecological intervention is deemed necessary from Step 1 of the MRA or MRDG.	ADEQUATE	NOT ADEQUATE	NOT APPLICABL[1]
1. Have different potential stakeholders and their values contributed to the development of alternatives?	X	☐	☐
2. Have national and local (e.g., site-specific, traditional knowledge[3]) values and perspectives contributed to the development of alternatives?			
3. Have agency and/or external resources that are necessary to implement the intervention and monitor effects contributed to the development of alternatives?	X	☐	☐

If all rows are ADEQUATE or NOT APPLICABLE, proceed with Step 2 of the MRA or MRDG; if any rows are NOT ADEQUATE, deny proposal and return for potential revision.

D1. Have different potential stakeholders and their values contributed to the development of alternatives?

Yes. The problems and proposed actions have been presented to stakeholder groups throughout western Montana and based on feedback received the concept appears to have broad public support. These communication will advance as the project goes through more formal public comment periods. Ultimately, broad stakeholder support will be needed to implement a project of this scale. Volunteers from many organizations have helped with backcountry data collections and have offered further assistance. The project has statewide importance, which includes support from FWP Fisheries Divisioin and the Governor's office.

D2. Have national and local (e.g., site-specific, traditional knowledge4) values and perspectives contributed to the development of alternatives?

Historical fisheries conditions have been researched through interviews, historical archives, oral histories and agency records[27]. To date, these investigations have identified no historical fisheries information upstream of the North Fork Falls prior to stocking of nonnative trout in the 1920s. However, as previously noted, the recovered history is a small fraction of the ecological history of these species in western Montana. The proposed project has been communicated to resource managers and tribal leaders with the Confederated Salish and Kootenai Tribes. These early communications tend to support the basic project concepts including the bull trout component of the project. Alternatives will be vetted during MEPA/NEPA.

D3. Have agency and/or external resources that are necessary to implement the intervention and monitor effects contributed to the development of alternatives?

Yes. Agency cooperators on the project include the USFS, USFWS, FWP and the Natural Resource Damage Program. The Montana DEQ will be involved as the project moves towards implementation. Following the Fish, Wildlife and Habitat Management Framework for the Bob

[4] Traditional knowledge refers to the knowledge, innovations and practices of indigenous and local communities around the world. Developed from experience gained over the centuries and adapted to the local culture and environment, traditional knowledge is transmitted orally from generation to generation. It tends to be collectively owned and takes the form of stories, songs, folklore, proverbs, cultural values, beliefs, rituals, community laws, local language, and agricultural practices, including the development of plant species and animal breeds. Traditional knowledge is mainly of a practical nature, particularly in such fields as agriculture, fisheries, health, horticulture, and forestry. (Convention on Biological Diversity, Article 8j).

Marshall Wilderness Complex[37], the project has been presented to, and discussed with, commercial outfitters and other stakeholders at the Bob Marshall Wilderness Complex Managers Meeting for the last three years. Various conservation and user groups (e. g., Trout Unlimited, The Backcountry Horsemen of Missoula, The Nature Conservancy, Professional Wilderness Outfitters Association, Helena Hunters and Anglers) have voiced initial support for the project. The Big Blackfoot Chapter to Trout Unlimited has an account established to help fund the project. Subsequent MRDG processes will be undertaken, and alternatives will likely be refined and potentially modified.

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Appendix O. : Chemical and Mechanical Fish Removal White Paper

White Paper: Chemical and Mechanical Means of Fish Removal

Methods, Effectiveness, and Environmental Effects

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Introduction

Intentional, widespread introductions of nonnative fishes have provided popular and economically valuable angling opportunities. Illegal introductions and invasion have further increased the distribution of nonnative fishes. Combined, intentional introductions, illegal introductions and invasion have had detrimental effects on native species worldwide. The mechanism by which nonnative fishes displace native species varies with species; however, competition, hybridization, predation, and disease are the primary threats.

The effects of these introductions range from reductions in abundance and distribution of native fishes to extinction. Freshwater fishes had the highest exctinction rate of all vertebrates in the 20th Century, and an estimated 53 to 86 species will go extinct in North America by 2050 (Burkhead 2015). Although many factors can lead to the decline of a given species, species introductions and habitat degradation are the main threats to imperiled freshwater fishes in North America (Jelks et al. 2008). Transglobal introductions of rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) have earned these species a place on the list of the world's 100 worst invasive alien species (Invasive Species Specialist Group http://www.iucngisd.org/gisd/), with their establishment threatening native fish communities in suitable habitat on most continents.

Rainbow trout, brown trout, and brook trout (*Salvelinus fontinalis*) have been introduced throughout the western U.S. and are popular and economically important game species. Unfortunately, the successful establishment and continued invasion of nonnative salmonids have been exceptionally detrimental to native, freshwater *Oncorhynchus*. This diverse genus of trout and salmon has many species, subspecies and genetically distinct populations of concern within the western U.S., Canada and Mexico. Reductions in the distribution and abundance of freshwater *Oncorhynchus* has resulted in 29 taxa ranking as imperiled, with 1 of those taxa being extinct, and another, the Alvord cutthroat trout, possibly being extinct (Table1-12; Jelks et al. 2008). All but 1 taxon had habitat degradation listed as a cause for the decline; however, all shared introduction of nonnative species as a factor threatening their existence.

Table1-12. List of imperiled taxa of *Oncorhynchus* in the western U.S. (from Jelks et al. 2008).

Scientific Name	Common Name	Status
O. chrysogaster	Trucha dorada mexicana	Threatened
O. clarkii alvordensis	Alvord trout	Possibly extinct
O. clarkii bouvieri	Yellowstone cutthroat trout	Threatened
O. clarkii clarkii	Coastal cutthroat trout	Vulnerable
O. clarkii henshawi	Lahontan cutthroat trout	Threatened
O. clarkii lewisi	Westslope cutthroat trout	Threatened
O. clarkii macdonaldi	Yellowfin cutthroat trout	Extinct
O. clarkii pleuriticus	Colorado River cutthroat trout	Vulnerable
O. clarkii stomias	Greenback cutthroat trout	Threatened
O. clarkii virginalis	Rio Grande cutthroat trout	Threatened
O. clarkii ssp.	Humboldt cutthroat trout	Threatened
O. gilae apache	Apache trout	Threatened
O. gilae gilae	Gila trout	Endangered
O. clarkii seleniris	Paiute cutthroat trout	Endangered
O. mykiss aguabonita	South Fork Kern River golden trout	Threatened
O. mykiss aquilarum	Eagle Lake rainbow trout	Threatened
O. mykiss gairdnerii	Redband steelhead trout Owyhee	Vulnerable
O. mykiss nelsoni	Trucha de San Pedro Mártir	Vulnerable
O. mykiss newberrii	Redband trout	
O. mykiss newberrii	Catlow Valley populations	Vulnerable
O. mykiss newberrii	Goose Lake populations	Vulnerable
O. mykiss newberrii	Harney-Malhuer Lake populations	Vulnerable
O. mykiss newberrii	Warner Valley populations	Vulnerable
O. mykiss stonei	McCloud River redband Trout	Vulnerable
O. mykiss whitei	Little Kern River golden Trout	Endangered
O. mykiss ssp.	Truchas de los ríos Acaponeta y Baluarte	Threatened
O. mykiss ssp.	Trucha del Conchos	Threatened
O. mykiss ssp.	Truchas de los ríos Piaxtla, San Lorenzo y Presidio	Threatened
O. mykiss ssp.	Truchas de los ríos Yaqui, Mayo y Guzmán	Threatened

In addition to fishes of the genus *Oncorhynchus*, bull trout (*Salvelinus confluentus*) and Arctic grayling (*Thymallus arcticus*), also salmonids, have decreased substantially in distribution and abundance across their historical range (Liknes and Gould 1987; Quigley and Arbelbide 1997; Rieman et al. 1997; USFWS 1999). Numerous factors have contributed to their declines. Siltation, loss of habitat complexity, passage barriers, warming water temperatures, dewatering and nonnative species have diminished the range and abundance bull trout and Arctic grayling considerably.

States and federal agencies classify organisms based on their relative security and conservation needs. The State of Montana further classifies species based on their security within the state, and throughout their historical distribution, which sometimes differ. The Montana Natural Heritage Program and Montana Fish, Wildlife & Parks (FWP), with input from the Montana Chapter of the American Fisheries Society assign these rankings. Several native salmonids in Montana have 1 or more special status rankings, and these rankings can be complex (Table1-13). For species of concern in Montana, the complex rankings address polytypic species, where the species is secure, but a subspecies has a different status. Federal rankings are straightforward and are listed as threatened or sensitive. As the U. S. Fish and Wildlife Service (USFWS) is responsible for deciding whether a species requires protection under the Endangered Species Act (16 U.S.C.A, §1531-155 [Supp. 1996]), a species on the list has a status of listed threatened or listed endangered. The U.S. Forest Service (USFS) and Bureau of Land Management (BLM) rate salmonid species of concern in Montana as sensitive or threatened.

Table1-13. Salmonid species of concern in Montana and assigned status. Definitions of state rankings follow the list.

		State of Montana		Federal Agencies		
Species	Scientific name	Global Rank	State Rank	USFWS	USFS	BLM
Arctic grayling	*Thymallus arcticus*	G5	S1		Sensitive	Sensitive
Bull trout	*Salvelinus confluentus*	G4	S2	Listed Threatened	Threatened	
Columbia River redband Trout	*Oncorhynchus mykiss gairdneri*	G5T4	S1		Sensitive	
Lake trout	*Salvelinus namaycush*	G5	S2			
Pygmy whitefish	*Prosopium coulteri*	G5	S3			
Westslope cutthroat trout	*Oncorhynchus clarkii lewisi*	G4T3	S2		Sensitive	Sensitive
Yellowstone cutthroat trout	*Oncorhynchus clarkii bouvieri*	G4T3	S2		Sensitive	Sensitive

G5 = common, widespread, and abundant (although it may be rare in parts of its range). Not vulnerable in most of its range
G4 = Apparently secure, though it may be quite rare in parts of its range, and/or suspected to be declining.
G5T4 = globally secure; however, subspecies is apparently secure, although it may be quite rare in parts of its range, and/or is suspected to be declining.
G4T3 = apparently secure globally, although the subspecies is potentially at risk because of limited and/or declining numbers, range and/or habitat, even though it may be abundant in some areas.
S1 = At high risk because of extremely limited and/or rapidly declining population numbers, range and/or habitat, making it highly vulnerable to global extinction or extirpation in Montana.
S2 = at risk because of limited and/or potentially declining population numbers, range and/or habitat, making it vulnerable to global extinction or extirpation in Montana.

Implementation of projects that conserve or restore native species are required by state and federal laws aimed at preventing further loss of distribution, restoring populations when possible, decreasing the need for protection under the Endangered Species Act, and preventing extinction. In accordance with these laws, state and federal agencies have developed policies, and conservation planning documents that provide the framework to conserve native fishes. Several planning documents have been prepared for conservation of westslope cutthroat trout, Yellowstone cutthroat trout, and bull trout in Montana (Table 1.).

Table 14. Planning and strategy documents with relevance to native salmonid conservation in Montana.

Agency	*Citation*	*Website*
Montana cutthroat trout Steering Committee	Memorandum of understanding and conservation agreement for westslope Trout and Yellowstone cutthroat trout in Montana (2007)	http://fwp.mt.gov/fishAndWildlife/management/yellowstoneCT/
U.S. Congress	The Wilderness Act of 1964	https://www.gpo.gov/fdsys/pkg/STATUTE-78/pdf/STATUTE-78-Pg890.pdf
Montana Bull trout Restoration Team	Restoration plan for Bull trout in the Clark Fork River basin and Kootenai River basin, Montana	http://fwp.mt.gov/fishing/license/bullTrout.html
FWP	Wild Fish Transfer Policy (1996)	http://fwp.mt.gov/fishAndWildlife/management/westslopeCT/default.html
USFWS	Columbia Headwaters Recovery Unit Implementation Plan for Bull trout (2015b)	http://www.fws.gov/pacific/bullTrout/pdf/Final_Columbia_Headwaters_RUIP_092915.pdf
FWP	Statewide fisheries management plan (2014)	http://fwp.mt.gov/fishAndWildlife/management/fisheries/statewidePlan/
YNP	Native fish conservation plan environmental assessment (2011)	http://parkplanning.nps.gov/document.cfm?parkID=111&projectID=30504&documentID=37967
USFWS	Recovery plan for the coterminous United States population of Bull trout (2015)	http://www.fws.gov/pacific/bullTrout/pdf/Final_Bull_Trout_Recovery_Plan_092915.pdf

Typically, high elevation waters provide suitable habitat for native salmonids, and constructed or natural barriers protect these waters from reinvasion of nonnative species. The Wilderness Act of 1964 created the National Wilderness Preservation System and designated areas as wilderness, “where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain”. Often, designated wilderness occurs at high elevations, and these areas provide habitat that will be resilient to climate change and will be highly suitable for obligate cold-water species, such as cutthroat trout and Bull trout. Climate change models predict a substantial reduction in cold-water habitats in the historical ranges of Bull trout and cutthroat trout in the U.S. over the next 25 years, and designated wilderness has the potential to provide

refuge, or a "climate shield", for native salmonids, and increase the probability of their long-term persistence (Isaak et al. 2015).

The goal of this document is to provide the best scientific evidence to inform decision-making about the preferred method of fish removal for a given project, including those in designated wilderness. Relevant topics include the potential of mechanical and chemical removal to alter nontarget species composition, stream ecology, water quality, stream morphology, and the duration of alterations to these aspects of ecology and stream function. In addition, the effect of fish removal methodologies on wilderness values is a major consideration. This document also identifies conditions that may prevent a method from being ineffective or infeasible.

Mechanical Removal

Mechanical removal entails the use of electrofishing, nets, or traps to capture fish. Mechanical removal can be the sole mode of fish removal, or it can be used in conjunction with piscicide. Mechanical removal as the only method can be successful under specific circumstances (Shepard et al. 2014). In some situations, mechanical removal may have greater public acceptance than chemical removal.

Often, angling is suggested as a mechanical means of fish removal, and it can be an adjunct to other methods. Increasing daily catch and possession limits and implementing mandatory kill of nonnatives in fishing regulations, may increase harvest of nonnative fish. For example, in Yellowstone National Park, the National Park Service (NPS) has implemented must kill regulations for rainbow trout caught in Slough Creek and Lake Trout caught in Yellowstone Lake (NPS 2015). Likewise, FWP has liberal daily catch and possession limits for brook trout, and anglers can have 20 brook trout in possession (see State of Montana Fishing Regulations 2017). Nevertheless, angling alone will not meet targets for removal of nonnative fish, which usually require 100% removal, or sufficient reductions of hybridizing species, to meet conservation goals.

Angling is not a viable means of meeting project goals of eradication due to its inefficiency and the difficulty in fishing in remote headwaters. Fry and age-1 fish are invulnerable to fishing and would mature to provide a perpetual source of the targeted species. Moreover, fish targeted for removal often live in high gradient streams covered by deadfall timber. These relatively unfishable reaches would harbor nonnative fish and be a continual source of fish to invade the waters below. Angling may have a role as an addition to other measures; however, because angling would not eliminate all nonnative fish, or appreciably decrease numbers or distribution in many watersheds, it will not be considered further in this document.

Effectiveness of Mechanical Removal

Mechanical removal using electrofishing can be effective under specific conditions (Shepard et al. 2014). Crews of 2 to 3 people removed fish from stream reaches measuring from 1 to nearly 2 miles of stream. Successful removal through electrofishing took as few as 6, or as many as 14 treatments, with each treatment consisting of 2 to 4 electrofishing passes through the reach. Increasing effort from once a year to targeting autumn spawning and winter aggregating behavior also improved efficacy.

Clearing riparian vegetation and woody debris contributed to successful fish removal using electrofishing (Shepard et al. 2014). Before mechanical removal began, field-workers cleared riparian vegetation and woody debris with chain saws. Woody debris and overhanging vegetation are critical components of high quality fish habitat; however, this complex habitat reduces the ability to net fish. Dip nets are easily snagged on branches and twigs or are too large to reach spaces protected by woody debris. Removal of obstructions to netting fish increases capture efficiency.

Debris removal increased project costs (Shepard et al. 2014). Mechanical removal cost from $3,500 to $5,500 per kilometer. This amount was comparable to the use of piscicide, including labor, chemical, per diem, and travel costs. When clearing vegetation and wood was necessary to eradicate nonnative fish, project costs increased to $8,000 to $9,000 per kilometer.

Mechanical removal has been attempted in several projects in small, headwaters streams with mixed success. Biologists successfully eliminated nonnative rainbow trout from 0.5-miles of stream in Tennessee in 5 treatments (Kulp and Moore 2000). Another effort to remove rainbow trout in streams in the Great Smoky Mountains National Park achieved a great reduction in rainbow trout after 6 years of effort but not eradication (Moore et al. 1986). Mechanical removal efforts in the Rocky Mountains varied in success. Thompson and Rahel (1996) substantially reduced brook trout densities in 3 streams small streams ranging from approximately 2 to 6 miles in length, and no recruitment was observed in the following year. No follow up data were presented to determine if the low numbers of fish that evaded capture were able to reproduce in years after removal efforts stopped. A 3-year mechanical removal effort in a nearly 5-mile long, 2nd order stream in Idaho achieved up to an estimated 88% reduction in brook trout numbers in repeated removal efforts (Meyers et al. 2006). However, 2 years after cessation of brook trout removal, age-0 fish increased by 789%, leaving these researchers to conclude removal on larger streams would be “costly, quixotic enterprises”. Shepard (2010) eradicated brook trout in 4 small streams in Montana less than 2 miles in length, but habitat complexity in the form of dense shrubs, overhanging vegetation, beaver dams and high density of woody debris were effective precluded eradication in 2 other streams.

Native species conservation often happens on a watershed scale, and mechanical removal is infeasible in these situations. For example, over 60 miles of stream and 1 lake were reclaimed for westslope cutthroat trout in the Cherry Creek watershed and 21 alpine lakes and 45 miles of stream habitat were reclaimed for westslope cutthroat trout in the South Fork Flathead River watershed. In the Cherry Creek drainage, piscicide application began in 2003, and westslope cutthroat trout stocking began in 2006, with embryos placed in remote site incubators (RSIs) within streams. By 2015, the watershed supported over 40,000 westslope cutthroat trout (B. B, Shepard, Montana State University, personal communication). Costs associated with debris removal and personnel required for multiple passes on complex watersheds of this size are prohibitive. Moreover, assigning field-workers to a prolonged mechanical removal effort would preclude work on other native species conservations projects for many years.

Soda Butte Creek, a stream that enters Yellowstone National Park near its northeast corner, provides a case study of failure to remove all nonnative fish on a watershed scale, despite substantial effort. Soda Butte Creek is a relatively large watershed with complex habitat, and 21 miles of fish-bearing stream. Brook trout were present in a private pond connected to a headwater tributary but were prevented from escaping because heavy metals from mine tailings created a chemical barrier. Following remediation of the tailings, brook trout invaded this stronghold for Yellowstone cutthroat trout.

The invasion was alarming due to the extreme threat brook trout pose to the cutthroat trout, especially in headwater streams (Dunham et al. 1997; Petersen et al. 2008; Shepard 2004; Shepard 2010). Moreover, this population of brook trout is poised in the headwaters of the Lamar River watershed, which is a basin-wide stronghold for Yellowstone cutthroat trout. Spread of brook trout downstream would endanger a population of Yellowstone cutthroat trout with immeasurable conservation and recreational value. Total elimination of brook trout was necessary to prevent further invasion and protect the Yellowstone cutthroat trout in Soda Butte Creek.

Removal efforts began in the early 1990s, and a concerted, multi-agency, intensive effort began in 2004, and ended in 2014. FWP, the Custer-Gallatin National Forest (CGNF), and the NPS each sent crews of 10 or more field-workers to conduct intensive yearly electrofishing. This annual event accrued the cost salaries of over 30 field-workers, and their travel and per diem costs. Moreover, the yearly brook trout removal diverted resources from priority actions under the strategy to conserve Yellowstone cutthroat trout in Montana, which include securing imperiled populations, field surveys to evaluate the status of populations that had not been sampled in decades and searching for previously unidentified populations (Endicott et al. 2012).

The greatest number of brook trout were removed in the first 3 years, with a peak of nearly 11,000 fish in 2005 (Table 1-15). In the remaining years, the overall number of brook trout

removed from Soda Butte Creek and its tributaries was relatively static, with efforts yielding approximately 100 to 150 brook trout removed from Soda Butte Creek and its tributaries. The number of brook trout captured decreased in the upper reaches, whereas removal reaches 5 through 7, which extended into Yellowstone National Park remained static, or showed an increasing trend in brook trout numbers.

Table 1-15. Total (and young-of-year) brook trout mechanically removed from Soda Butte Creek within the CGNF, State of Montana, and YNP.

Site	*Removal Reach*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*
1	HWY 212 to McClaren Mine Tailings	19(1)	3(0)	0(0)	0(0)	0(0)	NS	NS	NS	0(0)	0(0)	1(0)
2	McClaren Mine Tailings to Woody Creek	15(0)	17(0)	3(0)	3(0)	2(0)	NS	NS	NS	NS	NS	0(0)
3	Woody Creek to Sheep Creek	8(2)	43(0)	16(0)	0(0)	1(0)	NS	NS	2(0)	0(0)	0(0)	1(0)
4	Sheep Creek to Silver Gate	251(79)	932(51)	142(6)	45(8)	5(0)	6(0)	NS	30(1)	5(0)	4(0)	2(0)
5	Silver Gate to Yellowstone Park Boundary	9(3)	80(9)	54(2)	48(19)	13(0)	30(2)	16(0)	22(2)	10(0)	2(0)	30(3)
6	Yellowstone Park Boundary to Warm Creek	7(0)	11(0)	0(0)	50(27)	23(2)	56(10)	43(2)	15(0)	29(9)	35(0)	8(0)
7	Warm Creek to Highway X Bridge	0(0)	1(0)	0(0)	0(0)	3(1)	51(12)	68(29)	35(6)	53(10)	54(23)	55(4)
8	Road Bridge I to Road Bridge II	NS	NS	NS	NS	0(0)	1(0)	7(0)	2(0)	11(2)	16(3)	3(0)
9	Road Bridge II to Ice Box Canyon	NS	NS	NS	NS	0(0)	0(0)	NS	0(0)	NS	NS	NS
T	Tributaries	0(0)	17(0)	15(0)	4(0)	1(0)	8(0)	NS	NS	0(0)	54(19)	2(0)
	Total	309	1,104	230	150	48 (3)	152(24)	134(31)	106(10)	108(21)	165(45)	102(7)

*NS= Not Sampled

From 2009 through 2014, the reach from Warm Springs to the next highway bridge downstream consistently yielded about 50 brook trout, and variable but sometimes substantial numbers of brook trout were removed the lower 2 sections. The failure to achieve declines in this reach indicated mechanical removal would not eradicate brook trout, and the downstream reaches of Soda Butte Creek would be a continued source of brook trout to reinvade waters upstream and move downstream into the Lamar River watershed. Habitat complexity in the form of massive debris jams contributed to the inability to achieve full removal (Figure 0-1).

Figure 0-1. Example of a debris jam that decreases the ability of removing all brook trout, showing 2-ft diameter log for scale.

The size and number of debris jams also affects feasibility of woody debris removal. For example, in a reach with numerous debris jams of the size and complexity as shown in Figure 0-1, heavy equipment would be necessary, which would greatly increase project costs, and would be infeasible in remote locations and designated wilderness. Furthermore, disturbance associated with the use of heavy equipment to remove large debris jams would be considerable and may be unacceptable to the public.

The failure of repeated mechanical removal to eradicate brook trout, combined with the threat these fish posed to the Lamar River watershed, led fisheries managers to reevaluate mechanical removal as the preferred option. Removal efforts were costly and other conservation efforts were indefinitely delayed given the amount of effort expended in Soda Butte Creek each year. Moreover, brook trout are capable of explosive resurgence from low densities of fish within a

few years (Meyers et al. 2006), which suggested easing up on the expensive and labor intensive yearly mechanical removal efforts would reverse progress within a few years. Consequently, chemical removal emerged as the method with the greatest potential for successful eradication and would allow the agencies involved to attend to other high priority projects.

Piscicide application occurred in 2015 and 2016, and each treatment was preceded by salvage of resident Yellowstone cutthroat trout in Soda Butte Creek. Sampling for environmental DNA (eDNA) with brook trout markers in summer 2017 found a cluster of brook trout DNA in samples collected downstream of Silver Gate, in reach 5 (Table 1-15). In response to these findings, intensive electrofishing and additional eDNA sampling ensued; however, these efforts did not find evidence of brook trout. Testing for eDNA is sensitive and positive results could be the result of a brook trout carcass stuck in debris still casting off DNA, or transfer of brook trout DNA from waders or piscivorous birds. Monitoring using electrofishing and eDNA sampling will continue to evaluate the effectiveness of piscicide treatment, but no additional treatments are planned, unless monitoring data indicate otherwise (J. Rhoten, FWP, personal communication).

Mechanical removal and chemical removal of nonnative fish usually share the need of a barrier at the downstream end of the project reach. Ideally, a natural barrier, such as a waterfall, is present. Otherwise, one or more barriers must be installed. In streams where mechanical removal is feasible, features such as perched culverts, log cribs, concrete structures, or creation of waterfall by blasting rock are options. If removal approach involves sequential downstream removal efforts, where eradication begins in smaller headwaters, a few to many temporary barriers would be necessary, depending on the spatial scope of the project. The adjacent, downstream reach would later be protected by a barrier, and the upstream, temporary barriers would be removed when the threat of reinvasion from downstream has been eliminated. As mechanical removal has not been successful in larger streams, or streams with complex habitat, large watershed projects would require a prohibitive number of barriers.

In conclusion, mechanical removal can be an effective method of removal of nonnative species under limited circumstances. The length of stream is a major consideration. Mechanical removal has been effective in streams reaches from approximately 1.5- to 2 miles long; however, the level of effort can be considerable, with up to 14 treatments of up to 4 electrofishing passes required (Shepard et al. 2014). Habitat complexity is another concern, with electrofishing being ineffective in complex habitat. Removal of woody debris and riparian vegetation increases probability of removal using mechanical means but adds considerably to project costs. Moreover, debris removal may not be feasible in large scale projects with remote tributaries and substantial amounts of woody debris. Finally, mechanical removal is not feasible in large, connected watersheds with complex habitat, given limitations in the amount of available labor, the need for numerous barriers, and constraints on capture efficiency. This reality presents a challenge for

conservation practitioners since large, complex, interconnected habitats provide the greatest opportunity for long term population persistence.

Potential Disturbance from Mechanical Removal of Fish in Streams

Disturbance associated with mechanical removal differs substantially from chemical removal in several ways. Both require the presence of field-workers; however, the frequency and duration of human activity is project specific. Unless a waterfall or other existing feature prevents reinvasion of fish from downstream, mechanical and chemical removal require construction of at least 1 barrier, although mechanical removal may require additional barriers as removal proceeds downstream from headwater reaches. Removing vegetation and debris to facilitate capture of fish using electrofishing is a pronounced difference between the methods and has potential for short-term and long-term effects on streams.

Presence of Humans

Mechanical removal requires presence of field-workers performing multiple passes, often for several years. The number of passes and duration of treatment depends on capture efficiency, but crews of 2 or more people would be walking streams, and shocking and netting fish. For small streams, a battery powered backpack electrofisher is the most likely method of removing fish. On larger streams, a boat-mounted electrofishing unit powered by a gas generator would be pulled along the stream. This method typically requires crews of 3 or more people. Gas-powered generators are relatively loud and create noxious exhaust. As removal efforts are effective in short reaches of small streams, backpack electrofishers are more likely to be used than the boat-mounted electrofishers. In wilderness, gear for removal would likely need to be flown in by helicopter, especially if a boat-mounted electrofisher and generator is required.

Barriers

In many cases, mechanical and chemical removal require construction of 1 or more barriers to prevent reinvasion of nonnative fishes. The types of barriers vary, and constructing barriers results in variable amount and type of human activity. In addition, barriers alter sediment and woody debris transport and may require regular maintenance. The type and duration of disturbance varies with the type of barrier. Blasting rock to create a waterfall results in considerable noise but is brief. Construction of log cribs requires a variety of power tools, field-workers, and transportation of materials and equipment to the site. Installation of perched culverts or concrete barriers requires mobilization of heavy equipment to the site, which includes excavators, concrete trucks, contactor’s vehicles, and materials. In some cases, a road needs to be constructed to provide access to the site, or materials and equipment can be transported by helicopter. The time required to build a barrier varies with size, materials, and equipment required to construct the barrier.

The upper Shields River watershed is an example of an effort to remove brook trout on a watershed scale that is capitalizing on existing or temporarily placed barriers. Periodic sampling beginning in the 1970s found only nonhybridized Yellowstone cutthroat trout, until 2009, when basin-wide sampling found an early invasion of brook trout. Fortunately, this finding coincided with the CGNF's multimillion dollar road improvement project intended to improve water quality, provide fish passage, and improve public access to the forest. Planners made strategic decisions on which fish barriers were to remain, and where to install temporary perched culverts to protect tributaries that had not yet been invaded. A large, permanent barrier was constructed at the downstream end of the project area. FWP, the CGNF and other project partners began mechanical removal from waters not protected by barriers in 2014. Brook trout have apparently been eliminated in a small tributary that was in an extremely early phase of invasion, with only 3 brook trout found over repeated removal efforts. The overall success remains unknown; however, in the event chemical removal becomes the preferred option, not all fish-bearing waters will need to be treated, and the protected streams will provide areas to hold salvaged Yellowstone cutthroat trout during piscicide treatment.

The number of barriers required to prevent reinvasion of nonnative species during a long-term removal effort, in a watershed that did not have heavy equipment already mobilized, would be prohibitive. As fish removal in reaches greater than 2 miles in length are ineffective, barriers would need to be installed at regular, close intervals, and removal would need to proceed in a step-wise fashion. On a watershed scale, and in remote country or designated wilderness, installation of temporary barriers would be costly, result in considerable disturbance, and would potentially be inconsistent with wilderness management objectives.

The influence of the constructed barriers at the downstream end of the treatment reach has potential to affect channel morphology, sediment transport, and conveyance of woody debris. Barriers used in fish removal projects vary with the site. The wood cribs alter bed load and debris transport and have the potential to fail during floods. Perched culverts need to be installed where road access is available. Moreover, culverts and concrete barriers also have potential to impair transport of bed load and woody debris. Barriers need to be inspected regularly for maintenance, and removal of woody debris and accumulated bed load.

Vegetation and Debris Clearing

Clearing vegetation and debris increases the potential for successful mechanical removal of nonnative fish and can be economically and logistically feasible for small streams less than 2 miles in length (Shepard et al. 2014). Aside from the limited practicality of removing streamside vegetation and debris, these actions have potential for short-term and long-term alterations to stream ecology, benthic invertebrate community composition, water quality, fish habitat, and channel stability.

Removing over-hanging shrubs would have relatively short-term effects on streams, as the functional attributes of riparian vegetation recover quickly in absence of additional disturbance. Nevertheless, these alterations need to be considered, especially given the potential of vegetation removal to affect habitat, forage availability, and water quality for native fish stocked into reclaimed waters, and the influence of vegetation on benthic invertebrate communities, which are highly reliant streamside vegetation as a source of organic input and stream shading.

In forested headwater streams, macroinvertebrate communities depend on terrestrial inputs of organic matter (Vannote et al. 1980). Removing vegetation and increasing primary productivity through greater sun exposure may shift the community composition from invertebrates eating leaf matter, to species that graze algae from rocks and other substrates within the stream. In Montana, cold-water, headwater streams provide habitat for 8 invertebrate species of concern of the genus *Utacapnia* that are cold-water stenotherms and consume leaf litter, (see Montana Natural Heritage Program website). Pre-project planning should include sampling invertebrate communities to evaluate if invertebrate species of concern are present before removing riparian cover.

Removing riparian vegetation can change thermal regime, which would have implications for fish and macroinvertebrates. Canopy density has been found to affect thermal inputs to streams, and warmer water temperatures resulted in reduced salmonid biomass (Platts and Nelson 1989). Increased insolation of the stream surface would be detrimental to Bull trout and cutthroat trout, as these fishes are more sensitive to warmer water than nonnative salmonids (Selong et al. 2001; Sloat et a. 2002; Bear et al. 2011; Dobos et al. 2016). Warmer water temperatures may also alter the community composition of macroinvertebrates, as species vary in their thermal tolerance.

Elimination of these debris jams would increase capture probability; however, it would have longstanding consequences for channel stability and fish habitat. Woody debris promotes channel stability during flood events (Heede 1985). Furthermore, woody debris produces scour that promotes the formation of pools and other habitat features (Heede and Rinne 1990). Recruitment of large woody debris occurs over decades, so woody debris removal would result in long-term alteration of this important component of stream stability and habitat formation.

Compatibility of Wilderness Values with Mechanical Removal of Fish in Streams

Mechanical removal of nonnative fish brings several potential disturbances that may affect wilderness values and diminish visitors' appreciation of the wilderness experience. Electrofishing in streams generally entails several crews making multiple electrofishing passes over the course of up to 14 treatments (Shepard et al. 2014), and these are often multiyear projects. The extended and repeated presence of field-workers in the stream increases the human

imprint in wilderness. Backpack electrofishers produce a frequent beep when an electrical current is in the water. Larger streams require boat mounted electrofishers equipped with a gasoline powered generator, which produce noise and exhaust. Setting and checking of nets also requires field-workers be present. These disturbances could diminish the peace and solitude of recreationalists visiting designated wilderness.

Transportation of gear into remote areas also has potential to alter wilderness character, increase the human imprint, and diminish the visitor's enjoyment of the peace and tranquility. Personal gear, provisions, and field gear are transported by backpack, horse train, or helicopter. Each mode is a disturbance that increases human presence, causes noise, and results in conditions that may affect enjoyment of wilderness. Constructing barriers in wilderness also entails transporting materials and equipment into wilderness, and the associated noise and human presence is inconsistent with maintaining wilderness character.

Removal of woody debris and streamside vegetation increases the efficiency of electrofishing; however, it brings several short-term and long-term disturbances to the wilderness character. Field-workers removing woody debris would bring more humans into wilderness. The noise and exhaust of power tools is incompatible with wilderness values. Moreover, vegetation and debris removal may alter the ecology of the stream and remove important components of stream habitat and stability. Regrowth of riparian shrubs would make increased temperatures and reduction of leaf matter a relatively short-term alteration. In contrast, large woody debris may take decades to recruit, which could have long-term effects on fish habitat and channel stability. The long-term alterations with woody debris clearing would be a substantial human imprint and may not be acceptable under the Wilderness Act of 1964.

Clearing debris and vegetation also affects the aesthetics of the stream and is inconsistent with the concepts of "untrammeled" and "wilderness character". Sawed off stumps, reduced wood in the stream, and significant reduction of the natural riparian overstory are considerable manipulations of the natural environment. Moreover, removal of wood could have long-term effects on recreation, as streams with reduced habitat complexity may have lower carrying capacity for fish. From conservation and recreational angling perspectives, fewer fish is undesirable.

Methods and Efficacy of Mechanical Removal of Fish in Lakes

Mechanical removal in lakes is typically accomplished through deployment of nets, especially gill nets. Genetic swamping may be used in conjunction with nets. Genetic swamping involves frequent or annual stocking of nonhybridized native fish into a lake, with the goal of decreasing the frequency of nonnative genes within the population.

Not all lakes are candidates for mechanical removal. Connected lakes, those with tributaries and an outlet capable of supporting fish, have a perpetual source of nonnative fish to reinvade. Mechanical removal is an option for isolated high mountain lakes with outfalls that are not connected to fish-bearing streams, or in conjunction with removal efforts in the inlet and outlet streams.

Potential Disturbance from Mechanical Removal in Lakes

Using netting to eradicate fish may have several negative consequences. The nets may be aesthetically unappealing to people accessing the lake, and they are a relatively long-term disturbance, as they are set for several months. Moreover, non-target species may suffer mortality in nets. Beavers captured in submerged trap nets drown, as do diving birds that become entangled in gill nets.

Compatibility of Wilderness Values of Mechanical Removal of Fish in Lakes

The primary disturbances associated with mechanical removal of fish in lakes involve increased presence of fieldworkers, and the extended use of nets. Backpackers seeking the tranquility of a mountain lake could have their enjoyment decreased due to presence of other people and gill nets.

Chemical Removal

Background on Rotenone

Piscicides used in fish removal projects include rotenone and antimycin. Rotenone is the focus of this document, as it is currently the most commonly used piscicide in Montana. State and federal agencies tasked with fisheries management have a long history of using rotenone to manage fish populations, spanning as far back as the 1930s. Rotenone is principally applied to improve angling quality and for native fish conservation. Rotenone has been an invaluable tool in restoring native species to waters where they have been extirpated or are threatened by nonnatives. In cases where nonnative fish have been introduced upstream of natural barriers in waters that was historically fishless, rotenone has been applied to remove nonnative fish, and stock fish in previously unoccupied habitat in its historic range.

Rotenone is a naturally occurring substance derived from the roots of tropical plants in the pea family (Fabaceae), such as the jewel vine (*Derris* spp.) and lacepod (*Lonchocarpus* spp.), which are found in Australia and its surrounding Pacific islands, southern Asia, and South America. Native people have used locally available rotenone for centuries to capture fish for food. Rotenone is also a natural insecticide and was formerly used in organic gardening and to control parasites such as lice on domestic livestock (Ling 2002).

Rotenone works on the cellular level by disrupting cellular respiration in mitochondria (Hayes 1991), which are the cellular organelles responsible for converting chemicals to energy. Fish are especially vulnerable to low levels of rotenone, as they readily absorb rotenone into the bloodstream through the gill lamellae. Many gilled invertebrates are also vulnerable to rotenone, although many are not nearly as sensitive as fish. In addition, amphibians respire with gills during their earliest life history stage and are vulnerable to rotenone. Mammals, birds, reptiles and other non-gill breathing organisms lack this rapid absorption route into the bloodstream and can tolerate exposure to concentrations that are several orders of magnitude higher than levels lethal to fish.

Currently, CFT Legumine™ is a formulation of rotenone most commonly used for nonnative fish removal in Montana. CFT Legumine has the advantage of using nonorganic solvents and dispersants to dissolve and disperse the relatively insoluble rotenone. In contrast, formerly used formulations used organic solvents. These formulations had the disadvantage of being more toxic to field-workers handling and dispensing rotenone, and fish could detect and elude these aromatic compounds.

Method of Applying Rotenone Treatment in Streams

Rotenone projects begin with a bioassay, or field experiment, to determine the lowest effective concentration of rotenone to kill fish in the receiving water. In practice, lowest effective concentration of rotenone for salmonids in cold-water streams is 25 to 50 parts per billion (ppb), which is roughly equal to ¼ to ½ grains of table salt per liter. The rotenone treatment begins in the headwaters, and tributary streams in the headwaters are treated first. Because rotenone degrades rapidly, drip stations are typically placed at intervals to ensure that chemical from upstream drip stations overlaps with that from downstream drip stations. The spacing between drip stations is also determined with a bioassay that assesses how long rotenone remains lethal to fish during treatment. Sentinel fish in mesh bags allow for determination of the appropriate interval. The treatment proceeds downstream in steps, until all surface waters have been treated.

Wetlands, seeps, and side channels have potential to harbor fish or dilute concentrations of rotenone to sublethal levels. In these areas, powdered rotenone mixed with sand and gelatin is placed at the mouths of small tributaries or seeps, to prevent fish from finding refugia from lethal concentrations of rotenone. Likewise, field-workers with backpack sprayers treat backwaters and isolated pools as toxic concentrations of rotenone may not be achieved in off-channel habitats.

Rotenone treatments need a consistent and sufficient flow of solution to promote a full fish kill. CFT Legumine uses solvents and dispersants to keep the relatively insoluble rotenone in solution and allow it to spread through the water. These inert ingredients can gel at the colder temperatures occurring during autumn application. Therefore, drip stations require regular

monitoring to ensure the diluted rotenone formulation does not clog the aperture dispensing rotenone. To provide a steady supply of rotenone, field-workers stay at each drip station for the duration of the treatment, and monitor flow rate, and unclog the aperture as required. Drip stations may also lose pressure and need to be equilibrated, which requires frequent monitoring. In addition, drip station attendants monitor the sentinel fish upstream of the drip station, to ensure toxic concentrations of rotenone are maintained between drip stations.

Beaver dam impoundments can prevent dispersal of lethal concentrations of rotenone given their depth and complex habitat. Beaver dams are typically breached during the piscicide treatment to foster flow through the area and eliminate potential refugia from rotenone.

Rotenone detoxifies naturally through oxidation, dilution by freshwater and binding with organic sediment. Factors influencing natural oxidation include water temperature, water chemistry, and exposure to organic substances, air, and sunlight (Engstrom-Heg 1972; Gilderhus et al. 1986; Loeb and Engstrom-Heg 1970; Ware 2002). Dilution results from contributions of water from tributaries or upwellings of groundwater.

Establishment of a deactivation station limits the spatial extent of the fish kill by oxidizing rotenone with potassium permanganate. Full neutralization of rotenone requires a short mixing zone, which allows rotenone and potassium permanganate 1/2 -hour of contact time in the stream. Application rates of potassium permanganate are based on stream flow and natural background levels of oxidation. A small handheld colorimeter measures levels of potassium permanganate to guide application rates.

Application of potassium permanganate often requires a power auger that is run soon after piscicide application begins and continues until sentinel fish show no signs of distress for 4 hours. The amount of potassium permanganate can be considerable, as FWP piscicide policy requires twice the estimated amount of potassium permanganate be on-site during treatment. When the deactivation station is in a remote location, potassium permanganate, the power auger, a generator, and fuel need to be transported to the deactivation station by helicopter or pack stock.

Caged fish allow evaluation of the toxicity and deactivation within the project area, and downstream of the project area. These sentinel fish are placed upstream of drip stations to ensure toxic concentrations of rotenone are maintained between stations. During treatment, the status of sentinel fish downstream of the deactivation station indicates when the water is no longer toxic. The CFT Legumine label specifies that once caged fish show no signs of distress for 4 hours, stream deactivation can cease. Sentinel fish need to be transported to the project area and dispersed throughout the treated area in coolers, which requires helicopter support or pack stock.

Post-treatment monitoring allows evaluation of the efficacy of the rotenone treatment. Traditionally, electrofishing has been the sole method of determining the effectiveness of the piscicide treatment. Electrofishing is labor intensive, time consuming, and has the potential to yield false negative results, especially in areas with complex habitat that decrease capture probability. Environmental DNA (eDNA) is now being used as an adjunct to electrofishing. Water samples collected in the field are tested for the presence of DNA from the fish targeted for removal. This technology requires far less labor and time, and the cost of sample analysis is considerably less than costs associated with employing field crews to cover miles of stream with electrofishers. Furthermore, eDNA results allow for a targeted approach to retreatment, which results in a smaller treatment area, less disturbance to aquatic communities, and less labor.

Once fish are eradicated, native trout are returned or stocked in the project area. In streams where nonhybridized, aboriginal populations of native fish remain, these fish are salvaged before rotenone treatment and returned to the stream the day after rotenone treatment ends. Otherwise, native fish are returned using several approaches. Potential sources of fish include streams in the same watershed, neighboring streams, brood stock acquired from wild fish, or captive brood stock that is regularly infused with wild genes. Imprinting fish on the receiving water prevents fish from leaving. Therefore, raising fertilized eggs to fry in remote site incubators or egg boxes is a primary means of reestablishing the fishery. In waters supporting a recreational fishery, catchable native fish are translocated to the project area, which requires horse trains or helicopter support.

Methods of Piscicide Treatment in Lakes

Piscicide treatment in lakes differs from stream application, as lakes lack the flow to disperse rotenone. Rotenone is applied to the surface of the lake from a boat, helicopter, or plane. Where incoming tributaries are present, drip stations are placed at their mouths. The treatment concentration follows the same procedure as stream application, with a bioassay determining the lowest effective dose. An electric or gas motor will mix rotenone in the lake, to ensure lethal concentrations occur throughout the lake. Natural deactivation is slower in lakes than in streams, although the same mechanisms contribute to the breakdown of rotenone.

Toxicity, Persistence, and Fate of CFT Legumine and Its Inert Ingredients in Treated Waters

As CFT Legumine is currently the most commonly used formulation of rotenone in Montana, this is the only formulation addressed. The Environmental Protection Agency (EPA) registered this formula (Reg. No. 75338-2) and approved its use as a piscicide. Information on its chemical composition, persistence in the environment, risks to human health, and ecological risks come from the material data safety sheet (MSDS) and manufacturer’s instructions. An MSDS is a form

detailing chemical and physical properties of a compound, along with information on safety, exposure limits, protective gear required for safe handling and procedures to clean up spills safely. In addition, Fisher (2007) analyzed the concentrations of major and trace constituents in CFT Legumine, evaluated the toxicity of each, and examined persistence in the environment.

The MSDS for CFT Legumine lists three categories of ingredients for this formula (Table 16). Rotenone comprises 5% of CFT Legumine by weight. Associated resins account for 5%, and the remaining 90% are inert ingredients. The MSDS confirms rotenone's extreme toxicity to fish.

Table 16: Composition of CFT Legumine from the material safety data sheet (MSDS)

Chemical Ingredients	*Percentage by Weight*	*CAS. No.[1]*	*TLV[2] (units)*
Rotenone	5.00	83-79-4	5 mg/m^3
Other associated resins	5.00		
Inert ingredients including n-methylpyrrolidone	90	872-50-4	Not listed

[1]Chemical abstracts number
[2]A TLV reflects the level of exposure that the typical worker can experience without an unreasonable risk of disease or injury

Analysis of the chemical composition of CFT Legumine found that on average, rotenone comprised 5% of the formula (Table 2-17), consistent with MSDS reporting. Other constituents were solvents or emulsifiers added to assist in the dispersion of the relatively insoluble rotenone. DEGEE, or diethyl glycol monoethyl ether, a water-soluble solvent, was the largest fraction of the CFT Legumine analyzed. Likewise, the solvent n-methylpyrrolidone comprised about 10% of the CFT Legumine. The emulsifier Fennedefo 99 is an inert additive consisting of fatty acids and resin acids (by-products of wood pulp and common constituents of soap formulations), and polyethylene glycols (PEGs). PEGs are common additives in consumer products such as soft drinks, toothpaste, eye drops, and suntan lotions. Trace constituents included exceptionally low concentrations of several forms of benzene, xylene, and naphthalene. These organic compounds were at considerably lower concentrations than measured in Prenfish™, another commercially available formulation of rotenone that uses hydrocarbons to disperse the rotenone. Their presence in trace amounts in CFT Legumine relates to their use as solvents in extracting rotenone from the original plant material.

Table 2-17: Average percent concentrations and ranges of major constituents in CFT Legumine lost (Fisher 2007).

Major CFT LegumineFormula Constituent	*Rotenone*	*Rotenolone*	*n-methylpyrrolidone*	*DEGEE[1]*	*Fennedefo 99*
Average %	5.12	0.718	9.8	61.1	17.1
Range	4.64-5.89	0.43-0.98	8.14-10.8	58.2-63.8	15.8-18.1

[1]diethyl glycol monoethyl ether

Persistence in the environment and toxicity to nontarget organisms are major considerations in determining the potential risks to human health and the environment. Rotenone is a highly reactive molecule; a factor that favors its rapid breakdown in the environment. The molecular constituents of rotenone are carbon, hydrogen, and oxygen and deactivation breaks rotenone into nontoxic compounds of these elements.

The effective rotenone concentration for removal of fish from the family Salmonidae is 25 to 50 ppb, which is roughly equivalent to ¼ to ½ of a grain of table salt per liter and is well below concentrations found to have lethal or sublethal effects on organisms other than fish or gill-bearing invertebrates and amphibians. The National Academy of Sciences suggested concentrations of 14 ppm (about 8,900 grains of salt per liter) pose no adverse effects to human health from chronic ingestion of water (National Academy of the Sciences 1983). Moreover, concentrations associated with acute toxicity to humans are 300-500 mg per kilogram of body weight (Gleason et al. 1969), which means a 160-pound person would have to drink over 23,000 gallons in one sitting to receive a lethal dose (Finlayson et al. 2000). Similarly, risks to wildlife from ingesting treated water are exceptionally low. For example, ¼-pound bird would have to consume 100 quarts of treated water, or more than 40 pounds of fish and invertebrates, within 24 hours, for a lethal dose (Finlayson et al. 2000). The EPA, in their recent reregistration evaluation of rotenone (EPA 2007), concluded that exposure to rotenone, when applied according to label instructions, did not present unacceptable risks to humans or wildlife. In summary, applying rotenone according to label instructions has no adverse effect on humans or wildlife associated with ingesting water, dead fish, or dead invertebrates.

Several factors influence the persistence of rotenone. Rotenone has a half-life of 14 hours at 24 °C, and 84 hours at 0 °C (Gilderhus et al. 1986, 1988), meaning half of the rotenone is degraded and is no longer toxic in that time. As temperature and sunlight increase, so does degradation of rotenone. Higher alkalinity (>170 mg/L) and pH (>9.0) also increase the rate of degradation. Rotenone tends to bind to and react with organic molecules rendering it ineffective, so nutrient rich waters may need higher concentrations to counteract binding to organic matter. Without deactivation, rotenone degrades to nontoxic levels in one to several days due to its break down and dilution in the aquatic environment.

In streams, mitigative actions further reduce the spatial and temporal extent of rotenone toxicity. A deactivation station releases potassium permanganate up to the effective concentration of 0.5 to 1 ppm. This strong oxidizer rapidly breaks down rotenone into its nontoxic constituents of carbon, oxygen, and hydrogen, with total breakdown occurring within 15 to 30 minutes of exposure, which is typically ¼ to ½-miles stream travel time. Potassium permanganate in turn breaks down into potassium, and manganese dioxide, which are common constituents in surface waters (Finlayson et al. 2000). In addition, potassium permanganate is a commonly used oxidizer

in wastewater treatment plants, so its release into streams and rivers is a regular and widespread phenomenon. The result of release of potassium permanganate on water quality is the elimination of toxic concentrations of rotenone, although potassium permanganate can be at lethal concentrations within the deactivation zone. An additional, back up deactivation station provides a safeguard if sentinel fish show signs of rotenone toxicity.

In lakes, the toxicity of rotenone persists longer than in streams. Although deactivation occurs through the same mechanisms, sunlight, natural oxidization, and dilution with inputs of groundwater and streams, inflows are relatively small compared to the volume of the lake. Binding with organic matter in lake sediments and littoral zones also facilitates the deactivation of rotenone and is synergistic with temperature. In earthen bottom ponds treated with rotenone, the half-life of rotenone was 2 to 3 times shorter than in concrete lined ponds (Dawson et al.1991). The half-life of rotenone in earthen lined ponds was 1.8 days at 8 °C, 0.7 days at 22 °C, and 1.8 days at 15 °C.

Application of CFT Legumine for 2 days in Lake Davis in California to eradicate invasive northern pike (*Esox lucius*) provided an opportunity to evaluate the persistence and fate of the primary constituents of CFT Legumine in the field (Vasquez et a. 2012). Water temperature, alkalinity, and exposure to sunlight, factors that influence degradation or rotenone were not reported; however, rotenone degradation was within the expected range for a relatively high elevation lake in September. The average maximum lake concentration of rotenone of 58.4 ± 36.6 ppb was attained 2 days post-treatment. This range of concentrations is within the effective concentration for fish eradication efforts. Breakdown of rotenone into rotenolone resulted in the maximum average lake concentration of rotenolone of 174 ± 4 ppb 6 days after treatment. The overall half-life of rotenone and rotenolone in lake water was 5.6 days and 11.1 days respectively. Rotenone had degraded to concentrations lower than analytical reporting limits in 34 days, and rotenolone was below detection limits by 62 days posttreatment. Despite not being able to control for temperature, sunlight or alkalinity, breakdown of rotenone in CFT Legumine was within the predicted range as described by Gilderhus et al. (1986, 1988).

Rotenone can bio-accumulate in the fat tissues of fish that are not exposed to toxic levels (Gingerich and Rach 1985); however, the short duration of exposure, and goal of total fish kill does not allow for accumulation of rotenone in salmonid conservation projects. Field studies of the rotenone-tolerant brown bullhead (*Ameiurus nebulosus*) surviving treatment concentrations of CFT Legumine provided no evidence of prolonged bioaccumulation of rotenone or rotenolone (Vasquez et al. 2012). Rapid degradation of rotenone in treated water was attributed to limiting the opportunity for fish to bioaccumulate rotenone.

Potential toxicity and persistence of the other constituents of the CFT Legumine formulation are additional considerations. Concentrations of n-methylpyrrolidone in treated water (about 2 ppm) have no adverse effects to humans ingesting treated waters. According to the MSDS, ingestion of 1000 ppm per day for three months does not result in harmful effects in humans. In addition, n-methylpyrrolidone does not persist in surface waters given its high biodegradability. In Lake Davis, the average maximum concentration of n- methylpyrrolidone occurred 10 days after treatment and was 156 ± 127 ppb, which is considerably lower than concentrations deemed safe for human consumption in the MSDS. The half-life of n-methylpyrrolidone was 4.6 days, and this chemical degraded to undetectable concentrations by 34 days.

Fisher (2007) examined the toxicity and persistence of other major constituents in CFT Legumine, including DEGEE, fatty acids, PEGs, and trace organic compounds, (benzene, xylene, naphthalene). With proposed application of CFT Legumine, none of these compounds violate water quality standards, nor do they reach concentrations shown to be harmful to wildlife or humans. Furthermore, persistence of these chemicals is not a concern. The trace organics degrade rapidly through photolytic (sunlight) and biological mechanisms. Likewise, the PEGs biodegrade in a few days. The fatty acids also biodegrade, although they would persist longer than the PEGs or benzenes.

Field investigations in Lake Davis (Vasquez 2012) confirmed Fisher's (2007) conclusions that inert constituents of CFT Legumine would degrade rapidly and be well below concentrations harmful to aquatic organisms or humans. The maximum average lake concentration of DEGEE was 779 ± 632 ppb. Toxicity information from the MSDS for DEGEE indicates bluegill (*Lepomis macrochirus*) survived 96 hours at 10 million ppb. DEGEE degraded relatively rapidly, with a half-life of 7.7 days, and was no longer detectable in treated water after 70 days (Vasquez et al. 2012).

Fennedofo 99 comprises approximately 18% of the CFT Legumine formulation (Fisher 2007). Fennedofo 99 was the most persistent of the main ingredients in CFT Legumine. The maximum average lake concentration was 389 ± 310 ppm at 6 days post-treatment. It had the longest half-life of 13.5 days. Fennedefo 99 dissipated to below reporting limits in 70 days. Despite its longer persistence, this substance is nontoxic, so its persistence did not pose a threat to aquatic life.

Benzene is among the trace compounds in the CFT Legumine formulation. Its treatment concentration in streams would reach 3.44 ppb, whereas the human health standard for chronic exposure to benzene in Montana is 5 ppb. This means the short-term treatment concentrations are less than levels that result in negative health consequences with long-term exposure. Concentrations resulting in acute toxicity, or death of 50% of tested organisms (LD_{50}) for

laboratory rats, range from 232,500 ppb to 279,000 ppb. Mice are substantially more tolerant of ingested benzene than rats.

The concentration of naphthalene in treated water is 0.00225 ppm. As a moderately volatile compound, naphthalene does not break down as rapidly as the highly volatile benzene and xylene. Nevertheless, this concentration is exceptionally low, and is undetectable in laboratory analyses. Furthermore, naphthalene concentration of 0.00225 ppm is well below the Montana drinking water standard of 0.1 ppm. The minute concentration of naphthene is treated water is likely inconsequential and short-lived. The lethal dose for 50% of tested organisms (LD_{50}) for rainbow trout is 1.6 ppm, and the LD_{50} for fathead minnow (*Pimephales promelas*) is 6.14 ppm. These concentrations are exorbitantly higher than treatment concentrations of naphthalene.

Trace concentrations of xylene were present in some lots of CFT Legumine (Fisher 2007), but it was not consistently encountered. Like benzene and naphthalene, concentrations of xylene, when present, were orders of magnitude lower than human health standards and acute toxicities for tested organisms. Moreover, dilution in stream application, and its high volatility, means xylene does not present a threat to human health and the environment.

The presence and fate of dead fish is another potential alteration of water quality associated with piscicide treatment. Although removing dead fish is often recommended to avoid conflicts with wildlife, the decay of dead fish does not increase the nutrient budget of the body of water. Decaying fish will return nutrients to the lake or stream, which fertilizes primary producers, and feeds scavenger, which form the base of the trophic pyramid. Therefore, the dead fish do not result in a net increase in the stream or lake's nutrient budget.

Deactivation at the downstream end of the project area limits the spatial extent of toxic water. Even without deactivation, the rotenone dilutes or breaks down in a matter of days through natural oxidation, binding with organic material or dilution, making the effects on water quality short-term and minor. Effective concentrations of rotenone generally do not travel far, which is why drip station spacing is typically at 1 to 2-mile intervals. The other constituents of the CFT Legumine are not toxic at the concentrations applied, and break down rapidly through hydrolysis, bacterial action, and oxidation (Fisher 2007). Likewise, potassium permanganate degrades rapidly when applied according to the manufacturer's label. Constituents with longer persistence are nontoxic and do not pose a threat to the environment.

To reduce the potential risks associated with the use of CFT Legumine, the following management practices, mitigation measures, and monitoring efforts are employed.

1. Project personnel are trained in the use of these chemicals including the actions necessary to deal with spills, as prescribed in the MSDS for CFT Legumine.
2. Signs are posted at trailheads and along the stream to warn people not to drink the water, consume dead fish, or have recreational contact with the water.
3. Only the amount of rotenone and potassium permanganate that is needed for immediate use is held near the stream.
4. A deactivation station is set up downstream of the target reach. Potassium permanganate neutralizes the rotenone at this location.
5. Sentinel fish are located below the deactivation station and within the target reach to determine and monitor the effectiveness of both the rotenone and potassium permanganate.
6. An additional deactivation is established downstream from the initial deactivation station as a safeguard.
7. People handling the rotenone wear protective gear as prescribed in the CFT Legumine label.
8. A pretreatment bioassay is conducted to determine the lowest effective concentration and travel time of the chemical in the stream.
9. Rotenone is diluted in water and dripped into the stream at a constant rate using a device that maintains a constant head pressure.

Effects of Rotenone on Groundwater

Rotenone binds readily to soils and is broken down by soil and in water (Dawson et al. 1991; Skaar 2001; Ware 2002). Because of its strong tendency to bind with soils, its mobility in most soil types is only one inch; although, in sandy soils, rotenone can travel up to three inches (Hisata 2002). Vasquez et al. (2012) reported concentrations of rotenone in lake sediments in units of nanograms per gram, with 1 gram being equal to 1 million nanograms. These exceptionally low concentrations of rotenone and rotenolone in lake sediments suggests leaching of rotenone compounds from the lake bed into groundwater is negligible, as the concentrations of rotenone in lake sediments were minute. Combined, the low mobility, rapid breakdown, and biologically insignificant concentrations of rotenone in lake sediments prevents rotenone from contaminating groundwater.

Groundwater investigations associated with several rotenone projects also indicate application of rotenone, and the inert ingredients, do not threaten groundwater quality. California investigators monitored groundwater in wells adjacent to, and downstream of, rotenone projects, and did not detect rotenone, rotenolone, or any of the other organic compounds in the formulated products (CDFG 1994). Likewise, case studies in Montana have concluded that rotenone movement through groundwater does not occur. For example, FWP monitored a domestic well two weeks

and four weeks after applying 90 ppb of rotenone to Lake Tetrault (FWP, unpublished data). This well was down gradient from the lake and drew water from the same aquifer that drained and fed the lake; however, no rotenone or associated constituents were detectable. FWP has monitored groundwater associated with several other rotenone projects, with wells ranging from 65 to 200 feet from the treated waters. Repeated sampling occurred within periods of up to 21 days, with no detectable concentrations of rotenone or the inert ingredients found.

Changes in the Diversity or Abundance of Aquatic or Semi-Aquatic Species

As discussed in Toxicity, Persistence, and Fate of CFT Legumine and Its Inert Ingredients in Treated Waters, terrestrial species will not be negatively affected by rotenone. The low concentrations used in piscicide projects, rapid breakdown in the environment, exceptionally low toxicity from ingestion, and deactivation at the downstream end of projects makes exposure orders of magnitude lower than toxic levels. Moreover, the duration of exposure would be short, not chronic. Therefore, this section addresses toxicity to organisms with an aquatic life history phase, as these organisms are most likely to be affected by rotenone treatment.

Aquatic Invertebrates

Gilled aquatic invertebrates are nontarget organisms with considerable potential to experience negative effects from rotenone treatment. In streams, benthic populations of true flies, stoneflies, mayflies, and caddisflies are the primary affected taxa. Mayflies, stoneflies, and caddisflies are often grouped as EPTs, which is an abbreviation of the orders Ephemeroptera (E), Plecoptera (P), and Trichoptera (T), and refers to mayflies, stoneflies, and caddisflies respectively. Although individual taxa of EPT vary in tolerance to rotenone, as a group, EPTs are generally more sensitive than non-EPT taxa, such as true flies, aquatic worms, snails, and beetles, and their relative abundance and richness are commonly used measures of stream health.

Drawing general inference on the effects on aquatic invertebrates from the literature is challenging. Treatments in the scientific literature vary in terms of duration and concentration of rotenone. Moreover, investigations often fail to include information such as proximity of treated waters to a recolonization source, such as downstream drift, or dispersal by aerial adults. Sampling methodology often differs among studies, and inconsistency in reporting abundance and taxonomic resolution present other confounding factors.

Although differences in formulation, concentration, and duration of rotenone treatment complicate making robust predictions on the effects of rotenone on macroinvertebrates, the scientific literature allows for some generalizations. Investigations into the effects of rotenone on benthic organisms indicate that rotenone can result in temporary reduction of stream-dwelling invertebrates. In one case, no significant reduction in aquatic invertebrates occurred despite concentrations of rotenone being twice as high as the proposed maximum concentration (Houf

and Campbell 1977). In other cases, invertebrates recovered quickly following treatment. For example, following piscicide treatment of a California stream, macroinvertebrates experienced an “explosive resurgence” in numbers, with black fly larvae recovering first, followed by mayflies and caddisflies within six weeks after treatment (Cook and Moore 1969). Stoneflies returned to pretreatment abundances by the following spring.

Another mitigative factor is that invertebrates that were most sensitive to rotenone also tended to have the highest rate of recolonization due to short life cycles (Engstrom-Heg et al. 1978). Although gill-respiring invertebrates are a sensitive group, many are far less sensitive to rotenone than fish (Schnick 1974; Chandler and Marking 1982; Finlayson et al. 2010). Due to their short life cycles (Anderson and Wallace 1984), strong dispersal ability (Pennack 1989), and generally high reproductive potential (Anderson and Wallace 1984), aquatic invertebrates are capable of rapid recovery from disturbance (Boulton et al. 1992; Matthaei et al. 1996).

A study of response of benthic invertebrates in streams in Montana and New Mexico is representative of concentration of CFT Legumine and duration of treatment used in current practice in Montana (Skorupski 2011). Notably, this research included comparisons to nontreated controls, so differences among sampling events resulting from natural variability and temporally consequential conditions, such as weather, could be evaluated statistically. In Cherry Creek and Specimen Creek, both in Montana, rotenone resulted in minimal effects on macroinvertebrates immediately after treatment, although potassium permanganate did influence benthic communities. Rotenone had a greater effect on benthos in streams in New Mexico. Regardless of the initial response, invertebrate communities recovered in all streams within a year.

A native species conservation project in Norway used CFT Legumine to kill all salmon in the watershed to eradicate a parasite that causes high mortality in salmonids (KJærstad et al. 2014). Unlike most piscicide projects in the western U. S., the species of fish targeted for removal was the same species that was intended to benefit from removal. The community was infected with a parasite that causes high mortality in salmonids, and the only way to eliminate the parasite was to remove the fish, as the parasite is short-lived without its salmonid host.

CFT Legumine was applied to maintain a minimum concentration of 0.5 ppm, which is lower than the 1 ppm typical of most piscicide projects in Montana. Duration of treatment was not reported. Like Skorupski (2011), these researchers also sampled untreated areas as controls. CFT Legumine was applied 3 times over a 2-year period, and water temperature varied seasonally with the April and October treatments measuring 4 °C and 8 °C respectively. Water temperature during the August treatment was 20 °C.

After treatment in cool waters in April and October, overall density of invertebrates was slightly depressed, but not significantly. The densities of a few sensitive taxa had decreased; however, these taxa were still present. The response of the macroinvertebrate community to treatment in August was considerably different, with a significant reduction in density, and many taxa remained absent from samples until several months after treatment. Nevertheless, most taxa had recolonized with a year. Warmer water temperature was attributed to the decreased abundance and reduction in richness following the treatment in August. In Montana, treatments usually occur in the fall, when water temperatures are relatively cool, as a mitigative measure to protect amphibians and aquatic invertebrates.

Mangum and Madrigal (1999) is a frequently cited study that evaluated the response of invertebrate population composition following application of rotenone in the Strawberry River watershed in Utah. In contrast to other researchers who reported small reductions in species richness and abundance, followed by rapid recovery of benthic communities (Cooke and Moore 1969; Houf and Campbell 1977; Skorupski 2011; KJærstad et al. 2014), Mangum and Madrigal (1999) reported statistically significant reduction in numbers of select taxa and putative "absence" of up to 8 taxa per sampling station after 5-years of yearly sampling. The disparity of results compared to researchers who found full recovery within a year may be explained by examining the concentration and duration of piscicide application, the validity of key assumptions, and rigor of the study design.

In the Strawberry River project, rotenone application was drastically more excessive than concentrations allowed in FWP's piscicide policy (FWP 2017). Application of rotenone was 150 ppb, which is substantially higher than the 25 to 50 ppb applied in piscicide projects in Montana. Moreover, the duration of treatment was 48 hours, compared to 4 to 8 hours that is required under Montana's piscicide policy (FWP 2017). Furthermore, this high concentration of rotenone, applied at an extremely long duration, was repeated 1 month later. Other studies examined here entailed a single treatment (Cooke and Moore 1969; Houf and Campbell 1977; Skorupski 2011), or evaluated response after subsequent treatments (KJærstad et al. 2014). Combined, these factors make the Strawberry River project profoundly different than piscicide projects implemented under FWP's protocols (FWP 2017) and other studies in the literature, in terms of intensity and frequency of exposure to rotenone.

Mangum and Madrigal's (1999) initial findings were like those reported by other researcher (Cook and Moore 1969; Skorupksi 2011; KJærstad et al. 2014), although reductions in EPT taxa were more pronounced. Invertebrate abundance was decreased in the first sample following treatment, but resurgence of midges, blackflies, crane flies, and aquatic worms, all early colonizers, occurred within 1 to 2 months. Richness of mayflies, stoneflies, and caddisflies was

decreased after the first treatment by 45% to 82% for mayflies, 50% to 69% for stoneflies, and 30% to 75% for caddisflies. Mangum and Madrigal (1999) did not report abundance or richness of EPT taxa in subsequent sampling events, so it is not possible to determine if community richness or abundance recovered in the following years.

A limitation of this investigation is its unsupportable assumption that taxa "missing" from samples were missing from the stream. Sampling is not a census, and absence cannot be proven from a sample. The natural variability in distribution, abundance, and species presence in streams confounds assumptions of absence. Streams provide diversity in habitat complexity, and in the number of invertebrate species they support. Rarity of many taxa is common; however, streams can support several hundred species of aquatic invertebrate. Given the substantial potential for rarity, complexity of the habitat, patchiness in distribution, and seasonality of life history stages, no stream has had a census, or complete inventory, of all species present (Entrix 2010). A taxon missing from the sample, is not necessarily absent from the stream.

Mangum and Madrigal (1999) did not account for the natural among month or among year variability of species collected in streams, which is considerable. Monthly sampling of the same location Logan River for 10 years provides a case study of community composition dynamics across time (Vinson et al. 2010). Little variability in numbers of species or genera occurred among sampling events; however, the presence of individual genera or species showed considerable variability. Over 60 genera had been collected at this site; however, the number of individual genera captured regularly was about 40% of the total number of genera found cumulatively. The list of genera continued to grow, with a new one appearing about e 2 months. The genera accumulation curve had been increasing steadily and showed no sign of flattening out. Mangum and Madrigal (1999) did not report species composition, richness, and abundance in any sampling event, so examination of variability among sampling events is not possible. They also did not report if new taxa appeared in samples, which research suggests is likely (Vinson et al. 2010).

The lack of an untreated control is another limitation in the Mangum and Madrigal (1999) investigation, is inconsistent with the scientific method, and does not allow for prediction based on their data. Without collecting macroinvertebrates in similar reaches that have not been treated, it is not possible to conclude with any certainty that absence of a taxon was the result of piscicide, and not related to natural variation among sampling events or resulting from natural variation in environmental conditions. Macroinvertebrate community composition is naturally stochastic over time. Combined with patchiness in distribution, the naturally random presence of some taxa makes the measure of species presence or absence in a sample an unreliable measure of the effects of rotenone. Current macroinvertebrate assessment protocols evaluate calculated metrics of abundance and richness of categories of invertebrates based on larger taxonomic

groups, sensitivity to pollutants, life-span, and trophic function, as natural variability of species composition is considerable (Vinson et al. 2010). This approach controls for random variation in species composition and evaluates stream health on a community level.

Reporting and sampling methodology also confounds the ability to assume absence of a taxa or draw conclusions with statistical certainty. Mangum and Madrigal (1999) state that the abundance of select taxa of invertebrate were statistically less in the years following piscicide treatment; however, they do not present data in narrative, tabular or graphical form, so critical review of these findings is not possible. Moreover, the assumption that Surber samplers yield a representative sample of invertebrates that captures all the taxa present is not supported by research. A power analysis to estimate the number of invertebrates with a statistical certainty within 5% of the mean, found nearly 450 Surber samples would be required (Chutter 1972). The tremendous variability in biomass among samples suggests similar variability in species collected and limits the inference that is possible on the presumed absence of a taxon from 3 replicate Surber samples per site. Note that Skorupski (2011) used Surber samplers and traveling kick nets. The traveling kick net method covers the wetted perimeter from bank to bank, and therefore, covers more variability in microhabitats than Surber samplers, which sample discrete patches of streambed.

Given the great natural variability of taxa present among samples, and the highly biased sampling method, Mangum and Madrigal's assumption that absence of a taxon from a sample meant that it was missing from the stream is unsupportable. The Logan River study shows that the great variability among samples limits inference on taxa present. The putative missing taxa accounted for 10% or less of the baseline species present, and Mangum and Madrigal (1999) did not report their abundance in the pre-project samples, so the relative abundance in baseline sampling is unknown. Considering Vinson et al.'s (2010) findings, the presumed absence of 10% of taxa may be attributable to natural variability. Moreover, proving absence is impossible.

The recovery of macroinvertebrate communities reported by most researchers is the result of evolved mechanisms to persist in a disturbance driven ecosystem. Larval drift and reproduction by aerial adults are the primary mechanisms of recovery, and untreated, fishless headwaters provide a source of invertebrates drifting into reclaimed waters. Likewise, aerial adults flying upstream lay eggs and repopulate invertebrate communities. Proximity to adjacent sub-watershed populations further expedites this recovery. Moreover, macroinvertebrates are in a diverse array of life history stages, and recently emerged adults can reproduce soon after treatment. Observations on Lower Deer Creek documented a substantial hatch of caddisflies and midges the day following treatment of an area (C.L. Endicott, FWP, personal communication).

The well-established ability of macroinvertebrates to recover following disturbance, combined with the lower susceptibility of many taxa to rotenone, contributes to rapid recovery of invertebrate populations. Disturbance is a common occurrence in streams, and includes floods, wildfire, and human-caused alterations such as incompatible livestock grazing practices (Mihuc and Minshall 1995; Wohl and Carline 1996; Minshall 2003). These disturbances have greater potential to have long-term effects on stream-dwelling assemblages than rotenone treatments, given longer-term changes in geomorphology, impairment of riparian health and function, and reduced water quality. Rotenone treatment mimics a pulse disturbance, which is common in streams, and macroinvertebrates have evolved under this type of disturbance regime.

In conclusion, the weight of evidence, especially with reference to the more recent investigations that reflect current practice and have a study design with an untreated control (Skorupski 2011; KJærstad et al. 2014) indicates treatment of streams with CFT Legumine results in initial, minor reductions in abundance and richness of benthic invertebrates and recovery of populations within a year. Biomass recovers rapidly as early colonizers exploit available resources and have short-term relief from predation by fish or other invertebrates.

Zooplankton

Rotenone has greater initial effects on abundance and diversity of zooplankton than lotic invertebrates, given the longer period of exposure (Vinson et al. 2010). Recovery of zooplankton varies among taxa, with a dramatic bloom of early colonizers in the first couple of months (Anderson and Beal 1993). Other taxa take longer to recover, but the diversity and abundance can return within 6 months. Leaving dead fish within the lake likely provides the nutrients for recovery of lentic invertebrates, and 70 % of dead fish do not surface (Bradbury 1986).

Biomass of zooplankton recovers rapidly; however, zooplankton community composition can take from 1 week to 3 years to return to pretreatment conditions (Beal and Anderson 1993: Vinson et al. 2010). Like stream-dwelling invertebrates, zooplankton have life history strategies that aid in rapid recolonization following disturbance (Havel and Shurin 2004). Many taxa are capable of asexual reproduction, which favors rapid recolonization from existing eggs and zooplankton that survived treatment. Moreover, lakes have a long-term bank of dormant eggs that are resilient to a range of harsh conditions and provide many years of recruitment of zooplankton within a lake. In addition, wind, animals, and humans are primary agents of dispersal of dormant eggs. Numerous fishless lakes are within the project area, and these lakes would provide a nearby source of zooplankton to supplement the existing benthic egg bank.

In a Norwegian lake, the zooplankton were sampled before application of CFT Legumine in 2014, immediately after treatment, and 1-year post-treatment in 2015 (Amekleiv et al. 2015). CFT Legumine had an initial negative effect on zooplankton, with none being detected

immediately after treatment. The relative abundance of species of zooplankton changed from pretreatment to 1-year post-treatment with some species comprising a much higher proportion of the zooplankton community. In addition, overall abundance of zooplankton increased considerably in 2015, compared to 2014. Removal of common roach (*Rutilus rutilus*), a species of minnow that preys on zooplankton, was attributed to greater biomass of zoonplankton in 2015, compared with pretreatment abundance in 2014.

Amphibians

Amphibians are closely associated with water and have potential to be exposed to rotenone during treatment. Montana has several salamanders, toads, and frogs that need to be considered before rotenone application (Table 18). Information on reproductive ecology, habitat requirements, and life-history comes from descriptions and literature compiled in the Montana Natural Heritage Program's field guide (MNHP Field Guide: Amphibians) and species descriptions provided by Reichel and Flath (1995).

Table 18. Amphibians with potential to be exposed to rotenone in piscicide projects (from Montana Natural Heritage Program).

Order	Common Name	Scientific Name	Gilled Phase Coincide with late summer/early fall piscicide treatment	Status
Caudata/ salamanders	Idaho giant salamander	*Dicamptodon aterrimus*	Yes	G3[1], S2[2]
	Coeur d'Alene salamander	*Plethodon idahoensis*	No	G4[3], S2, sensitive (USFS)
	Long-toed Salamander	Ambystoma macrodactylum	No	G54, S45
	Western tiger salamander	Ambystoma mavortium	Yes, neotenic adults	G5, S4
Anura/toads and frogs	Boreal chorus frog	Pseudacris maculata	No	G5, S4
	Pacific tree frog	Pseudacris regilla	No	G5, S4
	Rocky Mountain Tailed Frog	Ascaphus montanus	Yes	G4, S4
	Columbia Spotted Frog	Rana luteiventris	Yes, at higher elevations	G4, S4
	Western Toad	Anaxyrus boreas	Yes	G4, S2, sensitive (USFS and BLM)

[1] G3 = Globally the species is potentially at risk because of limited and/or declining numbers, range and/or habitat, even though it may be abundant in some areas.
[2]S2 = In Montana, at risk due to limited and/or potentially declining population numbers, range and/or habitat, making vulnerable to extirpation.
[3]G4 = Globally, is apparently secure, although it may be rare in parts of its range, and/or suspected to be declining.
[4]G5 = Globally, the species is common, widespread, and abundant, although it may be rare in parts of its range. The species is not vulnerable in most of its range.
[5]S4 = In Montana, the species is apparently secure, although it may be rare in parts of its range, and/or suspected to be declining.

The potential to be exposed to rotenone varies by species. The Idaho giant salamander is present in streams and rivers, and occasionally ponds and lakes, in larval form, or as gill-retaining neotenic adults (Adam Sepulveda, U.S. Geological Service, personal communication) and is the only salamander in Montana that rears in streams. Terrestrial metamorphic adults are rarely seen and occupy lotic and lentic waters only while breeding. Information on their reproductive ecology and longevity is limited, so evaluating the potential for piscicide projects to have population level effects is difficult to predict. Their vulnerability to rotenone is unknown; however, as gilled life stages occupy water, rotenone would likely result in mortality. Otherwise, little information is available on fecundity and longevity; however, terrestrial adults would likely

be present to replace lost year classes. The Idaho giant salamander has extremely limited distribution in Montana, and piscicide projects in these waters should determine their presence, and pre-project monitoring should determine whether waters slated to be treated are occupied habitat.

Couer d'Alene salamanders are present in western Montana and are restricted to cool, moist environments. Eggs are terrestrial, and larvae do not have an aquatic phase. As adults, these salamanders occupy springs, seeps, waterfall spray zones, stream edges, and talus far from running or standing water. Adults occupying stream edges and treated seeps within a piscicide project area would potentially be exposed to rotenone. Although their vulnerability to rotenone is unknown, other adult amphibians do not experience acute toxicity from exposure to rotenone at concentrations used in fish eradication projects (Grisak et al; 2007; Billman et al. 2011). Moreover, Couer d'Alene salamanders are relatively long-lived, and do not become sexually mature until 3.5 years for males and 4.5 years for females, so other year classes occupying nontreated areas may recolonize treatment areas. Nevertheless, piscicide projects occurring within the range of Couer d'Alene salamanders should determine if this species has potential for exposure. If so, bioassays should be conducted to determine their sensitivity to rotenone, and potential mitigative actions should be evaluated if rotenone exposure is likely to have long-term population level effects on this species.

Long-toed Salamanders occupy portions of western Montana east and west of the Continental Divide. This species is unlikely to experience long-term population effects of piscicide treatment. Long-toed Salamanders usually lay eggs in fishless ponds or lakes, which would not be treated with rotenone. Even so, larval long-toed salamanders were 5 times more tolerant to Prenfish, a formulation of rotenone using organic solvents and dispersants, than fish, and adult long-toed salamanders survived 96-hour exposure to treatment concentrations of Prenfish used in piscicide projects (Grisak et al. 2007). Adult long-toed salamanders are terrestrial, and breed immediately after snowmelt, they would not be present for fall application of piscicide. The combination of preference for fishless lakes for breeding and terrestrial existence as adults make long-toed salamanders unlikely to be affected by piscicide treatments. In cases where this species breeds in fish-bearing lakes, piscicide treatment may result in the loss or reduction of a year class; however, breeding in following seasons would allow the population to recover.

In mountain lakes, western tiger salamanders are present as gill-bearing adults, or axolotls. At lower elevations, western tiger salamanders exist as terrestrial adults, gilled larvae, and neotenic adults. Little information is available on toxicity of rotenone to western salamanders, although larval salamanders were presumed to be as vulnerable to rotenone as fish (Maxell and Hokit 1999). Nevertheless, observations of substantial numbers of neotenic forms in a reservoir a year after rotenone achieved eradication of fish suggests some resilience to rotenone (Jim Olsen, FWP

personal communication). Moreover, western tiger salamanders are resilient to loss of a year class (Bryce Maxell, MNHP, personal communication). Frequently, the older year class of western tiger salamander larvae will cannibalize the newer generation. This strategy ensures the success of the older year class, resulting in staggered year class success.

Clearly, insufficient information is available to draw strong conclusions on the potential for western tiger salamanders to be negatively affected by rotenone treatment. Should native fish conservation projects be considered in waters supporting larval or neotenic western tiger salamanders, bioassays should be performed to evaluate their response to rotenone exposure. Projects should proceed if no long-term population level effects are expected based on tolerance to rotenone, existence of life-history strategies that allow for recovery, or when mitigative actions prevent long-term effects on western tiger salamander populations.

Like gill-bearing aquatic macroinvertebrates, frog and toad larvae are sensitive to rotenone, and exposure to rotenone at levels used to kill fish is acutely toxic to Columbian spotted frog larvae, Rocky Mountain Tailed Frog larvae, and Western Toad larvae (Grisak et al. 2007; Billman et al. 2012). Although tadpoles may be vulnerable to rotenone, at least some species may be up to 10 times more tolerant than fish (Chandler and Marking 1982). Treatment in late summer or early fall is a recommended practice to prevent effects on frogs and toads, as many are past the gilled life history stage (Grisak et al. 2007). In the short-term, this practice may not be protective of species that remain as gilled larvae for more than 1 year, or at high elevations, where delay in the breeding season and low temperatures delay metamorphosis. Nevertheless, toads and frogs have considerable potential to recover from this short-term disturbance.

Rocky Mountain Tailed Frogs are the most tied to water of all the frogs and would likely experience short-term and minor effects from treatment with rotenone. Their reproductive strategy is to mate in August to September, and store the sperm overwinter. Eggs are oviposited the next spring, and metamorphosis occurs up to 4 years later. Therefore, at least 1-year class of tadpoles would be exposed to rotenone, with 2 or more exposures being possible. Nevertheless, their life history strategies make Rocky Mountain Tailed Frogs resilient to rotenone treatment. Rocky Mountain Tailed Frogs are a long-lived species, and do not reach reproductive maturity until age 7 or 8. This species would be resilient to rotenone treatment because many older year classes would survive, and treatment concentrations of rotenone do not have an adverse effect on adults (Grisak et al. 2007).

Rocky Mountain Tailed Frogs are relatively fecund and lay up to 170 eggs. In the spring following rotenone treatment, numerous age classes of adults would be present to oviposit eggs in streams and lakes. When treatments have ceased, Rocky Mountain Tailed Frogs would have a short-term advantage, as tadpoles would experience little to no predation by fish, until fish

populations recover within treated streams. Field observations suggest Rocky Mountain Tailed Frogs are resilient to rotenone projects. Moreover, this species can disperse downstream, from untreated reaches into treated reaches. A field study in alpine lakes found no significant effect on Rocky Mountain Tailed Frogs in 2 to 4 years of monitoring following a rotenone treatment (Fried et al. in press), suggesting rotenone treatment would have short-term and minor effects on this species.

Effects on other adult amphibians are insignificant given their low vulnerability to rotenone because of loss of gills, development of lungs, maturation of liver function, mobility, and project timing. Adult Columbian spotted frogs do not suffer an acute response to trout killing concentrations of Prenfish, another commonly used formulation of rotenone that includes organic compounds (Grisak et al. 2007). Piscicide treatments are acutely toxic to gilled tadpoles, but not metamorphs or juveniles (Billman et al. 2011). Columbian spotted frogs breed in mid-April to early June and metamorphose about 60 days after hatching. Vulnerable populations of Columbia Spotted Frogs are those at tree-line, or elevations above 6,500 to 7,000 feet. These populations are temperature limited and will remained as gilled tadpoles throughout the winter (Bryce Maxell, Montana Natural Heritage Program, personal communication).

Even if a year class of tadpoles is exposed to lethal concentrations of rotenone, other life-history traits make this species resilient to piscicide projects. Columbian spotted frogs are a relatively long-lived species, and do not reach sexual maturity for 4 to 6 years, depending on sex. The presence of several older year classes means there is a continued source of recruitment. Furthermore, Columbian spotted frogs are relatively fecund and lay egg clusters of 300 to 800 eggs. Field investigation confirms with reproductive capacity of this species, with a substantial rebound of Columbian spotted frog larvae 1 year after piscicide treatment resulted in near total mortality of tadpoles (Billman et al. 2012)

Western Toads show the same life stage sensitivity to rotenone, with tadpoles suffering near total mortality to exposure to concentrations of rotenone used in current practice, but resilience to rotenone as metamorphs through adults (Billman et al. 2011). Moreover, adult Western Toads are likely less sensitive than frogs, given their impermeable skin (Maxell and Hokit 1999). Likewise, adult toads and frogs can leave the aquatic environment, which substantially reduces the potential for exposure (Maxell and Hokit 1999).

Western Toads have various characteristics that make them resilient to piscicide projects. Western Toads have exceptional fecundity, documentation of egg clutches averaging 5,000 in Colorado, and reaching 16,000 in Montana and 20,000 in the Pacific Northwest. Development from hatching to metamorphosis is related to temperature and can be rapid; however, populations

at tree line may fail to metamorphose, and these populations may rely on immigration from lower elevations to persist.

Variability of tolerance to rotenone among species of toad and frog is unknown; however, evidence for resilience to rotenone of other species suggests a general tolerance is possible. A study in Norway examined the response of lake-dwelling amphibians, the common frog (*Rana temoraria*) and common toad (*Bufo bufo*), to treatment with CFT Legumine (Amekleiv et al. 2015). These species were observed before and 1 year after treatment with rotenone, with adults, eggs, and tadpoles being present following treatment. They concluded CFT Legumine had little effect on these species.

Compatibility of Wilderness Values with Rotenone Treatment in Lakes and Streams

Chemical removal shares some of the same conditions that may affect wilderness values and disturb the wilderness experience with mechanical removal. The presence of field-workers, horses and helicopters transporting gear occurs with both scenarios. However, piscicide is more efficient, and requires fewer treatments, and in most cases, is completed over the course of fewer years. Conditions that increase the number of years of treatment include complex habitat, including beaver ponds and large woody debris jams. Mechanical removal is not feasible under these conditions.

Release of a toxic chemical into wilderness waters, and killing all the existing fish, and some of the invertebrates and amphibians, is a substantial human imprint. Moreover, piscicide is objectionable to some members of the public, not only in designated wilderness, but in principle. Fisheries managers need to weigh all options, and consider the status of declining native fish species, and their potential for long-term persistence within their historical range. Informed decision-making should account for the duration of the disturbance to aquatic communities, as well as the long-term benefits to native fish conservation, especially species of concern, or species listed as threatened or endangered under the Endangered Species Act.

Mortality of nontarget organisms alters wilderness character and is another factor that needs to be considered in planning piscicide projects. Pre-project sampling of invertebrates and amphibians provides a baseline of pretreatment communities and allows for detection of species of concern. Development of environmental assessments required through the Montana Environmental Policy Act and the National Environmental Policy Act, along with additional evaluations specific to designated wilderness, will assist in the decision-making process, and evaluate whether the negative effects of short-term disturbance outweighs the long-term conservation benefits, especially with federally listed species. Nevertheless, the weight of scientific evidence indicates nontarget aquatic invertebrates recover within 1-year post-treatment,

and amphibians are likewise resilient to rotenone treatment. The primary decision is a balance between long-term persistence of an imperiled fish species versus short-term changes in aquatic invertebrate communities.

The presence of dead fish has potential to diminish the enjoyment of designated wilderness and increase probability for conflicts with scavenging bears; however, dead fish would be present for a few days, and most fish would likely never be encountered. Even without scavenging, fish decompose rapidly in lakes and streams, with microbial action being obvious within a few hours. Nevertheless, retrieving dead fish along trails, and sinking dead fish in lakes by puncturing their air bladders would substantially limit the potential for dead fish to reduce the quality of the wilderness experience or increase conflicts with wildlife.

Finally, projects that restore or conserve native fish is consistent with wilderness character, as these would be the species that evolved in the area. Nonnative rainbow trout, brook trout, and brown trout, as well as hybrids, detract from the ecological heritage and potential of designated wilderness.

Conclusions

Chemical and mechanical methods to remove nonnative fishes are both viable options in management of native fishes, although mechanical removal is infeasible for removal in streams greater than 2 miles in length, or where complex woody, overhanging vegetation, and beaver dams increase habitat complexity. Each brings a level of disturbance that may negatively affect wilderness values. Conversely, restoring the native species to a stream increases its biological integrity and is consistent with the intent of the Wilderness Act of 1964.

Mechanical removal is feasible in relatively short reaches of stream, or small isolated lakes. Mechanical removal in stream reaches greater than 3 miles has not been attained. Mechanical removal is infeasible in large project areas that encompass many more miles of stream with complex habitat.

Mechanical and chemical removal of fish requires the presence or construction of a barrier to prevent reinvasion of nonnative species. Should mechanical removal be attempted in a larger watershed, temporary barriers would need to be constructed as fish are removed from headwaters

Mechanical removal requires considerably more labor than chemical removal in streams with complex habitat. Mechanical removal is often not effective without removal of streamside vegetation and woody debris, which requires crews using chainsaws. Furthermore, the number of removal events are considerably more numerous, and cover more years than chemical removal.

As a result, humans are present in the watershed for more days per year. Moreover, even where feasible, mechanical removal typically takes 4 or more years to achieve eradication.

Removal of streamside vegetation and woody debris results in changes in the trophic functioning of streams, increases water temperature, and decreases channel stability. With recovery of the woody canopy, trophic level composition of macroinvertebrates and water temperatures likely return to pretreatment conditions within a few years. Removal of large woody debris and complex woody debris takes considerably longer, as it requires trees to die and fall across or into streams.

Disturbance associated with chemical removal varies with the size of project area and includes introduction of a toxic substance to surface waters, presence of field-workers attending drip stations, and potentially motorized use for deli and application of piscicide. Typically, a single treatment lasts 4 to 8 hours, with additional treatments possible in subsequent years, if a full fish kill is not attained in the first year. Field-workers trample streamside vegetation while walking to and from drip stations, although vegetation would recover quickly from this disturbance. Most or all fish, and an unknown proportion of the invertebrate community, die from exposure to rotenone. This disturbance is short-term, as fish are restocked using the best available source. Macroinvertebrate communities recover from invertebrates that are not vulnerable to rotenone, larvae drifting from untreated headwaters reaches and dispersal of aerial adults. With application of best management practices, amphibians are resistant to rotenone, or recover through reproduction or recolonization the following spring.

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